Arthropodology and Entomology

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Definitions

- **Arthropodology** : a zoological science that study Arthropodes

- **Entomology** : a zoological science that study insects

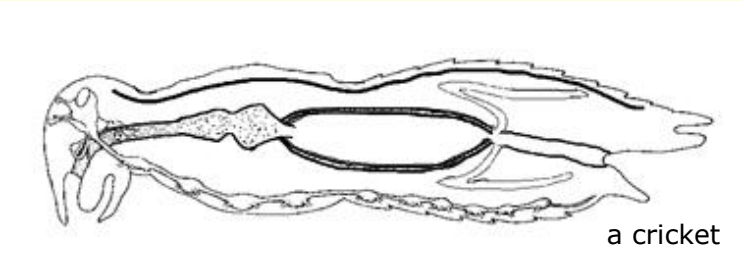
Main characteristics of Arthropods

- **Exoskeleton** : cuticle, development by moults

- **Articulated body** : segments with appendices (antenna, legs)

- **Internal organisation with a similar pattern**

  - dorsal blood vessel,
  - digestive tube in 3 parts,
  - muscles,
  - double ventral nerve cord + peri-oesophageal collar,
  - excretory organ (Malpighi tubes),
  - reproductive system (sexes are separated)


a cricket

No organ specialised in the respiration (ex. lungs)

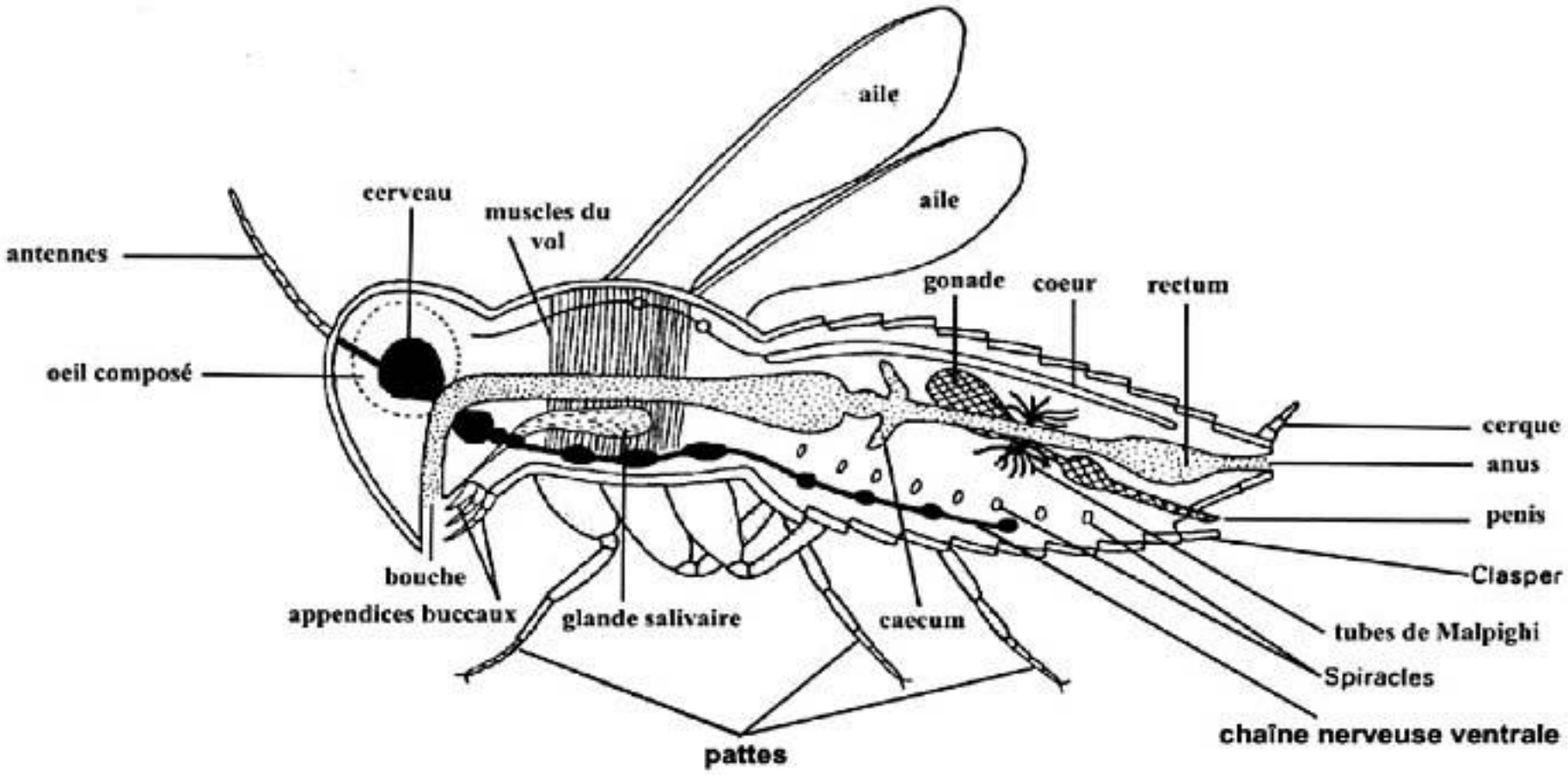


Schéma de l'organisation interne d'un Arthropode hexapode (Insectes)

Barnes, Calow, Olive

Simplified classification

Phylum *Arthropoda*

5 main sub-phylla

Chelicerata (**8 legs**)

Crustacea (**10 legs**)

Count the legs

Insecta (**6 legs**)

Myriapoda (**many legs**)

Trilobitomorpha (fossils) (**20 legs**)

Insects

Birds, insects and bats are the only flying organisms

An Arthropod with wing is a insect (without exception)

How many legs? Ex.1

How many legs? Ex.2

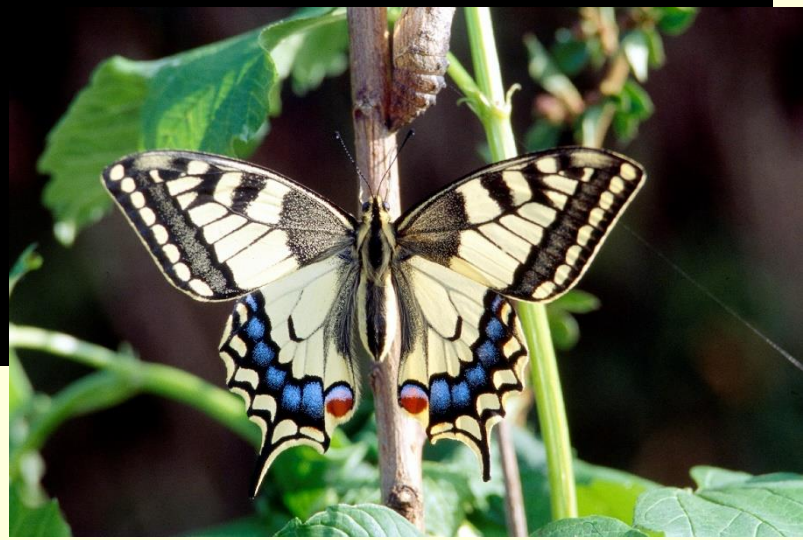
How many legs? Ex.3

How many legs? Ex.4

How many legs? Ex.5

How many legs? Ex.6

Three are not insects



How many legs? 6

Three are not insects

Class Insecta

- **Body : 3 parts (tagmata) : head, thorax, abdomen**
- **1 pair of antenna**
- **2 pairs of wings**
- **3 pairs of leg**

1 300 000 described species

A variety of entomologies in response to an enormous biodiversity

Agricultural entomology	Crop protection
Medical & veterinary entomology	Human & animal health
Entomology of museums	Taxonomy and systematic
Entomology of conservation	Preservation of biodiversity
Military entomology	Biological weapon, biosecurity
Entomology, as support of other life sciences	Ex: genetics (*Drosophila*), physiology (*Rhodnius*), medicine (maggot-therapy)
Forensic entomology	Cadaver dating
Nutritional entomology	Nutritional intake

Insect development

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Class Insecta

Sub-Class	Adult
Apterygota	no wings
Pterygota	with wings

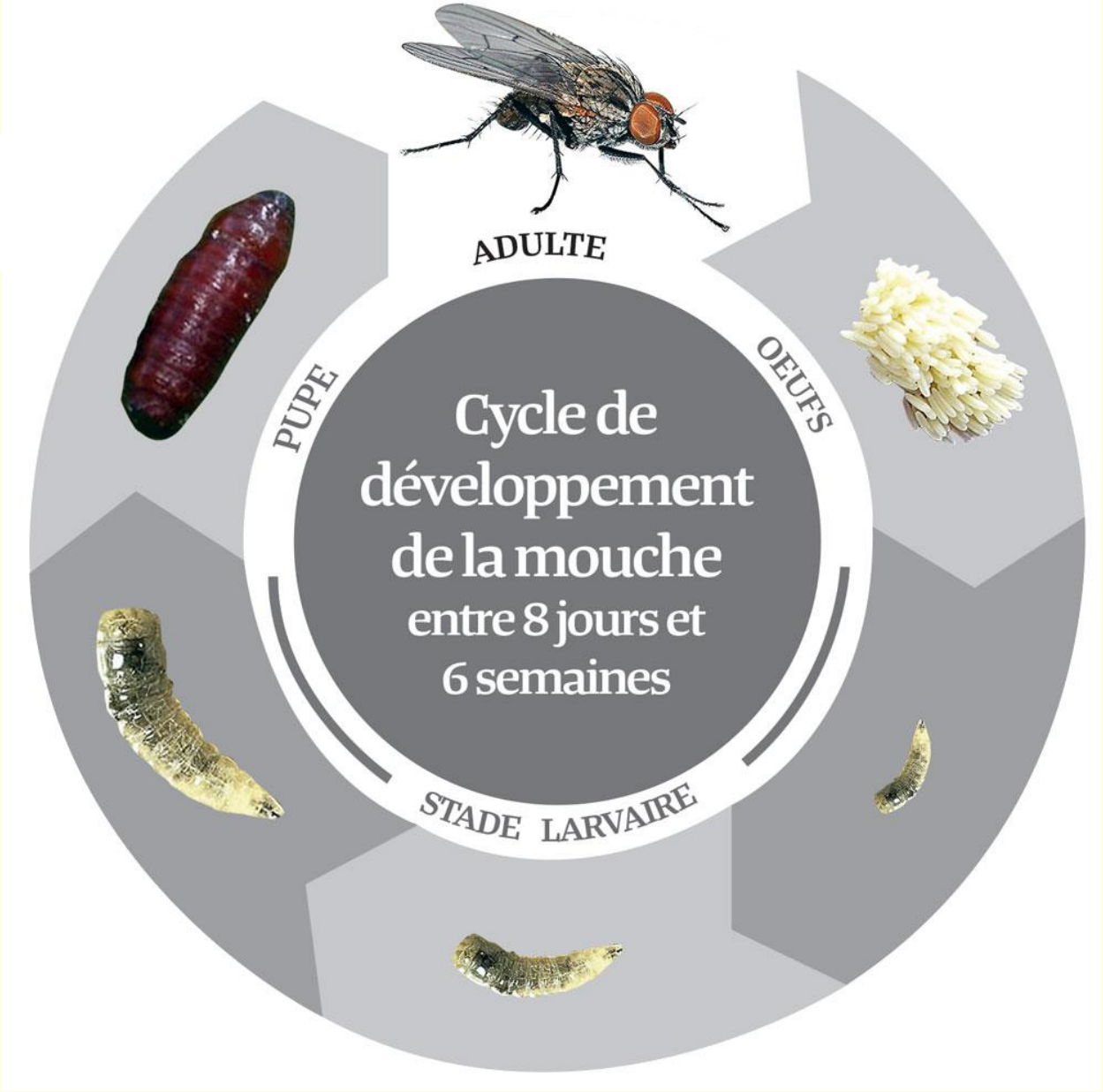
- Hemimetabolous
- Holometabolous

Example of hemimetabolous

Wings
genitalia
gonades

Example of holometabolous

Pupa (en)
Pupe (fr)
Nymphe (fr)



Example of holometabolous

Reproductive fonction

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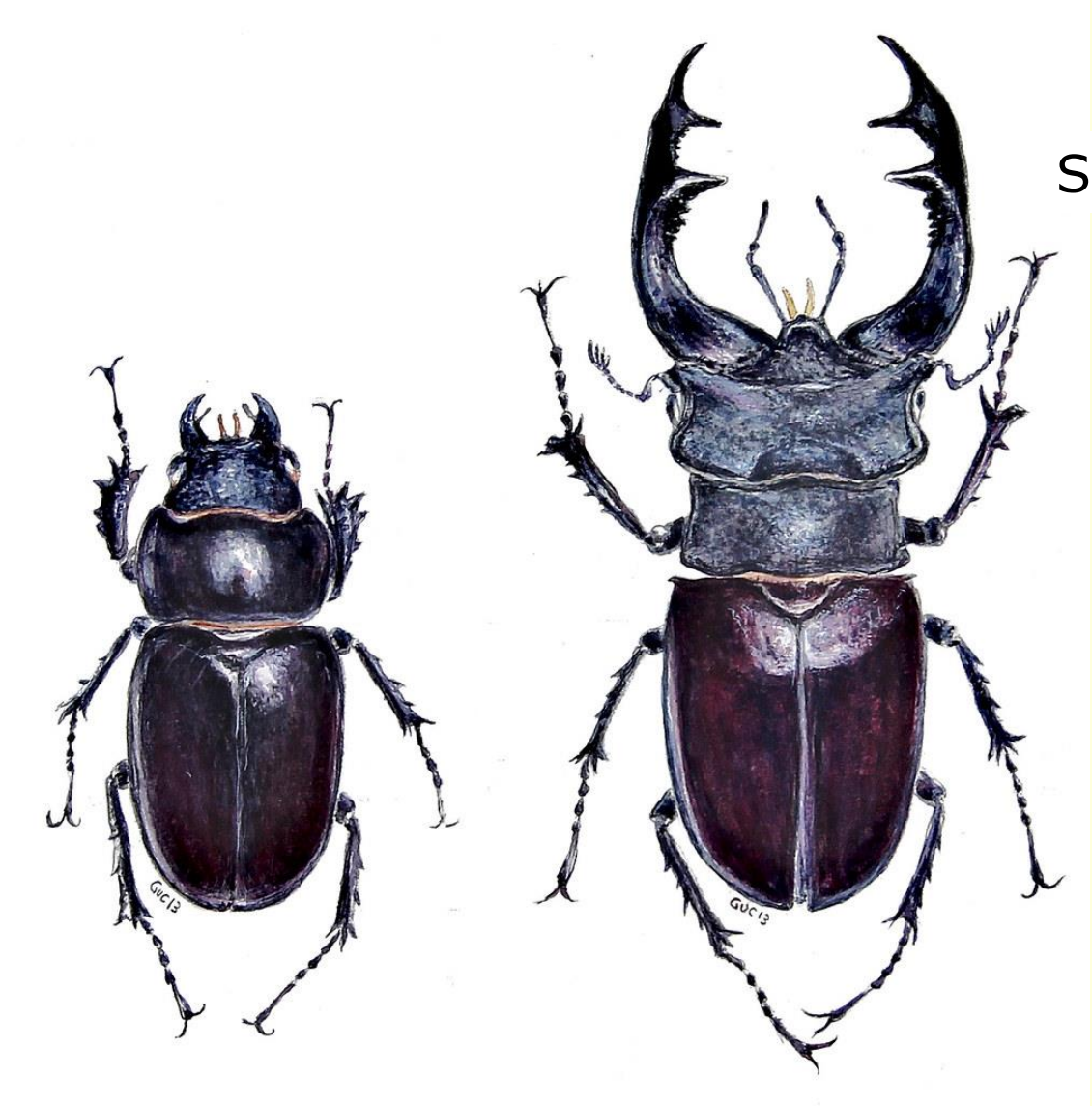
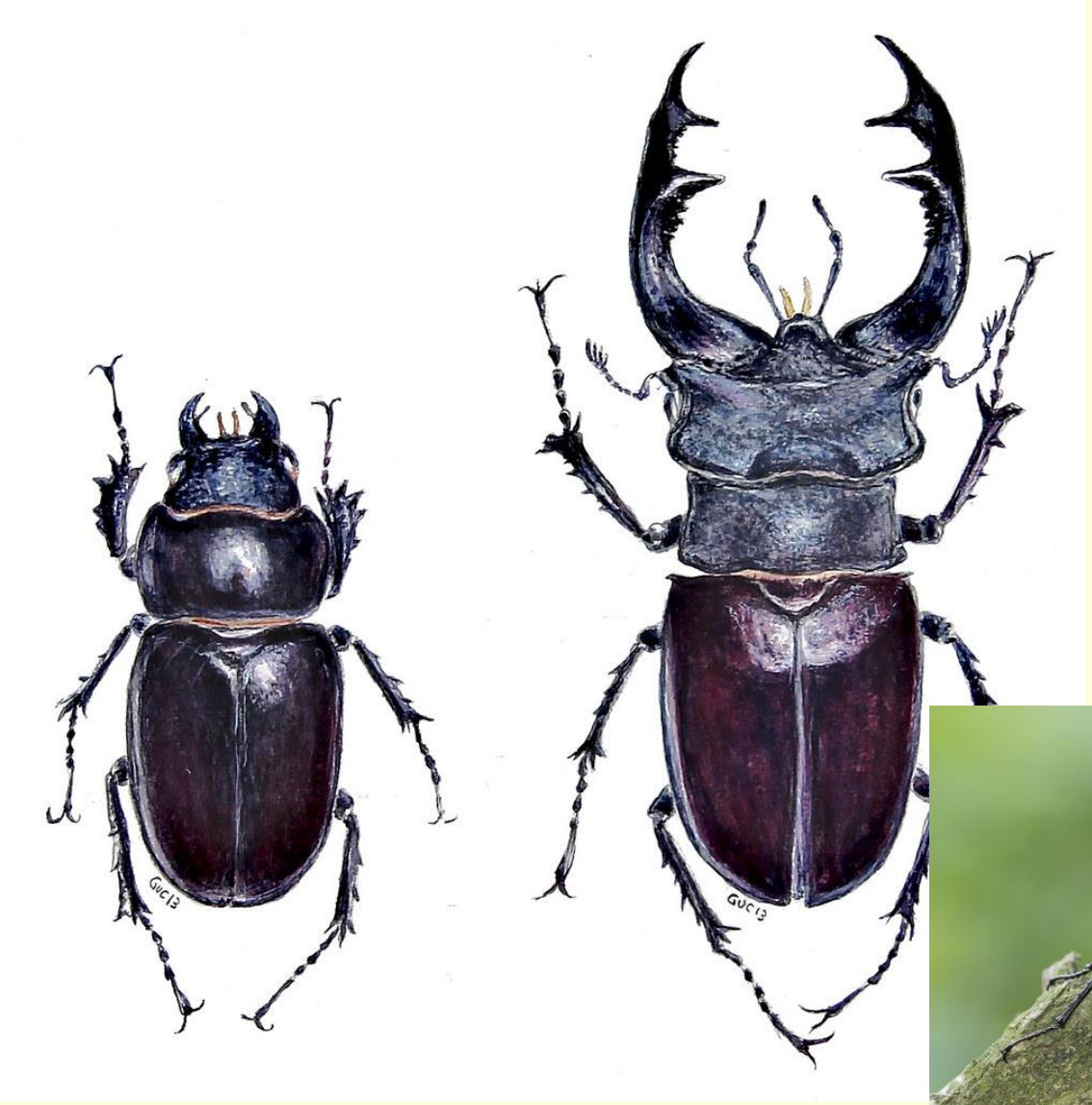
All adult insects are male or female



Sexual dimorphism

All adult insects are male or female



All adult insects are male or female

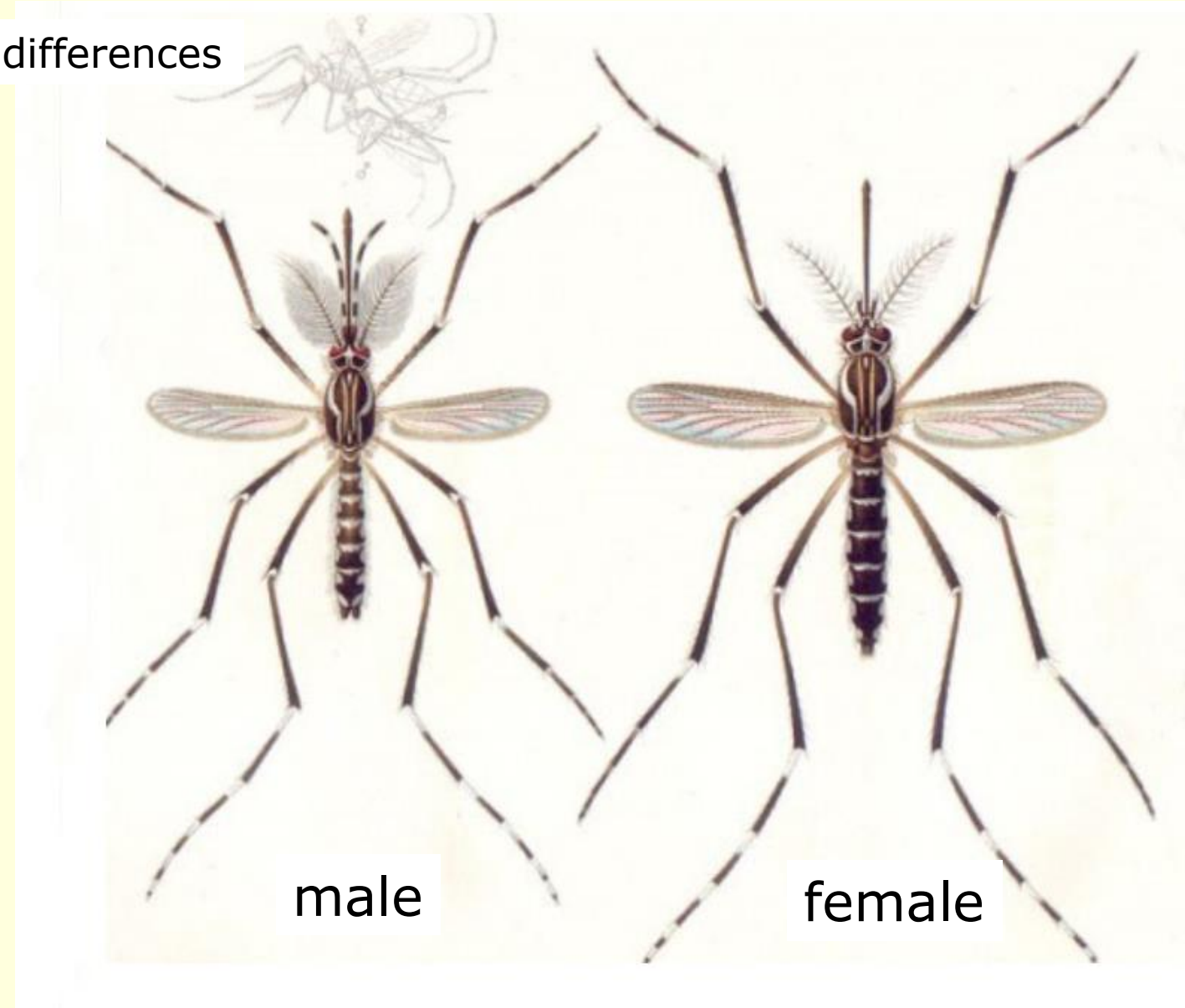
All adults are male or female

male or female ?

female

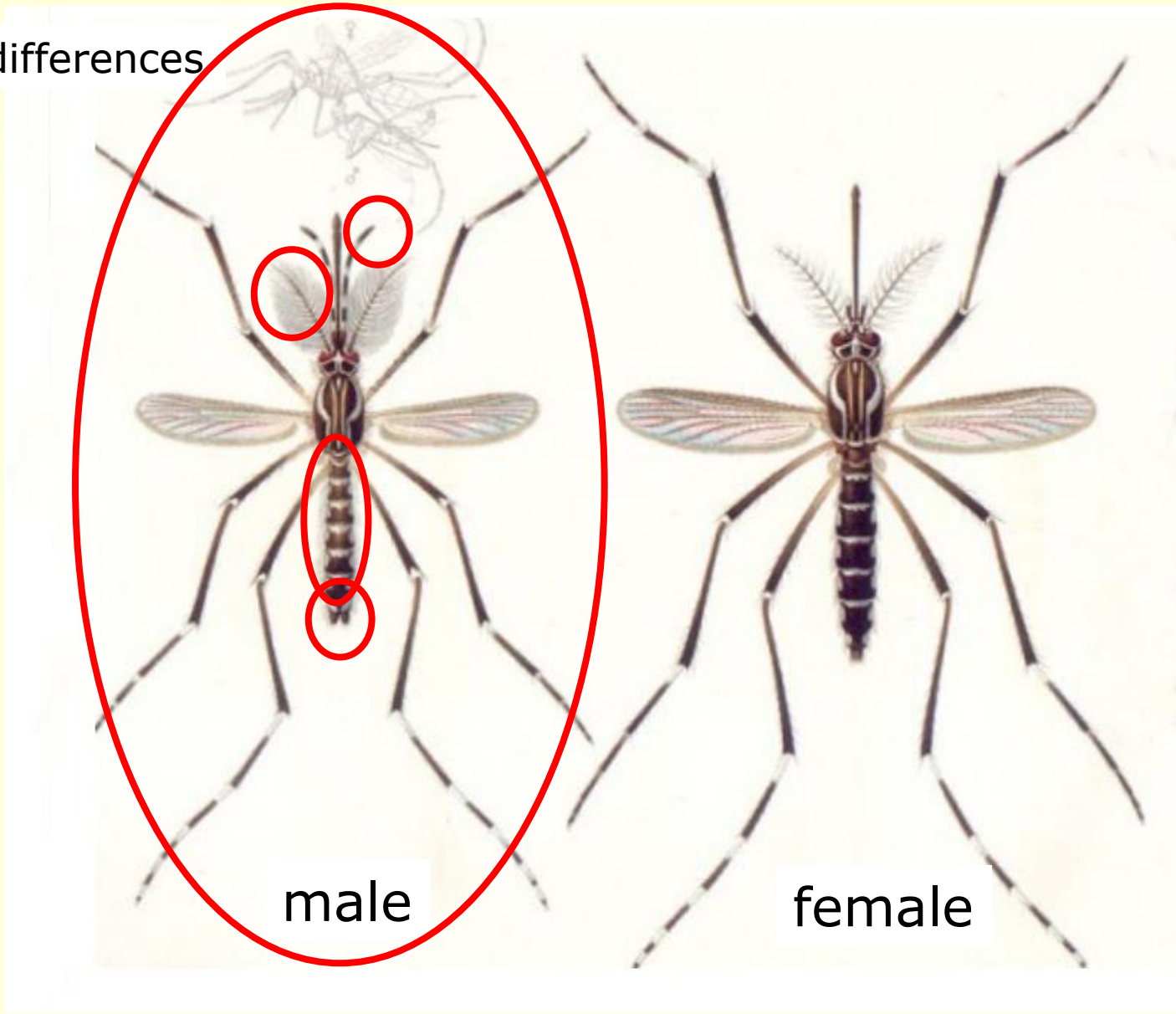
Aedes aegypti, the yellow fever mosquito

Four main differences



Aedes aegypti, the yellow fever mosquito

Five main differences



All adults are male or female

Exceptions: Gynandry

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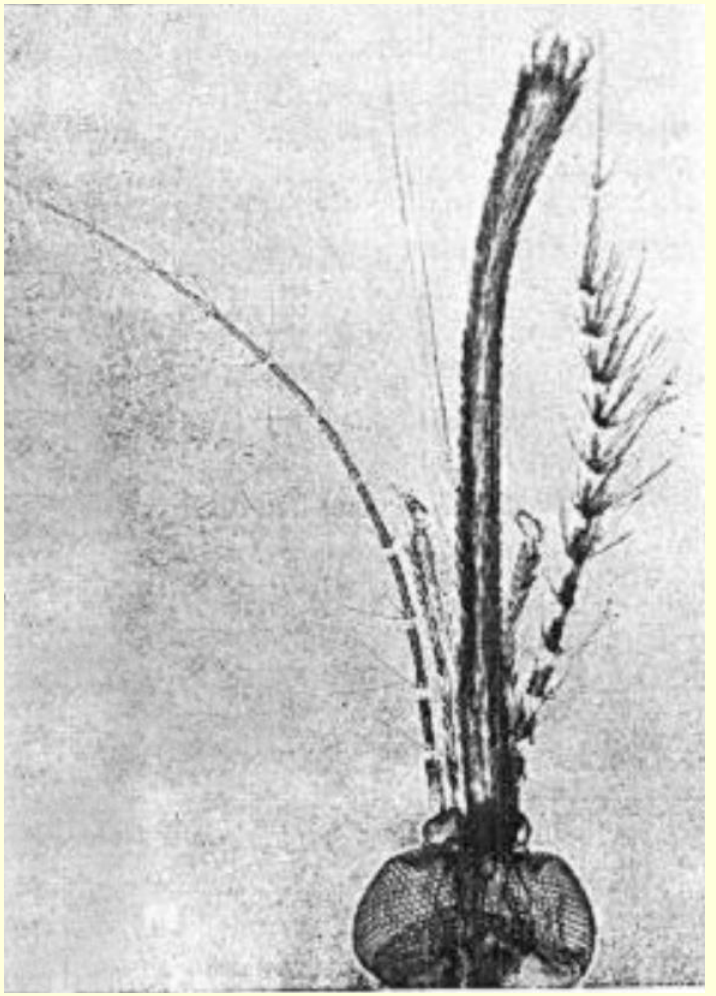
Exceptions: Gynandry



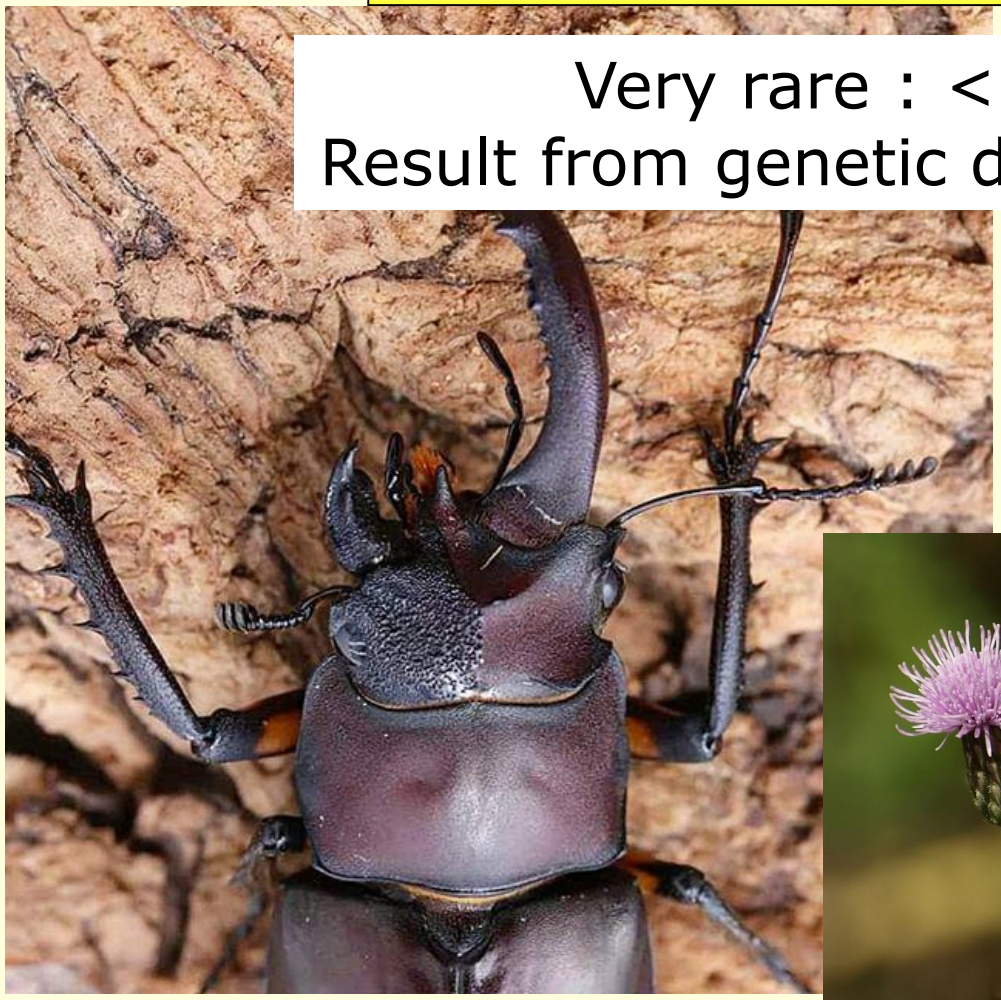
All adults are male or female

Exceptions: Gynandry

All adults are male or female

Exceptions: Gynandry

Very rare : <1/100,000
Result from genetic determinism of sex



Summary

Medical and veterinary entomology

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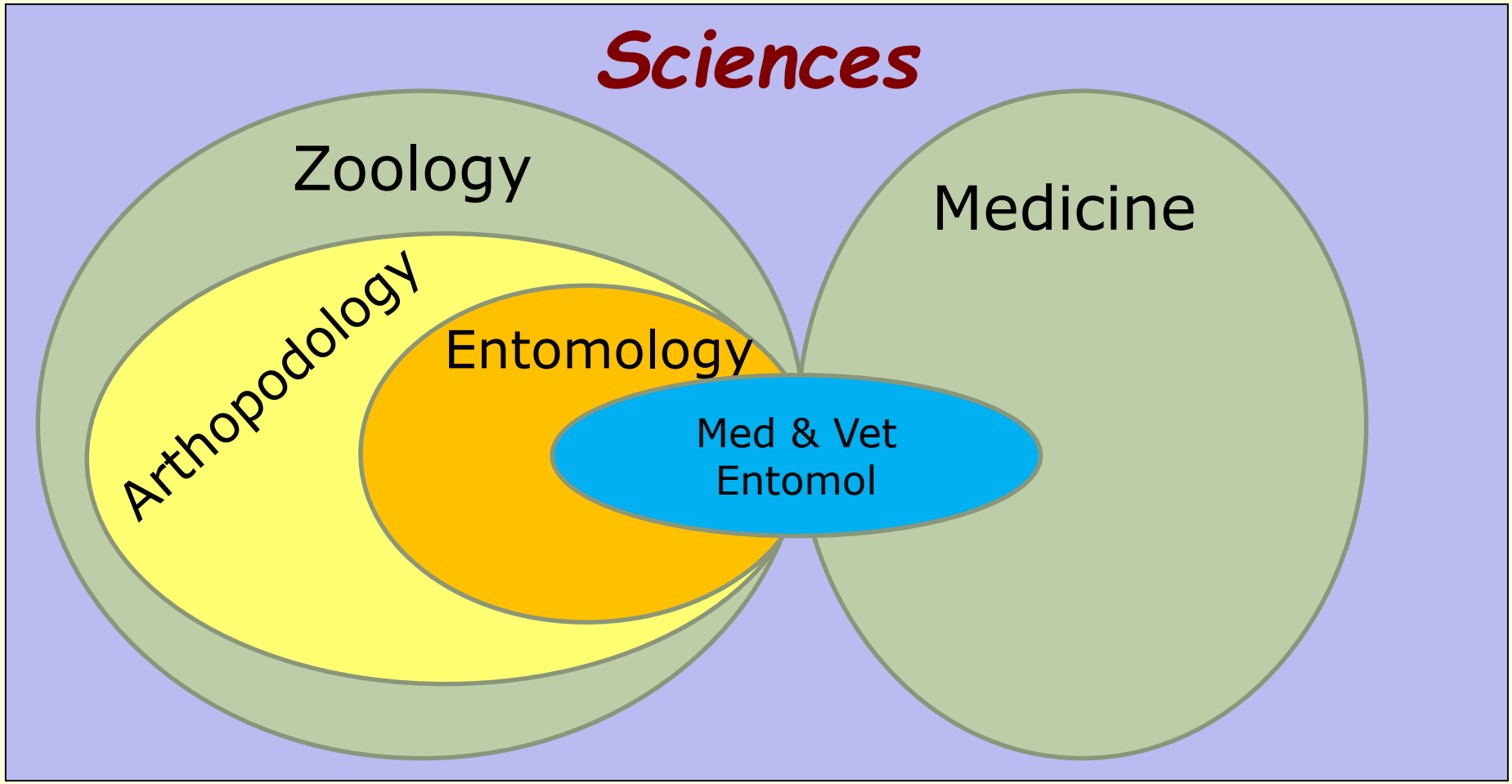
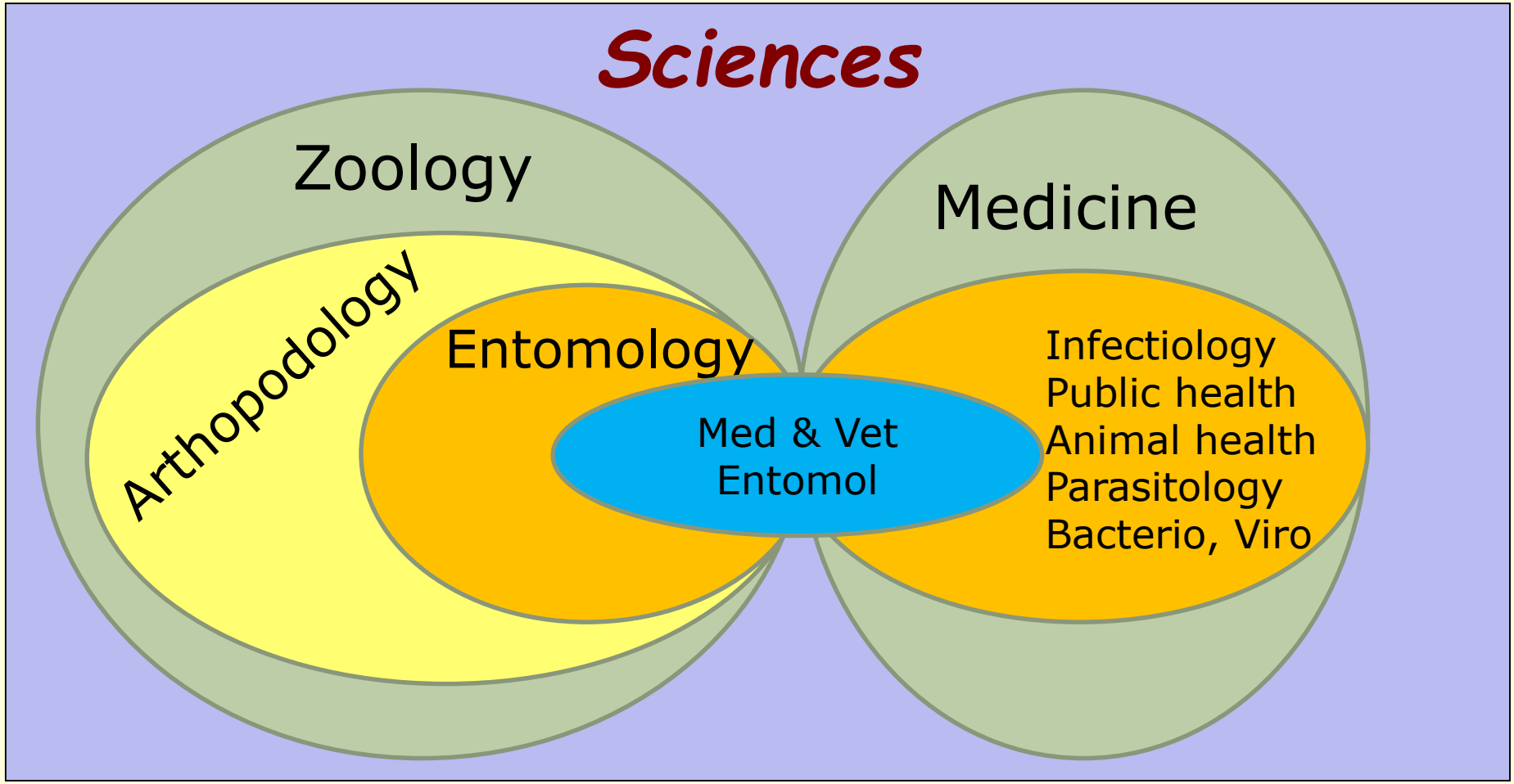
Definitions

- **Medical entomology** : science that study insects (by extension, Arthropods) of medical interest

Affect health of
- Humans (public health)
- domestic animal (livestock, companion animals; also captive animals in zoos)

==> Science at the interface between
- the Arthropods (mainly insects and ticks)
- health (human and animal health)


Sciences
Zoology
Medicine
Arthopodology
Entomology
Med & Vet
Entomol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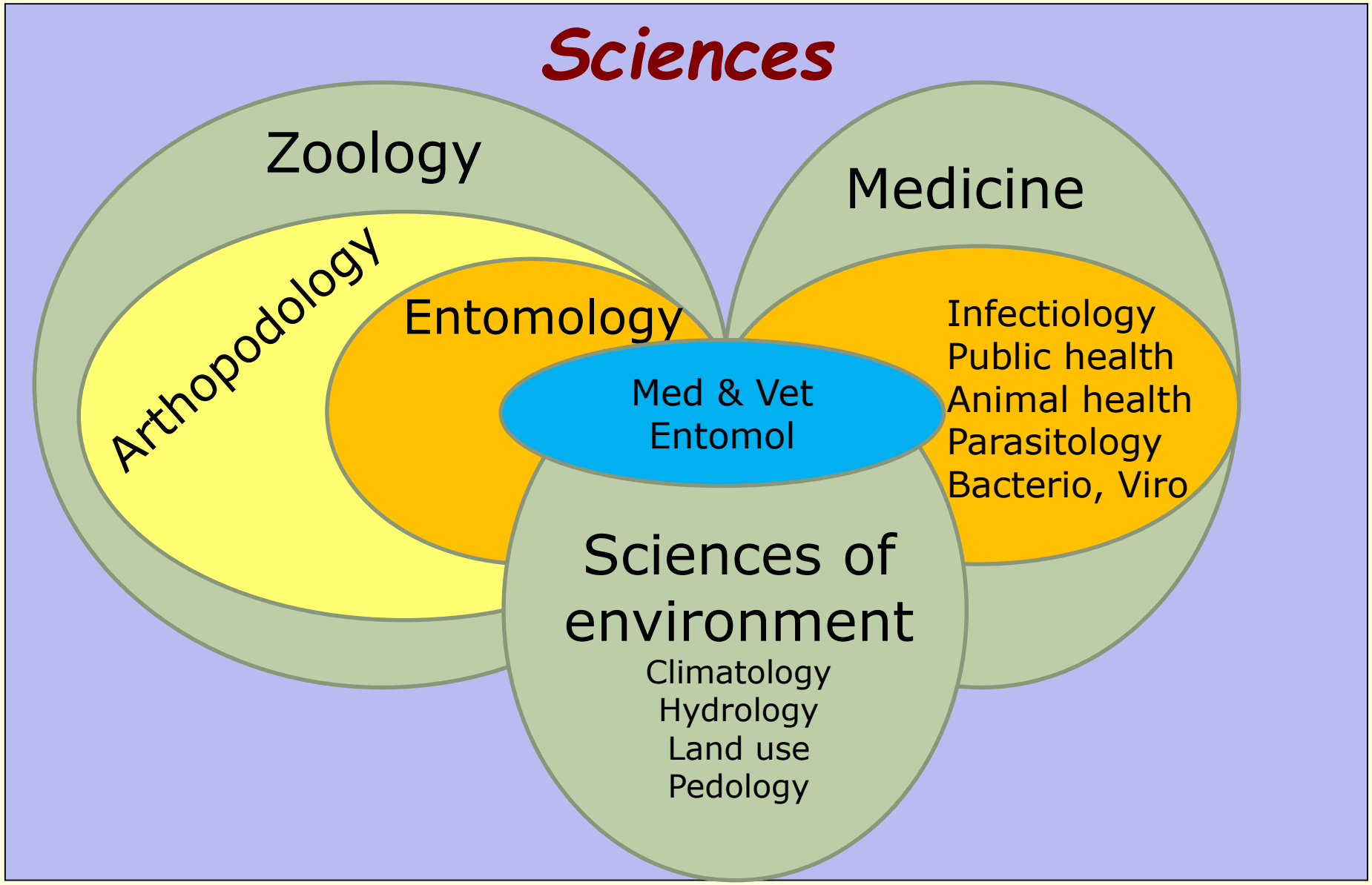
Animal health
Parasitology
Bacterio, Viro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Animal health
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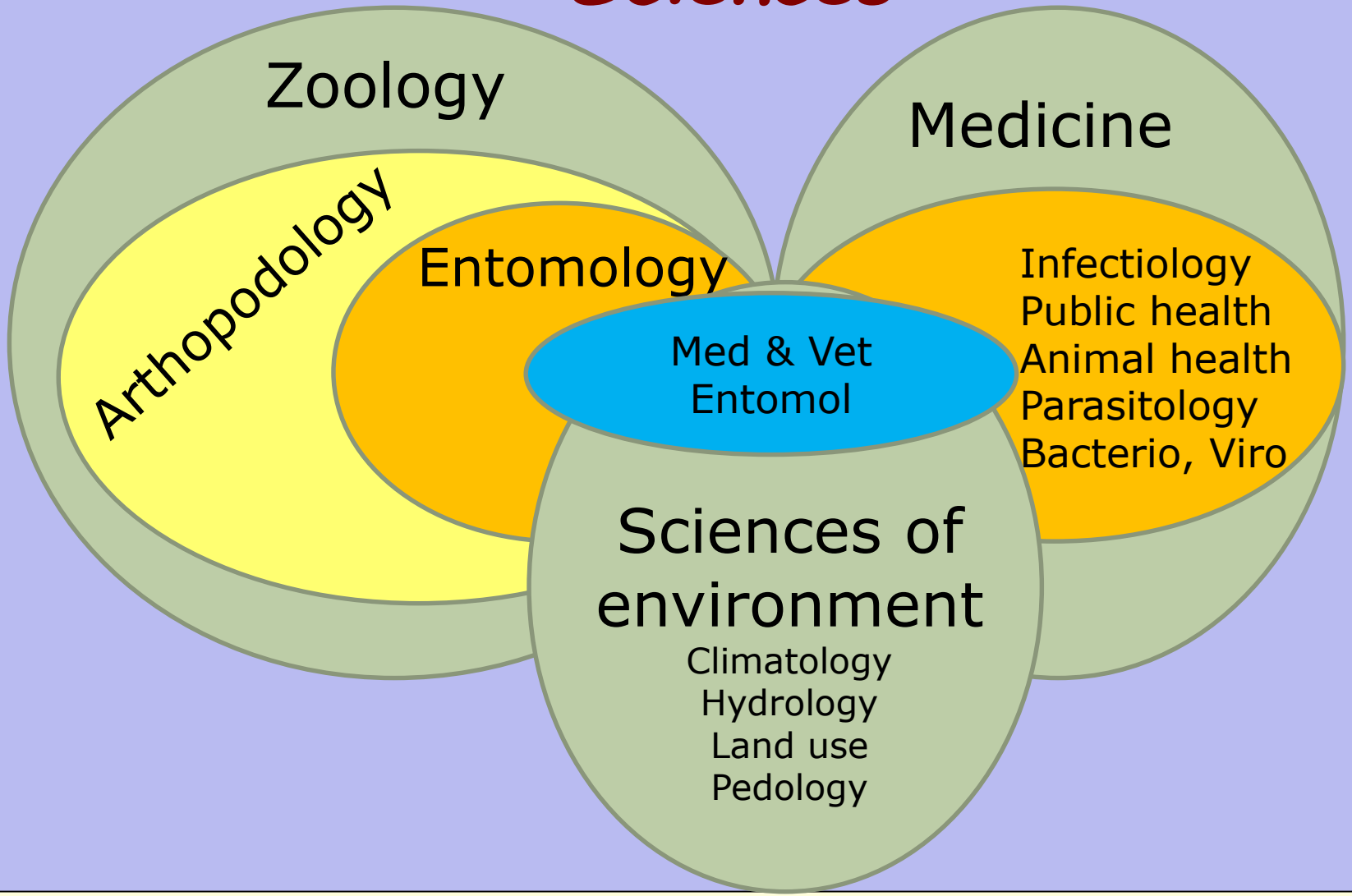
Bacterio, Viro
Med & Vet
Entomol
Sciences of
environment
Climatology
Hydrology
Land use
Pedology

Sciences

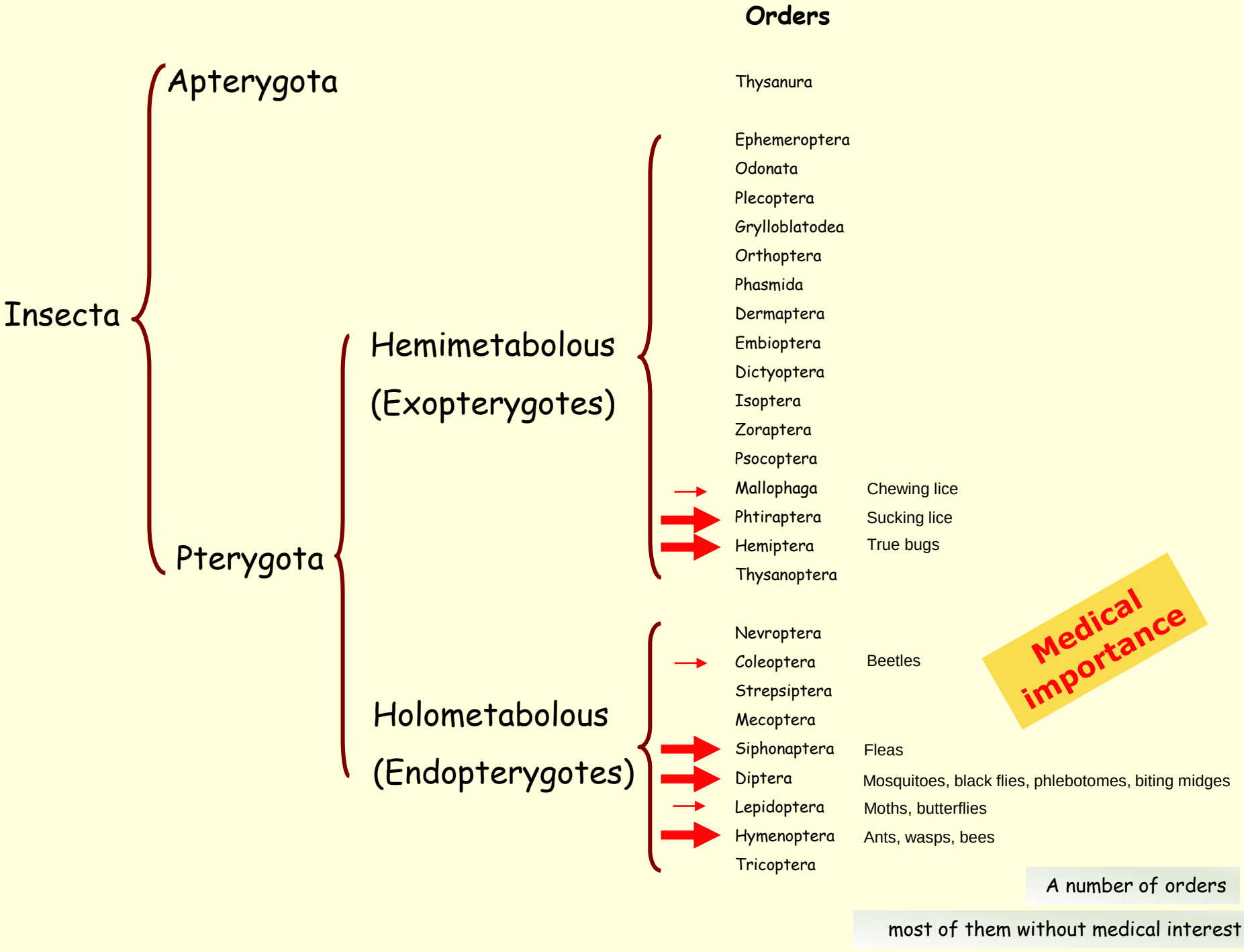


The discipline borned in 1877, when Manson observed the development of Bancroft microfilaria in midgut of the mosquito *Culex quinquefasciatus*

- **Arthropods of medical and veterinary interest belong mainly to:**
  - Insects
  - Acari (mites)
  - Ixodida (ticks)
  - Scorpions, spiders

} Arthropods but not insects

Scorpions: 1 million of Human are bitten per year, with 3000 deaths


Orders
Apterygota
Thysanura
Insecta
Pterygota
Hemimetabolous
(Exopterygotes)
Ephemeroptera
Odonata
Plecoptera
Grylloblatodea
Orthoptera
Phasmida
Dermaptera
Embioptera
Dictyoptera
Isoptera
Zoraptera
Psocoptera
Mallophaga
Chewing lice
Phtiraptera
Sucking lice
Hemiptera
True bugs
Thysanoptera
Holometabolous
(Endopterygotes)
Nevroptera
Coleoptera
Beetles
Strepsiptera
Mecoptera
Siphonaptera
Fleas
Diptera
Mosquitoes, black flies, phlebotomes, biting midges
Lepidoptera
Moths, butterflies
Hymenoptera
Ants, wasps, bees
Tricoptera
Medical importance
A number of orders
most of them without medical interest

A classification based on the pathogenic role

1 Arthropods that cause a nuisance

2 Arthropods that carry or host infectious agents

A classification based on the pathogenic role

1 Arthropods that cause a nuisance

2 Arthropods that carry or host infectious agents

A classification based on the pathogenic role

1 Arthropods that cause a nuisance

1. Parasite
2. Venomous
3. Urticating, blistering, allergenic
4. Blood depriving
5. Harmful, damaging

2 Arthropods that carry or host infectious agents

1. **Carriers** (uncertain dissemination)
2. **Intermediary hosts** (obligatory parasitism)
3. **Vectors** (active transmission to vertebrates)

Nuisant or pathogenic Arthropods
1. Parasites

Parasites of the body of Vertebrates, at least at one stage

The mite (Acaria), agents of scabies

An estimated 300 million cases of scabies occur each year

Males are not parasites

Inseminated females become endoparasites. They first penetrate perpendicularly in the skin, then burrow galleries in epidermis, where they lay eggs

The mite *Sarcoptes scabiei*

Nuisant or pathogenic Arthropods
2. venomous (= venom) and poisonous (= poison)

Injection of venom by bites through abdominal sting (scorpions, wasps, bees …)

Scorpio

Bee

Injection of digestive saliva by bites : spider, centipedes, true bugs …

Scolopendre

Belostoma

In case of bites by wasps or bees,
3 types of reaction are possible:

1- a local reaction with few consequences,
2- a toxic reaction linked to the number of bites (dose effect of venom)
3- an allergic reaction, eventually due to a single bite after previous exposure to allergens

Nuisant or pathogenic Arthropods
3. urticating, blistering, allergenic

The contact with some insects (scales, setae…) can lead to itching, urticaria, oedema, conjunctivitis, severe allergenic reactions…

Urticating moth

Moth dermatitis occurs in South America (French Guyana, Brazil, Argentina, Peru) and Africa (Gabon, RCA). The disease is due to urticating scales of adult moths, passively dispersed during the flight

Hylesia metabus

Urticating caterpillar

Pine processionary (*Thaumetopoea pityocampa*)

Nuisant or pathogenic Arthropods
4. Blood depriving

Blood spoliation due to Arthropods may lead to severe anaemia in Vertebrates

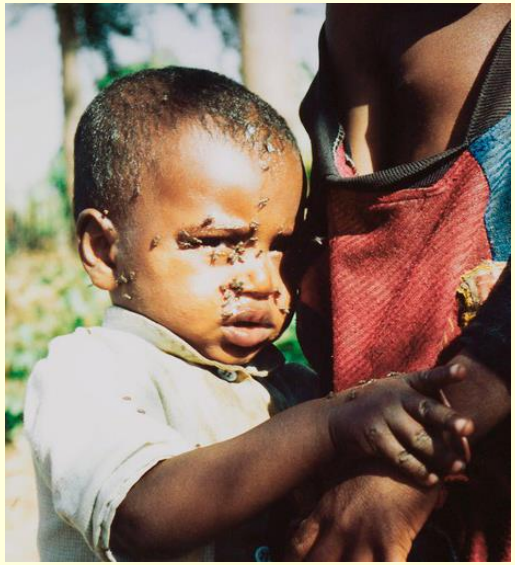
Ex, simulides (larvae in running water), mosquitoes in Canada…

Ex, ticks on Bovids

Nuisant or pathogenic Arthropods
5. Harmful, damaging

In case of huge densities, nuisance forbid some activities in specific areas.

Ex: mosquitoes in Northern lands and in some tropical islands, biting midges (Ceratopogonidae) on certain beeches…



Arthropods that carry or host pathogenic agents
1. Carriers

- Arthropods carry and move various pathogenic agents
- That allows a hazardous dissemination of the infectious agent

Ex: cockroaches, flies, ants, and every Arthropods in link with Human environment

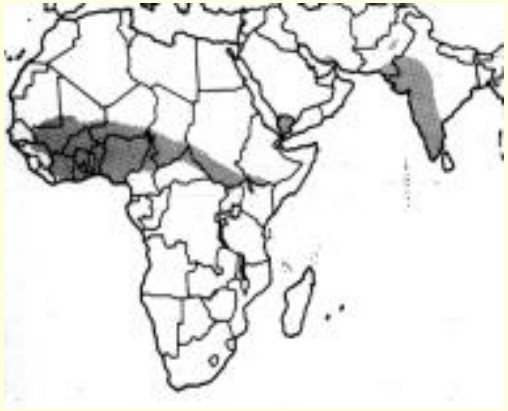
Arthropods that carry or host pathogenic agents
2. Intermediary hosts

- In case of complex life cycles (with several hosts), the parasite must obligatory infect an intermediary host before to infect the definitive host.
- The intermediary is often an insect (Coleoptera, Diptera, Hymenoptera) and a Crustacea.

Ex: Dracunculosis = Guinea-worm disease

Adult female filaria

Crustacea Copepod, obligatory intermediary host



Arthropods that carry or host pathogenic agents
3. Vectors

- A vector always exhibits a host-oriented behaviour that favours the transmission of pathogens.

- Most of the time, the Arthropod is mandatory in the pathogen life cycle.

- The vectors dominate all the medical arthropodology.

Vectorial transmission is not the rule, but rather an exception

Hay et al (2010) recognize 41 species of *Anopheles* as major vectors of *Plasmodium* (on ± 450 anopheline species)

Example of bubonic plague in Europe during the 14th century

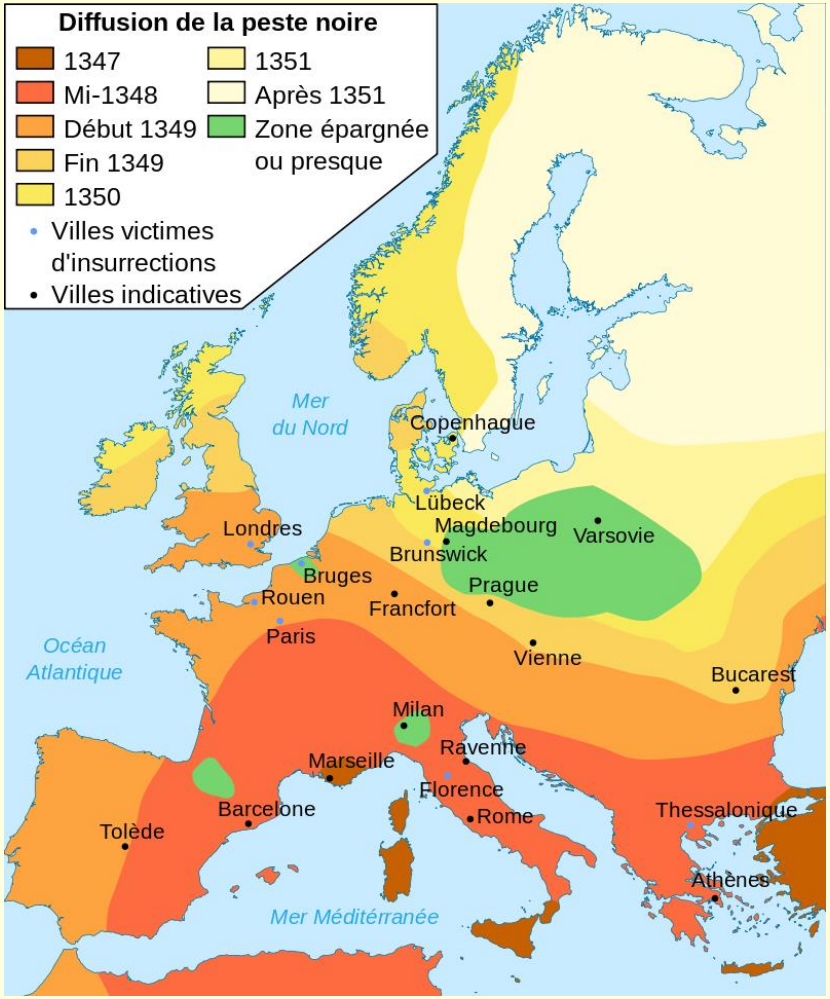
Importance of vectors

- The **Black Death**, also known as the **Great Plague**, was one of the most devastating pandemics in human history, resulting in the deaths of an estimated 75 to 200 million people in Eurasia and peaking in Europe from 1347 to 1351.

- Human mortality rate was 30% overall in Europe; 60 to 100% in infected populations.

- The bacillus *Yersinia pestis* have originated in Central Asia. Then from Mediterranean ports. Then, as a wave, from South to North of Europe.

- Epidemics run between rats and the rat fleas *Xenopsilla cheopis*. Humans were infected by flea bites after the rats died.



- Poor knowledge of the epidemics at that time:

- no vector identified (➔ no vector control)

- no pathogenic agent identified (➔ no treatment such as antibiotics)

- but knowledge of the implication of the rat, sick people and corpse.

Vector : two definitions

Large definition

Any organism involved in the transmission of an infectious agent

Any organism :

- carriers of pathogens,
- intermediary hosts without active behaviour (ex, mollusc),
- leeches (vector of fish parasites),
- dogs (vector of rabies),
- rats (reservoir of *Leptospira*)…

This definition is accepted by WHO

Stricto sensu definition of Arthropod vector

A hematophagous Arthropod that facilitates the active transmission of an infectious agent, from vertebrate to vertebrate

Hematophagous Arthropod: The blood feeding Arthropods encompass the quasi totality of blood-feeding animals.

Active transmission: The Arthropod, through its host-oriented behaviour, establishes a contact between vertebrates (infected and not infected).

Infectious agent: Not necessarily pathogen.

Vertebrate: Any terrestrial tetrapod reptiles, amphibians, birds, mammals (including Human).

Vector-borne pathogens

Virus : arbovirus (~500 listed of which >100 are pathogenic for Man), and other virus (non-arbo) such as *myxoma* virus and plant virus

Vectors : various insects and ticks

Bacteria : *Yersinia* (plague), *Borrelia* (recurrent fevers), *Rickettsia* (typhus, spotty fever…)

Vectors: lice, fleas, various Acaria

Protozoa : *Plasmodium* (malaria), *Trypanosoma* (Chagas disease, sleeping sickness), *Leishmania* (leishmaniasis)

Vectors: various Diptera

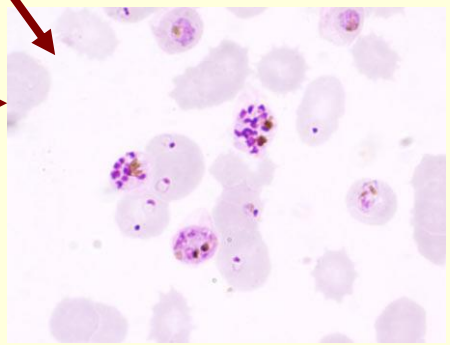
Parasitic worms (Helminths) : *Wuchereria bancrofti* (Bancroft filaria), *Loa loa* (filariasis), *Onchocerca volvulus* (onchocerciasis)

Vectors: various Diptera

The vectorial triad

(Host) Vector

(Vertebrate) Host



Infectious agent

Summary

The most important Arthropod vectors in med/vet entomology

Acaria (ticks) : hard ticks

soft ticks

Insecta : vectors belong to 4 orders :

- Diptera (Culicidae, Phlebotominae, Simuliidae, Ceratopogonidae, Tabanidae, Muscidae (Glossina) + flies (myiasis)
- Hemiptera (Triatoma…)
- Siphonaptera (fleas)
- Anoplura (lice)

Senses

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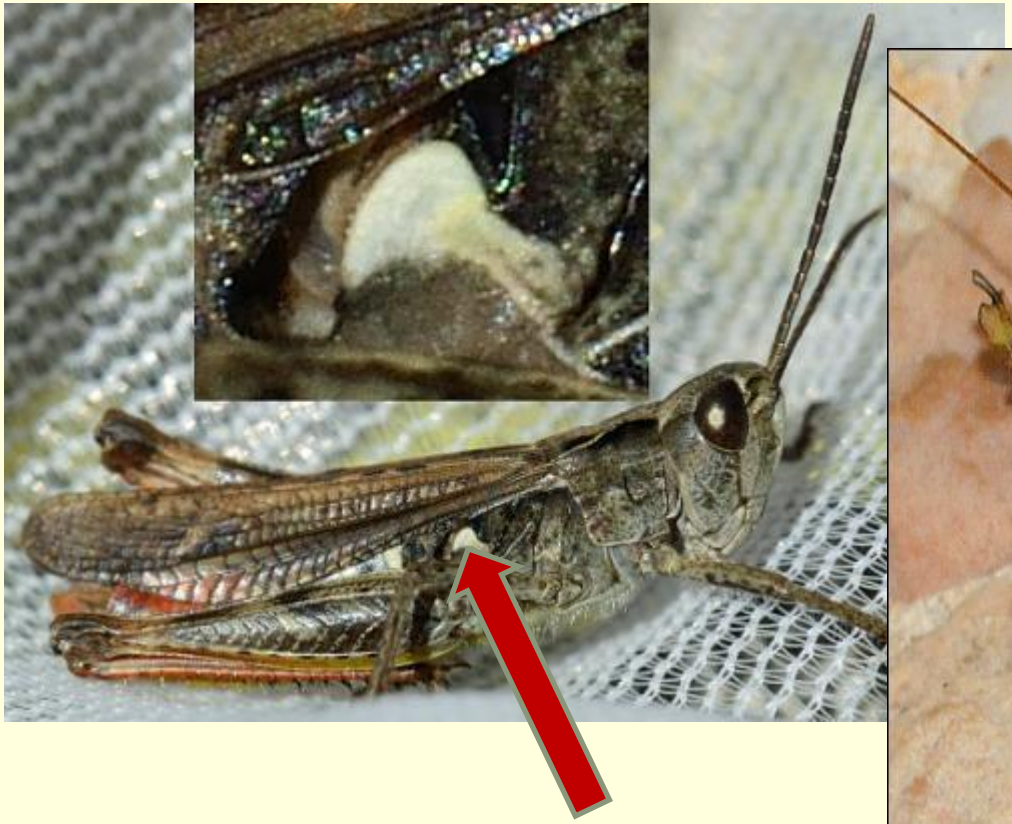
Antennas are the organ of smell

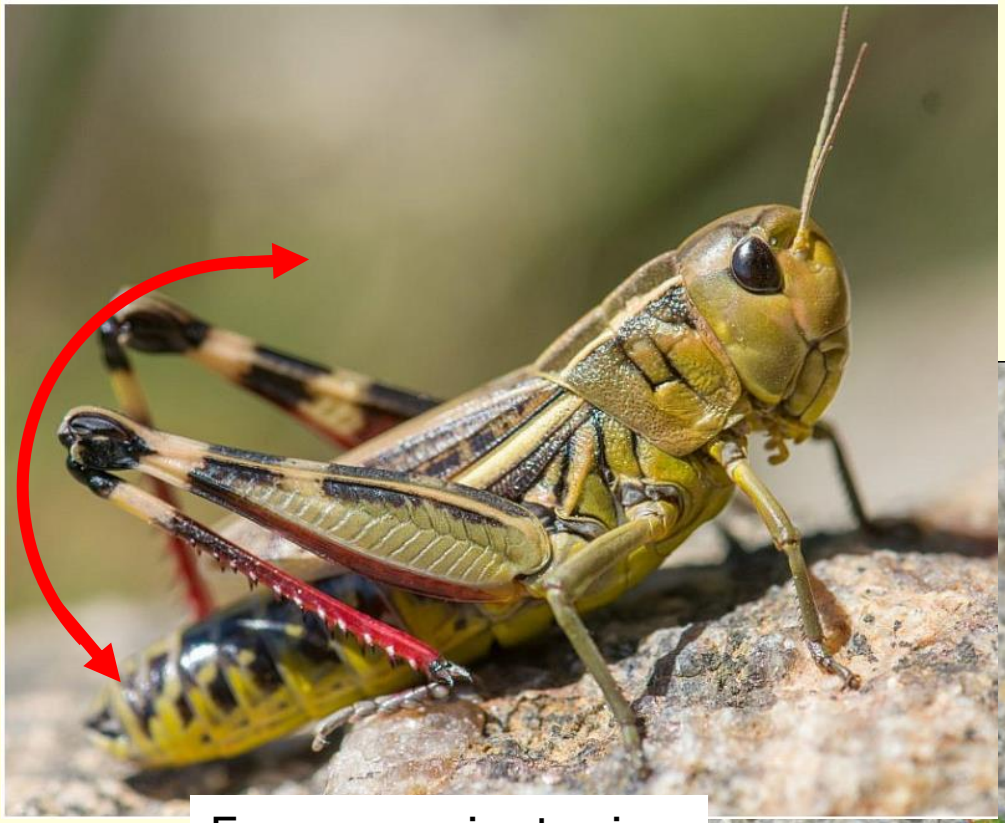
Example of organ of hearing

Example of organ of hearing

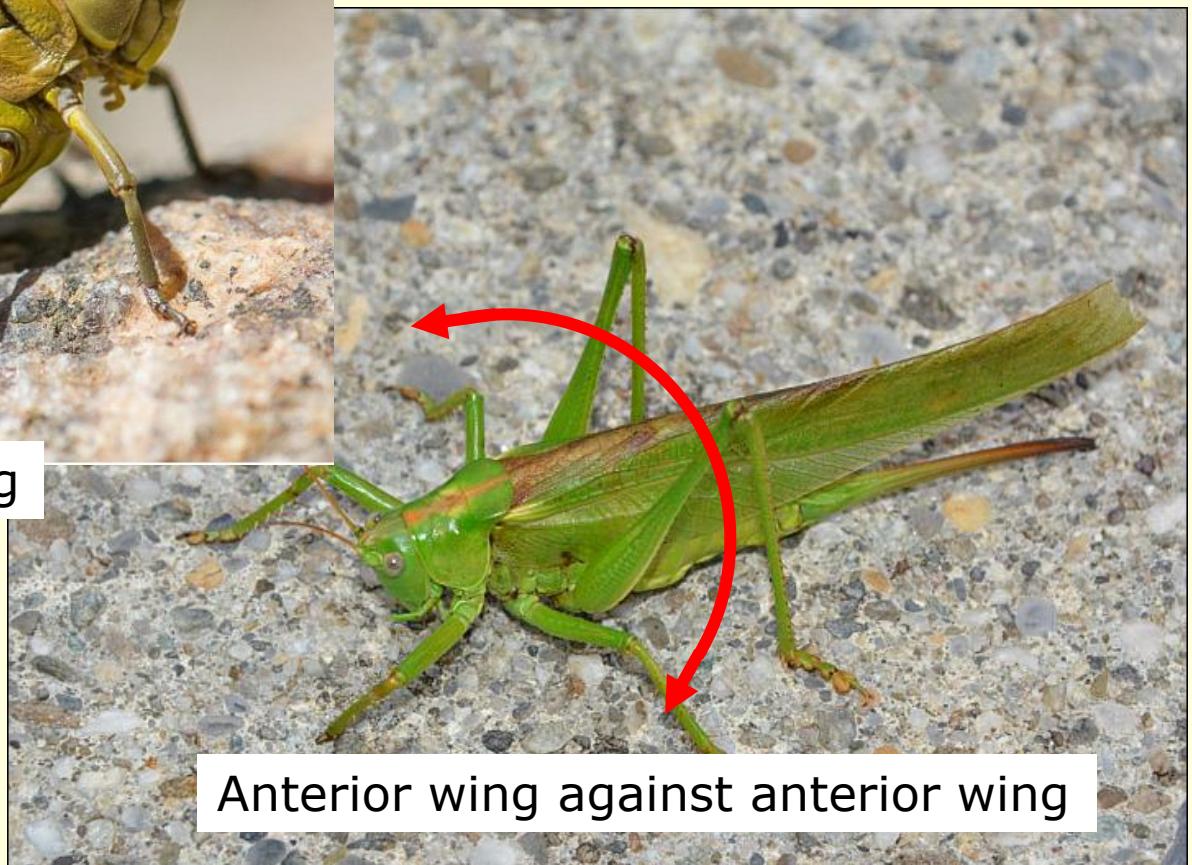


Example of sound emission

Example of sound emission

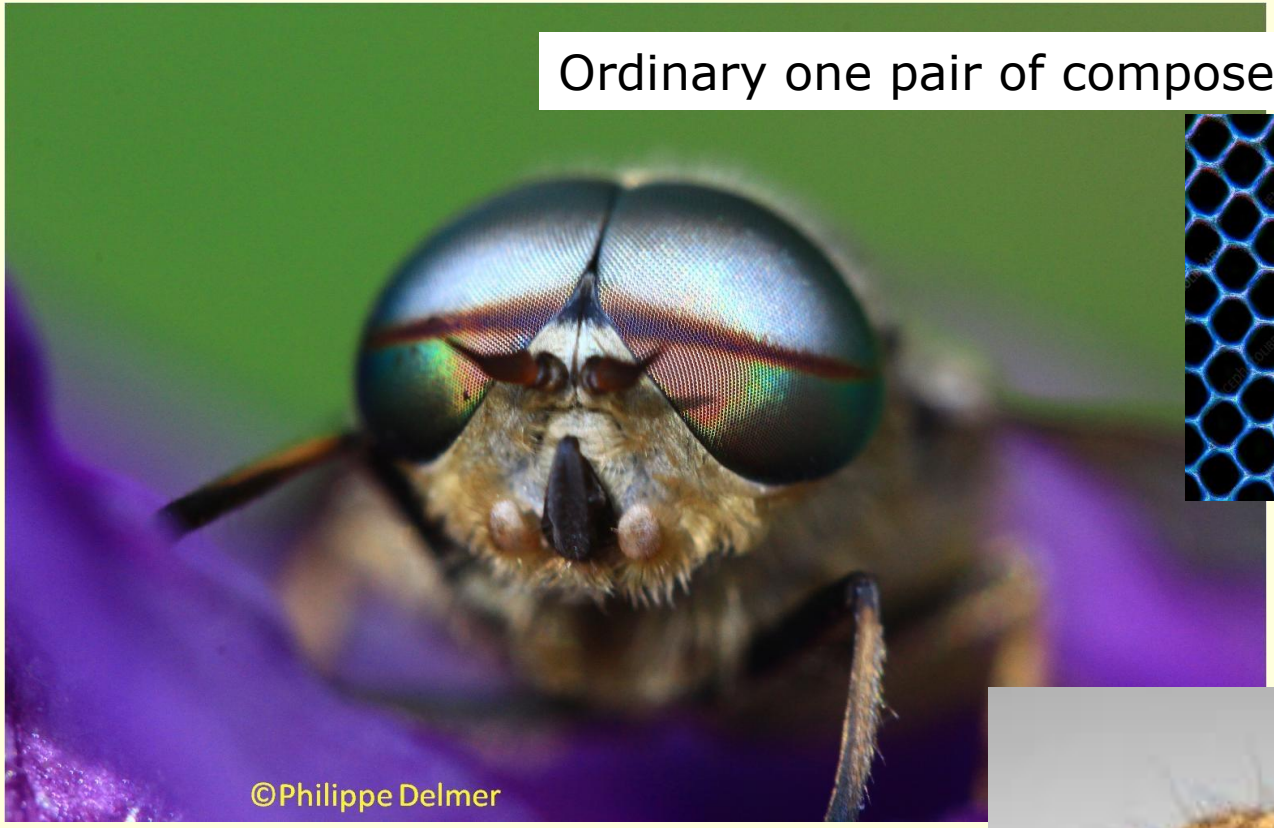


Femur against wing

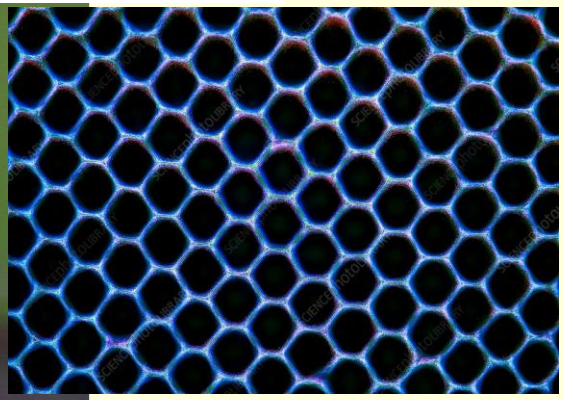


Anterior wing against anterior wing

Example of eyes



Ordinary one pair of composed eyes



Sometimes, more…

Example of eyes

Sometimes up to 3 ocella

Orientation towards host by mosquitoes

- Emission of volatile compounds:

  by the skin (e.g. 350 ≠ molecules by human skin)

  by the breath (among which CO_2 and H_2O)

  Ex: lactic acid, ammoniac, 1-octen-3-ol, butyric acid, terpene…

- Heath, for mammals and birds (warm-blooded animals)

- Visual indications

Localisation of bites

Breathing odour

An. atroparvus

European mosq

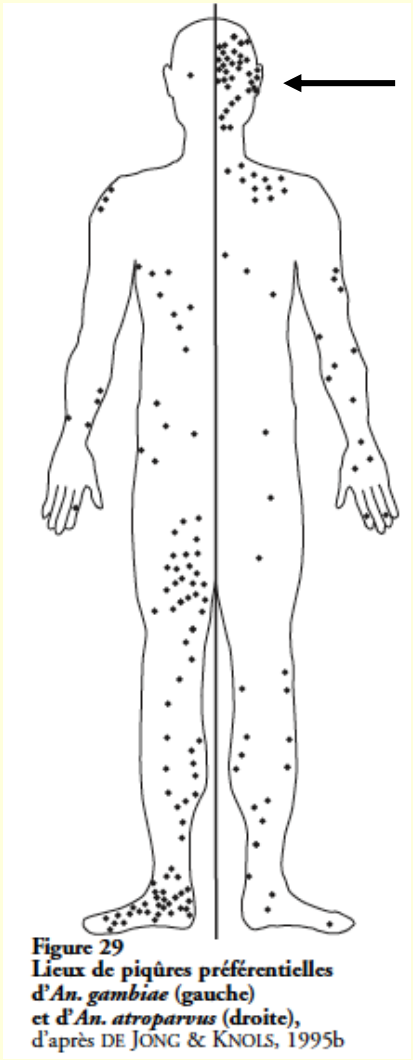


Figure 29
Lieux de piqûres préférentielles d'*An. gambiae* (gauche) et d'*An. atroparvus* (droite), d'après DE JONG & KNOLS, 1995b

An. gambiae

African mosq

Skin odour

(especially the feet)

Why some people are they more bitten than other one by mosquitoes?

- First, is-it true?

  Reality or false impression?

- Difference between mosq species? (Ex: *Culex pipiens* vs. *Aedes albopictus*)

- Reality of individual attractiveness for mosquitoes

Summary

Many sensitive organs

Importance of antennas

A variety of senses allow a lot of interactions with the environment

Calculation of EIR

(Entomological Inoculation Rate)

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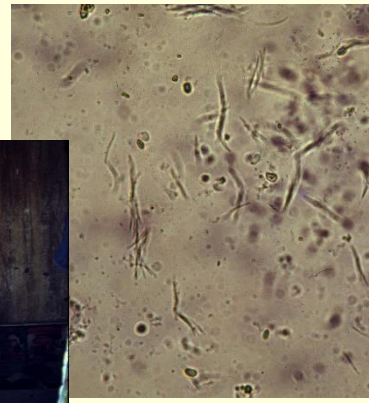
Definition

E I R : Entomological Inoculation Rate

(= Taux d'inoculation entomologique)



EIR = ma x s

ma = biting rate (= Taux de piqûres)

s = sprozoit index (= Indice sporozoïtique)

Unit : Nb of bites of infected anopheline mosqs per length of time (night, month, year, life)

Exercise 1 EIR calculation

High endemic area (a village in Central Africa end of XXth century)

ma = biting rate

50 bites of anopheles per man in one night

s = sprozoit index

2 of them have sporozoites in their salivary gland

EIR = ?

Exercise 1 EIR calculation

High endemic area (a village in Central Africa end of XXth century)

ma = biting rate — 50 bites of anopheles per man in one night

s = sprozoit index — 2 of them have sporozoites in their salivary gland

EIR = 50 x 2/50 = 2 bites of inf mosq per man per day

Exercise 2 EIR calculation

Low endemic area (a village in Savanna Africa, dry season)

ma = biting rate — 9 bites of anopheles per man in 31 nights (1-31 January)

s = sprozoit index — 2 of 458 mosqs have sporozoites in their salivary gland

EIR =

Exercise 2 EIR calculation

Low endemic area (a village in Savanna Africa, dry season)

ma = biting rate — 9 bites of anopheles per man in 31 nights (1-31 January)

s = sprozoit index — 2 of 458 mosqs have sporozoites in their salivary gland

EIR = 9/31 x 2/458 = 0.29 x 0.0044 = 0.00127 bites of inf mosq per man per day = 0.04 per month

In other words, 4% of villagers receive 1 infected bite in the month.

Summary

‘Entomological Inoculation Rate’ is a proxi for “malaria transmission”

EIR is closely related to the level of endemicity.

Population size and density in entomology

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Definitions

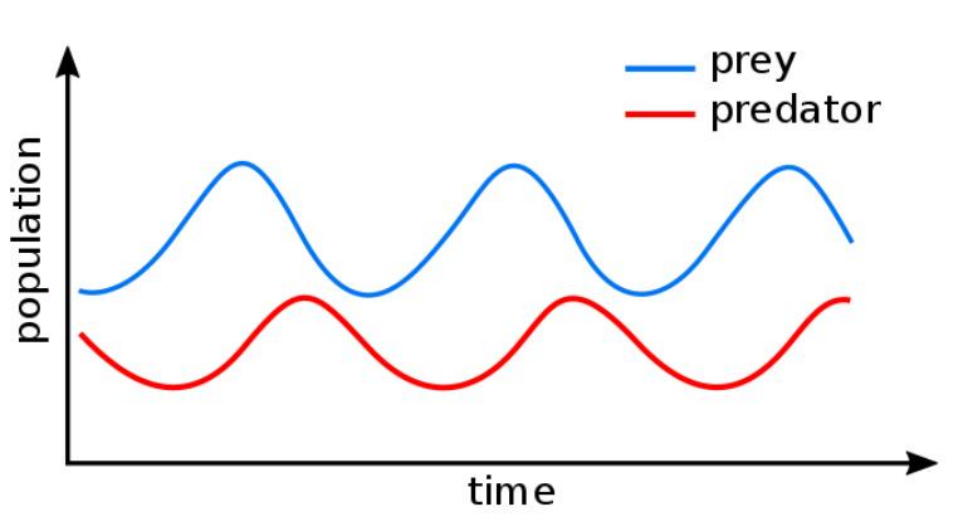
- **Population size**: is an absolute number

  Example: on May 18, 2022, there are 600,450,732 cats on the earth surface

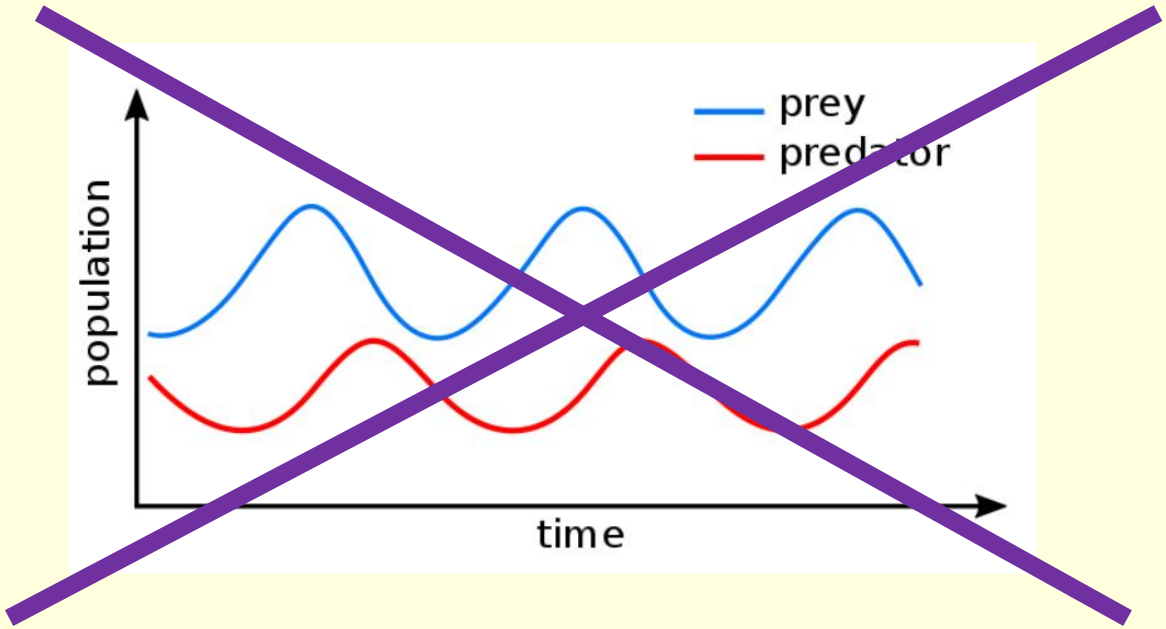
- **Population density**: is a relative number (by regard to a surface, a host)

  Example: there are 3.4 biting female mosquitoes per night and per unprotected human in the town of Haman

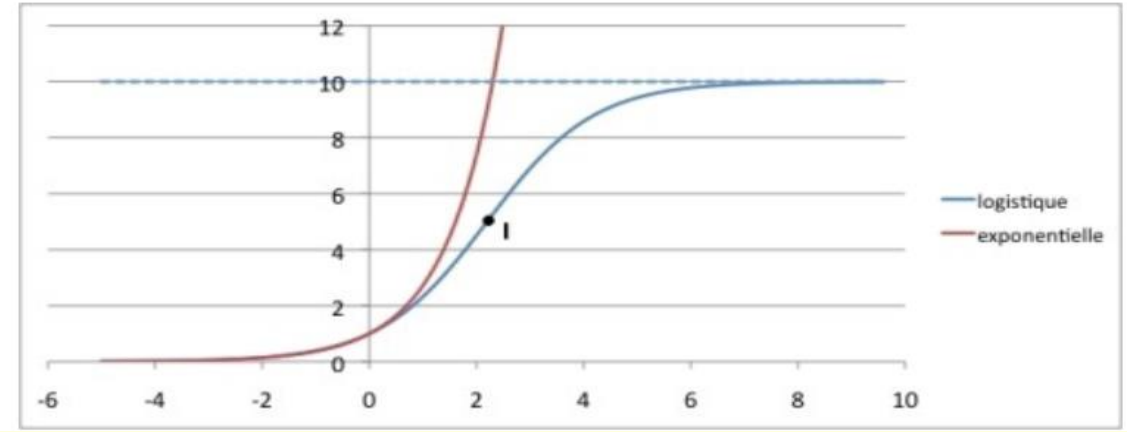
Type of regulation



Type of regulation

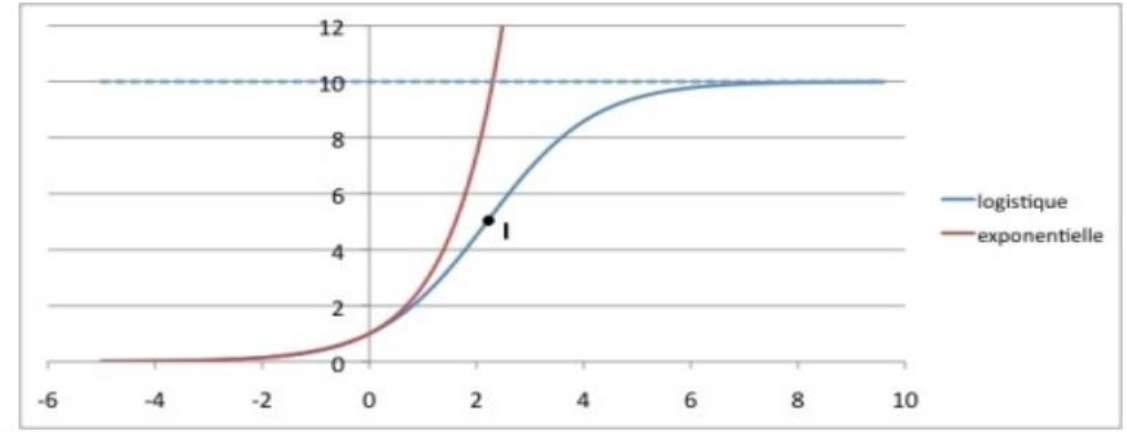


Type of regulation



	Example of mosquito
Short generation length of time	15 days
High progeny	2000 eggs per female
High rate of development success	Few predators, adults and immatures are not competitors

Type of regulation



	Example of mosquito
Short generation length of time	15 days
High progeny	2000 eggs per female
High rate of development success	Few predators, adults and immatures are not competitors

Population dynamic proceeds by outbreaks

Type of regulation

Example of Grasshopper Migratory Locust

Solitary phase in well localized areas

When conditions are favourable during several generations

Gregarious phase
(in response to high population density; under hormonal regulation)

Lighter
Longer wing
Smaller offspring
Gregarian behaviour

Departure without return: Africa, Asia, Australia, New Zealand (formerly Europe)
10 to 130 km per day
Up to 80 millions individuals per km2

Other infrequent type of regulation

Example of tsetse fly

Very small progeny

7 pupa per female

Population dynamic is much more stable

Summary

The dynamic of populations proceeds ordinary by outbreaks

with exponential type of density variations, for both increase and decrease

Natural dispersion of insects

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Definitions

The dispersion is the process by which individuals or populations colonise or recolonise a territory.

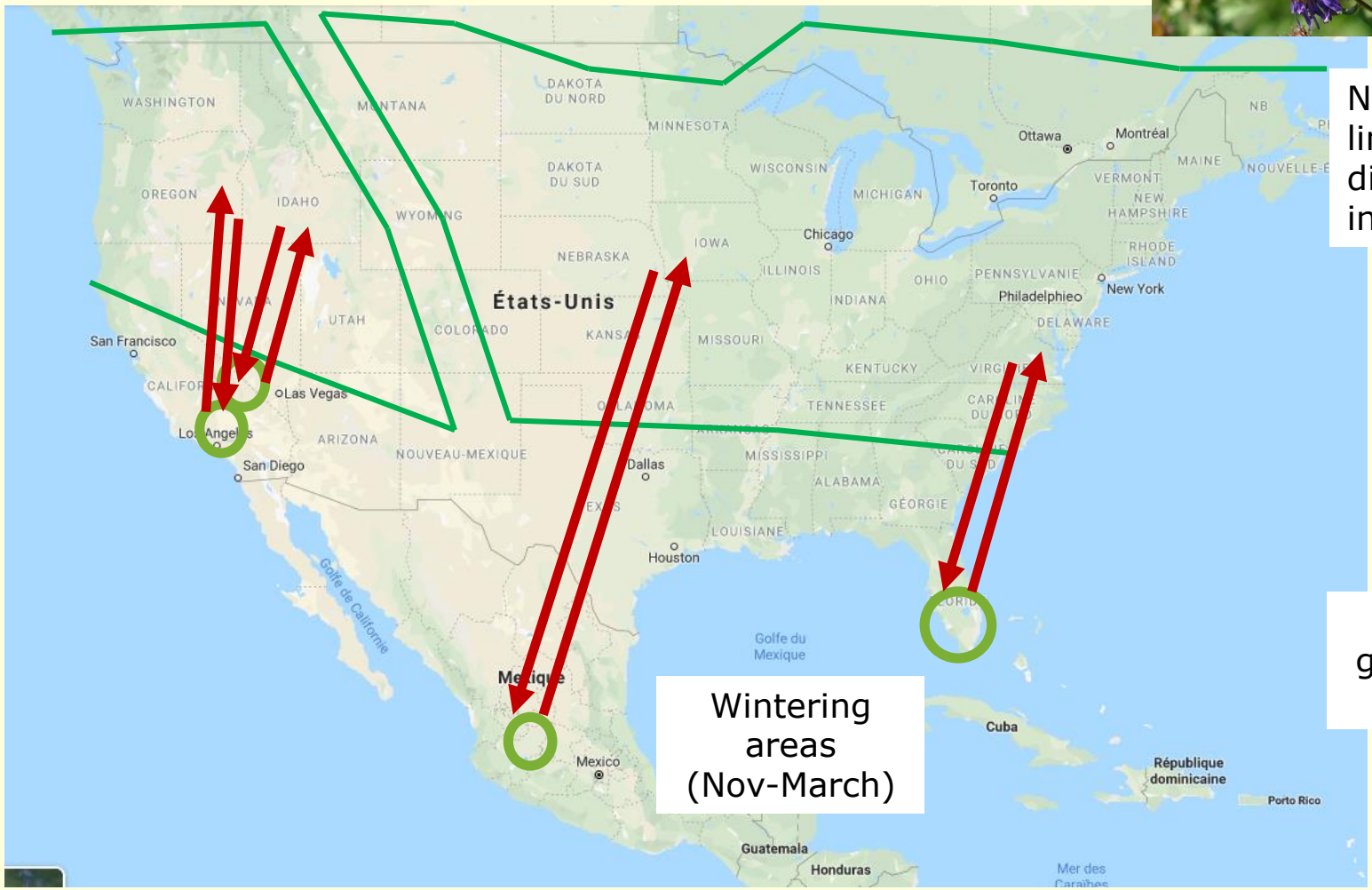
Natural dispersion may occur through walking and flying (including flying downwind)

Most of species disperse few (some km)

But some exceptions are nice, with true migration process (return within departure area) :

Ex: *Monarchus* butterfly

In North America



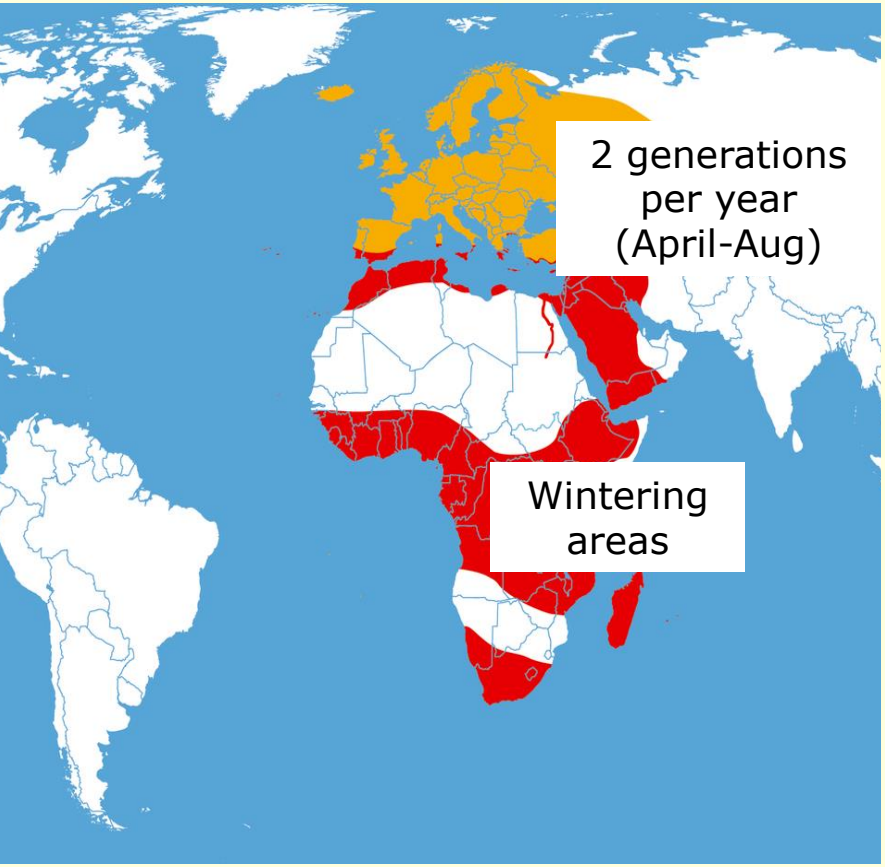
Northern limit of disperssion in July-Sept

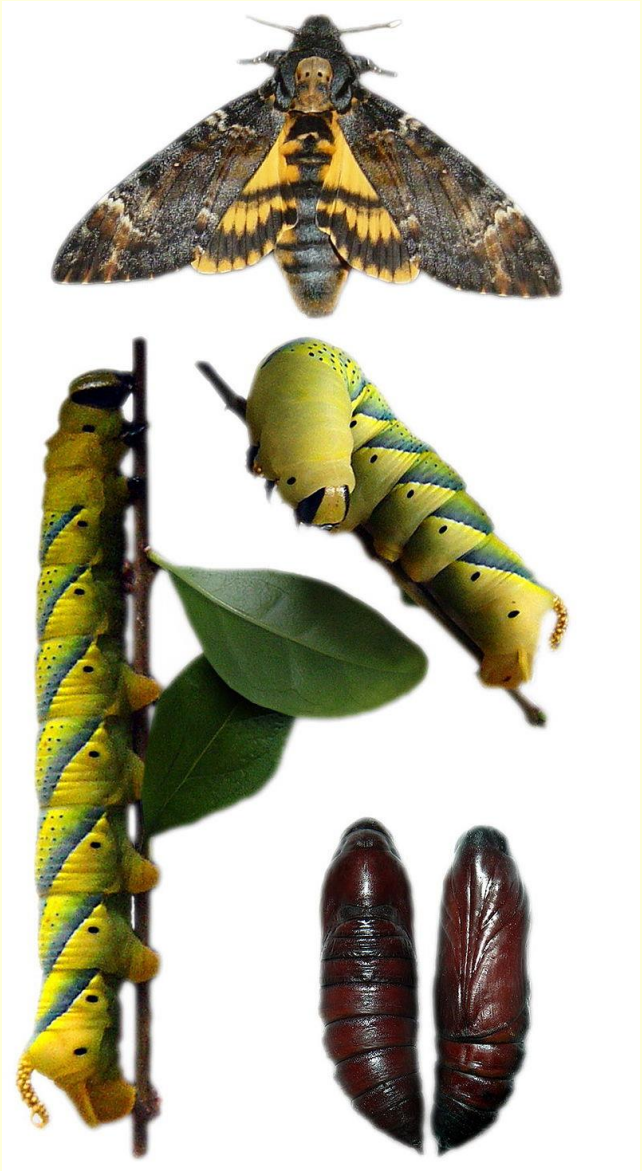
Wintering areas (Nov-March)

4-5 generations per year

Ex: *Monarchus* moth

Between Africa & Europe





Summary

Most of species disperse few (some km)

Natural dispersion of mosqs ranges between 100 m and 10 km; exceptionally 100 km if downwind (*Anopheles pharoensis* in Saharan oasis)

Human assisted dispersion of insects

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Definitions

The dispersion is the process by which individuals or populations colonise or recolonise a territory.

Human assisted dispersion may occur through plane, boat, car

Between two localities on earth, the distance-time may always be lower than 48 hours.

Huge increase of trade and mobility in the last centuries

Importance of global changes (traffic)

Air traffic

Maritime traffic

Examples of transports due to Human traffic

Anopheles arabiensis from Africa to Brazil

Anopheles gambiae from Madagascar to Mauritius

Tunga penetrans from Tropical America to Africa, then to Madagascar

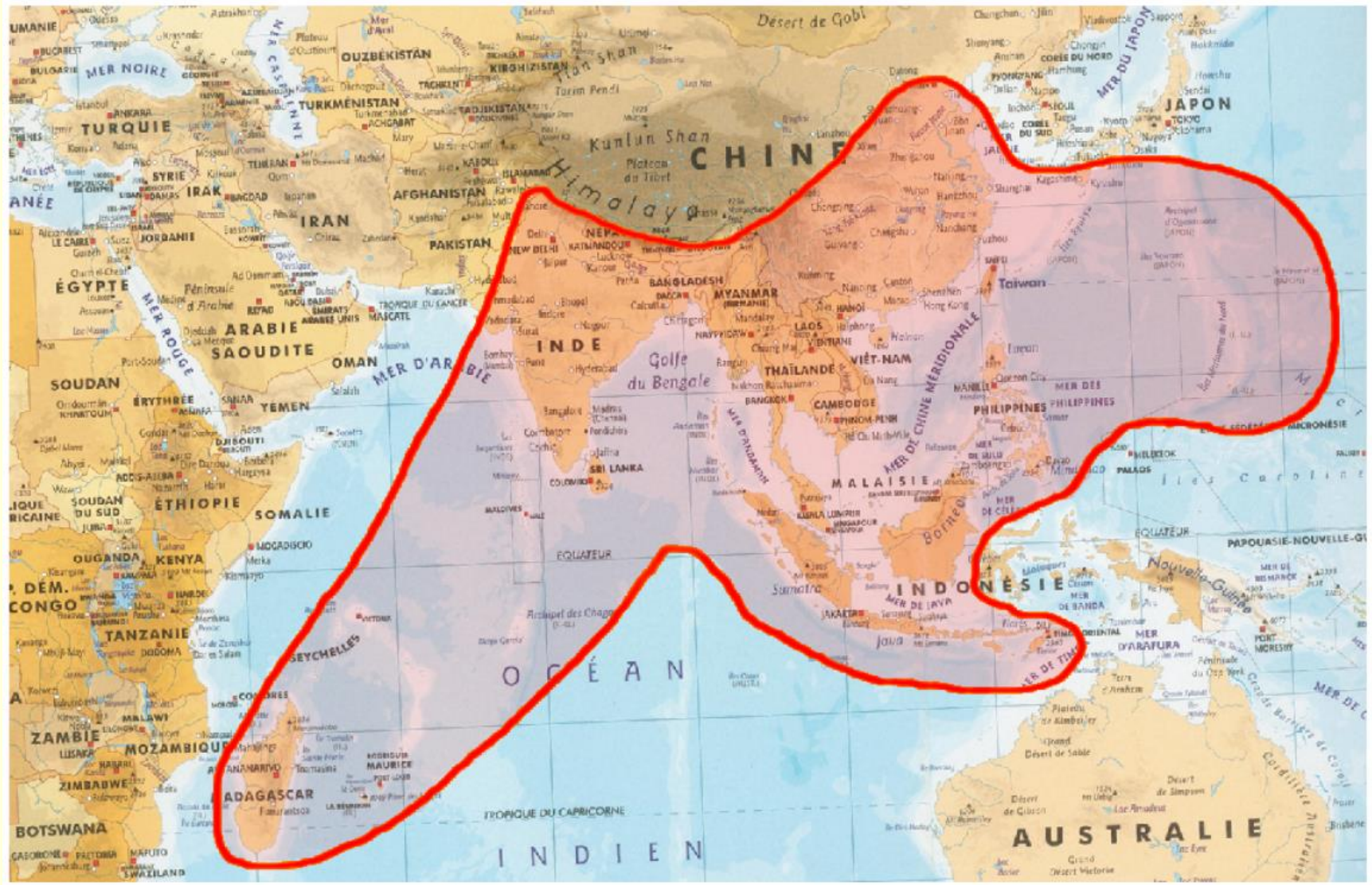
Many cases of 'airport malaria'

Aedes aegypti all over the world

Aedes albopictus now in the 5 continents

Aedes albopictus (the Asian tiger mosq)

Distribution area of *Aedes albopictus* around 1900



Source: Rhodain F - Problèmes posés par l'expansion *d'Aedes albopictus*. Bull Soc Path Ex, 1996, 89, 137-141.

Mechanisms of dispersion

A passive transportation due to globalisation

1) Intercontinental trades of tires, mainly by boats

➔ **Eggs are resistant to desiccation**

Mechanisms of dispersion

A passive transportation due to globalisation

1) Intercontinental trades of tires, mainly by boats

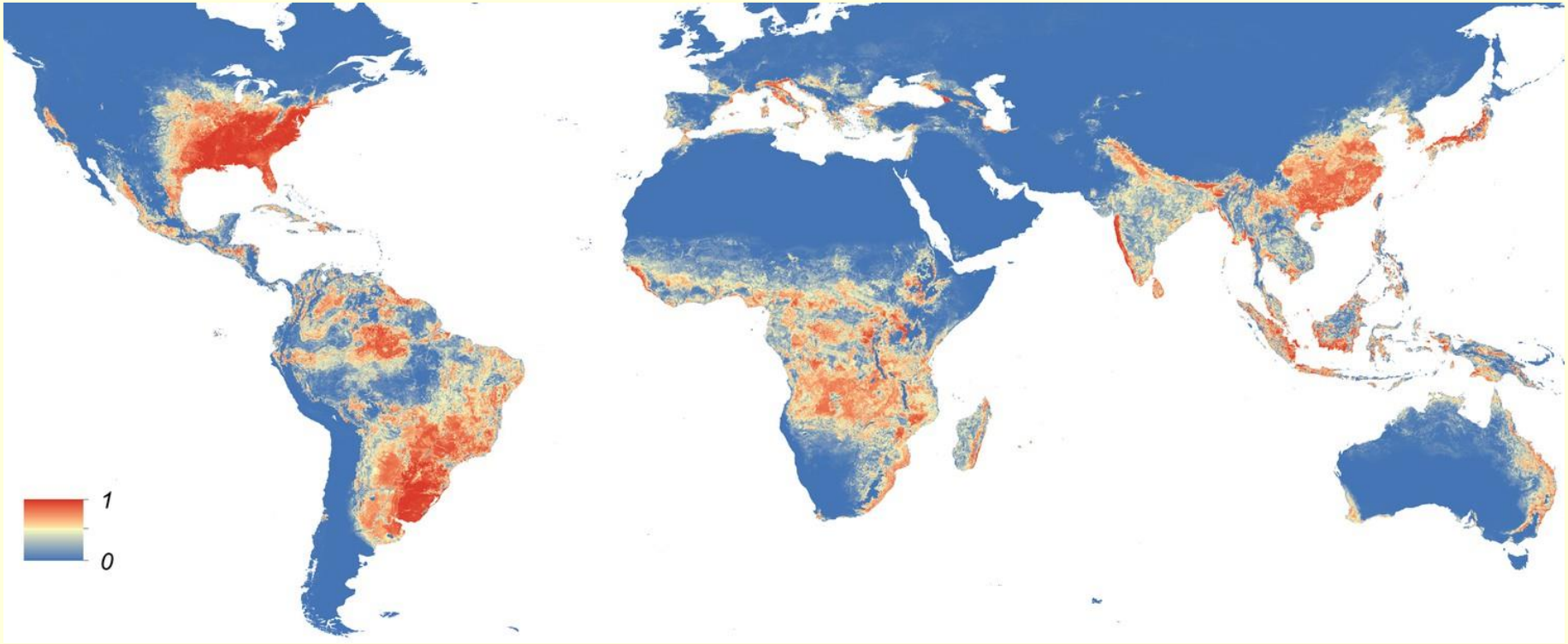
2) Intracontinental (short distance) dissemination, mainly by cars/trucks

➔ Adults (that spontaneously enter in cars)

In great contrast with the natural dispersion (about 150 m per adult female)

➔ And also eggs

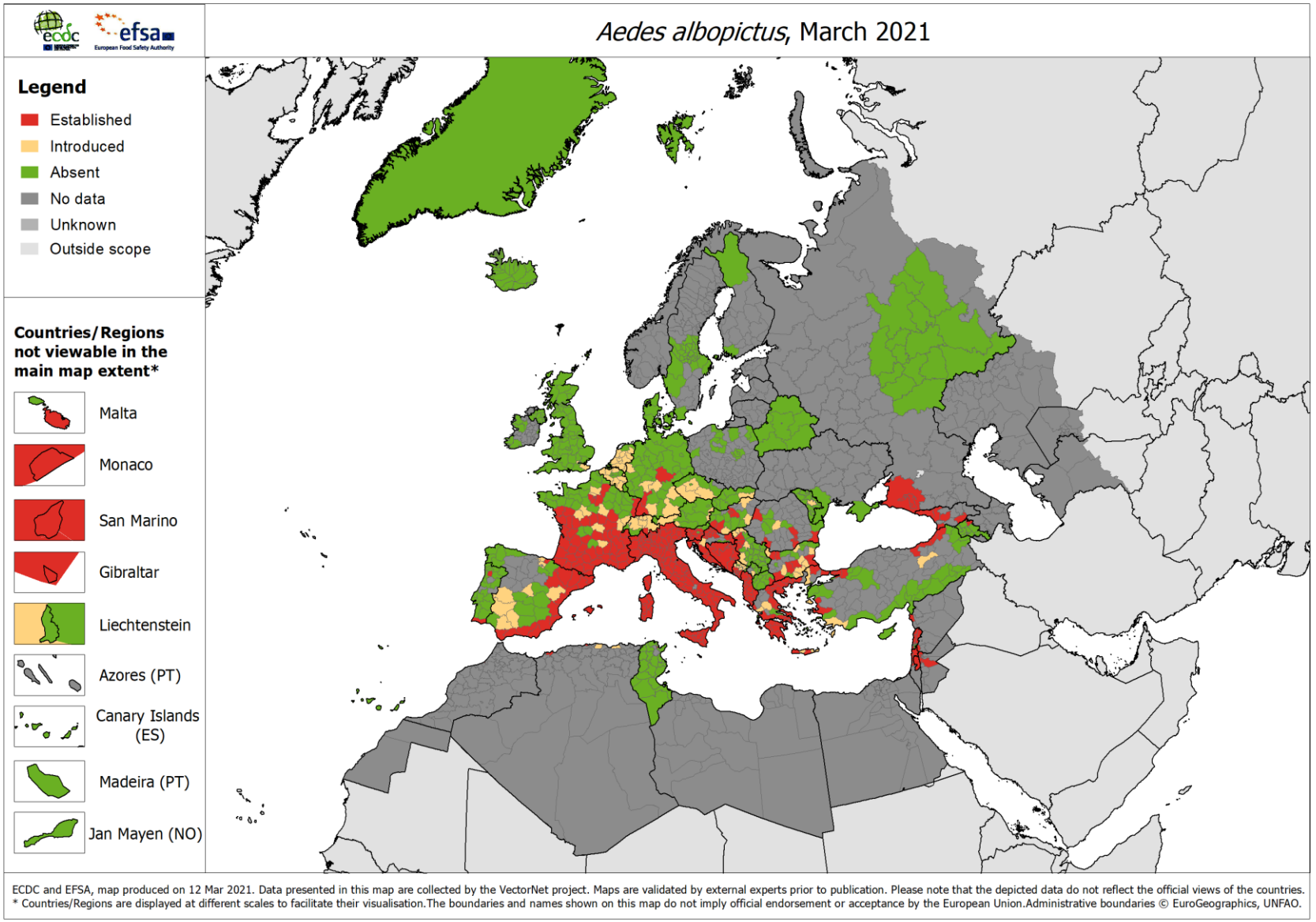
Signalisation of construction site

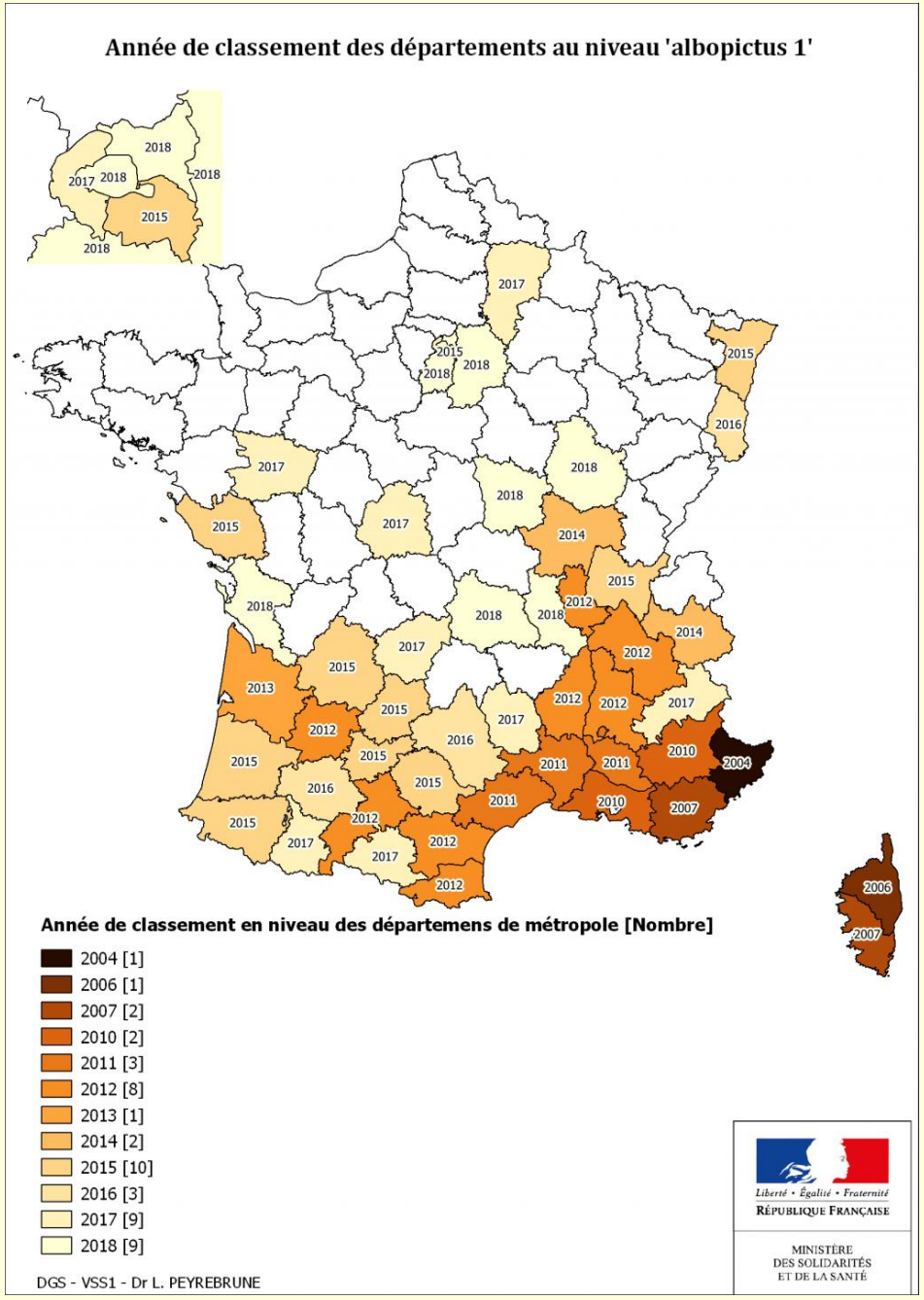


Global map of the predicted distribution of *Ae. albopictus*
The map depicts the probability of occurrence (from 0 blue to 1 red)

Kraemer et al – The global distribution of the arbovirus vectors *Aedes aegypti* and *Aedes albopictus.* Elife 2015 June 30:4. doi: 10.7554 eLife.08347

Aedes albopictus ECDC Distribution map - March 2021




Année de classement des départements au niveau 'albopictus 1'
Année de classement en niveau des départemens de métropole [Nombre]
2004 [1]
2006 [1]
2007 [2]
2010 [2]
2011 [3]
2012 [8]
2013 [1]
2014 [2]
2015 [10]
2016 [3]
2017 [9]
2018 [9]
DGS - VSS1 - Dr L. PEYREBRUNE
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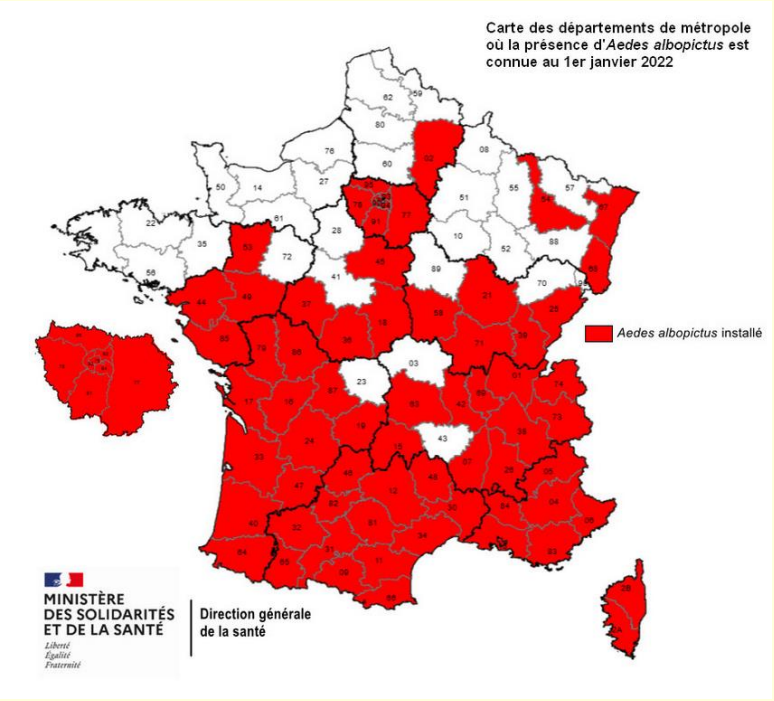
DES SOLIDARITÉS
ET DE LA SANTÉ


Carte des départements de métropole où la présence d'Aedes albopictus est connue au 1er janvier 2022
Aedes albopictus installé
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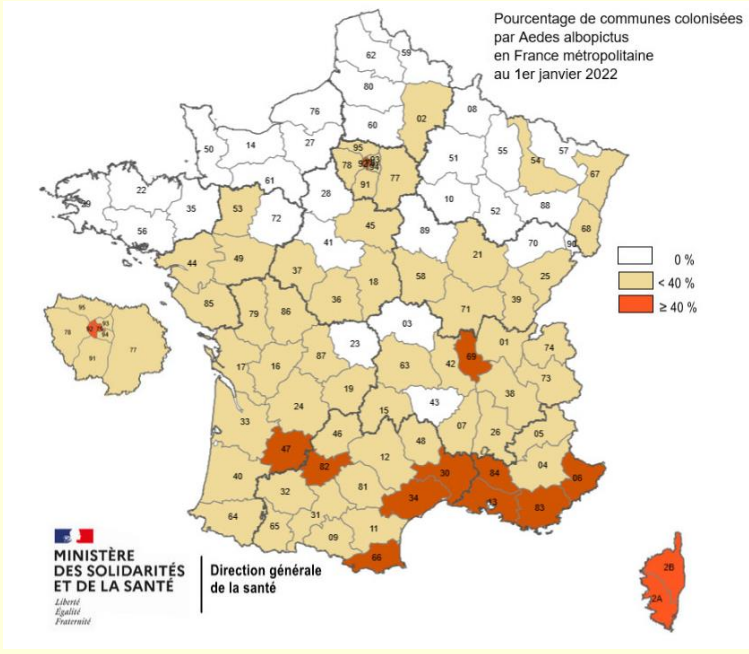
Direction générale
de la santé


Pourcentage de communes colonisées
par Aedes albopictus
en France métropolitaine
au 1er janvier 2022
0 %
< 40 %
≥ 40 %
MINISTÈRE
DES SOLIDARITÉS
ET DE LA SANTÉ
Liberté
Égalité
Fraternité
Direction générale
de la santé

Autochtonous cases in France

Year	Month	Region	Department	Code dept.	Virus	Total Nb. of cases
Before 2010						
2010	Sept	PACA	Alpes-Maritimes	06	Dengue	2
2010	Sept	PACA	Var	83	Chik.	2
2013	Oct	PACA	Bouches-du-Rhône	13	Dengue	1
2014	Aug	PACA	Var	83	Dengue	1
2014	Oct	PACA	Bouches-du-Rhône	13	Dengue	2
2014	Sept	PACA	Var	83	Dengue	1
2014	Oct	Occitanie	Hérault	34	Chik.	12
2015	Aug	Occitanie	Gard	30	Dengue	7
2017	Aug	PACA	Var	83	Chik.	17
2017	Sept	PACA	Alpes-Maritimes	06	West-Nile	2
2018	Juill	PACA	Alpes-Maritimes	06	West-Nile	22
2018	Aug	Occitanie	Pyrénées orientales	66	West-Nile	1
2018	Sept	PACA	Vaucluse	84	West-Nile	1
2018	Aug/Sept	Corse	Corse du Sud	2A	West-Nile	2
2018	Sept	PACA	Bouches-du-Rhône	13	West-Nile	1
2018	Sept	Occitanie	Hérault	34	dengue	1
2018	Sept	Occitanie	Hérault	34	Dengue	2
2018	Oct	PACA	Alpes-Maritimes	06	Dengue 2	5
2019	Aug	PACA	Var	83	Zika	3
2019	Sept	PACA	Alpes-Maritimes		Dengue	7
2019	Sept	Auvergne-Rhône-Alpes	Rhône	69	Dengue	2
2020	Juill	Occitanie	Hérault	34	Dengue	1
2020	Aug	PACA	Var	83	Dengue	3
2020	Aug	Occitanie	Gard/Hérault	30/34	Dengue	1
2020	Aug/Sept	PACA	Alpes-Maritimes	06	Dengue	5
2020	Aug	Occitanie	Gard	30	Dengue	1
2020	Sept/Oct	PACA	Var	83	Dengue	2
2021	Juill	PACA	Var	83	Dengue	1
2021	Oct	Occitanie	Hérault	34	Dengue	1

Source: https://sante-publique-France

Summary

Invasive (exotic, alien) species are closely linked to human environment

Their dispersion is quite unlimited

The Asian tiger mosquito *Aedes albopictus* is an emblematic example of invasive species

with huge consequences in terms of nuisance and public health

Hematophagy in insects

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Definitions

Hematophagy = ingestion of blood

Hematophagy may be:

- Mandatory: quasi exclusive source of nutriment, at all life stage (ticks, lice)
- Optional: Ex. mosquitoes (female only, for egg production but not for surviving; never for male and immature stages)

Blood ingestion occurs through:

- solenophagy = catherisation (that favours the ingestion of blood pathogens) Ex. mosquito

- telmophagy = broken skin (that favours the ingestion of blood AND lymphatic pathogens) Ex. phlebotomine sandfly, simulid

The blood

- A specificity of vertebrates (vs. haemolymph in Arthropods)

interest

- is rich in nutriments and water, ordinary sterile, very digest

constraint

- but is difficult (and dangerous) to reach

Hematophagy in animal kingdom

- Annelids Hirudinae = Leeches — Exclusive

- Arthropods (Insects and Acaria)
  - Siphonaptera — Exclusive in adults of both sexes
  - Anoploura — Exclusive
  - Hemiptera (Reduviidae, …) — Exclusive
  - Diptera
    - Culicidae, Simulidae, Phlebotominae, Ceratopogonidae — Optional in adult females
    - Glossinidae — Optional in adults of both sexes
    - Ixodidae, Argasidae — Exclusive

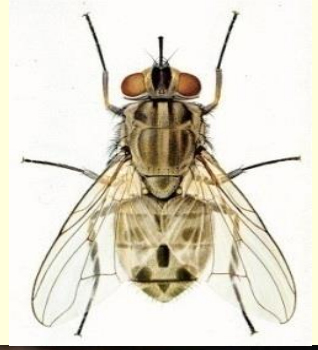
- Parasitic worms — Exclusive in adults of both sexes
  - Nematods (Hookworm)
  - Trematods (Schistosoma) and Cestods (Taenia)

- Fish Petromyzontidae Lamprey (38 sp.) — Exclusive in adults

- Birds (2 species in Galapagos Islands)
  - Thraupidae (Darwin's finches) : *Geospiza difficilis*
  - Mimidae : *Nesomimus macdonaldi*

  — Optional in adults and immatures

- Mammal Desmodontidae Vampire bats (3 species) — Optional in adults of both sexes

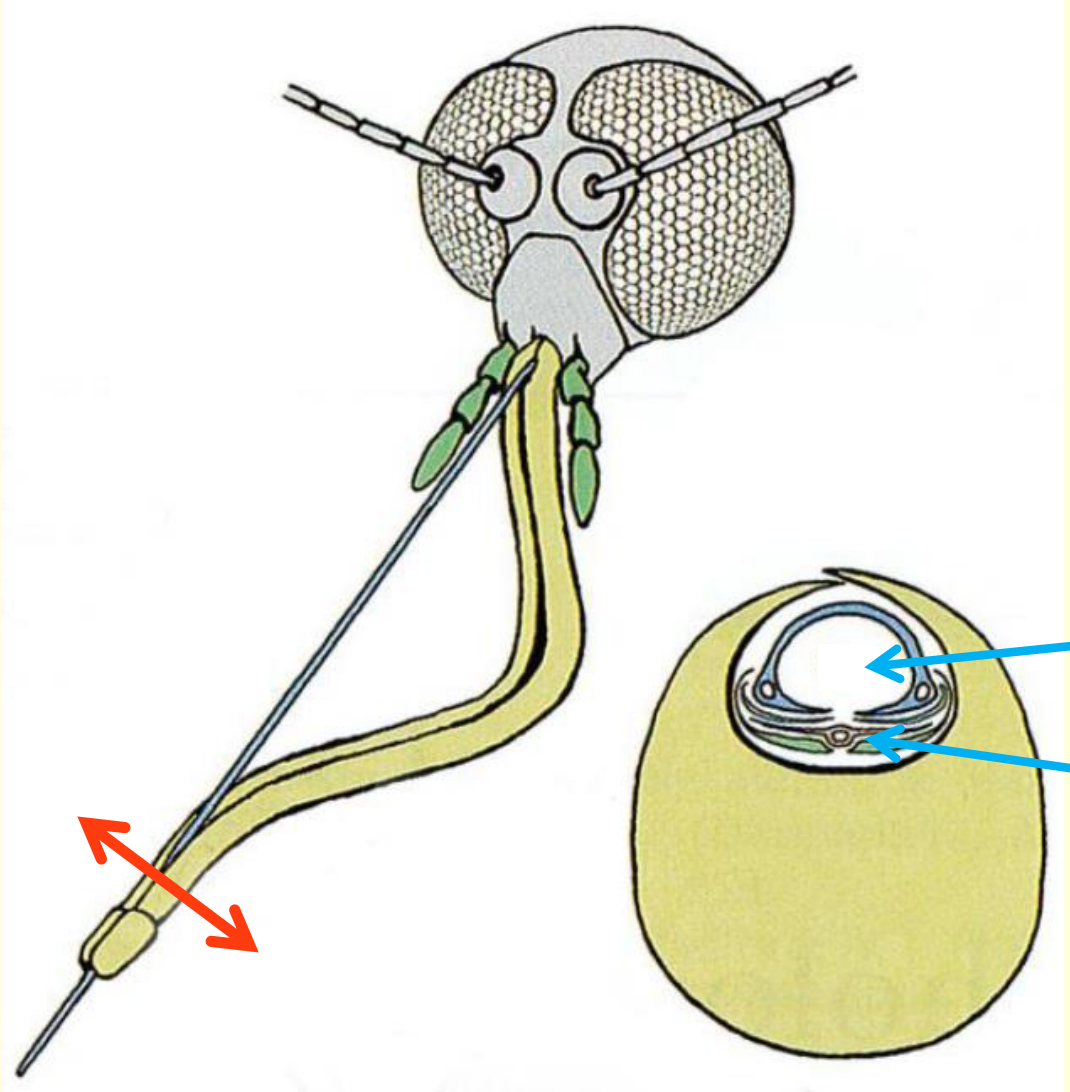


14,600 species of hematophagous Arthropods (Insecta + Acaria)

Estimates of the number of arthropod species vary between 1.17 million and 5 to 10 millions.

<1.2% of Arthropod species are hematophagous

The proboscis structure of a female mosquito



The bite of a female mosquito

Two steps :

- Probing = localization of a blood vessel
- Feeding = blood intake

The saliva

The saliva is ejected at the extremity of the proboscis.
Its ejection is continuous during the whole probing and feeding.

Gonotrophic cycle (3 phases)

oviposition

1 Search of suitable host to bite

bloodmeal

2 Blood meal digestion and egg maturation

rest

gravid

3 Search of suitable place to lay eggs

Summary

- Hematophagy concerns a minority of Arthropods:

  - Insects (fleas, lice, true bugs, mosquitoes, phlebotomine sandflies, tsetse flies, …)
  - Ticks (hard and soft ticks)

- The mosquito bite proceeds in two steps: (1) probing and (2) feeding

- The Arthropod saliva is essential in the physiology of blood intake and digestion

- The completion of a trophogonic cycle requires 2 to 4 days

- A female mosquito for her lifetime achieves ordinarily 3 to 7 trophogonic cycles

Vector definition

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The most important Arthropod vectors in medical entomology

Acaria (ticks) : hard ticks

soft ticks

Insecta : vectors belong to 4 orders :

- Diptera (Culicidae, Phlebotominae, Simuliidae, Ceratopogonidae, Tabanidae, Muscidae (*Glossina*) + flies (myiasis)
- Hemiptera (*Triatoma*…)
- Siphonaptera (fleas)
- Anoplura (lice)

Human diseases	Dedicated vectors
Epidemic typhus	Sucking lice
Rickettsiasis	Fleas & Ticks
(Bubonic) Pest	Fleas
Onchocerciasis	Simulidae
Loasis, Calabar swellings	Chrysops
Bancroftian filariasis	Mosquitoes
Trypanosomosis	Tse-tse flies
Chagas disease	Triatomes
Leishmaniasis	Phlebotomine sand flies
Dengue	*Aedes* mosquitoes
Rift Valley fever	*Aedes & Culex* mosquitoes
Chikungunya fever	*Aedes* mosquitoes
West Nile fever	*Culex* mosquitoes
Malaria	*Anopheles* mosquitoes
Tick encephalitis	Ticks (*Ixodes*)
Lyme disease (Borreliosis)	Ticks (*Ixodes*)
Tick hemorrhagic fever	Ticks (*Hyalomma*)

- Most of the time, the vector is mandatory in the pathogen life cycle.

- The vectors dominate all the medical arthropodology.

Vector : two definitions

Large definition

Any organism involved in the transmission of an infectious agent.

Stricto sensu definition of Arthropod vector

A hematophagous Arthropod that facilitates the active transmission of an infectious agent, from vertebrate to vertebrate.

- A vector exhibits a host-oriented behaviour that favours the transmission of pathogens.

Example of vector *Anopheles* mosquito and malaria

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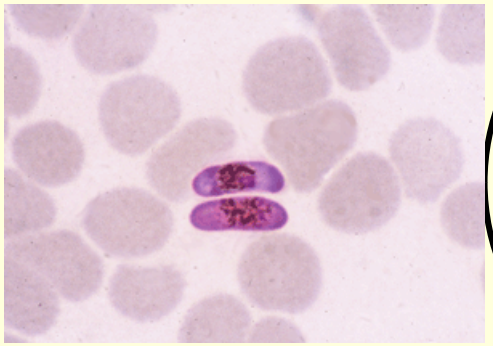
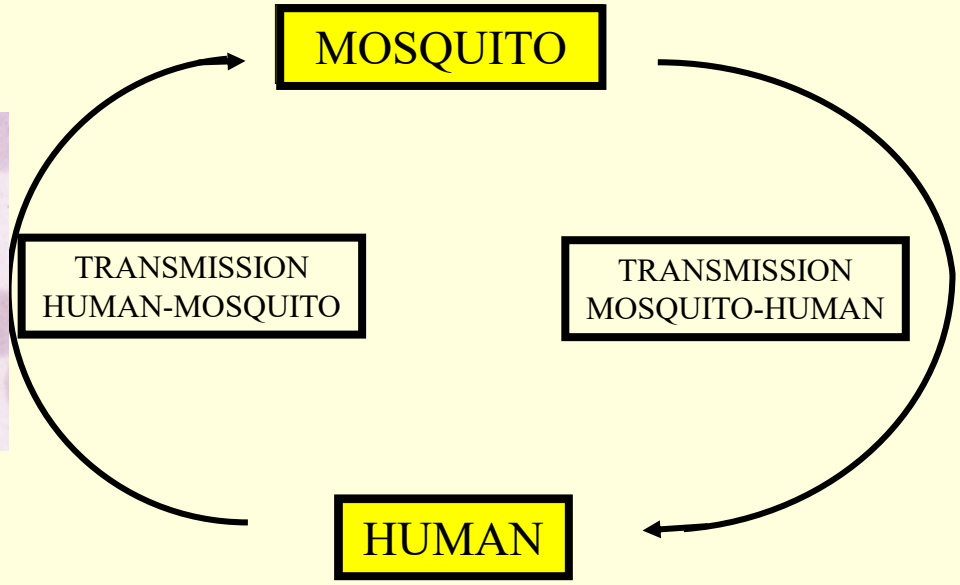
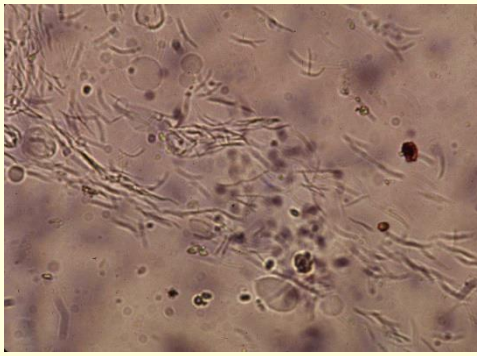
The transmission of *Plasmodium*

(in fact, there are two transmissions)



Gametocytes in the peripheral blood of the Human



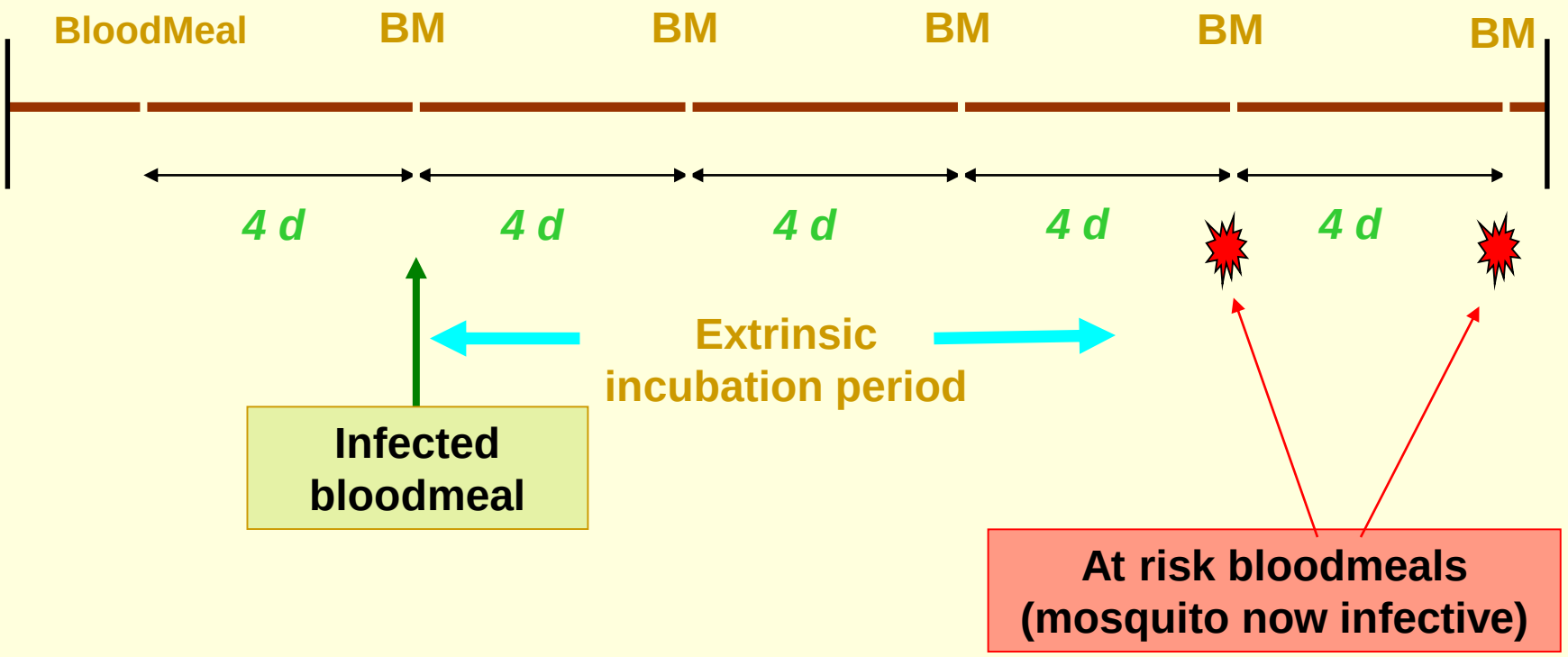


Sporozoites in the salivary glands of the mosquito

Be always precise with the transmission you address.

Numerical example of *Plasmodium* transmission

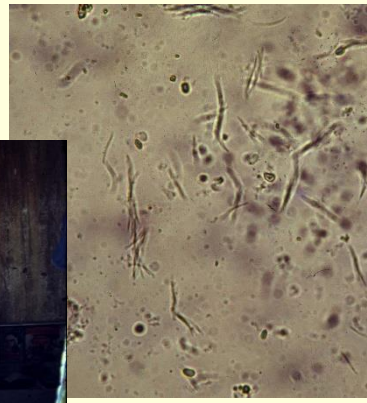
Longevity: 23 days	**Gonotrophic cycle : 4 days**
Extinsic period: 10 days	**First bloodmeal at 2 days**



Definition

E I R : Entomological Inoculation Rate

(= Taux d'inoculation entomologique)



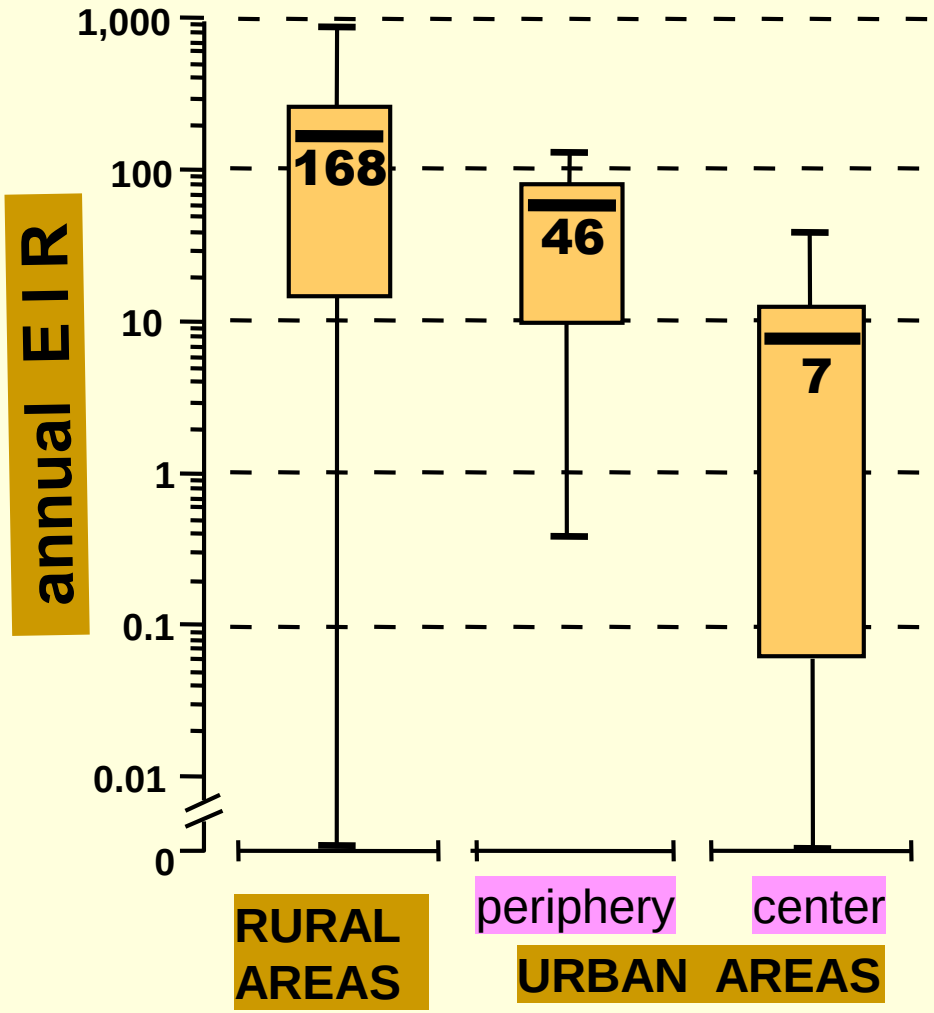
EIR = ma x s

ma = biting rate (= Taux de piqûres)

s = sprozoit index (= Indice sporozoïtique)

Unit : Nb of bites of infected anopheline mosqs per length of time (night, month, year, life)

Importance of global changes (urbanization)



Box plot showing the mean annual entomological inoculation rates, expressed in number of infected anophelines per man per year

Robert et al, 2003. Malaria transmission in urban sub-Saharan Africa.

Summary

- The idea of “malaria transmission” encompasses two types of transmission:
  Human-Mosquito and Mosquito-Human.

- Ordinarily “malaria transmission” designates the transmission from Mosquito to Human.

- This transmission may be measured by EIR (Entomological Inoculation Rate)
  and expressed in terms of Number of infected bites per human and per year.

Example of vector
Aedes mosquito and arbovirus

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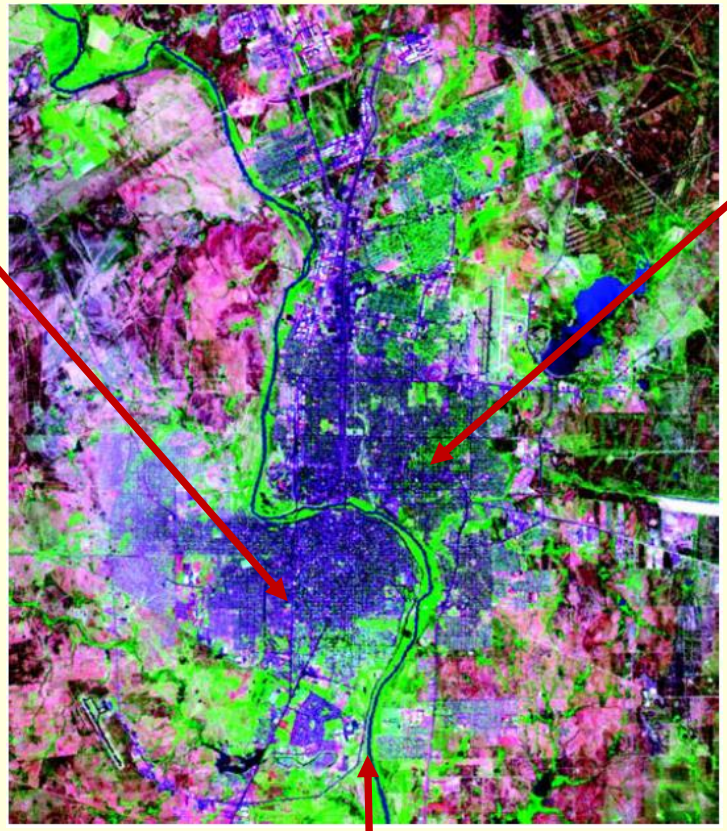
Importance of Human-vector contact

In bording states of Mexico, 62,514 suspected dengue cases in 1980-1999

In whole Texas, 48 dengue cases, in 1980-1999



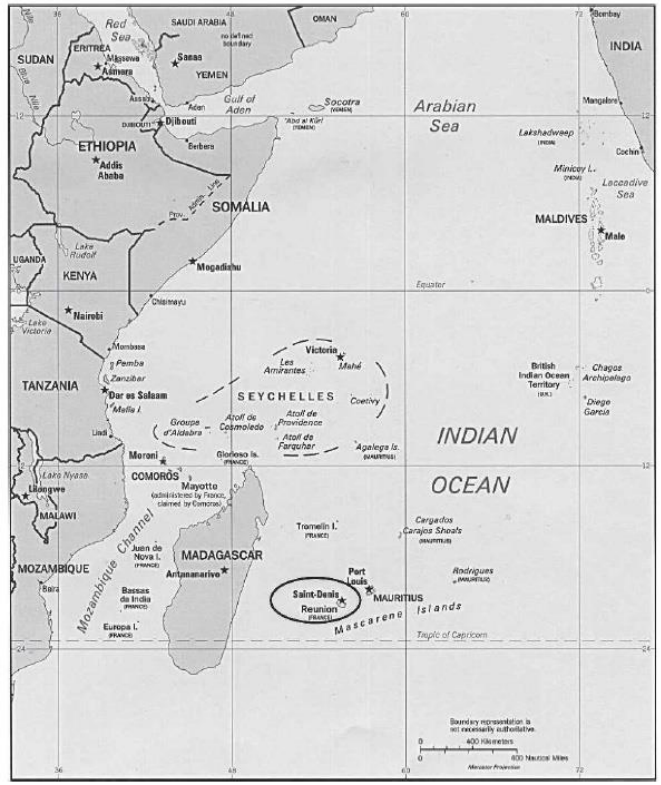
	Nuevo Laredo, Mexico	Laredo, Texas
Aedes aegypti density	High	High
Anti-dengue IgM prevalence	16 %	< 1 %
Habitat	Windows and doors are left open, particularly at day-time	Air-conditioning, window screens

Rio Grande international border

Reiter P et al – Texas lifestyle limits transmission of dengue virus. *Emerging Infectious Diseases*, 2003, 9(1): 86-89.

Importance of vector-parasite relationships (1/2)

Example of *Aedes* – virus relationships



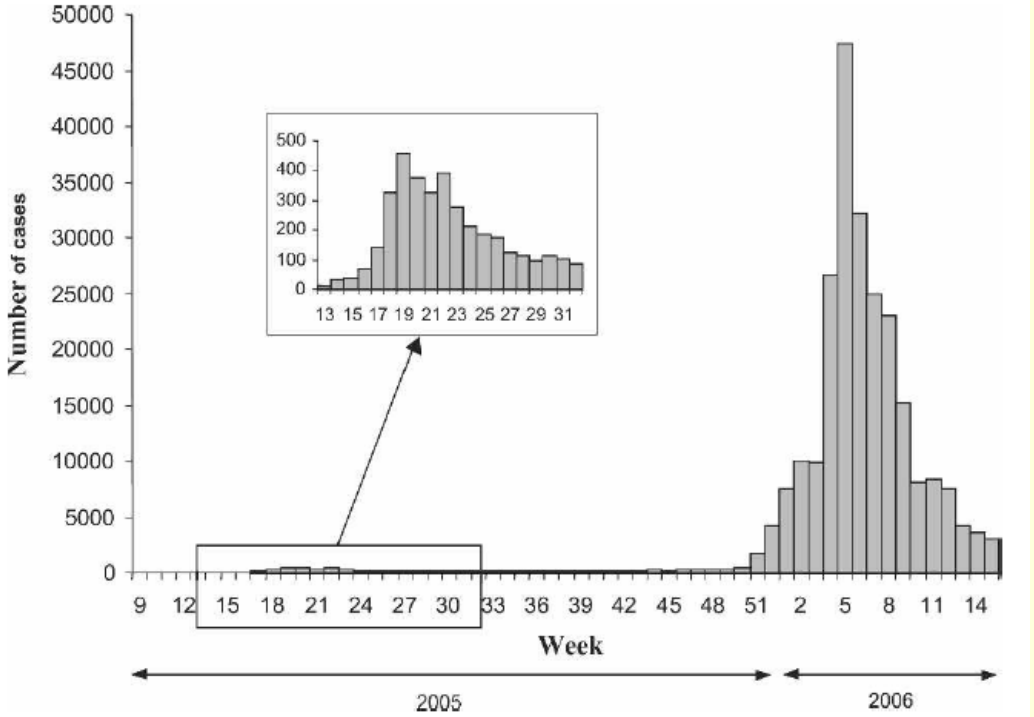
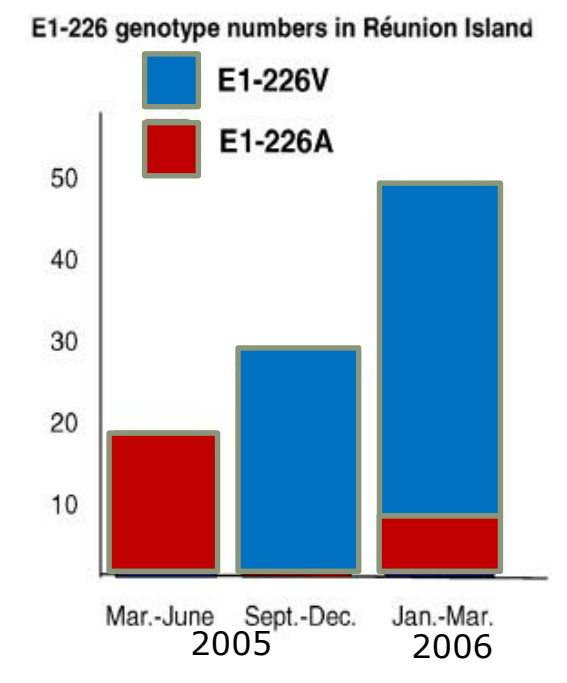


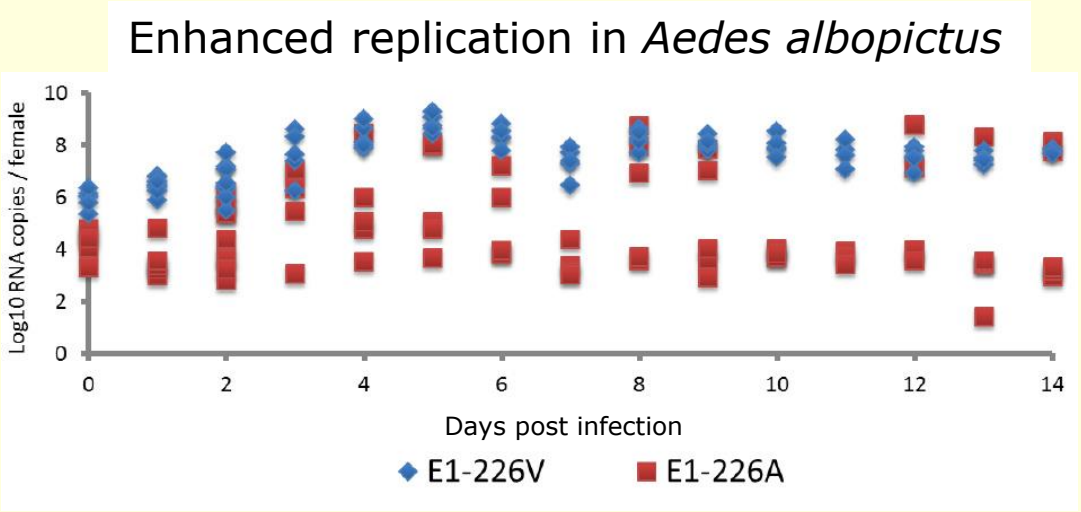
FIGURE 2. Number of weekly incident cases of chikungunya, Réunion Island, March 28, 2005–April 16, 2006 (n = 244,000). *Reported by the active case-finding system between weeks 9 and 50 of 2005 and estimated from the sentinel physician network between week 51 of 2005 and week 15 of 2006.

La Réunion Island
Up to 2005, no chickungunya cases
Very few *Ae. aegypti*, good vector. A lot of *Ae. albopictus*, poor vector

Importance of vector-parasite relationships (2/2)

Example of *Aedes* – virus relationships





Vazeille et al PLoS One (2007)

One single amino acid change from alanine to valine at position 226 of CHIKV E1 glycoprotein (E1-A226V)
Increases transmission by *Ae. albopictus* (but not by *Ae. aegypti*).

illustrate the finesse of vector-parasite relationships

Importance of vertical transmission

Ex. from an infected female to her progeny

METHODS: Vertical transmission of DENV was monitored in Mexico states in which DEN is endemo-epidemic.
Aedes eggs were collected in ovitraps, then adults were reared under laboratory conditions and their heads were used to infect C6/36 cells.

RESULTS: 54 of 713 (7.8%) of *Ae. aegypti* pools tested positive.
A minimum infection rate of 2.52 per 1000 mosquitoes was estimated for *Ae. aegypti*.
DENV-1, DENV-2 and DENV-3 serotypes were detected even during interepidemic periods.

Danis-Lozano et al - Vertical transmission of dengue virus in *Aedes aegypti* and its role in the epidemiological persistence of dengue in Central and Southern Mexico. Trop Med Int Health 2019, 24: 1311-1319

Summary

- Environmental factors (i.e. non entomological or non virological factors) are of paramount importance to allow the circulation of arbovirus
- Vector-virus relationships are also of paramount importance to allow the circulation of arbovirus
- Vertical transmission (i.e. from Adult female to her progeny) is a concern for the conservation of the virus in interepidemic periods