6. Insect viruses (RNA viruses)

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* RNA insect viruses received less attention as compared with the insect DNA viruses because of their low pathogenicity and the resulting limitation in insect pest control

1) Reoviridae (ds RNA, non-enveloped)
   - name derived from "respiratory enteric orphan viruses"
     → "orphan viruses" means that a virus is not associated with any known disease (though viruses in the family have been recently identified with various diseases)
   - nearly all insect viruses in the family Reoviridae are CPVs

![TEM micrograph of rotavirus particles](https://example.com/rotavirus_micrograph.png)

- They are ds RNA viruses which replicate in the cytoplasm, indicating they have everything they need for replication and do not utilize the cell's replication enzymes.
(1) CPV (a.k.a. Cypovirus)
  - Ishimori (1934): first report of a CPV (cytoplasmic polyhedrosis virus) from midgut epithelial cell of the silkworm (*Bombyx mori* cypovirus 1, cause "flacherie")
    - polyhedral bodies occurred in the cytoplasm (cf. nuclear polyhedrosis virus)

A  Structure
  - icosahedral (60-80nm)
  - multisegmented ds RNA
  - differ from other Reoviruses by the viral particle with single-shelled capsid (other Reoviruses have double-shelled capsid)

  ![Structure diagram](image)

  - mostly isolated from Lepidoptera (80% of more than 250 insect species)

B  inclusion body (=polyhedron)
  - due to some of them do not occlude virions
  - formed in the cytoplasm of midgut epithelial cells (strictly restricted to this tissue)
  - typical polyhedron occludes (contains) one (in mosquitoes and chironomids) to several thousand viral particles (virions)
  - inclusion bodies are not bounded by an envelope (not virion envelope) so that CPV polyhedra are more easily stained with Giemsa and other stains than the NPVs (which has polyhedra bounded by an envelope)
    - one way to separate the two types of polyhedrosis

C  Infection and symptom
  - CPV polyhedra dissolved at a high pH
  - infection site: midgut (tissue specificity), but not always (found from fat body of coleopteran larvae)
  - symptom: not striking (chronic disease), but due to the infection of midgut,
the infected insect stop feeding (may develop diarrhea) and showed signs of typically starved larvae (e.g., smaller and lighter body, increased number of molt)
- in general, infected larvae begin to show symptoms in about 4 days (e.g., become sluggish, cease to feed, and often develop diarrhea)
- color change of heavily infected midgut: from opaque yellow to white (compared with translucent, clear midgut of an uninfected larvae)
- infected larvae produce pupae generally smaller than uninfected pupae
- adults, emerging from infected pupae may appear normal and produce viable eggs, but they are often small and malformed, especially with abnormal wings

2) Birnaviridae (ds RNA, non-enveloped)
   - Bisegmented ds RNA viruses
   ➔ replicate in the cytoplasm
   - described mostly from vertebrates
     ▶ Aquabirnaviridae (fishes)
     ▶ Avibirnaviridae (birds)
   - Entomobirnavirus
     ▶ Drosophila X virus (DXV)
     ; found in laboratory populations of adult Drosophila melanogaster ➔ adults sensitive to CO₂
     ; in natural population, it has been detected from Culicoides spp. (Ceratopogonidae) not from Drosophila

3) Tetraviridae (ss RNA, non-enveloped)
   - members of the family are confined to insects [exclusively to the members of Lepidoptera (15 species)]
   - first isolated from larvae of the emperor gum moth, Antherea eucalypti

< Female and 5th instar of Antherea eucalypti >
- two genera (based on the segment of genome)
  ▪ Betatetravirus: one segmented ss RNA
  ▪ Omegatetravirus: two segmented ss RNA
- infected larvae become discolored and flaccid, death occurs in 6 to 8 days

4) Picornaviridae (ss RNA, non-enveloped)
- among the smallest (pico = very small) RNA viruses (22-30nm)
- includes many important viruses infect vertebrates
  ▪ *Enterovirus* (poliovirus)
    ; cause acute viral infectious disease, polio or infantile paralysis
  ▪ *Rhinovirus* (common cold virus)
  ▪ *Aphthovirus* ([foot-and-mouth disease virus](#))
    ; highly contagious and sometimes fatal viral disease of cloven-hoofed animals (e.g., cattle, sheep, pig)

A Cricket-paralysis virus
- cause progressive paralysis of hind legs and die rapidly
  (densovirus also cause hind leg paralysis to cricket and cockroach)
- early to midinstar nymphs are most susceptible
- adult crickets showed some degree of resistance
- replicates in the cytoplasm of cells of epidermis, alimentary tract, and nerve ganglia

B *Drosophila* C virus
- DCV was first isolated from laboratory and natural populations of *Drosophila* (cf. DXV only found in laboratory population)
- very similar to Cricket-paralysis virus but differ in host range and RNA sequence

C Sacbrood virus ([낭충봉아부패병](#))
- honey bee (*Apis mellifera*) has the largest number of diseases caused by RNA viruses
- disease of honey bee has been known as early as 19C
- name derived from the closed sac of dead larva
- infect only larval stage of honey bee ⇒ failure to pupate and death
- dead brood occurs mostly in capped cells (similar to AFB), but infected larvae have particularly no odor
- virus multiplies in adult bees and infects larvae through food
- highly infective, no treatment available so far
- sacbrood occurs most frequently in spring, when the colony is growing most rapidly and large numbers of susceptible larvae and young adults are available

**Acute bee paralysis virus (ABPV)**
- previously placed in the Picornaviridae, but reclassified into the family Dicistroviridae
- symptom: make unable to fly (trembling and sprawled legs and wings), and unable to feed normally (due to disjointed mouthpart)
- infected adults usually show the first symptom in 2 to 4 days and then die within a day (possibly because they are unable to feed)
- both adult and brood are susceptible when the colony is infested by a parasitic mite that may serve as a vector in transmitting the virus from severely infected to healthy bees

< Parasitic mite, *Varroa destructor*, in honey bee adult and pupa >

★ The condition called "string wings (or deformed wing)" usually occurs with high level of *Varroa destructor* infestation, caused by deformed wing virus (DWV; Iflaviridae). DWV is a virus of minor virulence in the absence of *Varroa destructor* allowing infected brood to develop through the pupal stage to adult.
Chronic bee paralysis virus (CBPV)
- the virus causing chronic bee paralysis virus is not a picornavirus (undetermined)
- infected adult honey bee exhibit distinct sets of symptoms or syndromes
  - **bloated abdomen**, caused by the distension of the honey sac with liquid → **unable to fly** → crawl on the ground, exhibiting an abnormal **trembling motion** of the wings and bodies
  - bees with second syndrome are initially able to fly → become **almost hairless**, appearing dark or almost black and shiny (hairless black syndrome) → uninfected, healthy bees nibble (chew) at them and prevent their return to the colony → in a few days, they start **trembling**, remain flightless, and die

because of bees afflicted with the virus appear shiny and greasy due to the lack of hairs sometimes they are confused with robbing bees. Also, adult bees are chewed by other bees and harassed by guard bees at the entrance to the hive (may be confused with signs of robbing).

- the virus is spread from bee to bee by unusually prolonged **bodily contact** or **rubbing** which causes many hairs or bristles to break exposing live
tissue. Bees do not transmit sufficient virus to cause paralysis by food exchange because many millions of virus particles are required to cause paralysis when given to a bee in food

Flacherie virus (of silkworm)
- previously placed in the Picornaviridae, but reclassified into the family **Dicistroviridae**
- flacherie is a general descriptive term used to describe a syndrome where the diseased larva is flaccid from dysenteric condition (disorder of the digestive system) and appears loosely (weakly) hanging
- infection only occurred in the midgut epithelial cells
- viral agent: BmDNV (*Bombyx mori* densovirus, Paroviridae), BmCPV-1 (*Bombyx mori* cypovirus 1, Reoviridae), BmIFV (*Bombyx mori* infectious flacherie virus)
- bacterial agent: *Serratia marcescens, Streptococcus bombycis, Bacillus bombycis*
- it was Louis Pasteur (1870) who definitely separated the flacherie from fungal (muscardine), protozoan (pebrine), and baculovirus (jaundice; yellowish discoloration of the skin) infection

5) **Nodaviridae (ss RNA, non-enveloped)**
- characterized by the divided (bipartite) genome (two ssRNA molecules in a virion)
- isolated from mosquito (*Culex tritaeniorhynchus*) from Nodamura, Japan ➜ called "Nodamura virus"
- two genera
  • Alpha nodavirus; infects insects
    ➔ Black beetle virus (BBV): infect black beetle (*Heteronychus arator*)

scarabaeid beetle are serious pests of pasture in New Zealand. The BBV causes substantial mortality.
• Boolarra virus: infect Lepidoptera
• Flock House virus: infect grass grub (*Costelytra zealandica*)
• Beta nodavirus; mammal

6) **Caliciviridae (ss RNA, non-enveloped)**
- members of the family are mainly vertebrate pathogens
- isolated from navel orangeworm (*Amyelois transitella*, Pyralidae)
  ➔ larvae infect almonds, pistachios, walnuts
- called the chronic stunt virus (CSV, exhibit retarded growth)
- highly pathogenic to newly hatched larvae, but older larvae (usually fourth instar) acquire a chronic infection and exhibit retarded growth

7) **Rhabdoviridae (ss RNA, enveloped)**
- infect vertebrates, invertebrates, and plants
- many of them are arbovirus (arthropod-borne virus)
- Rhabdoviruses infecting animals are usually bullet-shaped

● Sigma virus
- isolated and restricted to *Drosophila* spp. (ca 10% of natural population)
- generally non-pathogenic (only known effect is the egg viability)
- **infection develops CO₂ sensitivity**
  ➔ adults of *Drosophila melanogaster* are commonly immobilized by exposure to CO₂ to facilitate the genetic experiments. They recover from the anoxia (lack of oxygen) when returned to normal air condition
  ➔ sigma virus infected adults (lesser degree in larvae) suffered fatal paralysis after exposure to CO₂
- transmitted vertically thru both females and males
  ➔ infection must occur in the oocytes of the female and in the spermatocytes of the male