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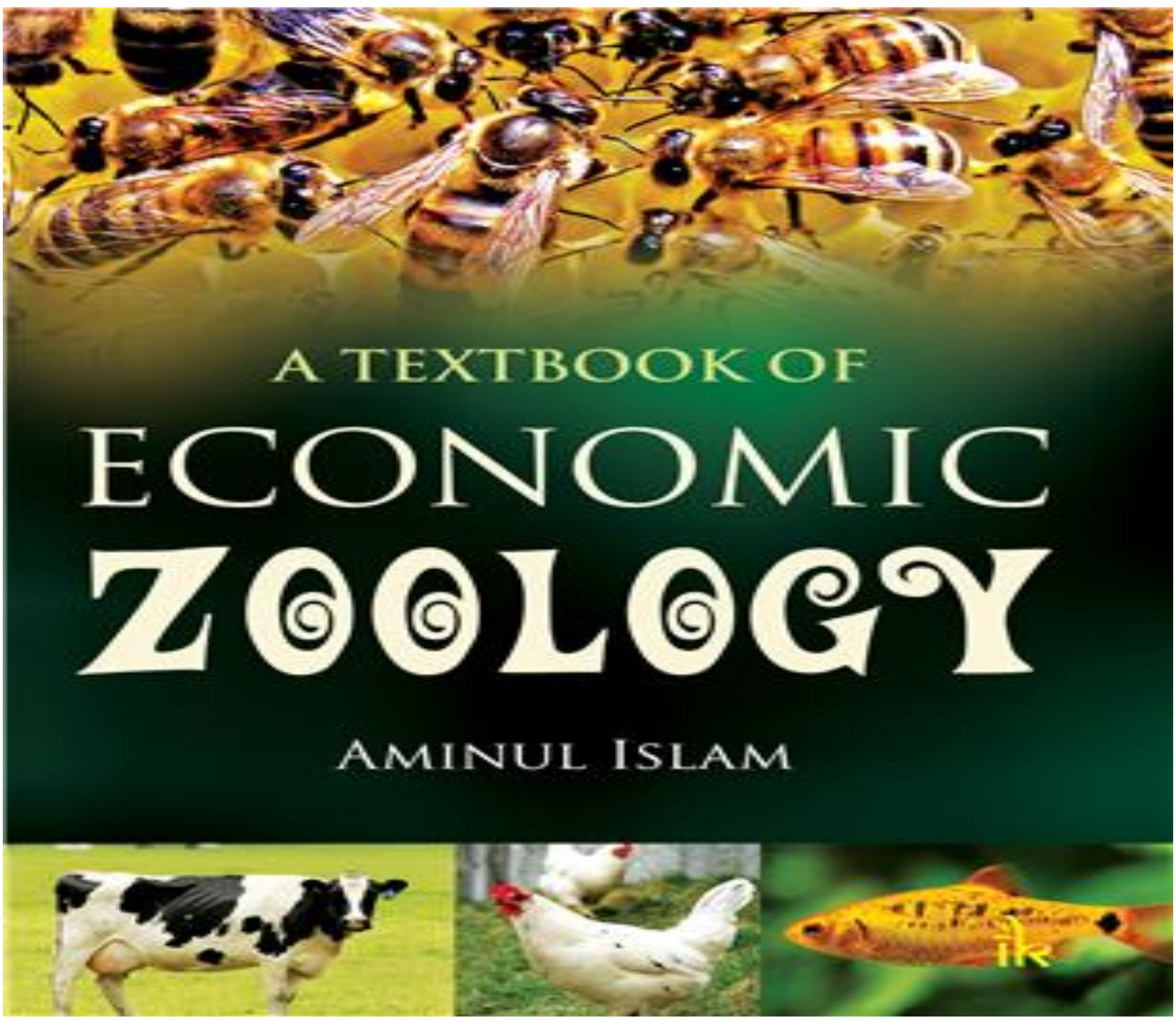
ZOO510-Economic-Zoology



HANDOUTS TOPIC NO 1 TO 239

MUHAMMAD IMRAN

ZOO510-Economic Zoology

1 Fisheries and Aquaculture Introduction

Introduction to Aquaculture

Aquaculture

- The art of cultivating the natural produce of water.
- Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.
- Aquaculture therefore is Farming of aquatic organisms in natural or controlled marine or freshwater environments
- Both under controlled or semi-controlled conditions.
- Mariculture – (old name) marine or brackish water"
- Aquaculture encompass farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants."

Types of Aquaculture

- **Extensive Aquaculture:** Minimal control, lower density • E.g., ponds, prevalent in third world countries

- **Intensive Aquaculture:** Highly controlled, high density, RAS, raceways, confined • E.g. industrialized

2 History of Aquaculture

1. Egyptian tombs have bas-relief (sculpture)of fish (tilapia) being removed from ponds – 2500 B.C.
2. Carp were farmed in China as early as 2500 B.C.
   a. Wen Fang – founder of the Chou Dynasty is called the first fish farmer
   b. (during exile he kept records of fish growth and behavior)
   c. Fan Li – wrote first book on fish farming 475 B.C.
   d. Lee family – Were the first to polyculture carp during the Tang Dynasty 600 to 900 A.D.
3. England – 1500 A.D. carp culture was introduced
4. U.S. – first fish hatchery was in Oregon 1877

World Aquaculture

Species Selection

1. Producer's expertise
2. Water supply and climate
3. Species biology
4. Marketability
5. Production methods
6. Production economics

3 Commonly Cultured Species

Commonly Cultured Fish species

- **Food fish**

Many species, Catfish, Tilapia, Rainbow trout, Atlantic Salmon, shrimp, Shellfish, Striped Bass, Others

Ornamental fish

Aquaria
Backyard ponds .

Bait fish

Minnows
Shiners
Goldfish
(carp)

Natural stock enhancement

Salmon
Trout
Black sea bass

Red Drum

Many others…

Commonly Cultured Crustaceans

- Marine (Penaeid) shrimp
- Freshwater shrimp (prawns)
- Crabs
- Crayfish
- Lobsters
- Brine Shrimp

Commonly Cultured Mollusks

- Clams
- Oysters

- Mussels
- Abalone
- Urchins

Additional Cultured Organisms

Seaweed

- Food for Abalone
- Extraction of nutrients for vitamins **Corals / Sponges / Sea Fans**
- Extraction of medicines
- Aquarium trade **Live rock**
- Inhabiting macro and micro life Aquarium trade

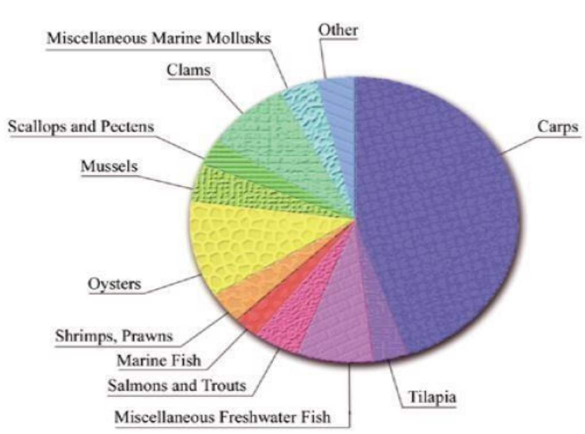
4 Status of Aquaculture

- **Aquaculture** is the fastest growing sector of agriculture with an approximate annual growth rate of 10%
- Currently aquaculture accounts for 25% of all seafood consumed in the U.S.
- Percentage is very low in Pakistan about 2 kg against world consumption of above 16 kg

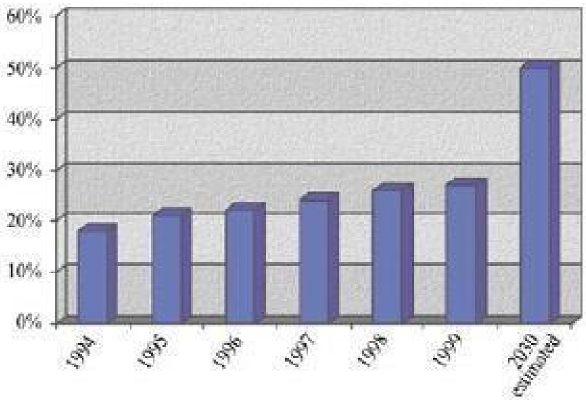
World Aquaculture Production

- In 2000 45.51 million metric tons by weight of aquaculture products
- Equal to US $56.47 billion
- China is the largest aquaculture producing country in the world

Proportion of Total Aquaculture Production for Different Taxonomic Groups



Percent of Total Food Fish Supplied by Aquaculture



5 Why Aquaculture

- **Control**: Food fed, Density, Quality of product
- **Sustainable** in the face of Finite Resources—overfishing and habitat destruction antagonists
- **Diversify** farm income
- **Proximity—**Farms may be closer to local markets.
- **Health Consciousness** (protein, FA's, micronutrients)
- -2 fish meals/week decreases mortality from heart problems 50% o **-**Omega-3 fatty acids decreases occurrence of heart disease (oily marine fish – Salmon)
    - **American Cancer Association**
    - **-**Regular fish consumption decreases chances of colon cancer 50%
    - **Efficiency of growth**

Feed Conversion (grain/feed:flesh)

Beef cattle on feedlot	8:1
Swine	3.3:1
Poultry	2.25:1
Rainbow trout	1.5:1
Tilapia	1.25:1

Why *are* fish so efficient? Aquaculture is a Diverse Field

- Biology
- Ecology
- Nutrition
- Handling and hauling
- Water quality
- Disease
- Marketing
- Culture techniques

Employment Opportunities

1. Fisheries biology
2. Public aquariums
3. Research positions
4. Education

5. Laboratories
   a. Genetic studies
   b. Nutritional studies
   c. Disease studies
   d. Water quality
6. State hatcheries
   a. Technicians
   b. Biologists
7. Private operations
   a. Biologist
   b. Assistant manager
   c. Manager
8. Open your own operation

Aquaculture Journals

- Journal of the World Aquaculture Society
- North American Journal of Aquaculture (PFC)
- Aquaculture
- Journal of Applied Aquaculture
- Aquaculture Nutrition
- Aquaculture Research
- Journal of Aquatic Animal Health
- Transaction of the American Fisheries Society

6 Types of Aquaculture Systems

1. Pond Fish Culture
2. Raceway Culture
3. Cage Fish Culture
4. Recirculating Water Fish Culture

Pond construction and Designing

- Ponds were used as one of the first forms of aquaculture.
- Dates back to ancient China.
- Already had the water...just add fish and feed,
- Pond production has come along way since then!

Parameters to Consider

1. **Site Considerations**
   a. Water
   b. Soil
   c. Topography

d. Types of ponds

e. Cost

2. Construction of ponds

a. Levee ponds

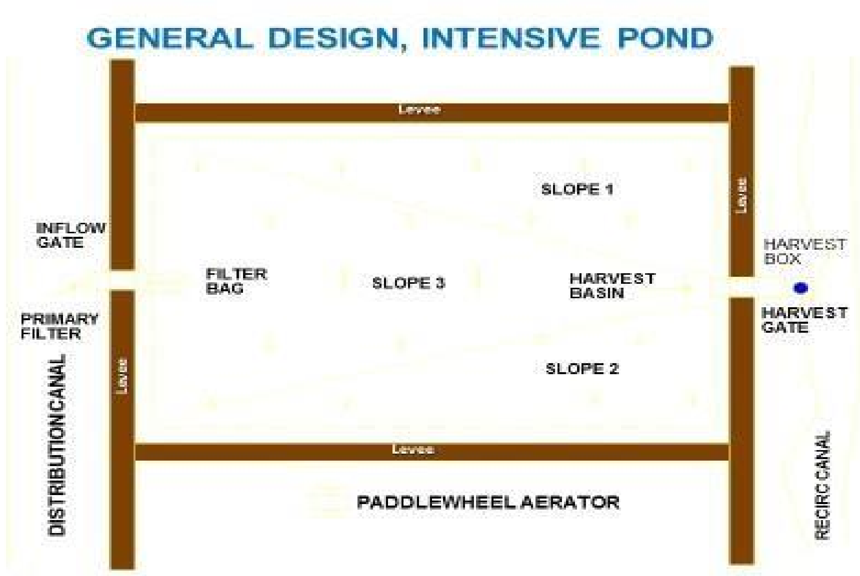
b. Watershed ponds

c. Lined ponds

7 Pond Design Criteria

- Screened inflow gates at shallow end of pond
- Screened harvest gates at deep end
- Slope to harvest basin (0.5-1.0%)
- Water depth 1.25 2.00 M
- Feeding tray piers(docks)
- Rounded or square corners, steps or ramps for entry
- Primary dikes (levees) wide enough to accommodate vehicles

GENERAL DESIGN, INTENSIVE POND



- Heights determined by pond bottom elevation, tidal amplitude
- Perimeter levee often required for protection in flood areas
- Levees with slopes 1:2 for high clay, 1:3-4 low clay
- Levee crown width varies with use
- Width of crown: 5 m (driving), 3m (walking)
- Crown is sloped to reduce puddles on levee top
- Once formed, levees are sprigged with grass to reduce erosion
- Levees are typically constructed by Caterpillar sized bulldozers
- Construction is first undertaken on ponds nearest the sedimentation basins and pump station
- Bulldozers push earth up to create general form of the levee walls

- Follow stakes set along the length of the pond
- Smaller dozers used to put on finishing touches
- Erosion is the main problem in maintaining levee slopes
- Source: both rainfall and wave action
- Solution: plants and vegetation (local grasses or *Salicornia sp.*) as soon as possible
- Pond sides receiving wind could be reinforced with rocks (contractor services)
- Tops of levees definitely need layer of rocks, especially if high clay content

8 Water and Soil

Water

1) Availability
   a. 25 gallons per minute per acre
2) Source
   a. Wells
   b. Springs
   c. Streams
3) Pesticides
   a. TEST Water!!
4) Alkalinity
   a. 80 ppm minimum

Soil

1) Clay Content
   a. Take samples at various locations.
2) Water Table
3) Wet soils aren't best!
4) Pesticides
   a. TEST Soil

Topography

1) Slope
   a. 2-10% best
2) Flooding
   a. Do not build on floodplain

9 Levee Pond Construction

Levee Pond Construction

1) **Freeboard and Depth**

   a. 1-2 feet freeboard

   b. Depth 5 feet in shallow end

   c. 7 feet in drain end

2) **Slope of Levees**

   a. 3: 1 minimum

   b. 4: 1 maximum

3) **Size**

   a. Larger ponds are cheaper per acre

   b. 1-10 acres for new farmers

4) **Shape**

   a. 10 acre square

      i. requires 2,569 linear feet

   b. 10 acre rectangular

      i. requires 2,729 linear feet

5) **Levee width**

   a. 20 ft for main

   b. 16 ft for others

Orientation

- Right angle to prevailing winds reduces levee erosion
- Parallel increases wind action and aeration
- Site Preparation and Construction
- Remove vegetation and topsoil.
- Compaction is critical

10 Pond Drains

Pond Drains

- Typically 6 inch pipe is sufficient for ponds less than 10 acres
- If ponds must be drained to harvest (shrimp) then use one 10 inch per acre of water
- PVC pipe is preferred
- Use anti-seep sleeve around pipe deep in levee

Water Inlets

- Water source pipes should have control valves on them
- May be designed to flow into adjacent ponds
- An independent **Electrical source** for each pond if filled by tube well

Lined Ponds


Watershed Ponds

- Watershed is containment (control)free
- Depth is a function of topography
- Requires 5-7 acres of watershed per acre of water
- Must have emergency spillway

Preventing Leaks

- Minimize amount of loss due to seepage

- Proper compaction
- Core trenching

- - Optimum clay content

- Vertical plastic membranes
- Vegetative coverage

- Remove burrowing animals (turtles, muskrat)

Optimal clay content

- Construction during dry season

11 Pond Bottom Construction Criteria

If detailed pond bottom slopes are required, usually accomplished by scrapers

Small 4-6 m^3 earthmovers towed by 4X4 tractors, laser-guided

Bottom slope from upper end to lower end of pond usually 1m:250-500m or 0.4-0.2% for large ponds, pond should be drainable all the time

In simple ponds, follows natural slope to estuary

Must insure at least 20 cm height of harvest gate above high tide elevation (varies considerably by site)

Pond Control Structures Inflow gates

Used for control of pond water exchange

Concrete structures with screen/bag filters on both sides of Levee

Dual primary screens for pre-filtration (1/4" to 1/2")

Secondary filtration screen bag eliminates

Potential predators (250-500 µM)

- Flashboards for controlling flow rate of water entering pond
- Multiple gates in larger ponds

12 Water Control Structures

WATER CONTROL STRUCTURES

HARVEST GATE

Concrete w/harvest basin in pond

- Number/size of gates depends on speed of harvest required
- Screen to retain shrimp, mesh according to size
- Use of flashboards
- Canal side often modified for harvest pump

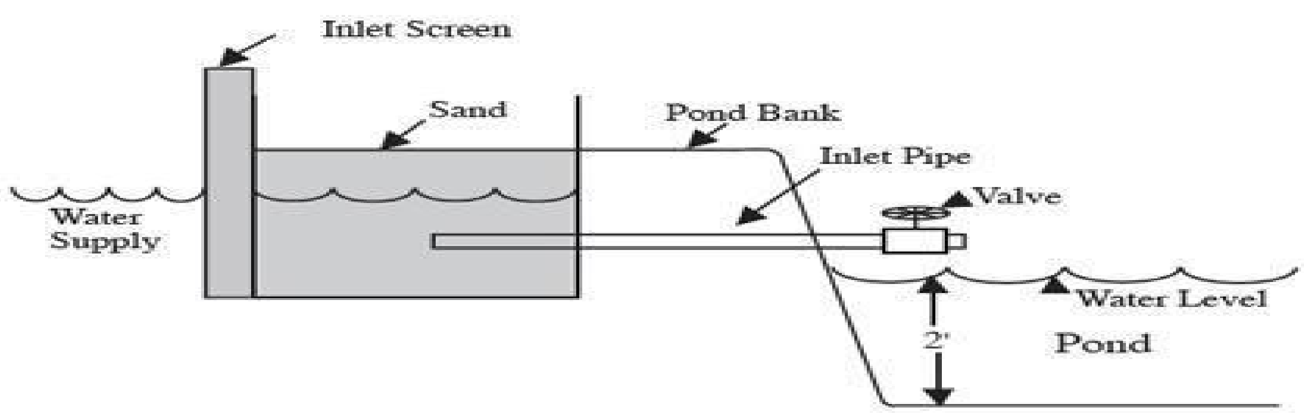


Figure 3

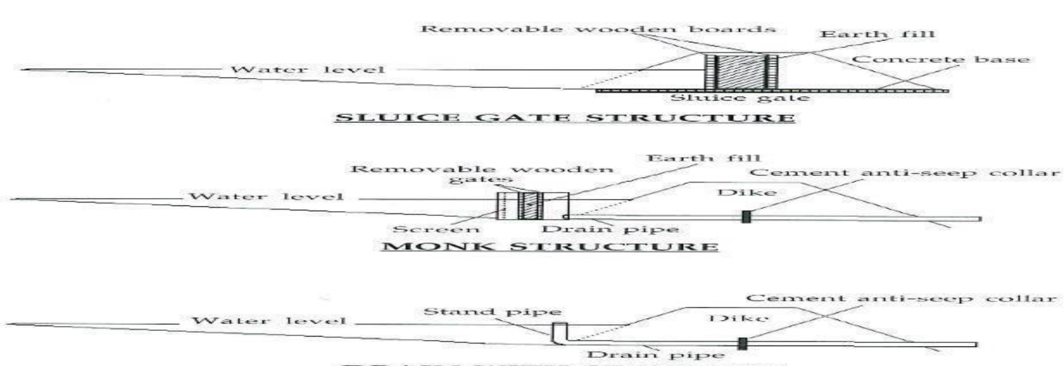


Figure 15: Cross sections of three structures used for draining ponds.

1 2

Harvest Gate: outflow

13 Water Sources

Rivers, lakes and streams

- **Advantages**
  - large volumes
  - inexpensive
- **Disadvantages**
  - excessive nutrients

Springs

- **Advantages**
  - few or no predators
  - no pathogens

Wells

- **Advantages**
  - no predators
  - no pathogens
- **Disadvantages**
  - low O_2

Surface

- **Advantages**
  - inexpensive
- **Disadvantages**
  - contaminates
  - 5-7 acre watershed per surface acre of water

14 Qualities of Cultured Species

- Hardy (resistance to diseases)
- Fast growth
- Easy adaptability
- Easy to breed
- Cheaper to culture
- Compatibility with other species
- High market demand
- Ability to tolerate low oxygen levels if it happens

Species cultured in ponds

- Rohu *Labeo rohita*
- Morakhi *Cirrhinus mrigala*
- Catla/Thaila *Catla catla*
- Grass carp *Ctenopharyngodon idella*
- Silver carp *Hypophthalmichthys molitrix*
- Big head carp *Aristichthys nobilis*
- Common carp *Cyprinus carpio*
- Tilapia *Oreochromis niloticus*

Stocking density and ratio

Stocking density

- 800 to 1000 fish per acre

3 species culture

- Rohu 50% Morakhi (Mori)20% Catla 30%

5 species culture

- Rohu 35%, Morakhi 20%, Grass carp 15%, Silver carp 30%

6 species culture

- Rohu 35%, Morakhi 20%, Grass carp 15%, Catla 20%, Silver carp 10%

15 Fertilization

Addition of fertilizers

Natural feeding

Inorganic fertilizers

- DAP, NH4SO4, NaNO3, SSP, Nitrophos, triple super phosphate, Urea

Organic fertilizers

- Cow dung, poultry waste, duck waste, green manure, compost

Artificial feeding

- Rice polish, maize gluten meal, sunflower meal, cotton seed meal, soybean meal, wheat bran, canola meal, mustard oil cake

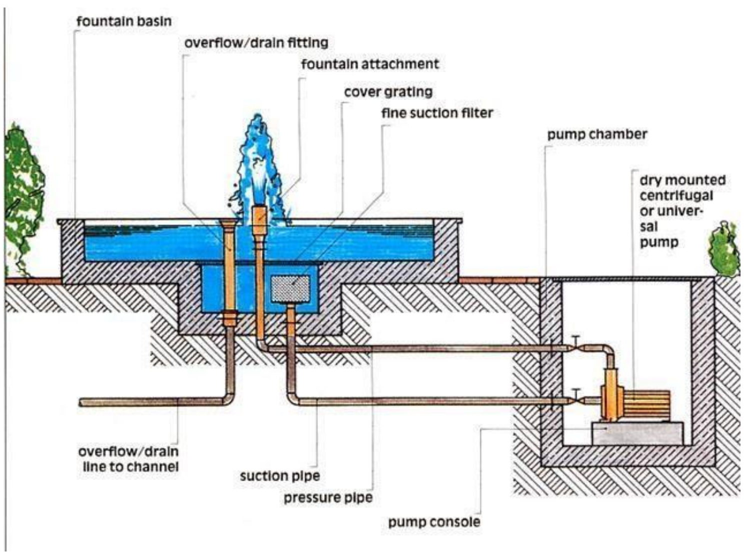
Time and ratio of artificial feeding

- Up to 400gm 360 kg per acre feed 9% protein feed
- Up to 700 gm, 560 kg per acre 22% protein feed
- >700 gm, 560 kg per acre feed >22% protein
- Share of natural feed
- Up to 100 gm fish 100% Natural food
- Up to 400 gm natural food 50%
- Up to 700 gm natural food 32%
- 700 gm natural food 25%

16 Pond Aeration Oxygenation

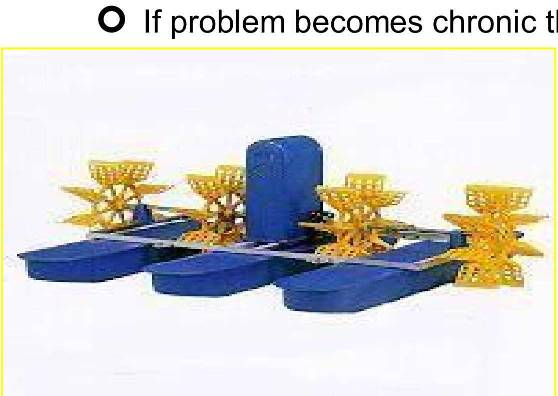
POND AERATION/OXYGENATION

- level determined by oxygen demand
- pumping vs. artificial aeration
- used for oxygenation and solids mobilization
- efficiency of devices varies
- paddlewheels: 2.13 kg O_2/kwh
- propeller/aspirator: 1.58 kg O2/kwh
- diffusors: 0.97 kg O2/kwh



Typical Aerators

- If oxygen deficiency occurs;
- Pump water preferably with sprinklers
- Stop feeding and fertilizers forthwith
- Turn on emergency aeration
- If problem becomes chronic then stop feeding and fertilizers for several days



Estimating Oxygen Requirement

- During paddlewheel aeration and high density culture O_2 requirement is usually estimated on the basis of feed application to pond e.g.
- 1 kg of feed = 0.2 kg O_2 consumed via respiration

- 300 kg feed = 60 kg O_2 consumed/day
- Caveat(caution): Some O_2 consumed by shrimp/fish, but more by primary productivity

Estimating Paddlewheel Requirements

Biomass density (kg/ha)	Hp (flow-through)	Hp (limited water exchange)
< 1,000	None	None
1,000 – 2,000	2-4	4-8
2,000 – 4,000	4-8	8-16
4,000 – 8,000	8-10	16-20
Above 8,000	Above 10	Above 20

17 Raceways

Introduction

- Raceways are considered flow-through systems.
- Being simple to construct they are some of the oldest designs in aquaculture.
- Water sources for raceway aquaculture operations are usually streams, springs, reservoirs or deep wells.

Construction material and length

- Raceways are made of concrete!
- Length x width of 6:1 is recommended.
- This prevents the fish stock from swimming in circular movements, which would cause debris to build up in the center.
- If the width is too large this could result in a feeble current speed which is not desirable
- Length is usually constrained by the water quality or stocking density.

Determination of Raceway volume

- If water Flow rate is 20 L/sec X3600 sec/hr ÷ 4 exchanges /hr X m3/1000 = 20 x 3600/4x1000 = 18 m3 /exchange
- Now if flow is 0.020 m3 =W(width) x0.2(depth) x 0.033(velocity meter/second) = 3.0 m then length will be
- L = 18/3.0 x 0.2 = 30 m

Depth and stocking density

- Average depth of a raceway for fin fish, such as rainbow trout, is about three feet.
- So raceway should be about 90 ft long, 6-9 ft wide with slope of 1-2%
- For trout, stocking rates of 30 to 50 kg/m^3 are normal at the end of a rearing cycle!
- While for marine species, such as sea-bass and sea-bream, the achievable load is lower, between 15 and 20 kg/m^3.
- Raceway volume required = total amount of fish in kg/stocking rate in kg per m^3.
- Loading rate = lb fish /gpm
- = (Oa-Ob)(0.0545)/F
- Where Oa and Ob are incoming and outgoing oxygen and F= lb feed/lb fish per day
- Oxygen consumption in mg/kg of fish/hr = Oc ={3xCxΔL/L}9155.23
- Ammonia production and toxicity
- A= 56 P (decimal fraction of protein)
- Oxygen consumption (mg DO/kg of fish per hr = 200 mg in raceway In case of feeding O2 consumed per kg of feed is 0.2 kg O2

18 Recirculating Systems

Recirculating Aquaculture Systems

Recirculating aquaculture systems (RAS) are systems in which aquatic organisms are cultured in water which is serially reconditioned and reused.

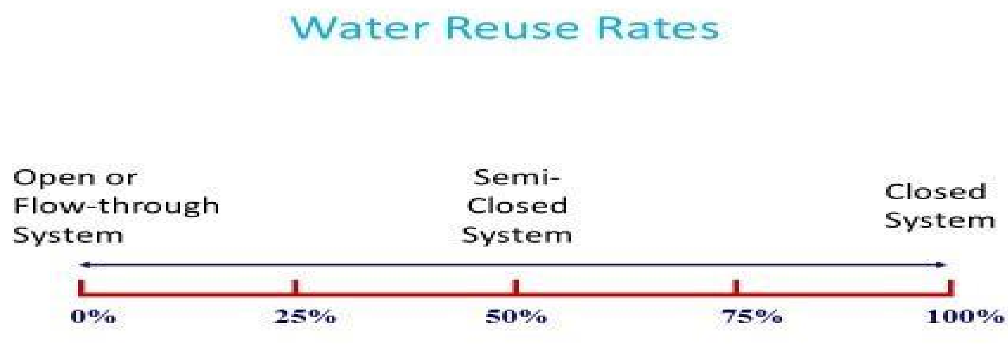
Why recirculation

- Conserves water
- Permits high density culture in locations where space and or water are limiting
- Minimizes volume of effluent, facilitating waste recovery
- Allows for increased control over the culture environment, especially indoors
- Improved biosecurity
- Environmentally sustainable

Integrated Treatment

An assembly of components that creates an artificial environment suitable for production, breeding or display of aquatic animals

  – Must be reliable
  – Must be cost effective
  – Must be compatible with the intended user group



19 Characteristics of Culture Water Effluent

- High concentrations of suspended o and dissolved solids
- High ammonia levels and high concentration of CO_2
- Low levels of dissolved oxygen
- Application of Recirculation system
- Brood stock maturation
- Nursing and Larval rearing systems
- Nutrition and health research systems
- Short-term holding systems
- Ornamental and display tanks
- High density grow-out of food fish

Factors those dictate Classification of Culture Systems

- Trophic Level
- Temperature
- Salinity **Trophic Level**

Distinguishes the level of nutrient enrichment

- Oligotrophic
- Mesotrophic
- Eutrophic

20 Types of Culture Waters

Oligotrophic

- Excellent water quality
- Very Clear
- Used in display aquaria
- Most frequently used for breeding purposes
- Some species are kept in these conditions all of their lives, while others for a period of time

Mesotrophic

Describes the bulk of high-density production systems where risk and economics must be carefully balanced to achieve profitability

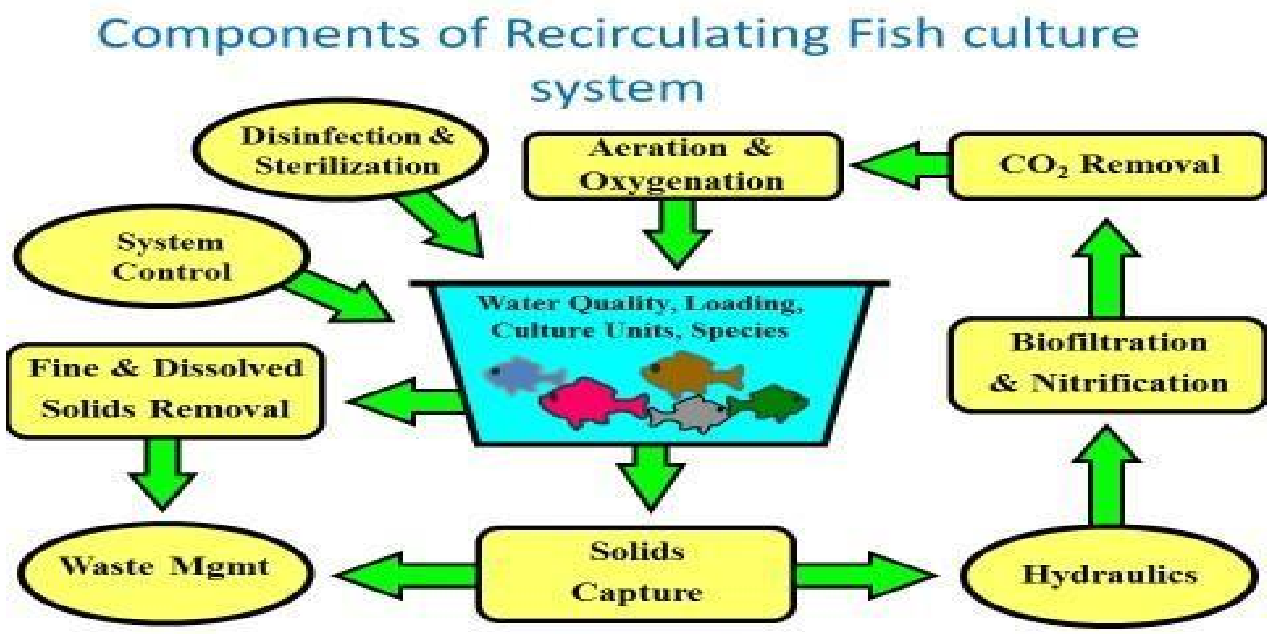
- Some deterioration in aesthetics
- Water quality at safe levels
- Dissolved Oxygen- above 5 mg/L
- TAN & Nitrite – less than 1mg-N/L
- Total suspended solids – less than 15 mg/L

Eutrophic

Exist for the grow out of the most tolerant species that show vigorous growth under moderately deteriorated water quality conditions

- Dissolved oxygen levels- economic optimum level
- Ammonia & Nitrite – less than 2mg-N/L
- Water quality – marginal
- Species evolved under similar natural conditions prosper in these conditions

21 Components of Water Culture System



22 Temperature and Salinity

Temperature

Impacts the rates of chemical and biological process at the most fundamental level

Affects: bacterial growth, respiration, nitrification efficiency Cool-

water species: below 20º C

Warm-water species: above 20º C

Salinity

Major effect on the oxygen saturation level

Freshwater

Less than 10 ppt

Marine

Greater than 10 ppt

23 Types of Water Filtration

Mechanical filtration

1: Screen filters

2: Granular Media filters

Biological Filtration

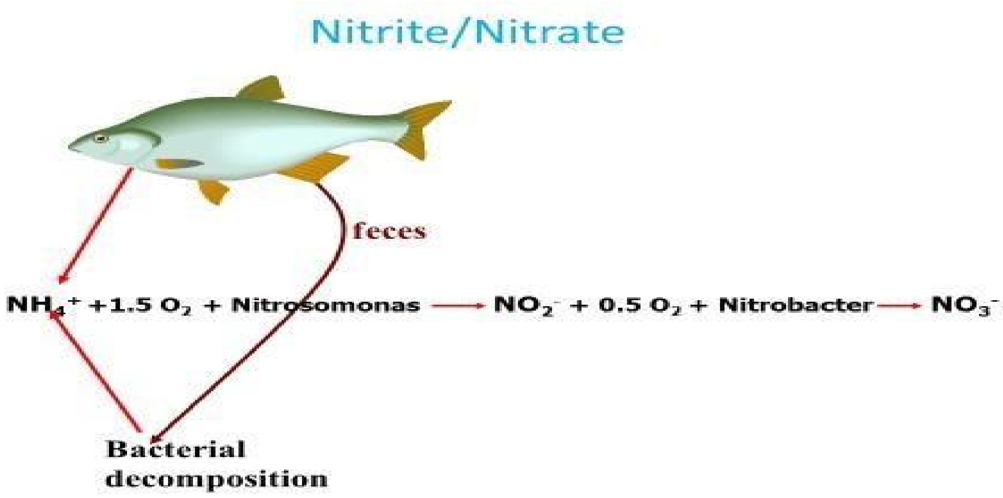
Screen Filters

• Used with various mesh screens

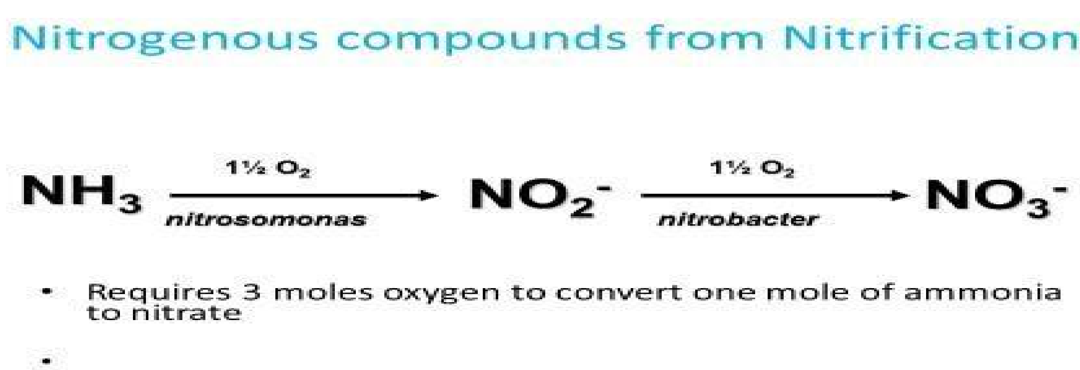
24 Biological Filtration

Nitrogen is an essential nutrient for all living organisms and is found in proteins, nucleic acids, adenosine phosphates, pyridine nucleotides and pigments In aquaculture there are 4 primary sources of nitrogenous wastes:

- 1: Urea, uric acid and amino acids excreted by fish
- 2: Organic debris from dead and dying organisms
- 3: uneaten feed and feces and
- 4: Nitrogenous gas from atmosphere



- NH_3, NO_2 and NO_3 are highly soluble in water
- NH_3 exist in water in two forms dependent on temperature and pH of water
- NH_3 is converted to NO_3 by oxidation process and overall process is called Nitrification while reversal is called denitrification
- $NH_4^+ + 1.5O_2 \geq NO_2^- + 2H^+ + H_2O$
- $NO_2^- + 0.5O_2 \geq NO_3^-$
- These reactions need 4.57 g of O_2 and approximately 7.14 g of alkalinity as $CaCO_3$ for complete oxidation of 1 g of NH3



- Maximum safe unionized ammonia level is 0.025 ppm
- or 1 mg/L or ppm for total NH_3-N for cool water fish and 2-3 mg/L for warm water fish
- production rate of NH_3 (TAN) is P(TAN) = F x PC x 0.092
- Where F is daily feeding level and PC is protein content in feed for one day period

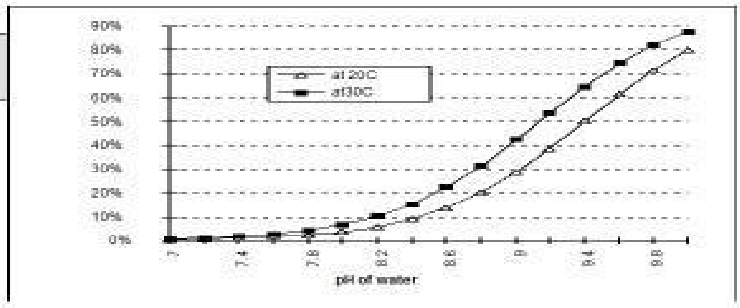
25 Total Ammonia N Concentration Varies with Temperature

Total Ammonia Nitrogen concentration varies with Temperature and pH

Total ammonia nitrogen (TAN) is a measure of the NH_3 and ammonium levels (NH_4^+) in the water

The ratio of ammonia and ammonium varies in an equilibrium determined by pH and water temperature.

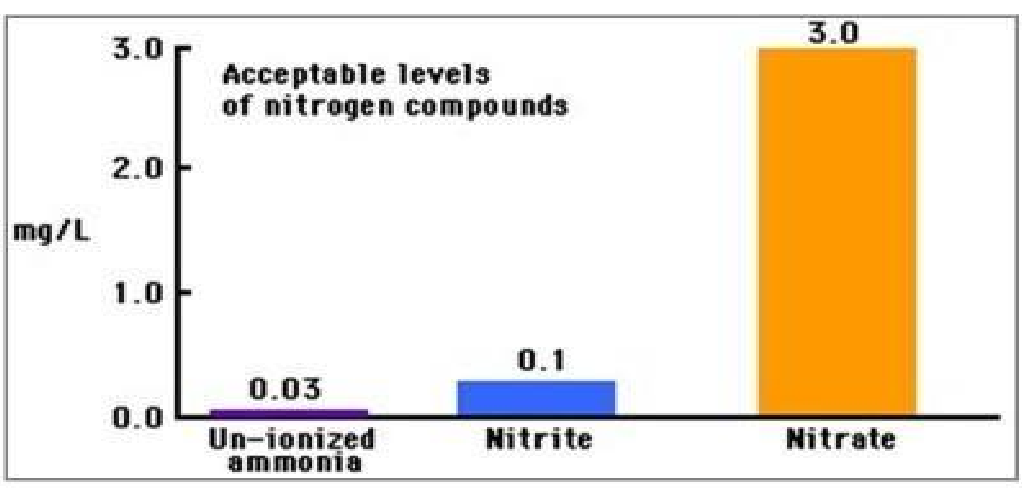
Ammonia as a % of total ammonia nitrogen



Percent of Total Ammonia in the Un-Ionized Form at Various Temperatures and pH

		Percent Ammonia		
Temperature (F)	(pH)	7.0	8.0	9.0
50		0.19	1.83	15.7
68		0.40	3.82	28.4
86		0.80	7.46	44.6

Nitrogenous compounds Acceptable ranges

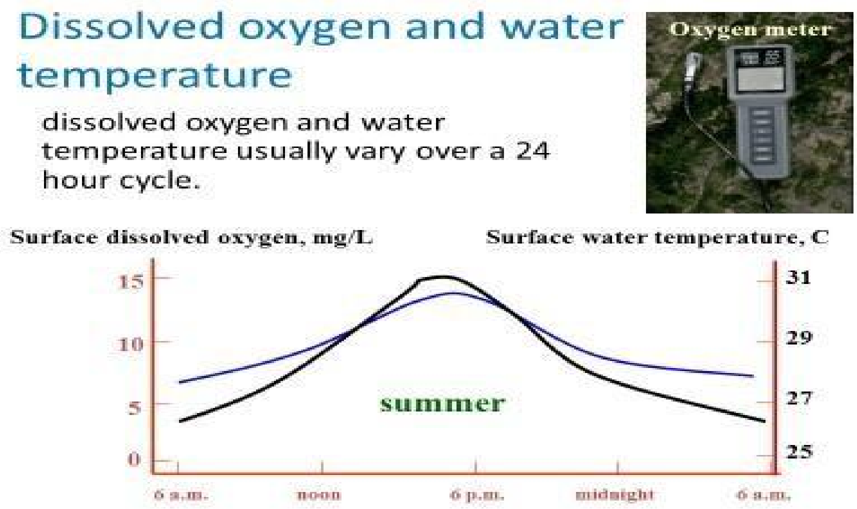


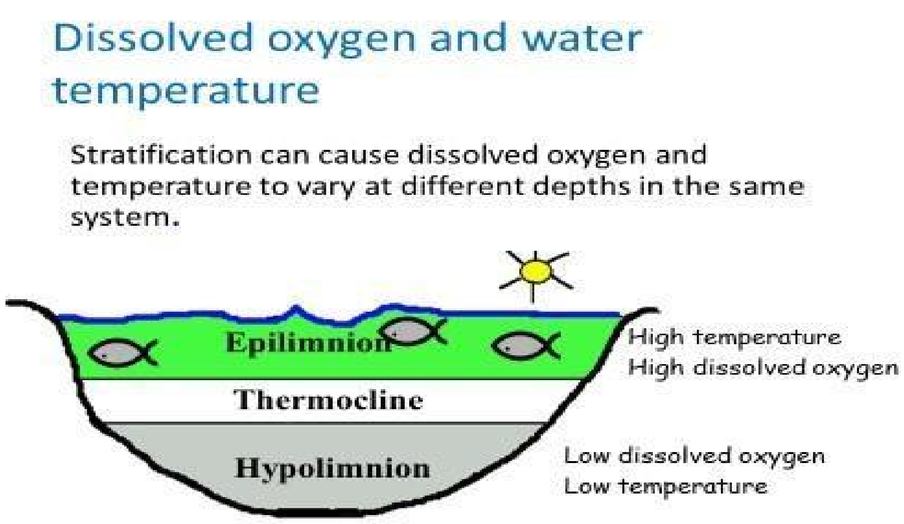
- **Types of Bio filters Used**
- commonly used in commercial intensive recirculating aquaculture systems are:

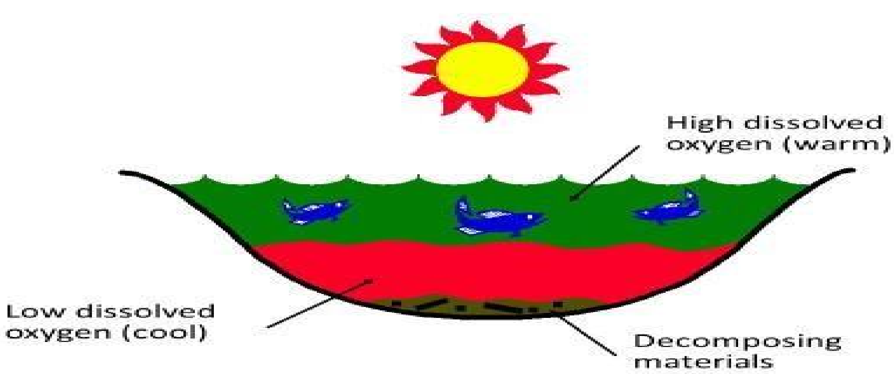
- Trickling filters
- Floating bead filters
- Fluidized bed filters
- Down flow micro-bead filters

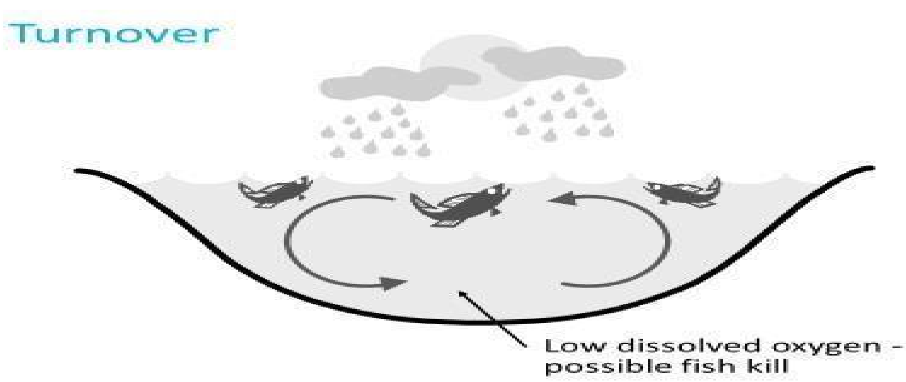
26 Aeration and Oxygenation

- Oxygen first limiting factor in recirculation fish culture system
- O_2 is consumed by fish and bacteria inhabiting bio filter
- In fish tank O_2 should not be less than 5 ppm and in outgoing bio filter water not less than 2 ppm
- When these levels drop below these concentrations aeration becomes necessary
- Induction air into water is called aeration while induction of pure oxygen is oxygenation
- For stocking density up to 45kg/m^3 aeration is enough but for higher stocking densities oxygenation is must
- Following production term is used for oxygen
- $P_{(Oxygen)}$ = -0.25 kg per kg feed consumed by fish – 0.12 kg per kg feed consumed by nitrifying bacteria -0.13 kg per kg feed consumed by heterotrophic bacteria(can be as high as 0.5) = -0.5 kg(sum of the above) per kg feed for system
- Poor mechanical filtration will let the solid accumulate in the system which will increase O2 consumption
- Safe level is 1 kg O_2 consumption for each 1 kg of feed used









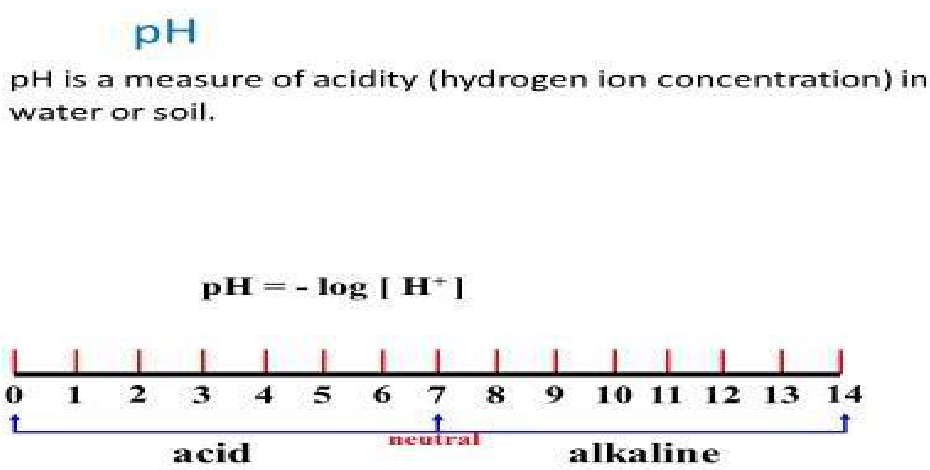
27 Important water Quality Parameters to Consider

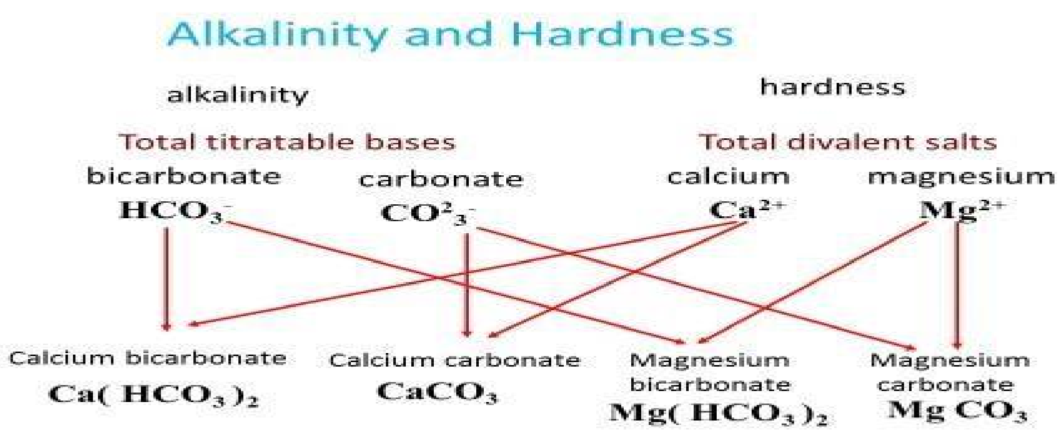
Carbon Dioxide Removal

- CO_2 is product of fish and other organisms in the system
- P_{CO2} = 1.375gram produced for each gram of O_2 consumed
- CO_2 obstructs fish respiration by reducing capacity of blood to transport O_2 by Bohr effect
- It decreases pH of the system and decreases bacterial efficiency
- It can be removed by trickling filter by keeping gas/liquid ratio of 5:1

Suspended solids

- Effective control of suspended solids probably most important task that must be accomplished to ensure long term successful operation of RAS
- P_{solids} = TSS = 0.25 x kg feed fed (dry matter basis)





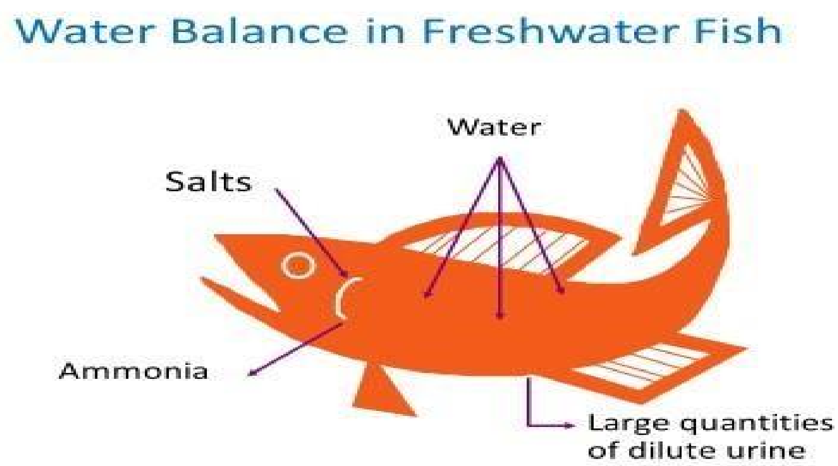
28 Why Water Quality for Fish

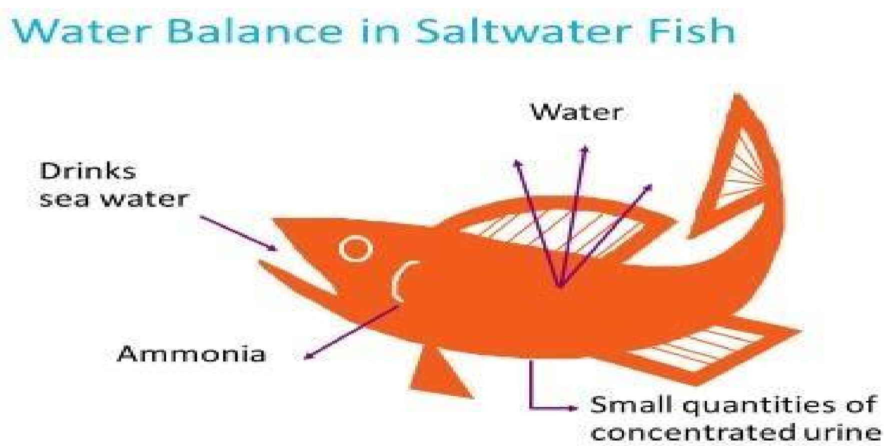
Why water quality for fish

Because fish need good water quality to;

perform all bodily functions in water like

- Eating
- Breathing
- Taking in and losing salts





Testing Water Quality

Water quality parameters often tested are:

Dissolved oxygen

Water

temperature pH

Total Ammonia Nitrogen

Nitrite/Nitrate

Alkalinity/Hardness

Salinity

How water quality values are expressed

Parameter	Value
Dissolved oxygen	ppm or mg/L O_2
Water temperature	C (Celsius)
pH	
Total ammonia nitrogen	mg/L N
Nitrite	mg/L NO_2^-
Nitrate	mg/L NO_3-
Alkalinity/Hardness	mg/L $CaCO_3$
Salinity	g/L salt /ppt(‰)

29 Fish Nutrition digestion and metabolism

FEEDING OF FISH

B-According to environment:

1-Warm water fish: Tilapia & Carp

2-Cold water fish: Rainbow trout

CAccording to water:

1-Fresh-water fish

2-Marine fish

Nutrient requirements of fish:

- The Standard Environmental Temp. (SET) for cold-water fish about 10C (salmon) & warm-water fish 30C (channel catfish).
- If water temp. deviates upward than SET , nutrient requirements increased & vice versa
- Most requirements for nutrients that have been published focus on juvenile fish/shrimp
- many represent single lab experiments, unchallenged, unsupported by others
- optimum performance can be affected by management, environmental factors and fish/shrimp size
- in formulating diets for a species for which nutrient requirements are unknown, those for a related species are used

Nutrient Requirements

- Most variation among aquatic species can be associated with whether the animals are:
- 1) cold water vs. warm water; 2) freshwater or marine; 3) finfish vs. crustaceans as mentioned earlier
- values in nutrient requirement tables only represent minima, don't allow for processing or storage losses
- AA's, minerals stable with reference to heat, moisture, oxidation
- vitamins and lipids are not stable (affected by heat, oxidation, light, moisture, etc.; store in cool area)
- 50% of ascorbic acid is lost in processing, half-life of 2-3 months in storage

30 Feeding of fish Protein Requirements

FEEDING OF FISH

- Most important nutrient
- Main source of essential amino acids
- The most expensive source
- Carnivorous fish consume foods with ~50% of protein
- Herbivorous & omnivorous = less

1-Protein requirements:

❑ Function of protein for fish:

A-Provide energy

B-To supply amino acids

C-Functional proteins, hormones & enzymes

- **Functions:**

  - Component for muscle tissue formation
  - Component for enzyme, antibody, hormone & blood protein serum
  - Tissue recovery
  - Growth
  - Reproduction

Sources of protein:

A. Animal products (fish & meat meal)
B. Agriculture by-products (algae, cereals, legumes)
C. Industrial waste products

- **<u>Protein from animal</u>**

Fish meal, meat & bone meal, feather meal, by-product slaughtery (bones, organs)

Soybean meal, maize meal etc.

31 Protein Requirements of Fish

- Fish contain 60-93% crude protein, thus, fish diets are higher in protein than birds & animals.
- Fish appear to be relatively efficient utilizer of protein to energy with 84%.
- Fish can not synthesize their amino acids & obtain chiefly from the diet & absence affects growth of fish

FEEDING OF FISH

Item	Starter	Grower	Finisher
Cold water fish	40-50	35-40	30-40
Warm water fish	35-50	25-50	28-32

Protein requirements

- **Species**

  - Tilapia - 28-40% diet
  - Baung - 42-55%
  - Keli - 30-40%
  - Lampam - 30-50%

- **Size (e,g,, Tiger shrimp)** Larva-PL9 - 50-55%
  - PL10-24 - 46%
  - PL25-1g - 40%

1-10g - 38%

>10g - 35%

- Minimum dietary requirement = balanced mixture of amino acids
- Fish synthesize body proteins from amino acids

Deficiency in essential acids = limit protein synthesis

=> Consequences: Reduced weight gain etc

Table 1. Two major classes of amino acids.

Indispensable (essential)	Dispensable (nonessential)
Arginine	Alanine
Histidine	Asparagine
Isoleucine	Aspartic acid
Leucine	Cystine
Lysine	Glutamic acid
Methionine	Glutamine
Phenylalanine	Glycine
Threonine	Proline
Tryptophan	Serine
Valine	Tyrosine

32 Factors affecting Protein

Requirements More Waste Limited

Digestion

- About 36% of feed is excreted as organic waste
- Live fish biomass = 5x more waste than human
- Why?

- Limited digestion
- Large fraction of feed remain undigested & is excreted

FEEDING OF FISH

Factors affecting protein requirement:

1-Species

2-Age

3-Stocking density

4-Water temperature

5-Production stage

Deficiency symptoms of amino acids:

- Def. of lysine dorsal & caudal fin erosion & increased mortality
- Def. of methionine cataract
- Def. of tryptophan scoliosis, renal calcinosis, cataract, caudal fin erosion & decreased carcass lipid content

33 Feeding of Fish Energy Requirements

FEEDING OF

FISH Energy

requirements:

A-Carbohydrates:

- Fish digest simple sugar efficiently & decrease digestibility of large molecule.
- Efficiency of carbohydrate in fish 39% compared to 96% in mammals.
- Carbohydrates can be used to spare protein since less protein will be used for energy.
- Fibers as cellulose & hemicellulose controlling passage of feed through gut & not exceed 8%, while 10% reduction in nutrient intake & digestibility.

- **Carbohydrates**

  Fish do not have a specific dietary requirement for carbohydrates

  Most abundant & least expensive

  Carbohydrates => simple sugars
  Range from easily digested sugars to complex cellulose

  Complex cellulose = Hard to digest

  Intake of carbohydrates depend on enzyme production

-**Carbohydrates also gives pellets integrity & stability (less dense)**

<u>Prepared feed</u>

- Carnivorous fish = <25%
- Omnivorous = 25- 45%

<u>Amylase</u>

- In herbivores => amylase occurs through entire digestive tract

Requirements in Fish feed

- 20% carbohydrates = cold-water fishes
- 30% carbohydrates = warm water fishes

<u>Carbohdyrates from plants</u>

- Starch in seeds, tubers, wheat, paddy

Energy metabolism in fish:

❑ Fish do not spend much energy towards maintaining body temperature (cold blooded).

Factors affecting energy requirement:

1-Species 2-Size
3-Light exposure 4-Composition of diet
5-Physiological activity 6-Age
7-Temperature of water

8-Other environmental factors (water flow, water composition, pollution)

34 Fat Requirements

Fat:

- Fat-soluble compounds occurring in plant & animal tissues
- Consist of fats, phospholipid, sterols, fatty acids etc.
- Excessive dietary lipid = nutritional disease e.g., fatty liver or visceral fat Fish can utilize energy of fat by 84% efficiency
- **Functions of fat:**

1-Providing energy

2-Cushions for vital organs

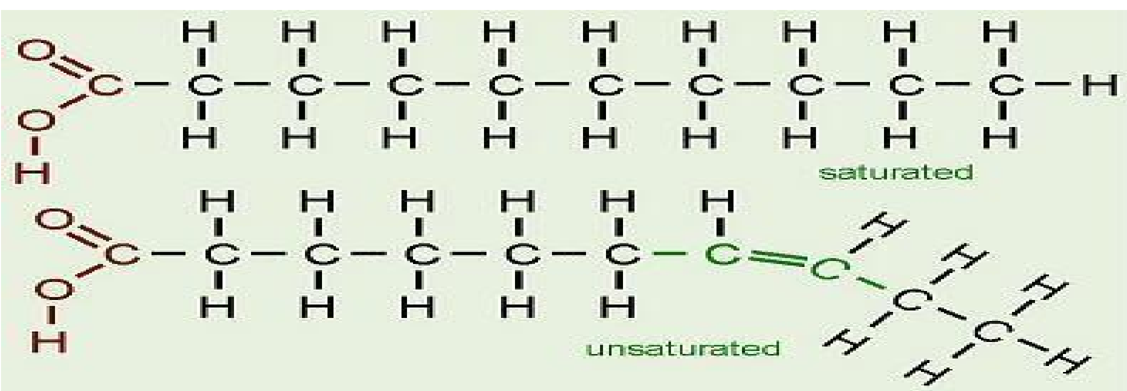
3-Energy reserves

4-Insulators & lubricants

5-Transports of fat-soluble vitamins

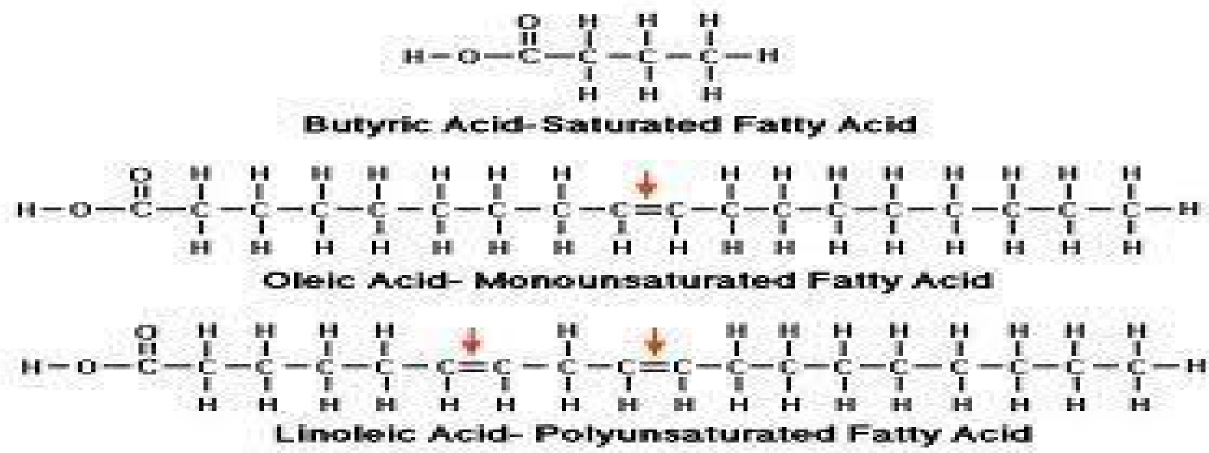
Fatty acids

- Saturated FA = no double bonds
- Unsaturated FA = double bonds



- Most important = EFA
- EFA = Organisms need it but can’t synthesize it Example
- PUFA =

Saturated and Unsaturated Fatty acids



The best

❑ supplement of fat are fish oils & SBOM.

Fish oil (5%) is the best source of EFAs

Def. of EFAs:

1-Reduced growth & poor feed conversion

2-Increased mortality

3-Elevated muscle water content

4-Increased susceptibility to caudal fin erosion

5-Fatty infiltration in liver

Lipid for tiger shrimp

Size	lipid (% diet)
Larva-PL9	10-15
PL10-24	7.5
PL 25- 1 g	> 3.3
1-10 g	>3.0
> 10 g	> 2.8

35 Vitamins

- Only needed in small amount
- Critical for the maintenance of normal metabolic & physiological functions
- Water soluble & fat soluble
- Problem:

- Leaching of water soluble vitamins
- Hypervitaminosis, rare but causes enlargement of liver & spleen, abnormal growth, bone formation etc.

Vitamin requirements:

- □ Vitamin req. of fish resemble those of poultry.
- □ There is not enough bacterial activity in gut to satisfy B-complex & vit.K requirements
- □ Fish feed contain high levels of oils □oxidation may result inactivation am□ounts must be in excess to ensure adequate levels of requirements.
- Vitamins can be of two types

Fat-soluble vitamins : Vit. A, D, E, K

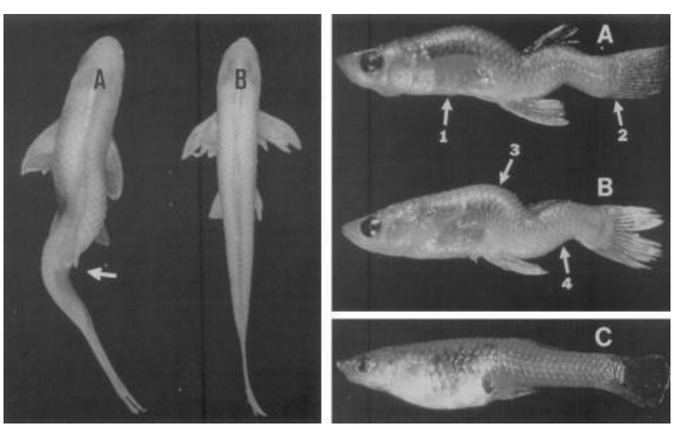
Water- soluble vitamins : Vit. C, Vit B12, thiamin, riboflavin etc.

- Vitamin in feed = Sold as vitamin premixes

Table 3. Vitamins and some of their major functions as established in fish.

Fat-soluble vitamins	Function
vitamin A, retinol	epithelial tissue maintenance, vision
vitamin D, cholecalciferol	bone calcification, parathyroid hormone
vitamin E, tocopherol	biological antioxidant
vitamin K	blood clotting
Water-soluble vitamins	
thiamin, B_1	carbohydrate metabolism
riboflavin, B_2	hydrogen transfer
pyridoxine, B_6	protein metabolism
pantothenic acid	lipid & carbohydrate metabolism
niacin	hydrogen transfer
biotin	carboxylation & decarboxylation
choline	lipotrophic factor, component of cell membranes
folic acid	single-carbon metabolism
cyanocobalamin, B_{12}	red blood cell formation
ascorbic acid, vitamin C	blood clotting, collagen synthesis
inositol	component of cell membranes

Scoliosis (Vit. C deficiency)



36 Mineral Requirements of Fish

Minerals

• Inorganic elements for Calcium, phosphorus

Function:

Formation of skeletal tissue, respiration, digestion & osmoregulation

Macromineral & micromineral (based on quantities required in the body)

Calcium, phosphorus, magnesium etc. are Macrominerals

While cobalt, chromium, copper, Zn, Selenium are Microminerals (trace minerals)

Minerals requirements:

- Fish have the ability to absorb a number of minerals directly from water reducing mineral requirements in the diet.
- Fish require all macro-and micro-elements required by other animals for enzymes & cofactors.
- Fish in soft water (low mineral content) require additional supplements in diet.

Table 2. Trace minerals and some of their prominent functions.

Trace mineral	Function
Copper	metalloenzymes
Cobalt	vitamin B_{12}
Chromium	carbohydrate metabolism
Iodine	thyroid hormones
Iron	hemoglobin
Manganese	organic matrix of bone
Molybdenum	xanthine oxidase
Selenium	glutathione peroxidase
Zinc	metalloenzymes

37 Mineral requirements of Certain Fish

Table 7.8 Mineral requirements of certain finfish, in percentage or amount per kg feed. (After Castell *et al*., 1986.)

Species	Ca (%)	P* (%)	Mg (%)	Fe (mg)	Cu (mg)	Zn (mg)	Mn (mg)	I (µg)	Se (mg)
Rainbow trout (*Salmo gairdneri*)	0.02	0.7–0.8	0.05–0.07	—	3	15–30	12–13	—	0.15–0.38
Atlantic salmon (*Salmo salar*)	0.03	0.6		R	R	R	R	R	R 0.1
Chinook salmon (*Oncorhynchus tshawytscha*)	—	—	—	—	—	—	—	0.6–1.1	—
Chum salmon (*Oncorhynchus keta*)	—	0.5–0.6	—	—	—	—	—	—	—
Catfish (*Ictalurus punctatus*)	0.03	0.6–0.7	0.04–0.05	—	3	15–30	12–13	—	—
Tilapia (*Tilapia nilotica*)	—	0.9	—	—	—	—	—	—	—
Eel (*Anguilla japonica*)	0.27	0.30	0.04	170	—	—	—	—	—
Red sea bream (*Pagrus major*)	0.34	0.56–0.6	NR	150	—	—	—	—	—

* Inorganic.
R: Required.
NR: not required.

Table 7.9 Mineral deficiency symptoms in certain finfish. (After Castell *et al.*, 1986.)

Mineral	Deficiency symptoms
Calcium	Poor growth and feed efficiency,[1,8] high mortality.
Phosphorus	Skeletal abnormalities,[5,7,8] poor growth and feed efficiency and bone mineralization.[1,3,5,7,8]
Magnesium	Renal calcinosis,[1] loss of appetite,[1,8] poor growth,[1,8] high mortality, sluggishness, skeletal abnormalities.
Iron	Hypochromic microcytic anaemia.[2,7,9]
Copper	Poor growth.[7]
Manganese	Poor growth,[1] short and compact body,[1] abnormal tail growth.[7]
Iodine	Thyroid hyperplasia.[6]
Zinc	Cataract,[1] caudal fin and skin erosion,[1,7] growth depression.[1]
Selenium	Muscular dystrophy,[3] exudative diathesis.[3]

[1] *Oncorhynchus mykiss* [2] *Salmo fontinalis,* [3] *Salmo salar,* [4] *Oncorhynchus keta,* [5] *Ictalurus punctatus,* [6] *Oncorhynchus tshawytscha,* [7] *Cyprinus carpio,* [8] *Anguilla japonica,* [9] *Chrysophrys major.*

38 Type of fish Feeds

Finely ground meals

Crumbles

Flakes

Pellets of various size & density

- Sinking
- Floating
- Slow sinking

• **Microdiet**

39 Fish Feed Preparation

Diet preparation

- Grinding, mixing & pelleting
- Grinding
- **reduce ingredient particle size to**

1) Easy handling of ingredient

2) Improve feed digestibility, acceptability, mixing properties & pelletability

• **Mixing**

Achieve uniformity of ingredients

• **Pelleting**

Transformation from soft, dusty mixture to compacted form

Cooking extrusion = floating pellet

Extrusion process

- Feed mixture subjected to heat & moisture
- Pellets expand, reducing density
- **<u>Advantages</u> = Expanded pellet able to absorb more lipid**

40 Proper Feed Storage 1

Proper Feed Storage

Because feeds contain ingredients that are susceptible to degradation, you are concerned with storage conditions and shelf life

What breaks down? Vitamins, lipids, proteins

fats and oils break down via rancidification

proteins can become deaminated: do not use any feed over 3 months old

big problem for those who import feed

Proper storage = protection against high temperature, humidity, moisture, insect & rodent infestations

Minimum length of time

Feed sacks should not touch the floor or side walls

Store = 100% waterproof

Cool, dry environment

Formulations affect storage – fish meal and oil

Nutrient losses – fatty acids, vitamins

Contamination – rodents, fungal, bacterial

Watch out if your are importing!! = delays

Delays can turn feed into high-priced fertilizer or make it downright toxic!

Feed typically shipped in 100 lb bags

sea freight or over-land trucking

normal shipment: 450 x 100 lb bags in one 40 ft container

if mill is nearby: shipment is *a granel* or loose-pelleted

a granel would imply that the farm has a silo and bagging system

41 Proper Feed Storage 2

- Feed bags are made of many materials:
- paper on outside, plastic liner

- continuous plastic (no weave, no air holes)
- woven polymer
- typically contain labels stating feed type, pellet size, proximate analysis, ingredients, date of manufacture, etc.
- must be unloaded immediately and placed in proper storage
- Direct sunlight will adversely affect the vitamin and lipid quality of the feed
- do not store feed more than 3 months *post manufacture*
- feeds should be purchased, delivered, and utilized on a monthly basis (2-3 containers per month for large farms)
- spoiled, wet or old feeds cannot be used
- economic loss of feeding deficient feed may be greater than cost associated with discarding it
- Feeds should be stored in a dry, cool and well-ventilated area
- spoilage will occur immediately if feeds become wet: temperature needs to be consistent
- bags stored on wooden pallets, not on floor
- no more than 5 bags high between pallets
- allows for adequate air circulation between bags, constant or similar moisture, temperature

42 Proper Feed Storage 3

- Do not store bags directly on concrete floors or touching walls of building
- surfaces are often cooler than the bag: moisture migration
- feed moisture (around 8-12%) will migrate to the cool area, accumulate
- this encourages growth of molds (REM: *Aspergillus flavius*, aflatoxin??)
- also avoid direct sunlight: diurnal temperature flux

Storage problem

- **Oxidative damage**

- Oil rancidity, oxidation PUFA

- **Microbial damage**

- Fungi & bacterial growth

- **Insect/rodent damage**

- Ingestion & contamination (feces)

- **Chemical damage**

- Breakdown of fatty acids, reduced amino acids & vitamins (esp. vit C)

43 Fish Feeding

What are some common methods of feeding fish?

- **Feeding fish is very important.**
  - Provide the appropriate nutrition.
  - Opportunity to observe fish for any abnormal signs.
- **Feeding systems differ based on size of the operation.**
  - Small operations
  - Large operations
- **Small Operations**
  - ***Hand feeding***
    - Feed is distributed by hand, shovels, or other non-automated means.
    - Most common method.
    - Used for feeds not suited for automated systems.
    - Meat scraps are hand fed.

Advantages:

1-Operator can note feeding behavior gauge the feed required 2Operator can ensure that feed is dispersed over wide area.

Disadvantages:

1-high labor cost

2-increased handling of the feed.

- **Large Operations**
  - ***Automated feeding systems***
    - Utilize machinery to distribute the feed.
    - From relatively simple to very complicated, computer-controlled.
    - Blowers
    - Demand feeders
    - Auger feeding systems

Advantages:

1-Reducing labor cost

2-Known quantity of feed dispersed to fish

Disadvantages:

1-**Less observation of the fish** • ***Blowers***

- Drive along the side of the pond and blow feed out into the pond.

– Attached to trucks or tractors.

– Common in levee pond and watershed pond operations.

44 Fish Feeding Methods

What are some common methods of feeding fish?

- ***Demand feeders***

  – Allow fish to bump a rod and release feed when they are hungry.

  – Used in raceways.

  – Fish must be trained how to use them.

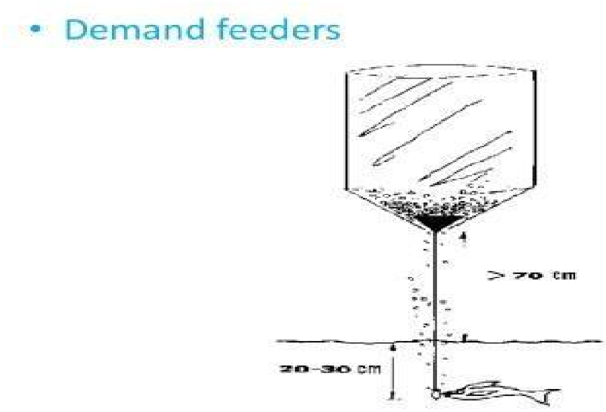
Fish can obtain food on demand by depressing a trigger.

Advantages:

Fish can obtain much food as required

Disadvantages:

Trigger happy feed wastage & water pollution



- ***Auger feeding***

  – Similar to systems used by swine and poultry farmers.

  – Feed stored in large tanks

  – Moved by augers that drop feed in pond

  – Common in tanks and raceways

Nitrogen excretion

- Animal = Urea
- Fowl = Uric acid
- Fish = Ammonia

Feeding Frequency

- Small = 4-8 times/day

- Big = 2-3 times/day

Fish = One specific place at a time

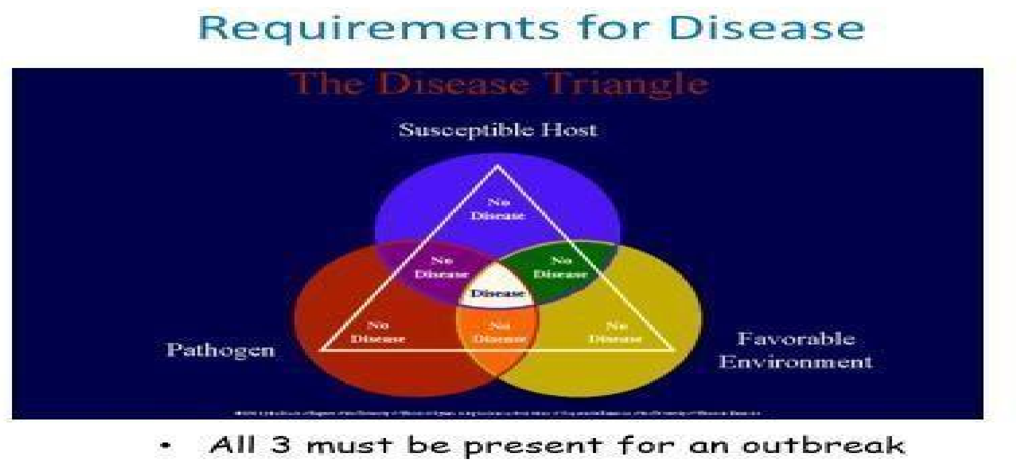
Shrimp = whole or half of the pond at a time

45 Fish Health and Disease what it is

- Health or well being important for
- feeding
- Growth
- Reproduction
- Diseased fish results in poor growth and ends up in losses
  - Further when diseased fish is sent to consumer, it changes
  - Texture
  - Appearance
  - Taste
- Now what causes disease
- Pathogens
- Disease causing organisms
- If present in fish environment, fish is always at risk
  - pathogens attack fish,
  - It shows abnormal behavior,
  - Stop feeding and
  - growth
  - if conditions prevail fish succumb(surrender) to death
- Which system has maximum possibilities to accept disease
- extensive , semi-intensive and intensive
- Intensive system

Reasons

  - Crowding
  - Competition
- Food
- Space



46 Fish Disease Introduction

Introduction

We will focus on

- **How** do you recognise that a fish might be ill?
- **What** are the causes of fish disease?
- **How** do you know that a fish has a parasite?
- **What** can you do to prevent a disease / parasite?

How do you treat diseased fish?

Fish Diseases

- **How do you recognise that a fish might be ill?**
- Colour may fade out / change
- Body shape, condition and / or behaviour will be abnormal
- The fish may refuse to feed or overfeed and trailing faeces appear at vent.
- Condition of the fins and gills will deteriorate.
- Fins may be clamped close to body.
- The fish may not keep its swimming position.
- There may be signs of injuries, outgrowths or abnormalities.

What are the causes of fish disease?

- Bad water quality
- Inappropriate diet
- Temperature (too high or too low)
- Stress
- Bullying(mistreatment, oppression)
- Viral diseases
- Fungal infections
- Bacterial infections
- Parasites
- Parasitic conditions: What is a parasite?

- A parasite is an organism that lives off another often to the detriment of the hosts health.
- Parasites can be internal (endo-parasites) or External (ecto-parasites).

They can be:

- Protozoan (single celled)
- Nematodes/ cestodes / trematodes (worms)
- Crustacean (e.g. louse)

47 Parasitic Diseases

- Itch or White Spot Disease (*Ichthyophthirius)*

Causes

Protozoan parasite either free swimming in the water or carried in with new fish or plants.
Fish under stress from bad water conditions are more susceptible.

Symptoms

- The fish's skin and fins are covered in tiny white spots
- A badly affected fish may make rapid gill movements

Treatment

- Remove plants and the activated carbon from filters as they can affect / be affected by the medicine.
- Treat with a methylene blue based medicine which kills the free swimming larval stage (theronts)
- After finding their new host, they will eat into the fish's skin.
- Adults fall from the fish and become free swimming till it settles on the gravel.
- Once settled it forms a cyst which begins to reproduce by dividing itself up to as many as 2,000 times.
- The result of this division produces what is called Tomites.
- These emerge from the cyst when it bursts as free swimming Theronts ready to re-infect the fish.
- N.B. If a Theronts is unable to find a new host within 24 – 48 hours they will usually die.
- Whirling disease *Myxobolus cerebralis*
- Caused by protozoan
- Skull deformation from *Myxobolus cerebralis*

48 Trematodes Gill Flukes

TREMATODES

Gill flukes and skin flukes (*Dactylogyrus* & *Gyrodactylus*), monogeneans

Cause

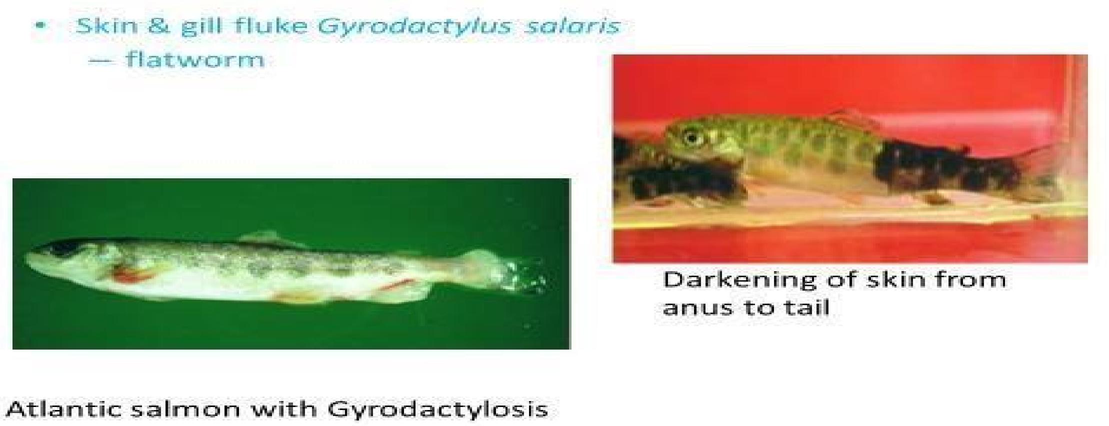
- Trematode (flatworm / flukes) attack by direct contact with contaminated fish, eat gill/skin tissue and blood, free swimming larval stages can attach to the bottom and side of housing.

Symptoms

- The gills may move rapidly and fish may gasp at the water surface
- The fish may scrape itself against objects
- Colours fade as damaged areas are covered in mucus.
- The skin may redden in places
- The fins may become ragged

Treatment

- These parasites can be treated with a formalin based medicine.



CRUSTACEAN

Anchor Worm *(Lernaea)*

Cause

- The crustacean parasite *Lernaea* it can grow up to 12mm. Usually brought in by non quarantined fish.

- **Symptoms**

- Whitish-green threads hang out of the fish's skin, with an inflamed area or ulcer at the point of their attachment.

- **Treatment**

- The water can be treated with insecticide. The adult parasite can be removed manually and the wound treated with antiseptic to prevent bacterial infection.

49 Fungal Infections

Fungal infections: What is a fungus?

- Fungus are multi-cellular, spore producing organisms that live off other organisms, and dead matter, some are parasitic.
- Fungal spores are commonly found in aquarium water.
- Healthy fish have a protective mucus covering which can prevent infection by fungal spores.

Fish fungus

Cause

- Aquatic fungi e.g. *Saprolegnia*.

Fish that are in poor health and have damaged mucus membranes through bad water quality, rough handling, fighting or physical injury are more prone to infection. Fungus can be a secondary infection to other conditions.

Symptoms

- Grey white or brown cotton wool like growths on the skin or fins.
- **Treatment**
- Medicines containing malachite green can be used and salt baths help recovery.

50 Bacterial Infections

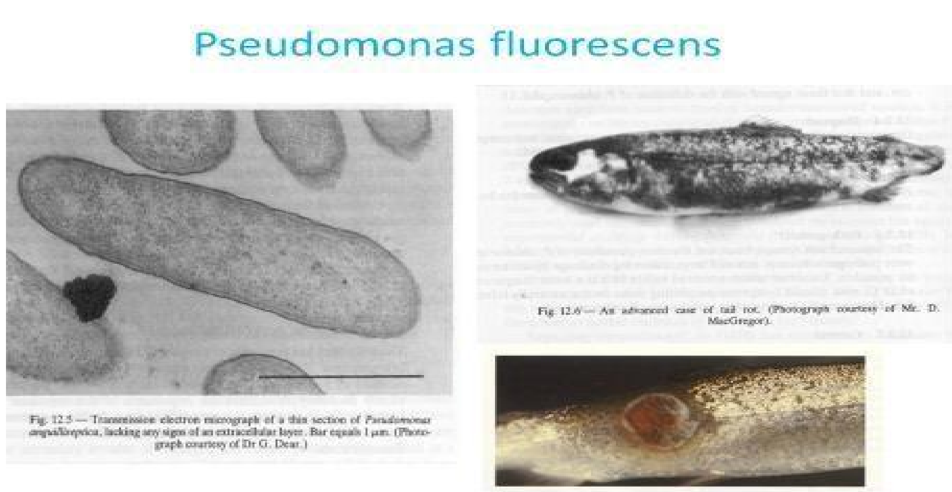
Bacterial Infections : What are Bacteria?

- Bacteria are microscopic single celled organisms that can reproduce rapidly.
- They are naturally present in aquarium water.
- Fish in good health kept in good water conditions can fight bacterial infections.
- Fish are most prone to such infections if in poor condition as a result of bad or sudden changes in water quality, over crowding or bullying, bad handling or transportation.
- A poor diet lacking in sufficient protein, fatty acids and vitamins can reduce fish resistance to such disease.

Pseudomonas fluorescens

Causes

- pseudomonas Septicemia (blood poisoning due to bacteria) mainly in general pond fish, seldom in salmonids
- normally a secondary invader, hard to distinguish from Aeromonas Septicemia, not a huge concern in fish
- Agent: ubiquitous bacterium of soil, water,
- culture: standard media, round glistening colonies w/undulating edge, radial striations, easily seen green pigment under UV light



Pseudomonas fluorescens

Epizootiology: worldwide in fw/sw, all fish susceptible but mainly ww, problem for aquarium fish

reservoirs: mud and water; infected or carrier fish and others (frogs)
transmission: horizontal, no vertical

environment: stress, mainly elevated temps

Pathology: in catfish, largely hemorrhaging and necrosis of internal organs, external lesions, loss of pigmentation

individuals can withstand large losses, bone exposure

Diagnosis: isolation from kidney on TSA Tryptic soy agar

confirmation via serology

Control: remove stressor, drug therapy as with other G-(oxytet @50-75 mg/kg/f/day for 10 days)

no vaccine yet

51 Fin Rot Mouth Fungus

Fin Rot / Mouth Fungus Cause

- Bacteria such as *Aeromonas, Pseudomonas (fin rot) and Flavobacterium (mouth fungus)*

Symptoms

Damaged, split or ragged looking fins (fin rot)

Cotton wool like tufts around the mouth (mouth fungus)

May cause loss of appetite and listlessness (lethargy) When chronic may develop ulcers on the body.

Treatment

Aquarium anti-bacterial medicines are available and in serious cases veterinary treatment is needed.

It is easier to prevent bacterial infections than cure them.

Aeromonas hydrophila (MAS)

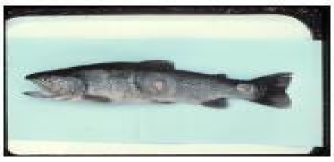
- **Causes**
- Motile Aeromonas Septicemia(blood poisoning), often referred to as a complex of species, mainly affecting warm water fish, opportunistic pathogen, can cause red-leg in frogs
- **culture:** TSA; can grow at 4ºC, but best at 18-25ºC;
- white, circular, convex colonies, often confused w/*Citrobacter*
- **Epizootiology**: worldwide in fw, all fw species susceptible (both ww and cw); others such as frogs, alligators, snails, shrimp and humans
- **reservoir:** freshwaters w/high organic loads, usually in sewage, normal gut flora of healthy fish; diseased fish/frogs; survivors are carriers
- **transmission:** horizontal only from intestinal tract, external lesions, through water, via external parasites
- **environment:** stress from crowding, variable temperatures, changes in weather; rough handling, low DO, high organics

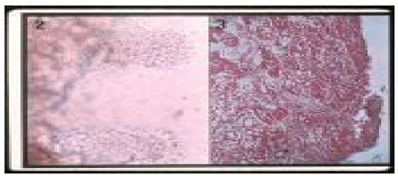
External pathology: usually hemorraghia + necrosis or internal organs + necrotic lesions on skin/muscles

- superficial circular or greyish-red ulcerations

- lesions around mouth similar to ERD(esophageal reflux disease)
- hemorrhaging of fins, exopthalmia
- **Internal pathology:** swollen, soft kidney;
- petechiae (little red spots) of musculature, intestines free of food

Aeromonas hydrophila





- **Diagnosis:** isolation from kidney into TSA Tryptone or tryptic soy agar
- **presumptive:** G- motile rod
- ferments in glucose, no fluorescent pigment
- **Control:** prevention via good management, injection w/chloramphenicol, no vaccines;
- therapy via oxytet (50-75mg/kg fish/day for 10 days), chloramphenicol in Europe

52 Aeromonas salmonicida

Aeromonas salmonicida (furunculosis)

First isolated from farmed trout in 1894

name of disease derived from boil-like lesions known as “furuncles”

at one time very common, resulted in Furunculosis

diminished as of late due to better management

Agent: comes in three subspecies, the most common is salmonicida (produced pigment),

G- non-motile rod, bipolar staining

Culture: TSA, brown pigment in presence of TYR/PHE, grows well at 18-25ºC, small white round raised convex colonies

Pathogenicity: both virulent and a-virulent strains, produces endotoxin

Epi-zootiology: wherever salmonids are cultured in fw (besides Tasmania/NZ), entered Australia via goldfish, brook trout most susceptible

reservoirs: obligate fish pathogen, found in waters w/infected or carrier fish

transmission: primarily horizontal, contaminated water, eggs, carriers, equipment, clothing, surface of aquatic birds; no vertical demonstrated

pathogenesis: acute, sub-acute, chronic forms (dose, temp, host resistance, virulence of strain)

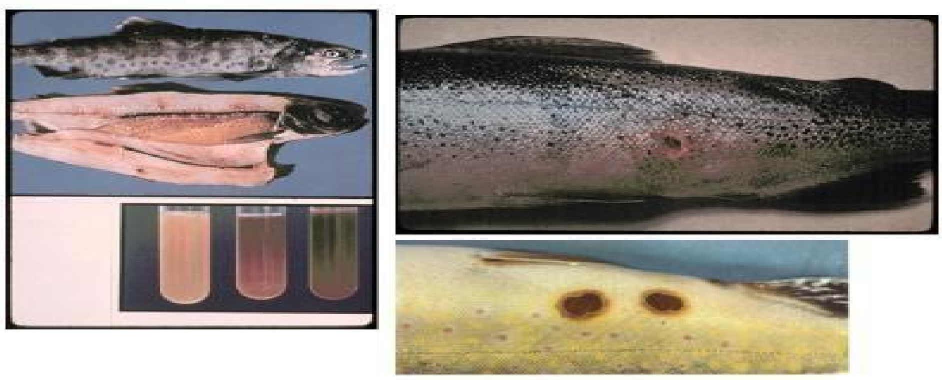
environment: severity increases w/temp, nutrition, handling stress

Pathology: similar to other G- septicemias w/hemorrhaging, necrosis of internal organs, external lesions

external: focal necrosis in muscle develops to abscess, hemorhaging and lesions at base of fins, fraying of fins, bloody discharge from vent; blue irridescent sheen on body near eyes, bleeding from gills

internal: petechiae(purple or red spot due to bleeding) in body musculature, congestion (cramming)of posterior intestine, no inflammatory response

Furunculosis



53 Furunculosis

Aeromonas salmonicida (furunculosis)

- **Diagnosis:** look at hatchery history with disease; isolation easy from kidney into TSA, BHI(Brain heart infusion for fastidious bacteria);
- **presumptive:** G-, non-motile rod, brown diffuseable pigment, oxidase +
- **definitive:** serological (rapid slide agglutination)
- **Control:** avoidance via clean water/fish; several vaccines on the market; selective breeding??
- **therapy:** oxytet @ 50-75mg/kg fish/day for 10 days, sulfamerazine, sulfonamide (Romet)

Ulcer Disease & Haemorrhagic Septicaemia

Cause

- A number of different bacteria including *Aeromonas* and *Pseudomonas*. These could be transmitted from other infected fish, and /or bad water conditions.
- **Symptoms**
- Open sores and ulcers, reddening of fins and vent, may lose their appetite and colour may change.

Treatment

Fish can be fed antibiotic medicine in feed. If severe fish should be isolated and antiseptic applied to infected areas. May require veterinary injection of antibiotics.

- Ensure tank conditions are correct.

54 Viral Infections

Viral infections: What is a virus?

- A virus is a microscopic organism that can only reproduce by inhabiting host cells and using the genetic material in the cells of a host.

- Healthy fish that have a balanced diet and good water conditions have strong immune systems to fight off such infections. .

Cyprinid Herpes Virus

Causes

- A herpes virus

Symptoms

- Causes growths that are white or grey in colour and look like melted candle wax.

Treatment

- Fish with a strong immune system can fight off the infection but retain the virus within the body.
- When in poor health the virus symptoms can re – appear.

Spring Viremia of Carp

Cause

- A viral infection caused by *Rhabdovirus carpio*.

Symptoms

- Darkening of skin, pale gills, pop eye, protruding vent, bleeding in gills skin and eyes.
- Lethargy, abnormal swimming positions, sitting on bottom of the tank.

Treatment

- No known treatment .

55 Swim Bladder Problem

What is a Swim Bladder problem?

Cause

- This can be caused by a number of things, from internal swellings, tumours, viral and bacterial infections, internal deformities, constipation, parasites etc, to overfeeding.

Symptoms

- Bobbing/jogging to the surface, swimming upside down or listing to one side with abnormal swimming patterns.
- **Treatment**
- Unless the cause can be identified this is difficult to treat. Starvation of fish for a few days might correct the problem if it is as a result of overfeeding.

What can cause growths and abnormalities?

Abnormalities can be brought about by :

- Inbreeding and congenital deformities
- Tumours and swellings
- Viral growths
- Malnutrition or inappropriate diet
- Internal disorders / parasites that cause fluid retention & swelling.

Fish Injuries

- Injured fish have often been bullied by tank mates.
- Injuries can be the site of secondary infections, bacterial and fungal.
- Stress caused by bullying, injuries and infections can lower their immune system further which can in some cases be fatal.

56 Prevention of Disease and Parasites

Prevention of diseases and parasites

- Provide an appropriate well filtered tank with suitable water conditions for the species, i.e. correct
- Appropriate ranges of temperature, pH, water hardness, low nitrate levels etc.
- Provide appropriate diet to meet species needs.
- House only suitable species together, make sure they are compatible and not likely to bully or eat each other.
- Only select healthy looking fish to add to the tank and do not overstock.
- Quarantine new fish to ensure they are healthy before introducing them to an established tank.
- Sterilize décor and clean new plants to ensure they are not carrying parasite eggs / larvae.

Prevention, Prevention, Prevention!

- The ultimate way to stop an outbreak is to prevent it
- Prevent stressful situations
    - Proper stocking situations
    - Proper management practices
    - Ideal water treatment
- Prevention measuresVaccinations
- Stress-treatments (chemical)
- Anti-biotics
- **Selective breeding (unintentional &** intentional)
    - Disease-free brood stocks

- Batch culture/ single batches reared to size
- Fungal control of eggs

- **Intensive systems**
  - Control of multiple environmental factors

57 Sericulture

Silk and Rearing of Silkworm *Bombyx mori* or Sericulture

Overview

- History
- Silkworm: *Bombyx mori*
- Mulberry tree
- Cocoon
- Silk
- Effect of nutrition
- Problems
- Conclusion

History of Silk

- Begins over 5000 yrs ago
- Debates over the origins of sericulture

58 History of Sericulture 1

History of silk- Origins (China)

- “Chronicles of Chou-King”
- 2200 BC
- Yellow River (Hwang He/Hwang Ho)

History of silk- Legends

- Multiple legends
- Empress Ksi-Ling-Shih (2500BC)

History of silk

- China kept the secret of sericulture for 3000 yrs.
- Chinese traded silk for gold
- Smuggling silkworm eggs or mulberry seeds was punished by death

History- From China to Japan

- Chinese emigrants smuggled silk cultivation into Korea
- From Korea, it was taken to Japan

59 History of Sericulture 2

History- India

- Silk culture dates to antiquity
- Mulberry culture spread in India by 140BC from China

History- Silk Road

- Contact between East and West
- Silk, silver, porcelain etc.
- China to Europe
- 6400km.
- Cultural, religious and economic importance

History- Han Dynasty

- 202BC-220AD
- Silk trade prospered
- By 126BC silk was the most important traded material

60 History of Sericulture Europe

History- Europe

- In mid 6th cent.
- Emperor Justinian sends 2 Persian monks to steel the secret of sericulture
- The supplies they smuggled supplied the western world for 1200yrs.
- The 1st king of Sicily invaded Greece in 747AD
- Captured silk weavers
- Sericulture began in Italy
- From Sicily to France
- Tours and Lyon
- Henri IV introduced rearing
- James I introduced sericulture to England
- He also took sericulture to America

61 History of Sericulture 20th Century

History- 20th century

- Sericulture stopped because of war
- In 1940 it boomed with the use of silk for parachutes
- Silk re-emerged
- China, India and Japan brought it to global market Silkmoths

Major Silkmoths of the World

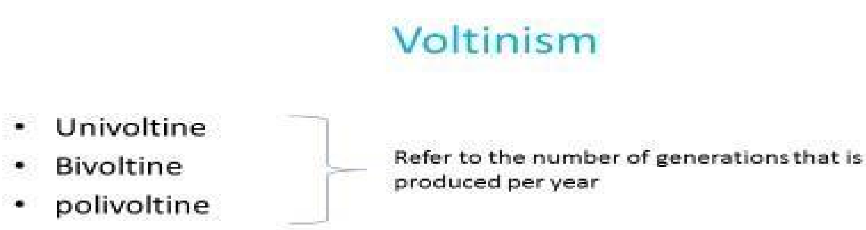
Antheraea assamensis	Muga silkmoth
Antheraea mylitta	Tusseh silkmoth
Antheraea peryni	Chinese oak silkmoth
Antheraea polyphemus	Polyphemus silkmoth
Antheraea yamamai	Japanese oak silkmoth
Attacus atlas	Atlas silkmoth
Automeris io	Bullseye silkmoth, Io silkmoth
Bombyx mori	Bombyx silkmoth
Callosamia promethea	Spicebush silkmoth
Hyalophora cecropia	Robin or cecropia silkmoth
Hyalophora gloveri	Glover's silkmoth
Pachypasa otus	Syrian silkmoth
Samia (Eri) cynthia	Eri or Ailanthus silkmoth

62 Silkworm Bomby mori

Bombyx mori

- Produces over 90% of the world's raw silk
- Common model for research and study
- Genome decoded in 2004
- 432Mb
- 3000 genes with no other homologs
- Important in evolution studies and in combating pests.
- Silkworm classified according to origin and voltinism

Voltinism

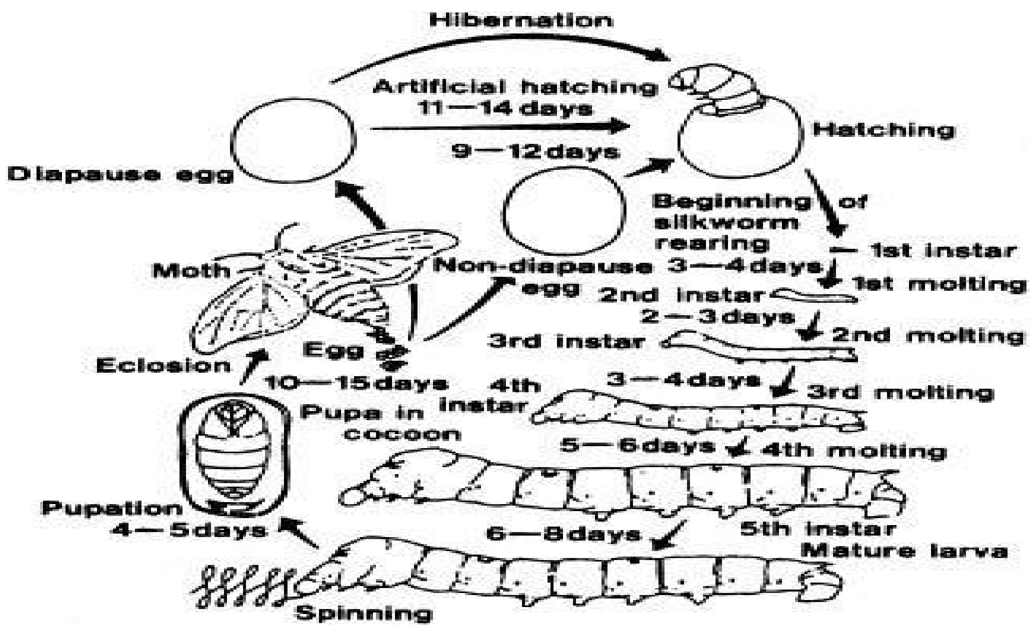


Characteristics

- It cannot fly
- Caterpillars with no real locomotion
- Female larger than male
- Male has big plumose antennae

63 Life Cycle

Life cycle



- After mating, the female lays 300-400 eggs
- 1g of eggs = 2000 eggs
- Eggs enclosed in gluten
- Yellowish then darker
- Each egg has a micropyle

Polyvoltine vs. Uni/bivoltine

Polyvoltine
- Hatch after 10 days
- Life cycle repeats itself 6 to 7 times a year

Uni/bivoltine
- Eggs go through diapause
- Hatch in time for spring
- Temperature is the main trigger

- When first hatched they vary from 1/8 to 3/8 of an inch in length
- Diameter of a human hair
- 1 ounce= 50-60000 worms
- Go from black to brownish yellow to white
- Polyvoltine species go through the 5 instars in 20-24 days
- Uni/bivoltine go through them in 24-28 days
- Total of 4 molts

64 Mulberry Tree

Mulberry tree

- Fast growing
- Tropical and temperate habibtat
- *Morus spp.*
- *Moracea* familly
- 95 species in total

- *M. alba, M. nigra, M. indica, M. rubra etc.*

Life cycle

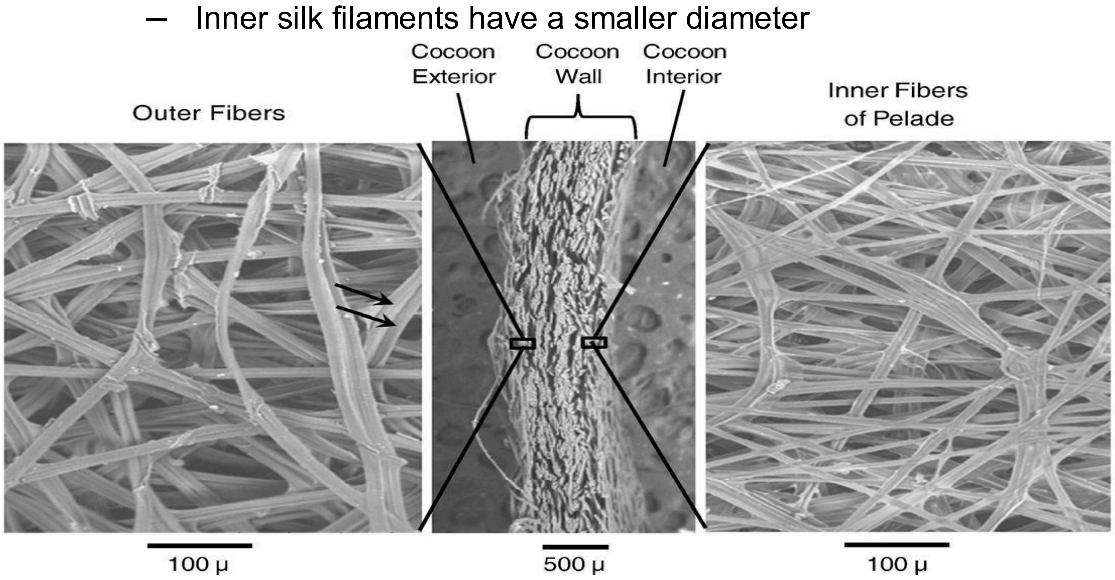
- During the first 3 instars, the larvae feed on chopped leaves.
- When they grow, they become able to chew on whole leaves
- The silkworm goes from
  - 3.0mm to 95mm in length
  - 0.00045gm to 5gm

5th instar

- Silkworm attains max size
- JH decreases
- Ecdysone triggers metamorphosis
- Color change
- Cocoon making
- Pupation occurs

65 Cocoon

- 5 day process
- Silk laid with figure-8 movement
- **Why spin a cocoon?**
  - Protection
  - Silk as a way of excretion
- **Heterogenous:**
  - Inner silk filaments are tightly packed
  - Inner silk filaments have a smaller diameter



- **Shape variable** – Breed

– disease

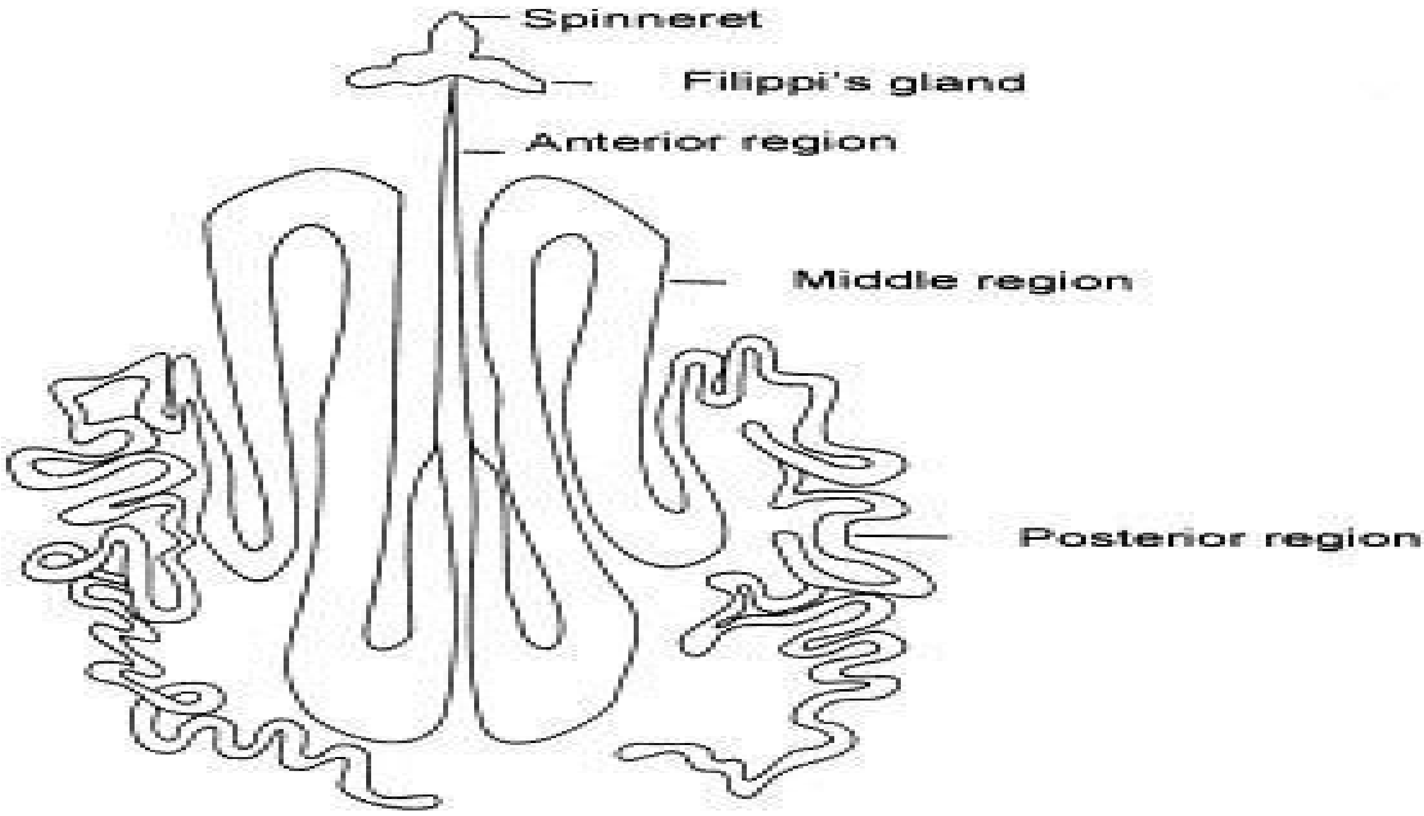
Life cycle

- Metamorphosis occurs
- The moth emerges
- Cocoonase

66 Silk Gland

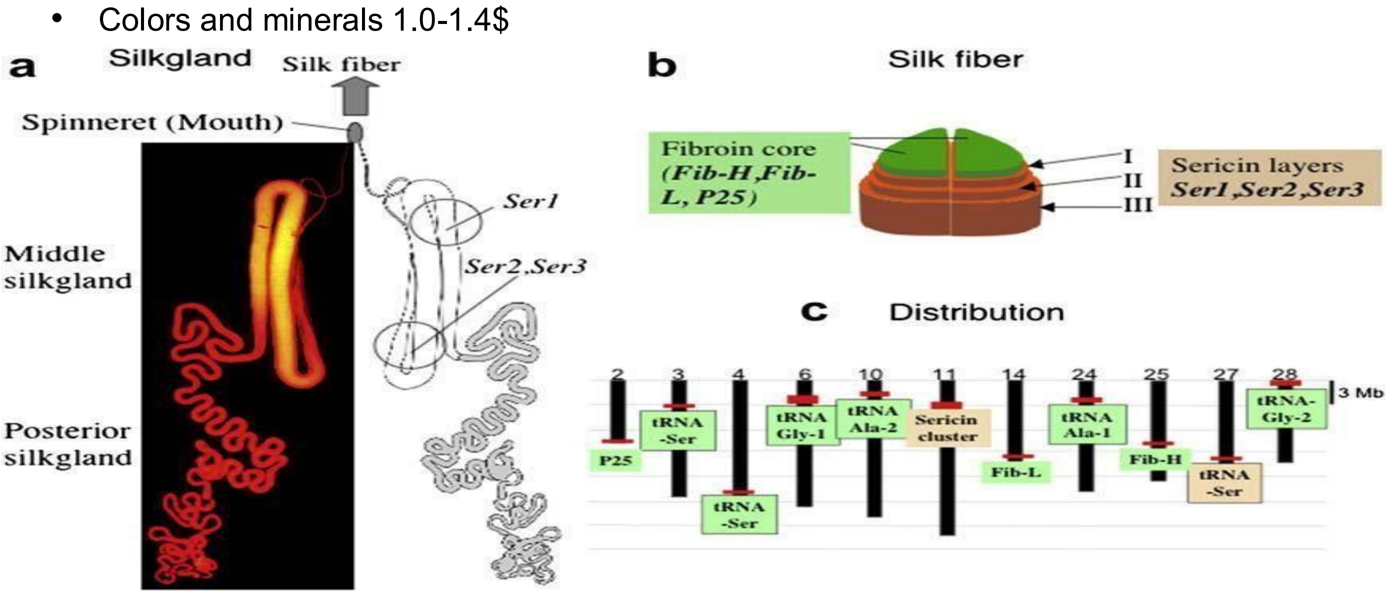
Silk gland

- Runs all along the body
- At 5th instar it becomes the largest tissue
- Ectodermal
- One cell layer
- 2 types of secretory cell
  - Fibroin secretory cells
  - Sericin secretory cells
- 3 parts: ASG, MSG and PSG



Silk filament

- Sericin 18-20%
- Fibroin 75-80%
- Carbohydrates 1.2-1.6%
- Lipids and wax 0.5-1%
- Colors and minerals 1.0-1.4$



67 Effect of Nutrition

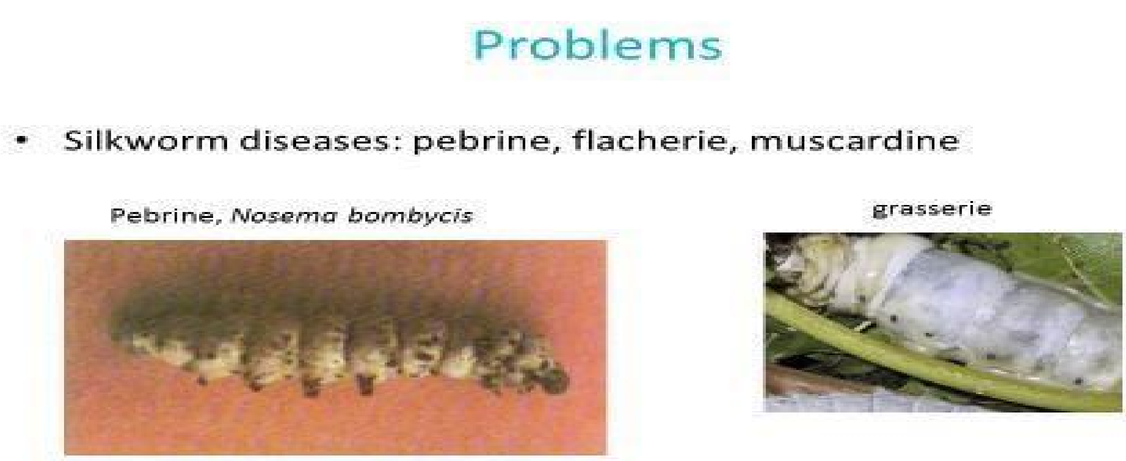
Effect of nutrition

- Composition
- Quantity
- Mulberry leaves satisfy the min. need of the larvae
- Amount of vitamins found in them varies
- Focus is on giving young and healthy leaves

Artificial diet

- Since processing of leaves is costly
- Introduced in 1960s
- Mulberry leaf powder
- By 1970, they had made a dry powder with no mulberry in it

68 Problems and Diseases



69 Lac Culture

Nature has given much for welfare of human beings through animals and their products.
On the other hand human beings never seem to tire of discovering the mysteries of nature. But the animals seem to be greater experimenters as some of them have astounded most human beings by their complex, strange and at times bizarre performance.

One of such performer known to man from good old days is the tiny insect that has given a very valuable product in the form of lac, to the civilization of man.

Lac is a natural resin of animal origin. It is secreted by an insect, known as lac-insect in order to obtain lac, these insects are cultured and the technique is called lac-culture. It involves proper care of host plants, regular pruning of host plants, propagation, collection and processing of lac.

- Lac is a resinous exudation from the body of female scale insect. Since Vedic period, it has been in use in India.

- Its earliest reference is found in Atherva Veda. There, the insect is termed as ‘Laksha’, and its habit and behavior are described.

- The great Indian epic‘Mahabharata’ also mentions a ‘Laksha Griha’, an inflammable house of lac, cunningly constructed by ‘Kauravas’ through their architect ‘Purocha’ for the purpose of burning their great enemy ‘Pandavas’ alive.

‘LAKSHA GRIHA’, AN INFLAMMABLE HOUSE OF LAC,

70 Histroy and importnce

- **History:**

- Lac has been used in India from time immemorial for several purposes, from the epic of Mahabharat it has been recorded that Kauravas built a palace of lac for the destruction of Pandavas.

- We come across references of lac in the Atharvaveda and Mahabharata, so it can be presumed that ancient Hindus were quite familiar with lac and its uses.

- Scientific study of lac started much later. In 1709 Father Tachard discovered the insect that produced lac. First of all Kerr (1782) gave the name *Coccus lacca* which was also agreed by Ratzeburi (1833) and Carter (1861).

- Later Green (1922) and Chatterjee (1915) called the lac- insect as *Tachardia lacca* (kerr).

- Finally, the name was given as *Laccifer lacca*.

Lac --- Nature’s gift to mankind

- Lac is the only known commercial resin of animal origin.

- It is the hardened resin secreted by tiny lac insects belonging to a bug family.

- To produce 1 kg of lac resin, around 300,000 insects lose their life.

The lac insects yields

1. **Resin**
2. **Lac dye**
3. **Lac wax.**

- Application of these products has been changing with time. Lac resin, dye etc. still find extensive use in Ayurveda and Siddha systems of medicine.
- **Importance of Lac**
- With increasing universal environment awareness, the importance of lac has assumed special relevance in the present age, being

1. An eco-friendly
2. Biodegradable
3. Self-sustaining natural material

- Since lac insects are cultured on host trees which are growing primarily in wasteland areas, promotion of lac and its culture can help in eco-system development as well as reasonably high economic returns.
- It is a source of livelihood of tribal and poor inhabiting forest and sub-forest areas.

71 Lac Insects

LAC INSECTS

- The English word lac synonyms Lakh in Hindi which itself is derivative of Sanskrit word Laksh meaning a lakh or hundred thousand.
- It would appear that Vedic people knew that the lac is obtained from numerous insects and must also know the biological and commercial aspects of lac industry.
- It is also worth to mention that a laksh griha would need a lot of lac which could only come from a flourishing lac industry in that period.

LAC INSECT TAXONOMY

- The first scientific account of the lac insect was given by J. Kerr in 1782 which was published in Philosophical Transaction of Royal Society of London (vol. 71, pp.374-382).
- The first scientific name given to it was *Tachardia lacca* following the name of French Missionary Father ‘Tachardia’.
- It was later changed to *Laccifer lacca Kerr.*
- The other name given to it has been *Kerria Lacca Kerr.*

Phylum - Arthropoda

Class - Insecta

Order - Hemiptera

Super family - Coccoidea

Family - Lacciferidae

Genus - *Laccifer*

Metatachardia

Laccifer

Tachordiella

Austrotacharidia

Afrotachardina

Tachardina

72 Systematic Position of Laccifer Lacca

- **Systematic Position:** *Laccifer lacca*
- A number of species of lac insects are known, of this *Laccifer lacca* is by far the most important and produces the bulk of the lac for commerce. It belongs to—

Phylum — Arthropoda
Class — Insecta
Order — Hemiptera
Super-family — Coccidae
Family — Lacciferidae
Genus — Laccifer
Species — Lacca

STRAINS OF LAC INSECT:

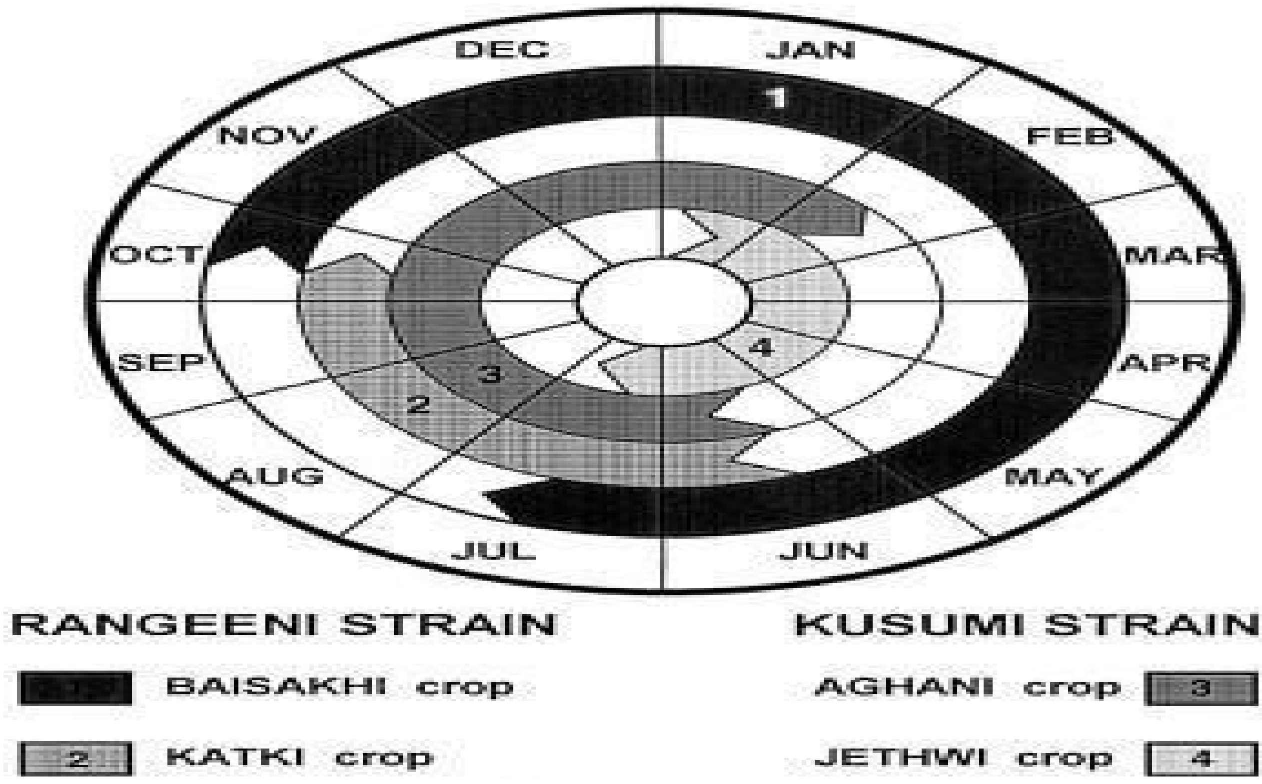
- In India, *lac insect* is known to have two distinct strains: **Kusumi and Rangeeni.** The Kusumi strain is grown on Kusum or on other host plants using Kusumi brood.
- The Rangeeni strain thrives on host plants other than Kusum.
- The life cycle of lac insects take about six months, hence, two crops a year can be obtained.
- **In case of kusumi strain, two crops are:**

I) Jethwi (June / July) and II) Aghani (Jan. / Feb).

II) **In case of Rangeeni, two crops are:**

I). Karrtiki (Oct. / Nov.) and II) baisakhi (May / June).
The crops have been named after Hindi months during which these are harvested.

- The lac of Rangeeni crops is harvested while it is still immature.
- Aghani and baisakhi strain are the main corps contributing about 90% of lac production.
- The kusumi crop lac is considered superior resin, because of the lighter color of resin, and it fetches better price.



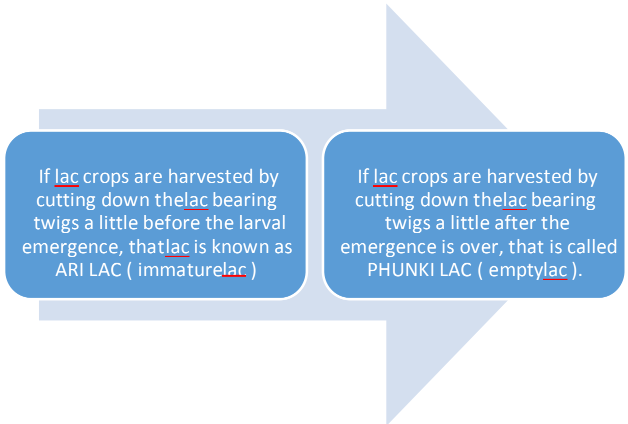
73 Kusumi Lac

Kusumi lac

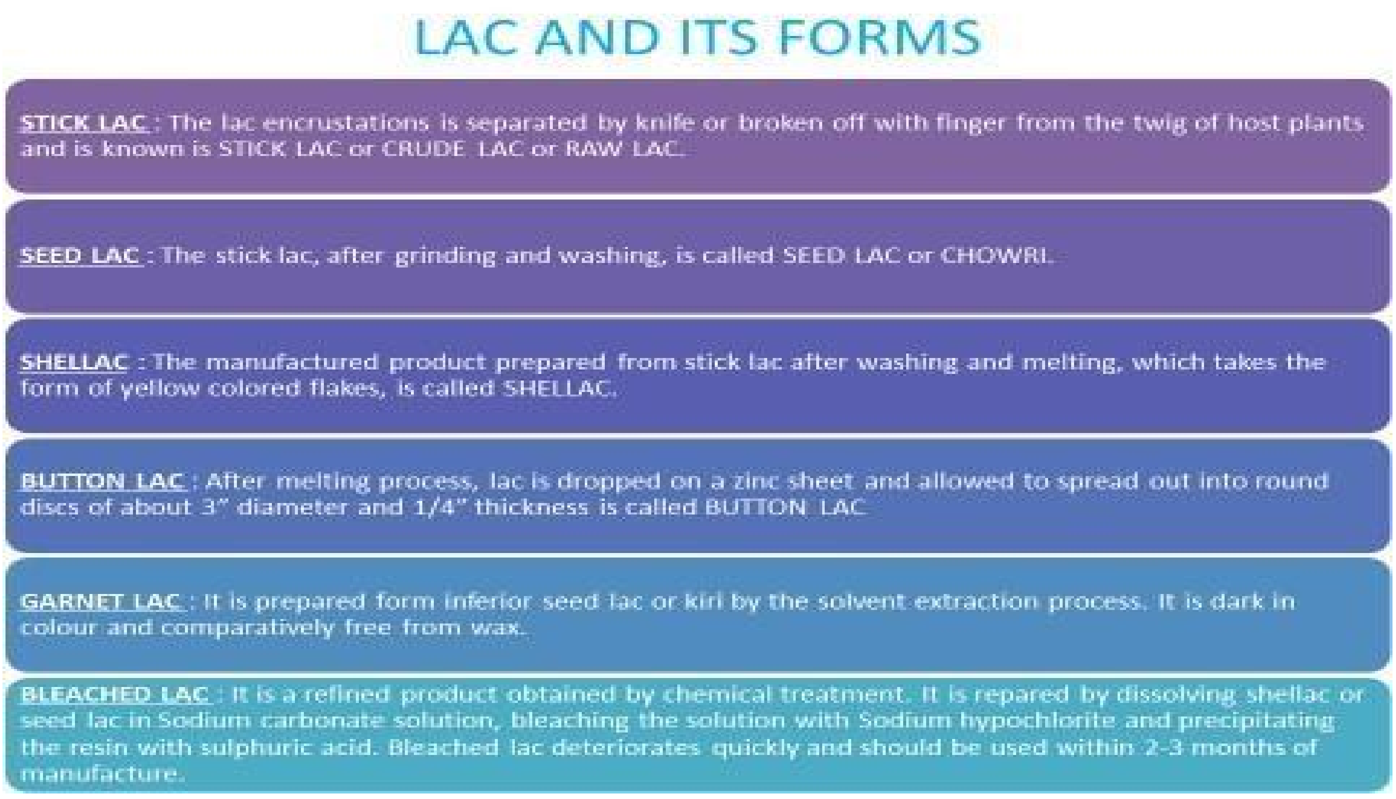
- lac is directly related to the host plant and to the strain of lac insects.
- Based on industrial parameters, kusumi lac is better and fetches higher price in market.
- **In this respect, ber tree as** a potential kusumi lac host is already getting momentum.
- This host species is available in plenty and can supplement and fulfill the kusmi brood lac requirement in many areas.
- Similarly, siris (*Albizzia sp.) has also been identified as good host for kusumi brood lac.*
- *The* trees can be raised and utilized within a period of 5-6 years of plantation in comparison to around 15 years for kusum.

74 Ari Lac and Phunki Lac

ARI LAC AND PHUNKI LAC



LAC AND ITS FORMS



LAC AND ITS FORMS

STICK LAC : The lac encrustations is separated by knife or broken off with finger from the twig of host plants and is known is STICK LAC or CRUDE LAC or RAW LAC.

SEED LAC : The stick lac, after grinding and washing, is called SEED LAC or CHOWRI.

SHELLAC : The manufactured product prepared from stick lac after washing and melting, which takes the form of yellow colored flakes, is called SHELLAC.

BUTTON LAC : After melting process, lac is dropped on a zinc sheet and allowed to spread out into round discs of about 3" diameter and 1/4" thickness is called BUTTON LAC

GARNET LAC : It is prepared form inferior seed lac or kiri by the solvent extraction process. It is dark in colour and comparatively free from wax.

BLEACHED LAC : It is a refined product obtained by chemical treatment. It is repared by dissolving shellac or seed lac in Sodium carbonate solution, bleaching the solution with Sodium hypochlorite and precipitating the resin with sulphuric acid. Bleached lac deteriorates quickly and should be used within 2-3 months of manufacture.

75 Distribution

• Lac is currently produced in

1. INDIA
2. MYANMAR
3. THAILAND
4. MALAYA
5. YUAN PROVINCE OF CHINA.

- India and Thailand are main areas in the world, while India has prime position in relation to lac production.
- Lac cultivation is introduced into Thailand from India.

HOST PLANTS

- Lac insects thrive on twigs of certain plant species, suck the plant sap, and grow all the while secreting lac resin from their bodies.
  These plants are called host plants. Although lac insect is natural pest on host plant, these insects enjoy the privileged position not being treated as pest.
- **This is because:**

i) **They yield a useful product,**

Ii) The host plants are economically not so important

Iii) The insects cause only temporary and recoverable damage to the host plants.

- About 113 varieties of host plants are mentioned as lac host plant. Out of which the followings are very common in India:

1. *Butea monosperma (Vern. Palas)*

2. *Zizyphus spp (vern. Ber)*

3. *Schleichera oleosa (Vern. Kusum)*

4. *Acacia catechu (Vern. Khair)*

5. *Acacia arabica (Vern. Babul)*

6. *Acacia auriculiformis (Vern. Akashmani)*

- Arhar (*Ca]anus indicus*)
- The insects live as a parasite, feeding on the sap of certain trees and shrubs. The lac insects breed and thrive well on them until they start producing lac.
- Before coming to the actual mechanism of lac secretion and its processing, it is advisable for a lac-culturist to have detailed knowledge of lac insect and its life cycle.
- The adult lac insect shows a marked phenomenon of sexual dimorphism.
- The male and female insect varies in shape, size and also in presence or absence of certain body parts.

76 Lac Insect

- Lac insect is a minute crawling scale insect which inserts its suctorial proboscis into plant tissue, sucks juices, grows and secretes resinous lac from the body.
- Its own body ultimately gets covered with lac in the so called 'CELL'.
- Lac is secreted by insects for protection from predators.

Male lac insect

- Male is red in colour and measures 1.2 - 1.5mm in length.
- It has reduced eyes and antennae.
- Thorax bears a pair of hyaline wings.

Structure of Male Lac-insect:

- It is red in color. The body is typically divided into head, thorax and abdomen.
- The head bears a pair of antennae and a pair of eyes. Mouth parts are absent so a male adult insect is unable to feed. Thorax bears three pairs of legs.
- Wings may or may not be found.
- Abdomen is the largest part of the body bearing a pair of caudal setae and sheath containing penis at the posterior end.

77 Male and Femal Lac Cell

Male Lac Cell

- After the first molt, both male and female nymphs lose their appendages, eye and become degenerate.
- While still inside their cells, the nymphs cast off their second and third molt and mature into adult.
- Both the male and female larvae become sexually mature in about eight weeks.
- Only the male one undergoes a complete metamorphosis or transformation into another form; it loses its proboscis and develops antennae, legs and a single pair of wings.
- It is contained in a brood cell somewhat slipper like with a round trap door (operculum) through which it emerges.
- The adult male is winged and walks over the females to fertilize them.

Female lac insect

- Female is larger than male, measures 4-5 mm in length and has a pyriform body.
- The head, thorax and abdomen are not clearly distinct.
- The antennae and legs are in degenerated form, and wings are absent.

Structure of Female lac-insect:

- Head bears a pair of antennae and a single proboscis. Eyes are absent.
- Thorax is devoid of wings and legs. The loss of eyes, wings, and legs are due to the fact that the female larvae after settling down once never move again and thus these parts become useless and ultimately atrophy.
- Abdomen bears a pair of caudal setae. It is female lac insect which secretes the bulk of lac for commerce.
- The female brood cell is larger and globular in shape and remains fixed to the twig.
- The female retains her mouth parts but fails to develop any wings, eyes or appendages.
- While developing, it really becomes an immobile organism with little resemblance to an insect.
- Females become little more than egg producing organisms.

78 Life Cycle of Lac Insect 1

Lifecycle of lac insect

• The Life cycle of lac insect takes about six months and consists of stages: 1. EGG,

2. NYMPH
3. INSTARS,
4. PUPA AND

5. ADULT.

- The lac insects have an ovoviviparous mode of reproduction.
- Female lays 200-500 ready to hatch eggs, i.e. the embryos are already fully developed in eggs when these are laid.

Fertilization:

- After attaining the maturity, males emerge out from their cells and walk over the lac incrustations(crusts).
- The male enters the female cell through anal tubular opening and inside female cell it fertilizes the female.
- After copulation, the male dies. One male is capable of fertilizing several females.
- Females develop very rapidly after fertilization.
- They take more sap from plants and exude more resin and wax.

Brood lac is used for inoculation

- When the eggs hatch, larvae emerge and the whole process begins all over again

After the cycle has been completed and around the time when the next generation begin to emerge, the resin encrusted branches are harvested.

- They are scraped off, dried and processed for various lac products.
- A portion of brood lac is retained from the previous crop for the purpose of inoculation to new trees.

79 Life Cycle of Lac Insect 2

- **Life Cycle of Lac Insect:**
- The females after fertilization are capable of producing eggs. But it has been noticed in case of lac insects that the post fertilization developments start when the eggs are still inside the ovary.
- These developing eggs are oviposited into the incubating chambers (formed inside the female cell by the body contraction of females).
- A female is capable of producing about one thousand eggs (average 200-500). Inside incubating chamber, the eggs hatch into larvae.
- Female cell is oval, having a pair of small branchial pores in anterior side and a single round anal tubular opening in posterior side.
- Through the anal tubular opening are protruding waxy white filaments, secreted by the glands in the insects body, which is an indication that the insect inside the cell is alive and is in healthy condition.
- These filaments also prevent the blocking of the pore during excess secretion of lac.
- The cell produced by male and female differ in shape, and can be easily distinguished sometimes later.
- Male cells are elongated and cigar shaped.
- There is a pair of branchial pores in the anterior side and a single large circular opening covered by the flap in the posterior side.
- It is through the posterior circular opening that the matured male lac insect emerges out of its cell.

80 Life Cycle of Lac Insect 3

- **The Life Cycle of Lac Insect**
- The larvae are minute, boat shaped, red colored and measure little over half millimeter in length.
- Larva consists of head, thorax and abdomen. Head bears a pair of antennae, a pair of simple eyes and a single proboscis. All three thoracic segments are provided with a pair of walking legs.
- Thorax also bears two pairs of spiracles for respiration. Abdomen is provided with a pair of caudal setae.

- These larvae begin to wander in search of suitable center to fix them. This mass movement of larvae from female cell to the new off-shoots of host plant, is termed **as "swarming".**

Lifecycle of lac insect

Swarming occurs after the emergence of nymph and it may continue for 5 weeks.

- The nymphs crawl about on branches.
- On reaching soft succulent twigs, the nymphs settle down close together at rate of 200300 insects per squire inch.
- At this stage, both male and female nymphs live on the sap of the trees.
- They insert their suctorial proboscis into plant tissue and suck the sap.
- The emergence of larvae from female cell occurs through anal tubular opening of the cell and this emergence may continue for three weeks.
- The larvae of lac are very sluggish and feed continuously when once they get fixed with the twig.
- In the meantime the larvae start secreting resinous substance around their body through certain glands present in the body. After some-time the larvae gets fully covered by the lac encasement, **also known as lac cell.**
- Once they are fully covered, they molt and begin to feed actively.

81 Life Cycle of Lac Insect 4

Lifecycle of lac insect

- After a day or so of settling, the nymphs start secreting resin from the glands distributed under the cuticle throughout the body, except mouth parts, breathing spiracles and anus.
- The resin secreted is semi-solid which hardens on exposure to air into a protective covering.
- The nymphs molt thrice inside the cells before reaching maturity.
- The duration of each instar is dependent on several factors, viz. temperature, humidity and host plant.

Ovoviviparous nature

- The female increases in size to accommodate her growing number of eggs.
- Lac resin is secreted at a faster rate, and a continuous layer coalesces or grows into one body.
- After fourteen weeks, the female shrinks in size allowing light to pass into the cell and the space for the eggs.
- About this time, two yellow spots appear at the rear end of the cell.
- The spots enlarge and become orange colored.

- When this happens, the female has oviposit a large number of eggs in the space called '**Ovisac'.**
- The ovisac appears orange due to crimson fluid called lac dye which resembles cochineal.
- It indicates that the eggs will hatch in less time.
- Eggs deposited hatch within a few hours of laying, and a crimson-red first instar nymph called crawlers come out.

The crawler measures 0.6 x .25 mm in size.

82 Lac Insect Nature of Attack

Lac Insect; Nature of Attack

Adult female scales produce a high-domed 'test' or shell with four to six lobe-like projections that anchor the test to the plant surface.

The test is hard and glossy with a reddish-orange tint around the edges, and darker toward the center.

- In some specimens, white string-like wax fiber extrusions project from the dorsum of the test, but these may break off.

- In heavy infestations, the tests of multiple females will develop into a single, aggregated mass such that the distinctive appearance of the individual tests is lost.
- The test darkens as the scale matures.
- The female scale, which is a deep red color, lives inside the test and requires a special procedure to remove without damage.
- The sticklac is a protection for the insects.
- By excreting sugars they also attract the Praetorian Guard (weaver ants, *Oecophylla smaragdina*).

83 Lac Secretion and Cultivation

Lac Secretion:

- Lac is a resinous substance secreted by certain glands present in the abdomen of the lac insects. The secretion of lac begins immediately after the larval settlement on the new and tender shoots. This secretion appears first as a shining layer which soon gets hardened after coming in contact with air.

- This makes a coating around the insect and the twig on which it is residing.
- As the secretion continues the coating around one insect meet and fuses completely with the coating of another insect.
- In this way a continuous or semi-continuous incrustation of lac is formed on the tender shoots.

Cultivation of Lac:

Cultivation of lac involves proper care of host plants, regular pruning of host plant, infection or inoculation, crop-reaping, control of insect pests, and forecast of swarming, collection and processing of lac.

- The first and perhaps the most important prerequisite for cultivation of lac is the proper care of the host plant.
- It is the host plants on which lac insects depend for their food, shelter and for completion of their life cycle.
- There are two ways for the cultivation of host plants. One is that plants should be allowed to grow in their natural way and the function of lac-culturist is only to protect and care for the proper growth of plants.
- Another way is that a particular piece of land is taken for the purpose and systematic plantation of host plant is made there.
- Regular watch is necessary in this case by providing artificial manures, irrigation facilities, ploughing and protecting the plants from cattle and human beings for which the land should be fenced.
- The larvae of lac insects are inoculated on host plants only after the host plants have reached a proper height.
- The lac larvae feed on the cell sap by inserting their proboscis in the tender twigs. The proboscis can only be inserted in the tender young off-shoots. For this before inoculation, pruning of lac host plants is necessary. The branches less than an inch in diameter are selected for pruning.
- Branches half inch of less in diameter should be cut from the very base of their origin. But the branches more than half inch diameter should be cut at a distance of 1 ½ inch from the base.

84 Inoculation

- **Inoculation:**
- The method by which the lac insects are introduced to the new lac host plant is known as **inoculation.**
- This may be of two types, namely “**Natural infection” and “Artificial infection”.** When infection from one plant to other occurs by natural movements of insect, it is called natural infection. This may be due to overcrowding of insect population and nonavailability of tender shoots on a particular tree.
- Artificial infection takes places through the agencies other than those of nature. Prior to about two weeks of hatching, lac bearing sticks are cut to the size of six inches. They are called “**Brood lac”.**

- Brood lacs are then kept for about two weeks in some cool place.
- When the larvae start emerging from this brood lac, they are supposed to be ready for inoculation.
- Strings can be used for tiding the brood lac with the host plant may be of different types in longitude infection the brood lac is tied in close contact with host branches.
- In lateral infection the brood lac is tied across the gaps between two branches.
- In interlaced method, brood lac is tied among the branches of several new shoots.

85 Lac Crops

Lac Crops:

- The lac insects repeat its life cycle twice in a year. There are actually four lac crops since the lac insects behave in two ways either they develop on Kusum plants or develop on plants other than Kusum.

- The lac which grows on Non-Kusum plants is called as "Ranjeem lac," and which grows on Kusum plant is called as "Kusumi lac.

- Four lac crops have been named after four Hindi months in which they are cut from the tree. They are as follows:

Ranjeeni Crop:

(i) Katki:

• Lac larvae are inoculated in June-July. Male insect emerges m August-September. Female give rise to *swarming larvae* in October-November and the crop is reaped in Kartik (October and November).

(ii) Baisakhi:

• Larvae produced by Katki crop are inoculated in October-November, male insects emerges in February-March, females give rise to swarming larvae in June-July, the crop is reaped in Baisakh (April-May).

Kusumi Crop:

(i) Aghani:

- Lac larvae are inoculated in June-July, male insect emerges m September, female give rise to swarming larvae in January-February and crop is reaped in Aghan (DecemberJanuary).

(ii) Jethoi:

- The larvae produced by Aghani crop is inoculated in the month of January- February, male emerges in March-April, female give rise to swarming larvae in June- July and the crop is reaped in the month of Jeath (June-July).

- The time of infection with swarming larvae, the time of emergence of male insects, the time of reaping the crop, and the time of producing swarming larvae by female etc., are shown m tabular form below

86 Scraping and Processing of Lac

Scraping and Processing of lac:

- Lac cut from the host plant is called as "**stick lac**". Lac can be scraped from the twigs before or after the emergence of larvae. If it is used for manufacturing before the emergence of larvae, the type of lac produced is called as "**Ari lac"** and if it is used for manufacturing purpose after swarming of larvae has occurred, the lac is said to be "**Phunki lac".**

- The scraping of lac from twig is done by knife, after which they should not be exposed to sun. The scraped lac is grinded in hard stone mills. The unnecessary materials are sorted out In order to remove the finer particles of dirt and color, this lac is washed repeatedly with cold water.

- Now at this stage it is called as **“Seed lac”** and is exposed to sun for drying. Seed lac is now subjected to the melting process. The melted lac is sieved through cloth and is given the final shape by molding. The final form of lac is called “**Shellac”.**

- Colour or different chemicals may be mixed during melting process for particular need.

Lac Enemies and Their Control:

- A lac enemy imposes a challenge to the lac culturist, as they not only decreases the population of lac insects, but also retard the production and quality of lac. Damage caused to lac insects may be grouped under two heads, (a) damage caused by insects

87 Lac Enemies and Their Control 1

(b) damage caused by animals other than insects. Insect enemies of lac crop may be predators and parasites.

- The common parasites of lac insect are known as “Chalcid.” They are small, winged insects which lay their eggs inside the lac coat either on the body of the lac insect or inside the body of the lac insect.

- The larva which hatches from these eggs feed upon the lac insects, thereby causing mortality of their host. Damage done by this parasite constitute about 5-10% of the total destruction of the lac crop.

- Damage done by the predators is of greater intensity (35% of the total destruction).

- The major predators of lac insects are *Eublemma amabilis* (the white moth) and *Holococera pulverea* (the blackish grey moth).

- They not only feed on lac insects but also destroy the lac produced by term. Squirrels, monkey, rat, bat, birds (wood peckers), man etc., are the enemies other than insects which destruct the lac crop in different ways.

- Damage is also done by climatic factors such as excess heat, excess cold, heavy rain, and storm and partly by the faulty cultivation methods.

88 Lac Enemies and Their Control 2

Control:

- Damage caused by the above mentioned animals can be reduced to certain extent by the use of the following methods.

Cultural Method:

- The amount of damage by infection can be reduced to a greater extent by taking care during the culture of lac insects, especially at the time of inoculation.

- The brood lac showing the minimum enemy attack should be selected for inoculation and should be cut from the host plant very near to the time of emergence of larvae (about one week before the emergence).

- This will reduce the chances of parasite attack on the emerging larvae at new place (host).
- The brood lac used for inoculation should be removed from the new host’s branches as soon as the emergence of larvae stops (approx. 3 weeks after inoculation). It reduces the chance of transference of enemies to the new host plant from the brood lac.

- The infected brood lac not fit for inoculation or the used up brood lac should not be retained for long. The lac should be scrapped at once and the rest may be crushed or dropped into fire in order to destroy the predators and parasites.

- The delay in processing also gives chances to the enemy insects to escape into field.
- So the manufacturers should try to convert stick lac into seed lac as soon as possible.
- By these cultural methods the future production can be saved from infection to some extent.

89 Artificial Methods and use of Lac

Artificial Method:

- During the crop reaping, it is not always possible for the manufacturers to convert the huge amount of stick lac to seed lac at a time.
- To avoid the spreading of enemies at this time from stocked stick lac simple artificial method can be used. Bundles of stick lac should be tied with stones and immersed in fenced water (river or ponds) for about a week.
- This kills all the parasitic and predator insects as they cannot survive in water.

Biological Method:

- It is an indirect method for killing the parasitic and predator insects.
- For this purpose hyper-parasitic insects are used which attacks the parasitic insects of lac and kill them.
- These hyper-parasitic insects are however, not harmful for lac crop.

Use of Lac:

- Lac has been used for the welfare of human beings from the great olden days
- No doubt the development of many synthetic products have made its importance to a little lesser degree, but still it can be included in the list of necessary articles.
- Lac is used in making toys, bracelets, sealing wax, gramophone records etc.
- It is also used in making grinding stones, for filling ornaments, for manufacturing of varnishes and paints, for silvering the back of mirror, for encasing cable wires etc.,
- Waste materials produced during the process of stick lac is used for dying purpose. Nail polish is a good example of the by-product of lac.
- **Composition of Lac:**
- Lac is a mixture of several substances, of which resin is the main constituent. The approximate **percentage of different constituents of lac is given below:**

  Resin – 68 to 90%

  Dye – 2 to 10%

  Wax – 5 to 6%

90 Composition of Lac

Mineral matter – 3 to 7%

Albuminous matter – 5 to 10%

Water – 2 to 3%

Present Position of this Industry

- Lac is produced in a number of countries including India, Thailand, Mayanmar, China, Indonesia, Vietnam and Laos.

- India and Thailand are the major producers, producing on the average 1700 tons of lac annually, followed by China.

- India alone, accounts for about 70 % of global lac production.

- Former Bihar is the most important lac producing state of India. The Indian council of Agriculture Research has established Indian Lac Research Institute at Namkum in Ranchi district of Jharkhand.

- The average of different states in the total quantity of stic lac produced in this country is given below:

- Bihar – 55.5%
- Madhya Pradesh – 22%
- West Bengal – 10%
- Maharashtra – 7.1%
- Gujrat – 2.7%
- Uttar Pradesh – 1.8%
- Assam – 0.6%
- Orissa – 0.1%

- Total annual global production of pure lac is estimated to be 20,000 tons. The average total production of stick lac in India is about 24,000 tons, while the annual average pure lac produced in the country is 11,890 tons. About 6000 tons of pure lac produced in India is exported to different countries of the world, with an average earning of Rs. 202.38 million in term of foreign exchange. It has been estimated that 3-4 million people mostly tribal are engaged in the cultivation and several thousands in addition are engaged in the trade and manufacture of lac.

- Two main competitors of Indian lac are (**i) Thailac,** which accounts 50% of the total lac exported, and **(ii**) Synthetic resin, which have replaced lac in certain field. Shellac being a versatile resin, there is immense scope of increasing its utilization in various fields and there is also scope to modify it to meet particular need.

91 Apiculture

Beekeeping

- Beekeeping is Applied Bee Biology

- Beekeeping is Anticipation not merely reaction

- Beekeeping is Colony Population Management
- Beekeeping is Science and Art

The place where a beekeeper keeps his bees is called an apiary or a bee yard.

  – The bee colony is kept inside a hive that is made from a series of wooden boxes and frames that hold wax sheets for the bees to use as a starting point when building honeycomb.

  – The top box contains honey, while the bottom box is used to hold the queen bee and most of the worker bees.

- In the United States, the most popular type of hive design used for beekeeping is known as a Langstroth bee hive.

Beekeeping, the practice of artificially maintaining honey bee colonies, one of the oldest forms of food production.

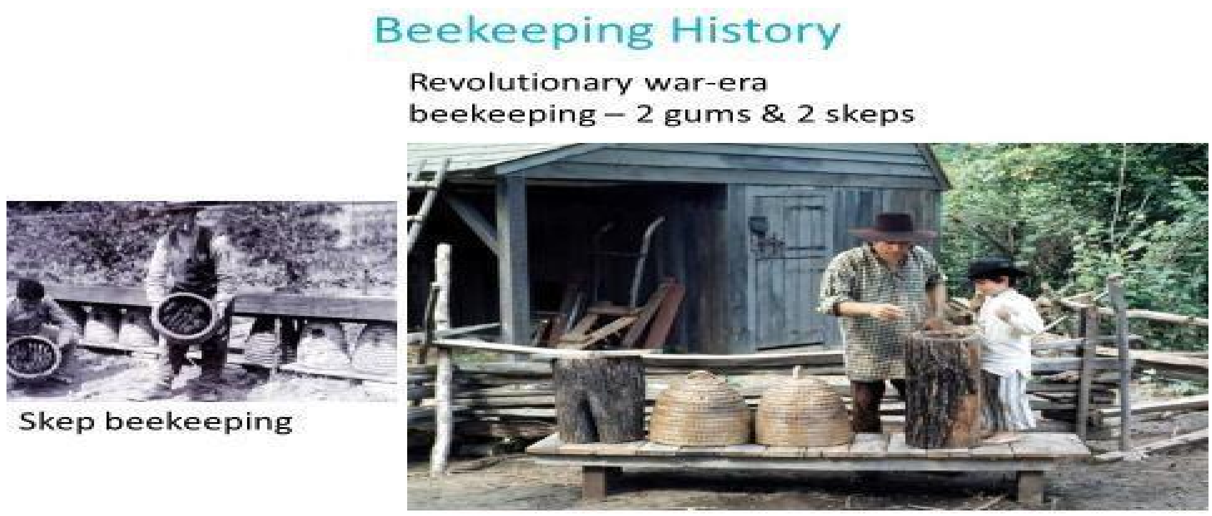
- Honey is a sweet yellow to rich amber colored fluid produced by bees. Other insects can also produce honey, but bee honey is the product which most people are familiar with, since it has been consumed for centuries as a sweetener.

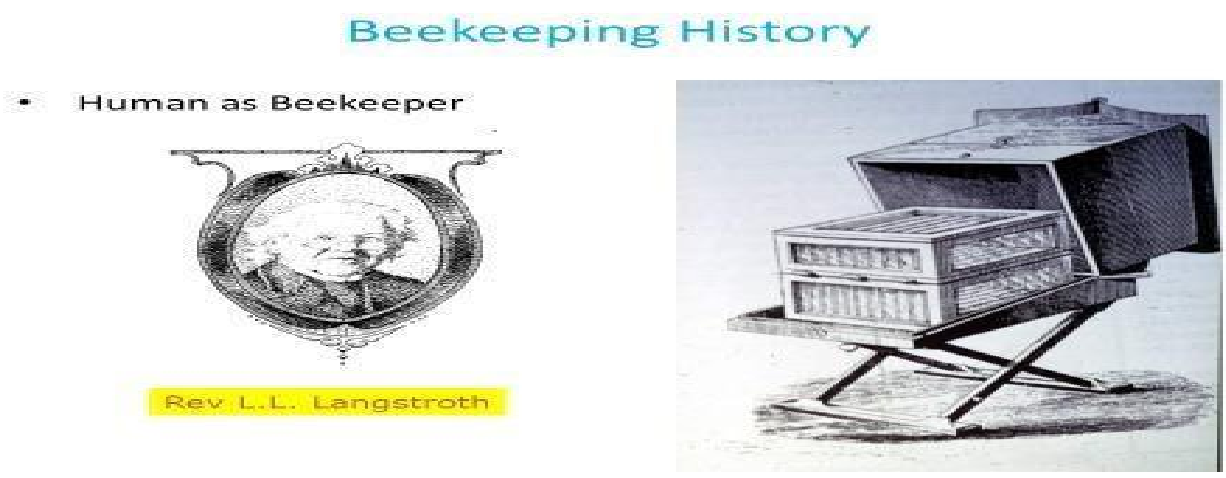
Formally known as *apiculture*, beekeeping is thought to have been practiced as early as 13,000 BC.

- The ancient Egyptians were particularly skilled in the art of beekeeping, since they considered honey to be an important part of their diet.

- Temples kept bees in order to satisfy the desire of the gods for honey and for the production of medicines and ointments.

92 History of Bee Keeping





Good beekeeping basics that can help.

93 Good Bee Keeping Basics

– Knowledge of bee science.

– Knowledge of bee botany.

– Familiarity with modern agriculture.

– Some elementary economics.

– Tools and the ability to work with wood.

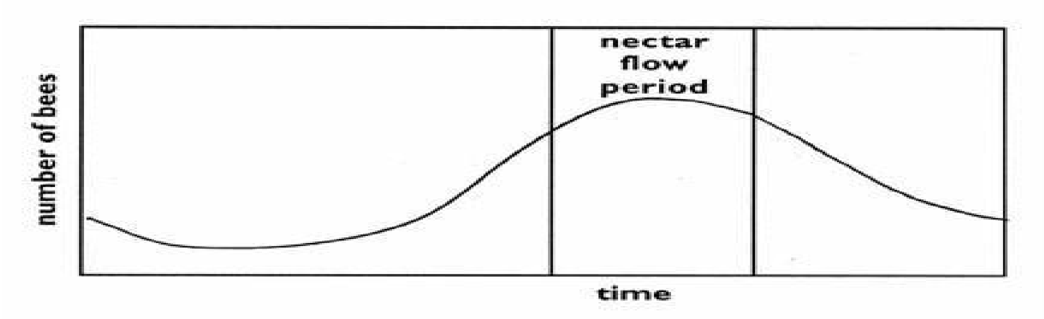
– Ability to keep vehicles running

– Fortitude(courage) to take bee stings. A bee's front end is sweet and kind, But never trust a bee's behind.

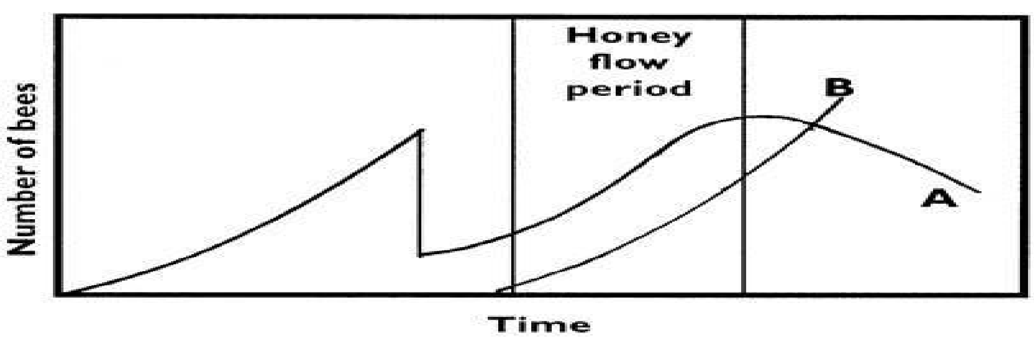
A bee can sting if it can sit,

So always stay in front of it!

Beekeeping – the real KEY!



Beekeeping – the real KEY!



Beekeeping – the KEY!

Manage colonies intensively

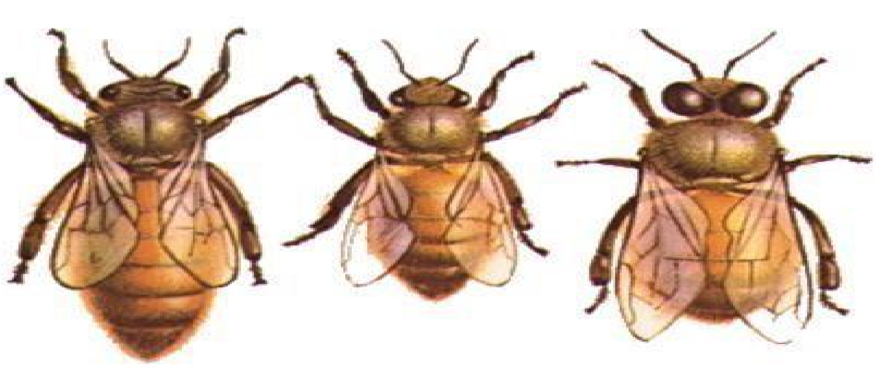
or

extensively

94 The Wonderful Creatures

So, let's meet these wonderful creature's.

Queen Worker Drone



The Queen

- The queen is the only sexually developed female in the hive.

- She is the largest bee in the colony.
- A productive queen can lay 2,000 eggs in a single day.

The Worker

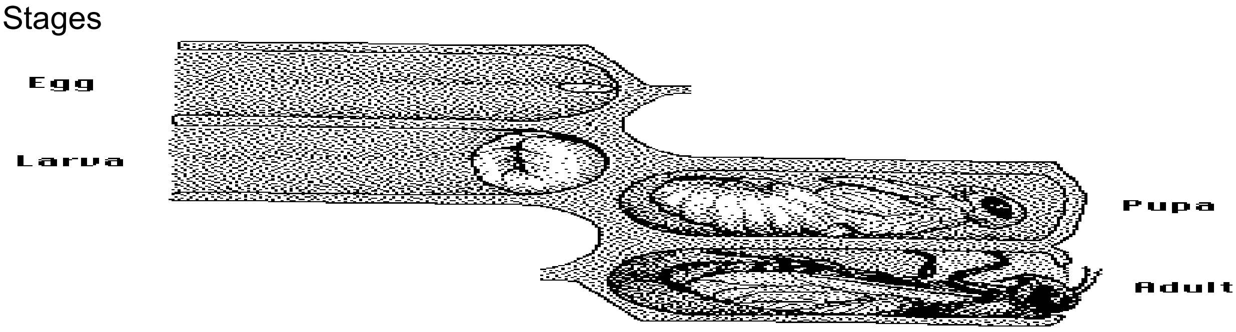
- Workers, the smallest bees in the colony, are sexually undeveloped females.
- A colony can have 50,000 to 60,000 workers. The life span of a worker bee varies according to the time of year. Her life expectancy is approximately 28 to 35 days.
- Workers that are reared in September and October, however, can live through the winter.
- Worker bees also collect nectar to make honey.
- Bees produce honey as food stores for the hive during the long months of winter when flowers aren't blooming.

The Drone

- Drones are stout male bees with large eyes and no stingers.
- Drones do not collect food or pollen from flowers.
- Their sole purpose is to mate with the queen.
- They die upon mating.
- If the colony is short on food, drones are often kicked out of the hive.

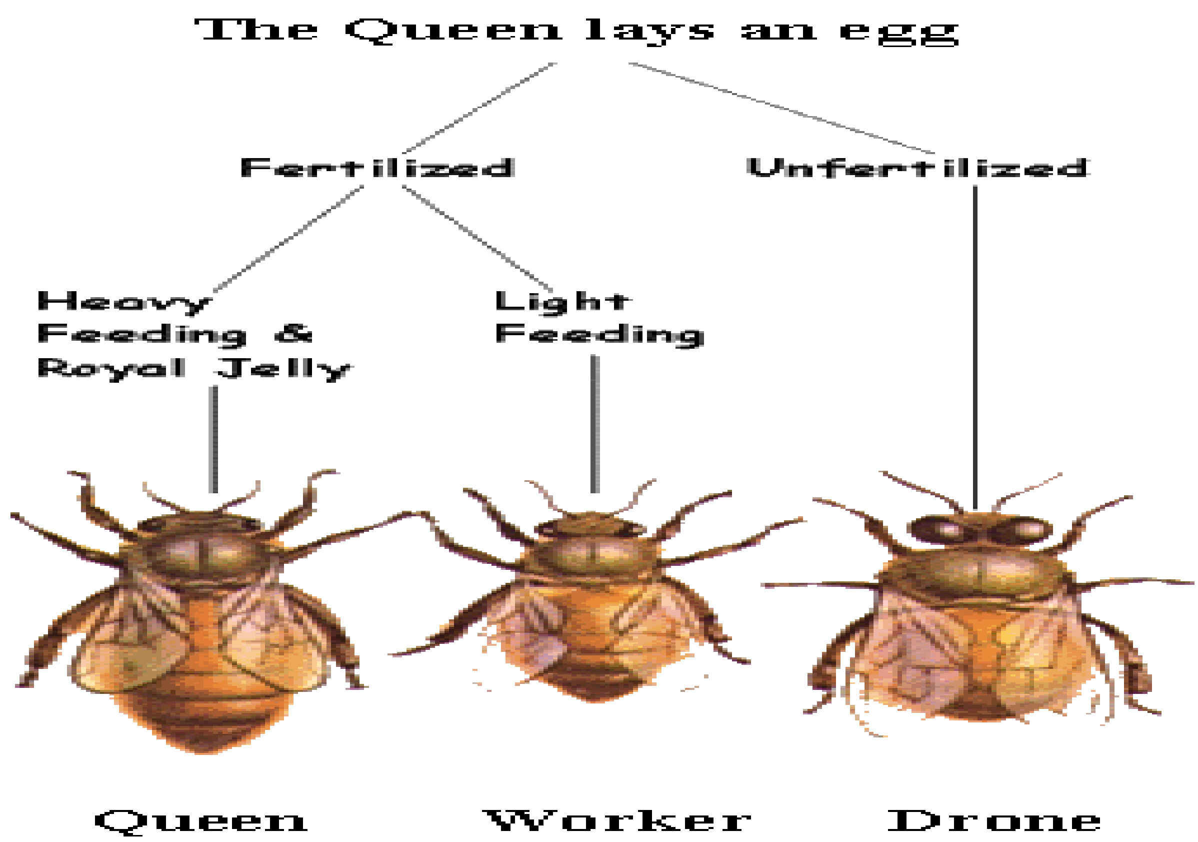
95 The Stages

Bee Stages



Type	Egg	Larva	Pupa	Total
Queen	3 days	5 days	9 days	17 days
Worker	3 days	6 days	12 days	21 days
Drone	3 days	7 days	14 days	24 days

Bee Development



Visit the life of the Worker Bee

(Day 1-2)

96 The Life of the Worker

- **Cell cleaning** - Brood cells must be cleaned before the next use - cells will be inspected by the queen and if unsatisfactory will not be used. Worker bees in the cleaning phase will perform this cleaning, if not clean worker bee must do it again.

(Day 3-11)

- **Nurse bee -** Feed the worker larvae, worker jelly, secreted from the same glands that produce royal jelly.

Life of a Worker Bee

(Day 6-11)

- **Advanced Nurse -** Bees Feed royal jelly to the queen larva. Drones receive worker jelly for 1 to 3 days at which time they are moved to honey and pollen.
- **(Day 12-17)**
- **Wax production** - Build cells from wax, repair old cells, and store nectar and pollen brought in by other workers. Early in the worker's career she will exude wax from the space between several of her abdominal segments. Four sets of wax glands, situated inside the last four ventral segments of the abdomen, produce wax for comb construction.
- **Honey sealing -** Mature honey, sufficiently dried, is sealed tightly with wax to prevent absorption of moisture from the air by workers deputized to do same.
- **Drone feeding -** Drones do not feed themselves; they are fed by workers.

Visit the life of the Worker

Bee (Day 12-17) Continued

- **Queen attendants** - Groom and feed the queen. They also collect QMP (Queen Mandibular Pheromone) from the queen and share it with the bees around them who

97 Life of the Worker 1

also share it spreading its effects through the hive.

- **Honeycomb building** - Workers will take wax from wax producing workers and build the comb with it.

- **Pollen packing** - Pollen brought into the hive for feeding the brood is also stored. It must be packed firmly into comb cells and mixed with a small amount of honey so that it will not spoil. Unlike honey, which does not support bacterial life, stored pollen will become rancid without proper care and has to be kept in honey cells.

- **Life of Worker Bee**

- **Propolizing** - The walls of the hive will be covered with a thin coating of propolis, a resinous substance obtained from plants. In combination with enzymes added by the worker this will have antibacterial and antifungal properties. Propolis is also used to close off excessive ventilation and entrances.

- **Mortuary bees** - Dead bees and failed larvae must be removed from the hive to prevent disease and allow cells to be reused. They will be carried some distance from the hive by mortuary bees.

- **Fanning bees** - Worker bees fan the hive, cooling it with evaporated water brought by water carriers. They direct airflow into the hive or out of the hive depending on need.

Visit the life of the Worker Bee

(Days 18 - 21)

98 Life of the Worker 2

- **Guard Bees** - protect the entrance of the hive from enemies.

- **Soldier bees** - Soldiers hang around near the entrance and attack invaders. They work in concert with entrance guards.

- **Entrance guard bees** - These inspect incoming bees to ensure that they are bringing in food and have the correct hive odor. Other bees will be rejected or attacked with soldier bees.

Life of Worker Bee

- **Outside guard bees** - Outer guards may take short flights around the outside of the hive in response to disturbances.

- **Water carriers** - When the hive is in danger of overheating, these bees will obtain water, usually from within a short distance from the hive and bring it back to spread on the backs of fanning bees.

(Days 22 - 35)

- **Foraging bees** - The forager and scout bees travel (2 to 5 miles) to a nectar source, pollen source or to collect propolis.
- **Die in field** - The life span of worker bees depend on the time of year. Most worker bees live about 28 to 35 days. However, workers that are reared in September and October can live through the winter.

99 Harvesting of the Honey 1

What do we need to harvest honey and how do we do it?

- Each stack is a hive. Each box is called a super. The supers are full of hanging frames. The frames are full of comb. The comb is full of honey, we hope! The bees glue absolutely everything together with propolis, which resembles resin more than wax. You have to pry(interfere, meddle) everything apart.

What do we need to harvest honey and how do we do it?

- There is only one correct way to smoke, but no two beekeepers agree what that is! My smoker is filled with pine straw. Smoke makes the bees unusually calm.

What do we need to harvest honey and how do we do it?

- Remove a super full of honey and get rid of the bees. I use a leaf blower without the snout. You can use a fume board and Bee-Gone but I do not use chemicals. Blow the bees out of the super in front of the hive, it's like taking them to Six Flags!

What do we need to harvest honey and how do we do it?

- Supers full of honey are heavy, shallow 37 pounds, medium 52 pounds and a deep 90 pounds so you need a device to carry from bee yard to honey house.

100 Harvesting of the Honey 2

What do we need to harvest honey and how do we do it?

- You need a honey house (a place where the bees can not get into), a decapping tank (holds wax and a little bit of honey that dripped off the open frames).
- Honey on a frame is somewhat like a bottle of soda, you can't taste it until it is open. Here we are using a decapping knife (gets hot like your mother's iron and has sharp edges on both sides).
- Sometime the bees do not build out the comb to where the decapping knife can cut it so we have to pick or scratch the capped comb open.
- We must get the honey out of the frames of comb and we do this with the aid of an extractor. Years ago beekeepers would squeeze it out by hand.
- When the extractor gets full you need a bucket or buckets to store the honey in. This is also a good time to filter the honey and I use panty hose stretched across the top of the five gallon storage bucket.
- Here the finished product, is a quart of honey. I usually let my honey sit for a few days so any particles that the panty hose did not filter out will rise to the top.

101 Bees Can be Dangerous

Bees can be dangerous, a beekeeper must take several safety precautions when working around a honey bee colony.

- A hat or veil is commonly used to keep the face and neck protected from stings.
- Gloves are another popular form of beekeeping protection, although many beekeepers complain that gloves restrict their movement.
- A hooded suit, typically made from a light colored fabric to help distinguish the beekeeper from the honey bee's natural predators, may also be used.

While working with a honey bee colony, a beekeeper uses a smoker to help calm the bees.

– Smoke is useful in beekeeping because it masks the guard bee's alarm pheromones and encourages the other bees to feed by tricking them into thinking they'll soon need to abandon their hive.

– The smoke gives the beekeeper enough time to inspect the colony and perform any needed maintenance.

– I use Pine needles for fuel in my bee smoker.

102 Bee Stings 1

Bee Stings

Normal Reaction

► Pain

► Wheal(swelling) develops at puncture site

► Redness develops around wheal

► Swelling

- a little at site

- a lot at site (large local)

► Itching

Bee Stings 201

Normal Reaction

Allergic Reaction

► widespread, rapid swelling

► itching of body

► disorientation feeling

► stomach upset

► Loss of consciousness

Treatment of allergic reactions must be rapid – beekeepers need to know what they would do if someone was demonstrating an allergic reaction to a sting in their apiary. See box 25 for emergency sting reaction kit.

Normal Reaction

Allergic Reaction

Toxic Reaction

Too many stings at one time

Toxic reaction results from too many stings in too short a time period. More common with very defensive bees such as Africanized bees. Normal adult should be able to tolerate several hundred stings without danger but smaller bodied children, seniors with other health issues (diabetes, heart condition, AIDS individuals) and animals with smaller body weight can tolerate fewer stings.

103 Be Stings 2

Bee Stings 601

A bee's front end is sweet and kind,
But never trust a bee's behind.
A bee can sting if it can sit,
So always stay in front of it!

Bee Stings 401

- What to do to avoid being stung.....
- proper clothing
- smoker
- best environmental conditions
- scrape sting out promptly
- slow movements- no jerking or 'windmills'
- extra care around hive/flowers
- don't remove veil too soon
- keep gentle bee stock

104 Poultry Farming

Introduction

Chicken, turkey, duck and goose are all types of birds called poultry.

They are reared for meat.

Things to Know About Poultry Farming

- Understanding poultry terms.
- Differentiate between a productive hen and a non- laying hen
- Identify parts of a chicken.
- Evaluate eggs.
- Where to get quality chicks from
- Where to sell the product
- Biosafety and
- Control of diseases

105 Poutry Farming Basic terms to Understand

Basic Terms to Understand

- **Scientific Name**: Galine
- **Chick:** Newborn chicken
- **Pullet**: Young, immature female chicken less than 5-6 months of age
- **Hen:** Mature female chicken
- **Rooster:** Mature male chicken
- **Roaster:** male or female chicken 3-5 months of age and raised for the production of meat
- **Capon:** Castrated male chicken
- **Layer:** Hen used for laying eggs
- **Broiler/Flyer**: Chickens grown for meat production
- **Group Name**: Flock
- **Candling:** examining a shell egg's content by holding it between one's eye and a light source
- **Clutch:** Nest of eggs
- **Egg:** hard- shelled; reproductive body produced by a bird
- **Green:** description of chicks that have recently hatched
- **Axial feather**: short wing feather that separates primaries from secondaries
- **Molt:** To shed feathers periodically
- **Oviposition:** laying of an egg by a bird
- **Plumage:** Feathers of a bird

106 Chicken Farming

Introduction to chicken farming

Chickens farmed for meat are called broiler chickens.

A group of chickens is called a flock.

Breeder farm

Eggs are laid by broiler hens (parent flock).

Male chickens are called cockerels and female chickens are called pullets or hens.

Male turkeys are called stags and female turkeys are called hens. The eggs are collected and sent to the hatchery.

Did you know?

At any one time there are approximately 7 million broiler chicken hens laying eggs for hatching in the UK.

107 Chicken Hatchery

Hatchery

The eggs are incubated at the hatchery. They are kept warm, until the chicks start to hatch out of their shells.

Chickens hatch at around 20 days and turkeys hatch at around 27 days.

Baby chickens are **called chicks.**

Baby turkeys are **called poults.**

The hatched birds are then sorted and transported to Rearing farms.

Do you know what a group of chicks is called?

A group of chicks (baby chickens) is called a clutch or peep.

About Chicks

When a chick hatches it can live healthily for up to two days without being given any food or water. This is because it still has nutrients in its stomach from when it was inside the egg.

This is why chicks do not need food or water when they are being moved to the rearing farm.

108 Rearing Farms

Rearing farms

- The baby birds are reared in special large houses, which provide them with water and a special diet.
- These houses are cleaned before each new arrival of baby birds.
- Trained staff look after the birds in the houses every day.
- If the birds are ill, special medicines are given in their food or water.
- The birds are reared until they reach their required weight.

Catching

- Once the birds reach their required weight they are transported to the processing plant.
- Trained staff called ‘catchers’ catch the birds and put them in special containers called modules.
- Catching is carried out quietly and with care to avoid unnecessary stress and to prevent injury to the birds.

- The modules are then loaded into lorries and taken to the processing plant.

Egg- Type Hens

- Characteristics to look for when examining hens:
- Bleaching of yellow pigment in the shanks, feet, and beak
- Condition and capacity of the abdomen
- Condition of plumage and rate of molt of the wing primaries
- Vigor and vitality
- Head characteristics

109 Bleaching of Body Pigments

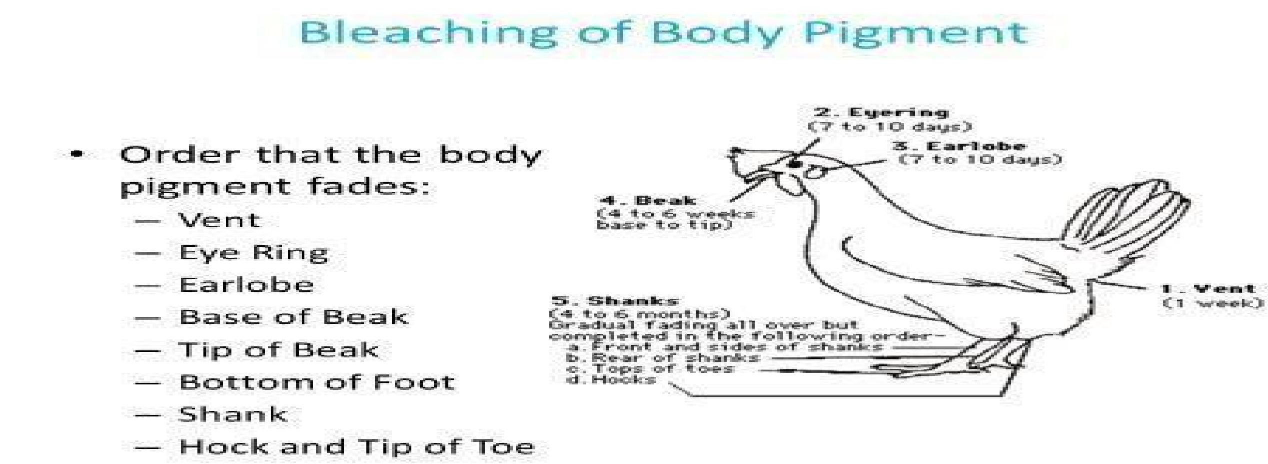


Figure 5. Photographs showing the loss of pigment from the front of the shanks and tops of toes

Figure 4. Comparison of the yellow color in the eye ring, ear lobe and beak of a poor layer (photo on the left) and a good layer (photo on the right)

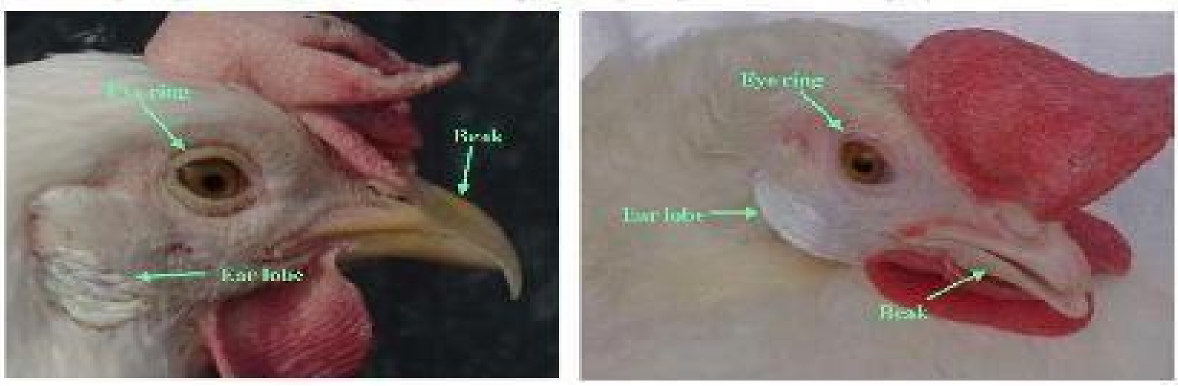


Figure 3. Comparison in the color of the skin around the vent of a poor layer (photo on the left) and a good layer (photo on the right)

Bleaching of Body Pigment

- Hens that show signs of returning pigment are decreasing in egg production
- Pigment returns to the body parts in the same order it faded

– **Returns 3 times quicker** – **Four factors:**

- Amount of pigment in feed
- Health and vitality of hen

- Whether the hen is confined or not
- Size and coarseness of the hen

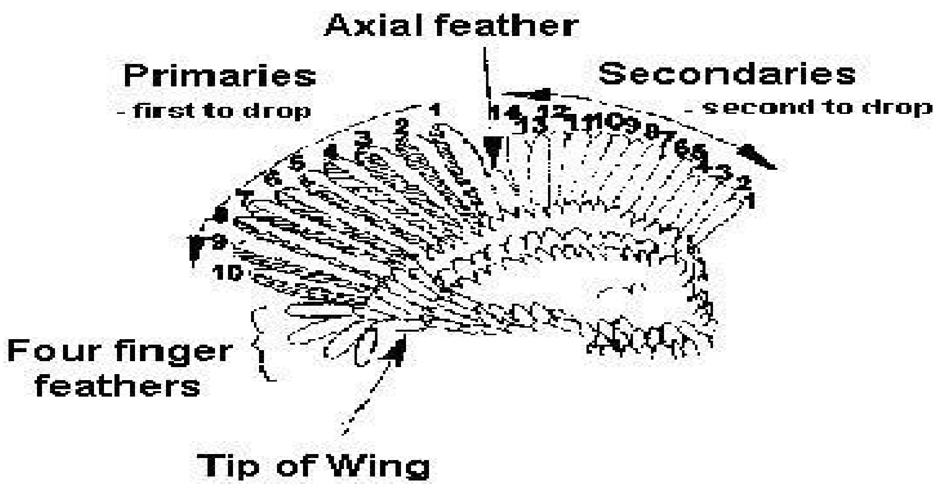
110 Condition and Capacity of Abdomen

Condition and Capacity of Abdomen

- **Good indicator of egg production**
  - Abdomen of a layer is wide, soft (lacks fat), and expanded
  - Pelvic bones are thin and flexible
  - Vent is moist, large, and oblong in shape
- **Non-layer**
  - Narrow, hard (fatty), and contracted
  - Pelvic bones are thick and rigid
  - Vent has some moistness but is small and round in shape

Plumage and Rate of Molt

- Two factors considered in appraising the plumage of hens include condition (feather appearance) and molting rate (speed of shedding feathers)



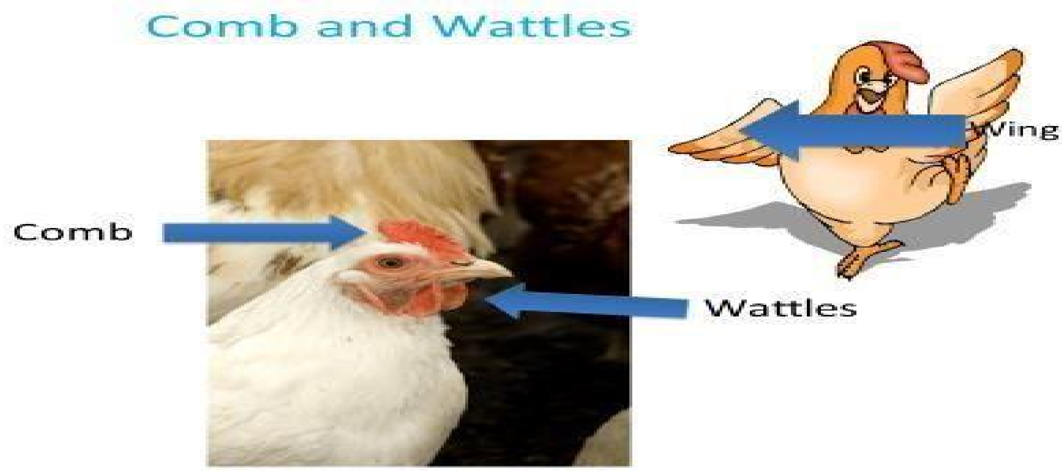
- A high producing hen appears vigorous, alert, and quick in movement
- Non-producing hen is sluggish **Head and Head Parts**
- **If not trimmed- a productive hen's beak is short** – The hens eyes are bright, alert and round.

111 Vigor and Vitality

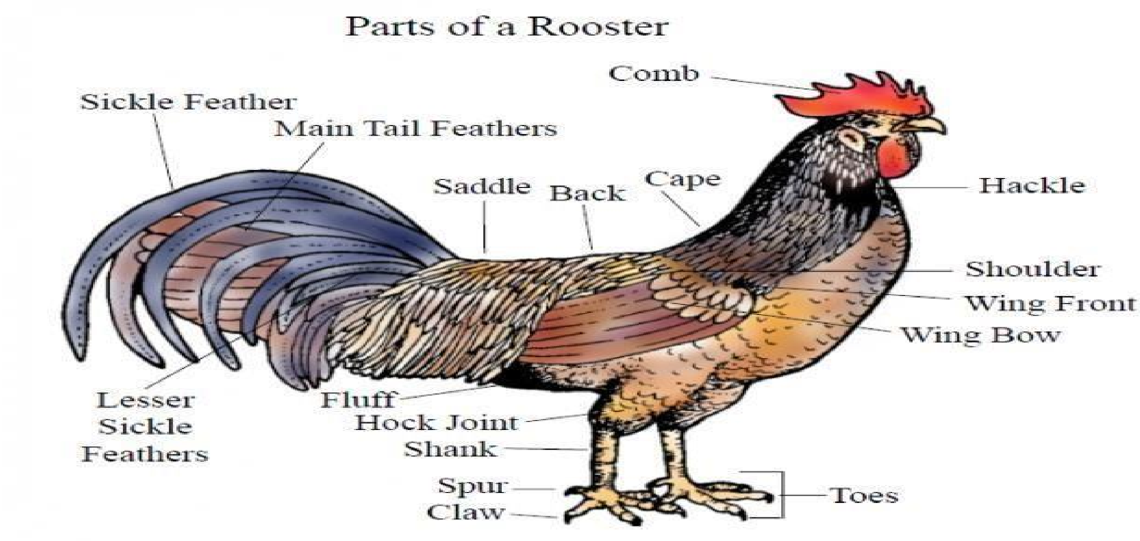
  - Her skull is flat from side to side
  - Her comb and wattles are large, bright red, and glossy – They feel velvety soft and warm when touched.
- **Non-producing hens beak is long**
  - The hens eyes are dull, sleepy, and oblong.
  - Her skull is rounded from side to side
  - Her comb and wattles are shrunken and dull

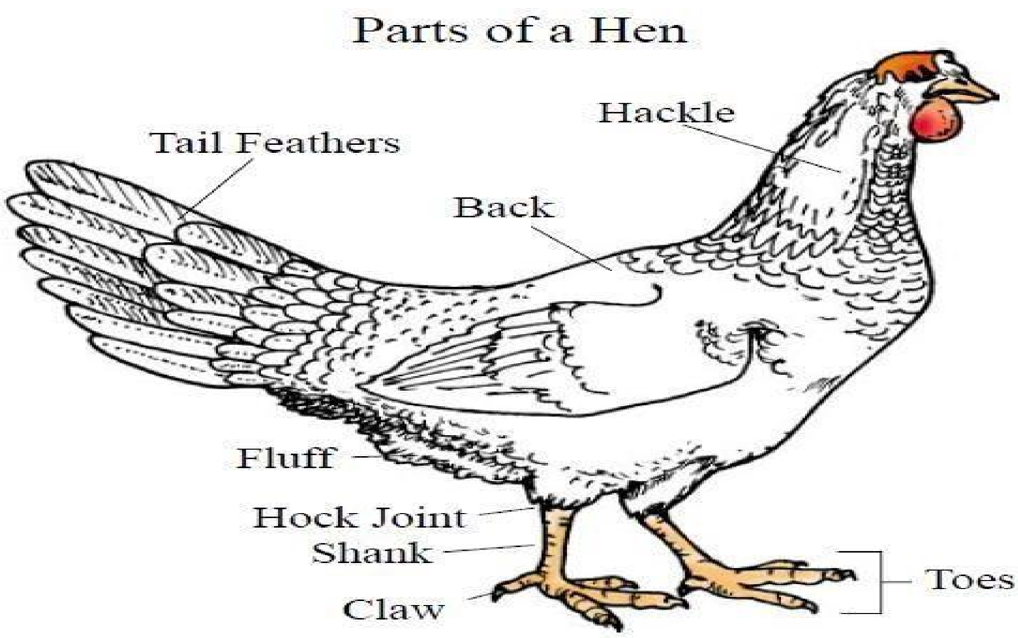
– They feel rough and cool when touched

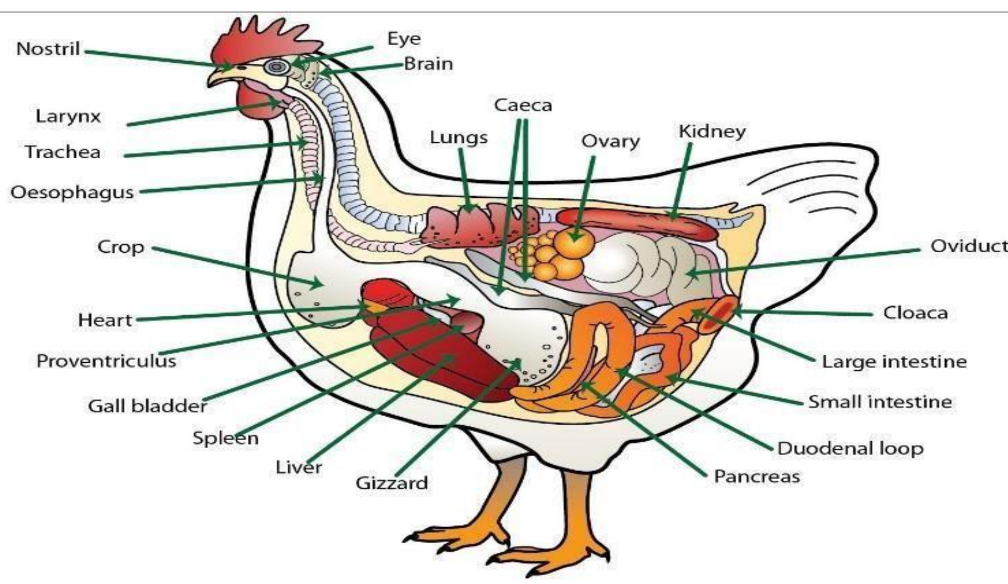
112 Parts of Chicken



Lesson 113: Parts of a Rooster and Hen

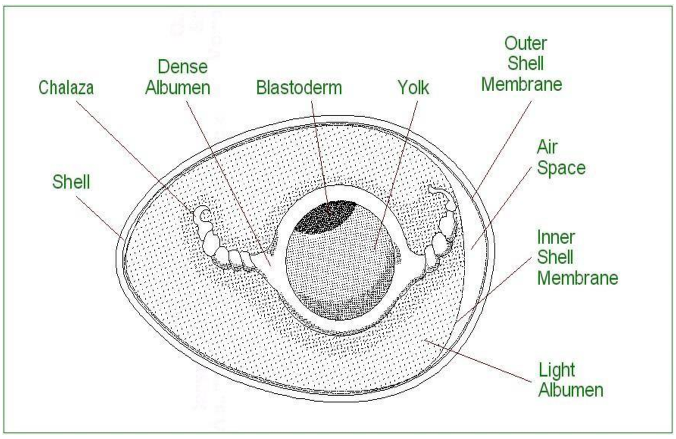






Lesson 114: Eggs

Egg and Its Parts



Candling Eggs

- [Candling Demo]
- **What do we look for when we candle eggs?**
  - Air Cell
  - Yolk
  - Cracks in shell
  - Blood spots and other foreign matter

Lesson 115: Before Candling of Eggs

Before We Candle Eggs

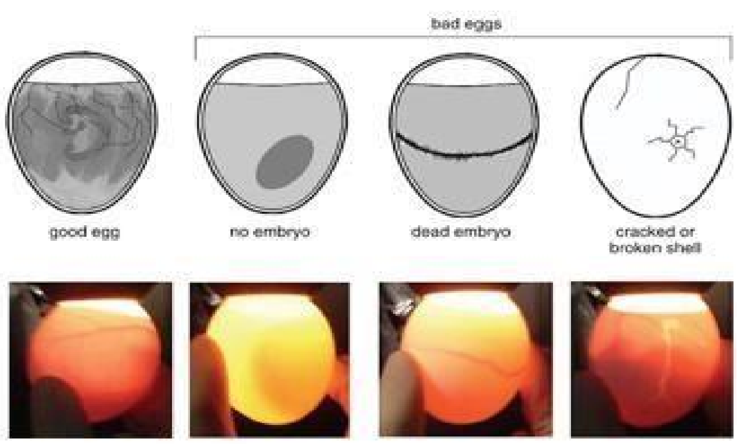
Air Cell

- Temperature- 105 degrees
- Is normally at the large end of the egg
- Quality Grades:
  - AA- up to 1/8"
  - A- 1/8"-3/16"
  - B- > 3/16"

Yolk

- Yolk size and shape
- Distinctness of yolk shadow outline
- Yolk defects and germ development

What Does Your Egg Look Like?



Processing Plant

- Here the birds are processed and packaged.
- After the birds have been processed they are weighed, and then either left whole or portioned.
- The meat is then packaged and labelled ready to be delivered to restaurants, shops and supermarkets.

116 Poultry Feeding 1

Following facts should be considered when computing ration for poultry:

1-Feed must contain all essential nutrients in right amounts & proportion required.

2-Different standards per age should be followed.

3-Palatability of the ingredients which used.
4-Unlike ruminants, poultry completely depend upon the dietary sources for all nutrients (essential AAs., vit.B groups & vit.K).

5-Include agro-industrial by-products to minimize cost of the ration,

6-Optimum level of ingredient inclusion as many of ingredients have a deleterious effect at higher levels.

7-Optimum Ca:P ratio for different purposes.

Nutrients requirements of poultry:

1-Energy requirement:

- Ration for poultry calculated on the basis of ME.
- Poultry eat to satisfy their energy needs when fed free choice, thus must control the intake of all nutrients by including them in a definite proportion to available energy level..

117 Poultry Feeding 2

- **High energy cereal grains are the principal energy sources.**
- Fat may be added at levels of 3-8% to increase dietary energy concentrations.

Factors affecting feed intake:

1-Energy levels in the ration: energy level

feed intake energy level feed intake

2-Environmental temperature:(SET, 16-24C)

Temp. feed intake

Temp. feed intake

3-Health of the bird

4-Genetics

5-Form of the feed

6-Nutritive balance of the diet

7-Stress

8-Body size

9-Rate of growth & egg production

2- Protein requirement:

- The amount of protein required is proportional to the energy level in the ration.
- Poultry required the 14 essential AAs.
- Temp. feed intake protein req. Temp. feed intake protein req.
- **Some AAs can met by other AAs:**

Cystine methionine, Tyrosine phenylalanine

Glysine Serine

Overheating or under heating during processing can affect the availability of some amino acids.

3- Mineral requirements:

- The major minerals needed in poultry diets are Ca, P, Na & Cl.
- Trace minerals may be added if feeds grown on soil deficient in them.

A-Calcium & Phosphorus:

- The recommended ratio P:Ca in diet of poultry is 1:1.2 (range 1:1 to 1:1.5) For laying hen 1:4 (Ca important for bone & shell formation) Ca in diet utilization of Mg, Mn & Zn.
- Inorganic P have a higher availability than organic P

- All P from animal origin & 40% from plant origin (wheat bran & rice bran) is available.

B- Salt (NaCl):

- The amount added depend upon the feed ingredients.
- The recommended level in the ration 0.5-1% of the ration.
- Adult poultry can tolerate much higher inclusion but the water consumption increased.

119 Poultry Feeding 4

C- Manganese:

- Def. Of Mn cause perosis with slipped tendon.
- A free flowing Mn supplements should normally be included in all poultry feeds.
- Mn needed for egg production & hatchability.
- Mn carbonate, oxide, sulfate & commercial mineral mixture can be used.

D- Iodine:

- Iodine included at rate of 0.5mg but when fish meal included at 5-10% no need iodine suppl.
- Ca & P in diet iodine requirement

E- Magnesium:

- No Mg Suppl. Needed for poultry ration.
- Mg in diet laxation 4-Vitamin requirements:

A- Vitamin A:

- Liberal supply of vit.A or carotene is needed for normal growth & health.
- Def. Symptoms: retardation of growth, emaciation, staggering gait & ruffled feathers, reduced immunity
- Sources: fish liver oils & other animal sources.

ZOO510 Economic Zoology

Final term 120 to 239

-

120 Poultry Feeding 5

B- Vitamin D:

Vit.D required for bone formation, egg production, reproduction & prevention of rickets.

Def. symptoms:poor growth, lameness & rickets.

Poultry do not exposure to sunlight, ration must suppl. With vit.D.

C- Vitamin E:

Vit.E in vegetable is not readily available as in oil concentrates.
Vit.E essential to prevent encyphalomalacia or crazy chick disease.

D- Vitamin K:

Def. of vit. K delay clotting time of the blood & produce serious hemorrhage
All mixtures should be suppl. With vit. K
Treatment by sulfonamide   vit. K req.

E- Riboflavin:

Def. of vit.B2 curled-toe paralysis, dwarfism & degeneration of nerve trunks.
Requirement: Broilers & breeder 4.4mg/kg

Layers 2.5 mg/kg ration

F- Thiamin:

✓ Def. of thiamin nerve deg., convulsion & heart abnormalities.

121 Poultry Feeding 6

G- Niacin:

Def. of niacin inflammation of tongue & mouth cavity (black tongue).
Young chick required niacin more than adult due to less bacterial action synthesis.

H- Vit.B12:

Animal proteins are good sources of vit.B12.
Def. of vit.B12 irritability, poor feathering & poor hatchability.

Feeding space:

1 inch feeder space /chick for 2 weeks age & 2 inches after that.

Water:

Bird drink about twice as much water by weight of feed consumed.
Water consumption increase or decrease according to the environmental temperature.
Some medications are administered in the drinking water.

122 Feeding of Broilers 1

Age / Nutrients	Protein (%)	ME (Kcal/kg)
Starter ration (0-3weeks)	22-24	2800
Grower ration (3-5 weeks)	20-22	3000
Finisher ration (5-7 weeks)	18-20	3200

$$\text{Feed conversion (FC)} = \frac{\text{Feed intake (g or kg)}}{\text{Weight gain (g or kg)}}$$

Feed conversion of broilers = 2.2

Factors affecting feed conversion:

1. Type of feed fed
2. Strain of the birds
3. Environmental temperature
4. Age and weight of the birds
5. Diseases and condemnations
6. Rodent & flying bird control in feeding area
7. Antibiotics and medications improve FC
8. Debeaking & size of baby chicks
9. Feed wastage
10. Form of the feed

123 Feeding of Broilers 2

Broiler breeding pullets:

Chickens bred for meat production grow rapidly & reach sexual maturity at early age too many small egg & not good for hatching.
Bird kept for breeding purposes, it is necessary to slow down their rate of growth & development of sexual maturity.

Methods used:

1-Restricting feed intake to approximately 70% (when pullets at 7-9 weeks till 23 weeks),or

2-A skip –a-day program involves full feeding every other day, or 3-Feeding a diet containing 10% protein.

Energy feeds:

- Grain, grain by-products and animal & vegetable fats and oils supply the most of energy in the poultry diets.
- Corn is the most common grain used in formulating poultry diets
- Other grains such as grain sorghum & wheat substituted part of corn
- Animal & vegetable fats added in limited amounts (5-10% of the diet)

124 Feeding of Broilers 3

Protein supplements:

Protein suppl. Added to provide the essential AAs.
Several protein sources used to achieve a better balance of the needed AAs.
Animal protein sources are more variable in their amino acids than plant protein
AAs req. for poultry differ from that of other animals in that glycine & serine are dietary req. & required glycine for uric acid formation.

A-Plant protein:

Soybean meal is most commonly plant protein source & has a better balance of AAs than other plant protein (cottonseed meal, corn gluten meal, linseed meal).
Cottonseed meal used in grower poultry ration to replace up to 50% of the soybean meal, while linseed meal not more than 3-5% of diet.

B-Animal protein:

The most commonly used are fish meal, meat by-products, milk byproducts, blood meal, feather meal & poultry by-product meal.
Fish meal have a good balance of AAs, but must not used in large amount (used at 2-5%) to avoid fishy flavor in eggs & poultry meat.

125 Feeding of Broilers 4

Mineral supplements:

Sources of Ca in poultry diets are ground oyster shell, limestone, bone meal, dicalcium phosphate.
Inorganic P supplied by bone meal, di-calcium phosphate, rock phosphate.
Na & Cl adding as common salt (0.5-1% of diet) Mn (Mn sulfate), Zn (Zn sulfate)

Vitamin supplements:

Natural feedstuffs provide some vitamins for poultry.
Vitamin premixes are commonly used to provide the required vitamins in poultry.

Feed preparation:

Commercial feeds for poultry as mash, pellets or crumbles.
Less wastage when using pellets or crumble and poultry grow faster and more commonly used for broilers and turkey than for laying hens (laying hen tend to become too fat unless they are on the restricted feeding program.

126 Feeding of Laying Hens 1

Nutrient requirements of laying hens:

1-Energy requirement:

For maintenance (2kg wt.) = 220 Kcal

For 70% production = 130 Kcal

For 1 g gain/day = 3 Kcal

The usual energy conc. Is 2.8 Mcal ME/kg diet

Energy conc. Than 2.3 Mcal energy intake & egg production

2-Protein requirement:

Laying hen receiving diet containing 3.1 Mcal ME/kg DM require 16.5% protein.
To get maximum economic return from laying hen flock, a feed efficiency of 1.6-1.8 kg of feed per dozen of eggs produced is need.
A laying ration should contain about 15% protein based on 2900 Kcal ME/kg of diet.

- **Effect of environmental temperature:**

Small light body weight hens consumes: ✓ In Summer
90g feed (19% protein ✓ 17g protein/ hen/ day).
In Winter 110g feed (15.5% protein 17g protein / hen / day)

127 Feeding of Laying Hens 2

Essential AAs for laying hens:

1. Leucine, isoleucine, lysine, methionine, tryptophan and arginine.
2. Methionine is first limiting AAs for egg production.
3. Mash for laying hens should contain not less than 3-4% animal protein supplement.
4. Feather are high in sulfur amino acids (required methionine).

Fat supplement:

Fat addition egg yield in winter
Fat addition amount of feed required / dozen eggs.

3-Mineral requirements:

A-Calcium:

Laying birds need large amounts of Ca because egg shells composed entirely of $CaCo_3$ •
Ca in laying ration egg production & egg shell weak.
Bird stored Ca for about 10-14 days before the first egg was laid in the marrow of long bone.

128 Feeding of Laying Hens 3

B-Phosphorus:

Protein supplement used in poultry rations (mat meal, tankage, fish meal & dairy byproducts) usually be sufficient in phosphorus.

Plant protein supplement (SBOM) should supplement with P & Ca.

Inorganic P is more available than phytate P.

C-Manganese:

Ca in laying ration egg production & egg shell weak & hatchability.

¼ lb Mn sulphate added to ton of mash fed without grain & ½ lb to mash fed with grain

D- Iodine:

Iodine in laying ration goiter

✓ Iodized salt must be used instead of common salt in the ration of poultry.

E- Selenium:

Se in laying ration Exudative diathesis

F- Zinc:

Zn in laying ration skeletal abnormalities, ataxia, necrotic dermatitis & thin shell & hyper keratinization of epidermis.

G- Salt:

- 0.5-1% of the total ration salt

129 Feeding of Laying Hens 4

4-Vitamin requirements:

A-Vitamin A :

Laying hens require higher content of vit.A in their feed in very hot weather than cold because they consume less feed. vit.A in laying ration Nutritional roup (sticky materials from eye & nostrils)

130 Feeding of Laying Hens 5

B-Vitamin D :

vit.D in laying ration thin shell eggs, egg production & hatchability, breast bone become soft & bones of legs & wings become fragile.

C-Riboflavin & vit.E :

Riboflavin & vit.E in laying ration low hatchability

Phase-feeding of laying hens:

To adjust nutrient intake in accordance with the rate of egg production

A-Phase I (most critical period):

During 20 W period (22-42 W of age) pullet :

1. egg production from zero to peak (85-90% production).
2. body weight from 1300 to 1900g.
3. egg size from 40g/egg at 22W to over 56g/egg at 42W of age

131 Feeding of Laying Hens 6

B-Phase II :

✓ Period after 42W of age when the hens attained mature body weight ✓ The period ranged from 42-72W of age.

Effect of temp. on egg shell:

- Hot weather respiration rate Co2 loss blood bicarbonate level egg shell formation

Stage of egg production:

Egg production hen usually cover a period of 15 months
Commences at 22W of age peak at 28-30W of age gradually decline to 65% after 15 months of lay. lighted period feed intake & stimulation of pituitary gland egg laid

Feeding systems:

1. Whole grain method
2. Grain & mash
3. All mash: fed at first 8W
4. Wet mash feeding (more palatable)
5. Pellets

- With grain fed must used insoluble grit
- Also fresh green feed is fed to poultry.

132 Feeding of Laying Hens 7

Nutrition and egg quality: A. Egg size (egg weight):

Factors affecting egg size:

1. Level of protein in diet:

14-20% CP rations balanced AAs heavier eggs
The choice of protein level in layer diet depend on accurate evaluation of extra-cost for the additional protein compare with the income from larger eggs obtained.

2-Energy intake

3-Mineral & vitamin levels:

Ca & vit.D egg weight

4-Level of linoleic acid:

❿ Linoleic acid formation lipoprotein in liver ovary uptake by ova higher egg weight

5-Strain

B-Shell quality:

The quality of egg shells depend on the presence of adequate levels of vit.D_3 & certain minerals including Ca, P & Zn.
Def. or imbalance of vit,D_3 , Ca & P shell thickness & misshapen eggs egg production
❿ Mn thin & brittle-shelled eggs

✓ The blood carbonate is the source of carbonate in the shell formation

133 Feeding of Laying Hens 8

Very hot weather poor quality egg shells
End of laying period falls egg shell quality due to failure in Ca metabolism & Ca of ration

Sulphonamide drugs thin shelled eggs
Insecticides & fungicides in grains malformed eggs
Rancid cod liver oil in diet rough shells Diseases poor shell quality

C-Internal egg quality:

The nutritive content of the egg depends upon the level of these nutrients in the diet of laying hen
Suitable iodine in diet content of eggs
Def. of vit.B2 slight yellowish-green tinge in albumin

D-Yolk color:

The color of egg yolk depend upon the presence of carotenoid pigment (xanthophylls) in the ration
(fresh & good dried green feeds & feed additives)
When 30% yellow maize or 5% good quality alfalfa or up to 22mg xanthophyll/kg deep-yellow yolks
Highly pigmented plants undesirable colored yolks
Large amount of untreated CSM brown mottled yolk & pinkish tint of albumin
Pimento pepper in diet orange-red yolks

134 Feeding of Turkeys 1

The general principles of feeding turkeys are similar to those for feeding broilers. Major differences are in the protein levels required and the importance of the vitamins biotin & pyridoxine in turkey diets
Poults must be fed & watered as soon as possible after hatching & if feeding delayed beyond 36h after hatching difficulty learning to eat & drink.
Vits. & minerals suppl. of the diet essential for good hatchability of turkey eggs.
At 10-12W of age separate hens from toms

Period	Protein (%)	ME (Kcal/kg)
First 3 weeks	30-33	2930-3000
0-4 W	28	2930-3000
4-8W	26	2900
8-12W	20-22	3100
13-16W	19	3200
17-20 W	16	3275
21 W-market	13-14	3350
Laying hen	15-18	2925
Peak production	19	2755

135 Feeding of Turkeys 2

Nutritional disorders of turkey:

1-Leg weakness disorders:

Cause: def. of Ca, P, vit.D, choline, biotine, folic acid, Mn & zinc.

2-Enlargment of hock joint:

Cause: def. Of niacin, biotin, vit.E & zinc.

3-Footpad dermatitis:

Cause: biotin deficiency

Symptoms: sticky droppings adhere to the feet & cause dermatitis

4Pendulous crop:

Cause: yeast proliferation in crop

Symptoms: gas production from fermentation of carbohydrate interfere with passage of ingesta from crops to proventriculus pendulous crop

Treatment: fungal inhibiting antibiotics

5-Ascitis:

Cause: high salt intake fluid accumulation in body cavities

6-Exudative diathesis:

Cause: Selenium deficiency

7Aflatoxicosis:

- Aflatoxin affect the immune system increase susceptibility to disease
- Mycotoxin hemorrhage may bluish the carcass

136 Feeding of Ducks and Geese

Commercial feeds in mash, pelleted or crumbles form available for ducks & geese
If a commercial feed for ducks & geese is not available, chicken feed may be used (not contain coccidiostat)
Geese will start to eat pasture when they are only few days old & feed additional grain if pasture is not of good quality.

FEEDING OF GEESE

Period	Protein (%)	ME (Kcal/Kg diet)
0-4 W (starter)	20	2900
After 4 W (grower)	15	3000
Breeding	15	2900

FEEDING OF DUCKS

Period	Protein (%)	ME (Kcal/Kg diet)
0-2 W (starter)	22	2900
2-7 W (grower)	16	3000
Breeding	15-18	2900

137 Biosecurity 1

Biosecurity for poultry Disease

Prevention

➢ There are basically 2 types of diseases that must be considered in poultry production:

1. diseases of detriment to bird health
2. diseases of potential human health concerns

Causes of Health Issues

1. Pathogens

i. bacteria, viruses, parasites, protozoa, fungi

2. Nutritional deficiencies
3. Chemical poisons
4. Overmedication
5. Poor management

Biosecurity

What is "Biosecurity"?

- Protecting your birds from disease
- Preventing or controlling disease transmission by vectors

What is a vector?

Something that may transmit a disease

Rodents, birds, insects, shoes, car tires, shared equipment, best friend, pet, feed, water, dust, air….

138 Biosecurity 2

Biosecurity

Preventative strategies to control disease causing organisms and their carriers (vectors).

Protection of poultry flocks from any type of infectious agent. ✓ Control transmission of disease from flock to flock.

Biosecurity is the cheapest, most effective means of disease control available.

Who should practice good biosecurity?

Everyone!

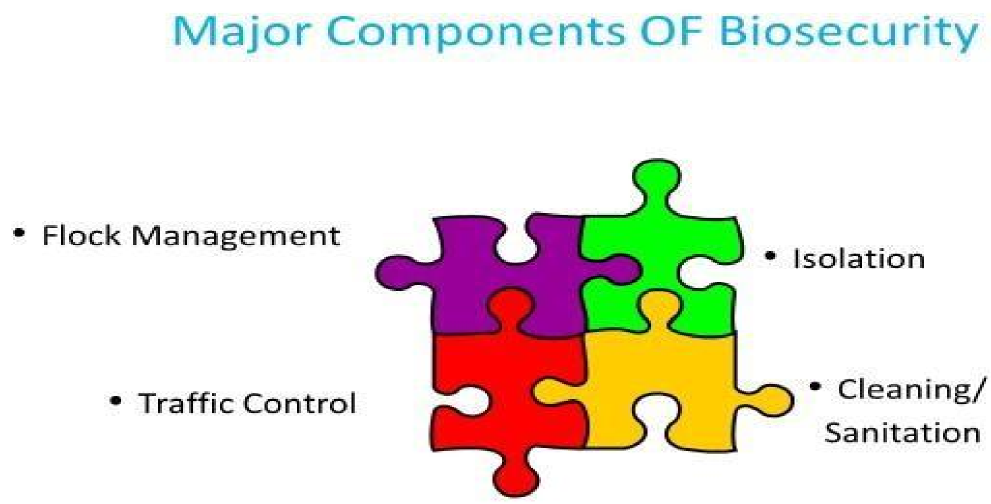
- Commercial producers
- Small flock/backyard poultry owners
- Hobbyists/breeders
- Youth poultry project owners for livestock shows (4-H and FFA members)

Why should I be concerned about biosecurity?

- **Because of what might happen:**

1. Disease and high mortality in flocks
2. Infected flocks euthanized
3. Loss of income for producers
4. Higher prices of poultry meat and eggs
5. Quarantines and restricted movement/sale of birds
6. Cancellation of poultry shows

139 Major Components of Biosecurity 1



140 Major Components of Biosecurity 2

Biosecurity Monitoring Points

1. Humans
2. Equipment
3. Environment
4. Animals
5. Contaminated eggs and chicks
6. Contaminated feed

Environmental Routes of Disease Transmission

➢ Environmental contaminants:

1. wind
2. water
3. dust
4. feathers
5. manure

❖ Drying and sunlight are very effective at killing many disease causing organisms.

141 Good Biosecurity Practices 1

Good Biosecurity Practices

- Keep pets, wild birds and animals and other livestock away from the flock
- No trading or purchase of untested birds – quarantine new birds
- Use dedicated footwear/clothing or disposable coveralls and boot covers when checking your birds
- Hand washing before and after handling birds, manure, coops, eggs, etc.

Isolation Measures

Confine flocks to controlled environment
Screen houses to protect flock from wild birds
Avoid contact with migratory waterfowl and other birds
Restrict visitors
Do not share equipment, coops or leftover feed

Reduce exposure Risks

Control vector habitat and attractants

- birds
- rodents
- varmints
- insects

– Make sure pen is animal and bird proof

142 Good Biosecurity Practices 2

Maintenance Flock health

➢ Minimize stressors to prevent increased susceptibility to disease

1. Fresh feed
2. Clean water
3. Clean, dry litter
4. Good ventilation
5. Provide an overall comfortable environment

Cleaning and Sanitation

Five steps to cleaning and disinfection (C&D)

1. Dry Clean (remove all organic matter)
2. Soap
3. Rinse
4. Dry
5. Disinfect

Disease/Health Checks

Watch for symptoms such as:

✓ Coughing, sneezing, watery eyes, ruffled feathers, loss of feathers, excessive picking, labored breathing and sudden drops in production and feed or water consumption

- Eliminate unhealthy or nonproductive birds
- Check birds periodically for lice, mites, and worms

143 Maintenance of Flock Health

COMMON DISEASE IN POULTRY FARMING

What is disease

Any condition that results in deviation from normal function

ETIOLOGY

Infectious Agents	Non-infectious agents

○ Bacteria ○ Viruses ○ Parasites ➢ Fungi	○ Chemical ○ Physical ○ Lack or excess of certain vitamins and minerals ➢ Toxins

144 Common Diseases of Poultry

General Signs of Disease

1. Poor appetite
2. Huddling
3. Depression
4. Runting /stunting
5. poor uniformity
6. Ruffled feathers
7. Coughing, sneezing,
8. oculo-nasal discharge,
9. difficult breathing
10. Bloody or wet litter
11. Increased mortality

- VIRAL DISEASES

FOWL POX

- Viral disease of domestic fowl
- development of nodular proliferative Skin lesions on the featherless parts of the body.
- fibrino necrotic and proliferative lesions in the mucous membranes

Family: Pox viridae

Genus: avipoxvirus

Double stranded DNA

CLINICAL SIGNS

- Appearance of nodular lesions
- combs
- wattles ○ eyelids
- other unfeathered areas of the body.

PREVENTION AND CONTROL

- Prophylactic vaccination
- Fowl pox vaccine at 4-6 weeks of age ➢ Second dose at 12-14 weeks of age.

145 Ranikhet Disease

RANIKHET DISEASE

- New castle disease
- Viral disease of domestic fowl is characterized by
- respiratory signs
- often associated with nervous and digestive disorders ➢ high mortality.

ETIOLOGY

- Paramyxoviridae
- Paromyxovirus-1

CLINICAL SIGNS **Opisthotonus**

1. Listlessness
2. Increased respiration
3. Weakness
4. Edema around the eyes
5. Torticolis
6. Paralysis of legs

Prevention and control

➢ Prophylactic vaccination

Lentogenic strain (F or B1)

- day old chicks
- intranasal ➢ intraocular route ➢ drinking water.

Mesogenic strain (R2B)

- 6-8 weeks of age ➢ intramuscular

- Subcutaneous route.

146 Bacterial Diseases

INFECTIOUS CORYZA

FOWL CORYZA

- Highly contagious
- acute disease of upper respiratory tract of chickens, ➢ turns into a chronic respiratory disease.

ETIOLOGY

- *Haemophilus paragallinarum*
- Small cocoid or gram negative rod
- Non motile
- Exhibits bipolar staining

CLINICAL SIGNS

1. Serous to mucoid nasal discharges with foul smelling
2. Facial edema
3. Conjunctivitis
4. Swollen wattles
5. Diarrhea
6. Reduced feed and water consumption.

Treatment and control

1. Gentamicin
2. Penicillin
3. streptomycin
4. delivered in feed or drinking water.
5. Proper Disinfection

147 Bacillary White Diarrhea

BACILLARY WHITE DIARRHEA

PULLORUM DISEASE

- Fatal septicemia of young chicks .
- Salmonella pullorum

CLINICAL SIGNS

1. Somnolecence
2. Weakness
3. Loss of appetite
4. Chalky white diarrhea
5. Stained greenish brown(sometimes) in and around vent

TREATMENT

1. Enrofloxacin
2. Parenteral injections
3. Oral liquids
4. Supportive therapy

148 Bumble Foot

BUMBLE FOOT

PODODERMATITIS

Injury to the lower surface of the foot and subsequent infection with *Staphylococcus bacteria*

Common causes of injury:

- Rough perches
- Splinters
- Wire floors
- Poor litter or bedding
- Quality

CLINICAL SIGNS

- Lameness
- Swelling of the foot pad
- Hard, pus-filled abscess on foot pad

TREATMENT

- Soak foot in warm water and Epsom salts.
- disinfect with alcohol.
- If skin is open, drain pus from abscess.
- Flush abscess cavity with hydrogen peroxide to cleanout pus and debris.
- Pack the cavity with antibiotic ointment .
- wrap the foot with gauze and elastic bandage.
- Repeat daily until foot heals.

PREVENTION AND CONTROL

- Provide good quality litter or bedding. ➢ Keep bedding clean, dry, and deep.

- Keep perches less than 18 inches from the floor to prevent foot damage due to impact from jumping.
- Remove potential sources of injury such as sharp objects and/or surfaces.

149 Deficiency Diseases

CURLED TOE PARALYSIS

- Deficiency of Riboflavin
- Poor growth
- Weakness
- Emaciation and diarrhea
- unable to walk as their toes are turned inwards
- Drooping of wings

TREATMENT

- Riboflavin @3.6 mg/kg of feed in chicks
- Riboflavin @ 1.8 mg/kg of feed in growers
- Riboflavin @ 2.2mg/kg of feed in layers

150 Cattle Farming Uses

Animal Science and Livestock Production

What is Animal Science?

• Refers to the total store of knowledge relative to the breeding, feeding, care and management of animals and the marketing and processing of animals and their products as gained through practical experience and research methods.

Animal Use as Food

- Meat – Beef, Pork, Lamb, Goat Poultry
- Milk – Cheese, Ice Cream, Yogurt
- Eggs – Pastries, Mayonnaise, Custards

151 Animal By-Products

Animal By-Products

- **Bones –** Button, glue, mineral supplement for livestock feed (Ca)
- **Fat –** Chemicals, salves, creams, dressings, lubricants, soaps, food
- **Glands –** Medicines, food additives
- **Collagen** – Glue, Gelatin
- Intestinal & Stomach tissue – lunch meats, surgical sutures, strings for musical and sports instruments
- **Fertilizer**

Animal Use as Work

- Cultivate land
- Transportation
- Control other animals (herding)
- Assist physically & Medically handicapped

  A. Blind

B. Epileptic & Diabetic

Other Animal Uses

Hides – Leather
Hair – Wool, mohair, fiber
Lab Animals – Mice, rats, guinea pigs etc.
Pets

152 Live sock Enterprises and Management

- **Numerous livestock enterprises**
  - Traditional
  - Exotic
  - Purebred/Crossbred
  - Recreational

Species

Cattle, Horses
Sheep, Goats, Swine
Poultry, Rabbits

- Different Space Requirements
- Different Nutrition and Management
- Many co-exist well

153 Dairy Farming

Basic Principles of Dairy Farming

Birth and Puberty

- A female calve (destined for dairying) weigh approx 40kg at birth.
- If reared correctly, she should reach puberty at 1 year, weighing 250kg.

Oestrous Cycle

The length of the oestrous cycle of a cow is 21 days and it lasts an average of 18 hours.
The gestation period of the dairy cow is 283 days (approx 9.5 months)

Lactation

A cow commences producing milk as soon as she has a calf.
If the cow is used to suckle calves, then she may continue to produce milk for up to 2 years.
If she becomes pregnant (in-calf) she will go dry two months before calving.
In commercial milk production, the aim is have the cow calve once a year, around the same time each year.
This means that she will me milking 10 months of the year or approx 305 days.

154 Lactataion Yields

Basic Principles of Dairy Farming

Lactation Yields

The milk yield of the cow depends on the breed.
Holstein: 5800kg per year
Jersey: 3400kg per year
Ayreshire: 4000kg per year

Friesian: 5000kg per year.
Dairy Shorthorn: 4000kg per year.
These vary significantly even amongst individual cows – A Friesian may vary from 2000kg a year to 12000kg of milk a year.
These yields have also increases over the last number of years due to better selection of breeds.

Basic Principles of Dairy Farming

- Lactation Yields also vary with a cows age:

Age	Lactation No	% Of Max Yield
2	1	75
3	2	85
4	3	90
5	4	95
6	5	100

- The yield of the average dairy cow decreases after the 5th Lactation.

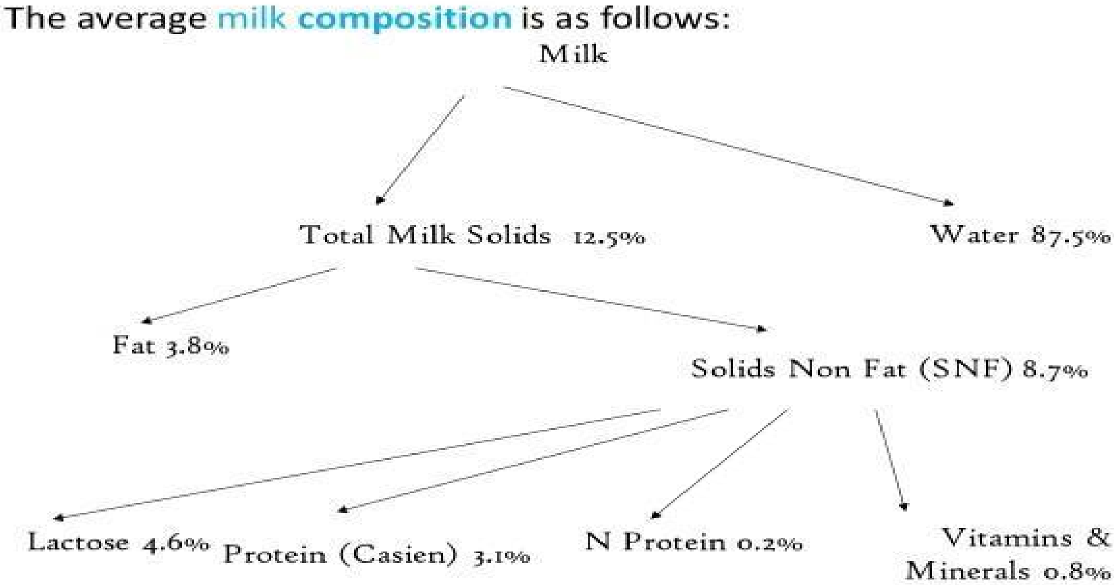
Frequency of Milking

Milking empties the udder of the cow, which stimulates milk-secreting alveoli to commence producing milk.
Frequently milked cows produce more milk than those milked irregularly.
Therefore a cow milked four times a day will produce more milk than a cow milked twice – it will work to demand.
BUT milking more than twice a day is uneconomical and leaves cows more prone to disease such as **mastitis.**
With milking twice daily, the ideal milking interval is 12 hours. This gives the cow less stress and will get the highest yields.
But this gives the farmer a very long working day and is uncommon. The most common intervals are 14/10 or 13/11 hour intervals.

155 Lactation

Basic Principles of Dairy Farming

- The average milk composition is as follows:



Basic Principles of Dairy Farming

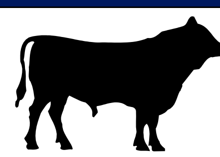
Milk used for bottling or drinking must by law contain 3.6% fat and 8.5% SNF.
Creameries buy milk in many different ways – sometimes at a flat rate per kg.
Sometimes, however, it may be by percentage butterfat or protein.
Milk composition varies also amongst different breeds.
The milk of the Jersey cow has the highest butterfat and SNF content of any cow.
Also the composition of milk varies during milking.
The milk at the start may only contain 1% fat, while the milk at the end ("The Stripping") may contain 10% fat.

Hygiene and Milk Quality

Dirty milk (containing dirt, bacteria or antibiotics) can cause serious problems when processing.
Dirty milk is caused by unhygienic milking machines or poor milk filters.
Antibiotics are found in milk as residues from treatments to cows for mastitis.
When milk is found to be not up to standard, it may be rejected by the creamery or bought at a lower price.

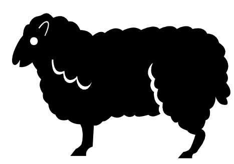
156 Beef Farming

Beef Farming



Great for the Part-time
Labor and facilities can be low cost
Land is required 1-5 acres per animal
Returns can be low and seasonal
Enterprises
– Freezer beef, feeders, purebred, contract heifers

Sheep Farming



- Low initial investment
- Low labor – expect when lambing
- Little investment
- Meat/Wool
- Not a huge market+

Rabbit Farming

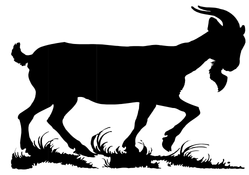
- Small acreage requirements

- Minimal cash outlay
- Small market – mostly pets and show

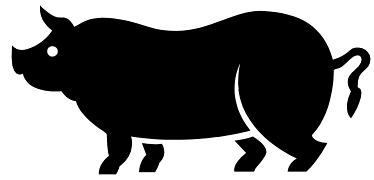
157 Goat Farming

Goat Farming

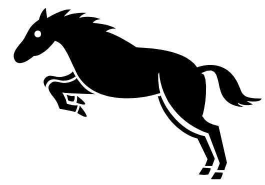
- Projects, Milk, Meat, Fiber
- Ethnic Populations
- Dairy – High labor
- Should explore markets **Swine**



Farming



- Low acreage – Higher maintenance
- More management than – sheep, cattle or goats
- More investment in housing, shelter and fencing
- Do not utilize forage



Horse Farming

- Facility and acreage requirements
- Higher acreage – higher maintenance
- Expense to purchase
- Enterprises – training, boarding, lessons, breeding

158 Livetsock Selection

Livestock Selection

➢ Profitability of any individual animal or of a herd or flock of animals is determined by

– Type or individuality based on the ability to produce high-quality products for a tough market

– Performance or efficiency of production which is the ability to utilize feed efficiently, in producing meat, milk, wool or power.

– **Bases of Selection**

- **Selection based on**

1. Type and individuality
2. Pedigree
3. Show-ring winnings
4. Production testing

- **Type or individuality**

➢ Selecting those animals that most closely approach an ideal or standard of perfection and culling out those that fall short.

Pedigree

- Used in most purebred operations
- Based on performance of ancestors

Show ring winnings

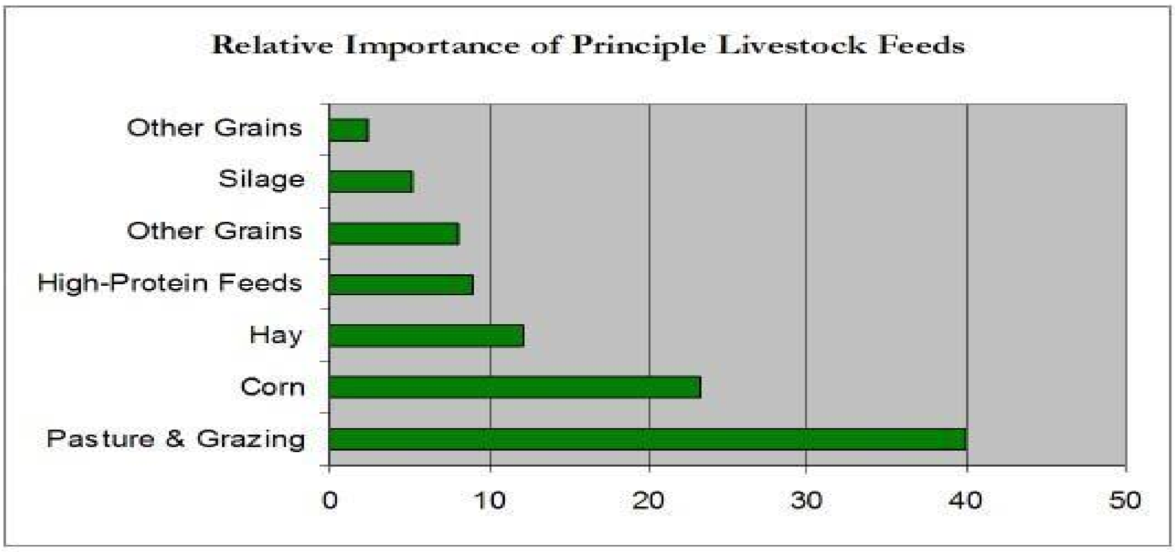
- Implies the animals that have placed well in one or more shows are superior.

Production

- Generally look at economics such as body type and feed utilization
- Performance testing, progeny testing

159 Feeding Livestock

Feeding Livestock



Feed Quality

- Quality of feed affects its value for animal nutrition.
- Quality factors include palatability and nutrient content.
- Palatability refers to how well the animal will accept feed.
- Improper harvesting or handling will reduce quality.
- If an animal does not find a feed palatable it will not eat enough, make good gains, grow properly or produce meat, milk or eggs.
- Feeds on produced on well fertilized soils will produce feed, especially roughages, that is of a higher quality.
- Vitamins, amino acid content and minerals will also be affected by soil type.

Digestion

- Monogastric (simple stomach)
  o Pig, Dog,
  Human
- Avain (poultry) – Gizard
  o Chicken, Turkey, Duck
- Polygastric (ruminants
  o Cow, Sheep, Goat
- Pseudo-ruminants (cecum) o
  Horse, Rabbits, Hamster

160 Feeding Goals and proper Animla Nutrition

Feeding Goals

- Maintenance
- Growth
- Finishing
- Reproduction
- Work
- Age

What is Proper Animal Nutrition?

The process by which animals eat and use food.

- **Proper animal Nutrition**

1. Increases feed efficiency
2. Increase Rate of Gain

A Nutrient is:

➢ A substance that is necessary for an organism to live and grow ➢ Nutrients make it possible for animals to carry out life processes. ➢ Nutrients are provided to animals through?

1. Feed Stuff

(Feed & Water)

161 Nutrient Needs of Animals

Nutrient Needs of Animals

6 Essential Nutrients

1. Water
2. Carbohydrates
3. Fats
4. Proteins
5. Minerals
6. Vitamins

Nutritive Needs

- **Energy** o Carbohydrates, Fats
- **Protein**
- **Mineral**

o **Macro**

✦ Salt, Calcium, Phosphorous, Magnesium, Potassium, Sulfur

o **Micro**

✦ Chromium, Cobalt, Copper, Fluorine, Iodine, Iron, Manganese etc.

- **Vitamin**

- **Most Important** o WATER
- **Roughages (Forages)**

Bulk feeds that are low in weight per unit of volume, >18% curde fiber, low energy
Hay
Pasture
Silage
Crop Residues

162 Why Roughages and Concentrates

Why are some animals fed roughages and others concentrates?

Types of digestive systems

1. Non- Ruminants

1. Mono-gastric – has one stomach
2. Avian – has a crop & gizzard
3. Pseudo–Ruminants

Ruminants

- Have 4 compartments or stomachs Ex Sheep, Cattle

Digestion -the mechanical and chemical breakdown of feed into a form which can be absorbed into the blood.

Ration

- The total amount of feed an animal has in a 24 hr period

- **Balanced Ration**

- Contains all the nutrients that the animal needs in the *correct proportions* .

Water

- Necessary for an animal to live
- Animal can liver longer without food than water
- Water makes up 75% of the weight of an animals body.

Basic functions of water

1. Regulate body functions
2. Promoting biochemical process

163 Nutrient Composition of Feeds

Carbohydrates

They provide Energy

- Should make up 75% of an animals diet

Types of Carbohydrates

1. Sugars
2. Starches
3. Fiber

Sources of Carbohydrates

Cereal Grains

1. Corn
2. Wheat
3. Barley
4. Oats
5. Hay
6. Rye
7.

Lipids

Fat is a good source of energy
Fats have 2.25 times more energy than carbohydrates

Protein

- Needed for

Grow new tissue and repair old tissue.

- Highest amount found it muscles

Proteins contain

A. Amino Acids

Building blocks of proteins

B. 23 Amino Acids (10 are essential)

164 Sources of Proteins

Sources of Protein

6 common sources

1. Soybean Meal
2. Cotton Seed Meal
3. Fish Meal
4. Tankage
5. Skim Milk
6. Alfalfa

Protein is the most common

Nutrient Deficiency

Minerals

Macro-minerals-Calcium, phosphorous
Micro-minerals
Essential for

1.Skeletal growth

2. Body systems to function properly

Common sources

Alfalfa Hay, Cereal Gains, Bone Meal, Molasses, Salt
Vitamins Functions

1. Help regulate body functions
2. Keep body health
3. Develop resistance to Disease

Types of Vitamins

1. Fat Soluble

- Vitamin A, D, E, K

2. Water Soluble

- Vitamin C & B

165 Feedstuffs used in Livetsock Diets

Feedstuffs Used in Livestock Diets

- **Feed Classes**

✓ 8 classes grouped by origin and like

characteristics ✓ Dry Forages & Roughages

- All feeds that are cut and cured
- All feeds w/ CF>18%
- Usually low in NE
- Carbonaceous Roughages

– Generally low in protein

– Straw

– Stalks

– Weathered grass

Proteinaceous Roughages

A. Legume hays
B. Some grass hays
C. Legume/grass mixtures

– **Pasture, Range Plants, & Fresh Fed Forages**

- ✦ Pasture grass
- ✦ Anything that is not allowed to ferment before feeding

Silages

Ensiled forages

Carbonaceous

- – Corn silage
- – Grass silage

Proteinaceous

- – Alfalfa silage
- – Clover silage

Energy Feeds

<20% CP, <18% CF

May be ensiled

Carbonaceous Concentrates

- ▪ All cereal grains & sorghums
- ▪ Byproduct feeds

- – Bran
- – Middlings
- – Cobs
- – Molasses

166 Protein and Vitamin Supplements

Feedstuffs Used in Livestock Diets

Protein Supplements

- **>20% CP**
- **Vegetable Origin**

Soybean Meal

Cottonseed Meal

Corn Gluten Meal

Brewer's Dried Grains

➢ **Animal Origin**

- – Animal tissues

Meat & Bone Meal

Blood Meal

Most are banned/restricted from livestock

diets – Fish Products

» Fish Meal

- – Milk Products

» Whey protein

- – Feather Meal

Mineral Supplements

- Calcium Carbonate

- Limestone
- Others

– **Vitamin Supplements**

✓ Fish Oil

✓ Others .

– **Additives**

- Propylene Glycol
- Titanium Dioxide (coloring agent)

167 International Feed Names

Feedstuffs Used in Livestock Diets

- **International Feed Names**

– Used to create a "common language" among the feed industry – 6 Facets are included in the naming process

- Original Material
- Parts of Material used as feed (may be affected by processing)

– Bran

- Processing and Treatments
  - – Dry-rendered
  - – Hydrolized
  - – Extracted

Stage of Maturity (plants & animals)

Cutting

Grade

- **Characteristics of Concentrate Feedstuffs .**

– Carbonaceous Concentrates

- <20% CP, <18% fiber
- Generally, high energy feeds

168 General Nutritive Characteristics

Feedstuffs Used in Livestock Diets

- **General Nutritive Characteristics**

Examples

High in energy

Low in fiber

Low in protein

Low protein quality and high variability ✓ Minerals

» Low Ca

» Med P

– **Corn**

» 80% TDN

» 8-9% CP

» Med P, low Ca

» Recent technologies – high lysine corn, waxy corn, high-oil corn

» Alternative feeding forms

– **Oats**

» 65-70% TDN

» 12% CP

» Very palatable, more expensive to feed » Where is it most commonly used? –

Dried Beet Pulp

» 65-70% TDN

» 8-10% CP

» Byproduct of sugar beet processing

» ~18% CF

– **Molasses**

» 55-75% TDN

» 3-7% CP (mostly NPN)

» Byproduct from same industry as above

» Usually fed in what form?

» What are the advantages to feeding?

– **Animal Fat**

» Byproduct of rendering »

Treated w/ antioxidant to prevent

rancidity » Why do we feed it?

» 5% max in ruminant diets, 10% in non-ruminants

– **Dried Bakery Product**

» What might this include?

» Similar to corn in energy, higher in fat, and salt?

169 Proteinaceous Characteristics

Feedstuffs Used in Livestock Diets

– Proteinaceous Concentrates

- **Quality**
  - Kinds, amounts, ratios of amino acids – Essential Amino Acids
    - » Must be supplemented
    - » PVT TIM HALL
    - » Phenylalanine, Valine, Threonine, Tryptophan, Isoleucine, Methionine, Histidine, Arginine, Leucine, Lysine
  - NPN may be used as a protein source (only in ruminants)
- **Examples**
  - **Urea**
    - » 281% CP
    - » Use only in very small amounts
    - » Very effective for feeding rumen bacteria
  - **Soybean Meal**
    - » Most commonly used plant protein supplement
    - » 44% or 48% CP available (depends on how much its diluted w/ soyhulls)
    - » 71-80% TDN
    - » Very low in fiber
    - » Very broad amino acid profile

What other forms are used?

- **Animal/Marine protein supplements**
  - Derived from meat/poultry packing/rendering, or from the marine industry, or surplus milk
  - Used only to improve the CP of basal feeds and improve amino acid profile
  - Balances protein sources (plant vs. animal) – Blood Meal
    - » 80+% CP
    - » Highly unpalatable
    - » High rumen undegradable protein for ruminants
  - **Fish Meal**
    - » 35-70% CP
    - » Excellent protein quality and good source of B vits
  - **Whey protein**
    - » 11% CP, 61% lactose
    - » Used in milk replacers or pig starter diets
    - » Highly palatable, excellent source of protein

- **Animal Waste**
  - » Nutrient content varies
  - » Used primarily in ruminant diets
  - » Usually high in NPN
  - » Has proven to be fairly effective, in certain diets

170 Feed Grain By-Products

Feedstuffs Used in Livestock Diets

- **Feed Grain Byproducts**
  - **Corn byproducts**

- **Corn Gluten Meal**
  - Dried residue remaining after removal of most of the starch, germ, and bran
  - 46-60% CP

- **Corn Gluten Feed**
  - Dried residue remaining after removal of most of the starch, germ, gluten, but contains bran
  - 20-25% CP

- **Distiller's Dried Grains**
  - Byproduct of the alcohol brewing industry
  - 25-27% CP, 9-11% CF

- **Distiller's Wet Grains**
  - Byproduct of ethanol production
  - Use usually restricted to geographical area close to the distiller
  - Will ferment if not used quickly
  - **Wheat byproducts**

- **Wheat middlings**
  - Fine particles of bran, germ, shorts, tailings
  - 16-18% CP
  - More commonly fed in swine diets, unpalatability makes its use limited in ruminants
  - **Soybean Hulls**
    - 12% CP, 78% TDN
    - Very good for replacing other high fiber feeds, without losing too much fiber
    - Very palatable

171 Characterisitics of Roughage Feedstuffs

Feedstuffs Used in Livestock Diets

- **Characteristics of Roughage Feedstuffs**

Generally low in energy
Higher in fiber
Higher mineral content
Extremely palatable to ruminants
Nutritive value can be extremely variable

Limited inclusion in beef finishing diets, excluded from swine rations
Must be present in dairy rations to maintain health rumen and milk fat content
Proteinaceous Roughages

- **Alfalfa**

Hearty, w/ extensive root system
May be pastured, baled, mealed, or ensiled
15-25% CP, >50% TDN
High in Ca, fair P ✓ 2-5 cuttings/yr.

– **Carbonaceous Roughages**

<10% CP
Nonlegume forages, low quality roughages
Ex. Switchgrass

– **Cool-season Perennial Grass Forages**

- Particularly productive during spring – early summer, and fall
- Orchardgrass

Grows in clumps
May grow to 2-4'
Grows early in the spring
Rapid developer
Highly palatable
8-18% CP
Good partner w/ alfalfa for hay or pasture grass

Timothy

- 8-12% CP
- Not great for pasturing alone, but good in a mixture
- Cut no later than early bloom for maximum nutritive value

172 Small Grains

Feedstuffs Used in Livestock Diets

- **Small Grains** (wheat, oats, etc.)

Generally same seeding rate as for grain, may increase if going to cut for silage
Effective in the pasture
Harvesting for silage should occur around boot stage
10-22% CP, 62-72% TDN
If harvested early, can mimic corn silage
Be cautious of low Mg levels, may see grass tetany

- **Corn Silage**
  - Most popular silage
  - Extremely palatable
  - Moderate to high energy, low in protein
  - May not be most efficient in a finishing diet
  - Many varieties available
  - High grain content is desirable
- **Corn Stover (Stalklage)**
  - Harvested at or just after grain harvest
  - Ensiled

– Should be fairly fine-chopped to ensure packing

– Good for wintering cattle, somewhat high in energy

- **Methods of Utilizing Forages**
  - **Pasture**
  - Major feed for dairy, beef, and horses
  - For certain situations, the most profitable option
  - **Essential Pasture Qualities**

– Durable both for longevity, and to stand up against the foot traffic

– Growth start early in spring continue late through fall

– Plant variety

Greater yields

Better nutritional value

More complete nutritional balance

– Monitor quality/growth

Use paddocks

Reduces under or overgrazing

Increases carrying capacity of the pasture

Costs more to maintain

– Manage w/ mowing, fertilization, or herbicides (if necessary)

– Avoid grazing in wet conditions – Proper

stocking rate

- Varies w/ pasture crops
- Some 1-2 acres/cow, others 10-20 acres/cow

173 Special Concerns

Feedstuffs Used in Livestock Diets

- **Special concerns**

– **Poisonous plants**

Highest risk w/ poorly maintained pastures or poor cattle management

– **Bloat**

Risk on legume pastures due to amount of lush plant material

Can reduce risk by adding other grasses into the alfalfa

– **Nitrate Poisoning**

Accumulation after drought, or cultivated forages

Seldom occurs in other types of pastures

Causes abortion or death

- **Green Chop**
- What is it? Is it still being used?
- **Advantages**

Maximizes yield/ac.
Less nutrient loss
Less fencing
May reduce bloat

- **Disadvantages**

No uniform quality
Weather
Cannot be fed year round

174 Hays and Common Losses in Hay Making

Feedstuffs Used in Livestock Diets

– **Hays**

- **Should be 15% moisture or less** – Why?

– What are the risks?

- **Keys to haymaking**

– Know when you want to mow

Stage of maturity directly correlated to nutritional value ✓ Nutritional value decreases quickly ✓
What kind of yield to you want?
How does it fit into your feeding program?

– **Allow for sufficient curing**

Conditioning can reduce curing time by 50%
Maximum moisture 18-22%

– **Raking**

Should be done prior to the end of curing to minimize leaf shatter losses
May be necessary to facilitate drying

– **Baling**

Squares – should be stored and stacked ASAP out of the weather
Round Bales – will survive outside storage if stacked in a pyramid shape (sheds water), grass hays last longer than legumes

• **Common Losses in Haymaking**

– **Leaf Shatter**

Leaves have 2-3x more protein than stems
Higher in most other nutrients, except fiber
~20% loss is normal, losses can be as much as 40-75%

– **Heat Damage**

>25-30% moisture may lead to mold and excess heating
During its sweating phase, hay should be not warmer than 84°, above 120° nutrient loss occurs
Spontaneous combustion risk is high is hay reaches 160°

– **Fermentation losses**

Should account for only 5-7% loss in total DM

Converts sugars and starches to carbon dioxide and water
Reduced energy content –

Bleaching

Loss of color ✓ Some vitamin losses

- **Losses under normal conditions**

20-30% DM
27-30% CP
25-28% TDN

175 Additives in Hay Making

Feedstuffs Used in Livestock Diets

- **Additives in Haymaking** –

Preservatives

Propionic acid, acetic acid, etc.
Allow storage at higher moisture
Should be applied at the bale chamber
~20#/t

– **Drying agents** – **Anhydrous ammonia**

Treatment for low quality hay to improve protein and energy content
Must seal and gas for 20-30 min
Can increase CP by 3-6%
Difficult to handle

- **Silages**
- Goes through acid fermentation under anaerobic conditions
- **Types of silos** – Upright

» Semiairtight

» Airtight

– **Horizontal**

Trench/pit
Bunker
Piles
Temporary
Bags

- **Silage activity in the silo**

– Plant cells continue to respire

Consume oxygen
Produce carbon dioxide
Mold inhibited due to lack of oxygen

Temperature increases

» Should increase to 80-100°

» Temperatures >100-120° result in carmelization

Fermentation

Acetic acid – first acid, reduces pH from 6-4.2, in the first 4 days
Lactic Acid – begins on d 3 and lasts 2 wks., most abundant acid, stops around pH 4.0
Butyric Acid – forms if an insufficient amount of lactic acid is present, or a result of excess moisture—leads to a putrid smell
Propionic Acid – very little present

– Lowered pH prevents bacterial growth and further fermentation as long as it is w/out oxygen

Takes ~21d, but many say 2-3 months is best
Corn silage can keep for several years, if stored well

176 Crops used for Silage

Crops used for Silage

Corn
Legumes

» Haylage is most common, very difficult to make well

Using silages

– **Advantages**

More feed/ac. Land
High quality feed
Harvest is mechanized, range of harvest dates are wider?

– **Disadvantages**

Once you have it, you got to feed it

May slow ADG ✓ Considerable cost ✓ Water is a factor?

Making good Silage

– 50-70% moisture range target

Too wet – sour smell, nutrient loss by seepage
Too dry – improper fermentation, difficult to pack
May add water during ensiling process

– **Proper stage of maturity**

When should we chop corn?
When should we chop alfalfa?

– **Proper packing**

Cut at proper length to ensure packability, but maintain good fiber
Distribute evenly in the silo
Uprights pack themselves
As much weight and time as possible on a bunker

– **Proper drainage** » Slope » Base of the silo

- **Losses from Ensiling**
  - Field losses
  - Gas/fermentation losses – Surface spoilage

    » Can be as much as 25% on a bunker silo

  - Seepage
- **Silage Additives**

Nutrient Additives

» Urea/ammonia – increase CP

concentration

– Preservatives

» Acids, Bacteria, Enzymes, cultures, etc. – all to promote proper fermentation

177 Ensiling vs Hay Making

General idea is do add/subtract DM, aid in fermentation, or increase nutrient content

Ensiling vs. Hay making

– Advantages

Wider harvest windows

More nutrients are accessible/maximized ✓ Weeds are prevented more effectively ✓ More yield/ac.

– Disadvantages

More and more expensive machinery?

More variability in quality

Fermentation problems may destroy good feed

Characteristics on Common Nutrient Additive Feedstuffs – Macro-minerals

• What are the major macro-mineral ingredients that will be used?

– Trace Minerals

- Cu – copper sulfate
- Zn – zinc oxide
- Se – sodium selenite
- Chelates may increase the amount absorbed in the SI

– Vitamins

• Fat soluble .

A

Found in all green plants

Usually don't need to supplement much

– D

- Can be synthesized by sunlight on the skin
- Fed through fish oil

– E

- Found in germ of grains
  - Green plants

– K

» Also found in green plants

May all be generated and fed synthetically

» E is the most supplemented and has the most health implications attached to it (especially in cattle)

Water soluble – Riboflavin

» Milk products, yeast, hay, etc.

– Niacin

» Some present in all feedstuffs

» Much is not available for digestion (especially swine)

– Choline

» Present in most feeds of animal origin

– Most all are synthetically made also

– Supplemented at extremely low rates

– Very expensive

178 Methods of Feed Stuff Preparation

Methods of Feedstuff Preparation

Why process?

- Increase ease of handling
- Increase efficiency of utilization
  - Palatability
  - Digestibility
    - » What does this have to do w/ it?
- Alter the density of the feed/diet
- Improve feed efficiency by 5-15%
  - May also observe improvements in gain

Processing Methods

• Grinding – Hammer Mill

- Can grind hay, ear corn, grains, etc.
- Well suited for fine-grinding
- Not effective for coarse-grinding

– Burr Mill

- 2 plates w/ unmeshed burrs, one moving, one stationary
- Relatively uniform grind
- Not designed for roughage materials
- Higher maintenance cost

– Degrees of fineness

- What are the advantages/disadvantages to a fine grind?
- Are there health risks?
- Finely ground – pass through 1/8-3/16” screen <700 microns
- Medium ground – pass through ¼-3/8” screen 8001000 microns
- Coarse ground – pass through ½” or larger screen >1300 microns

Swine

- Medium to fine grind
- Starter diets ~650-750 microns
- Breeding herd maybe 750-900 microns

Beef

- Grinding fineness depends on feeding program
- More forage = finer grind

– Dairy

- Coarsely ground ~1200 microns
- What will happen if it is ground finer?

Dry Rolling/Cracking

- Rolling if the rollers are smooth, crimping if rollers are corrugated

- Can produce similar feed to coarse grinding

179 Pelleting

Pelleting

- Combination of heat, moisture, and pressure forcing feed through a dye ➢ Reduces dust
- Reduces losses and fines
- Reduces sorting
- Increases digestibility
- Higher cost
- Pellet quality may be variable

Swine diets

➢ Improved performance due to increased consumption ➢ Higher rates of gain and feed efficiencies

Dairy diets

➢ Only recommended for concentrate portions of the diet ➢ Highly effective at improving digestibility of nutrients

Beef diets

- Can improve rates of gain, feed efficiency, etc.
- Not recommended as a large component of a high concentrate diets
- Useful for creep feeding

Horse diets

- Useful for creep feeding
- May pellet the entire diet

Pellet varieties

- Granules
- Crumbles
- Pellets

➢ Cubes

Heat Treatments and Grain Processing –

Steam rolling

1-8 min of steam, then roll
Slight increase in moisture
Not significant advantage in digestibility

– Steam Flaking

Steam 15-30 min, then roll
Thin flakes w/ 16-20% moisture
Gelatinizes starch increasing digestibility
Common in calf starters, and horse feeds

– Roasting

Heat to 300°F
Partial starch gelatinization
Caramelized appearance, and sweet smell
Common for soybeans

180 Extrusion Pelleting

Extrusion Pelleting

Heat and pressure forcing feed through a small spiral hole
Produces a flaked feed
Similar to pelleting

- **High Moisture Grains**

Harvested at 20-35% moisture (usually corn)
Coarsely ground and stored in a silo
Does goes through fermentation
Highly palatable
Can improve feed efficiency up to 8%

Feed Mixing Methods

– Must have accurate scales

Types of mixers

- Vertical
  - Cylindrical with vertical auger(s)
  - Cannot handle much molasses
- Horizontal
  - Rolling mixer w/ an auger and paddles inside
  - Handles higher molasses feeds better
  - Sequencing of feeds is important
    - Why?

Feed Storage

- Moisture level is key
  - What problems can be encountered?
- Must be void of insect problems and rodents

181 Factors affecting Feed Intake

Factors Affecting Feed Intake

Water Availability
Palatability
Dietary energy level

- Animals will generally eat to their caloric intake needs

Age and Size of animal
Temperature
Health

Expected Intake guidelines (% of BW)

Swine 4-5%
Cattle 2-3%
Horses 1.5-2.5%
Dogs 2-3%

182 What is Forage

What is forage?

- Vegetable matter in a fresh, dried, or ensiled state.

What can you do with forage?

- graze it

- machine harvest and store it

- it's animal feed

- Forage allows you to raise an agricultural crop on land where other crops cannot be produced.

Grasses

- Timothy
- Orchard Grass
- Kentucky Blue
- Fescue (endophyte free)

Legumes

- White Clover
- Alfalfa
- Ladino Clover
- Red Clover

183 Miing Forage Species

Mixing Forage Species

Consider the traits of each species.

Aggressive vs Passive

Maturity dates: early vs late

Other traits that can be utilized:

○ -N fixation	-heat tolerance
○ -fast germination	-wet tolerance
o sod(turf/grass) formation	- palatability
o -summer dormancy	- hay or grazing

o -life span -fertility needs

Forage Establishment

Plan at least 1-year ahead.
Planning includes soil testing.

Don't be cheap with fertilizer, limestone, and seed. ✓ Do proper field preparation.

Select the right forage species and best available varieties of forage. ✓ Need good seed/soil contact.

Don't bury seed too deep.

Harvesting Forages

Making quality forage is an art.

need to know your forage species
keep on top of the weather
have flexible production options
have timely access to equipment

have equipment in good working order ✓ have healthy forage and few weeds ✓ have some luck!

184 Forage Storage Losses

Forage Storage Losses

Uncovered bales stored outside
Hay baled too wet
Bales stacked in contact with the ground
Holes in plastic bags and tubes, or leaky silos
Poorly packed and uncovered trenches

Evaluating Hay Quality

Leafiness
Color
Foreign Material
Odor and Condition
ACTIVITY

185 Why Manage Pastures 1

Why Manage Pastures?

- **Pastures are profitable**

grazed forage is good, cheap feed
pastures are inexpensive to develop and maintain
animals do the harvesting, therefore there is a reduction in the need for machine harvesting and forage handling
while on pasture, animals spread manure in the field, reducing hauling

- **Protects surface and groundwater from nutrient pollution**

acts as a filler to screen out and traps soil particles which contain nutrients such as N and P

the nutrients are then utilized by the pasture plants once these nutrients have moved into the root zone of the soil

- **Reduces soil erosion**

the top growth of pasture plants lessons the impact of rain drops on the soil surface and also slows down the surface runoff of water across the field
pasture plant root systems bind the soil together, thereby holding it in place
most pastures keep the soil covered year around, unlike annual crops

- **Improves forage yield and quality**

plants that are maintained at the optimum fertility level and are not stressed by pests or by poor grazing management will be more productive

healthy, productive plants will provide a quality product

healthy plants will have a higher nutritional value

186 Why Manage Pastures 2

Why Manage Pastures?

- **Reduces weeds and improves esthetics**

weeds are opportunistic; they will move rapidly into an open area or an area occupied by a weak plant

weeds cannot gain a foothold in a field with vigorously growing plants

a clean, weed free pasture reflects well on your farm manage and how people passing by view your farm

Maintaining Pastures

1. Rotate
2. Clip
3. Irrigate
4. Drag Manure

Grazing Management

- Protecting pasture plant root reserves and maintaining plants in a vegetative state are keys to a good pasture.
- Overgrazing reduces root reserves which shrinks the root system and leads to fewer leaves being produced; plants also take longer to recover from grazing.
- Under grazing reduces quality and yield as over-mature plants become less vigorous and more fibrous.

Forage Re-Growth

- Slow to recover at first
- Rapid growth after recovery
- Slow after rapid growth period

187 How Grazing Affects Root Growth

How Grazing Affects Root Growth

% Leaf Vol. Removed	% Root Growth Stoppage
10%	0%
20%	0%
30%	0%
40%	0%
50%	2-4%
60%	50%
70%	78%
80%	80%
90%	100%

All root growth stops for 12 days with 80% removal & 18 days with 90% removal. When 60 % is removed, only half of the roots stop growing.

A Good Grazing Rule of Thumb

Take half ----------------------------Leave half

• In the long run, the animals will have more forage to graze.

Why Timely Mowing?

Mowing prevents plants from becoming over mature.
Vegetative plants are more palatable and more nutritious.
Mowing helps to control weeds.
Flash grazing can work in place of mowing to help reduce excess forage in paddocks.
Harvesting excess forage for hay is a good way to fully utilize forage resources.

188 Why Control Weeds

Why Control Weeds?

- Some weeds have been declared illegal noxious weeds by the State.
- Weeds look bad, they reflect poorly on your management.

Weeds will:

- Reduce the stand of desirable plants.
- Reduce overall quality and yield.
- Reduce overall animal yield.
- Some are poisonous, or can affect the animal product.
- Seeds are spread through manure.

Weed Management

- Cultural Control
  - mowing
  - grazing
  - over seeding
  - improved fertility

Chemical Weed Control Grazing Restrictions

- Ally…………………..none
- 2,4-D…………………milk cows, 7 days+
- Crossbow……………milk cows, 14 days+
- Banvel……………….milk cows, 7 days+
- Roundup……………livestock, 8 weeks
- Spike…………………none
- Stinger……………….none

189 Planning A Pasture System

Planning A Pasture System Sources of Info and Help

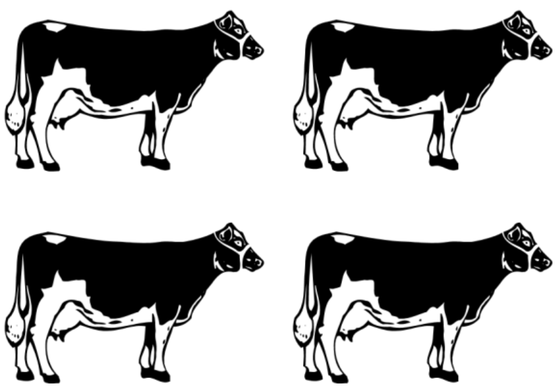
- **Resources**
  - soil survey map
  - soil capability assessment
  - aerial farm map
  - walking the farm
- **Assistance**

Cooperative Extension ✓
N.R.C.S ✓ F.S.A.
Farming Supply Companies

Basic Types of Pastures

- Continuous
    - animals are allowed to graze in the pasture for extended periods of time
    - animals often do well in this system since they are allowed to choose the plants they eat
    - plants are often overgrazed and under-grazed in this system

Continuous Grazing



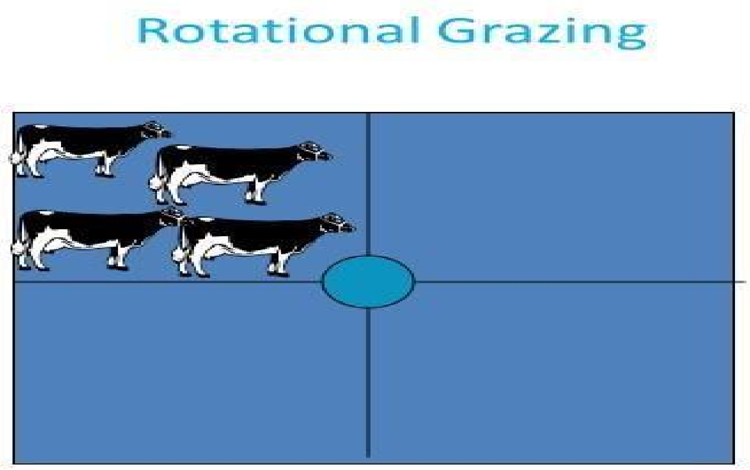
190 Basic Types of Pastures 1

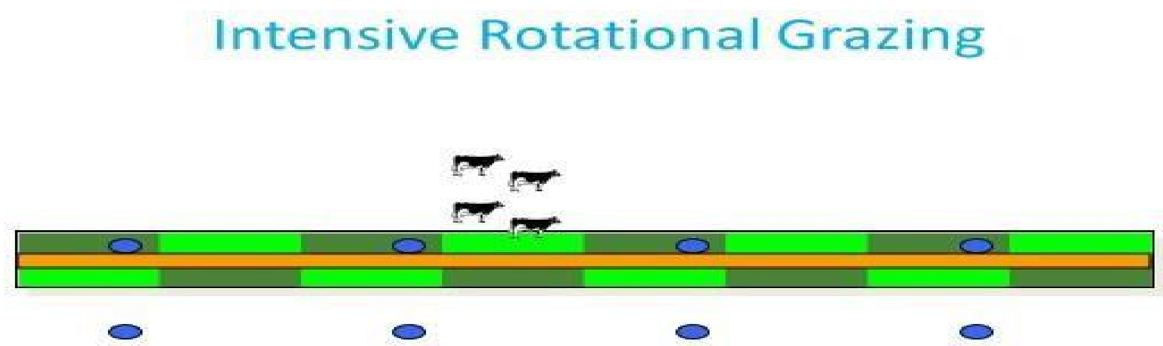
Basic Types of Pastures

- **Rotational**
    - animals are allowed to graze for only a limited period of time and animals are moved when existing forage has been removed
    - intensive rotational grazing systems subdivide pastures into paddocks and use high stocking rates where animals are forced to eat all forages
        - ➢ this system is most efficient
- **Deferred Grazing**

  – forage is allowed to accumulate in a pasture for grazing at a later date

• stockpiled tall fescue is an example



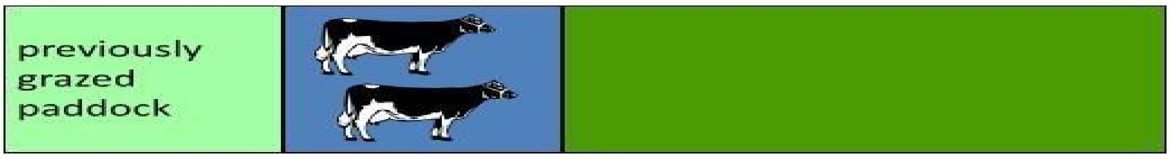


191 Basic Types of Pastures 2

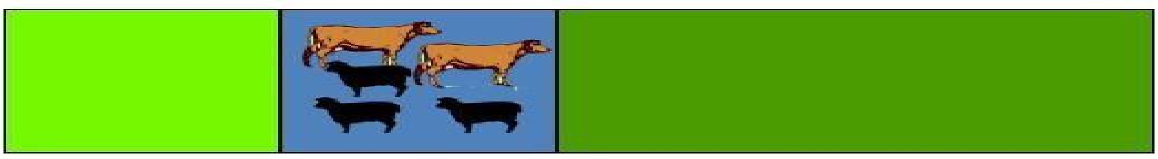
Basic Types of Pastures

- **Strip Grazing**
  - high stocking rate of animals are put into a pasture for a limited period
  - usually involves a specially planted crop typically an annual species i.e. rape, turnips, or summer grasses

Strip Grazing



Co-grazing



Rotating Pastures

- **Benefits**

Feeding less grain and hay
Reduce pest populations
Slow soil erosion
Allow daily exercise

BE OBSERVANT and watch your pastures

Setting Up A Pasture System Recommendations

Develop a 5 year farm/business plan
You need to plan ahead

– plan for when fields need to be renovated

Use existing resources whenever possible (fences, water, forage crops)
Establish crops according to your plan
Existing pastures can be renovated later if needed now for grazing

192 Pasture System Recommendations

Setting Up A Pasture System Recommendations

- Put your money into good perimeter fence.
  - this will help to keep predators out and your animals in.
- Map out farm, give each field own identity
- Soil test fields individually
  - each has its own personality, so treat it accordingly
- Develop a practical watering system
  - common problem for many
  - there are many factors to consider (costs, environmental, system)

Create a sacrificial area

- this will protect your pastures
- Estimate the carrying capacity of your pastures
  - impacts on the number of animals and paddocks (rotational)
- Calculate number of paddocks(enclosures) needed and days/paddock (rotational)
- Temporary fence works well to form paddocks

Sacrifice Area

This is a part of your pasture system that, just as it sounds, is permitted to become trashed.

What is important here is that the trashing is confined to one small area where the mess can be controlled.

Animals are kept in here during periods (i.e. wet) when it is not fit to put animals in the pasture.

193 Paddocks and Fencing

Paddocks

- Sacrifice area
- Turn out lots
- In a rotational grazing system pastures are divided up into smaller units within the pasture
  o these smaller units are called paddocks.
- In some smaller operations, permanent fencing is used to divide up the pasture.
- Temporary electric fence is a low cost, effective method of creating paddocks.

Fencing

- **Considerations**
  a) Safety
  b) Efficiency
  c) Cost
  d) Aesthetics

Fence height should be a minimum of 5 feet.

Fencing Materials

Wood Fencing

a) Different types (3 rail, spilt rail)

b) Low Maintenance

c) Expensive

d) 20-25 years life expectancy

Other

– PVC
– Plastic grid/mesh
– Electric Tape

Wire Fencing

Different Types (board and wire, high tensile, electric, V-mesh)

Less expensive

Maintenance is low to medium
Extended life expectancy

194 Facility Requirements

Facility Requirements

- **Things to think about**
  a) Water
  b) Air/Ventilation
  c) Space Requirements
  d) Shelter

Animal behavior

Animal Behavior

- **Causes**
  - **Genetic**
  - **Simple learning (training or experience)**
    a) Habituation
    b) Conditioning
    c) Reasoning, Insight
    d) Imprinting, Socialization
  - Complex learning (intelligence)

196 Pests and Their Management

Pest Management

Pest Control Is An Everlasting Problem

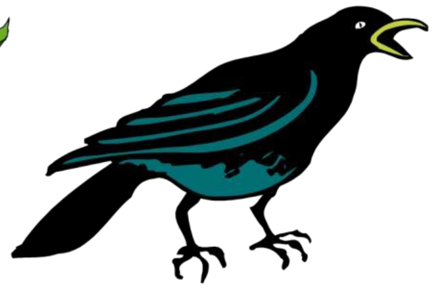
How does an organism become labeled as a pest species?
Pest control: winning the battles but losing the war.
Designing better mouse traps.

What is a Pest?

- **Technically,** any organism (bacteria, fungi, plant, animal) that has a negative effect on **human health** or economics (food).
- Realistically, any organism we don't want around (factors in convenience and esthetics).
- So generally speaking any organism that is detrimental to humans
  - destroys crops & structures
  - poses threats to human health and livestock
  - reduces aesthetic and recreational value
- **Pests** include insects, mites, plant pathogens, weeds, mollusks, fish, birds, and mammals

What is a PEST? A **pest** is any organism that is unwanted by humans. Pests may be unwanted due to their destructive nature, the health concerns they pose, or because they're plain annoying. Insects are not the only kind of pest. Mites, plant pathogens, weeds, mollusks, fish, birds, and even some mammals can be pests. They can be found in waterways, agriculture, landscapes, roadsides, natural areas, stored food, schools, hospitals and even swimming pools.





197 History Lesson

History Lesson: Bubonic Plague

14th Century Europe: mysterious scourge kills millions
Centuries later it was found that rat fleas became infected with disease-causing bacteria
Fleas sought other warm-blooded hosts (humans) when rat numbers declined
Plague is currently managed monitoring for plague and reducing the number of rodenthosts for fleas

Do you remember anything from your history lessons about Black Plague in Europe? During the 14th Century there were Plague outbreaks, millions of people died, and at the time it wasn't understood why. Centuries later, it was discovered that Plague was a bacterial disease and it was spread by fleas found in rodent populations. Besides biting rats, infected fleas would bite humans and other mammals. Bubonic plague is still present in some rodent populations today, even here in the United States. But with rodent management and plague monitoring, only a few people a year are infected with plague.

History Lesson: Potato Famine

Late blight, a fungal disease, decimated Ireland's potato crops ✓ Thousands starved; over a million migrated to U.S.
Today, late blight is still a major problem, but is managed by:

- resistant cultivars
- proper sanitation
- fungicide applications

Plant diseases have been important in our history, too. Late blight of potato is a fungal disease that was responsible for the Great Potato Famine in Ireland during the 19th century. Thousands of Irish people starved and more than a million migrated to the United States. The late blight fungus continues to be a major problem of potatoes around the world, but is now managed through the use of resistant cultivars, proper sanitation practices, and fungicides.

History Lesson: Pest Control

- **Primitive:** pulling weeds, clubbing rats, plucking insects from foliage
- ➢ Sulfur burning for mites/insects: 2500 B.C.

➢ Lead arsenate in orchards - 1892

- Lime and copper sulfate – Bordeaux mixture
- Early pesticides – plant extracts or inorganics
- World War II: **DDT** and low cost synthetic chemistry

Our ancestors controlled pests usually using brute force and manual labor. Thousands of years ago, chemicals that affected pests were discovered through trial and error. When sulfur was burned, it was found to affect insects and mites. Later several other inorganic materials, like lead and arsenate, were used as pesticides. Toxic plant extracts such as nicotine from tobacco were also used. Modern chemistry was used to develop pesticides during World War II. At the time, DDT was hailed as the insecticide to solve all insect problems. Countless other synthetic pesticides were produced. During this time, the modern chemical industry was launched. At relatively low costs, pesticides became a successful, primary means of pest control.

198 Concerns with Pesticide Dependence

Concerns with Pesticide Dependence

➢ Pest resistance

➢ **Environmental persistence**

- **Bioaccumulation**: when a chemical accumulates in animal fat (historical fact)
- **Bio-magnification:** when an organism accumulates residues at higher concentrations than the organisms they consume

However, during the 1970's it became obvious that relying completely on pesticides for pest management could have some negative impacts.

It was noticed that when certain pesticides were used repeatedly, some pests were no longer controlled by the pesticide. The pests had developed resistance to the chemical. Since the 1970's, pest resistance has surfaced in weed species, plant pathogens and insect pests. A prime example is the Colorado potato beetle which has developed resistance to every major group of insecticides, making the older chemical compounds nearly useless as pest management tools for Colorado potato beetle.

In her book Silent Spring, Rachel Carson discussed environmental concerns about the stability and persistence of DDT and other chlorinated hydrocarbon insecticides.

DDT and its relative compounds were also found to be stored in fat cells of insects, fish, birds, rodents and other animals. DDT didn't break down in fat cells. This is known as **bioaccumulation**.

Some organisms accumulate chemical residues in higher concentrations than those found in their food source. This process is called **biomagnification**. For example, invertebrates with pesticides in their tissues are eaten by fish, which are then eaten by birds. The birds at the top of the food chain accumulate the highest concentration of pesticide residues. Pesticides that bioaccumulate and biomagnify have been removed from the marketplace.

Pest Management

- Is the pest really causing the problem?
- **1st Step**: Always identify the pest before taking any action! ○ Become familiar with its life cycle and habits
- Use the information to design a pest management plan
- Misidentification results in lack of knowledge = ineffective control of the real pest

Lets talk about the principles of pest management now. In the old days, pest management may have meant simply using a pesticide to kill a pest. Due to the economics, environmental concerns, and regulations, pest management today involves a decisionmaking process and a carefully planned management approach. The first step in any pest management program is making sure you have properly identified the pest. Once the pest is properly identified, the pest manager can study the pest's life cycle, reproductive traits, and its growth habits. Understanding the pest's biology is critical when you are developing a pest management plan. Misidentification of the pest can result in ineffective pest management, wasting time and money.

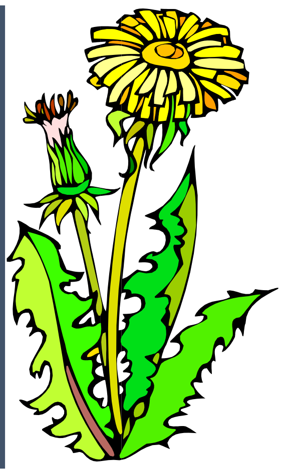
Philosophies of Pest Control

- **Chemical technology**
  - Use of chemicals to kill large numbers of the pest
  - Short-term protection
  - Environmental and health consequences
  - Ecological pest management
  - Control based on pest life cycle and ecology
  - Control agent may be an organism or chemical
  - Specific to pest and/or manipulate a part of the ecosystem
  - Emphasizes protection from pest

199 Four Major Pest Categories

Four Major Pest Categories

1 - Weeds: undesirable plants


We have many types of pests: weeds, insects, fungi, birds, fish, algae, rodents, and plant diseases. For this presentation on pest management, we'll introduce you to the 4 major pest categories.

Weeds are the most commonly targeted pests for control. A weed may compete with your crop, cause an injury on an athletic field, obstruct a roadway or utility powerline, or be unwanted for many other reasons.

2 - Invertebrates, such as:

1. Insects
2. Spiders and mites
3. Sowbugs, pillbugs
4. Snails, slugs, and mussels

Invertebrate pests include the wide variety of insects like aphids, caterpillars, grubs, and wasps.

Invertebrates also include the insect-cousins: spiders and mites, sowbugs and pillbugs, and snails, slugs, and mussels.

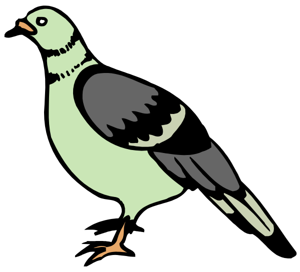
Pictured here are a cutworm larva which is the immature stage of a moth, a plant-feeding mite as seen from under a microscope, and a slug working its way through a backyard lawn.



3 _ Vertebrates, such as:

1. Birds
2. Snakes
3. Fish
4. Rodents and other mammals

Vertebrate pests include all of those animals with a backbone. These include pest birds, snakes, fish, rodents, and other mammals like mice, rats, raccoons and deer.



4 - Plant Diseases

- **Pathogens – living agents**
    1. Fungi
    2. Bacteria
    3. Viruses
    4. Nematodes
    5. Phytoplasmas

- **Non-living agents:** cold, heat, pollutants, dog urine

Plant diseases are the fourth major category of pests. A plant disease can be caused by disease organisms called pathogens, or they can be caused by non-living agents.

Disease pathogens or living agents include fungi, bacteria, viruses, nematodes, and phytoplasmas. These organisms infect plants and often depend on specific host species to survive. Rose mosaic virus symptoms are pictured at the top. The bottom image shows fruiting bodies of the fungus that causes Nectria twig blight in some fruit and ornamental tree species.

It's important to remember that non-living agents including temperature extremes, air pollution, and a lack of or excess levels of nutrients, can also cause damage to desirable plants resulting in 'plant disease'.

200 Pest Identification is Critical

Pest Identification is Critical

o Understand that all stages of a pest do not look the same Know the host of the pest ➢ Use books, extension bulletins, field guides, Web, etc. o Have pests examined by specialists

– Handle samples carefully

As mentioned earlier, it's important to correctly identify the pest in order to develop an effective management plan. Determining the cause of the problem or identifying the pest may be difficult. Immature stages of weeds and insects may not look at all like the mature stages.

Once you have properly identified the pest, learn about its biology. Resources that can help you identify and learn more about pests and host plants include books, extension bulletins, and field guides that contain pictures and biological information. Search the Internet. Illustrations of immature pest stages are helpful. Remember, weed seedlings and rosettes often don't resemble mature plants, and caterpillars don't resemble adult moths. If you can't identify the pest, take it to a specialist. When collecting specimens for identification, make sure you collect several specimens and store them in suitable containers. Don't forget to record important specimen information like the host plant and location where the specimen was collected.

Look for Characteristic Signs

1. **Birds and rodents:** unique nests
2. **Insects:** feeding damage
3. Fecal materials are distinctive – insect frass or bat guano
4. **Weeds:** particular flowers, seeds, or unusual growth habits

5. **Pathogens:** unique patterns or growths on plant tissue

Pests often leave signs of their presence or damage patterns that provide clues to their identity. Birds and rodents build nests that are often unique to each species. Insects have characteristic feeding damage such as notching or skeletonizing of leaves or leaf mining. Rodents and moles dig distinctive burrows in the ground and may leave gnaw marks on tree trunks or other objects. Fecal materials, like the frass from insects, droppings from rodents, or guano from bats, are distinctive. Weeds may have easy-to-identify flowers, seeds, or growth habits. Fungi and other pathogens often cause specific types of plant discoloration, damage, or deformation.

201 Pest Control Methods

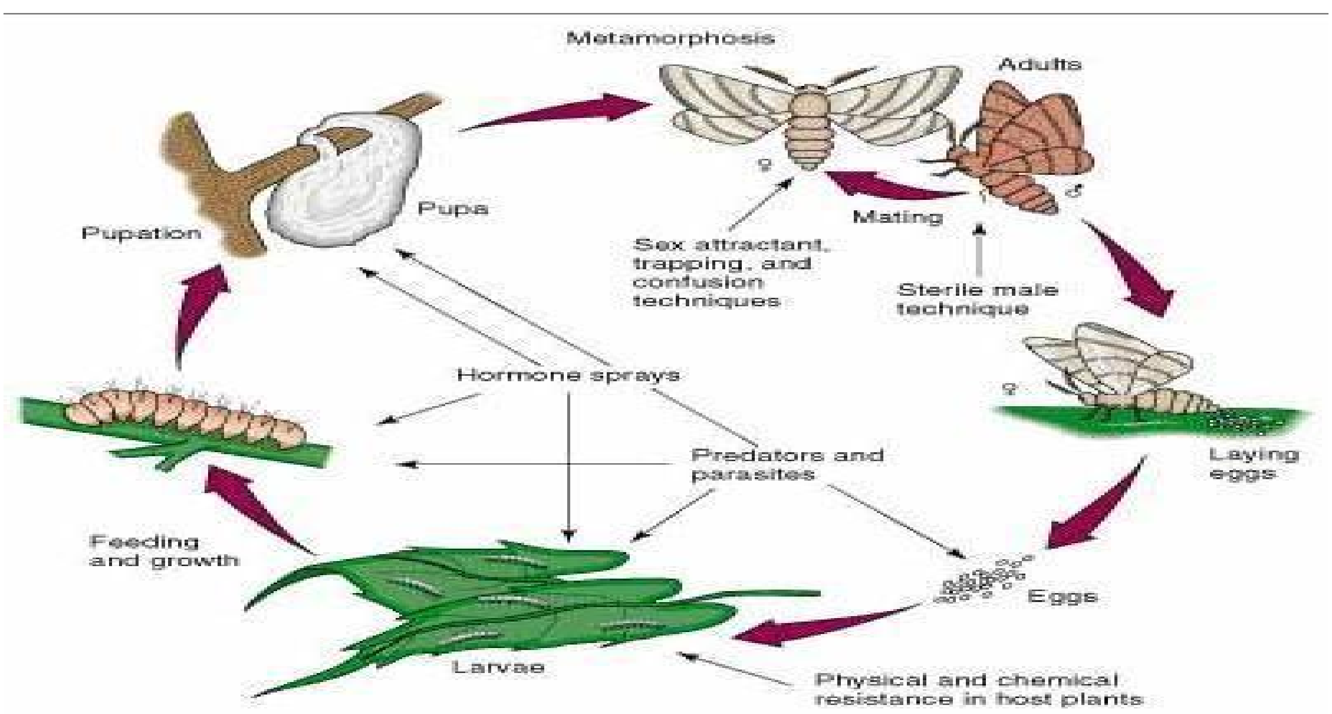
Natural Pest Controls

- Wind
- Temperature
- Humidity, rain
- Rivers, lakes, mountains
- Pathogens, predators
- Food supply of the pest
- Cultural control
- Control by natural enemies
- Genetic control
- Natural chemical control

Natural controls are out of man's control – Mother nature dishes these out. They are without a doubt the leading factors that manage pest populations. Natural controls include wind, temperature extremes, humidity levels, and rainfall. A cold snap in the spring or a wet spring can largely reduce insect pest numbers for that season.

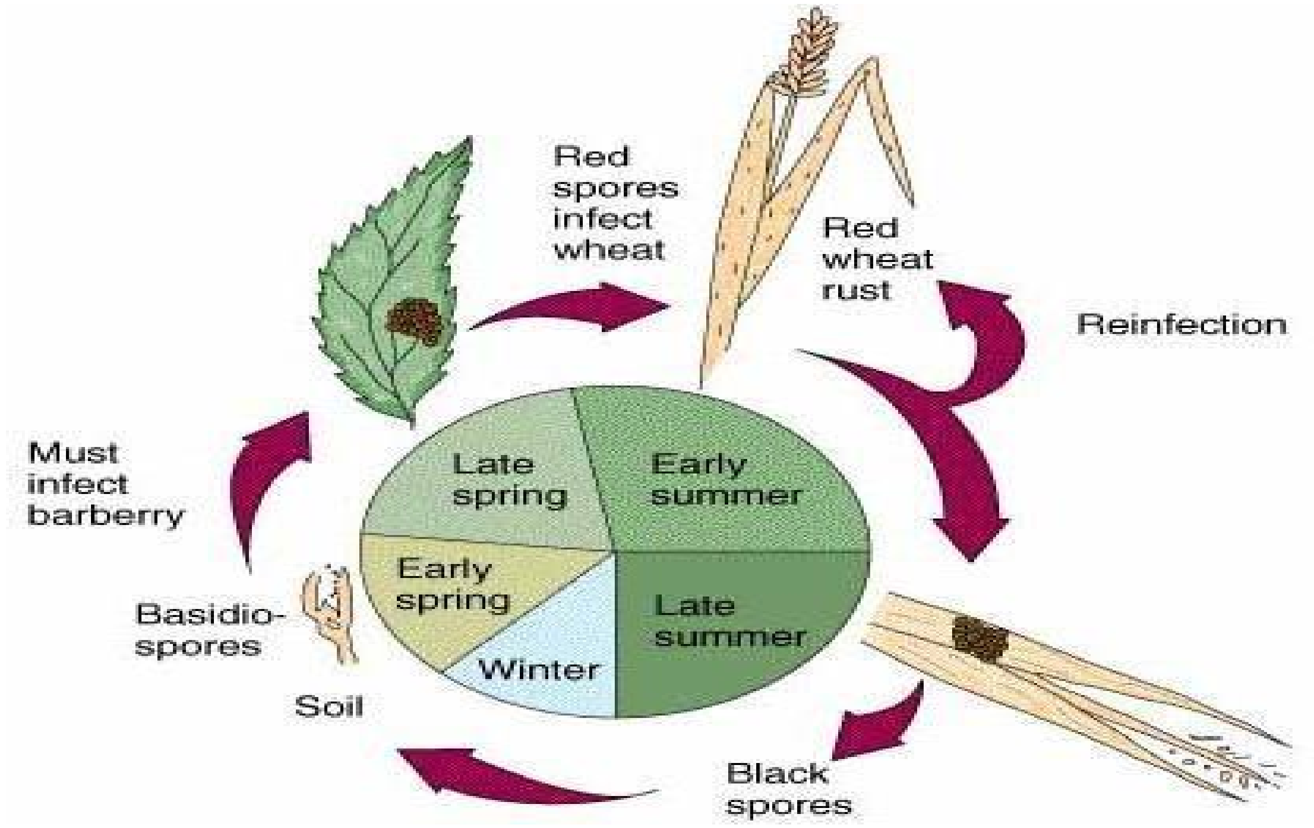
Rivers, lakes, and mountains provide significant barriers to pest movement and expansion. Naturally-occurring predators and pathogens hold down pest populations. The natural food supply of the pest also affects population density.

Insect Life Cycle



Cultural Control

Get rid of the alternative host!

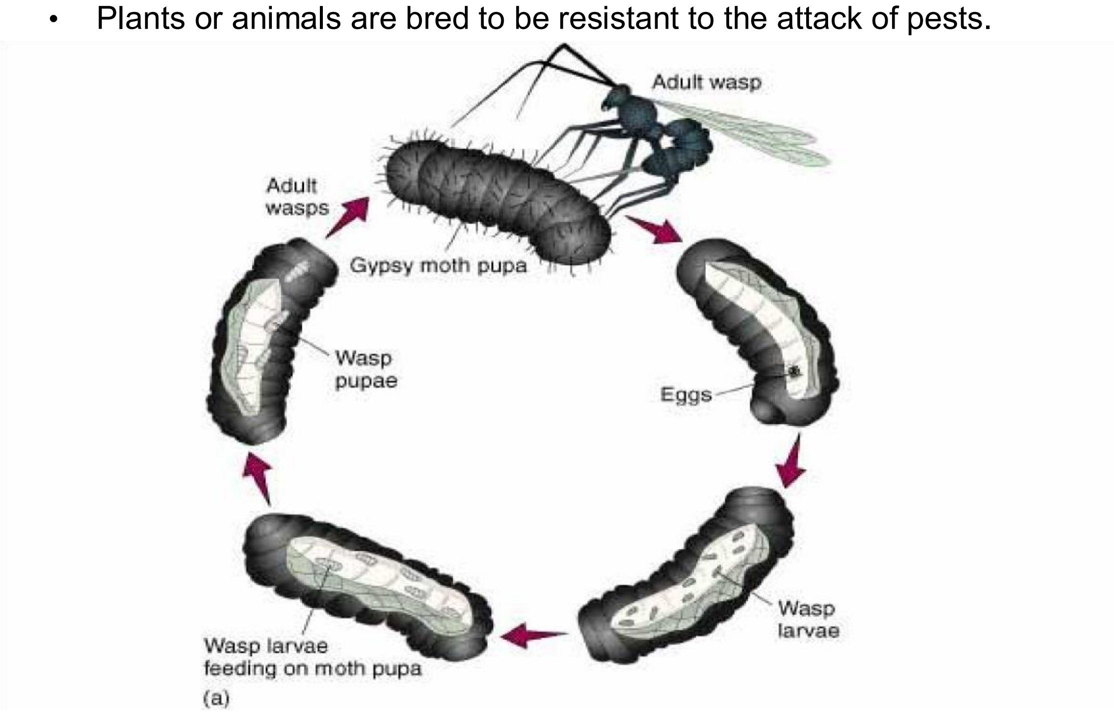


202 Control by Natural Enemies

Control by Natural Enemies

Genetic Control

- Plants or animals are bred to be resistant to the attack of pests.

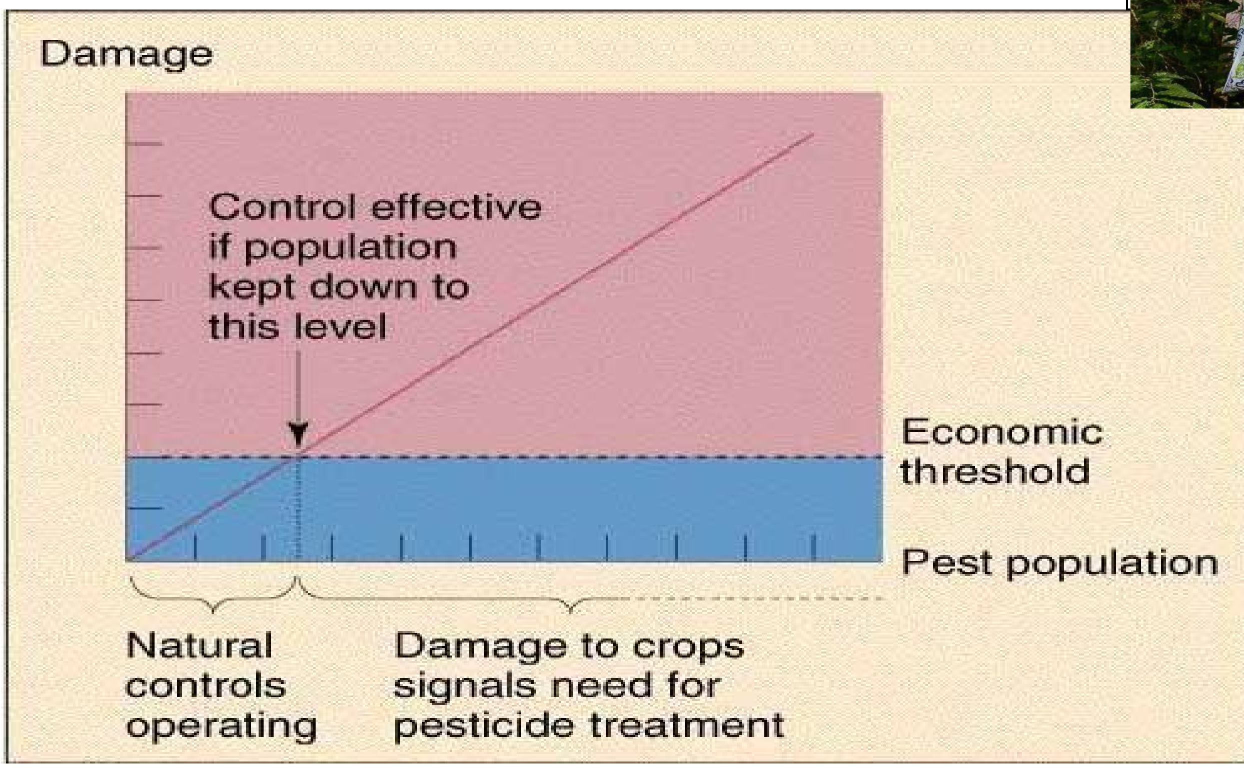


  - Chemical barriers.
  - Physical barriers.
- Introduction of genes into crops from other species: transgenic crops
- Sterile males are released into pest population.

Natural Chemical Control

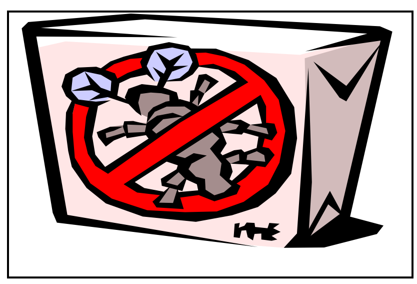
- Manipulation of pests' hormones or pheromones to disrupt the life cycle.
- Japanese beetle trap.

Economic Threshold of Pest Control



203 Human Applied Controls

Human-applied Controls



1. Biological
2. Mechanical
3. Cultural
4. Physical
5. Genetic
6. Chemical
7. Regulatory

Sometimes natural controls don't provide sufficient suppression of pest numbers. Then WE get involved and implement control tactics to reduce the pest populations. Applied controls include biological, mechanical, cultural, physical, genetic, chemical, and regulatory methods. We'll look at each of these applied controls now.

What is Biological Control?

- Usually, pests are not native to area
- Locate pest's native homeland and find natural enemies
- Before releasing natural enemy, evaluate if suitable ➢ Rear, release, redistribute

Biological control relies on the pest's natural enemies, such as birds, insects, fungi and viruses. Applied biological control is often directed against pests that are not native to a geographical area. When a non-native pest invades, it often doesn't come with its complement of predators, parasites and pathogens. So scientists visit the native pest range, usually in Eurasia, and collect the natural enemies. They evaluate the suitability of releasing the natural enemies into areas where the new pest has become established. As the newly released natural enemy population grows, scientists redistribute these beneficial organisms to other sites where the pest has become established.

Biological Control Results

✓ Release natural enemies may become established and reduce infestation levels ✓ May not require any additional releases

BEWARE:

The cane toad was introduced in Australia in 1935 to control two pests of sugar cane, but later emerged as an invasive species itself!

In undisturbed natural areas, forests, rangeland, and other sites, biological control has a good chance of becoming self-sustaining; in other more disturbed sites like landscapes and greenhouses, the pest manager may need to release biocontrol agents regularly. Introduction of biocontrol agents is strictly controlled because of the concern for the biocontrol agent to run amuck. There are several instances where introduced biocontrol agents have become pests themselves, like the cane toad in Australia.

Using Biological Control

- Periodic mass release from cultures o Natural areas, greenhouses, orchards
- Recognize naturally-occurring organisms
- Manage to conserve native beneficials
- Avoid broad-spectrum insecticides eating a lygus bug.

➢ Use non-chemical strategies

Again, depending on the establishment level of biocontrol agents, periodic releases may be required in natural areas, greenhouses, landscapes, and agriculture. Any person considering a pesticide application should assess the population of beneficial organisms to determine if an application is necessary. Your management plan should be designed to conserve the natural enemies. Environmental modifications, such as planting cover crops and groundcovers, may enhance natural enemy populations.

If you have predatory or parasitic insects present, be very careful and selective in the type of insecticide you use. Broad spectrum insecticides often kill natural enemies. Some selective insecticides won't harm beneficials.

Consider non-chemical control options to ensure conservation of the natural enemies.

204: Applied Control: Mechanical

1. Applied Control: Mechanical

Use of devices, machines, and other physical methods

to reduce pest populations or to alter the environment

Mechanical control is everyone's favorite – stomp or squash that bug! Mechanical control involves using devices, machines, or other physical methods to reduce pest populations. You may also use mechanical means to alter the environment so that it's unsuitable for pests to survive.

2.Mechanical: Cultivation

Disrupt soil conditions for weeds and insects

1. Hoes
2. Plows
3. Disks

Control growth or destroy plants

– Mowers

Cultivation is one of the more common forms of mechanical control. Hoes, plows, disks, mowers, cultivators, and bed conditioners are all mechanical devices that physically disrupt soil conditions. If you disturb the soil you can manage certain types of weeds, germinating weed seeds, and soil insects. Mowing can suppress certain types of weeds and destroy others.

3.Mechanical: Exclusion

- Prevent pests from entering or traveling

  Nets, screens, air curtains
  Caulking, steel wool
  Metal tree collars   Sticky materials
  Sharp objects


Exclusion is the use of a device that blocks the entry of pests into a specific area. This may be a screen on a window to keep out mosquitoes, or caulking to keep rodents and ants out of structures. Sealing cracks and crevices keeps insects, rodents, bats, and birds out of buildings. Metal tree collars can keep squirrels from climbing trees and sticky material painted onto trees, posts, and wires provides a barrier that many insect pests won't cross. Using sharp objects on roosting areas prevents birds from congregating.

4.Mechanical: Trapping

- Use of mechanical or sticky device
- Captures pests in a holding device
  - Restrains the pest
  - Kills the pest

Certain rodent and insect pests may be successfully managed with trapping. The trap may consist of a holding device like a snare or leg-hold trap. Some traps capture live animals for relocation or euthanasia. Traps that have a sticky surface don't allow the insects or rodents that come into contact with them to escape.

205 Applied Control Cultural

1. Applied Control: Cultural

Alter conditions or pest behaviors

1. Mowing ➢ Tolerant crop varieties
2. Irrigation ➢ Planting timing
3. Aeration ➢ Crop rotation
4. Fertilization ➢ Trap crops
5. Mulching

Cultural controls alter the environment in which the pest lives. The environment may be changed so it is unfavorable for the pest or the environment may be altered so the host plant grows more healthfully and is less susceptible to attack by the pest. For example, when turf is managed properly through mowing, irrigation, aeration, and fertilization, it's less likely to have weed, insect or disease problems. Mulching in a landscape bed prevents light penetration and greatly reduces weed seed germination. Selecting crop cultivars or landscape plants that are not susceptible to pest pressures is a key factor in preventive pest control. Simply by changing planting dates you may significantly reduce pest problems. The pest may emerge prior to the host plant being present, it dies off and then the crop germinates. Or you many plant early to get the crop a head start so it can outcompete the pest. In agriculture, use of crop rotation and trap crops can reduce the pest pressure on your crops.

2. Applied Control: Cultural

- **Sanitation**: eliminate food, water, and shelter
  - destroy infected crop residues or infected ornamental plant materials
  - weed to reduce pest harborage

- manage manure
- seal garbage cans
- remove soil near siding

A pest cannot survive if it doesn't have food, water and shelter. Practicing sanitation reduces the source of the pest or it eliminates food and water sources. If you have infected plant residues, they must be removed from the site and destroyed. Weedy areas near buildings, crop fields, or landscapes provide areas for pests to hide. If rodents and some insects have access to food, like manure or garbage cans, they'll be present and reproduce. Having soil near siding provides habitat for certain structural pests. Learn about the habits of your key pests. Evaluate your area for places where sanitation can be effective in reducing pest numbers.

Physical control is the altering of the physical environment – changing humidity, temperature, air flow, water and light.

Managing a pest may be as straightforward as pruning landscape plants for increased air flow and light penetration. More air movement and light in a plant's canopy reduces the amount of free moisture present and makes it unfavorable for pathogens. Lowering humidity and temperatures in stored grains prevents mold and insect infestations. Increasing air circulation in structures suppresses wood rot caused by fungal growth. Bright lights in attics are used to deter bats.

4.Applied Control: Genetics or Host Resistance

- Add or modify genetic material in crops and ornamental plants

206 Applied Control Physical

3. Applied Control: Physical

Alter physical environment

- humidity
- temperature
- air movement
- water
- light

- Breed or select plants for resistance

Refresh birdbath water weekly to manage for mosquitoes

Plant breeding and selecting resistant crop or landscape cultivars can prevent pest problems. This is true for livestock as well.

Traditional breeding programs select for characteristics that prevent attack by diseases and parasites. Genetic manipulation is becoming more common to acquire plants that tolerate pest presence or crops and turf that can tolerate herbicide treatments.

Resistance to Pesticides

- Chemical pesticides lose effectiveness
- Resistant pest populations produce next generations

207 Genetics of Pest Resistence

Genetics of Pest Resistance

- There are two copies of each gene. Each gene may have several variations (called alleles).Some alleles are more dominant than others.
- Consider a gene for an insect's reaction to a pesticide. See how the alleles are distributed among offspring if susceptible bugs (RR) mates with a resistant bug (RR)

RR x rr Susceptible x Resistant	R Susceptible allele	R
r resistant allele	Rr Mildly resistant offspring	Rr
r	Rr	Rr

Populations will have different proportions of dominant and recessive traits depending on selective pressures in the environment.

Consider what happens if mildly resistant bugs (Rr) mate with each other; and then offspring are exposed to a dose of pesticide.

Rr x Rr Heterozygous mildly resistant	R	r
R	RR dies	Rr May survive
r	Rr May survive	rr **SURVIVES!**

How many exposures does it take to make your population resistant?

Expose a population to a pesticide several times with mating in between exposures and see how many exposures it takes for resistant bugs to become the majority.

- **Rules of the Game:**

1. Toss your population (pennies) on the ground, and consider all with painted sides showing as exposed to pesticide
2. All exposed yellow (RR = susceptible) die so remove these pennies.
3. All exposed red (rr = resistant) survive and double; add a red penny for each exposed red penny.
4. For every three exposed blue (mild resistance) add one of each color. (Keep track of any remaining blues (<3) to ad to those on the next throw)
5. Keep track of the exposure count and repeat until most pennies are red.

208 Applied Control Chemical

5. Applied Control: Chemical

- **Pesticide:** any material that is applied to kill, attract, repel, or regulate pests
  - Disinfectants, fungicides, herbicides, insecticides, repellents, defoliants, piscicides, etc.

- **Advantages**: effective, fast, easy

Chemical control can be important to any IPM program when used as a preventive or curative method. A **pesticide** is defined as any material that's applied to plants, the soil, water, harvested crops, structures, clothing and furnishings, or animals to kill, attract, repel, or regulate or interrupt the growth and mating of pests, or to regulate plant growth. The broad category of chemicals termed pesticides includes disinfectants, fungicides, herbicides, insecticides, nematicides, repellants, defoliants, and desiccants. Unfortunately, people sometimes use the term pesticide and insecticide as synonyms when in fact an insecticide is only one type of pesticide. Pesticides can be quite effective, quick-acting, and relatively easy to use.

Pesticides (Biocides)

1. Insecticides (insects)
2. Herbicides (not just the weedy plants)
3. Rodenticides (mammalicides)
4. Fungicides (mildews and rusts)
5. Acaricides (ticks and mites)
6. Bacteriocide (e.g. antibiotic)

The Early Years of Chemical Pest Control

- **First-generation pesticides (inorganic)**
  - First attempt at chemical technology
  - Included heavy metals such as arsenic, copper and lead.
  - Toxic to humans and agricultural plants.
  - Pests developed resistance.

209 Pesticide Improvements

Pesticide “Improvements” (?)

- **Second-generation pesticides**

Organic chemical (organochlorines).
Used after WWII (presently in developing countries)
Synthesis begins with petroleum (“oil”) ✓ Mechanism of actions often unknown.
Bioaccumulation & Biomagnification.
Toxic to animals (humans) and agricultural plants.
Pests developed resistance.

Smarter Pesticides (?)

- **Third-generation Pesticides**

Organophosphates and carbamates
Less persistent in environment (good deal)
Acutely potent nerve toxins
More lethal in low dose than organochlorines
Fourth-generation Pesticides
Endocrine disruptors (hormonal chaos) ✓ Target a critical life cycle stage of insects.
Not direct killers per say.
Reduce reproduction (fertility) of population.

210 Chemical Technology Problems

Chemical Technology Problems

Development of resistance by pests
Resurgences (pest comes back stronger)
Secondary pest outbreaks (different pest)

Adverse human health effects
Adverse environmental health effects

Human Health Effects

- **Acute:** high dose, short-term response, rapid onset (headache, nausea, vomiting, respiratory failure, death). Agricultural workers suffer acute poisoning during pesticide application.
- **Chronic:** low-dose, long-term exposure, outcome takes many years before noticed (cancer, dermatitis, neurological disorder, birth defects, sterility, endocrine system disruption, immune system depression). Neighborhoods downwind of agricultural use; farm families; the innocent.

Environmental Effects

- **Bio-concentration:**
  – Movement against a concentration gradient; typically fat soluble.
- **Bio-magnification:**
  – Movement through the food chain to higher trophic levels; typically persistent.
- **Bioaccumulation:**
  – Combined effect of both; chemicals are typically fat soluble and persistent.
- **Resurgences:** after "eliminating" a pest, its population rebounds in even higher numbers than previous levels. Why?
- **Secondary outbreaks:** outbreaks of species' populations that were not previously at pest levels. Why?

Think about mechanisms of environmental resistance on any one population.

211 Pesticides Vary By

Mode of action: how they work to control the pest

– Systemic pesticides are absorbed through tissues and transported elsewhere where the pest encounters it through feeding
  - Used on plants or livestock

– **Contact** pesticides must come in direct contact with the target pest

Pesticides vary in how they work to actually control the pest. We call this the mode of action – how they kill or control the pest.

Some pesticides are systemic and actually move through animal or plant tissues and the pest encounters it when feeding on the animal or plant.

Other pesticides work by contact action like battery acid on your pants. You must make sure that you apply the material so that it comes into direct contact with the pest.

Selectivity: what range of pests they affect

– **Non-selective –** kills all related pests – for example some herbicides kill all green plant that gets a sufficient dose
– **Selective** – kills only certain weeds, insects, plant pathogens – for example other herbicides only kill broadleaf weeds not grasses

Pesticides also vary in their selectivity or how many different pest species they target.

Some affect all related organisms equally and are called non-selective. A good example is glyphosate, the active ingredient in Roundup Original. Glyphosate is non-selective when applied to green plants. ANY green plant that gets a sufficient dose will die whether it's a broadleaf or a grass plant.

In contrast, a selective pesticide only kills a small group of related organisms and does not harm others. The herbicide 2,4-D is a good example. It only kills broadleaf plants and does not harm grass plants when applied according to label directions.

Persistence: how long they remain active in the environment

- **Residual pesticides** – remain active for weeks, months, years – for example herbicides used around road guard rails
- **Non-residual –** inactivated immediately or within a few days – for example – some herbicides do not remain active in the soil once applied

Persistence is the term used for how long a pesticide remains present in the environment. DDT, which is no longer used, was a very persistent insecticide that's still found in the environment today. Many of the new products break down in a matter of hours or a few weeks. There are some persistent materials on the market today; we call them residual insecticides and herbicides and use them where we want long-term control.

Applications of residual herbicides are made to rights-of-ways so repeated applications are not required throughout the year.

Non-residual materials are also available, they break down very quickly.

212 Regulatory Pest Control

Regulatory Pest Control

- **Quarantine prevents** pests from entry to an area or movement from infested areas.
  - Monitor airports, ocean ports, borders
  - Nursery stocks and other plant materials
- **Eradication programs** eliminate a pest from a defined area
- Mosquito Abatement used for public health

The government uses several regulatory control programs to manage pests. Quarantines are used at airports and ocean ports to prevent entry of foreign pests. State borders and areas within states may be under a quarantine status to prevent the movement of pests from an infected area. Nursery stock and other plant material may be regulated to ensure no pests are transported on plant material. Federal and state governmental agencies may be involved in small to very large scale eradication programs with the goal being the total elimination of a pest from a defined area. Regulatory mosquito abatement districts and programs are established to manage for large-scale public health concerns.

Integrated Pest Management IPM: a balanced, tactical approach

Anticipates and prevents damage
Uses several tactics in combination
Improves effectiveness, reduces side effects
Relies on identification, measurement, assessment, and knowledge

Integrated pest management or IPM is a decision-based management style that implements a balanced, tactical approach. The decision-making is based on planning to anticipate damage to prevent it from occurring and if damage thresholds are met, using a variety of control tactics to suppress the pest population. When using a decision-based system, you increase effectiveness and reduce the negative side effects. IPM is dependent on proper identification and understanding of the pest biology along with proper measurement of population densities and assessment of control tactics.

213 Why Practice IPM

Why Practice IPM?

- Maintains balanced ecosystems
- Pesticides alone may be ineffective
- Promotes a healthy environment
- Saves money
- Maintains a good public image

The shift from using only a single control tactic to IPM provides for a more balanced ecosystem, since factors other than damage alone are part of the decision-making. We know that continued use of pesticides, without thought to resistance management and effects on the environment, can result in the product becoming less effective. Using IPM promotes a healthy environment…and it saves you money over time.

Considerations for Choosing Control Methods

- Determine damage level you can withstand
- Determine desired control outcomes
  - Prevention of pest outbreaks
  - Suppression to acceptable level
  - Eradication of all pest organisms
- Manage for pesticide resistance
- Estimate costs
  - Monetary
  - Environmental impacts

Management is decision-based. Once the pest is identified and its biology reviewed, assess the amount of damage you can tolerate. In some cases, this may be the presence of only one pest organism, in others you may be able to tolerate 100s of individuals. Next, set your goal for control. Are there strategies you can use to prevent the pest from becoming a problem? Can you tolerate to just knock the pest population back a little – suppress it, or do you actually need total elimination or eradication of the pest organism? This may depend on agricultural markets or a customer's demand for a pest-free environment. When selecting management tactics, most specifically when selecting pesticides, consider pesticide resistance. Is it wise to go back and treat with the same chemical that you have used the last few treatments – or should you change product types? Ultimately you'll want to consider the cost to your pocketbook and the impacts on the environment.

Integrated Pest Management is Driven by Decisions

1. Identify the pest and know its biology
2. Monitor and survey for pests
3. Set IPM goal: prevent, suppress, eradicate
4. Implement
   1) Select control strategies
   2) Timing
   3) Economics
   4) Environmental impacts
   5) Regulatory restrictions
5. Evaluate

Here are the major factors that drive the decision-making within an IPM program.

First and always foremost is pest identification and understanding.

Once you know what, when and where about the pest – you can develop a monitoring system using several survey techniques.
You need to set your management goal and decide what level of control is acceptable for your situation – a golf green will have a different goal than a fairway.

Once you set your goals and understand the pest, you can look at the factors that impact your selection of control tactics. These factors may include timing, economics, environmental considerations and regulatory constraints.

Don't forget to evaluate the entire process and record your findings. You can then tweak the plan in future years once you understand your successes and failures.

Lets look at some of these considerations in a little more detail.

214 Components of IPM

Components of IPM

1. Identify and Understand

- Is it a pest, beneficial, or just there?
- Study pest biology

  Pest classification
  Life cycle
  Over-wintering stage
  Damage impacts
  Environmental needs
  Vulnerable control stages/timing

Pest identification is critical. It's the most important step. You must know what pest is causing the problem, or what pest may potentially cause a problem. Often an insect or plant may be present, but it poses no threat whatsoever and requires no action. Some may even be beneficial organisms.

Once you have identified the pest, take some time investigating its classification and life cycle. They are key to mechanical, cultural, and chemical management options. Knowing the stage of the pest that overwinters may provide a key as to the timing for control measures to be taken.

Investigation is critical to understand what pest population levels trigger concern and what levels trigger action.

Having some knowledge of the pest and its environmental needs may shed light on what population levels may be anticipated due to the environmental conditions. Did the cold winter knock the population back? Did the early warm spring allow for another generation to be produced?

Knowledge of the life cycle may provide the key to timing your control activities to the pest's most vulnerable stage.

- **Key pests**

  Prior knowledge of which common pests may pose a problem
  Recognition of damage symptoms
  Recognition of diseases
  Recognition of beneficial insects
  Frequent monitoring

Using the concept of key hosts and key pests is a good way to start your IPM planning. Know what crop you are growing or what landscape plants you have growing or plan to grow. Do some reading and go to some seminars to learn what pests are the most common and most damaging for the plants you grow. Know what to look for and when to monitor. What symptoms does the plant express when the pest feeds on it? Can you recognize them? What symptoms does the plant express when it's infected by a disease?

What do the common and not so common beneficial predators and parasites look like that are associated with the pest.

Occasional pests may become troublesome from time to time

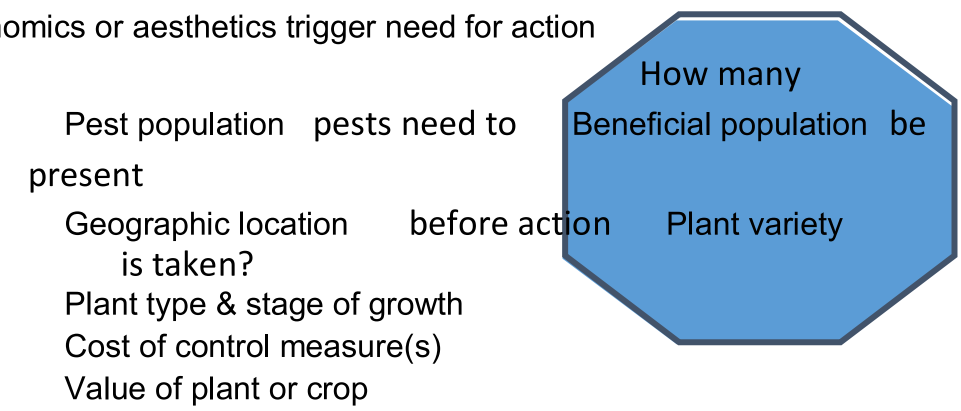
Secondary pests become problems when key pests are controlled or eliminated – such as spider mites

Other than the key pests, have a working knowledge of the occasional pests that appear every so often, such as an ant infestation. Their appearance may depend on the weather or even your use of chemicals.

Be aware that when you suppress the key pest, another low-level pest may become very problematic. We call these secondary pests. For example if you manage for codling moth in apples with a broad-spectrum insecticide, the insecticide will kill beneficial predatory mites as well. This sets you up for an explosion of the secondary, plant-feeding spider mites.

2. Monitor the Pest

- Use scouting, trapping, weather data, models
- Economics or aesthetics trigger need for action



If you have a working knowledge of the pest, you can learn about scouting and trapping techniques. Some scouting is dependent on weather data since growth of pest populations depends on temperature. Several factors will play into the decision when evaluating the trigger levels for control action. These may be based on the economics of lost yield and harvest costs, or they may simply be based on aesthetics. You have to know the answer to the question – how many pest numbers need be present before control action is warranted?

- **Action threshold:** unacceptable pest level – do something
- Sometimes the action threshold may be zero!
- Action thresholds vary by pest, site, and season

6 aphids per wheat plant = no problem - no action

15 aphids per wheat plant = hits the pocketbook take action

The action threshold is that pest number that triggers you to initiate corrective measures. Those corrective measures may be mechanical, cultural, or chemical. In agriculture, the action threshold is usually well-defined based on economics. Depending on the pest species, the site, or even the season, the trigger level may differ. At six aphids on a wheat plant, the plants can tolerate the feeding and the loss of yield does not approach the cost to control the aphids. However, once the aphid population builds to 15 aphids per plant, it makes good economic sense to take action to hold down your losses.

215 Treatments of Action Threshold

Treatment or Action Threshold

- **Economic Threshold**

- pest population density when *control is necessary* to prevent economic injury

- **Economic Injury Level**
  - when the cost of losses equals the cost of control measures
  - Apply control measure prior to reaching economic injury level

In agriculture we base these action triggers on economics. The 'economic threshold' is when the pest population reaches a specific density that causes significant damage and if not held in check,
'economic injury' will be realized. 'Economic injury' is a threshold of pest number just above the 'economic threshold'. At this point, the cost of control and the cost of the damage are equal. If you did not start control measures at the lower, economic threshold, you will end up with damage that exceeds the costs of control.

Components of IPM
2. Monitor the Pest

Action Threshold is also based on aesthetics or public health issues At what point does the cost of control ward off future expenses

For turf, ornamentals, and even public health, we simply call the threshold an action threshold. Ask yourself, at what point does the cost of control ward off future expenses or unacceptable damage levels? If you manage turf on a golf course green your tolerance for weeds is very different than for weed levels in the fairways and your action threshold is different.

Components of IPM
3. Develop the IPM Goal

- **Prevention:** weed-free seed, resistant plants, sanitation, exclusion, pesticide treatments
- **Suppression=reduction** cultivation, biological control, pesticides
- **Eradication=elimination** small, confined areas, or government programs

You need to set a goal. Prevention is an important goal. During your planning period for crop production or prior to seeding or establishing an ornamental bed or turfgrass, consider what actions you can employ to prevent pests from becoming established. Consider planting certified weed-free seed or use resistant plant cultivars. Build exclusionary devices to keep pests out. If you had a previous infestation, consider sanitation measures to remove infected source material. You may even want to consider some preventive pesticide treatments like using treated seed or using a preemergence herbicide application.

Again, prior to the growing season, set your pest management goal. Do you require total elimination of the pest, or would just suppressing the population offer sufficient protection? There are many tactics you can consider to hold a population in check.

If your goal is eradication, you'll have to develop a very intense, methodical plan to ensure the total elimination of the species and all of its life stages. Eradication is typically a goal when you have a very small, contained pest population or when the government is managing the program and they can employ wide-scale control activities on properties of private citizens.

Components of IPM
4. Implement the IPM Program

- Make sure you have taken initial steps
  - Identification and monitoring
  - Set action thresholds
  - Know what control strategies will work
- Select effective and least harmful methods!

- Observe all local, state, federal regulations!

Always follow these steps before implementing an IPM program:

Identify the pest and set up a monitoring program.
Know the economic or action threshold, as well as the economic injury level.
Consider the available management options.
Evaluate the benefits and risks of each method.
And make sure your control strategy falls in step with any regulations.

Components of IPM
5. Record and Evaluate Results

Know what worked and what did not
Some aspects may be slow to yield results
Might be ineffective or damaging to the target crop, beneficial insects, etc.
Use gained knowledge in future planning efforts

A very important step in any IPM program is recordkeeping and evaluation of your efforts. Keep track of climatic conditions. Record when and where actions were taken. Track the pest populations. Near the end of the season, review your records. Some control strategies may not be quick-acting, but may prove effective given sufficient time. Other management strategies may have caused negative impacts that need to be considered when making future decisions.

216 Considerations for Pesticide Use

Considerations for Pesticide Use

Identify the pest and select the appropriate product o old or new infestation
Avoid developing resistant pest populations
If using pesticides, use the correct application rate (dose) and timing

When you look to chemicals as a management option, there are several considerations. First make sure you have identified the pest. Make certain that the product you select is effective against the pest and is labeled for the site. If you have had a continual problem with a pest, your decision on a chemical may be slightly different than if you are targeting a new, invasive pest.

If you have used chemicals in the past to treat a pest population, consider using an alternative type of product to reduce the possibility of pesticide resistance. If you keep using the same product type repeatedly, year in and year out, resistance will likely develop.

Make sure you read the label carefully to understand the timing for the application and make sure you use the correct application rate. Using a dose that is over the label rate is illegal and can cause significant impacts. For example, using too much of a selective herbicide may result in damage to your crop or turf. Making an application with too low of a dose or at the wrong time can be a waste of money.

Be A Professional IPM Practitioner

Careful observation
Knowledge of the pest, control options
Professional attitude

With an IPM plan, you must keep your eyes open. Pay attention to all factors that contribute to pest populations. Be knowledgeable about the pest and the various management options you can employ when necessary. Be a professional – Be smart – Be careful -- and Be accurate.

Pesticide Resistance:the ability of a pest to tolerate a pesticide that once controlled it

- Intensive pesticide use kills susceptible pests in a population, leaving some resistant ones to reproduce

- Use of similar modes of action
- Frequency of applications
- Persistence of the chemical
- Pest rate of reproduction & offspring numbers

We've talked a little bit about pesticide resistance. Let's look at this phenomena that is a concern whether applying insecticides, herbicides, fungicides, or any type of pesticide. Any time you apply a pesticide, not all of the individuals in that population will be killed and removed. One in a million may resist the treatment. That one in a million is not obvious to the pest manager the first few years. But after repeated applications and the reproduction of the resistant individuals, a population of resistant pests becomes apparent. The chemical that historically controlled that population is now ineffective.

If you use products that have similar modes of action, those resistant individuals will not be controlled. So alternate between chemicals having different modes of action to manage for resistance. If pesticides are frequently applied during a growing season, resistance can show up more quickly.

Chemicals that are persistent tend to have resistance show up more readily than products that don't remain active over time.

The pest biology is also a key factor. If the pest has a high rate of reproduction and reproduces often, those resistant individuals show up more quickly as the population of those individuals increases. Also pests that have many offspring per generation tend to have a greater chance of resistance developing.

The pest manager must consider resistance management techniques when using pesticides in an IPM program.

Resistance Management

- Do not use products repeatedly that have similar modes of action
- Allow some pests to survive o Limit treatment areas o Consider using lower dosages
- Use caution: new compounds having very specific actions - may develop resistance more quickly
- Use non-chemical means to control resistant pest populations Again, to

manage for pesticide resistance. Alternate your chemicals and don't use pesticides with similar modes of action repeatedly. Break the cycle.

Instead of treating an entire block, consider leaving an untreated section to allow those susceptible individuals to reproduce to keep the susceptible gene pool present. Using lower doses may increase survivorship.

If you use pesticides that are highly selective with specific modes of action, there's an increased concern for resistance management – again use alternate modes of action to break the cycle.

You can also use other methods of control to break the cycle and kill off the resistant individuals.

217 Arthropode Vector Biology

MEDICAL ENTOMOLOGY

- the study of diseases caused by arthropods

- Public health entomology - arthropods and human health
- Veterinary entomology - arthropods and pets, livestock and wildlife
- These fields of study are linked by the ecology of most arthropod transmitted pathogens and parasites.

Arthropods affect the health and well-being of humans and animals in several ways:

- Direct Causes of Disease or Distress
- Vectors or Hosts of Pathogenic Organisms
- Natural Enemies of other medically harmful insects

Direct Causes of Disease or Distress:

1) Ectoparasites - ticks, fleas, mites
2) Endoparasites - chigoe flea, myiasis
3) Envenomization - wasps, bees, spiders
4) Allergic Reactions - dust mites
5) Annoyance - mosquitoes, black flies
6) Delusory parasitosis (DP) - psychosis

218 Vectors or Hosts of Pathogenic Organisms

Vectors or Hosts of Pathogenic Organisms:

Arthropod serves as intermediate host and vector of pathogenic microorganisms
Vectors and hosts – blood feeding
Hosts only - no blood feeding

Natural Enemies of other medically harmful insects:

Mites parasitic on mosquitoes
Fire ants consume tick eggs

219 History of Medical Entomology

History of Medical Entomology:

- References to associations between humans and arthropods – historical

(Homer and Aristotle, among others, wrote about the nuisance caused by flies, mosquitoes, lice and/or bedbugs.)

- **Important discoveries:**

Microscope - Leeuwenhoek 1700's
Infectious Disease - Koch et al. 1800's

History of Medical Entomology - 2:

Mosquitoes (*Culex pipiens*) and filarial worms (*Wuchereria bancrofti*) - Manson, 1877
Tick (*Boophilus annulatus*) and Texas cattle fever (piroplasmosis) transmission - Smith & Kilborne, 1891
Mosquito (*Aedes aegypti*) and yellow fever virus - Finlay, Reed, Carroll, Agramonte and Lazear, 1900
Trypanosomes in cattle blood - Bruce, 1895
Tsetse fly (*Glossina sp.*) transmission of trypanosomes - Bruce, 1896
Tsetse fly transmission of trypanosomes to humans (African Sleeping Sickness) - Bruce, 1903

History of Medical Entomology - 3:

Malaria parasites in human blood - Laveran, 1894
Anopheles mosquitoes with malaria parasites - Ross, 1897
Transmission of bird malaria by *Culex* mosquitoes - Ross, 1898
Complete development of human malaria parasite in mosquitoes - Grassi, 1898
Transmission of human malarial parasite by mosquitoes - Sambon and Low, 1899
Only *Anopheles* mosquitoes transmit human malarial parasites - Watson and Christophers, 1899

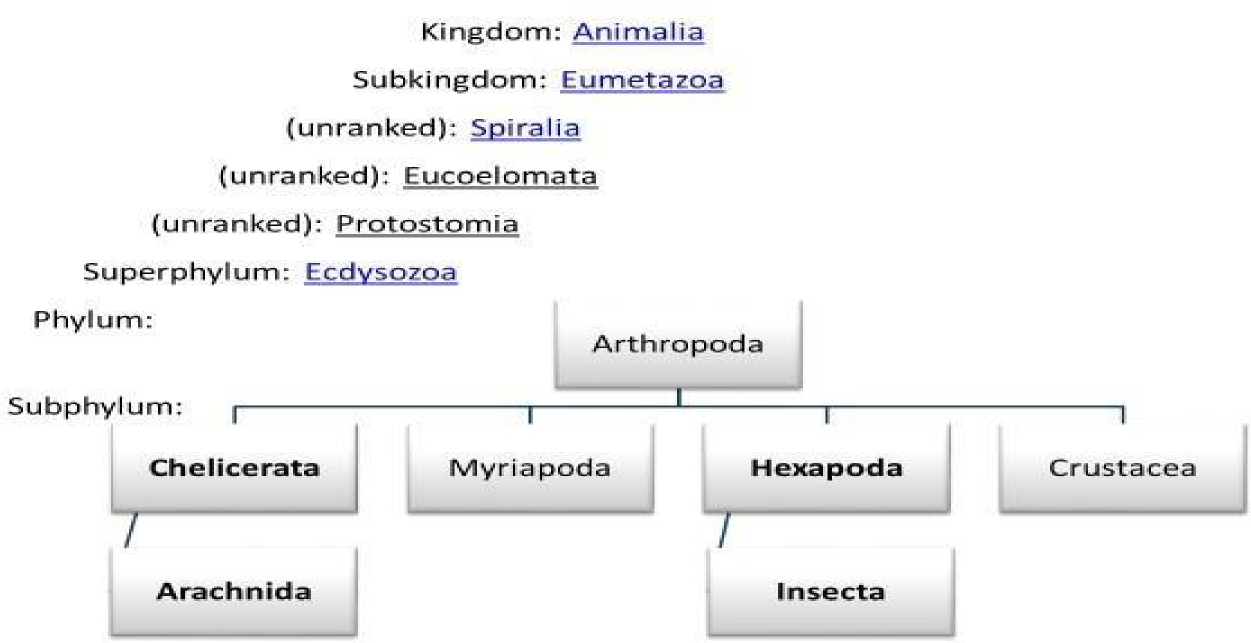
History of Medical Entomology - 4:

Mosquito transmission of dengue virus - Graham, 1902
Fleas and plague - Liston, Verjbitski et al., 1895 - 1910
Triatomine bugs and trypanosomes (Chagas disease) - Chagas, 1908

Black flies and onchocerciasis (river blindness) - Blalock, 1926
Mosquitoes and viral encephalitides - Hammon and Reeves, early 1940's
Ticks and Lyme disease - Spielman, early 1960's

220 Arthropods and Insects Taonomy and Characteristics

Arthropods and Insects Taxonomy and Characteristics



Arthropods

General Characteristics:

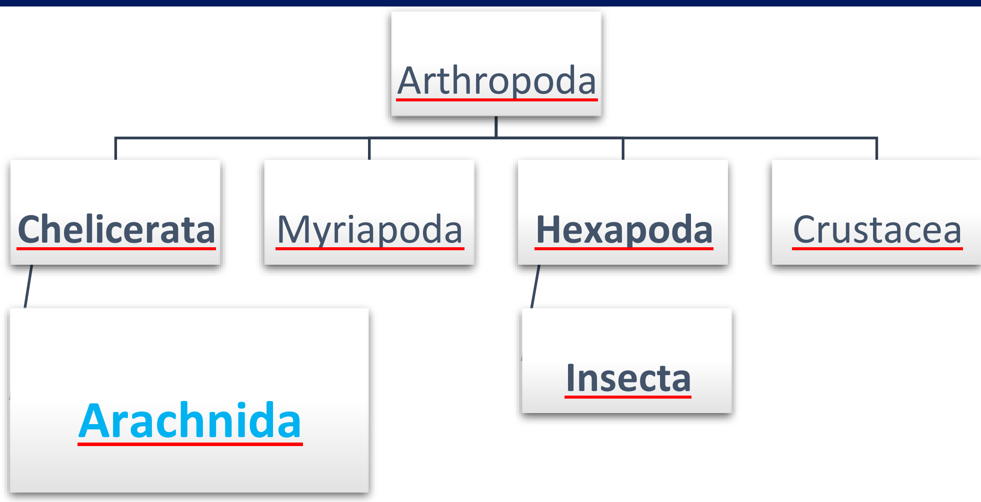
1) highly successful (⅔ of all known organisms are Arthropods)

1) segmented Eucoelomata with exoskeleton (Arthropod Metamerism)
2) Tagmata/Tagmatization (segments grouped into body regions)
3) Molting, Ecdysis (Ecdysozoa)
4) Hemimetabolous (gradual) / holometabolous (complete)
5) Cephalization (highly developed sensory organs)
6) Open circulatory system (hemolymph / hemocoel)
7) Respiratory system (trachea / book lungs)
8) Malpighian tubules / Coxal glands

9) Involved in virtually every kind of parasitic relationship ✓ definitive and intermediate hosts for protozoans, flatworms, nematodes,arthropods ✓ function as vectors (blood-feeding / need for protein for development)

221 Taxonomy and Characteristics

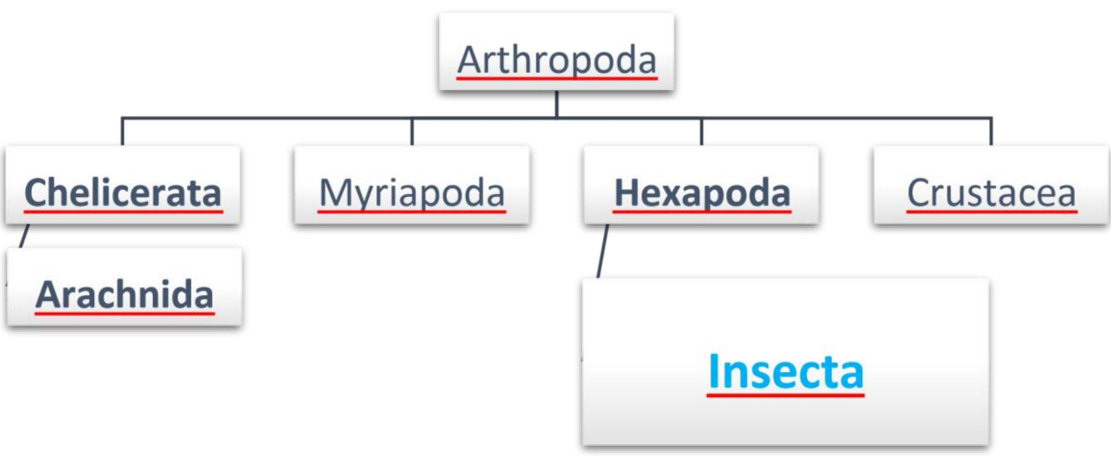
Class

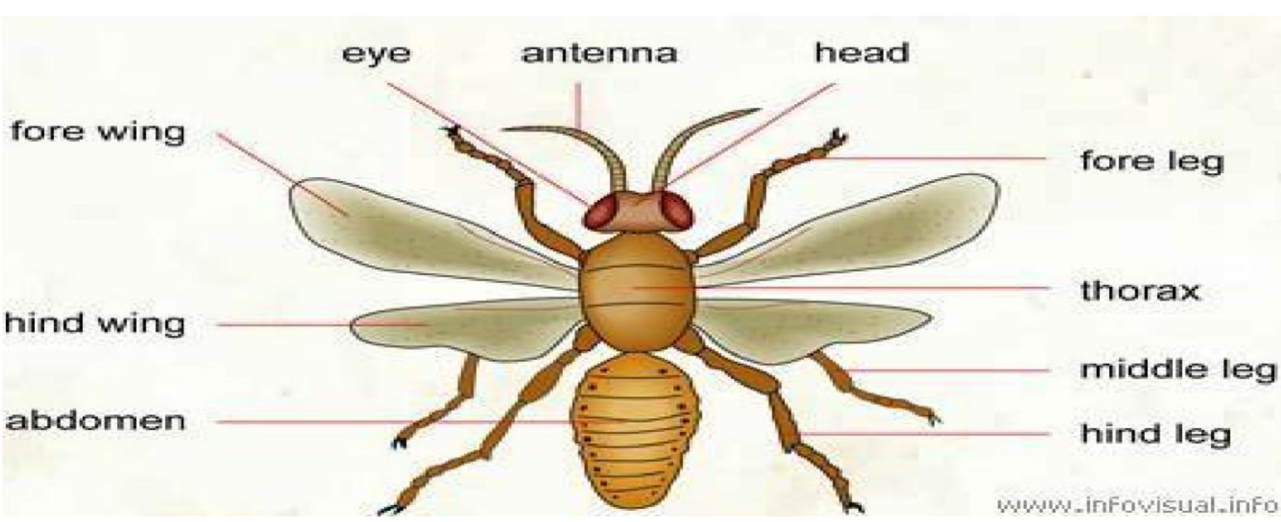


Arachnida:

o Prosoma (Cephalothroax) – Opisthosoma (Abdomen)

- Subclass Acari: Capitulum (head) – Idiosoma; transmit a large number of disease agents (viruses, rickettsia, apicomplexa, nemotodes)
- Ticks are pool feeders (once attached to the host, the tick will inject saliva into the wound, which liquidizes the tissues and allows them to suck up the fluid)
- Ticks sense CO_2, warmth and movement from animals
- Ticks are divided into two families: Ixodidae (hard ticks) and Argasidae (soft ticks).

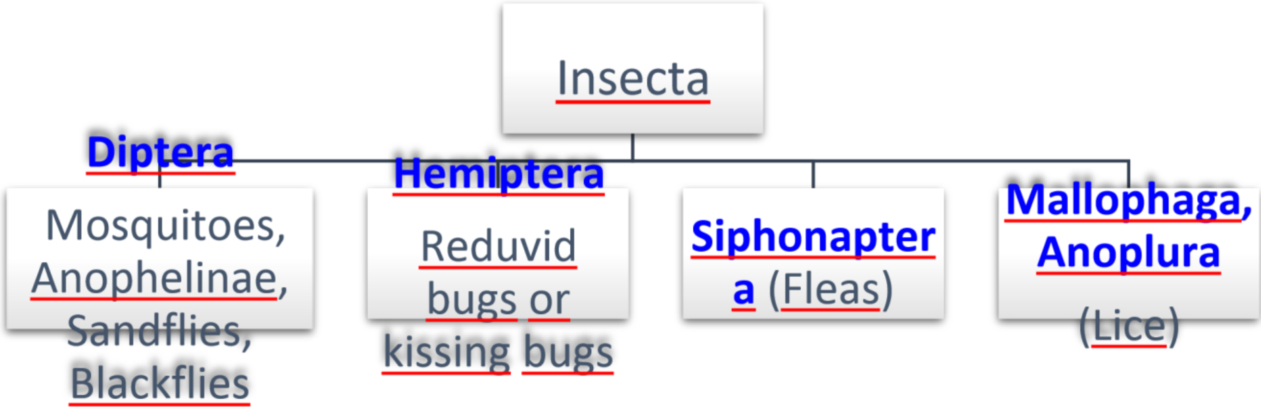




- outnumber all other known animals put together (almost 1million species described)
- Head – Thorax – Abdomen
- eyes, antennae, sucking , chewing mouthparts, 2 pairs of wings, 3 pairs of legs
- can vector many diseases (mechanical / biological)

- Blood-feeding (need for protein), Flexibility in development, Response to host presence

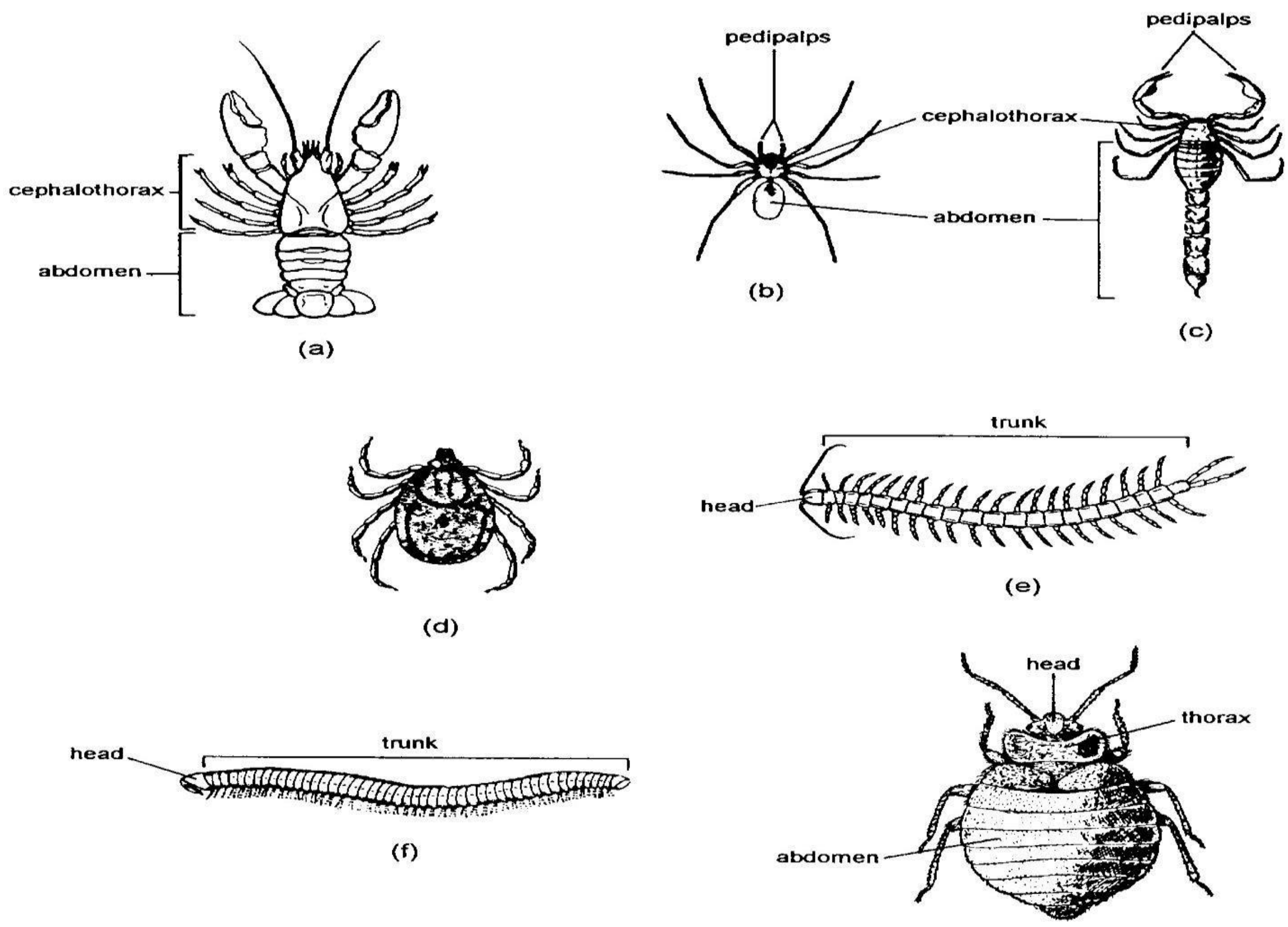
+/- low host specificity, can live near or in human dwellings…



222 Arthropods Classes and Representatives

Phylum Arthropoda (classes and their Representative in Brief)

1) Class Crustacea - lobsters, crabs, etc.
2) Class Chelicerata - spiders, mites, ticks, scorpions, etc.
3) Class Diplopoda - millipedes
4) Class Chilopoda - centipedes
5) Class Insecta - beetles, flies, moths, etc.



Phylum Arthropoda: Salient Features

- The phylum is probably monophyletic, but with 4 distinct groups.
- It includes lobsters, crabs, shrimp, centipedes, millipedes, daddy longlegs, insects, ticks, and mites, and spiders.
- There are over 1 million species of arthropods, making up the largest phylum in the animal kingdom.

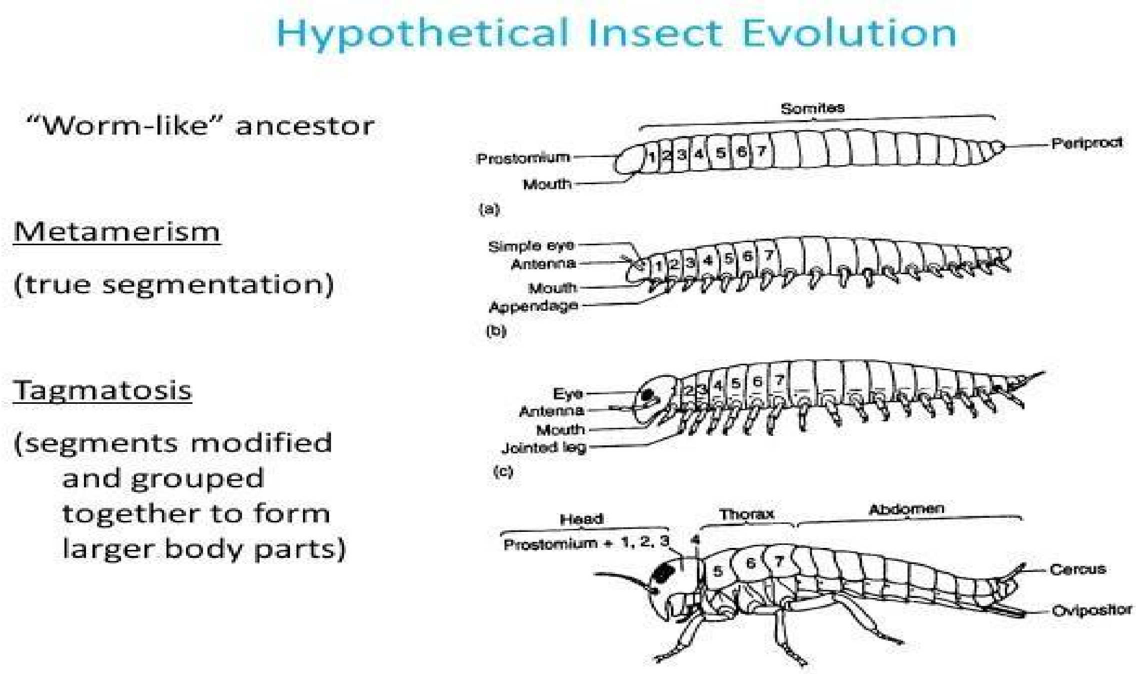
Phylum Arthropoda - 2:

- Metameric - (body exhibits true segmentation - replication of muscles and nerves)
- Tagmatosis - (segments of the body are modified and grouped together to form mouthparts and body regions such as the thorax)
- Chitinous exoskeleton – nitrogenous polysaccharide

223 Phylum Arthropoda

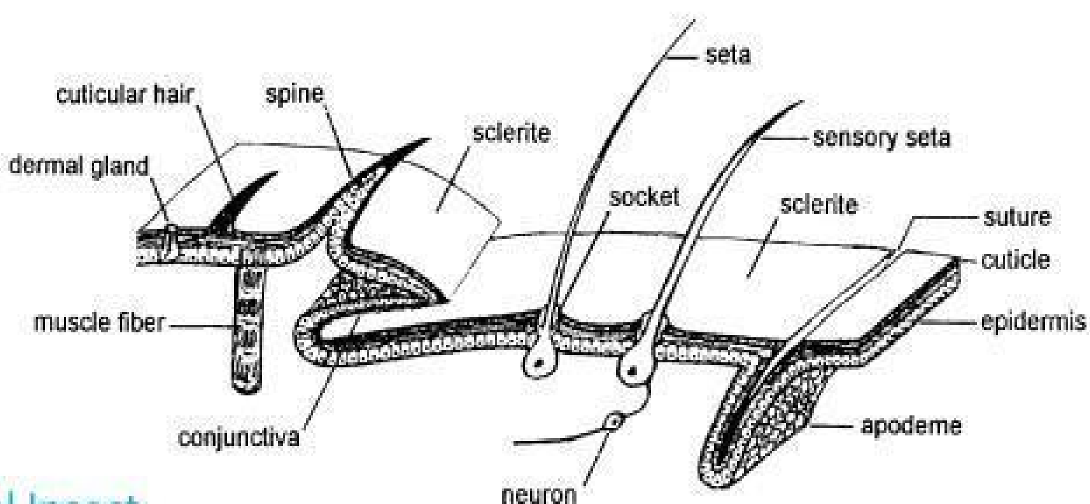
Phylum Arthropoda - 3:

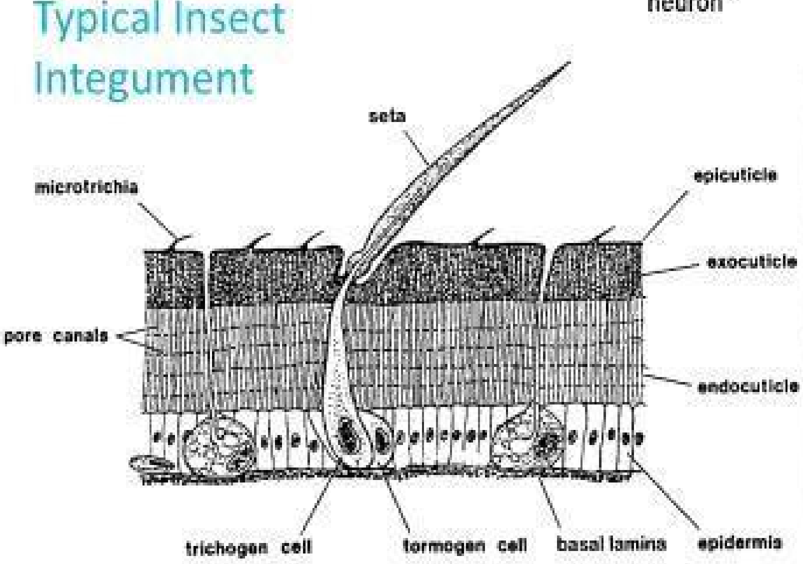
1) Bilaterally symmetrical
2) Jointed legs
3) Dorsal heart – open circulatory system
4) CNS (organized central nervous system)
5) Striated muscle

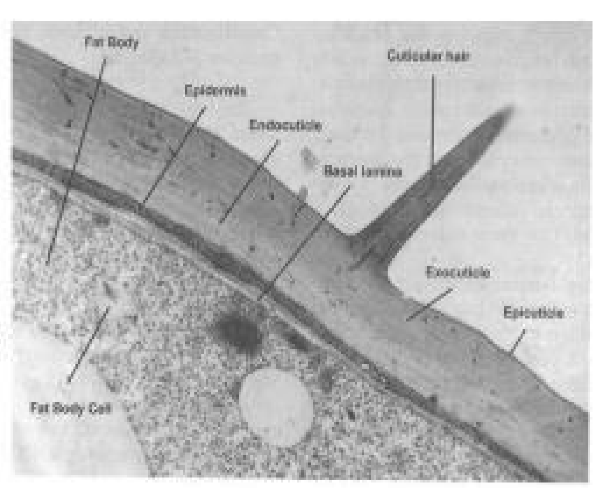


Insect Characteristics Insect Anatomical Characteristics THREE distinct body regions:

1) Head (feeding, sensory, CNS)
2) Thorax (locomotion, respiration)
3) Abdomen (feeding, reproduction)

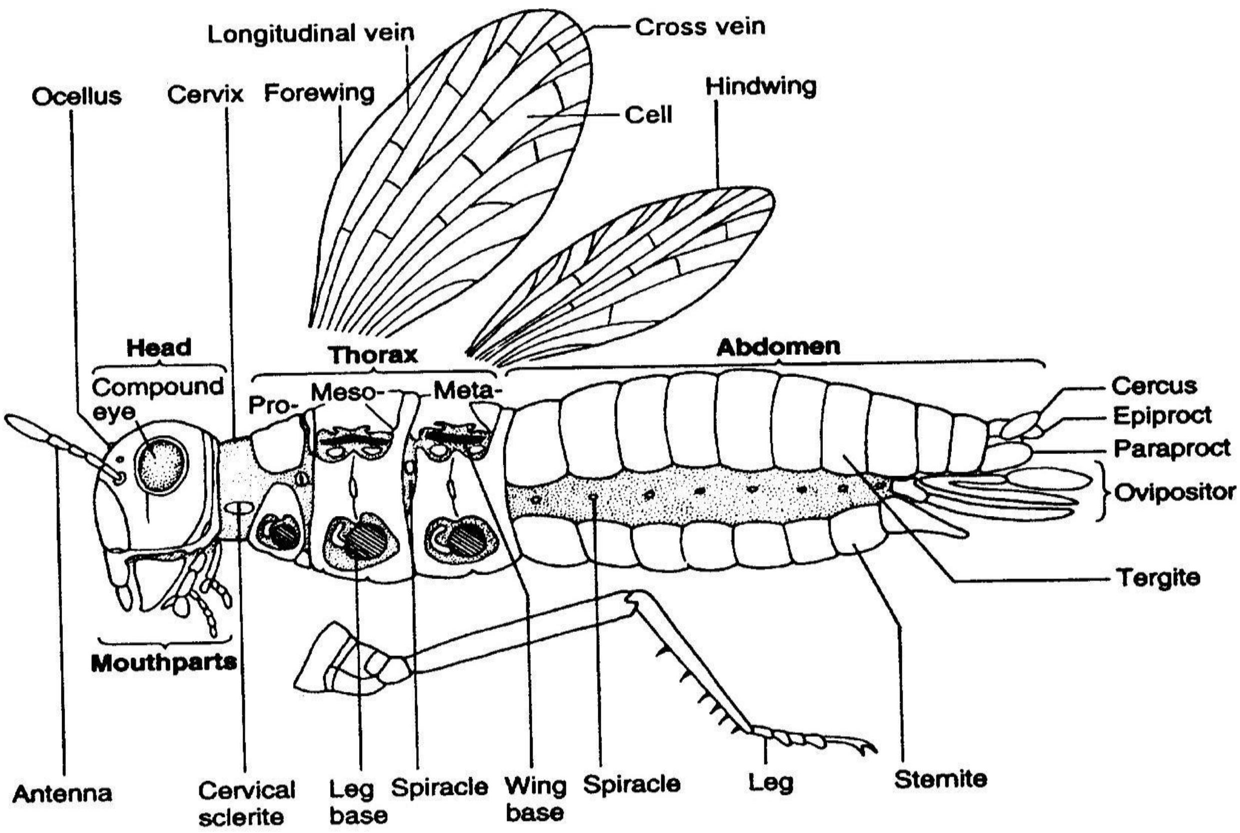




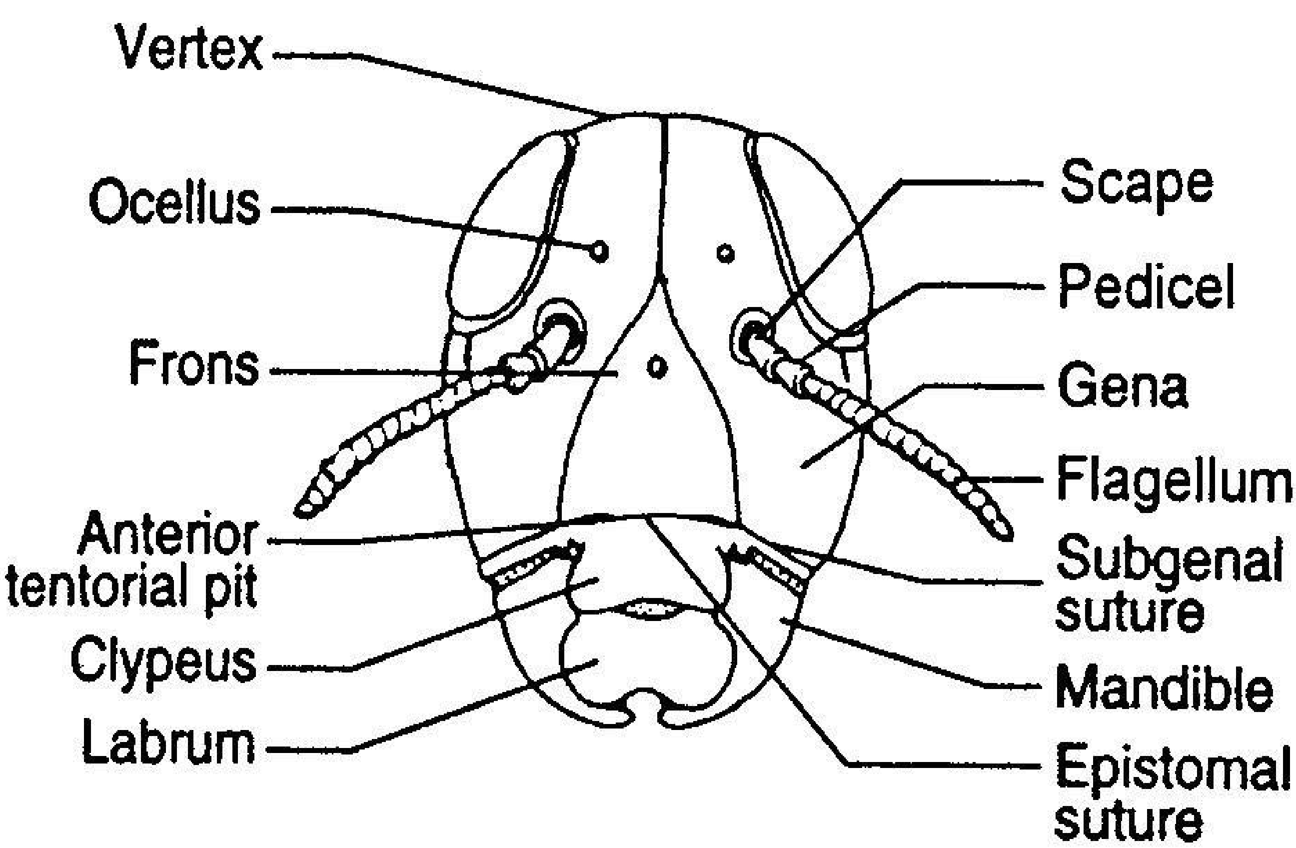


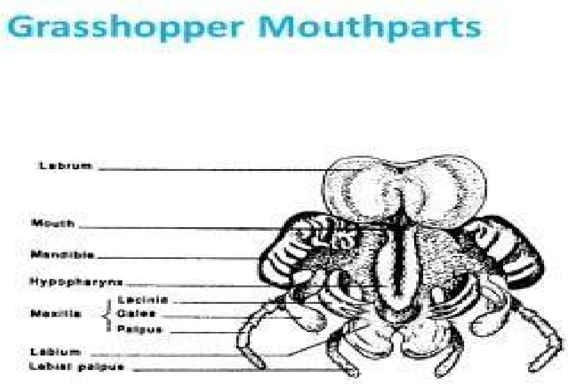
224 General Insect Structure

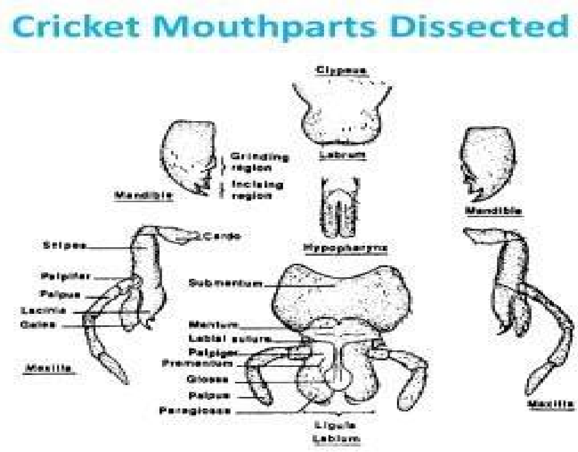
1.General Insect structure



2.General Insect Head

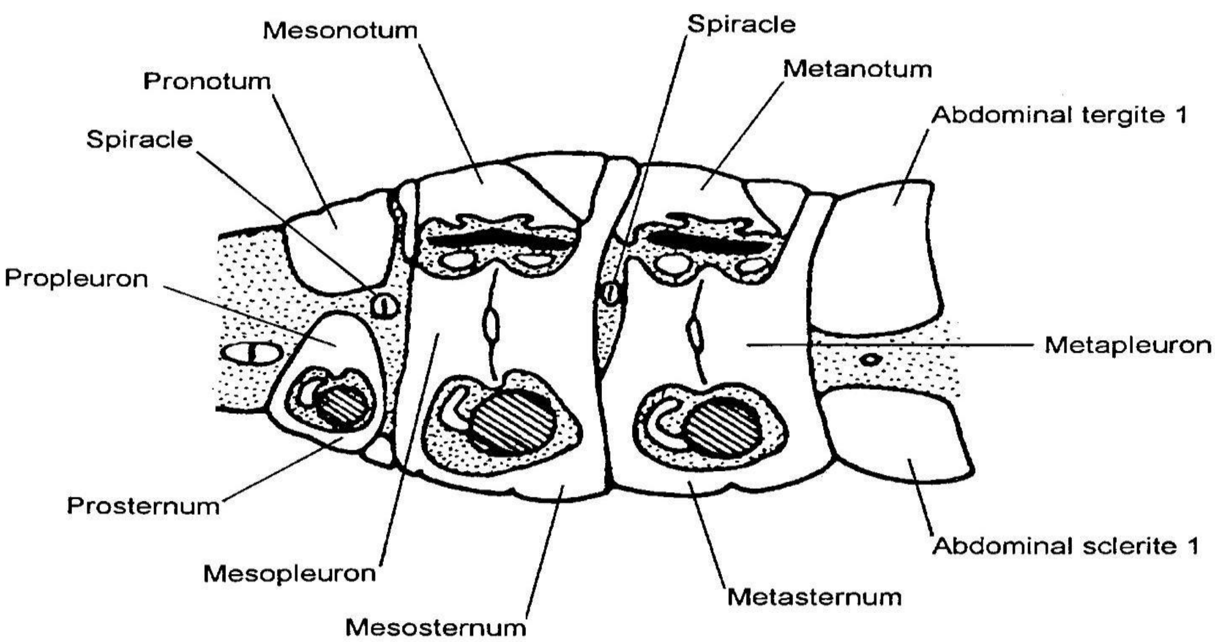




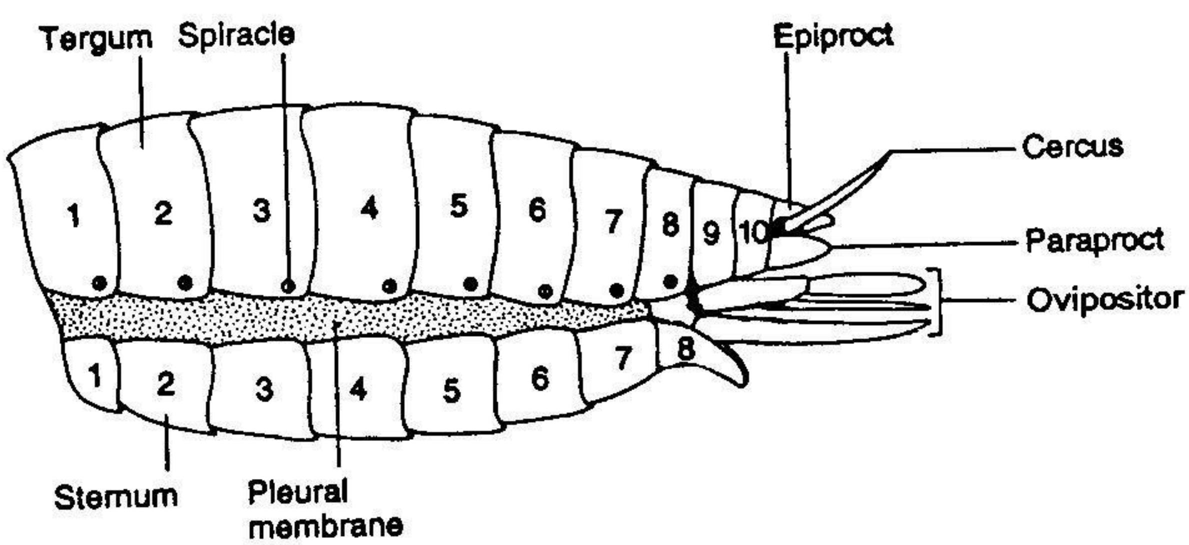


225 Insect Thorax

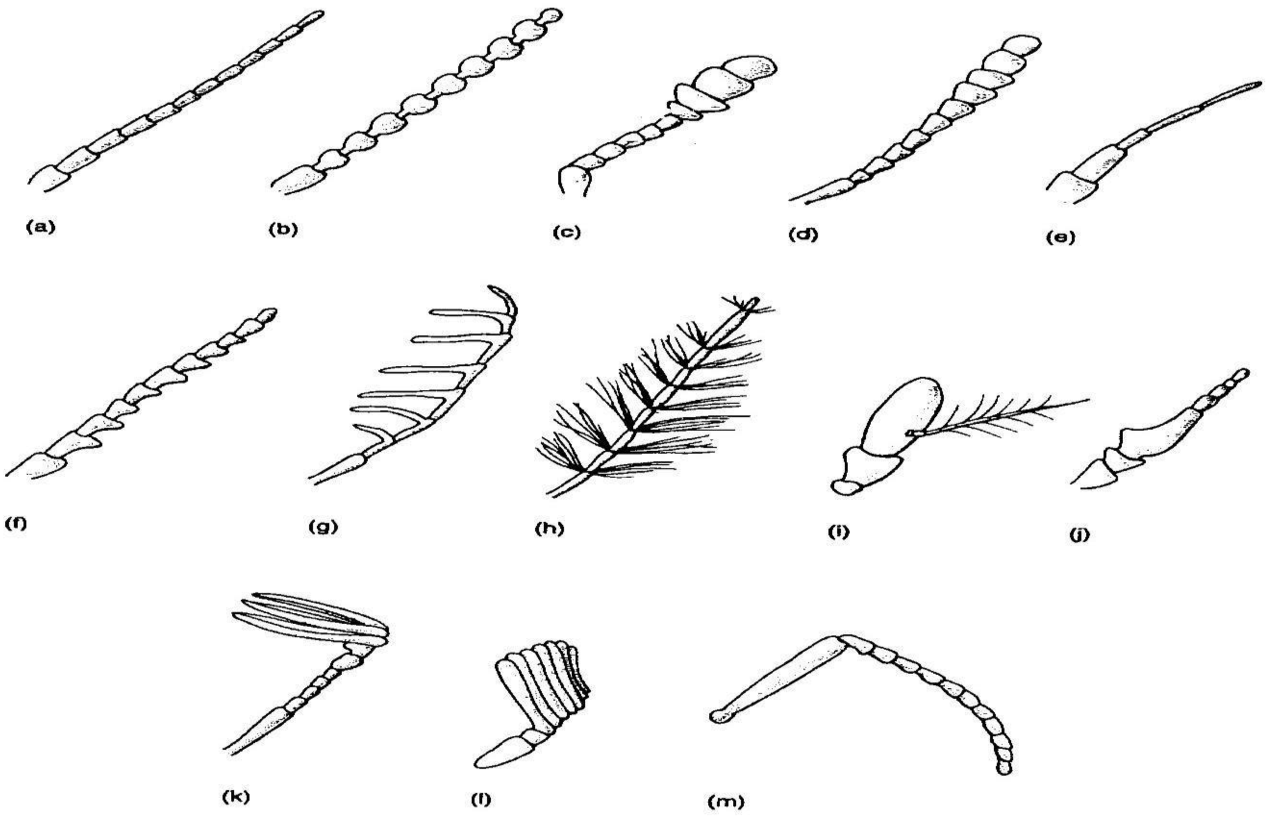
1. Insect Thorax



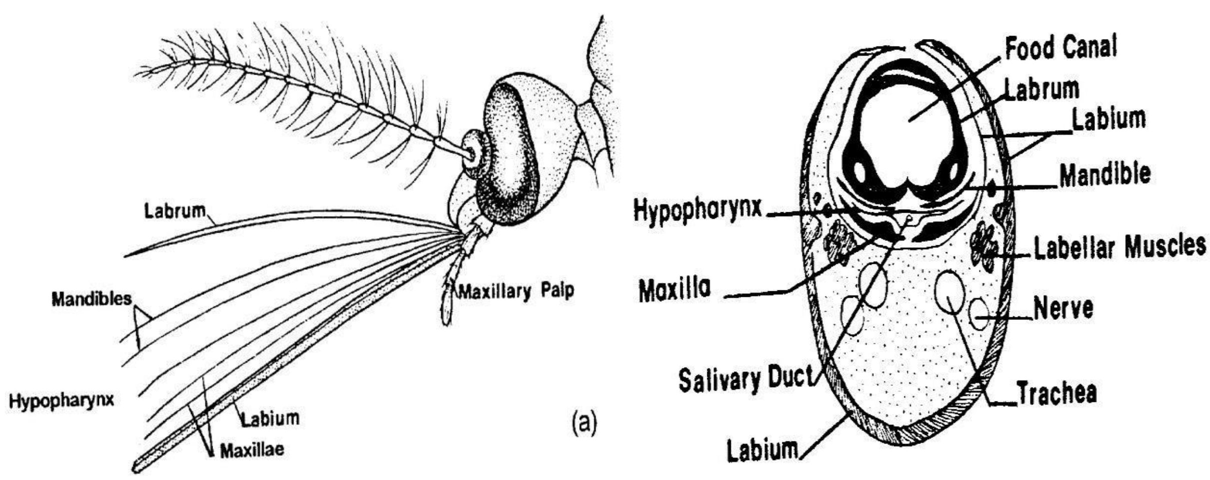
2. Insect Abdomen



3. Insect Antennae

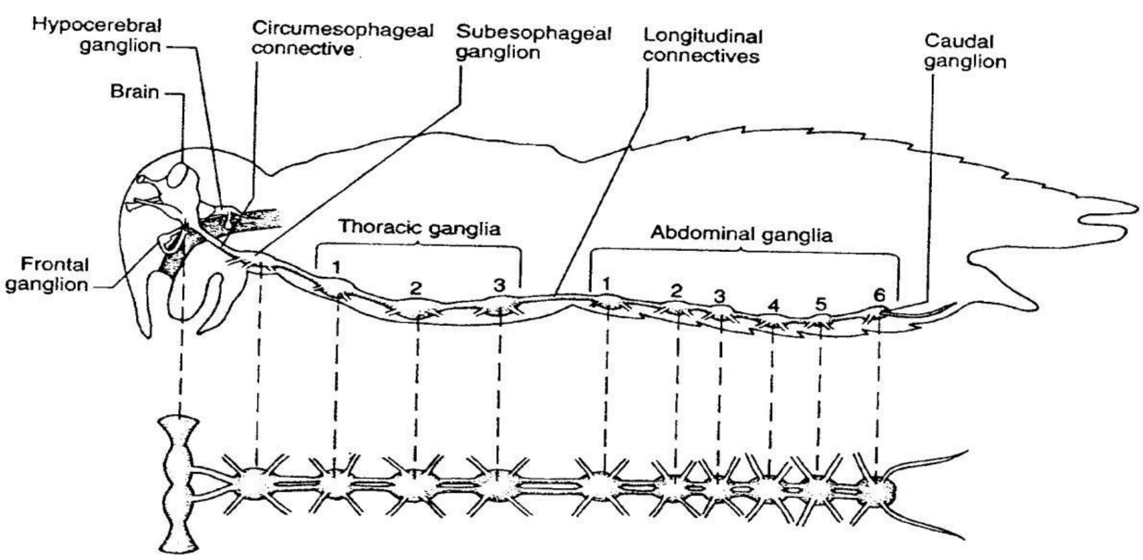


Piercing/sucking Mouthparts



226 Insect Nervous and Circulatory System

1. Insect Nervous System



2 Insect Endocrine Regulated Process

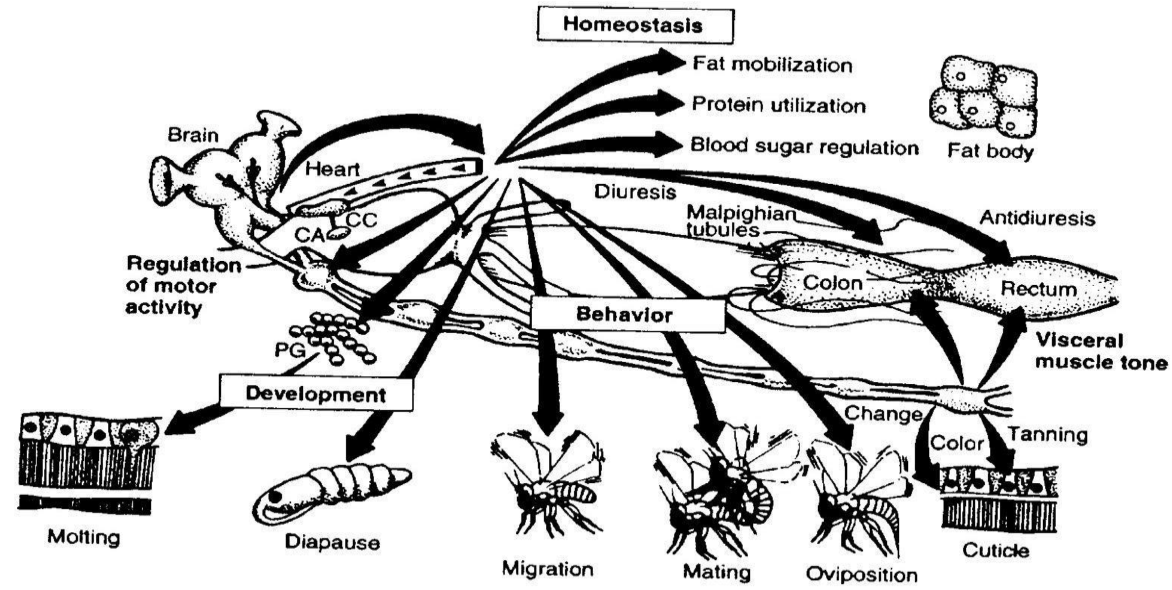
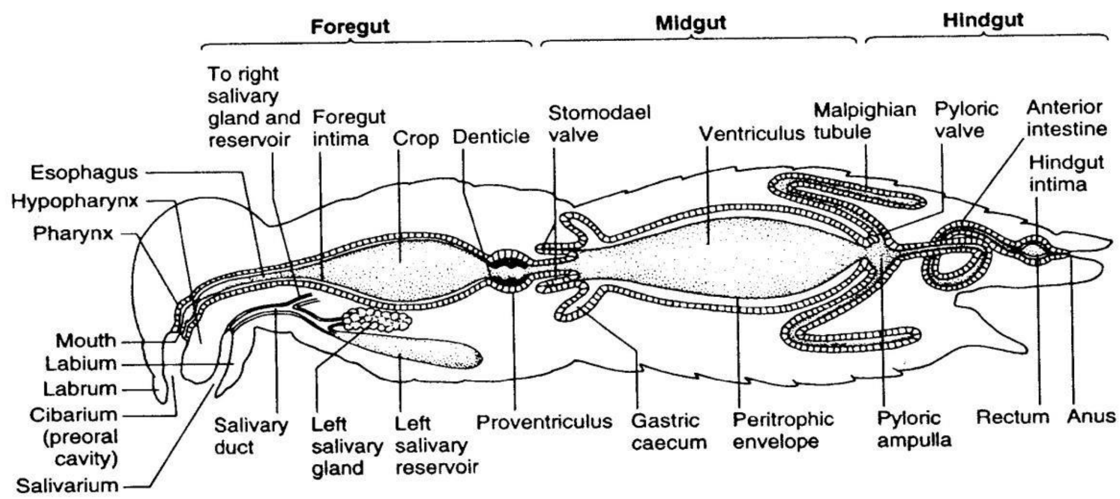
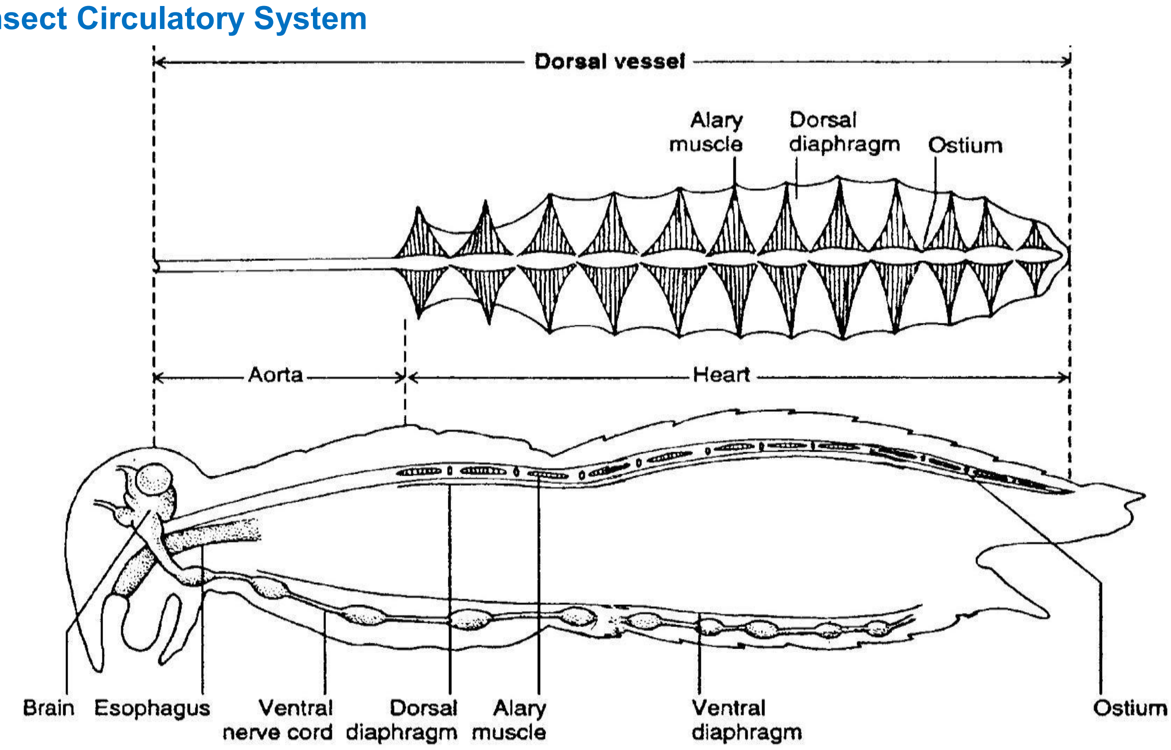


Figure 2.15. Endocrine regulated processes in insects (from Cook and Holman 1985, with permission from Pergamon Press Ltd., Headington Hill, Oxford, UK).

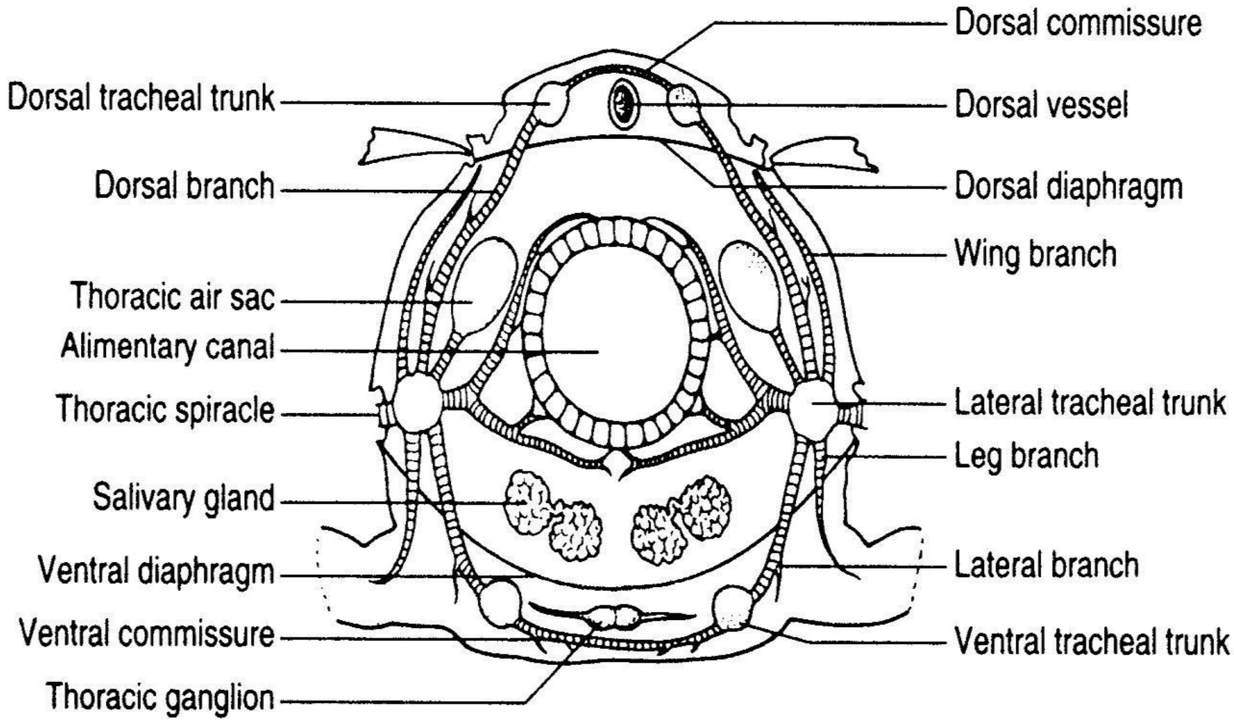
3 Insect Alimentary Canal



4 Insect Circulatory System

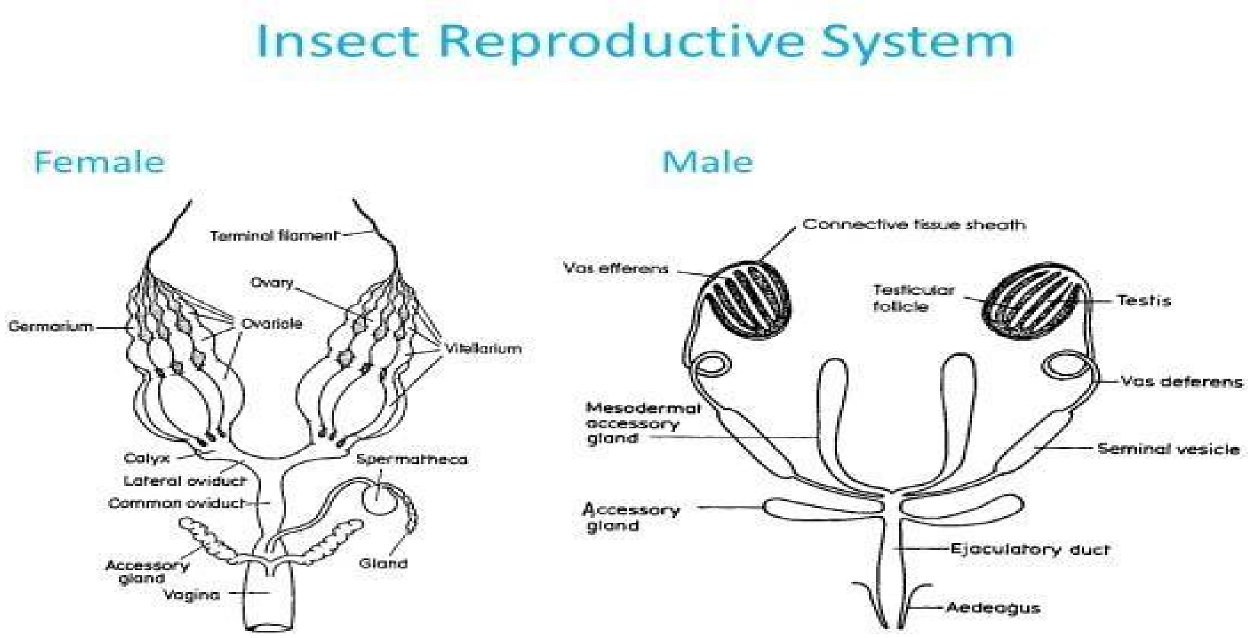


5 Insect thorax showing tracheal branches

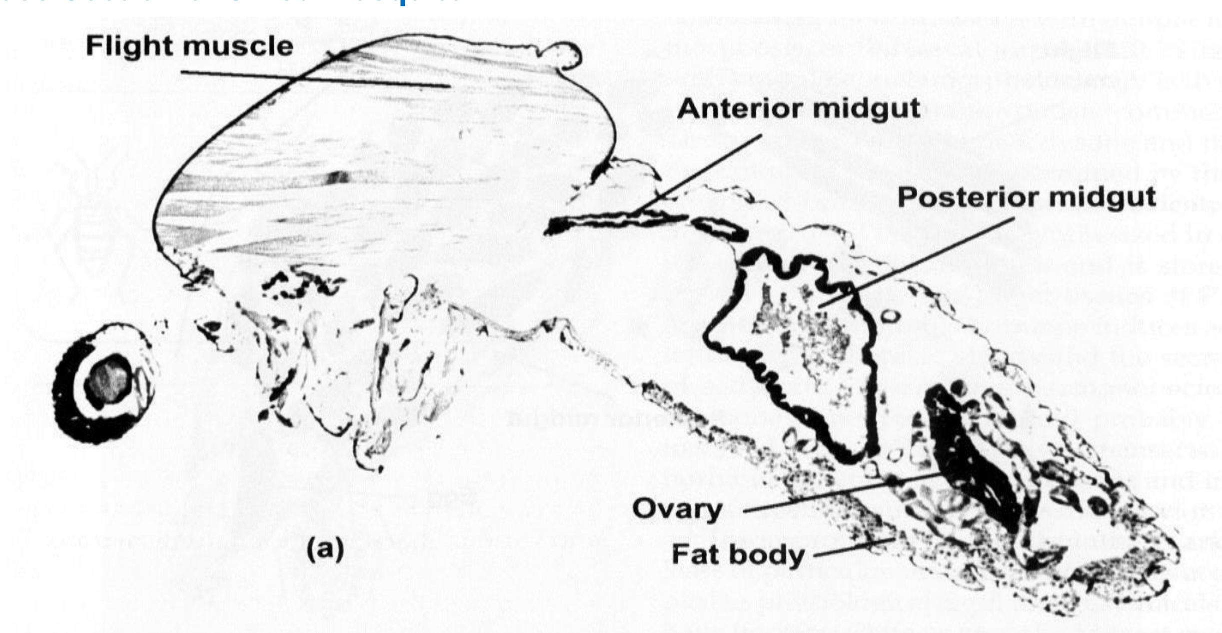


227 Insect Reproductive System

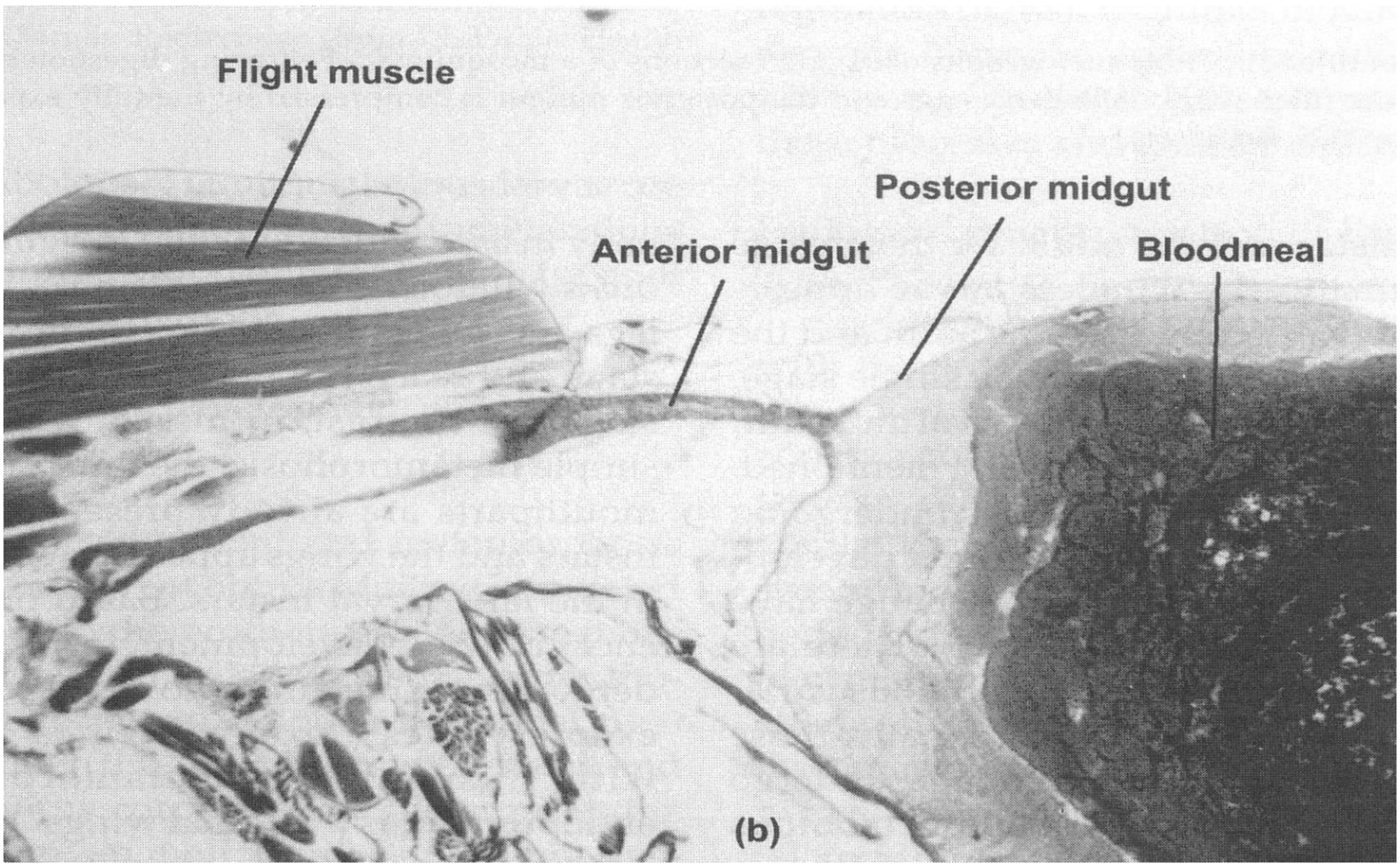
Insect Reproductive System



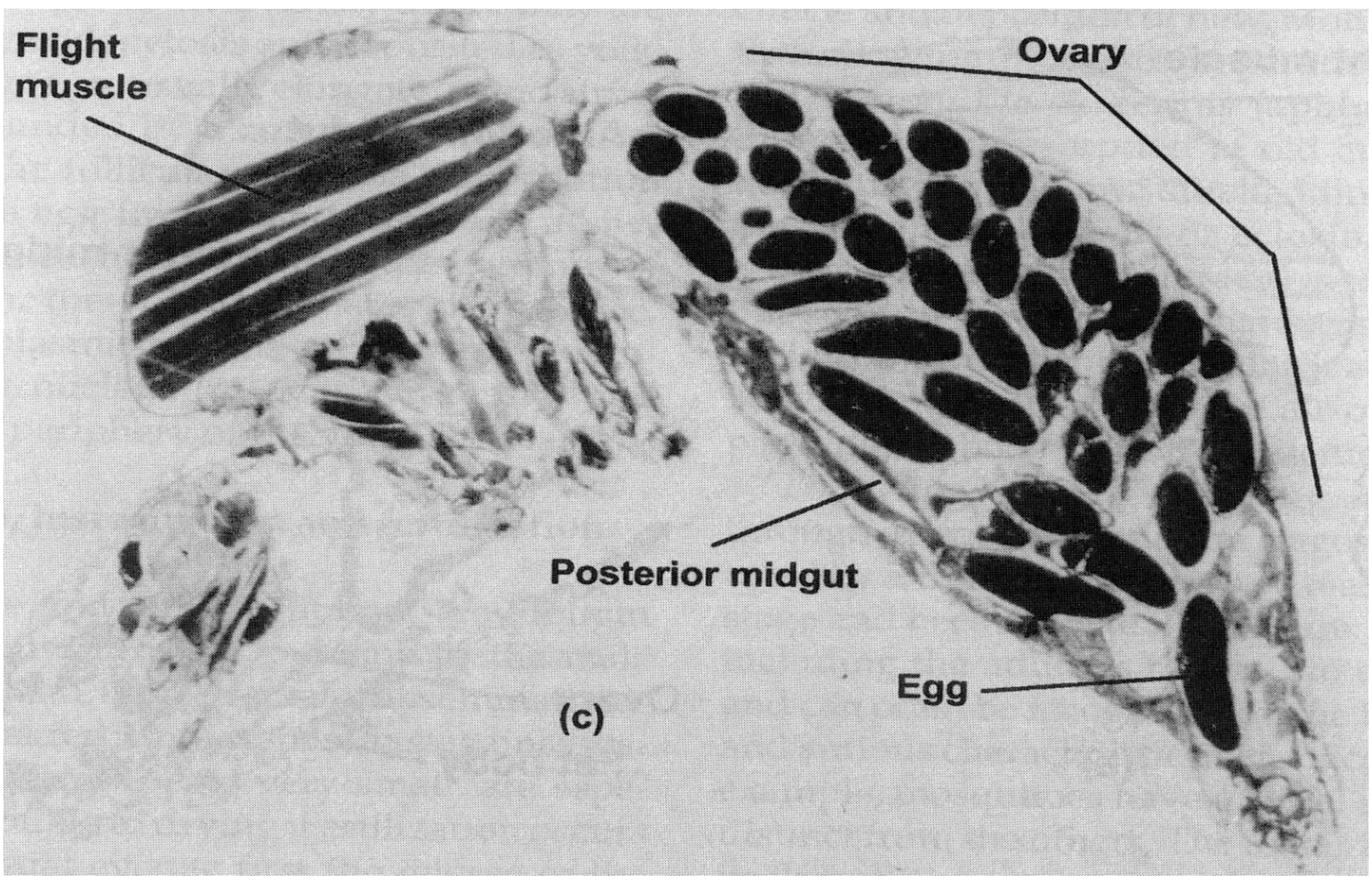
Cross Section of Unfed Mosquito



Blood fed Mosquito



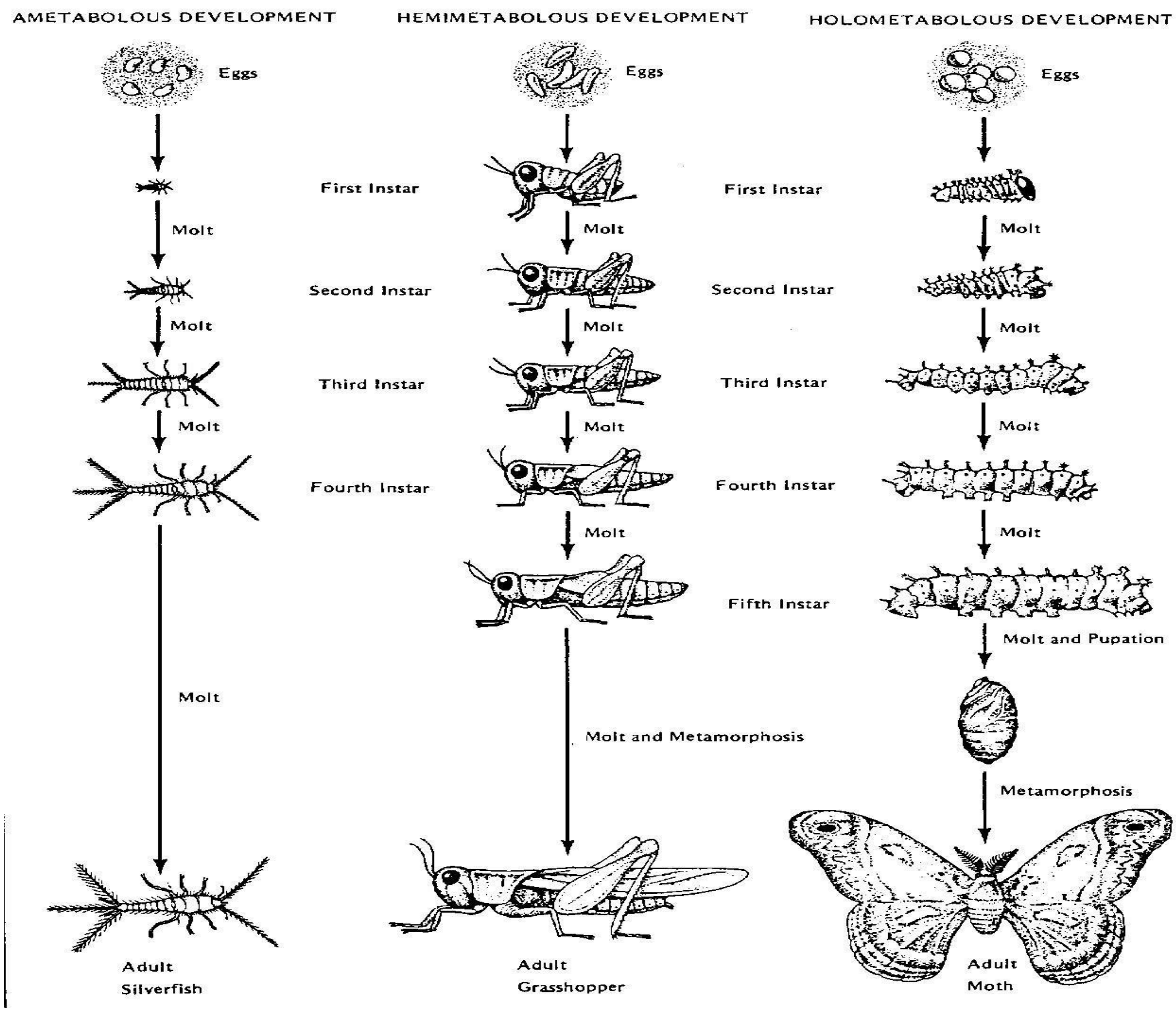
Gravid Mosquito



228 Types of Insect Development

Types of Insect Development

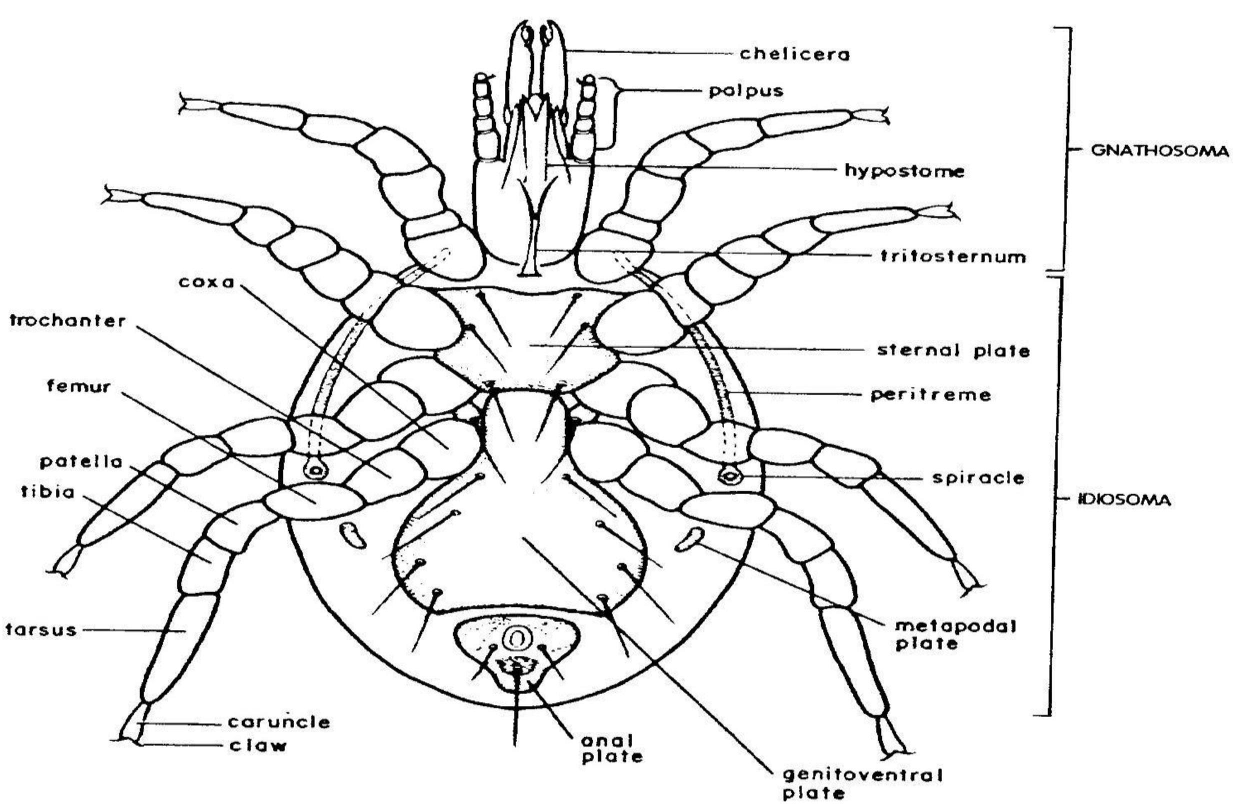
“A” – (lacking) “Hemi” -(incomplete) “Holo” -(complete)



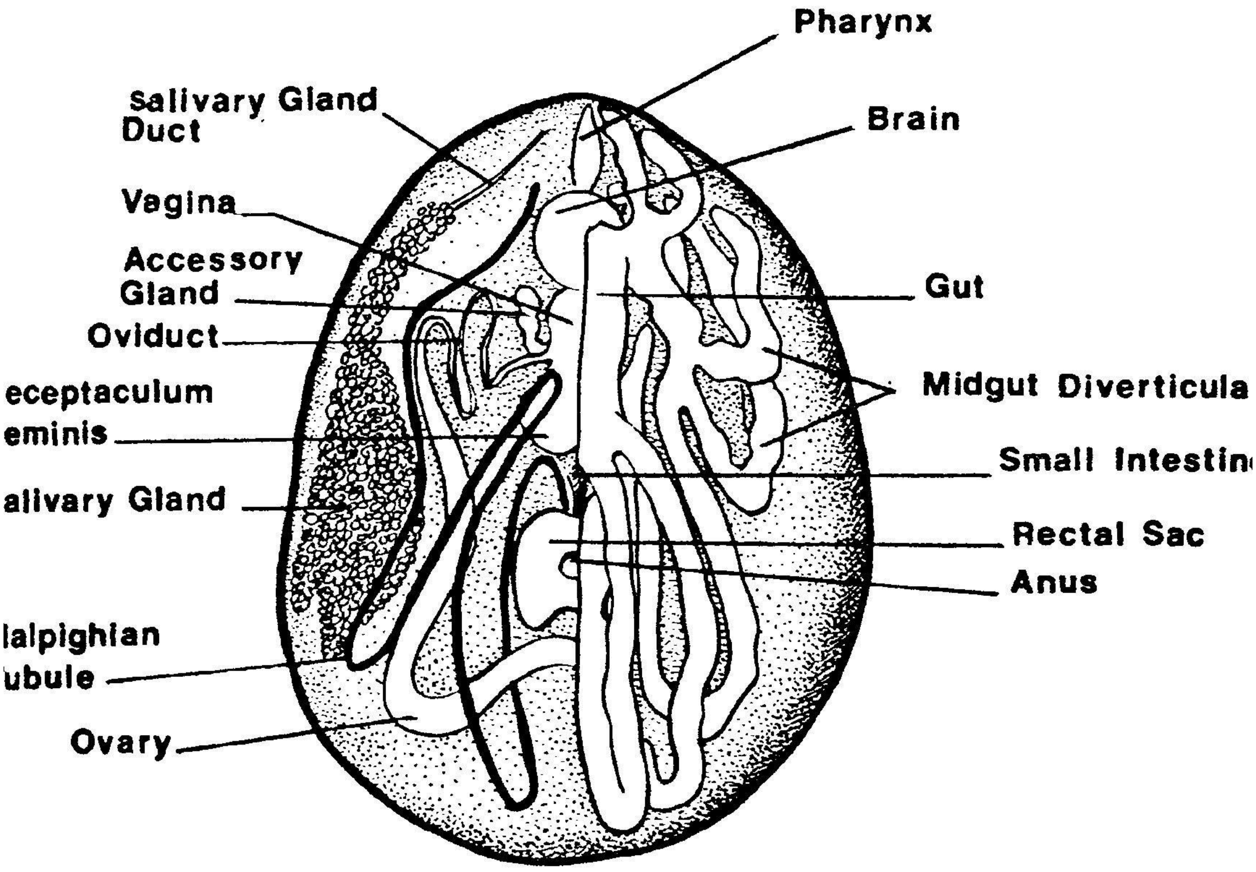
Other Medically Important Arthropods (non-insects)

Mite

External Anatomy

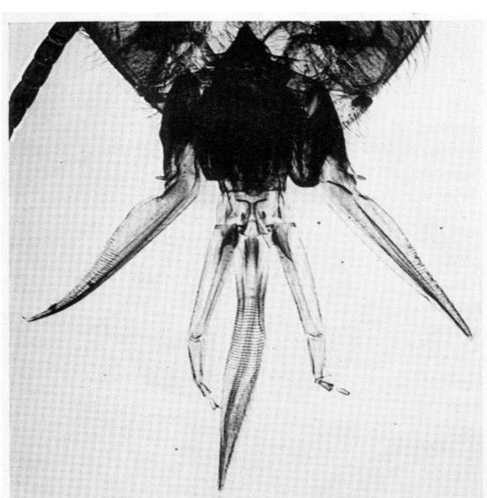


Tick Internal Anatomy

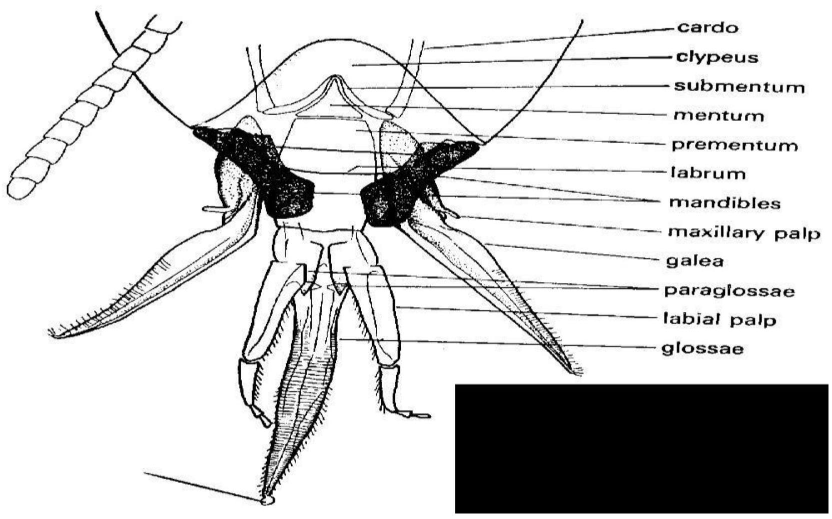


229 Insect Mouthparts and Their Importance

Insect Mouthparts and their Importance *Apis* (honeybee) mouthparts

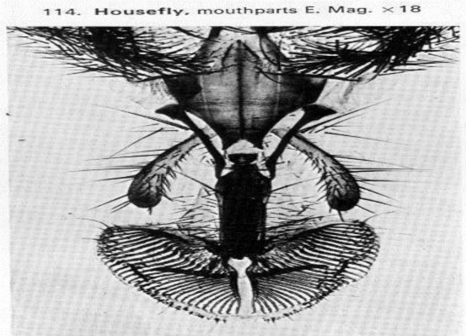


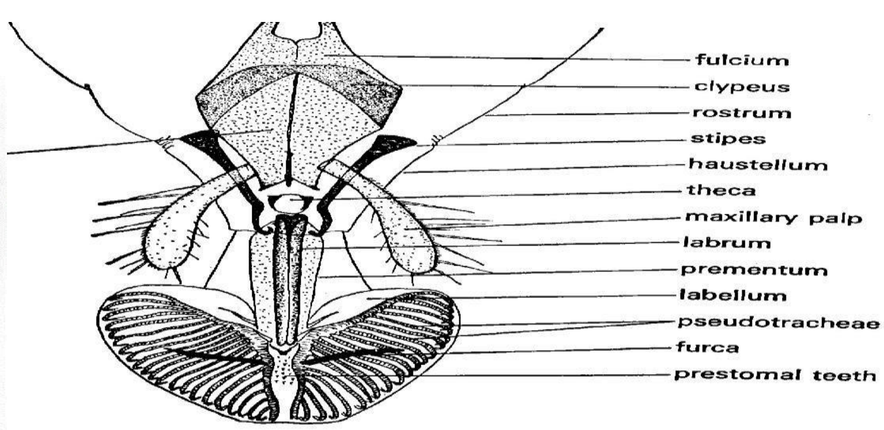
112. *Apis*, worker, mouthparts E. Mag. ×10



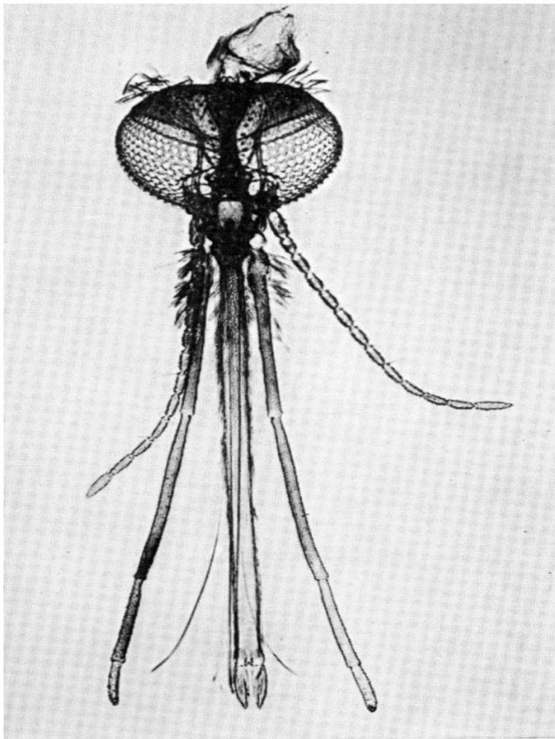
Housefly mouthparts

114. Housefly, mouthparts E. Mag. ×18

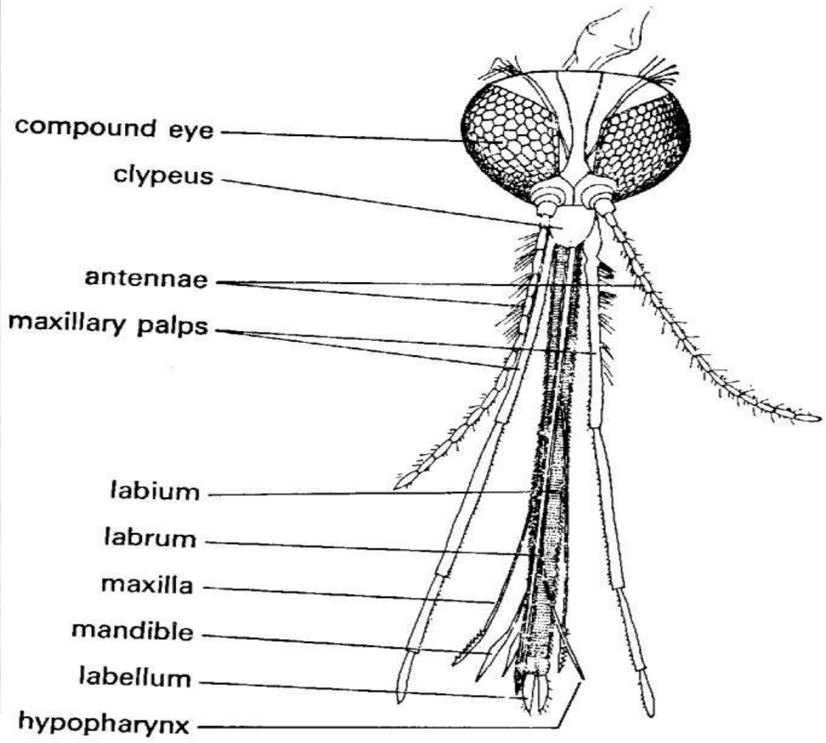




***Anopheles* (mosquito) mouthparts**



113. *Anopheles*, mouthparts E. Mag. ×12



230 Concepts in Vector Born Diseases 1

Concepts in Vector-Borne Diseases

Transmission efficiency:

- Geographic or host distribution of the parasite
- Incidence of any given parasite and associated host
- Parasite enhancement of transmission

Transmission frequency:

- Shorter life cycle of parasite = more frequent and more efficient transfer to be successful
- Both transmission efficiency and frequency related to blood feeding frequency and efficiency of the vector. These are important factors in vector capacity.

Host

reservoir host
disseminating host
dead-end (aberrant) host

Vector:

primary vector
secondary vector
maintenance vector

231 Concepts in Vector Born Diseases 2

Vector Biting Activity:

nocturnal
diurnal
crepuscular

Host specificity (blood meal source):

anthropophilic
anthropophagous
ornithophilic
ornithophagous
zoophilic

Feeding location:

1.exophilic

2.endophilic

Incubation periods:

- extrinsic incubation period (in arthropod vector)
- intrinsic incubation period (in vertebrate host)

Autogeny vs. Anautogeny

Number of blood meals:

ovarian scar/blood meal

parity status

Determines:

- age of vector
- blood feeding aggressiveness o vector importance

232 Types of Pathogen Transmission

Types of pathogen transmission:

1. mechanical
2. biological

Biological:

- propagative
- cyclopropagative
- cyclodevelopmental

Pathways of biological pathogen transmission:

Vertical transmission:

- transovarial transmission

Horizontal transmission:

- venereal transmission
- transstadial transmission

233 Intrinsic Barriers in Transmission

Intrinsic barriers to transmission in the vector - (genetically and environmentally controlled)

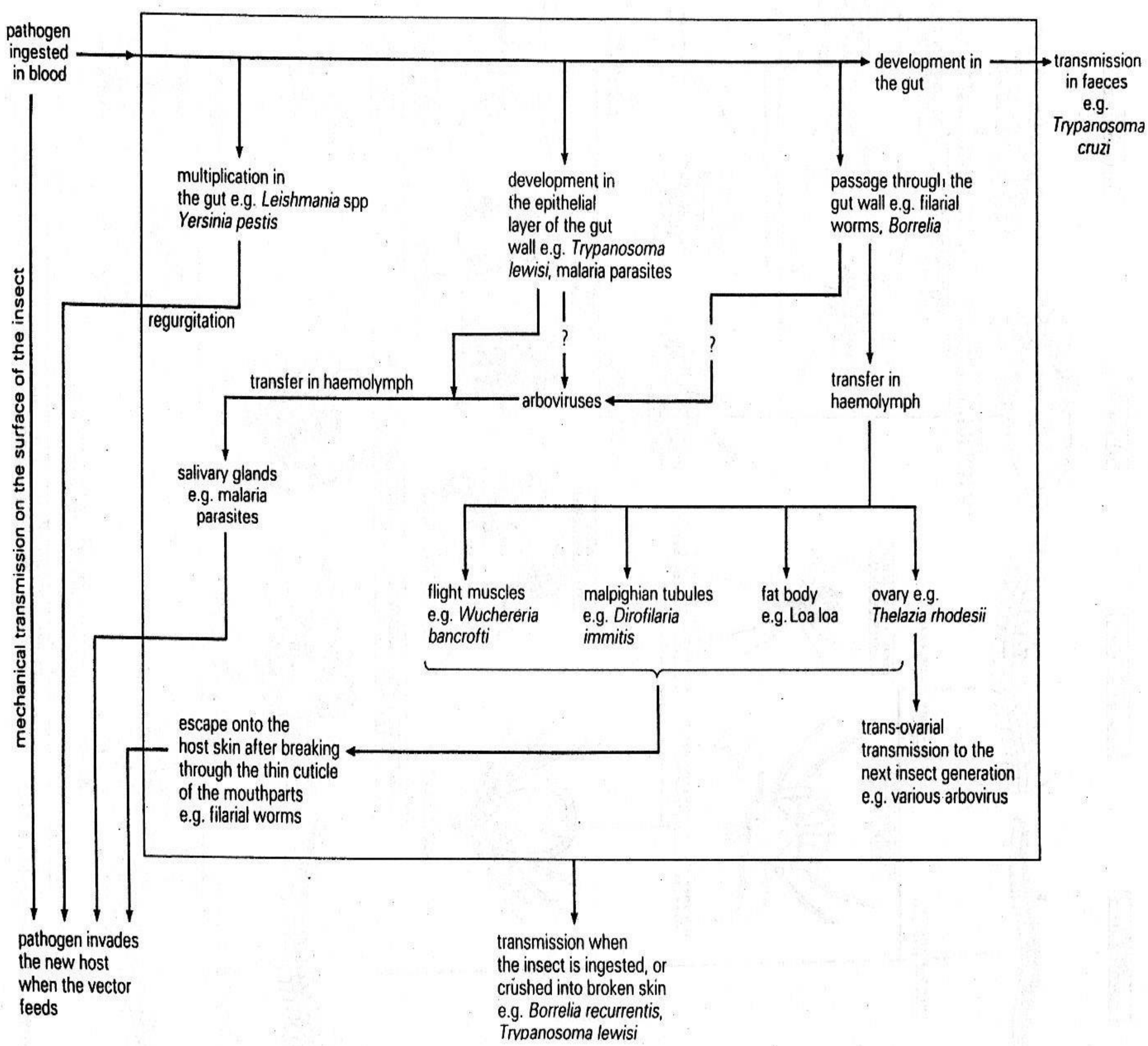
- midgut infection, midgut escape
- salivary gland infection, salivary gland escape ➢ insect immune

response, parasite encapsulation

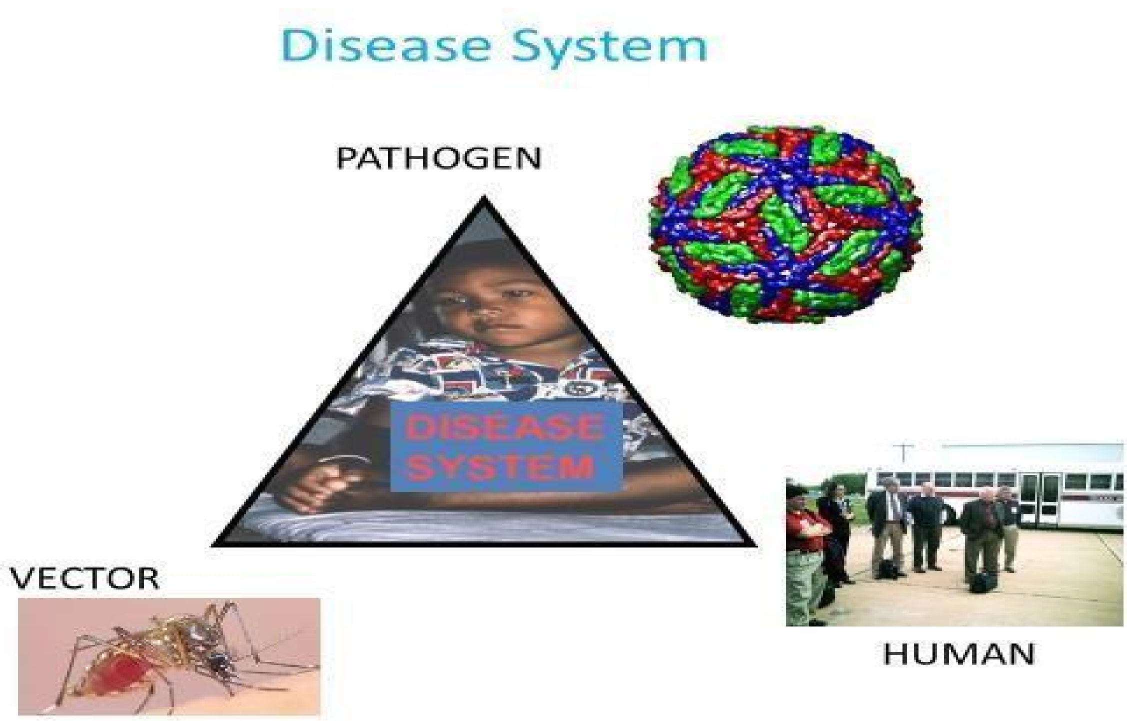
Vector competence vs. vector capacity

Capacity can be measured in the field using components of number of vectors per human, number of human blood meals per day per vector, daily survival rate, and the extrinsic incubation rate of pathogen; vector efficiency is expressed in terms of low - high capacity

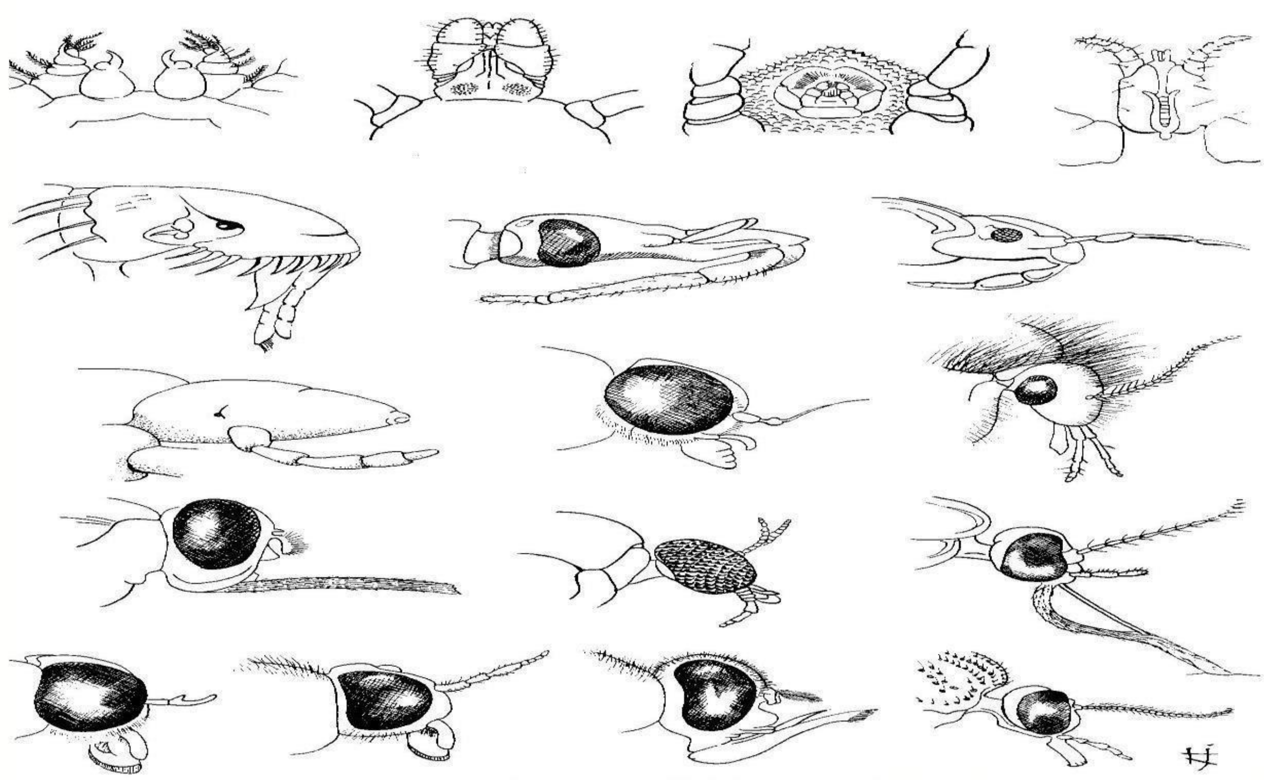
Competence can be expressed in the laboratory, but a competent lab vector is not necessarily important in disease transmission in the field.



234 Disease System



COMMON NAMES	SCIENTIFIC CLASSIFICATION	
	Order	Family
Arachnids		
Mite	Prostigmata and Mesostigmata	many
Chigger	Prostigmata	Trombiculidae
Tick	Ixodida	Ixodidae and Argasidae
Insects		
Bed bug	Hemiptera	Cimicidae
Kissing bug, vinchuca	Hemiptera	Reduviidae (subfamily Triatominae)
Fly	Diptera	many
Mosquito	Diptera	Culicidae
Black fly	Diptera	Simuliidae
Sand fly	Diptera	Psychodidae (subfamily Phlebotominae)
Biting midge, sand flea, sand fly, flying teeth, black gnat	Diptera	Ceratopogonidae
Snipe fly	Diptera	Rhagionidae
Horse fly, deer fly, cleg	Diptera	Tabanidae
Stable fly, dog fly	Diptera	Muscidae (species *Stomoxys calcitrans*)
Tsetse fly	Diptera	Glossinidae
Flea	Siphonaptera	many



235 risk from Insect Vectors

Risk from Insect Vectors

- **Background**
  - Overall death rate
  - Influenza in U.S. commonly 8.5% *per week*
  - Tuberculosis cases in U.S. 4.6 cases/100K
  - Traffic fatalities in U.S. 14.7/100K

Vector-Borne Pathogens

- Typhus

– 1996 Burundi 24K cases

– 1945-6 Japan and Korea 30K cases

– Historical outbreaks with millions

- Scrub typhus – Up to 20% of fever

- Chagas' Disease

– 18M cases of 100M in endemic areas

– Incurable chronic form

- Dengue

– 2000 cases/100K, reported cases lower

– 4 x increase 1975-1995

- Leishmaniasis – 57 cases/100K (350M at risk)

- Lyme disease – 31.6 cases/100K in 10 states

- WNV in US – 0.33 cases/100K in 2003

Malaria is King

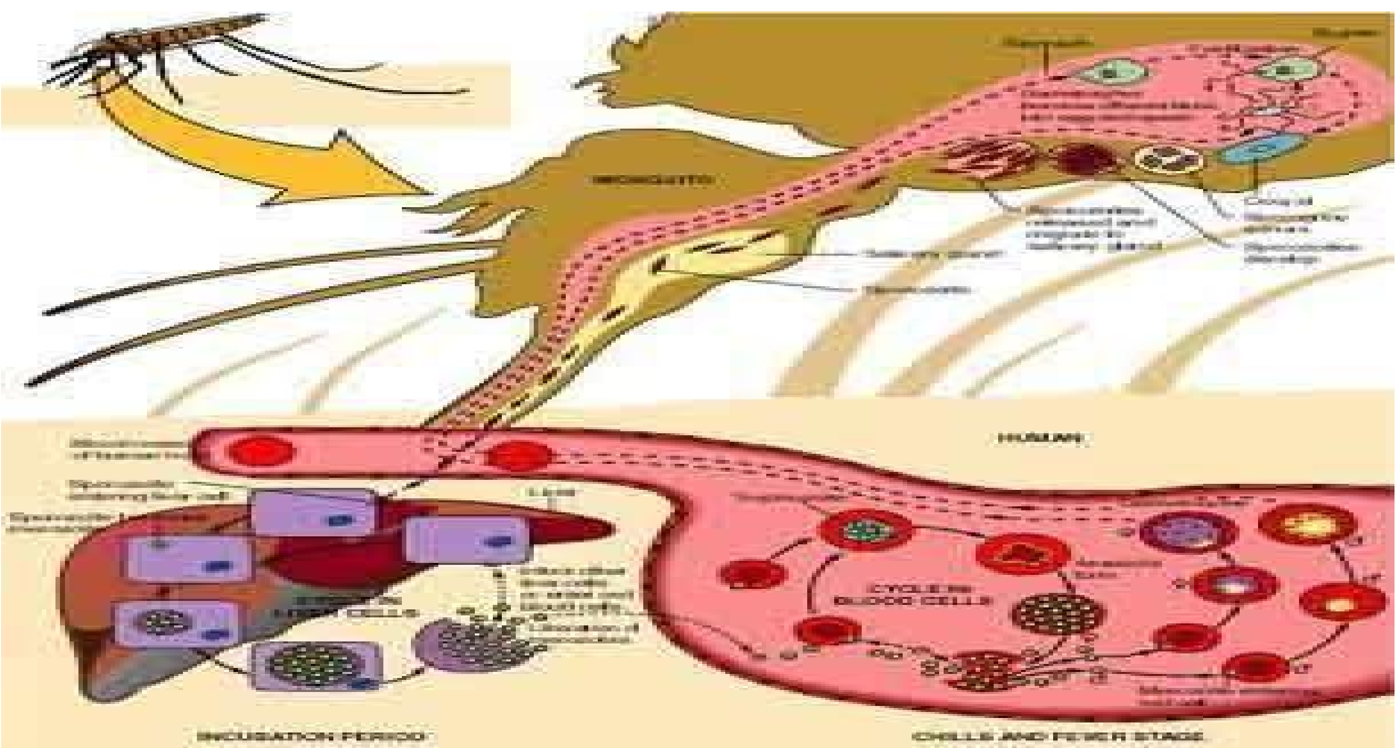
- Endemic areas (41% of world population)

– >14,228 cases/100K (350-500M/yr)

– >4.1 deaths/100K

– Accounts for 10.7% of childhood deaths

– Malawi: 28% of hospital deaths



236 Who is Responsible for This

Who is Responsible?

1. The individual
2. The local community
3. Local government
4. State government
5. National government
6. International organizations

Integrated Pest Management

- **Risk assessment**

– What you do to find out about the problem without on-the-ground measurements

- **Surveillance**

  – Direct measurements to find the target

- **Control**

  – The suite of techniques used to render the population

harmless – Hopefully integrated

Monitoring and Sustainability

– After success, then what?

– Our most common source of failure

Risk Assessment

- Much basic work can fit into this slot

  – Population biology

  – Genetics

  – Transmission biology

- **Global Information Systems**

  – What is adequately fine scale?

  – Integrate spatial analysis and modeling

- Products are localization, prioritization, and organization

Surveillance

- Sensitivity vs specificity
- Multiple methods often necessary
- How to handle dirty data
- Archival vs operational surveillance
- • Models

  – Scale of inputs and outputs

  – Consideration of communication (=politics)

237 Control of Pathogen Vectors

Control

- Stop them at their source
- Kill the population that remains
- Erect barriers against the ones you miss
- Advocate personal protection as the final layer of protection

Stop Them at Their Source

- **Household**

  Water sources
  Rodent harborage
  Access into the house
  Harborage in the house, animals

- **Community**

  Civil engineering, particularly drainage
  Zoning ✓ Economics

Wanted Dead or Dead Household – Outdoors

- Larvicides
- Barrier sprays, residuals
- Traps?

– Indoors

- Residuals
- Aerosols

- **Community**
  - Organized mosquito abatement
  - Organized campaigns against other vectors
    - Triatomines
    - Black flies

Good Fences Make Good Neighbors

Household

- Structure of walls, roof
- Screens
- Doors, interior and exterior

- **Community**
  - Screens (sand flies)
  - Barrier fogging
  - Barrier spray

238 Last resort or First Line of Defence

Last Resort or First Line of Defense

- **Personal**
  - Topical repellents
  - Clothing
    - Textile
    - Conformation
    - Chemical treatment

- **Household**
  - **Area repellent systems**
    - Passive chemical dispersion
    - Active chemical dispersion
  - **Excitorepellency**

Monitoring and Sustainability

Detect re-emergence of the problem

– Early detection –

Cheap to run

- Associated with other activities
- Inexpensive apparatus
- Clear interpretation

- **Resources and methods for response**
  - Mobile response team
  - Avoid need for new decision process
  - Informed public
- Political motivation in absence of active damage

Integrated Disease Management

- Objective is reduction or elimination of disease
- Considers medical interventions
- Intelligently applied, actions chosen to leverage IPM and medical

Challenges

- Public Health vs. Environmental Health
- Practical application of theoretical knowledge
- Communication and good will between action agencies

Additive Measures vs. Integration

- **Lintel vs. Arch**
  - Role of each piece
  - Strength of whole

Maintenance focus vs. expansion focus

Prioritization of targets
Attacking the life stages that matter most to transmission
Using most economical control of each element of disease system to achieve
IDM ✓ Breaking the chain of transmission

239 Scale of Problems

The Scale of the Problems

- **Macro: What's the point?**
  - Interventions limited (e.g., economics)
- **Meso: Getting to the point.**
  - Potentially powerful if cooperative forces unleashed
- **Micro: The point of the spear.**
  - Where interventions take place
  - Where all the action happens Where Does Research Fit In?
- Tends to form leadership positions
  - Most evidence based knowledge
  - Most scholarly knowledge
- Inherent communication gap between research and operations
- Problems solved through experience or experiments?
- Imagination and logic are rusty keys

Some Successes

1. 1890-1920: Transmission studies, mosquito abatement
2. 1942-1955: Antibiotics and pesticides
3. 1940s: Eradication of *Anopheles gambiae* 1940-1955: Elimination of malaria in US
4. 1950-present: Eradication of screwworm

5. 1940-1960s: Eradication of *Aedes aegypti*
6. 1950-1970: Reduction in malaria
7. 1980s-present: Reduction in *Onchocerca*
8. 2000s: Roll Back Malaria and PMI

Some Failures

1. 1980s-present: Resurgence of malaria
2. 1978-present: Expansion of dengue
3. 1980s-present: Reintroduction of *Aedes aegypti*
4. 1980s-present: Expansion of Lyme disease, ehrlichioses
5. 1986-present: Introduction and expansion of *Aedes albopictus, japonicus*
6. 1999-present: West Nile virus

What Does the Future Hold?

- **Negatives**
  - Global climate change
  - Exponential increases in introductions
  - Energy and nutritional impoverishment(failure)
- **Positives**
  1. Continuing discovery of interventions
  2. Management of wild habitats
  3. Intensification of agriculture
  4. Intensification of community effort
