

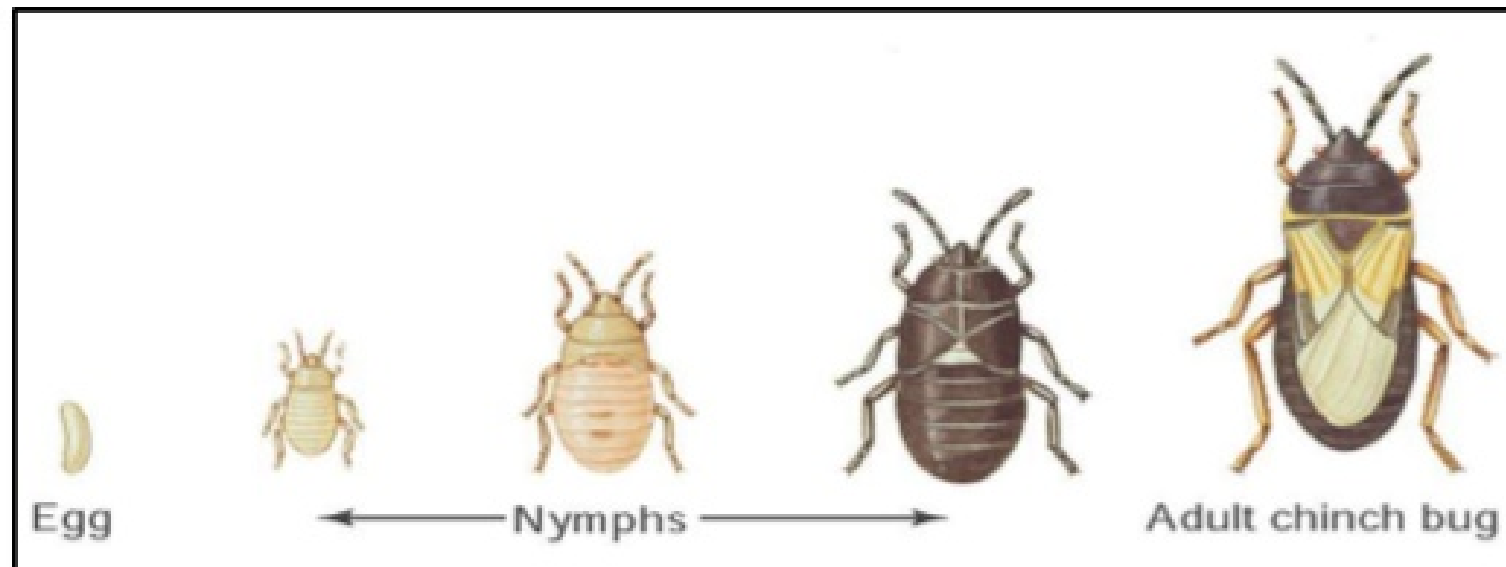
Metamorphosis and diapause in insects

Dr K.ARULDOSS
Assistant professor
Department of Zoology
Periyar Govt Arts College
Cuddalore

- Series of changes that takes place during the development of an insect from egg to adult are collectively known as **metamorphosis**.
- Metamorphosis is derived from Greek word '**Meta**' = **Change**, '**morph**' = **form or structure**.
- Metamorphosis include three developmental processes namely **growth, differentiation and reproduction which takes place in larval, pupal and adult stages** respectively.

Metamorphosis

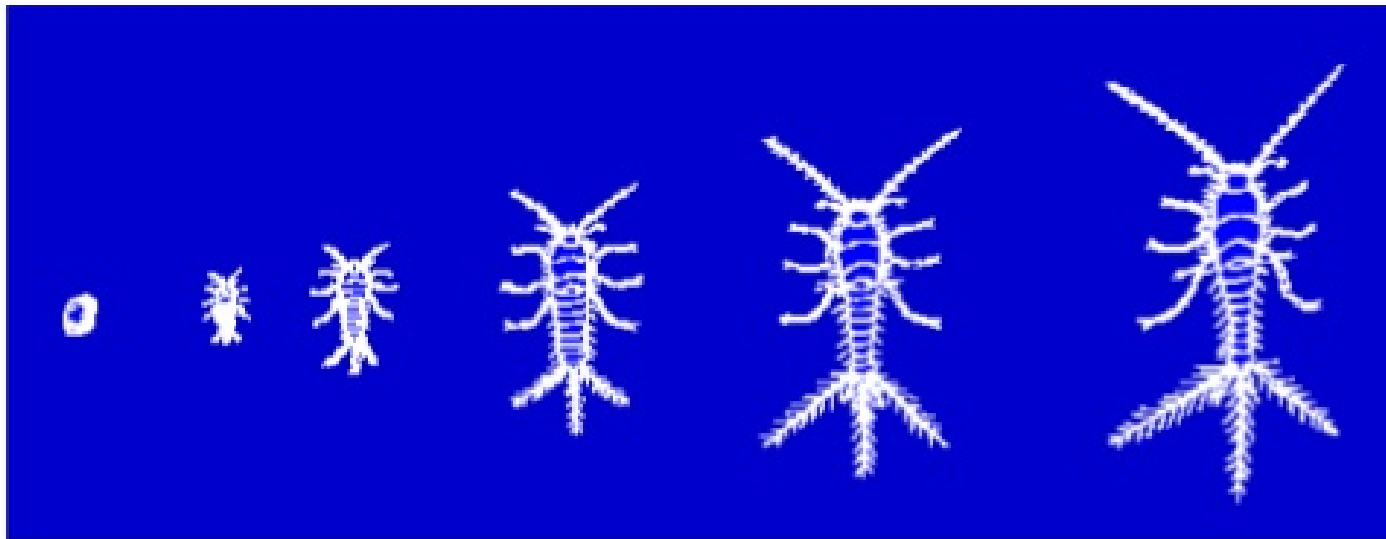
Metamorphosis refers to the change in form of an organism as it grows from the time of eclosion from the egg to the adult stage. Insects differ in the number and types of these developmental stages and on the basis of these differences, are broadly classified to represent different types of metamorphosis as follows.



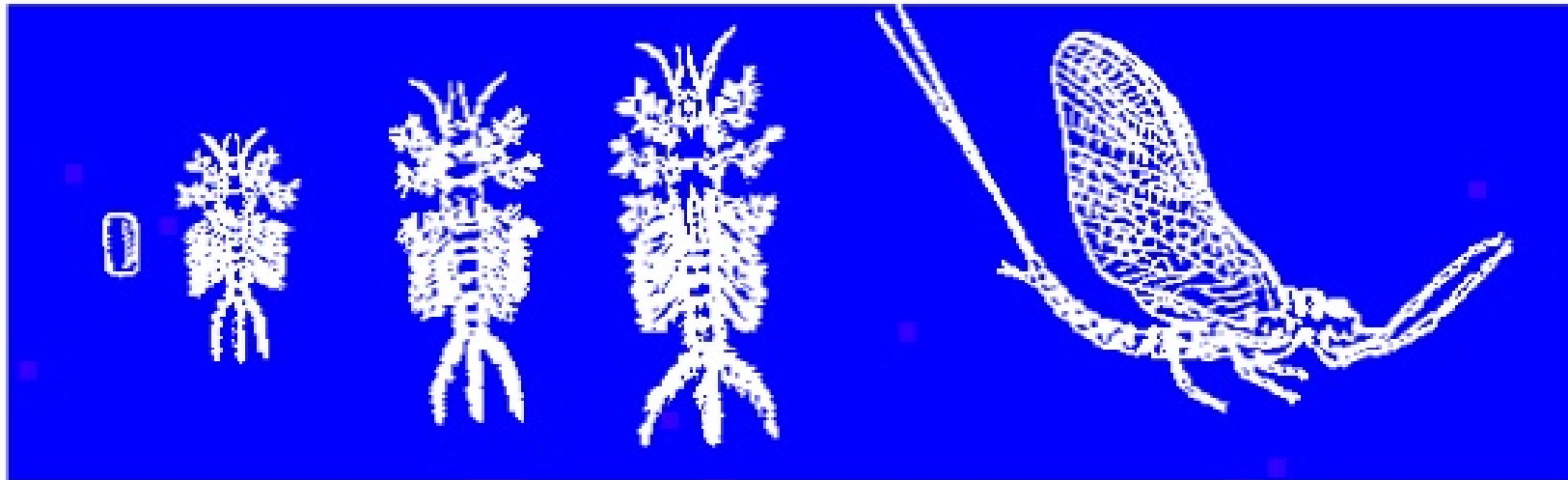
Types of metamorphosis:

1. Ametamorphosis/Ametabola
2. Hemimetabola
3. paurometabola
3. Holometabola
4. Hyper metamorphosis/ Hypermetabola

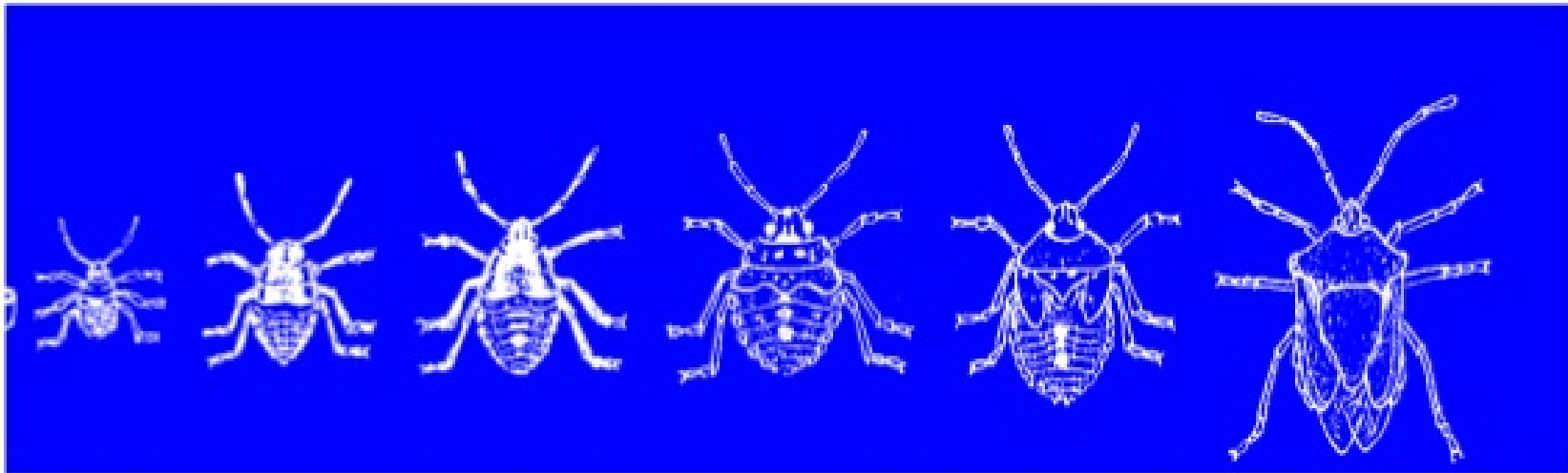
- **Ametabola** (No metamorphosis) : Primarily wingless insects - Apterygota exhibit three developmental stages viz. egg, larva and adult. Larvae of these insects resemble the adults and are called nymphs. e.g. : Silverfish



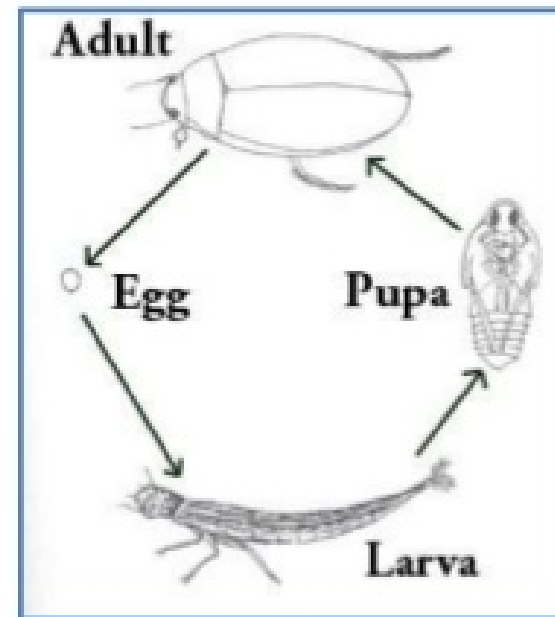
2. **Hemimetabola:**(Incomplete metamorphosis) e.g. Dragonfly, damselfly and may fly. These insects also have three stages in their life namely egg, young one and adult. The young ones are aquatic and are called as **naiads**. They are different from adults in habit and habitat. They breathe by means of tracheal gills. In dragonfly naiad the lower lip (labium) is called mask which is hinged and provided with hooks for capturing prey. After final moult, the insects have fully developed wings suited for aerial life.



- **3. Paurometabola:** (Gradual metamorphosis) e.g. Cockroach, grasshopper, bugs. The young ones are called **nymphs**. They are terrestrial and resemble the adults in general body form except the wings and external genitalia. Their compound eyes and mouth parts are similar to that of adults. Both nymphs and adults share the same habitat. Wing buds externally appear in later instars. The genitalia development is gradual. Later instar nymphs closely resemble the adult with successive moults.



- **Holometabola** : Insects exhibiting four developmental stages viz., egg, larva, pupa, and adult are considered to exhibit complete metamorphosis and are called *Holometabola*. The larvae of these insects do not exhibit any indication of wings present in the adult stage and constitute the true larval stages seen in insects. The development of wings is therefore, internal and insects that exhibit this kind of growth pattern are called Endopterygota. E.g. : Bees, beetles, butterflies, moths, flies etc.





butterfly



egg



hatching egg



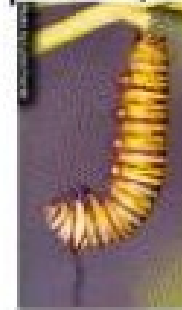
caterpillar (larva)



emerging butterfly



chrysalis (pupa)



resting caterpillar

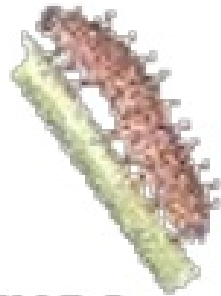


chrysalis (pupa)

*images used with permission from
www.monarchwatch.com*

Holometabolous Development

Eggs



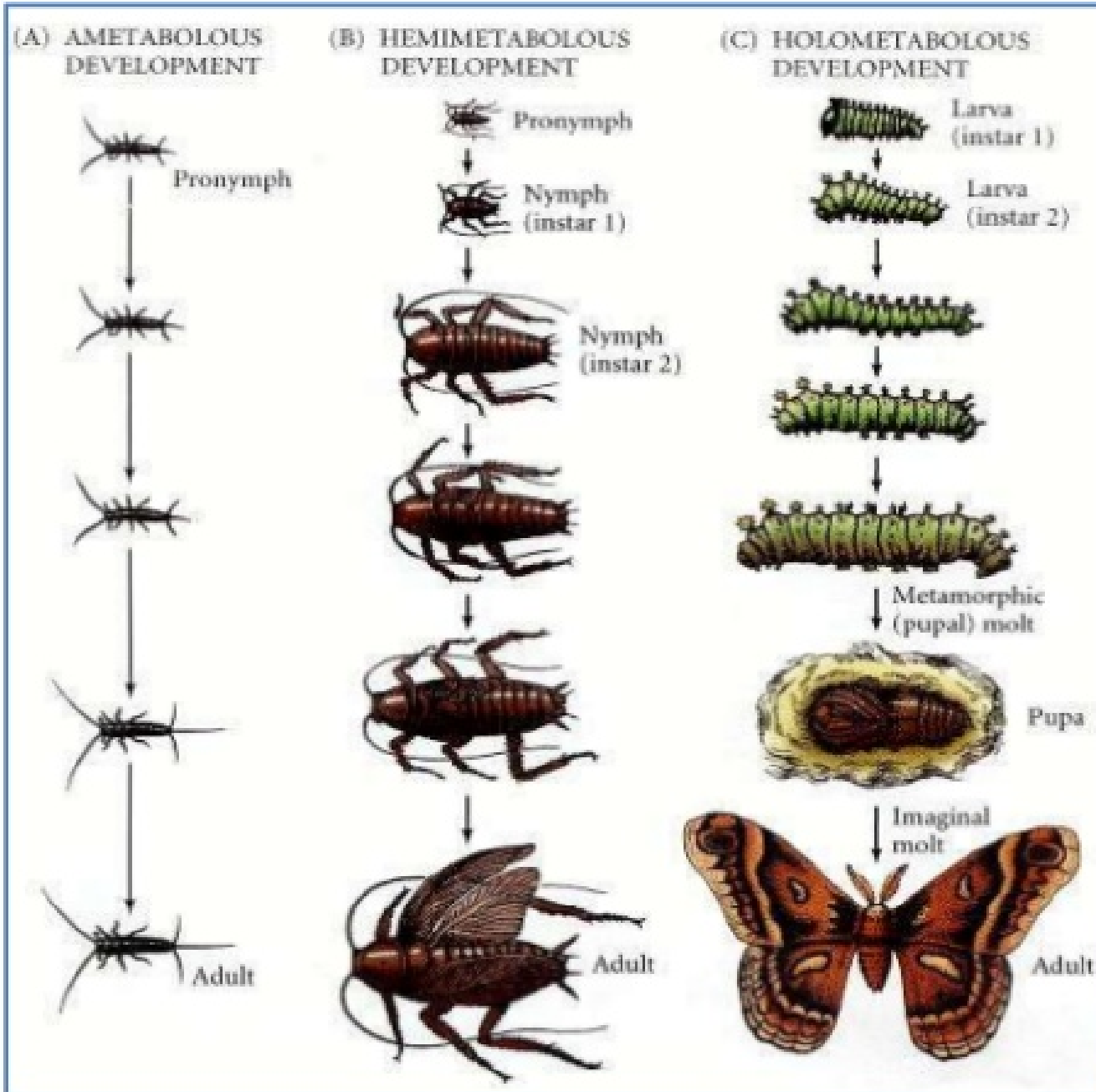
Larvae



Pupa

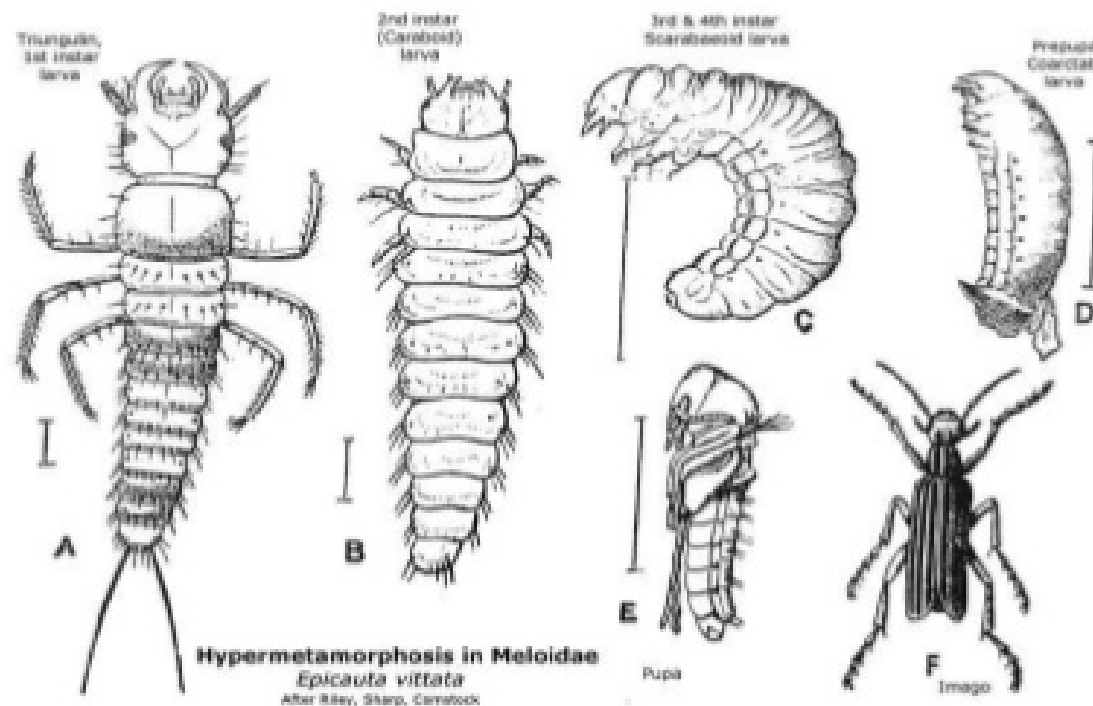


Adult



Hypermetamorphosis:

- This is a peculiar type of development which consists of two or more types or forms of larvae in the life cycle of insects.
- In majority of the cases the first larval instar is **campodeiform and the subsequent larval forms depends on type and mode** of life of the larva.
- E.g.: In blister beetle (Meloidae; Coleoptera), the first larval instar is **campodeiform** followed by **scarabeiform larval type**.

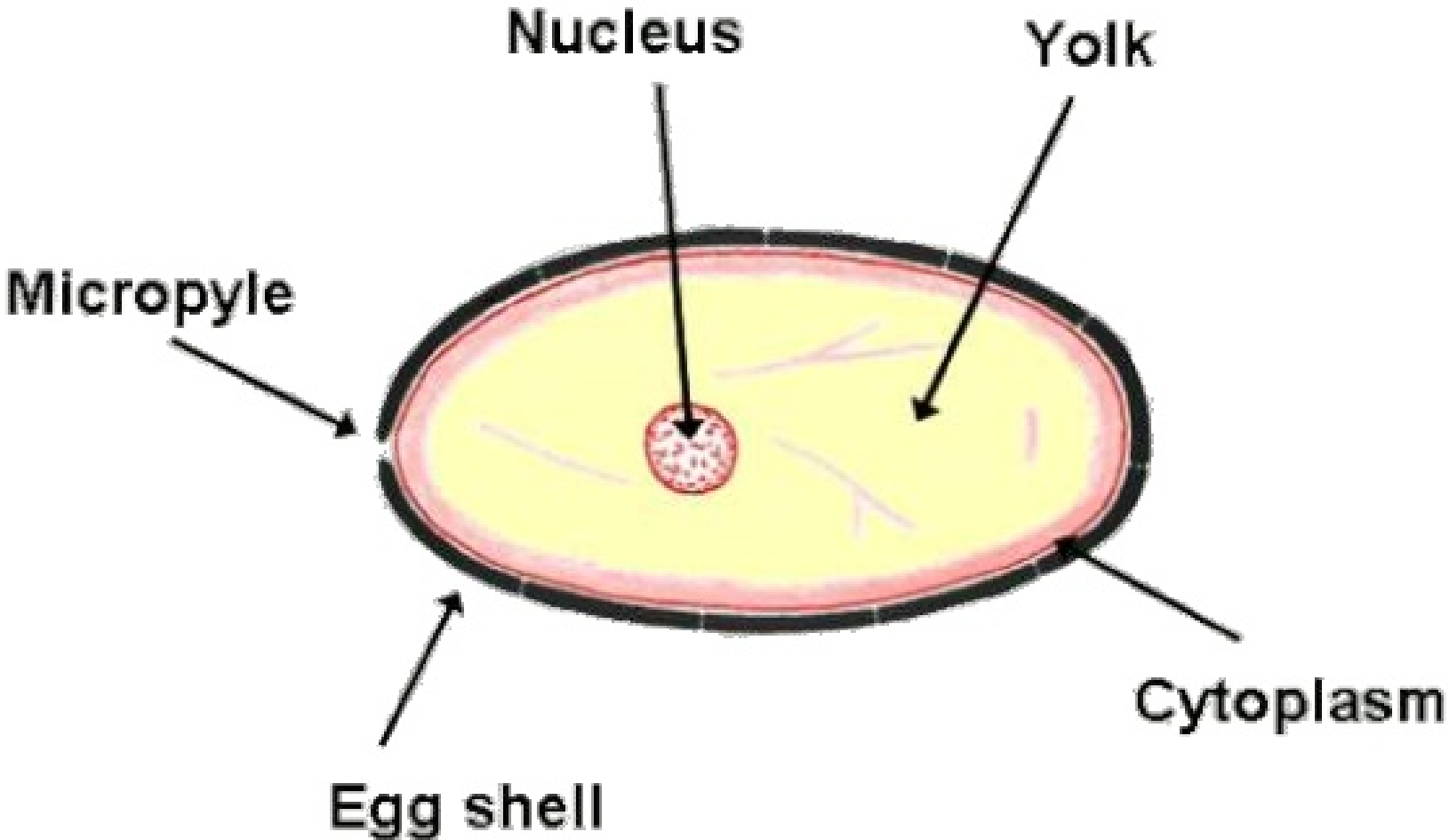


A-[triungulin](#), B-caraboid stage, C-coarctate larva, D-scarabaeidoid stage, E-[pupa](#), F-adult beetle

The immature stages of insects include eggs, nymphs, naiads, larvae and pupae.

EGG

- ✓ The first stage of development in all insects is egg.
- ✓ Majority of insects are oviparous.
- ✓ Egg stage is inconspicuous, inexpensive and inactive.
- ✓ Yolk contained in the egg supports the embryonic development.
- ✓ Eggs are laid under conditions where the food is available for feeding of the future Young ones.



Cont....

- ✓ Eggs are laid either **individually or in groups**.
- ✓ The outer protective shell of the egg is called **chorion**.
- ✓ Near the anterior end of the egg, there is a small opening called **micropyle** which allows the sperm entry for fertilization.
- ✓ Size and shape of the insect eggs vary widely.

TYPES OF EGGS

a) SINGLY LAID :

1) **Sculptured egg** : Chorion with reticulate markings and ridges

e.g. **Castor butterfly**.



2) **Elongate egg** : Eggs are cigar shaped.

e.g. **Sorghum shoot fly**.



3) **Rounded egg**: Eggs are either spherical or globular.

e.g. **Citrus butterfly**



4) **Nit** : Egg of **head louse** is called nit.

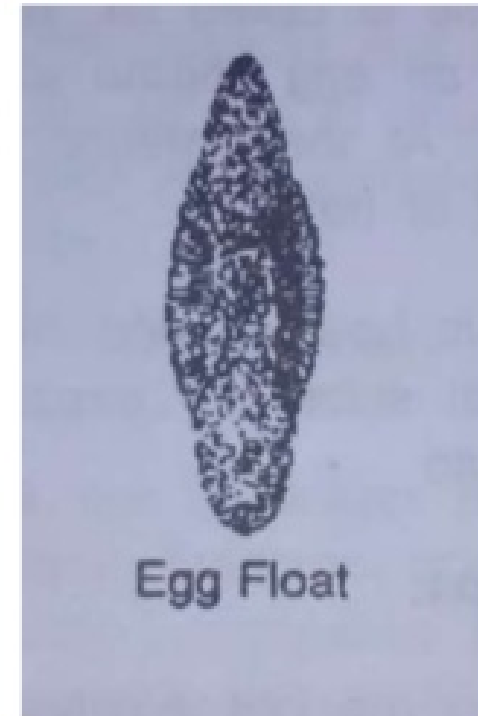
- It is cemented to the base of the hair.
- There is an egg stigma at the posterior end, which assists in attachment.
- At the anterior end, there is an oval lid which is lifted at time of hatching.



5) Egg with float :

- Egg is boat shaped with a conspicuous float on either side.
- The lateral sides are expanded.
- The expansions serve as floats.

e.g. *Anopheles mosquito*.



EGGS LAID IN GROUPS

1) **Pedicellate eggs** : Eggs are laid in silken stalks of about 1.25mm length in one groups on plants. e.g. **Green lacewing fly**.



2) **Barrel shaped eggs** : Eggs are barrel shaped. They look like miniature batteries. They are deposited in compactly arranged masses. e.g. **Stink bug**.



3) **Ootheca** (Pl. Oothecae) :

- Eggs are deposited by **cockroach** in a brown bean like chitinous capsule.
- Each ootheca consists of a double layered wrapper protecting two parallel rows of eggs.
- Each ootheca has 16 eggs arranged in two rows.



4) **Egg pod** :

- **Grasshoppers** secrete a frothy material that encases an egg mass which is deposited in the ground.
- The egg mass lacks a definite covering.
- On the top of the egg, the frothy substance hardens to form a plug which prevents the drying of eggs.



Cont.....

5. **Egg case :**

Mantids deposit their eggs on twigs in a foamy secretion called **spumaline** which eventually hardens to produce an egg case or **ootheca**.

Inside the egg case, eggs are aligned in rows inside the egg chambers.



6. **Egg mass:**

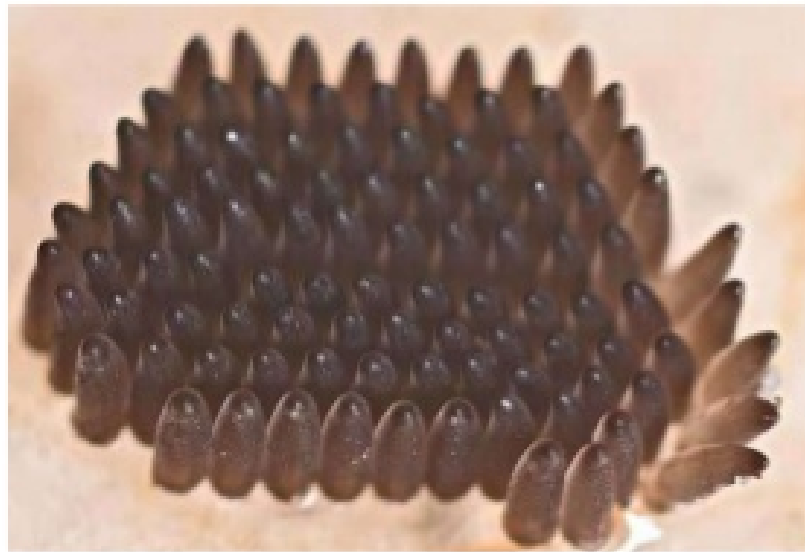
Moths lay eggs in groups in a mass of its body hairs. Anal tuft of hairs found at the end of the abdomen is mainly used for this purpose. e.g. **Rice stem borer**.

Female silk worm moth under captivity lays eggs on egg card. Each egg mass is called a dfl (diseases free laying).



7. Egg raft :

In *Culex* mosquitoes, the eggs are laid in a compact mass consisting of 200-300 eggs called egg raft in water.



A

© Robert Brown/Biological Photo Service



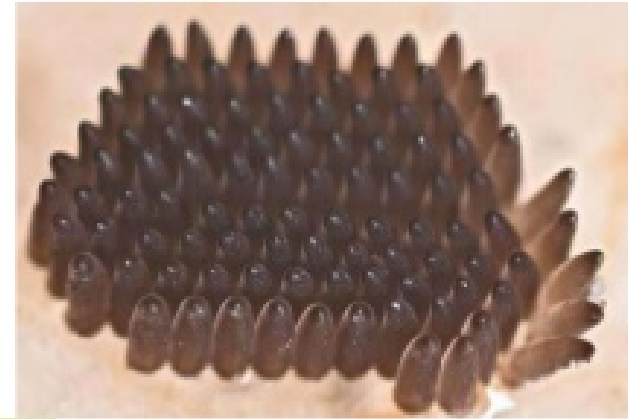
B



Eggs of housefly



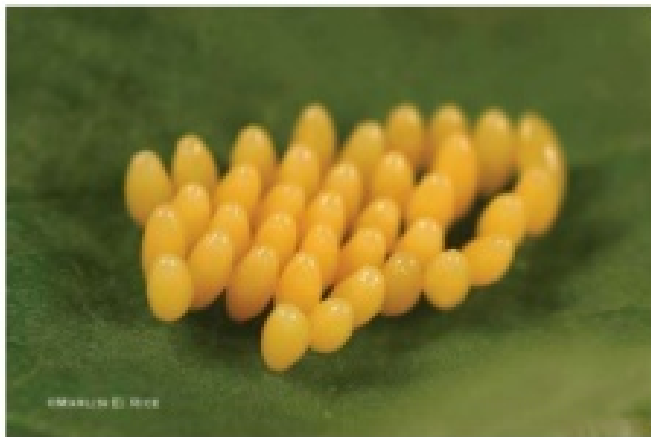
ootheca



Egg raft

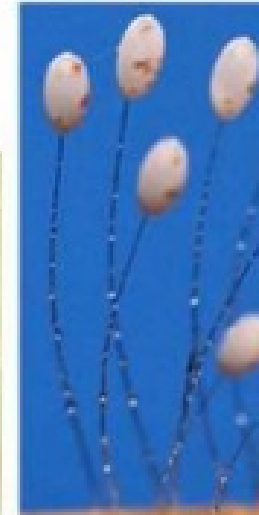


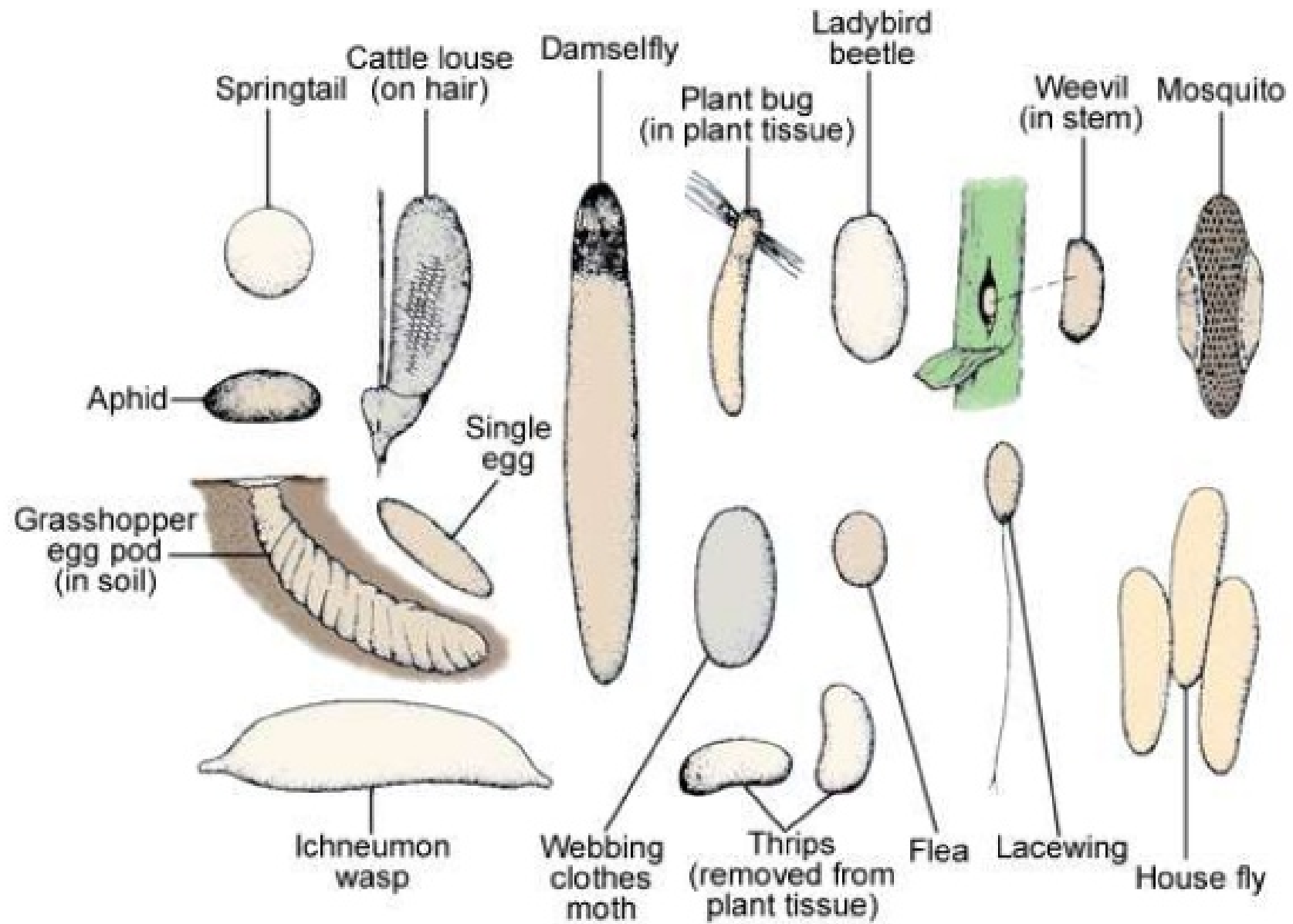
Pedicellate eggs



Eggs of beetles







2. NYMPHS AND NAIADS :

- Nymphs resemble the adults except for development of wings. Nymphs possess compound eyes and wing pads, they live in the same habitat as their adults and are usually terrestrial. Their food habits are identical to that of the adults. e.g. bugs, grasshopper, praying mantids
- Naiads are essentially nymphs but have aquatic adaptations. Like nymphs, they also possess compound eyes and wing pads. They possess tracheal gills and in some cases modified mouth parts compared to adults. They live in a habitat different from their adults, which are largely terrestrial. e.g. mayflies, dragonflies, stoneflies



Dragon fly naiad



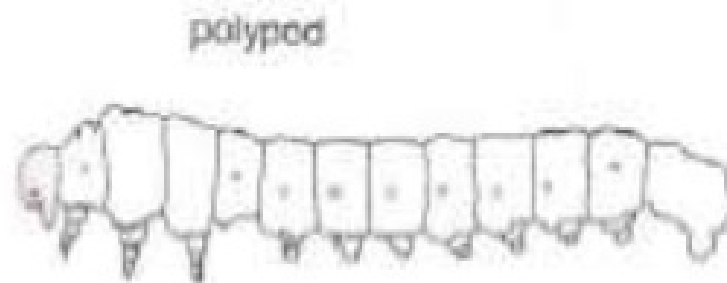
Nymph of bugs



Damselfly naiad

3. LARVAE :

- Based on the degree of morphological development and possession of legs they are classified into four groups - a) Polypod; b) Oligopod; c) Apodous and d) Protopod
- a) Polypod larvae (eruciform) : These have well defined body segmentation. Abdominal legs or prolegs are present. Antennae and thoracic legs are short; body is cylindrical and hence often called *eruciform* larvae. e.g. Larvae of moths and sawflies



**a) Hairy caterpillar: The body hairs may be dense, sparse or arranged in tufts. Hairs may cause irritation, when touched. Eg:
Red hairy caterpillar.**



b) Slug caterpillar: Larva has poisonous spines called scoli distributed all over the body. Such larva is also called platyform larva.



- c) Semilooper: either three or four pairs of prolegs are present. Prolegs are either wanting or rudimentally in either third or third and fourth abdominal segments. Eg: Castor semilooper.

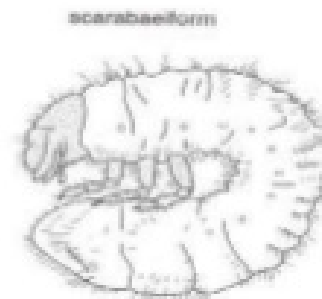
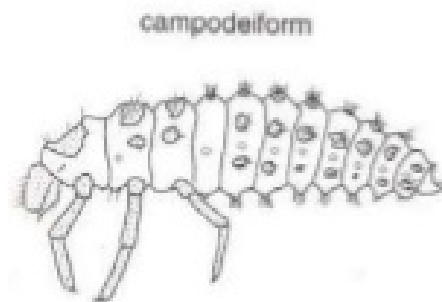


d) Looper: They are also called measuring worm or earth measurer or inch worm. In this type only two pairs of prolegs are present in sixth and tenth abdominal segments. Eg: Daincha looper.



b) Oligopod larvae : The presence of well developed thoracic legs, absence of abdominal legs and appendages, except the cerci and caudal processes, are the characteristics of oligopod larvae.

- **Campeidiform larvae** : Larval body elongate, somewhat flattened and well sclerotized. Head prognathous, thoracic legs long, cerci and antennae well developed. e.g., larvae of lady bird beetles, **first instar larvae of blister beetles.**
- **Scarabaeiform larvae** : Larvae are 'C' shaped, stout, sub cylindrical with a fleshy body, head well developed, thoracic legs short, prolegs and caudal processes absent. These larvae are generally sluggish. **e.g. white grubs, dung beetle larvae.**



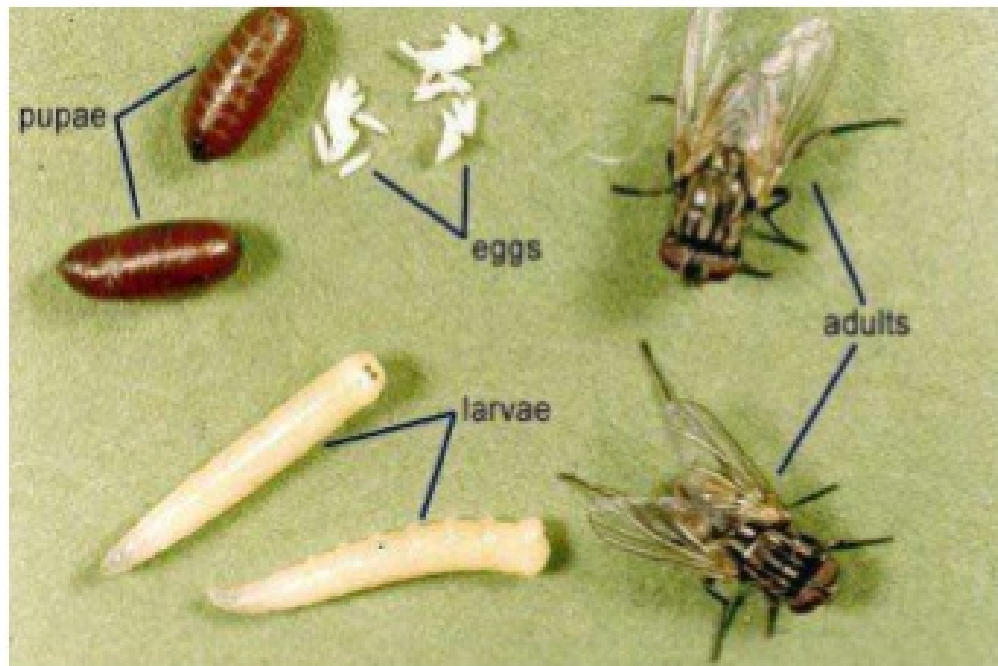
APODOUS

They are larvae without appendages for locomotion. Based on the degree of development and sclerotization of head capsule there are three subtypes.

- a. **Eucephalous** : Larva with well developed head capsule with functional mandibles, maxillae, stemmata and antennae. Mandibles act transversely. e.g. Wiggler (larva of mosquito) and grub of red palm weevil.

- b. **Hemicephalous** : Head capsule is reduced and can be withdrawn into thorax. Mandibles act vertically. e.g. Larva of horse fly and robber fly.

- c. **Acephalous** : Head capsule is absent. Mouthparts consist of a pair of protrusible curved mouth hooks and associated internal sclerites. They are also called vermiform larvae. e.g. Maggot (larva of house fly).



POLYPOD LARVAE



(a)



(b)

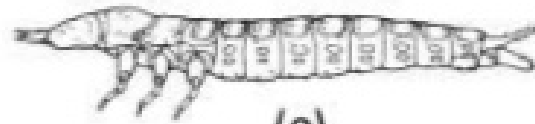


(c)

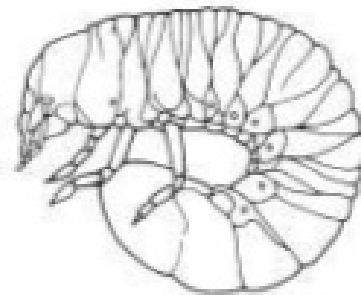
OLIGOPOD LARVAE



(d)

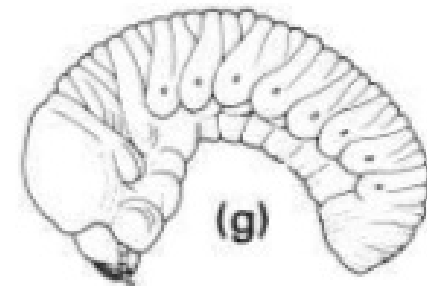


(e)



(f)

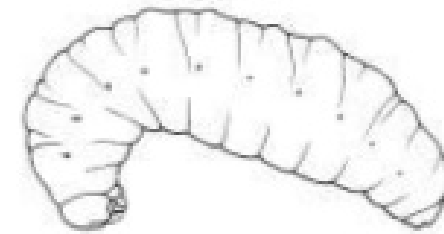
APOD LARVAE



(g)



(h)

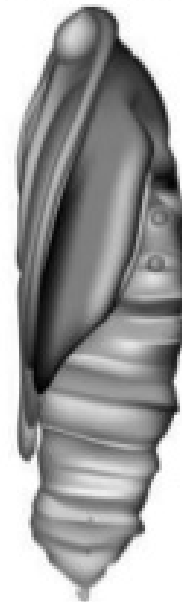


(i)

Pupae:

The resting, non-feeding or “inactive stage” of a holometabolous insect is the pupa. During this stage the larvae are transformed into adults through a process of reconstructive development leading to the formation of the ‘adult’. Three types of pupae can be distinguished.

- Obtect pupa : The appendages of the pupa are not free and are glued to body; Only the tip of the abdominal region shows movement. The pupa may often be enclosed in a cocoon as in moths, or may be naked as in butterflies (chrysalis). e.g. moths and butterflies.



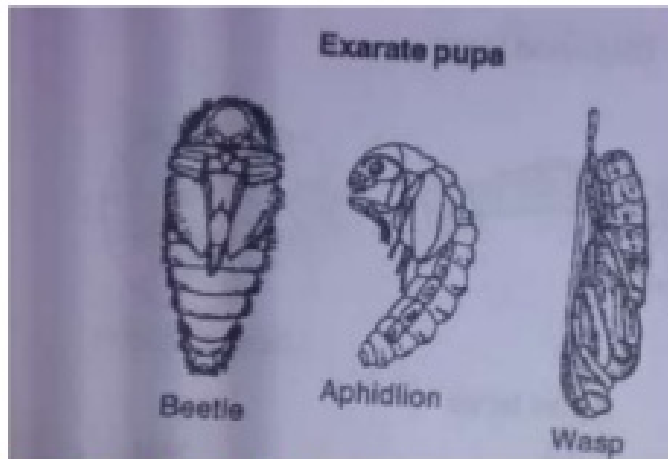
a. **Chrysalis** : It is the naked object pupa of butterfly. It is angular and attractively coloured. The pupa is attached to the substratum by hooks present at the terminal end of the abdomen called **cremaster**. The middle part of the chrysalis is attached to the substratum by two strong silken threads called **gridle**.



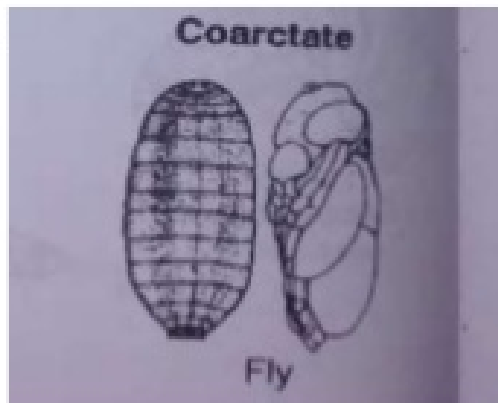
b. **Tumbler** : Pupa of mosquito is called tumbler. It is an object type of pupa. It is comma shaped with rudimentary appendages. Breathing trumpets are present in the cephalic end and anal paddles are present at the end of the abdomen. Abdomen is capable of jerky movements which are produced by the anal paddles. The pupa is very active.

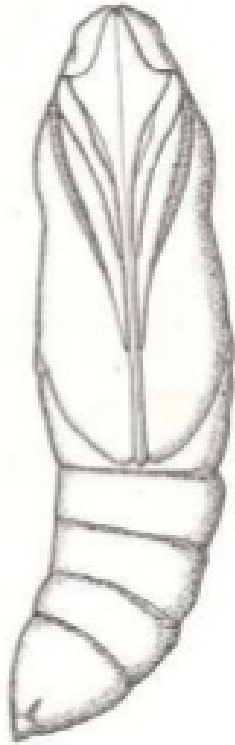
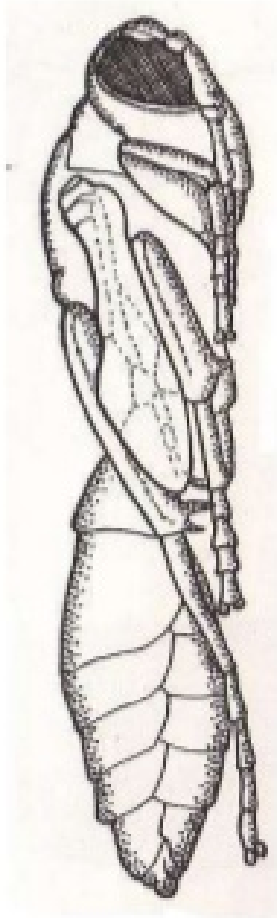


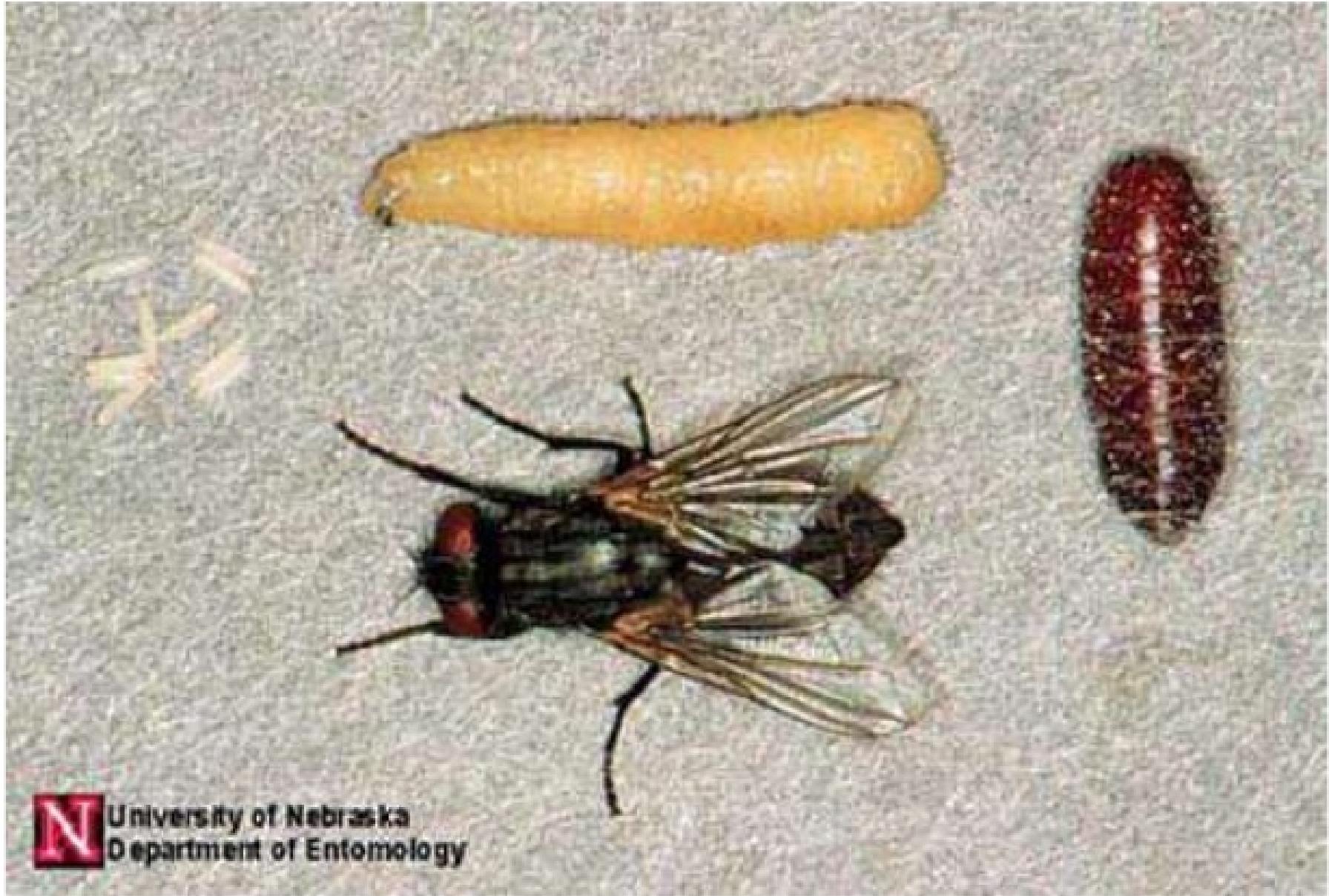
2. **EXARATE** : Various appendages viz., antennae, legs and wing pads are not glued to the body. They are free. All oligopod larvae will turn into exarate pupae. The pupa is soft and pale e.g. Pupa of rhinoceros beetle.



3. **COARCTATE** : The pupal case is barrel shaped, smooth with no apparent appendages. The last larval skin is changed into case containing the exarate pupa. The hardened dark brown pupal case is called puparium. e.g. Fly pupa.







University of Nebraska
Department of Entomology



Diapause

- It is the period of arrested growth or development in the life cycle of the insects during which the physiological processes like **differentiation and reproduction are** suspended.
- Diapause is represented by low rate of metabolism, low O₂ consumption, low body weight, low body water content and vitamin deficiency in the blood.
- Diapause may occur in **egg, larva, nymph, pupa or adult stage**. For example:
 - **Egg diapause - *Bombyx mori*;**
 - **Larval diapause- *Euproctis sp.*, *Pectinophora gossypiella*;**
 - **Pupal diapause- Redhairy Caterpillar (*Amsacta albistriga*)**
 - **Adult diapause- Mango nut weevil (*Sternochaetus mangiferae*)**

- **Diapause is of two types:**
- **1. Obligatory diapause:** It refers to the stage of suspended activity of the insect which is a hereditary character controlled by genes and is species specific. e.g. **egg diapause in silkworm**
- **2. Facultative diapause:** It is the stage of suspended activity of the insect due to unfavourable conditions and with the onset of favourable condition, the insect regains its original activity. e.g. **Cotton pink bollworm *Pectinophora gossypiella***

- The unfavourable conditions may be biotic or abiotic.
- Biotic conditions are natural enemies, population density etc.
Whereas abiotic conditions are temperature, rainfall, humidity, photoperiod, type of food material etc.
- The occurrence of diapause **during summer** due to high temperatures is known as “**aestivation**”
- where as the period of inactivity **during winter** due to low temperatures known as “**hibernation**”.