Basic Principles of Forest Entomology

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Introduction

Insect comes from the Latin word insectum, meaning divided into "segments" (plural of insectum is insecta, used as the name of the taxonomic class that insects belong to).

The Greeks had coined this term Entomon for insects because of the clear division of insect bodies into three segments,

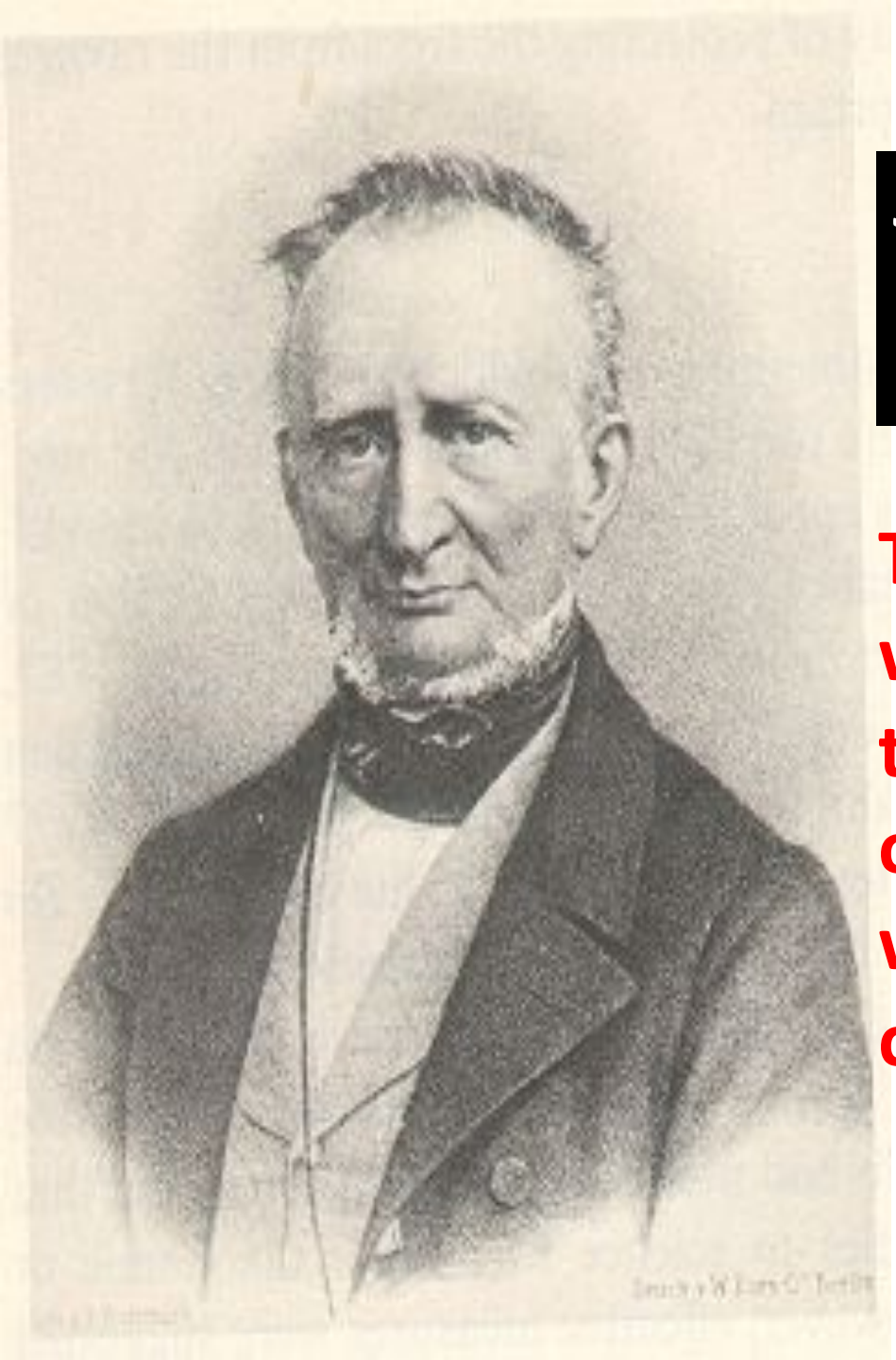
(i) Head
ii) Thorax
ii) Abdomen

Entomology

The branch of zoology concerned with the study of Insects, their origin, evolution, diversity and classification, body organization and functions, development, interactions with surroundings, history and their economic importance.

Forest Entomology

- The study of the Inter-relationship of insects and trees
- Includes damaging and beneficial species
- Does not include all insects in the forest
- Only those that affect health and use of trees



J.T.C. Ratzeburg (1801-1871)

Julius Theodor Christian Ratzeburg)

The study of forest insects which have an influence on the thriving and the utility of those wood plants with which the forester is concerned

Forest Entomology

Forest Entomology : It is concerned with Insects that affect the forest and forest products.

Forest Entomologist

- Forest Entomologist studies insects in forests, their damage to trees, interaction with plants and physical environment.
- Collection of Ecological information to reduce insect damage through forest management and silvicultural practices.
- Development of methods and conducting survey to determine insect abundance and insect impact.
- Development and use of biological enemies or other pest management techniques.
- Education on forest Insect pests and sound pest management Programme.

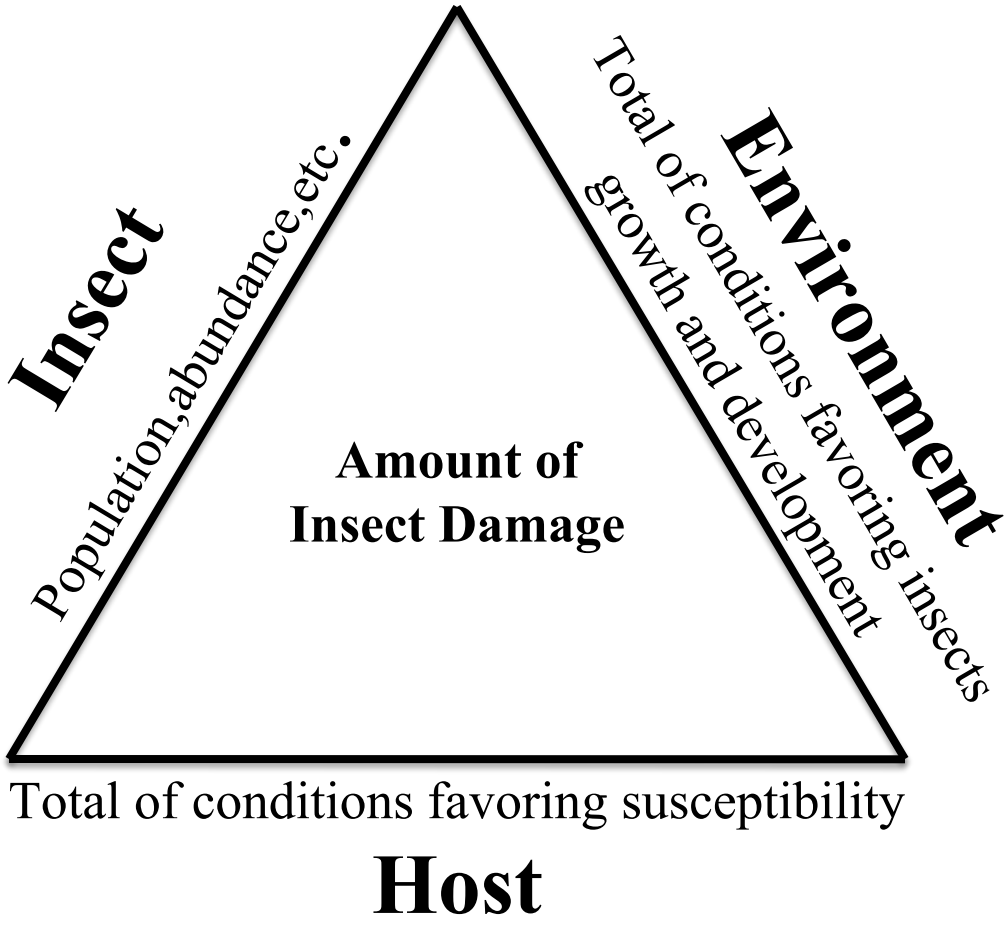
Forest Protection: It is concerned with minimizing the loss or other harmful effects, caused by harmful agents . Eg. Pests, Pathogens, Weeds and fire.

Forest Health: FH encompasses an array of issues relating to abiotic disturbances, nutrition, soil health, pests, diseases, invasive, fire and weather damage

History of Entomology In India

Period	References	
Ancient Time	Pathanga	Fleas, beetle, ants, silk worm , bees, flies
Modern India(18th Century)	*Systema Naturae* by Linnaeus in 1758	12 insects
1779 1782	Dr. J.G. Koenig Dr. Kerr (Lac insect)	Published special account on Termites of Thanjavaur District (TN)
1785	Asiatic Society of Bengal at Calcutta	100 of papers published
1800	Denovan published *Natural History of Insects*	
1875 1883	**Indian Museum, Calcutta** *Bombay Natural History Society* *J. Bombay Natural History Society*	Fauna of British India Appointment of Entomologists Agricultural Entomologist(1901), L de Nicevelle Forest Entomologist (1901) – E.P. Stebbing , C.F.C. Beeson

Amount of Insect damage is the result of an interaction of insect, susceptibility of the host and the conduciveness of the environment



Biological Interaction of Sal Heartwood Borer and Sal Tree

Inside Tree

Egg

Larva

Pre-Pupa

Pupa

Outside Tree

Adult

Appearance of Symptoms After Attack

Healthy Foliage in the Month of June

Falling of Foliage in the Month of December (4th Symptoms)

Wilted Foliage in the Month of September (1st Symptoms)

Brownish Foliage in the Month of November (3rd Symptoms)

Reddish Foliage in the Month of October (2nd Symptoms)

Insects and their Place in Animals Kingdom

Arthropoda

It is the largest Phylum of the animal kingdom. The arthropods possess jointed legs, each terminating into a claw, a characteristic not to be found in any other group of invertebrates. Moreover, these animals have a chitinous exoskeleton and their body is divided into segments which are discernible externally, but may be fused internally.

Insecta

- A class of the phylum Arthropoda comprising nearly those that breath by spiracles and trachea and have the body divided into a distinct head, thorax, abdomen, bearing a pair of antennae and usually compound eyes.
- In all these the thorax consists of three segment with three pairs of legs, the abdomen is segmented and without legs.
- Most insects have two pairs of wings on the thorax and some have secondarily lost one or both pairs.
- In addition to the above features insects have the general characteristics of all the Arthropodes viz., exoskeleton etc.
- Insects form the largest known group of animals consisting nearly one million species . (Linnaeus, 1758), ICZN.

Insect

- The insects are tracheate arthropods in which body is typically divided into three parts, namely head, thorax and abdomen.
- They posses one pair of compound eyes, one pair of antennae, two pair of wings generally, and three pairs of legs and they have their reproductive apertures placed at their end of abdomen.
- They grow and change by a serious of molting a process known as metamorphosis.
- This is the largest group of animal kingdom and , one million species of animals that have been

CLASS INSECTA (32 Orders)

Subclasses

APTERYGOTA

orders

1.PROTURA

2.COLLEMBOLA

3.DIPLURA

4.Zygentoma
=THYSANURA

5.Archeognatha

PETERYGOTA

divisions

EXOPTERYGOTA

orders

1. ODONATA
2. EPHEMEROPTERA
3. PLECOPTERA
4. EMBIOPTERA
5. PHASSMIDA
6. ORTHOPTERA
7. DERMAPTERA
8. GRYLLOBLATODEA
9. MANTOPHAMATODEA
10. ISOPTERA
11. BLATTODEA
12. MANTODEA
13. ZORAPTERA
14. PSOCOPTERA
15. PHTHIRAPTERA
16. THYSANNOPTERA
17. HEMIPTERA

ENDOPTERYGOTA

1.COLEOPTERA
2.NEUROPTERA
3. HYMENOPTERA
4. TRICHOPTERA
5. LEPIDOPTERA
6. MECOPTERA
7. SIPHONAPTERA
8. STREPSIPTERA
9. DIPTERA

Insect Growth and Development

Insect Growth:

- **Insects are enclosed in an exoskeleton, they must "shed their skins", to grow larger.**
- **The molting process in immatures and the transformation from larva to pupa to adult is regulated by hormones**
- **ecdysone (molting hormone) secreted by the prothoracic gland; it stimulates shedding of the cuticle.**
- **juvenile hormone (JH) is secreted from the corpora allata and it suppresses adult characteristics. As growth during each stage triggers secretion of ecdysone, if juvenile hormone is present, the cuticle is shed and replaced, and the insect reaches its next juvenile stage. As the immature insect grows and eventually discontinues production of juvenile hormone, secretion of ecdysone in the absence of JH triggers pupation and subsequent development of adult form. An application of understanding these processes: Synthetic juvenile hormones have been developed for use as insecticides that disrupt insect development and cause death.**

Development: Metamorphosis (change in form). Four types of metamorphosis are recognized for insects:

- **Ametamorphosis**
- **Gradual metamorphosis**
- **Incomplete metamorphosis**
- **Complete metamorphosis**

I. **Ametamorphosis:**

Changes in form during growth are minor; all immature stages resemble adults. Immatures are called juveniles. Eg. Springtails and silverfish.

2. **Gradual metamorphosis:**

Change in form is gradual, with the most obvious changes involving the development of external wing pads and differences in color or markings. Immatures are called nymphs. eg. Grasshoppers and Crickets

Incomplete metamorphosis:

Transition to adult form is gradual. Immatures are called naiads. . Immixtures do not closely resemble adults. Eg. Mayflies and dragonflies.

Complete metamorphosis: Immatures are called larvae and pupae. . Larvae do not resemble adults. Wings and other adult features develop during an immobile pupal stage. Immatures and adults may or may not share habitats. Eg.

butterflies, moths, beetles, flies, ants, bees, wasps, etc

Surviving adverse conditions

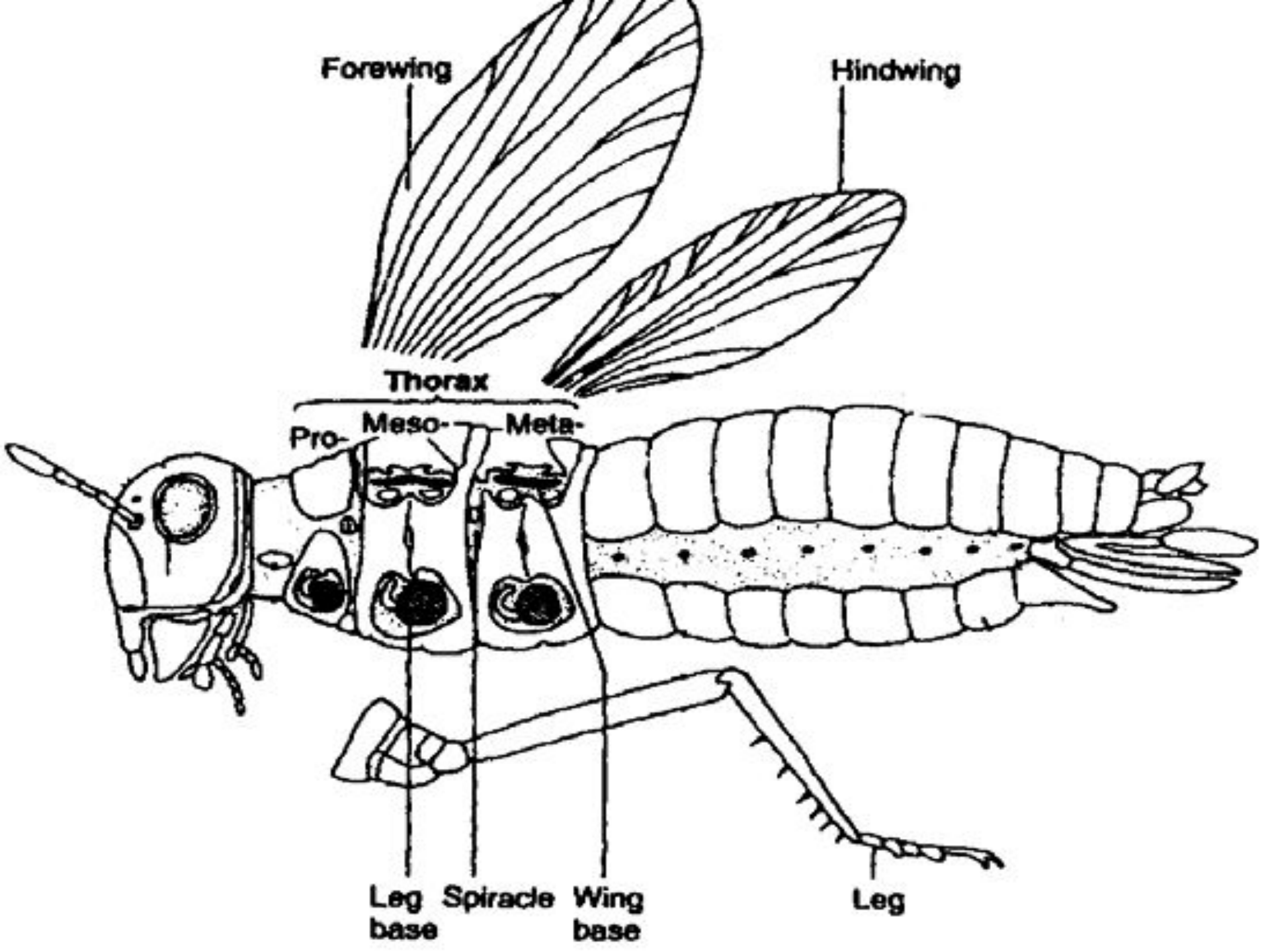
Quiescence: Immediate inactivity in response to unfavorable conditions.

Dormancy: Seasonally recurring suppression of growth, development, and/or reproduction

Diapause: Dormancy (sometimes delayed) invoked by an environmental condition that does not immediately limit development (often day length [photoperiod]). Once invoked, diapause usually continues for predetermined period

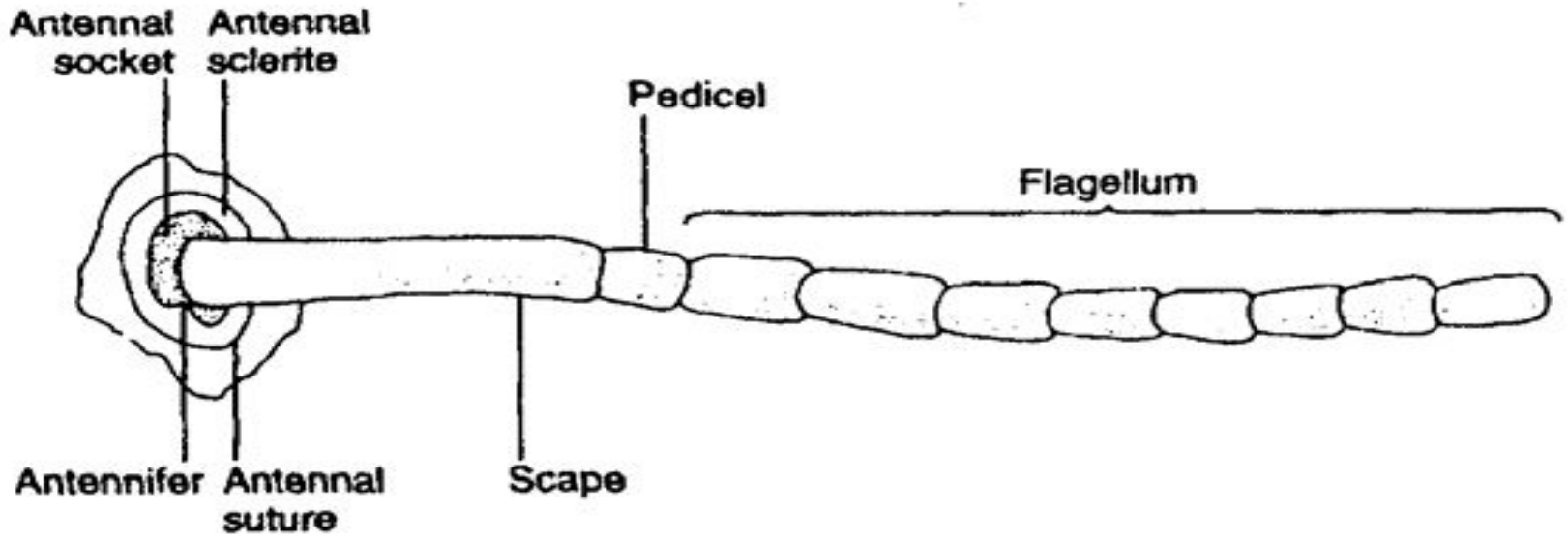
Technical Terms

Adult	Insect that has completed its fiinalstage of metamorphosis
Antenna	Sensory appendage
Cocoon	Silky protective case formed by larvae for pupating inside
cuticle	Non-cellular outer covering of the body of the insect
Exuviae	Cuticle stripped off by an insect at moulting
Grub	Soft –bodied aad C-shaped larva of some beetle burrowing in wood or soil
Instar	Any of various forms between moults of an immature insect
Larva	Immature stage between the egg and pupal stage
Maggot	Headless and legless larva
Moult	Shedding of old cuticle
Nymph	Juvenile form of an insect with incomplete metamorphosis
Ovipositor	Composite structure in female insects for laying eggs
Pupa	Motionless and covered stage between larva and adult of insect
scale	Small cuticlar outgrowths which from the outer covering of the cuticle
Spiracle	One of the several small opening through which air is taken in and expelled in respiration
Proboscis	Tubular sucking organ formed by the modification of various moth parts
Ocellus	Small eye of an insect
Elytron	Forewing of the beetle , modified into hard sheath- like structure


Forewing
Hindwing
Thorax
Pro-
Meso-
Meta-
Leg base
Spiracle
Wing base
Leg

ANTENNAE

Antennae vary greatly among insects, but all follow a basic plan: segments 1 and 2 are termed the scape and pedicel, respectively. The remaining antennal segments (flagellomeres) are jointly called the flagellum.



Functions

Antennae function almost exclusively in sensory perception. Some of the information that can be detected by insect antennae includes:

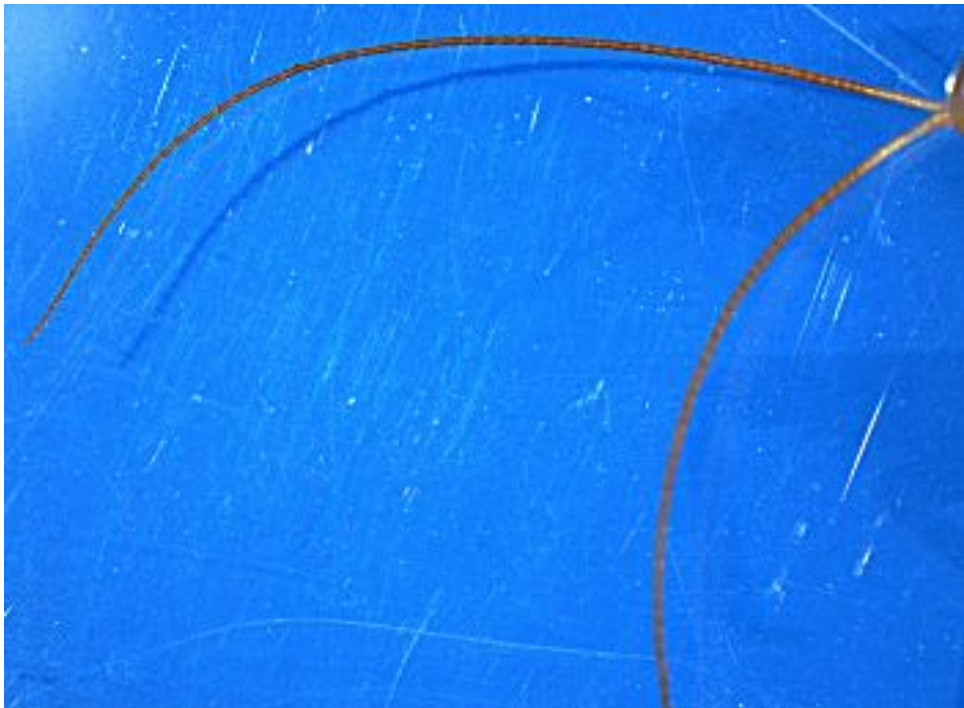
- Motion and orientation
- Odour
- Sound
- Humidity
- Variety of chemical cues

Types of Antennae

Moniliform: Antennae look like strings of beads. The segments are usually spherical, and uniform in size.

Filliform:

The segments are usually elongated and uniform in size.



Setaceous: There are many joints. The antenna tapers gradually from the base to the tip. e.g. Cockroaches, Mayflies Stoneflies

Serrate: the segments are angled on one side giving the appearance of a saw edge e.g. Beetles.

Insect Origin – Geological Age

Name of Geological Age	Period in Million Years	Remarks
Silurian Period	443 - 417	Ice age, although few insect like creature have been recorded, but doubtful
Devonian period	417 - 354	Profound changes in Ecosystem , Fossils record on Insects
Carboniferous period	290 - 354	1. Earliest Fossil records on Insects, 2. 10 orders of Insects become extinct 3. Total number of Insects recorded were 10,000
Permian period	299- 251	1. Fossil evidence shows that 34 % were of cockroaches and now, they are less than1%. 2. Beetle population rises from 1 % to 41 % of all living insects
Jurassic Period	196.6 – 145.5	Coniferous forest was dominant
Oligocene Period	34 - 23	Lepidoptera

Insects Species Number

World

Erwin, 1982: 30-50 million
Stork, 1988: 10-80 million
May,1986: 10 million
Geslon, 1991: 8.75 million
Hammond, 1992: 12.25 million
Briggs, 1991: 12 million

Total Number is 1,00,7,534
(Estimated No. about is 10 million)

India

Lefroy,1909: 25,700
Beeson, 1940: 40,000
Menon, 1965: 50,000
Roonwal,1989: 1,00,000
Varshney, 1998: 59,353

619 families representing
6.83% of the world species

Total Number is 67,000 and
Forest insects about 18,000
(NFIC, 2012)

Sl. No.	Name of order	Grouping	Sl. No.	Name of order	
1	Protura	Apterygota	21	Coleoptera	Endopterygota
2	Collembola		22	Neuroptera	
3	Diplura		23	Mecoptera	
4	Thysanura		24	Trichoptera	
5	Ephemeroptera	Exopterygota	25	Lepidoptera	
6	Odonata		26	Diptera	
7	Dictyoptera		27	Siphonaptera	
8	Isoptera		28	Strepsiptera	
9	Zorapetra		29	Hymenoptera	
10	Plecoptera				
11	Notoptera				
12	Phasmida				
13	Orthoptera				
14	Embioptera				
15	Dermaptera				
16	Psocoptera				
17	Mallophaga				

Basis of classification

1. Degree of Metamorphosis
2. Mode of Development of wings
3. Structure of the wings and arrangement of veins
4. Feeding habits and structure of the mouth-parts
5. Comparison of Biology

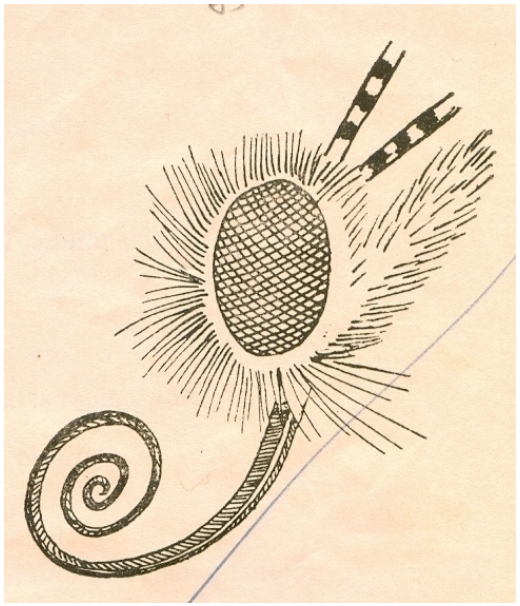
Biological attributes associated with this Predominance

- Small size (0.2 to 120mm)
- Strong Exoskeleton (Chitinous)
- High mobility through Flight
- Efficient Water Conservation (Waxy coating)
- Rapid reproduction
- Adaptability (Diverse Habitat)

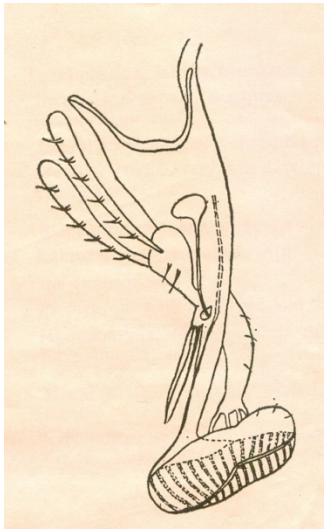
Feeding habits

- Chewing – lapping
- Piercing and Sucking
- Sponging
- Siphoning

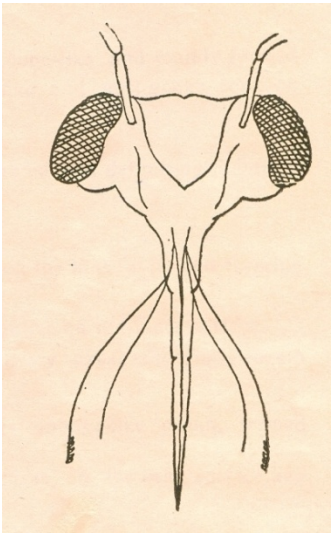
Siphoning – Butterfly

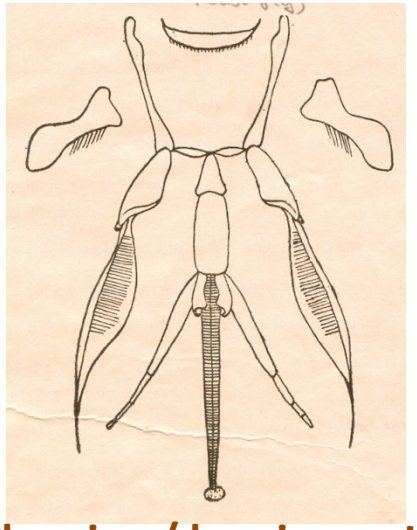


Sponging – House Fly



Piercing – Mosquito





Chewing / lapping – Honey Bee

Mode of Reproduction

- Oviporus – lay eggs (Coloeptera / Lepidoptera)
- Viviporus – No eggs Diptera
- Polyembrony – asexual
- Parthenogenisis – without Matting (Hymenoptera)
- Paedogensis – Immature stage become sexually mature (Isoptera)
- Hermaphrodites Male and Female organ in one individual (Homoptera)

Economic Impact of Forest Insects

- **Mortality – reduce growing stock**
- **Delay stocking levels – Reproduction**
  - **Seeds, cones, seedlings**
- **Reduce radial/axial growth**
  - **Defoliation of leaves/killing of buds**
- **Deterioration**
  - **Loss of product value**

Why Insects are Important in the Forests

Their activities result in damage. In 1950, Craighead estimated annual losses to be:

Bark beetles ----------$20 million

Defoliators ----------$20 million

Forest Product pests ----------$60 million

Shade and ornamental pests ---$100 million

Himalayan Moist temperate Forest

Biodiversity Park

Anogeissus pendula Scrub (5/DFS1)

West Himalayan Sub-alpine Birch/Fir

Betula utilis- Abies pindrow **in Udir Range, Marwah Forest**

Dwarf Juniper Scrub Forest (16/E1)

Dry Broad leaved and Coniferous Forest (13 (i)/ C1

Biodiversity Park

Olea cuspidata Scrub Forest


Total insects: 102
Defoliators: 48
Sap suckers: 32
Insect borers: 09
Others: 13
Total Birds: 10
Pest Status : Not known

ECOLOGICAL SIGNIFICANCE

- 1st biological agents to attack dead Wood material for further decay and deterioration
- Help in maintaining the vigorous growth of plants
- Recycling dead plant tissues
- Enhance the natural pruning process
- Reduce the fire hazards
- Recycling of diseases logs, injured trees on forest flour
- Increasing the soil fertility for ecosystem

Economic Importance of Insects

- Pests of crops, plants & forest trees
- Pests of Stored Products
- Inimical to man and Animals
- Beneficial insects: Bees, Silk. Shellac (Lac)
- Foods
- Helpful Insects: Pollination, Biological control agents, Scientific investigation, Aestheitc value
- Medicines

Apiculture

Total production : 10,000 T

Economy: Rs. 300 Million (Honey)

Bee Wax: Rs. 1500 Million

Work Force: 6 million

Insect species:

Apis mellifera

Apis dorsata

Lac Culture

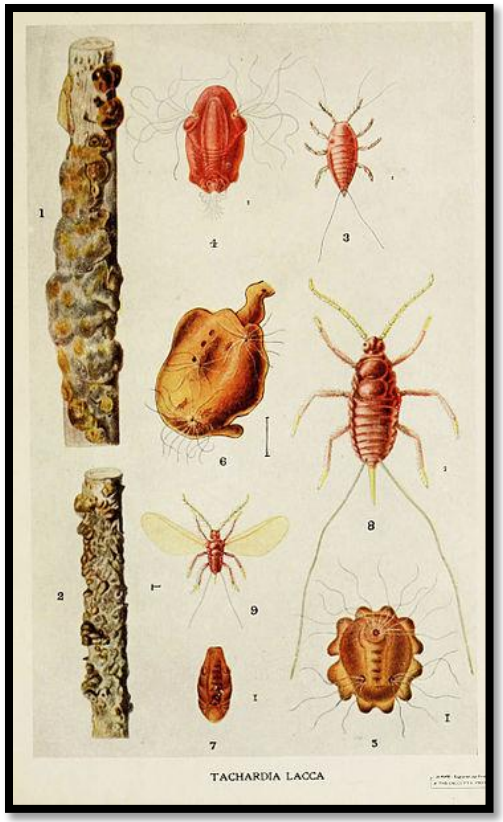
Total production : 20, 640 T

Economy: 1.7 Million

Man power: 1.2 Million

Insect species:

Laccifer lacca



Sericulture

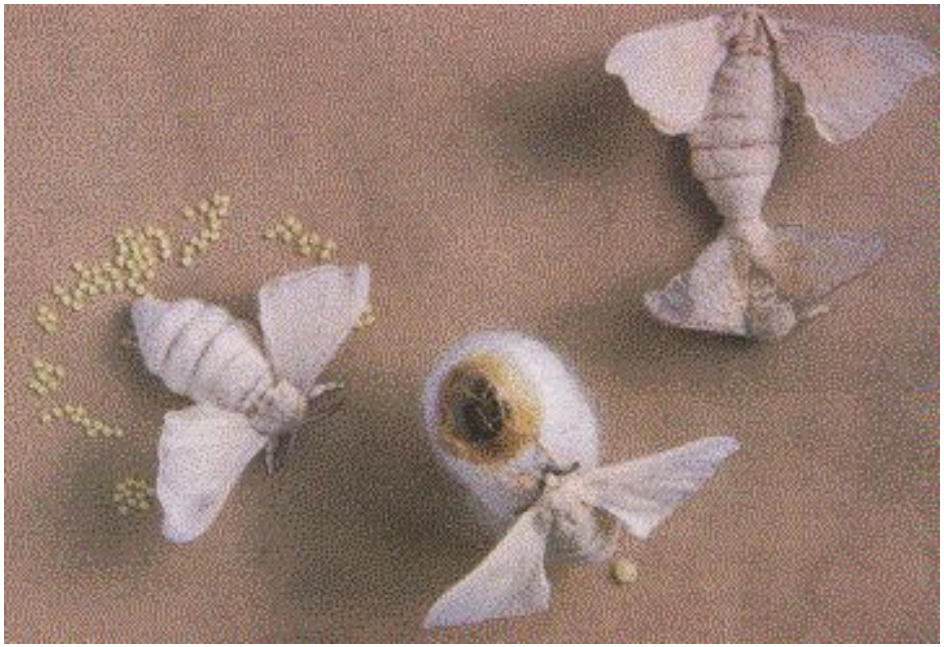
Total production :
13,000 T

Economy: 278.8 Crores

Man power: 2.5 Million

Insect species:

Bombyx moori



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Pest

- **PEST : It is derived from French word 'Peste' and Latin term 'Pestis' meaning plague or contagious disease - Pest is any animal which is noxious, destructive or troublesome to man or his interests**
- **CATEGORIES OF PESTS: Based on occurrence following are pest categories**
- **Regular pest: Frequently occurs on crop - Close association e.g. White Grub.**
- **Occasional pest: Infrequently occurs, no close association e.g. Root & stem borer.**
- **Seasonal pest: Occurs during a particular season every year e.g. Sal Heart wood borer.**
- **Persistent pests: Occurs on the crop throughout the year and is difficult to control e.g. Termite.**
- **Sporadic pests: Pest occurs in isolated localities during some period. e.g. Deodar defoliator.**

Causes For Insects Assuming Pest Status

- **Destruction of Forests: Set conditions favorable for some insects to develop enormously and assume pest status**
- **Destruction of Natural Enemies**
- **Intensive and extensive cultivation**
- **Introduction of new and improved clones**
- **Improved silvicultural Practices**
- **Introduction of Pest in new area**
- **Accidental introduction of Foreign pests**
- **Resurgence of Sucking Pests**

Insect and Pest Management

- Parasitic and Predacious Life of Insects (15%)
- ½ of the Hymenopteran
  - Trichogramma
  - Ichneumondis
  - Chalcids
- 12% of Diptera
  - Tachnidae
- Anoplura
- Mallaphaga
- Strepsiptera

Insect in scientific investigation

Drosophila melanogaster **is a species of Diptera, or the order of flies, in the family Drosophilidae.**

The species is known generally as the common fruit fly or vinegar fly.

Starting with Charles W. Woodworth's proposal of the use of this species as a model organism.

D. melanogaster **continues to be widely used for biological research in studies of genetics, physiology, microbial pathogenesis and life history evolution.**

It is typically used because it is an animal species that is easy to care for, breeds quickly, and lays many eggs.

Medicine from Insects: Dr. Mircea Ciuhrii, Scientific Applicative Center, Insect Farm, USSR

How did you come up with the idea of using insects for making medicines?

The idea came to me after 30 years of fundamental research in an institute in France, where I was making researches in the field of genetic engineering. My purpose was to create a baculovirus with new properties and I was concerned with certain types of proteins. Then I realized that these proteins can be found in the body of certain species of insects. After that I had to do an enormous amount of work in order to elaborate the production technologies for various types of pharmaceutical products, which today are widely known. I want to mention an important aspect: before actually using insects, I had to work with insect viruses, which at the present can be used for obtaining biologically active substances of great importance, such as high quality vaccines, interferons and insulin. This medicine production system is being intensively developed in USA, where special laboratories were created, but my system remains an international premiere.

- What biological products do you presently develop?

The Applicative Scientific Center INSECT FARM develops a wide range of biological products for pharmaceutics and cosmetics. The insect extracts are obtained in sterile conditions and are incorporated in specific adjuvants. One of the most successful products is HEPATITO-LIZ, which has a reparatory effect for hepatic cells and stops the multiplication of the A, B, C, D hepatic viruses. This product is not only used by patients in Romania, but also in USA, Italy, Germany, France and many other countries.

Mylabris phalerta Pollas (Meloidae)

Bugs as drugs, Part 1: Insects: the "new" alternative medicine for the 21st century?

Cherniack EP.

Source

The Geriatrics Institute, University of Miami Miller School of Medicine, Miami, FL, USA. evan.cherniack@va.gov

Abstract

Insects and insect-derived products have been widely used in folk healing in many parts of the world since ancient times. Promising treatments have at least preliminarily been studied experimentally. Maggots and honey have been used to heal chronic and post-surgical wounds and have been shown to be comparable to conventional dressings in numerous settings. Honey has also been applied to treat burns. Honey has been combined with beeswax in the care of several dermatologic disorders, including psoriasis, atopic dermatitis, tinea, pityriasis versicolor, and diaper dermatitis. Royal jelly has been used to treat postmenopausal symptoms. Bee and ant venom have reduced the number of swollen joints in patients with rheumatoid arthritis. Propolis, a hive sealant made by bees, has been utilized to cure aphthous stomatitis. Cantharidin, a derivative of the bodies of blister beetles, has been applied to treat warts and molluscum contagiosum. Combining insects with conventional treatments may provide further benefit.

Insects: Pollinators : 153 Billion Euro in world, 726 Million US Dollar

Honey bees

A honey bee that is deliberately gathering pollen is up to ten times more efficient as a pollinator than one that is primarily gathering nectar.

Millions of hives of honey bees are contracted out as pollinators by beekeepers, and honey bees are by far the most important commercial pollinating agents, but many other kinds of pollinators, from bluebottle flies, to bumblebees, orchard mason bees, and leaf cutter bees are cultured and sold for managed pollination.

proboscises.

Lepidoptera (butterflies and moths) also pollinate plants to various degrees.[4] They are not major pollinators of food crops, but various moths are important pollinators of other commercial

Biological control

Total Number of Insects attempted: 416 in 8 insect order

Complete Control : 75 species

Substional control 74

Partial control: 15

Benefit Cost Ratio is 30:1 as compared to chemical control 3:1

Insect as Food

Many people in Thailand enjoy eating insects as a snack food, often enjoyed with beer. They're usually fried in a wok, and seasoned with Golden Mountain sauce & a bit of Thai pepper powder. If you don't find street vendors selling fried insects, for sure you can always find them at Temple Fairs throughout Thailand. Temple Fairs help raise money for the temple, and sometimes last a whole week whereby all kinds of food & clothing is sold, along with traditional entertainment. Temple Fairs are held by each temple about once a year, and they offer not only a glimpse into the real heart of Thai culture but also provide a certain venue for you find tasty fried insects for sale.

Insect have aesthetic and entertaining value

Audubon Butterfly Garden and Insectarium

Butterfly Park IAP (Malaysia)

TV channels

Products from Plant Gall caused by insects

When feeding on plant tissues, many insects and mites inject or secrete a chemicls substance into the plant that causes the plant to grow abnormally and produce gall

Eucalyptus species (gum trees).

Hymenoptera (Cynipid wasp & sawfly)

Homoptera (Aphid)

Diptera (Gall Midge)

Coleoptera (gall borer)

Lepidoptera (Twig borer)

Tannic Acid

Inks

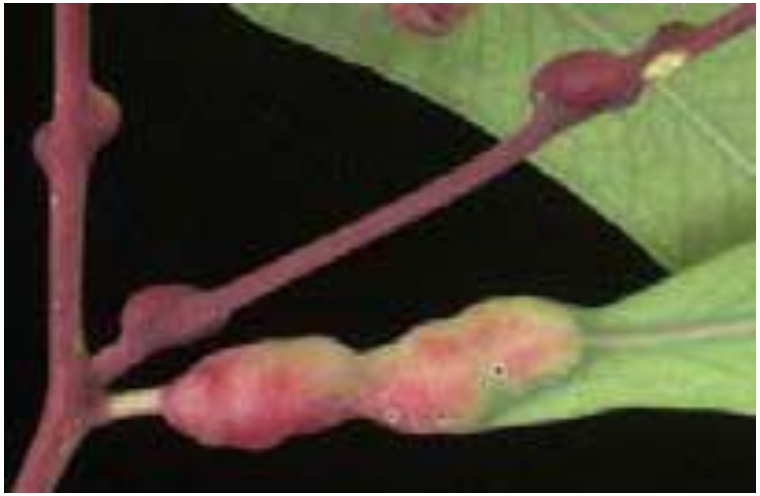
Dyes

***1 Www.survival.org.au/bf_galls.php* -**

Many insect galls were eaten by Australian Aboriginies.

2. These help-mate insects provide a vital service to their host plant in the form of pollination

3. Gall in *Pistacia integrima* used in medicine



Insects as Indicator of Environment changes and pollution

- Dragon flies
- Moths
- Butterflies
- Beetles
- Ants
- May flies
- Honey bee

Insects as Decoposer

- The dead bodies of plants and animals are a rich source of organic matter that provides nutrition for many insects called **saprophages** .
- Insects adapted to this lifestyle are an essential part of the biosphere because they help recycle dead organic matter.

THANKS

Insects Cause Damage: To seedlings

White Grub Adult

White Grub Larva

Acorn Weevil – Pest of Acorns of 4 *Quercus* species
Infestation Range : 34-50%

Ips longifolia

Adult Beetle


Polygamus galleries


Nutritional symbionts


Hole in bast

Indian Gypsy Moth – Potential Pest of Oak

Drying of Kail (*Pinus wallichiana*) in Himachal Pradesh

Insect-Pest:

***Pityogenes scitus* Blanford**

Control Measure:

Use of tree-trap to attract beetles for ovi-position in May & June

Problem Need for Research Inputs

OUTSIDE TREE

INSIDE TREE

Egg (7-10 days)

Larva / grub
(26 – 32 days)

Pupa (9-12days)

Adult beetle

(18- 22 days)

Bark moisture
15%

Schematic Showing the Life Cycle of the *P. longifolia*

Chrysomelid Beetle
(Leaf-eating Beetles)

Forest Fire – A Major Stress Factor in Ecosystem

Biological Control Mechanism Failed:

***Thanasimus himalayensis* Steb.**
(Coleoptera: Scolytidae)

Private Plantation at Lardoo

Forest Plantation at Langru

Feeding Sign in Plantation

Larva of Ermine Moth in action

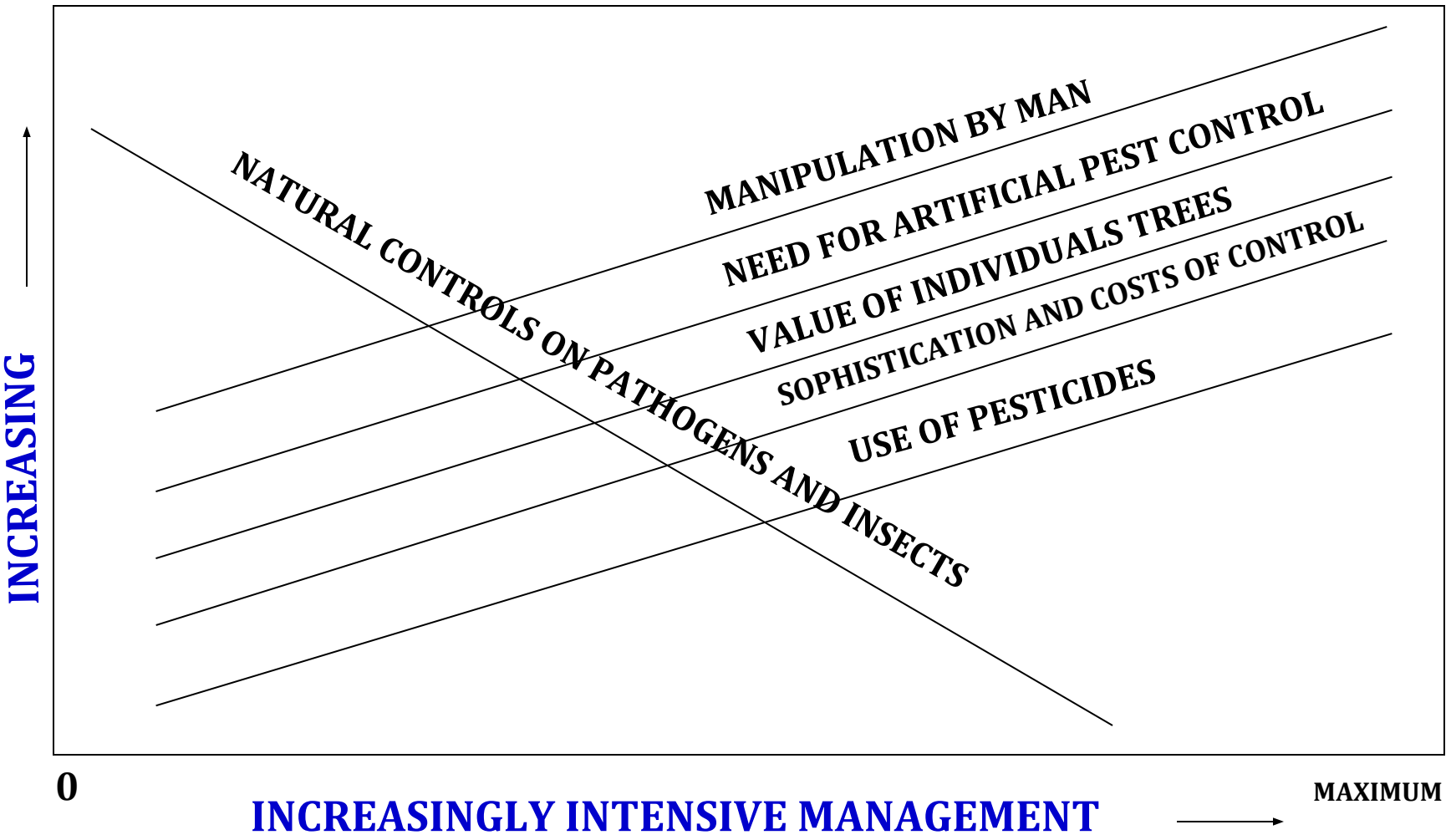
Yponomeuta rorellus

(Lepidoptera : Yponomeutidae)

(Web making and consuming entire foliage including apical branches)

IPM

General variables involved in Pest Management



FOREST ECOSYTEMS

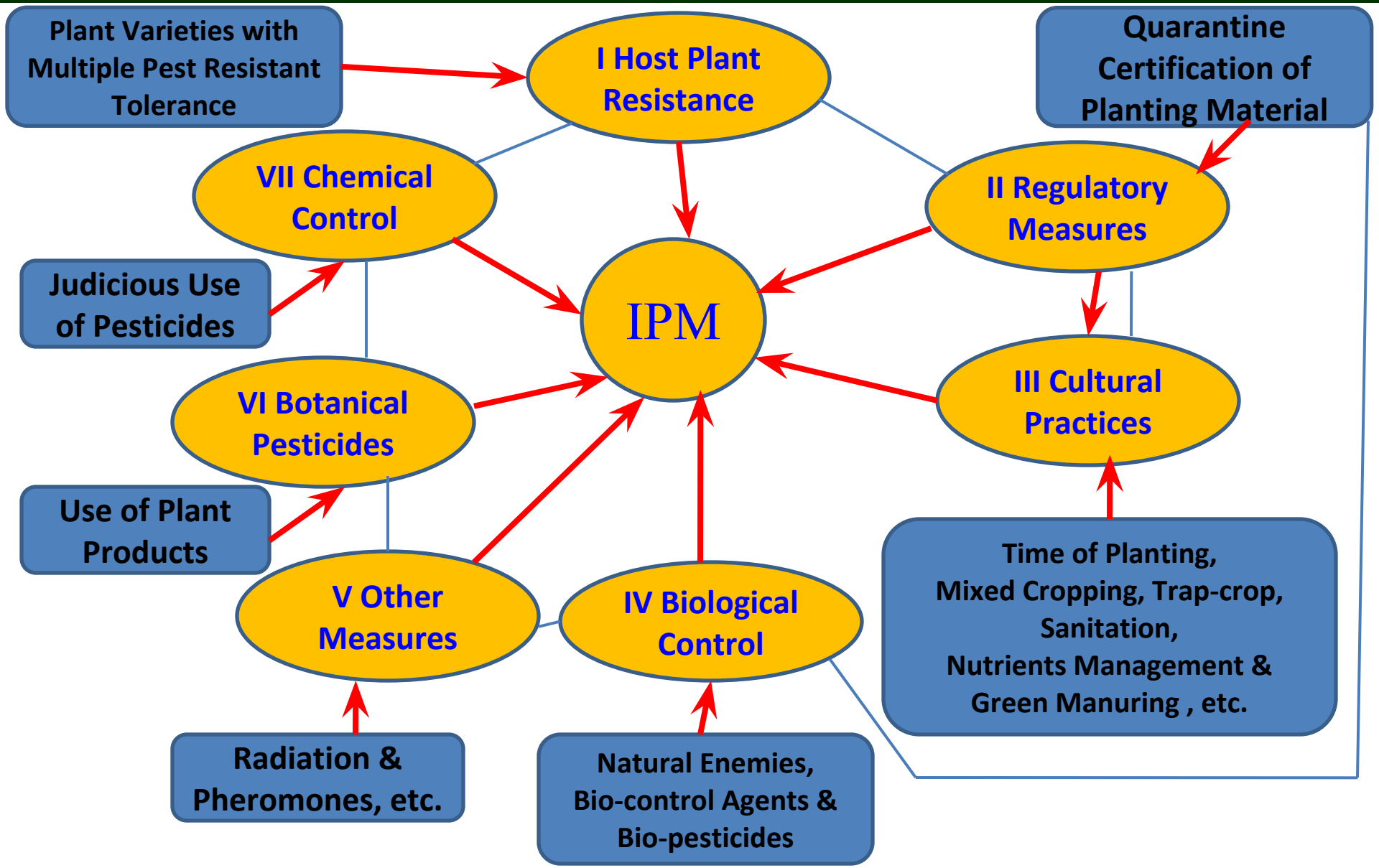
Much Non-commercial Forest | Extensively Managed Forest | Intensively Managed Production Forest

SPECIALIZED FORESTRY SETTINGS

Seed Orchard | Forest Nursery

URBAN FORESTS

Pest Management Methods



Saussurea costus: A Herb For Good Health

Syn: *S.lappa* C.B. clarke
Local Name: kuth

Altitude: 2600-4000 m
Crop: Perennial herb.

Marketable part: Root
Uses: asthma, dysentery, fever and perfumes.

Propagation: Root cutting and seed.
Act: The Kuth act 1978

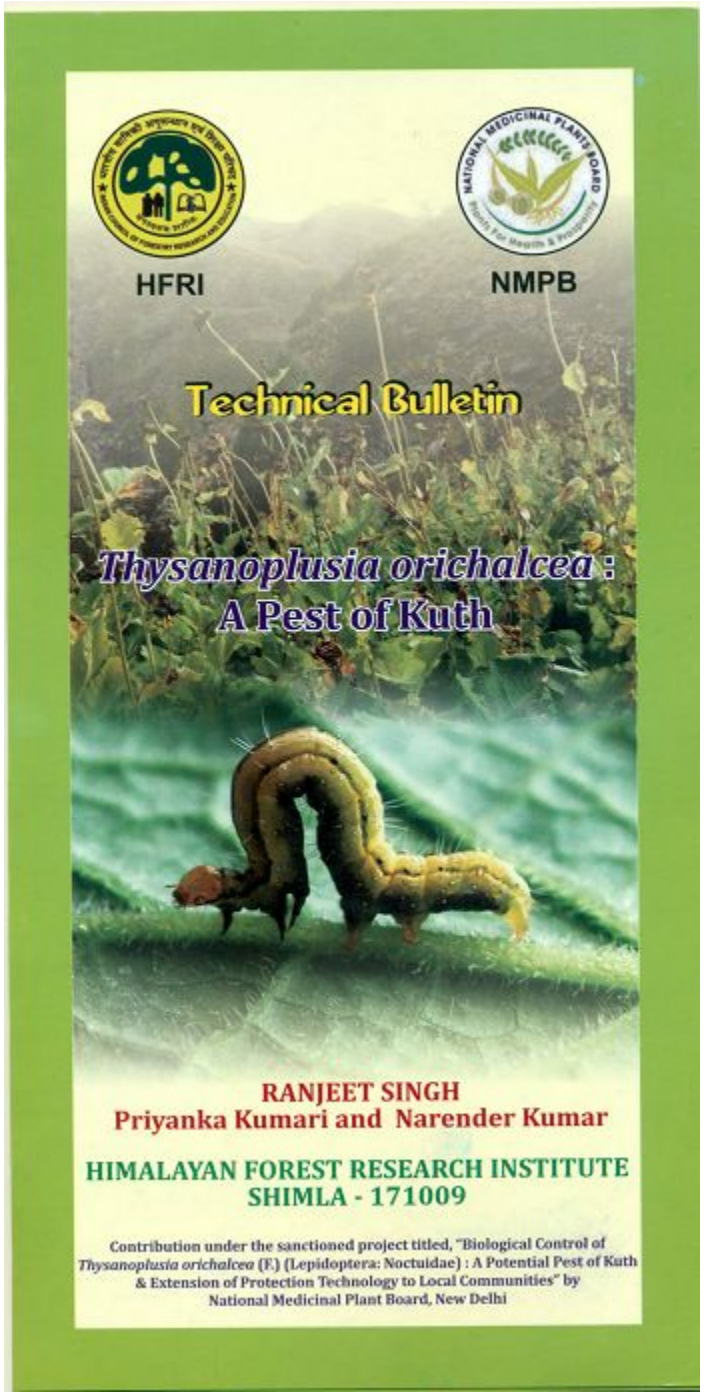
Production cost: Rs 27000-30000/1621.34 Sq m/ One Bigha
Income:Rs 40000-45000

Ingradients:
ostus oil (1.5-2.5%) **,**
Alkaloid saussurine (0.5%)
Preparatoin: Kustadi churna, hair oil.

Total registered farmers: 159
Area under cultivation: 562Bighas

Trade information: Roots, oil, extract, derivatives , herb exported from kashmir during colonial period, 15-20 ton /year to Dabur limited from Lahul valley.
Trading countries- Australia,Singapore, Mauritius,Netherland, Japan,China,Korea.
Import: 385720kg of roots imported from china.

Extension material for Kuth growers and other user agencies like State Forest Department



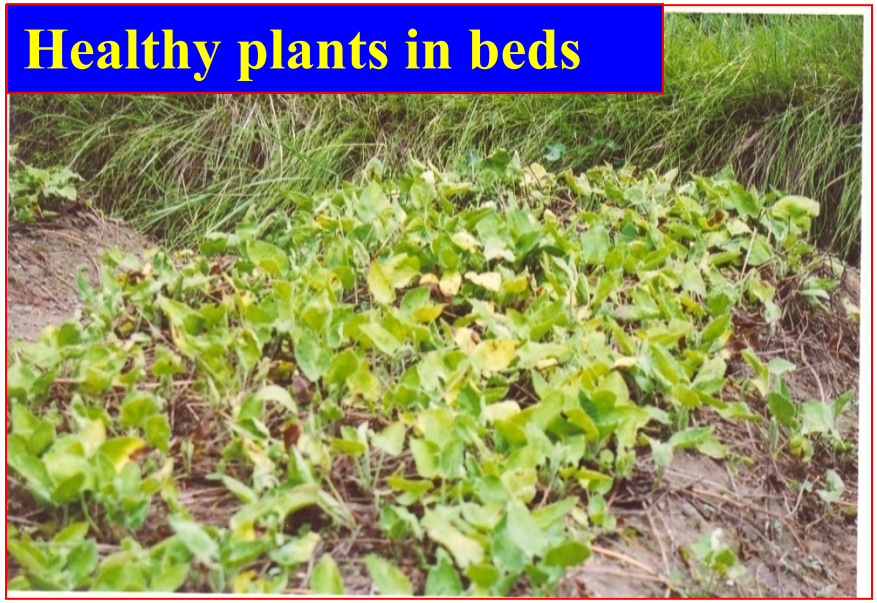
Dead High Altitude and Wind –blown Insects

ROHTANG PASS

Biological Control

Mite Attack on *Valeriana jatamansi in Nursery*

Healthy plants in beds



Infested plants in beds

Abnormal growth in Plant

Distorted foliage

Thanks