FORENSIC ENTOMOLOGY : BASIC CONCEPT

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FORENSIC FAUNA: CRIME-SCENE FRIENDS OR INSECT DETECTIVES

Forensic entomology is the scientific study of the invasion of the succession pattern of arthropods with their developmental stages of different species found on the decomposed cadavers to aid legal investigations.

3 Broad Categories:

i. **MEDICO-LEGAL**

Homicides (Post-mortem interval or **PMI** estimation)
Abuse/Neglect –Both Human (children/elderly) and Animal.
Postmortem transfer/ Storage of dead body.
Entomotoxicology- Death by poison/toxicants
Wildlife crime control

ii. **URBAN**

iii. **STORED-PRODUCT**

72 hours after death has occurred, these methods become the most accurate and sometimes the only method used to determine the time of death.

3 Broad Categories of Forensic entomology:

- **Medico-legal** - criminal component of the legal system and deals with the necrophagous (or carrion) feeding insects that typically infest human remains.

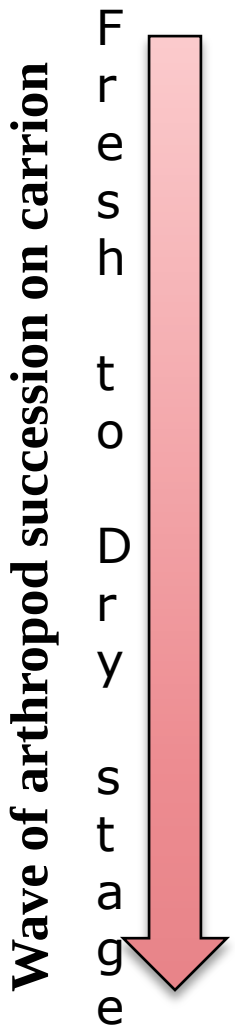
- **Urban** - both criminal and civil components as urban pests may feed on both the living and the dead.

- **Stored Products** – Civil & criminal cases involving food contamination.

Brief History

- Sung T'zu (1235)
  - First reference to forensic entomology
- Bergeret (1855)
  - Used forensic entomology to solve a case of a long-dead infant
- J.P. Megnin (1894)
  - "La Faun des Cadavres: Application l'entomologie a la Medicine Legale"
- Hall 1948
  - Monograph on identification of blowflies
- Pekka Nuorteva of Finland (1970's)
  - Rekindled interest in the technique, published series of case histories
- Keh (1985), Smith (1986), Catts and Goff (1992)
  - Textbooks and reviews

Fauna associated with cadavers



FORENSIC ENTOMOLOGY

DIPTERA (True-flies)
MECOPTERA(Scorpionflies)
HYMENOPTERA(Ants, wasps and bees)
COLEOPTERA (Beetles)
DICTYOPTERA(Cockroaches)
ORTHOPTERA(Crickets, grasshoppers)
HEMIPTERA(Plant-bugs, aphids)
ISOPTERA (Termites)
LEPIDOPTERA(Moths)
COLLEMBOLA (Springtails)

FORENSIC ACAROLOGY

SPIDERS
MITES

FORENSIC DIPLOPODS

MILLIPEDES

FORENSIC CRUSTACEANS
(For submerged corpses)

PRAWNS, CRABS & CIRRIPEDES

MAJOR INSECT ORDERS OF FORENSIC SIGNIFICANCE

INSECT FAMILIES CONSIDERED FORENSICALLY IMPORTANT WORLDWIDE:

ORDER DIPTERA	ORDER HYMENOPTERA	ORDER COLEOPTERA	ORDER LEPIDOPTERA
Calliphoridae(Blowflies) Muscidae(Houseflies) Sarcophagidae(Flesh-flies), Phoridae,Psychodidae, Sepsidae,Stratiomyidae, Anthomyiidae,Piophilidae, Chloropidae,Ephydridae, Fanniidae,Milichiidae, Micropezidae, Neriidae, Drosophilidae, Dixidae, Sphaeroceridae, Cecidomyiidae and Heleomyzidae.	Apidae Formicidae Chalcididae Braconidae Vespidae	Staphylinidae Histeridae Silphidae Dermestidae Trogidae Cleridae Scarabaeidae Nitidulidae	Pyralidae Tineidae Oecophoridae

Fresh stage to dry stage → **Advanced decay to later stages** → **Advanced decay to dry stage** → **Remains stage(Skeletonized stage)**

1. **Autolysis** (**Fresh**)
   - Cells autolyse aseptically
   - Internal bacteria act anaerobically
2. **Putrefaction (Bloating)**
   - Lower abdomen bloats, turns green
3. **Butyric fermentation (Black putrefaction)**
   - Body cavity ruptures, body darkens
   - Mumification & adipocere formation occurs at this stage
4. **Dry Decay (Skeletonization)**
   - Slow deterioration of skeletal remains

Stages of decomposition of Human Corpses

Most cases deal with human corpses

- Interaction between
  - Time that the corpse is available to insects
  - Insect species in the area & their activity
  - Temperature & other environmental variables
- Some insect species find corpses faster than do others, some are better colonizers at different stages of corpse decay.
  - Stage of decomposition
  - Insect community (species and age distribution)

- Rigor mortis followed by algor mortis sets in within 72 hours.
- Calliphorid flies (esp. green bottle flies) are the first to arrive & lay eggs.
- Hairy maggot blowflies (another calliphorid) are usually the second to arrive

Green Bottle Fly,

Chrysomya megacephala

Hairy Maggot Blowfly

Chrysomya rufifacies

Fresh

Putrefaction

- Begins 4 – 10 days after death
- Blowfly eggs have hatched, maggots are in orifices
- Histerid beetles appear under body (if on land)

Hister quadrinotatus

Order. Coleoptera ·

Family. Histeridae

Butyric Formation

- 10 – 25 days after death
- Maggots have begun to leave body, pupate in soil
- Carrion Beetles & Skin Beetles become the dominant necrophage.

About 15 days post mortem. Note the saponification or adipocere formation on the shoulder and arm.

Nicrophorus vespillo

Order: Coleoptera

Family: Silphidae

Dry Decay

- Begins 25 – 50 days after death, can last years.
- Only dry skin, hair, bones remain
- Fungus
  beetles, mites, clothes moths are most common.
  Normal soil fauna begins to inhabit the body.

INSECT FAMILY	STAGES OF DECOMPOSITION			
	FRESH	BLOATED	DECAY	DRY
CALLIPHORIDAE: (blow flies)				
MUSCIDAE: (muscid flies)				
SILPHIDAE: (carrion beetles)				
SARCOPHAGIDAE: (flesh flies)				
HISTERIDAE: (clown beetles)				
STAPHYLINIDAE: (rove beetles)				
NITIDULIDAE: (sap beetles)				
CLERIDAE: (checkered beetles)				
DERMESTIDAE: (dermestid beetles)				
SCARABAEIDAE: (lamellicorn beetles)				

*Each stage of decomposition is given the same amount of space in this table.

——— Indicates a small number of individuals present.
——— Indicates a moderate number of individuals present.
——— Indicates a large number of individuals present.

(a)

INSECT FAMILY	STAGES OF DECOMPOSITION			
	FRESH	BLOATED	DECAY	DRY
CALLIPHORIDAE: (blow flies)				
MUSCIDAE: (muscid flies)				
SILPHIDAE: (carrion beetles)				
SARCOPHAGIDAE: (flesh flies)				
STAPHYLINIDAE: (rove beetles)				
DERMESTIDAE: (dermestid beetles)				
SCARABAEIDAE: (lamellicorn beetles)				

*Each stage of decomposition is given the same amount of space in this table.

- Blowfly maggots are of two forms: smooth maggots, and 'hairy' maggots.
- The smooth maggots belong to pioneer flies that are purely corpse feeders.
- 'Hairy' maggots will often feed on corpses, but they are also active predators that feed on smooth maggots.
- Because they are predators, the arrival of the secondary flies that produce hairy maggots is normally later than that of the pioneer maggots.
- Beetle maggots also tend to be predatory like the adult beetles.

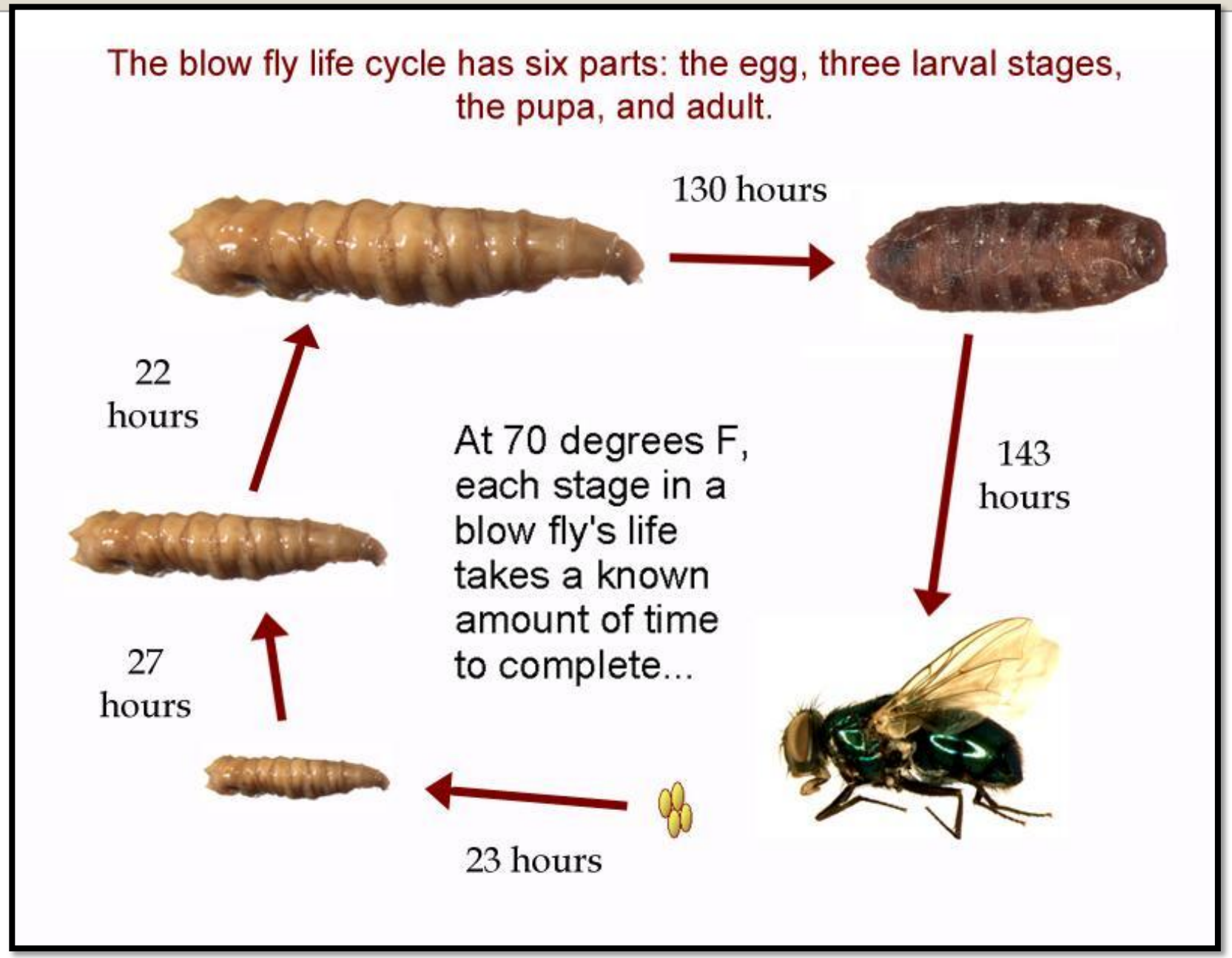
The Story Maggots Tell

3rd instar larva

Adult

Hairy maggot blowfly, *Chrysomya rufifacies*

The blow fly life cycle has six parts: the egg, three larval stages, the pupa, and adult.



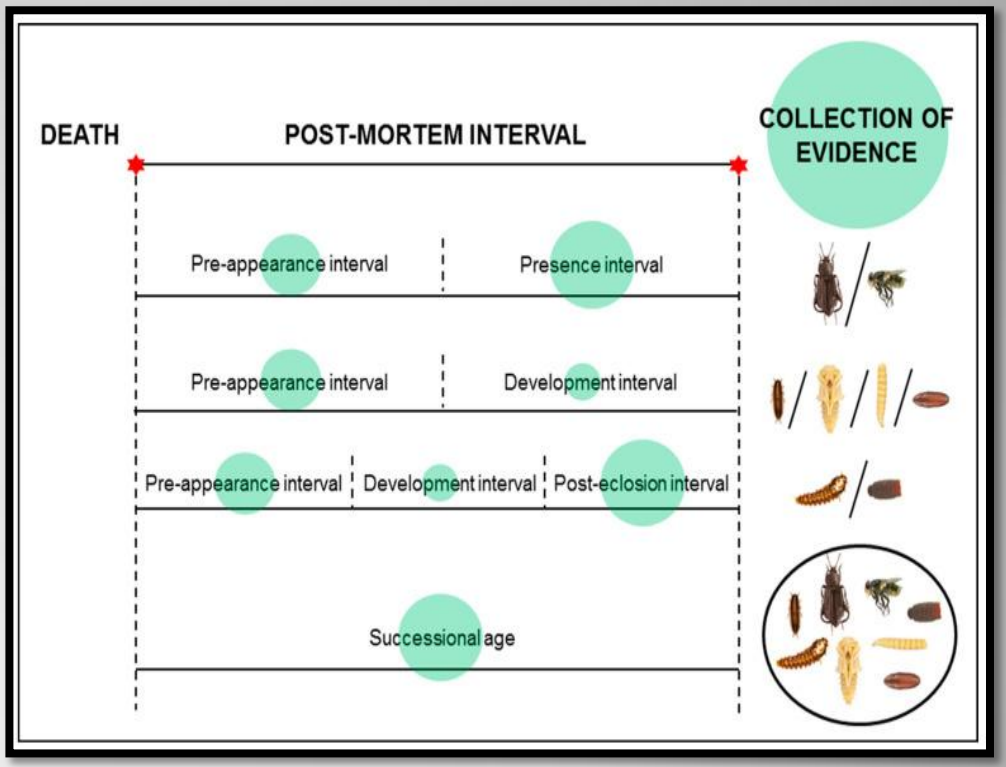
- A single female may lay from several dozen to several thousand eggs during her lifetime.
- Eggs can be laid singly or in clumps
- Larva feed voraciously – they can be predatory.
- The larval period varies between species but can be as long as several years.
- All beetle larvae go through several instars, which are the developmental stages between each molt.
- In many species the larvae simply increase in size with each successive instar as more food is consumed. In some cases, however, more dramatic changes occur.
- beetle larvae pupate, and from this pupa emerges a fully formed, sexually mature adult beetle, or imago.
- Adults have an extremely variable lifespan, from weeks to years, depending on the species.

General Life cycle of Beetles

Factors Affecting Decomposition

- Temperature/humidity
  - Lower temps slow down microbes & insects
  - Low humidity dries corpse, mummifies
- Access
  - Submerged vs. on land
  - In open vs. interred vs. in shade
- Reduction & Cause of Death
  - Large wounds lead to faster decomposition
  - Scavangers/vertebrate predators important too
- Coverings & Pesticides
  - Tightly wrapped bodies decompose slower
  - Heavy clothing slows decomposition more than thinner clothing
- Percent of body fat in corpse
  - More fat (higher water content, better heat retention) means faster decomposition
- Drugs & chemicals
  - Insects on coke or meth burn through a body faster, bodies with arsenic decompose slower.

- Can be used to determine Post Mortem Interval
  - PMI = Time since death (Actually, time since initial colonization).
  - Most entomologically useful range is 2 – 4 weeks
- Requires site-specific temperatures
  - Often a statistical correlation between the site and the nearest ambient temperatures
  - Statistical correlation produces a PMI range.



Temperature Especially Important

Post-mortem Interval or PMI ESTIMATION

2 Basics ways:

i. Analysing developmental rates of necrophagous insect species on the carcass-
Developmental rates vary according to meteorological parameters (especially temperature and humidity) of different geographical regions.

ii. Studying successional patterns of carrion colonisation by different insect species, based on the decompositional stages-
Strictly relies on the baseline fauna drawn from various geographical regions and varies even in same geoclimatic settings.

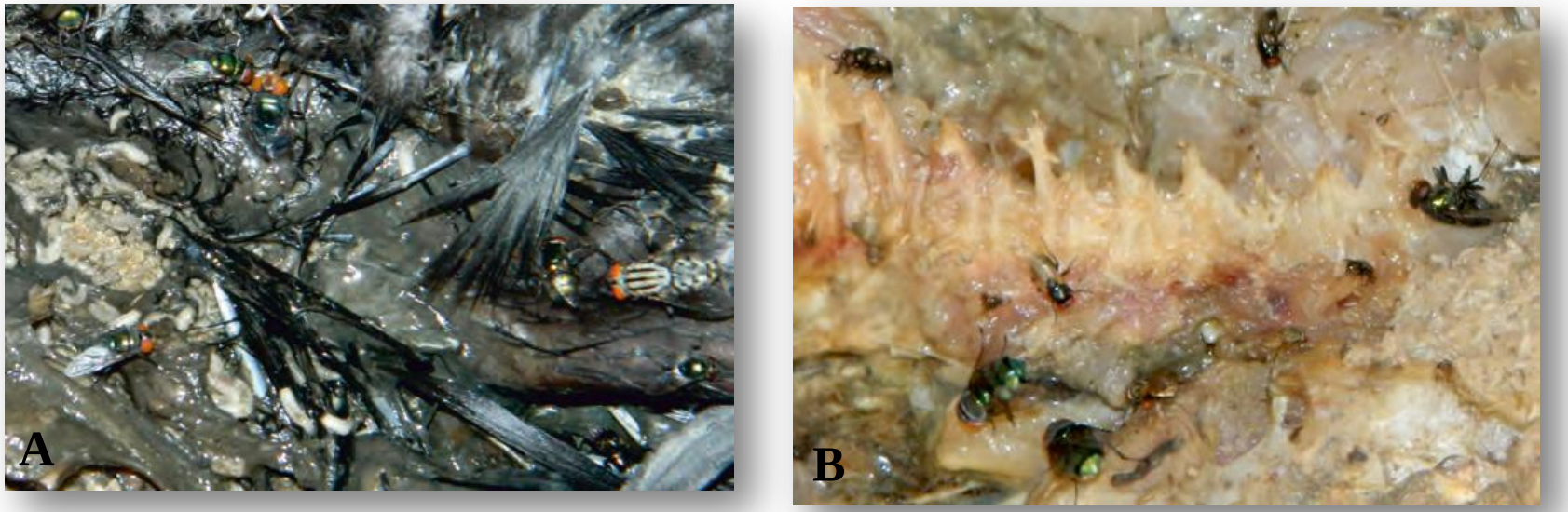


Figure: Forensic flies(Calliphorids and Sarcophagids) feeding on carcass of bird (A) and fish (B). Actual images obtained from forensic dipterological studies done in Kolkata by Diptera Section, ZSI.

PMI Calculation Example.

Body is found with Lucilia sericata larvae, prepupae, and pupae (in soil next to body). Temps at site had averaged 16° C. Pupae brought into the lab & held at that temp. began to eclose after 112 hours

Development rate of sheep blowflies, *Lucilia sericata,* (in hours) at three different temperatures

Temp(°C)	Egg	Larva 1st Instar	Larva 2nd Instar	Larva 3rd Instar	Pre-pupa	Pupa	Total time (days)
16	41	53	42	98	148	393	32
21	21	31	26	50	118	240	20
27	18	20	12	40	90	168	14

PMI = (41 + 53 + 42 + 98 + 148 + 393 – 112)/24 = **27 days**

THANK YOU