Identification of exotic mosquitoes

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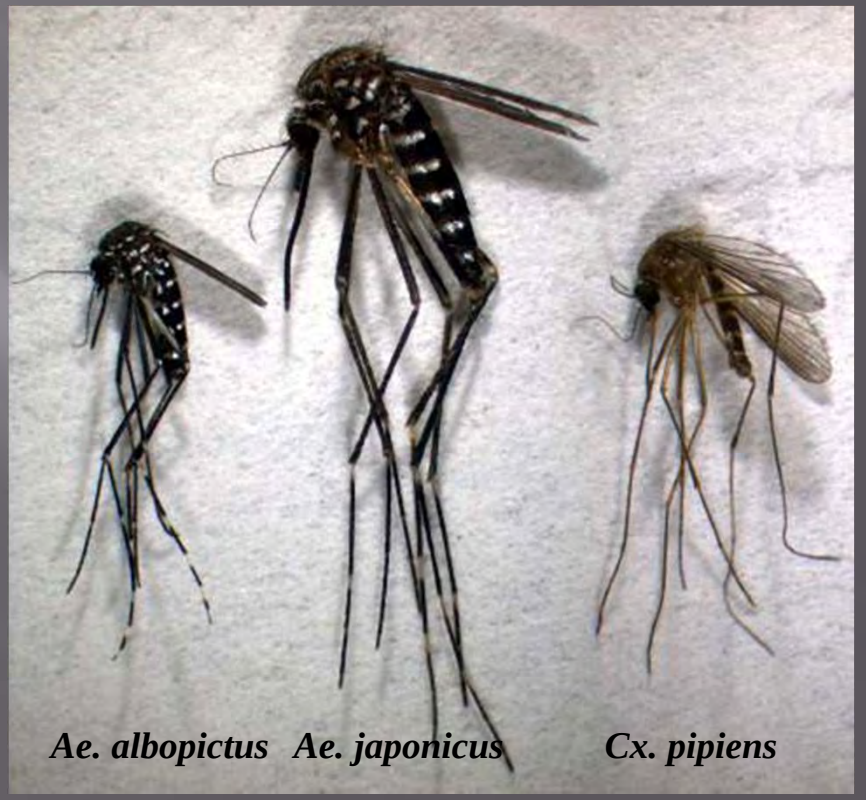
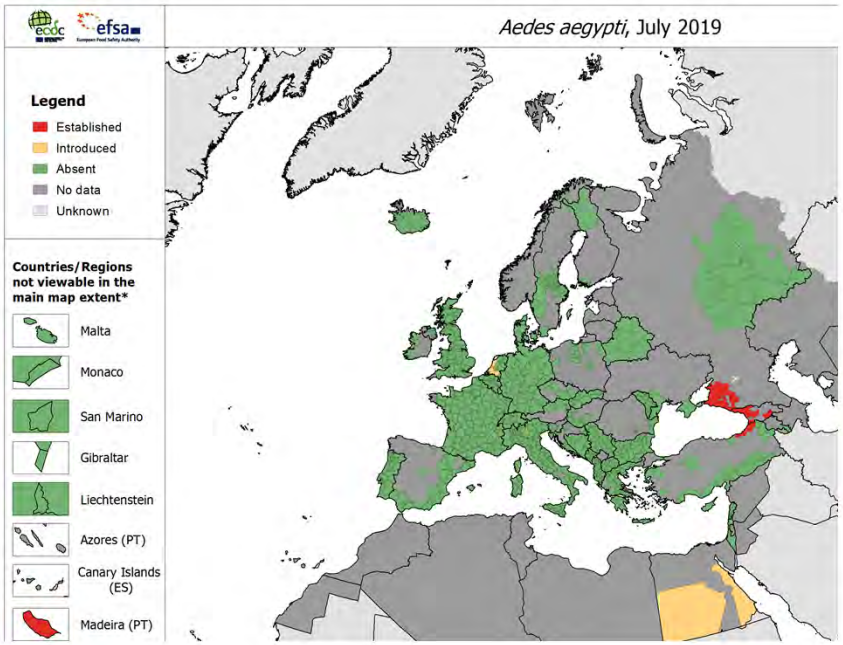
Invasive *Aedes* mosquitoes

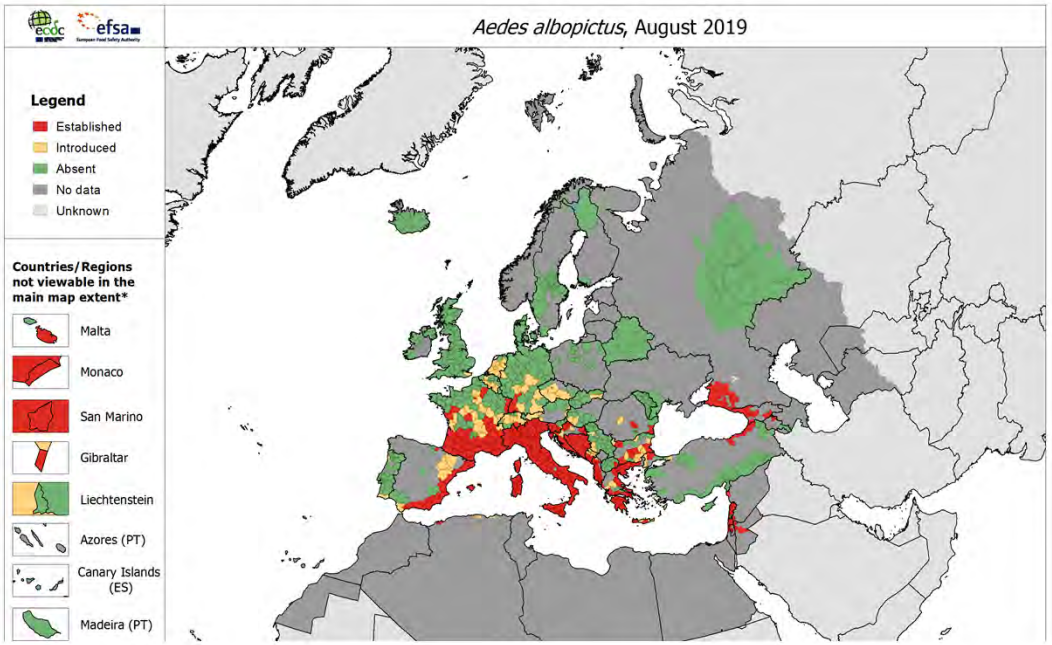
- ✓ *Aedes aegypti*
- ✓ *Aedes albopictus*
- ✓ *Aedes atropalpus*
- ✓ *Aedes japonicus*
- ✓ *Aedes koreicus*
- ✓ *Aedes triseriatus*

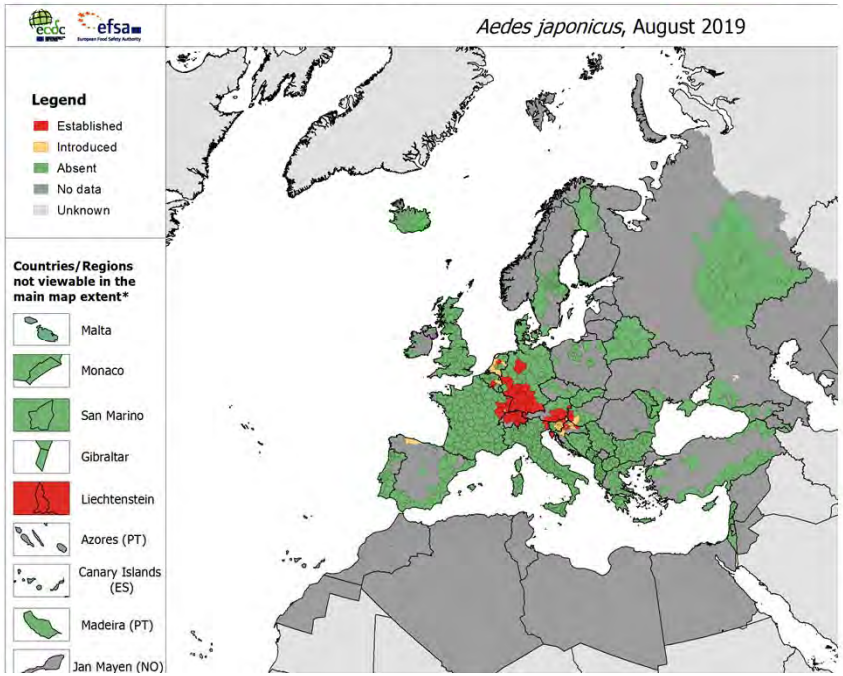


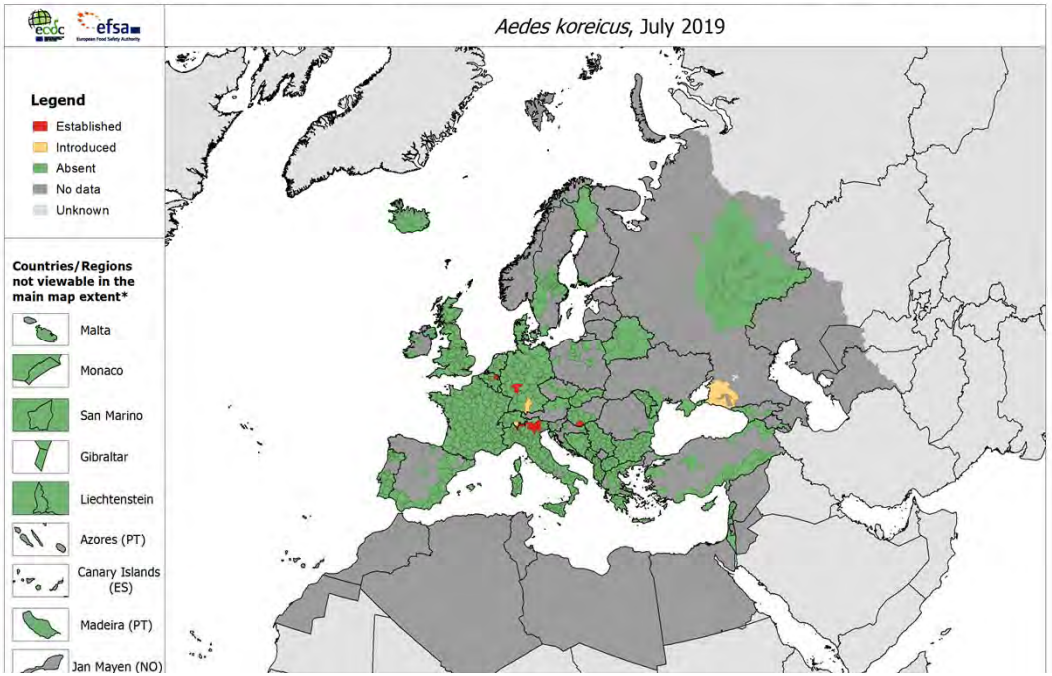
Ae. albopictus ***Ae. japonicus*** ***Cx. pipiens***

Current distribution map of invasive mosquitoes in Europe

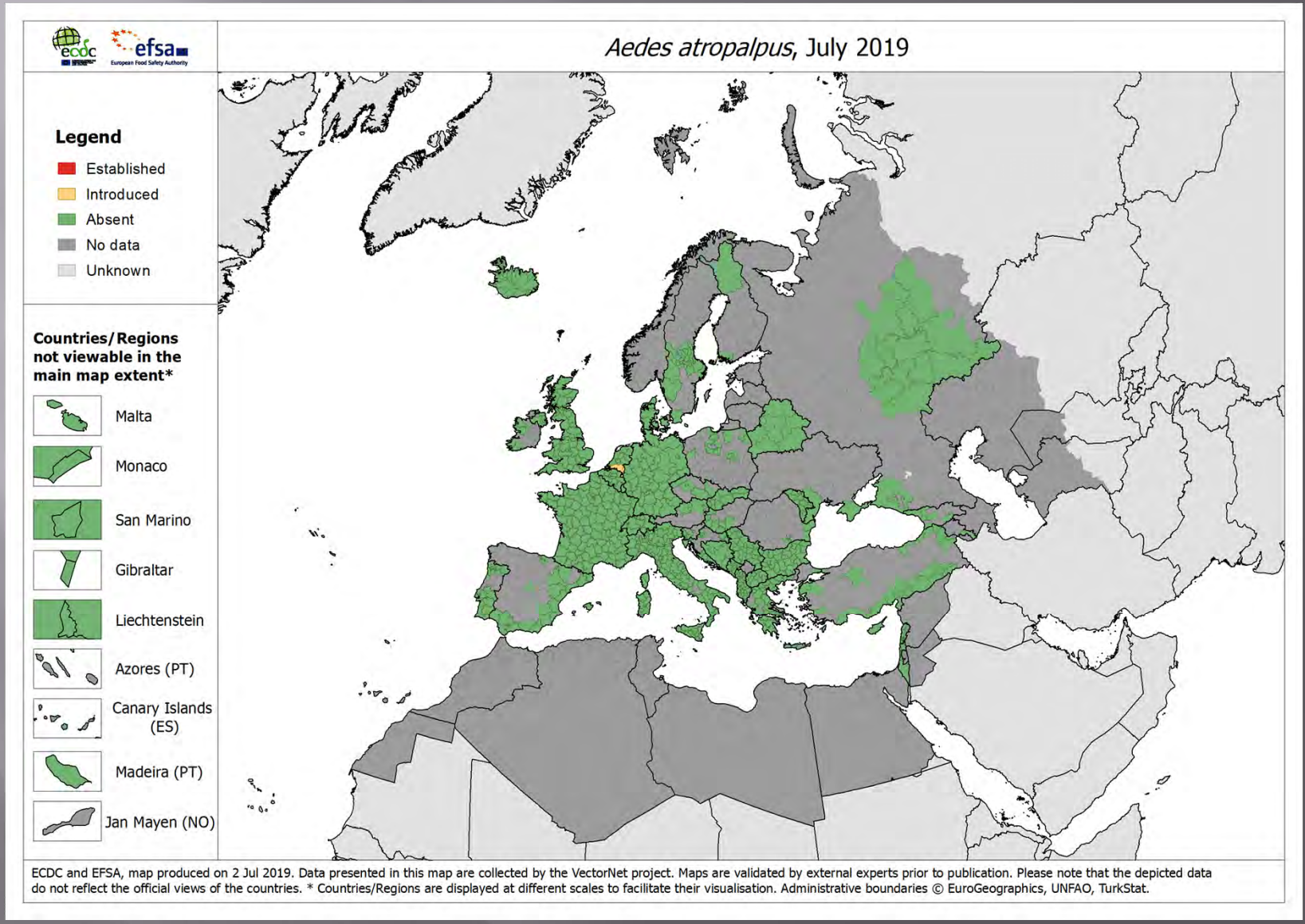








Current distribution map of invasive mosquitoes in Europe



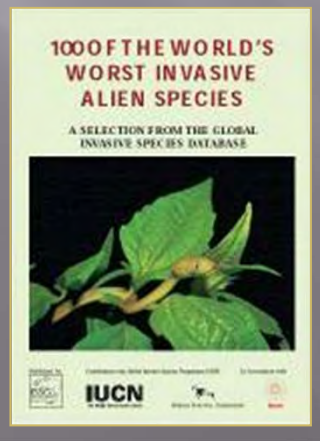
Aedes albopictus

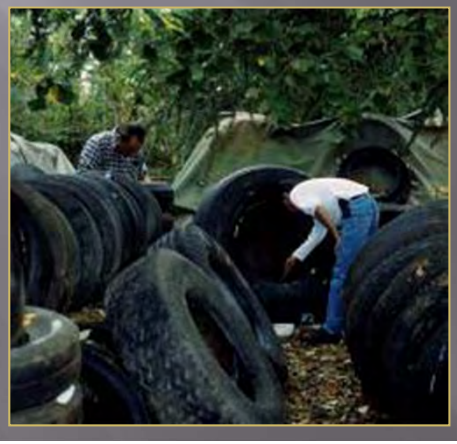
Asian Tiger mosquito *Aedes (Stegomyia) albopictus* Skuse, 1894

= *Stegomyia albopicta* sensu Reinert et al. 2004

A model of expansion success

1. Biological advantages
   - Adapted to artificial breeding sites (tyres, containers)
   - Eggs: resistant to desiccation + winter diapause (temperate regions)
   - No specific host preference
2. Human transportation
   - Larvae/adults transported by shipments (1850-1950)
   - Eggs transported by tyre trade (and others) throughout the world
   - Adults transported locally by ground vehicles from site to site



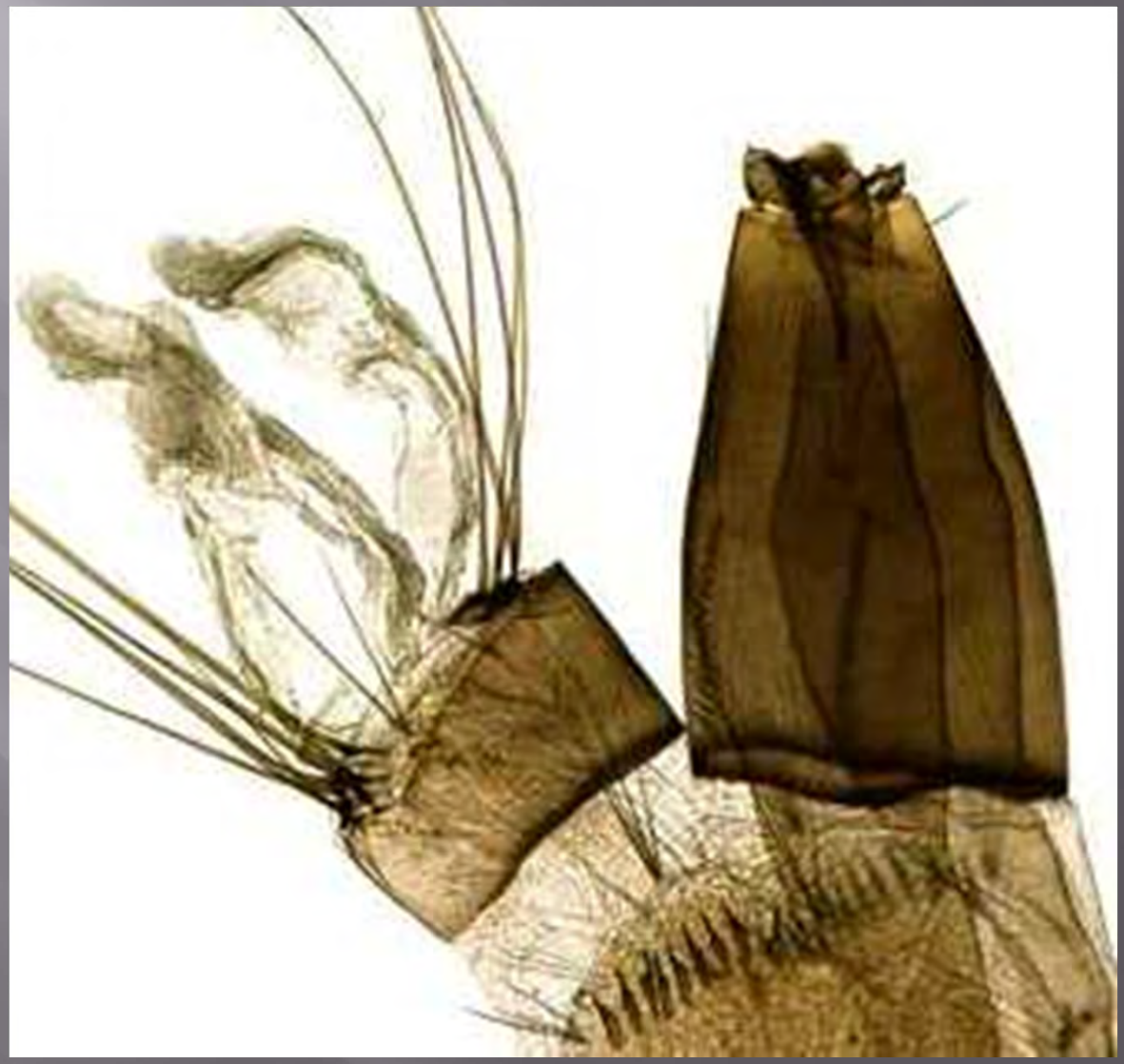


Aedes (Stegomyia) albopictus **(Skuse, 1894)** © CDC / J. Gathany

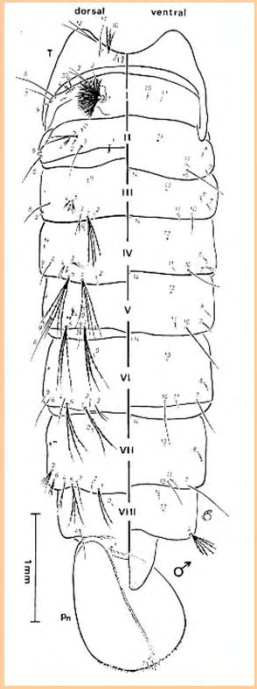
Imagoes

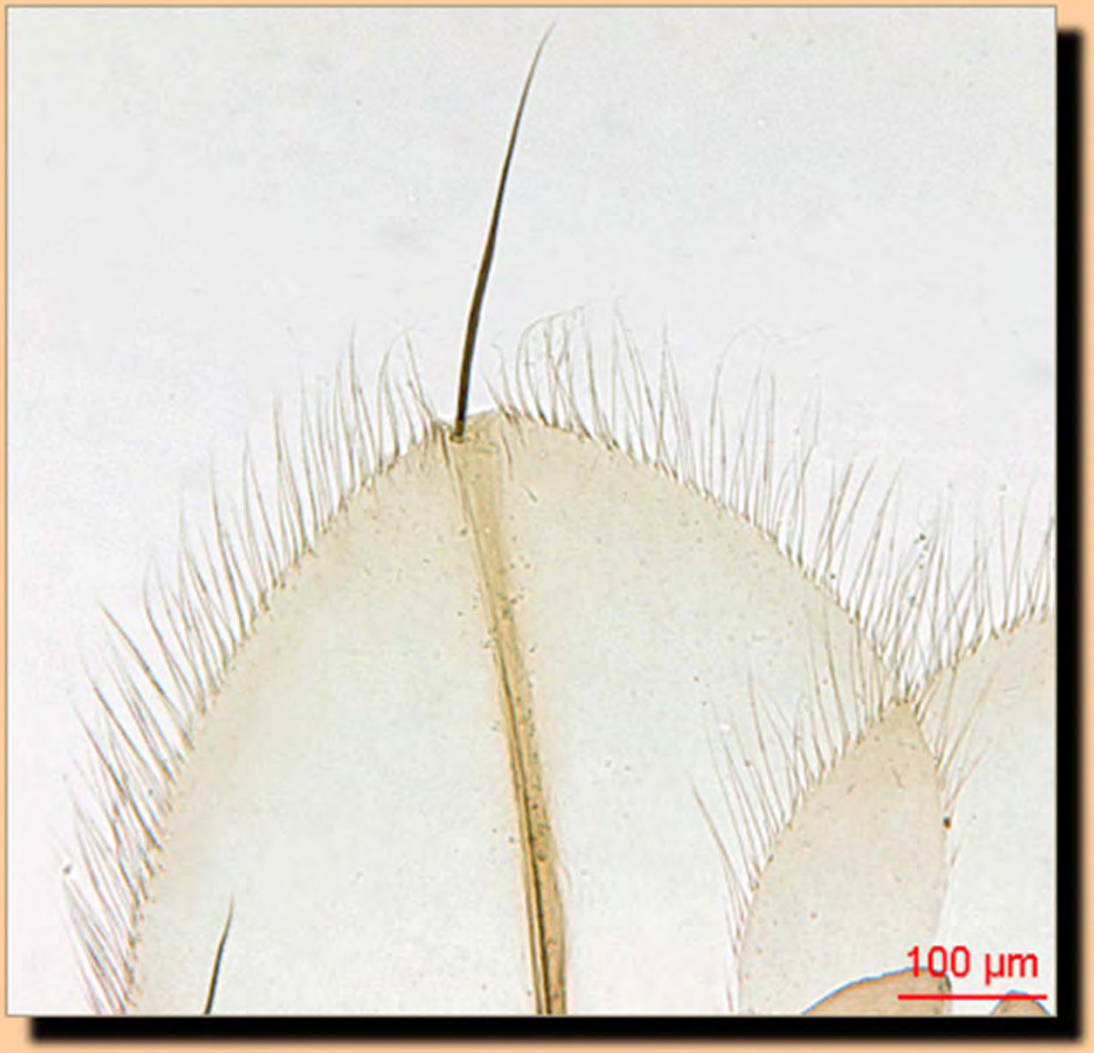
Aedes albopictus: Larvae

Larvae



Pupae





Aedes albopictus

- Overview of current hazards associated with *Ae. albopictus*
  - Top 100 invasive species; most invasive mosquito
  - Introduced to Europe via used-tyres, Lucky bamboo
  - Widely established and in Southern Europe, spreading northwards
  - Establishment is contingent on temperate/tropical strain
  - Risk mapping suggests further spread
  - Known vector of CHIKV, DENV, *Dirofilaria*, VC for …..
  - Involvement in Italian CHIKV outbreak
  - Biting nuisance
  - Ecological plasticity: cold acclimation, winter diapause

Aedes aegypti – Profile

'Yellow fever mosquito'

Aedes (Stegomyia) aegypti (Linnaeus, 1762)

= *Stegomyia aegypti* sensu Reinert et al. 2004

- 2 sub-species

Ae. aegypti aegypti

Light coloured form

'Domestic' form

Cosmopolite (tropics and sub-tropics)

High vector competence

Ae. aegypti formosus

Dark form

'Silvatic' form

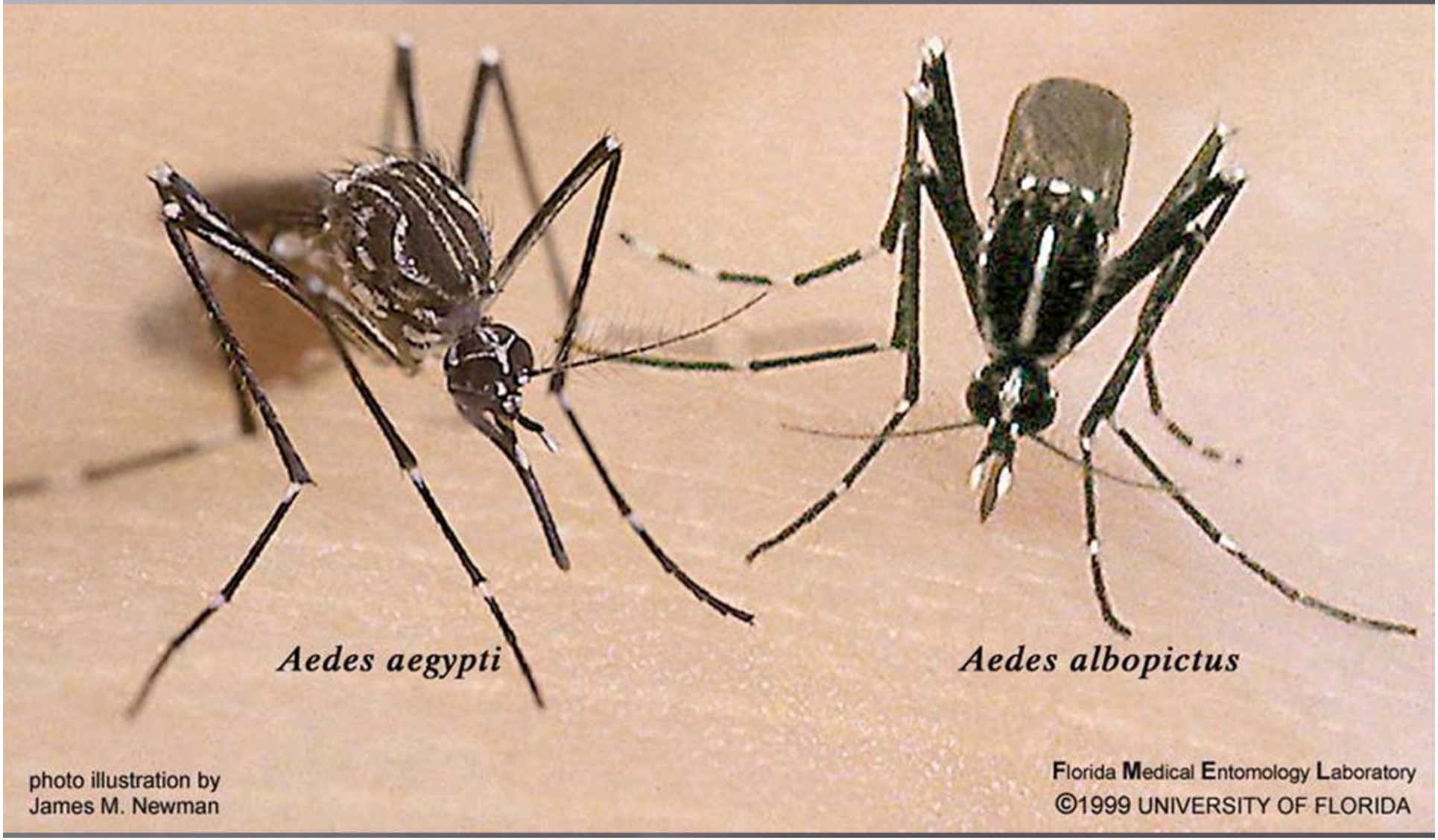
Africa, Indian Ocean Islands

Low vector competence

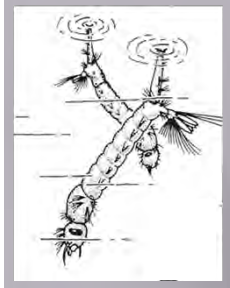
Aedes aegypti

Imagoes

Ornamentation of thorax (scutum)

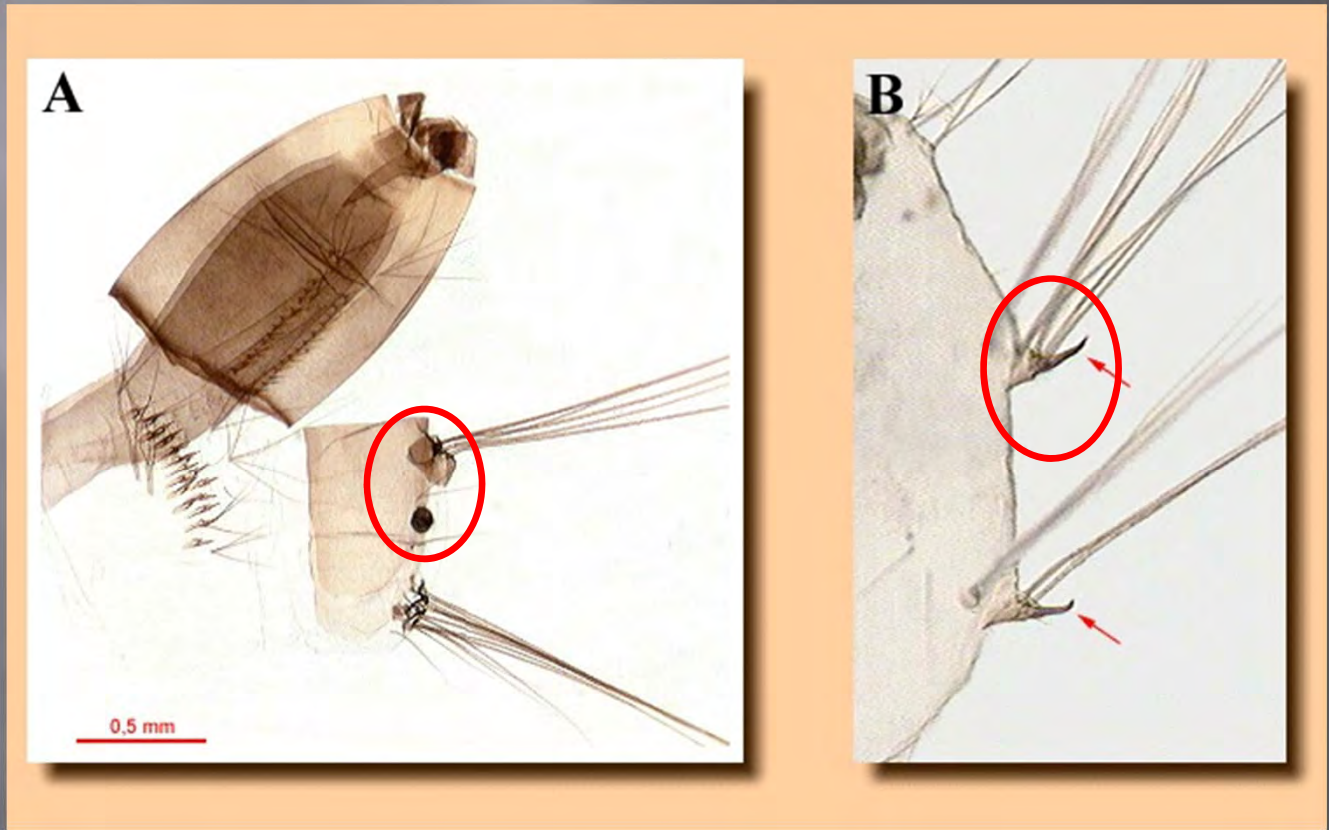


Ae. aegypti: diagnostic characters of larvae



Larva differs from *Ae. albopictus*:

- Stout spine at the insertion of setae 11-M and 11-T
- Spicules present on apicodistal border of segment X



Aedes aegypti

- Present in the past in Southern Europe
- Spreading at the Black See cost (since 2004), introduced in Madeira (2004)
- Introduced by second hand tyre trade in NL (2010)

  - Overview of current hazards associated with *Ae. aegypti*

    - Present (and vector of diseases) in the whole Mediterranean Basin in the past
    - Act as vector in overseas territories
    - Highly anthropophagic and synanthropic
    - Important disease vector: YF, DENV, CHIKV
    - Re-colonises some parts of Europe (Madeira, Eastern Black Sea coast)
    - Intolerance of cold temperatures will limit northerly spread

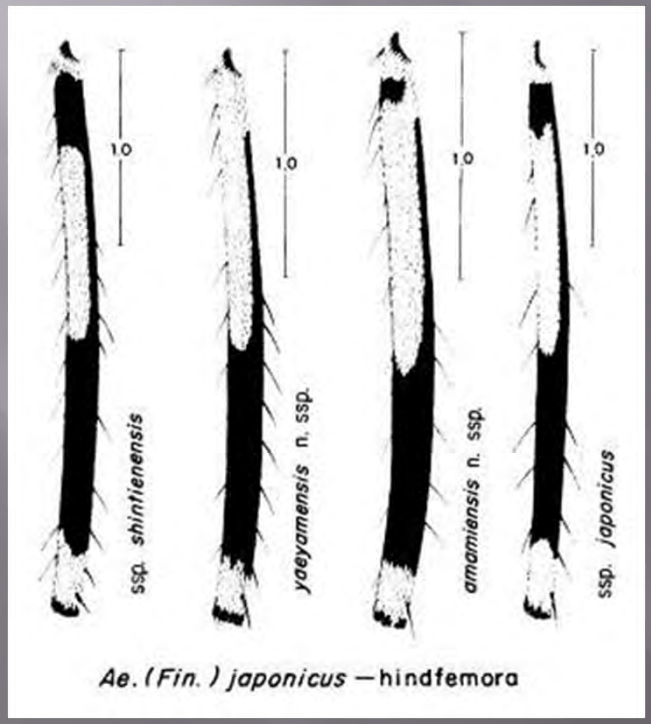
Aedes japonicus – Profile

'Asian bush mosquito'; 'Asian rock pool mosquito'

Aedes (Finlaya) japonicus (Theobald, 1901)

= *Ochlerotatus japonicus* sensu Reinert et al. 2004

= *Hulecoeteomyia japonica* sensu Reinert et al. 2006



- 4 sub-species

Ae. japonicus amamiensis (Tanaka et al. 1979)

Ae. japonicus japonicus (Theobald, 1901)

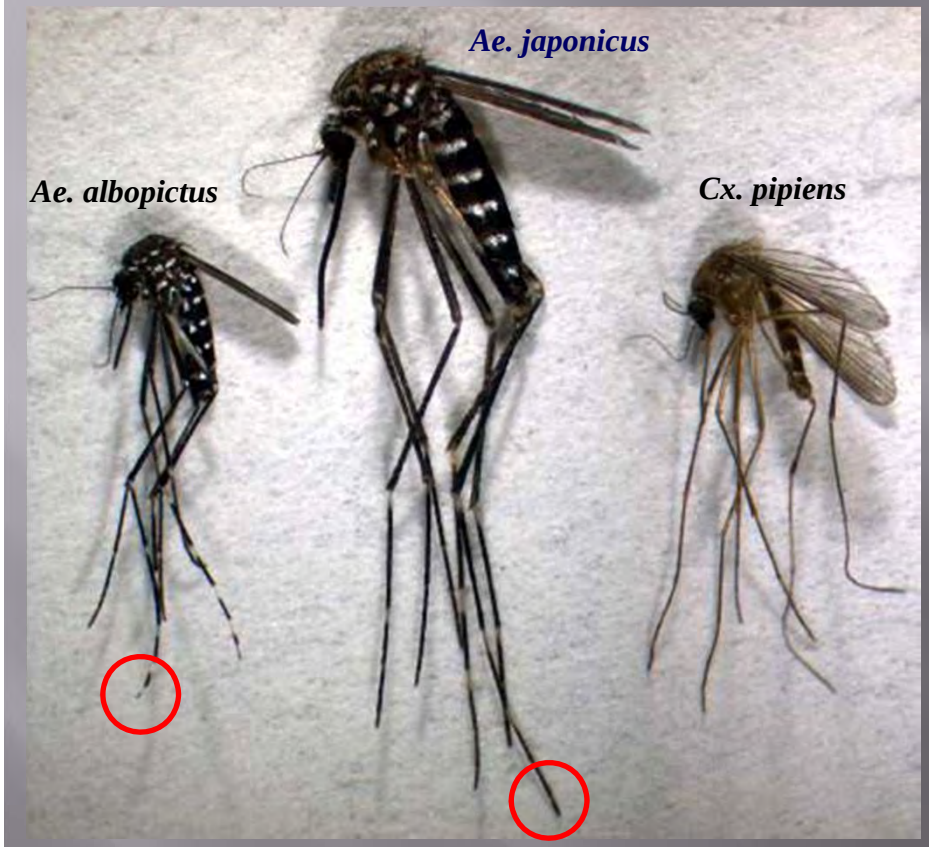
Ae. japonicus shintienensis (Tsai et Lien, 1950)

Ae. *japonicus yaeyamensis* (Tanaka et al. 1979)

➢ Differ in femur ornamentation

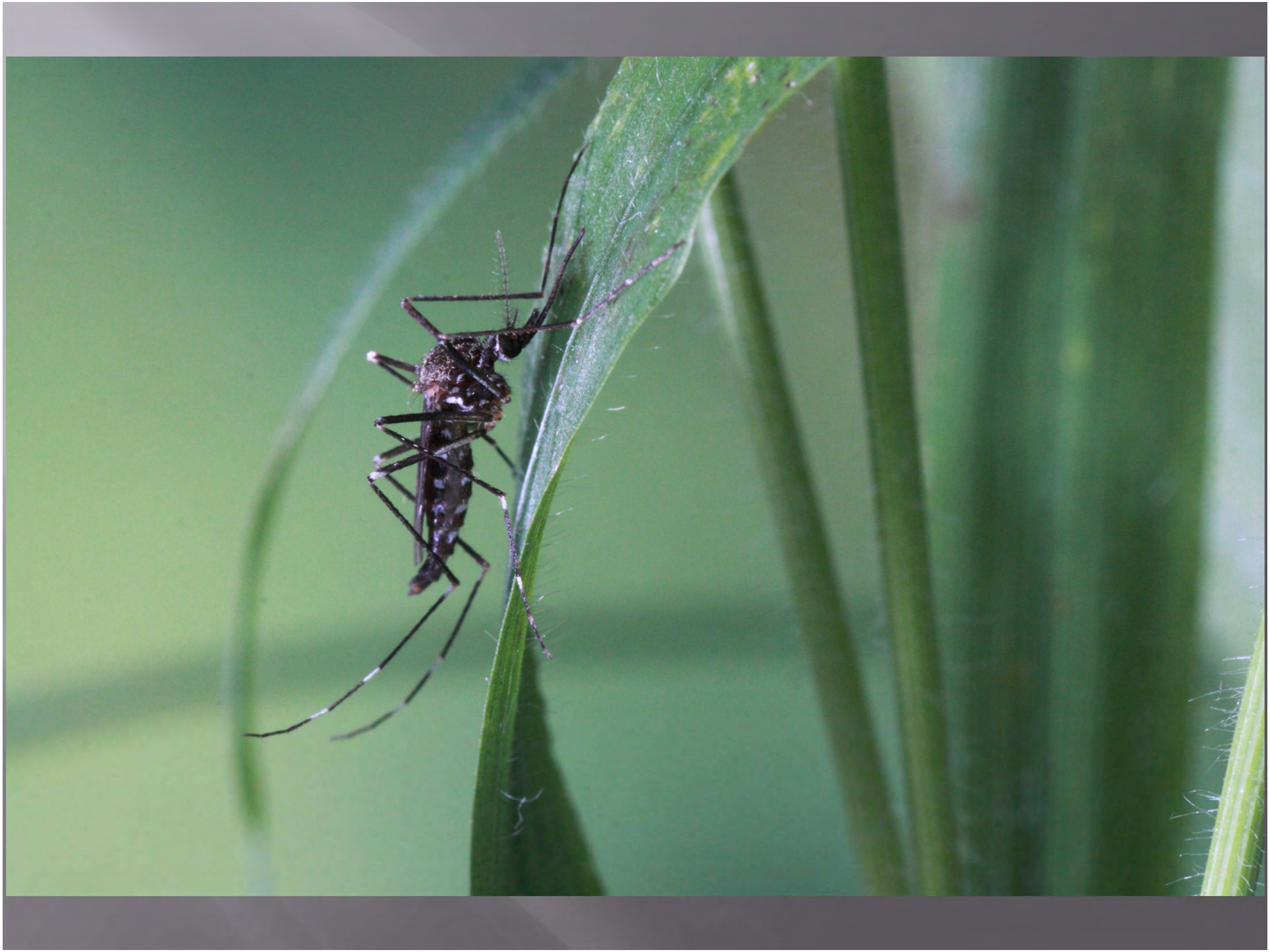
Source: Tanaka *et al.* 1979

Ae. japonicus: diagnostic characters of adults

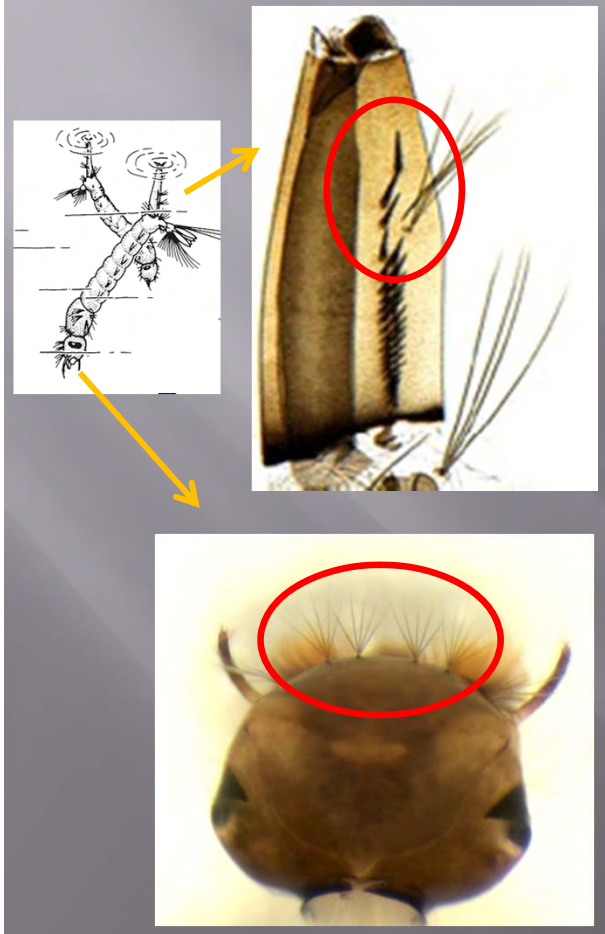


Black and white mosquito, usually large, similar to *Ae. albopictus*, but differs in ornamentation of:

- mesonotum
- palpi extremity
- fourth tarsomere



Ae. japonicus: diagnostic characters of larvae



Usually large larvae, differs from other mosquitoes of Europe by:

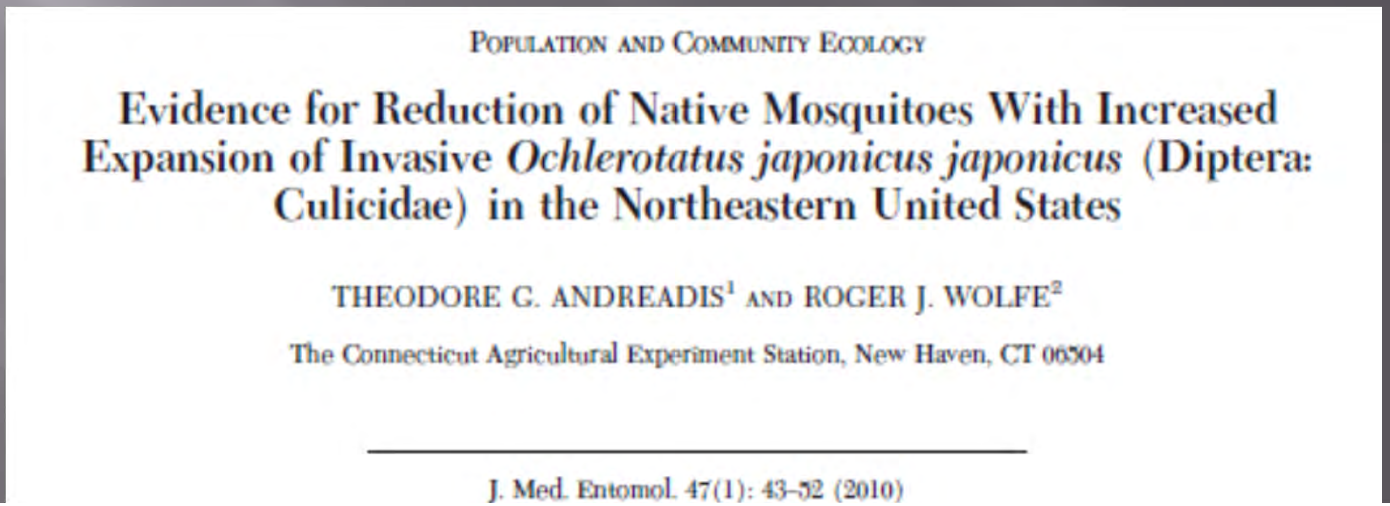
- Pecten with one or more distal strong spines, widely spaced

Similar species in containers: *Ae. atropalpus*

- Frontal setae 5-C and 6-C
  - branched for *Ae. japonicus*
  - single for *Ae. atropalpus*

Aedes japonicus – Life history and Hazards

- ✓ Breeds in rock pools and containers
  - ➢ Tolerance of cold temperatures will not limit spread
- ✓ Biting nuisance
- ✓ Putative vector of pathogens of medical and/or veterinary significance: possible WNV vector, but status unclear
- ✓ Potential threat to biodiversity



POPULATION AND COMMUNITY ECOLOGY

Evidence for Reduction of Native Mosquitoes With Increased Expansion of Invasive *Ochlerotatus japonicus japonicus* (Diptera: Culicidae) in the Northeastern United States

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J. Med. Entomol. 47(1): 43–52 (2010)

Ae. japonicus – Recent territorial expansion

Native range: Far East (Japan, Korea, China, Russia)

- ✓ Intercepted in New Zealand (1993, 1998 & 1999) (Laird *et al*. 1994; Fonseca *et al*. 2001)
- ✓ First established outside its native range in the USA in 1998, spread to 22 states incl. Hawaii, and parts of Canada (Williges *et al.,* 2008)
- ✓ Europe:
  - France (Normandie), 2000: detected on a platform for imported used tyres (then eliminated) (Schaffner *et al.,* 2003)
  - Belgium, since 2002: established, eliminated in 2015, re-introduced in 2018
  - Central Europe, 2007: Rapid spread in northern Switzerland and southern Germany (Schaffner *et al.,* 2009)
  - Austria/Slovenia, 2011: new finding of wide colonised area (Seidel *et al. in prep*)
  - Since 2012: Further spreading in Central Europe (Croatia, France, Germany, Italy, Hungary, Netherlands, Slovenia…)

Aedes atropalpus – Profile

Aedes (Ochlerotatus) atropalpus (Coquillett, 1902)

= *Ochlerotatus atropalpus* sensu Reinert *et al.* 2004

= *Georgecraigius atropalpus* sensu Reinert *et al.* 2006

- ✓ Native from North and Central America
- ✓ Original larval habitat: rock pools
- ✓ Diapausing eggs

Ae. atropalpus: diagnostic characters of adults

Add leg

Dark and clear mosquito,
differs in ornamentation of:

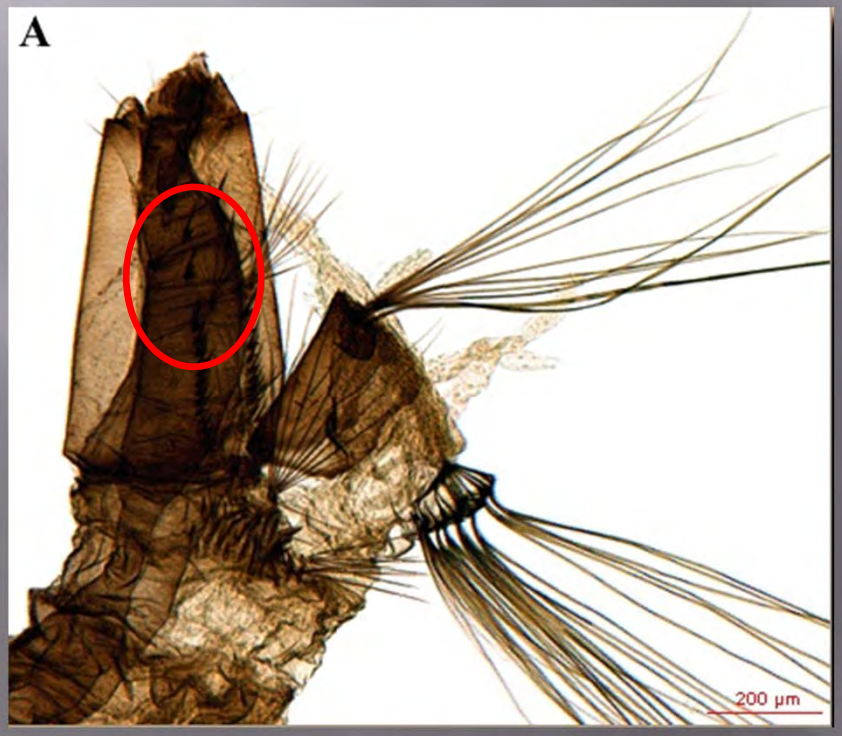
- mesonotum
- abdominal tergal plates
- fifth tarsomere

Aedes atropalpus – Diagnostic characters of larvae

Usually large larvae, differs from other mosquitoes of Europe by:

- Pecten with one or more distal strong spines, widely spaced

Similar species in containers: *Ae. japonicus*



- Frontal setae 5-C and 6-C
  - single for *Ae. atropalpus*
  - branched for *Ae. japonicus*

Aedes atropalpus – Spread and hazards

- ✓ Climate assessments suggest spread in Europe
- ✓ Readily bites humans; nuisance species
- ✓ Positive for WNV in US; vector status not clear

- ➢ Italy (1996), France (2004), Netherlands (2009)
- ➢ Introduced by used tyre trade
- ➢ Limited information on ecology/biology

Aedes koreicus – Profile & fact sheet

Aedes (Finlaya) koreicus (Edwards, 1917)

= *Ochlerotatus (Finlaya) koreicus* sensu Reinert *et al*. 2004

= *Hulecoeteomyia koreica* sensu reinert et al., 2006

- ✓ Introduced and established in Belgium, 2008 (Versteiert *et al., in prep*)
- ✓ New finding of wide colonized area in Italy, 2011 (Capelli *et al.*, 2011)

- ➢ Morphological particularities indicate Cheju-Do Island as the geographical origin of most of the introduced populations (but not Germany and Russia)

- ✓ Native from Asia
- ✓ Original larval habitat: rock pools and tree holes
- ✓ Winter diapause at egg stage
- ✓ Potential vector of arboviruses (Japanese encephalitis)
- ✓ Invasive character to be confirmed?

Ae. koreicus: diagnostic characters of adults

Black and white mosquito, similar to *Ae. japonicus*, but differs in ornamentation of:

- fourth and fifth tarsomeres bearing a basal white ring

Aedes triseriatus – Profile

‘American tree-hole mosquito’

Aedes (Protomacleaya) triseriatus (Say, 1823)

= *Ochlerotatus triseriatus* sensu Reinert *et al*. 2004

- ✓ Native from North America
- ✓ Original larval habitat: tree holes
- ✓ Winter diapause at egg stage

Aedes triseriatus – Fact sheet

- ✓ Introduced by second hand tyre trade
- ✓ Larvae intercepted in France in 2004, in tyres imported from USA (Louisiane)

- ➢ Primary vector of La Crosse virus in North America
- ➢ Potential vector of West Nile virus

Orthopodomyia signifera – Profile

Orthopodomyia signifera (Coquillett, 1896)

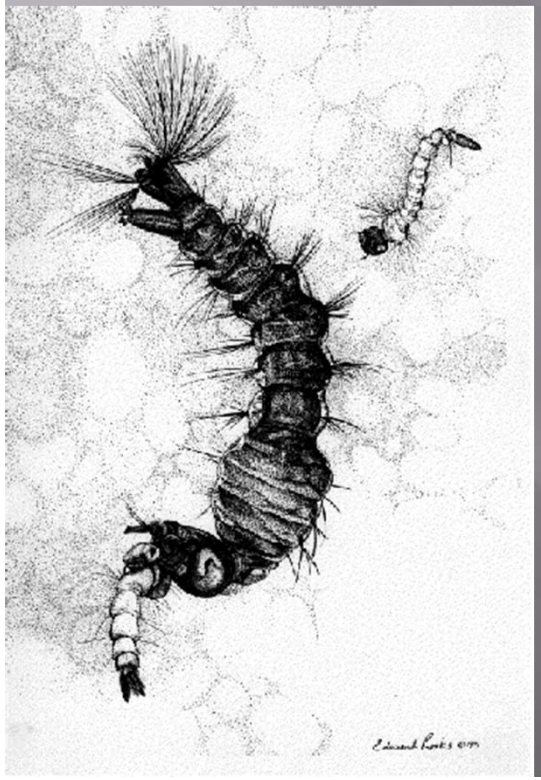
- Introduced by used tyre trade
- Larvae intercepted in 2004, in tyres imported from USA (Louisiane)

- ✓ Native from North America
- ✓ Original larval habitat: tree holes
- ✓ Winter diapause at larval stage
- ✓ Do not bite human

Toxorhynchites rutilus – Profile & fact sheet

Toxorhynchites (Lynchiella) rutilus (Coquillett, 1896)

- Introduced by used tyre trade
- Larvae intercepted in 2004, in tyres imported from USA (Louisiane)



- ✓ Native from North America
- ✓ Original larval habitat: tree holes
- ✓ Winter diapause at larval stage
- ✓ Do not take any blood meal
- ✓ Larvae are predators of other aquatic insect larvae

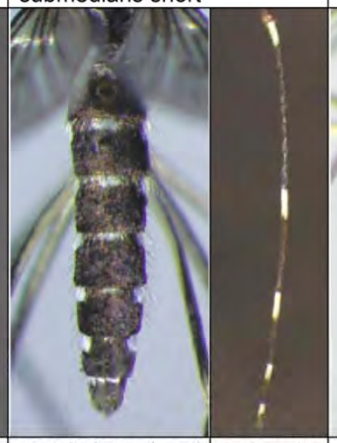
Native container-breeding mosquito species


Anopheles (Anopheles) plumbeus Stephens, 1828


Culex (Culex) pipiens Linnaeus, 1758

Aedes (Dahliana) geniculatus (Olivier, 1791)

Figure 9: Main diagnostic morphological characters for adults of IMS. A. Thorax (scutum, dorsal side); B. Abdomen (dorsal side); C. Hind tarsus (last segments of the third leg). Males have a more hairy and slender abdomen.

Ae. aegypti	*Ae. albopictus*	*Ae. atropalpus*	*Ae. j. japonicus*	*Ae. koreicus*	*Ae. triseriatus*
					
A. Silver scales in a shape of a lyre	A. Median silver-scale line	A. Mixed yellow and dark scales, dark median stripe	A. 5 stripes of golden scales, submedians long	A. 5 stripes of golden scales, submedians short	A. Broad median dark-scale band, sides with silver scales
					
B. Pale lateral marks and thin basal bands	B. Thin basal pale bands, laterally enlarged	B. Pale basal bands	B. Pale lateral and median patches	B. Pale lateral and median patches	B. Pale lateral patches
C. Segment V entirely white	C. Segment V entirely white	C. Inter-articular pale bands S. V white	C. Segments IV & V black	C. Seg. IV & V with basal pale bands	C. Tarsi entirely dark

Source: ECDC, 2012

Identification key of adult mosquitoes
breeding in man-made containers

1. Genera

1	Palps as long as proboscis; Scutellum evenly rounded and uniformly setose	*Anopheles*
	Palps distinctly shorter than proboscis; Scutellum trilobed, setae arranged in 3 sets	2
2	Prespiracular setae present	*Culiseta*
	Prespiracular setae absent	3
3	Tarsomere IV of fore legs reduced, not longer than broad	*Orthopodomyia pulcripalpis*
	Tarsomere I of fore legs usually shorter than tarsomeres II to V together	4
4	Postspiracular setae present; Abdomen tapering apically, cerci long easily visible . . .	*Aedes* (incl. *Ochlerotatus*)
	Postspiracular setae absent; Abdomen rounded apically, cerci short, hardly visible . .	*Culex*

Source: ECDC, 2012

Identification key of adult mosquitoes
breeding in man-made containers

1. *Aedes* (incl. *Ochlerotatus*)

1 Tarsomeres with pale rings, usually more distinct on hind legs 2
Tarsomeres without pale rings; white spot well visible on knee III . . . . . *geniculatus*

2 Each pale ring embraces two tarsomeres, the apex of one and the base of the next. . *pulcritarsis*
Pale rings present only at base of tarsomeres 3

3 Scutum with white longitudinal stripes; Palps with an apical white scale patch. 4
Scutum with longitudinal yellowish stripes or bands; Palps entirely dark or with a few white scales 5

4 Scutum with a medio-dorsal white band, no lateral bands. . . . . *albopictus*
Scutum without a medio-dorsal white band on anterior part, but with two lateral white broad stripes, lyre shaped. . . . . *aegypti*

5 Abdominal tergal plates with broad basal pale bands; Fufth tarsomera entirel pale . . *atropalpus*
Abdominal tergal plates with narrow basal pale bands or only pale basal lateral patches or both together; Fifth hind leg tarsomere with only pale scales at the base 6

6 Fifth hind leg tarsomere entirely dark or with a few pale scales at the base (no ring). *japonicus*
Fifth hind leg tarsomere with a short basal pale ring. . . . . *koreicus*

Identification key of mosquito larvae
breeding in man-made containers

1. Genera

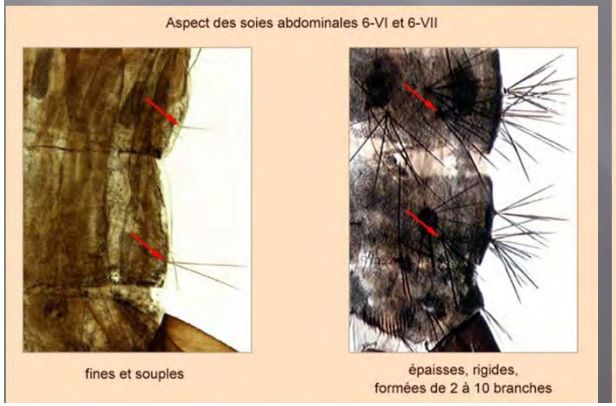
1	Siphon absent	*Anopheles*
	Siphon well developed	2
2	Pecten absent	*Orthopodomyia pulcripalpis*
	Pecten present	3
3	Siphonal setae (1-S) consisting of 3 or more pairs	*Culex*
	Siphonal setae (1-S) consisting of a single pair	4
4	Siphonal setae (1-S) inserted near base of siphon	*Culiseta*
	Siphonal setae (1-S) inserted nearer to middle of siphon	*Aedes, Ochlerotatus*

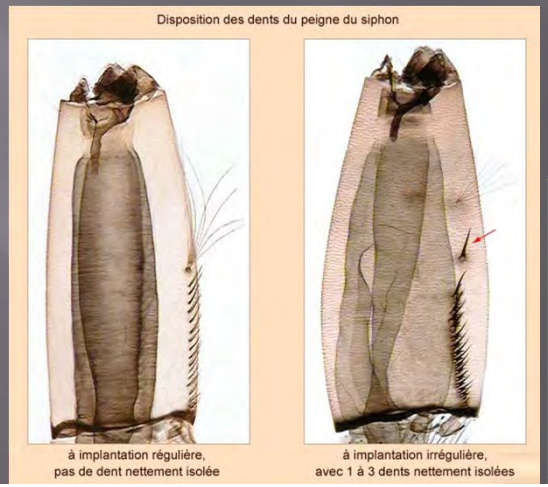
Identification key of mosquito larvae
breeding in man-made containers

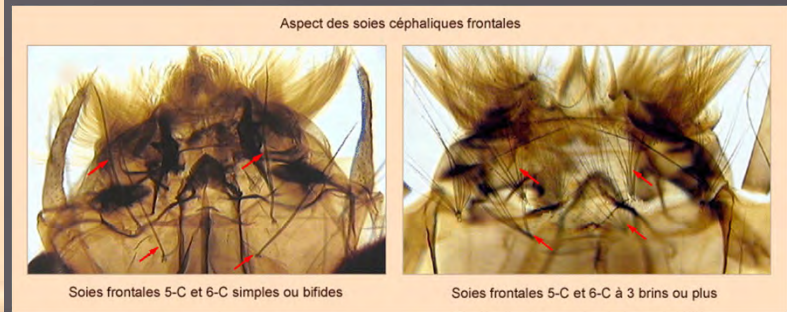
2. *Aedes* & *Ochlerotatus* species

1	Abdominal lateral setae (Setae 6 and 7) on segments II – VI strong and stellate; pecten spines long and closely approximated	*Oc. geniculatus*
	Abdominal lateral setae (Setae 6 and 7) on segments II – VI not strong and stellate; pecten with short and normally spaced spines	2
2	Pecten spines all evenly spaced.	*Ae. albopictus*
	Pecten with one or two of the distal spines more widely spaced	3
3	Frontal setae 5-C and 6-C single.	*Oc. atropalpus*
	Frontal setae 5-C and 6-C branched	*Oc. japonicus*

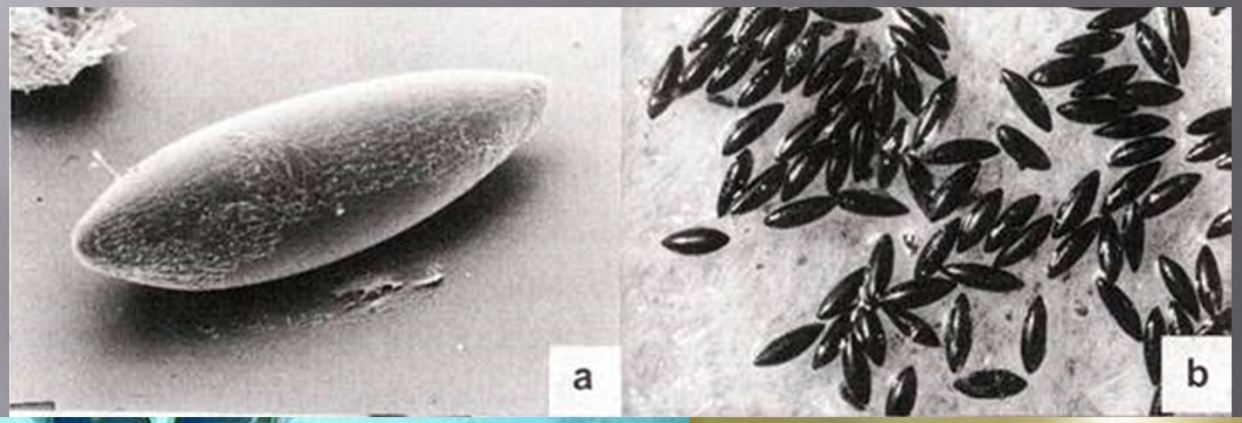
Ae. aegypti
Ae. koreicus

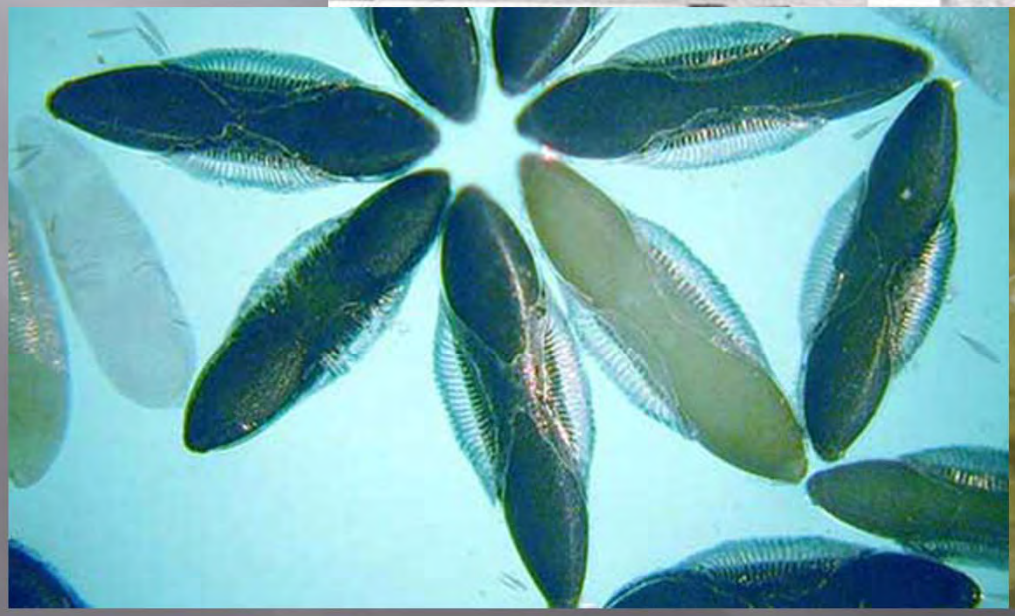






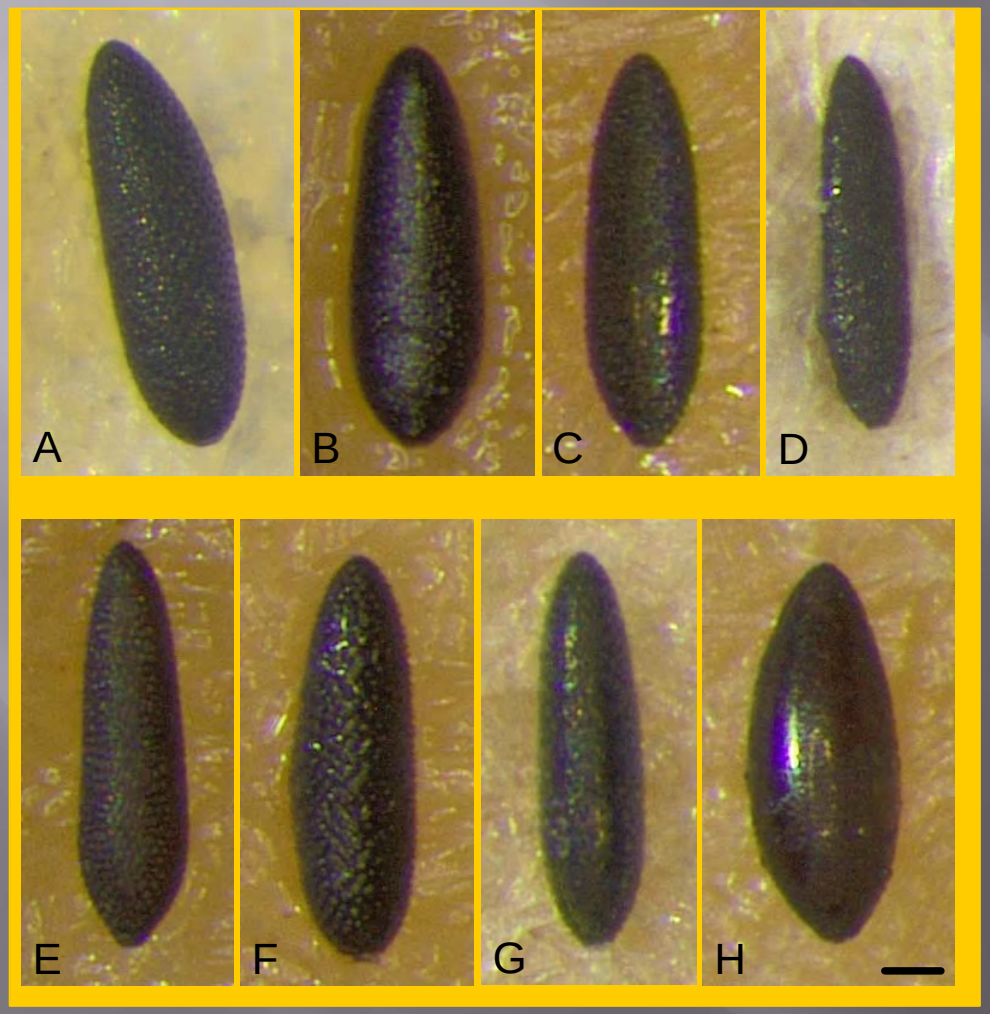
Identifying eggs?





Eggs

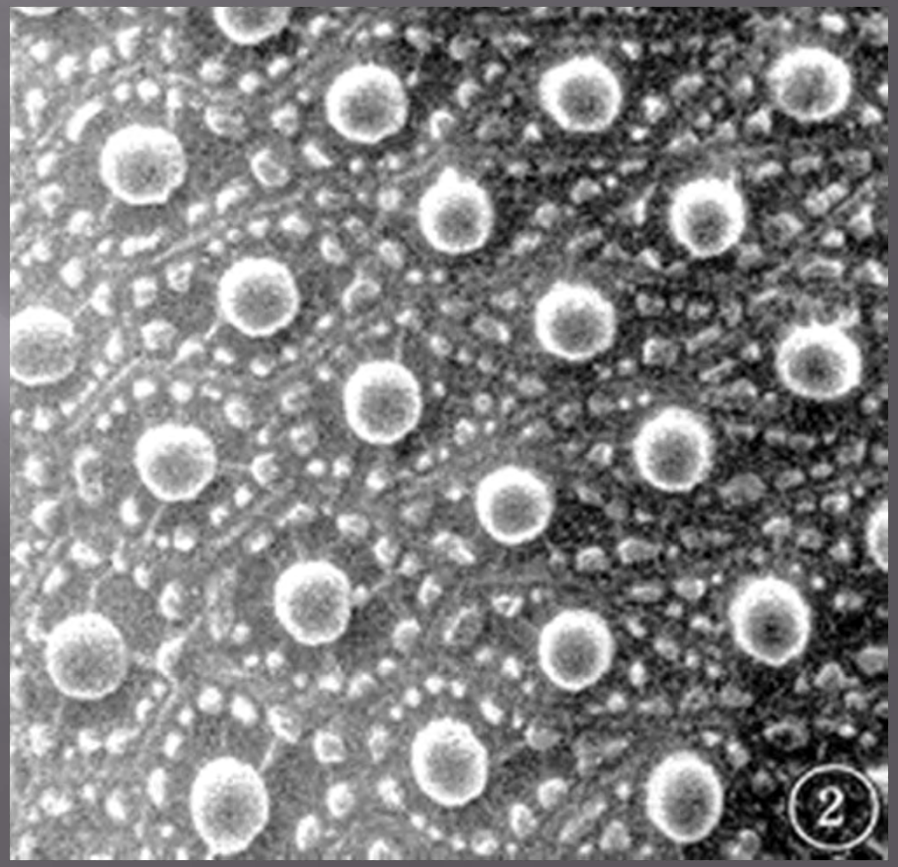
Eggs



A- *Aedes geniculatus*
B- *Ae. japonicus*
C- *Ae. albopictus*
D- *Ae. koreicus*
E- *Ae. atropalpus*
F- *Ae. triseriatus*
G- *Ae. aegypti*
H- *Ae. phoeniciae*

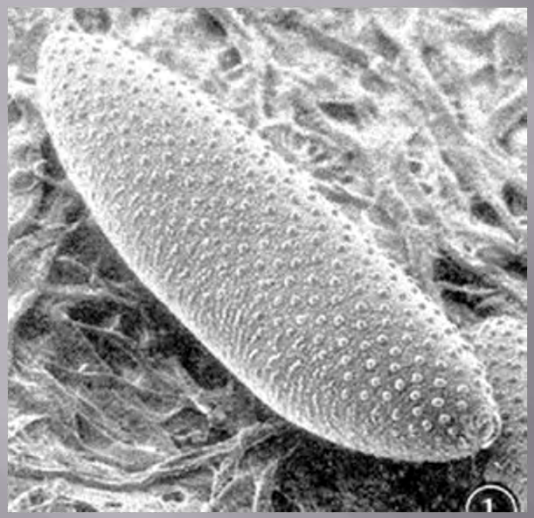
D'après Rey L., 1991

Eggs

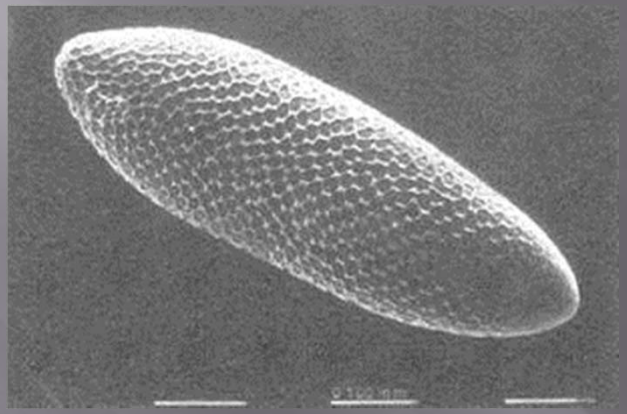


Source: Matsuo et al., 1972

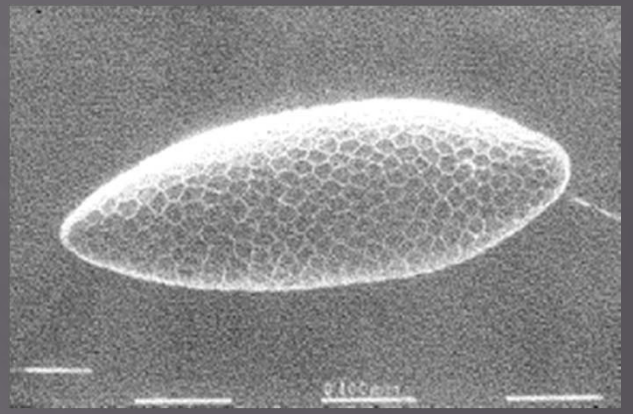
Eggs



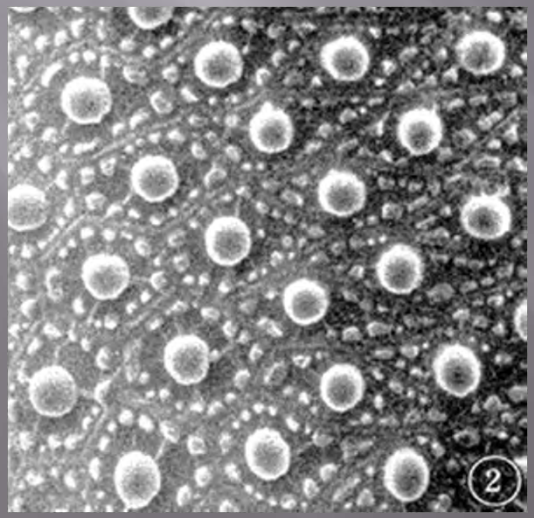
Aedes albopictus

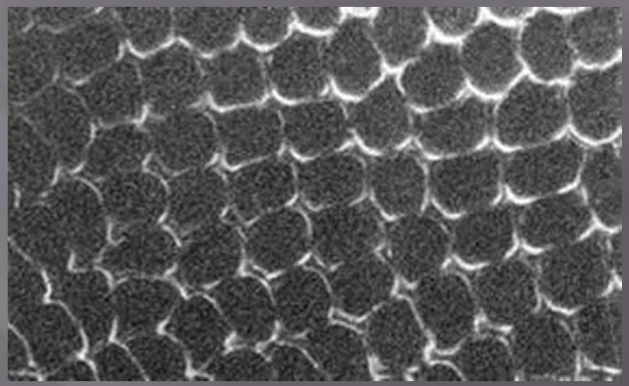


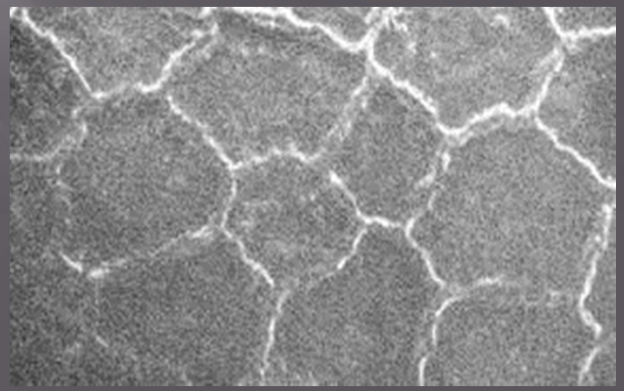
Aedes geniculatus



Aedes berlandi

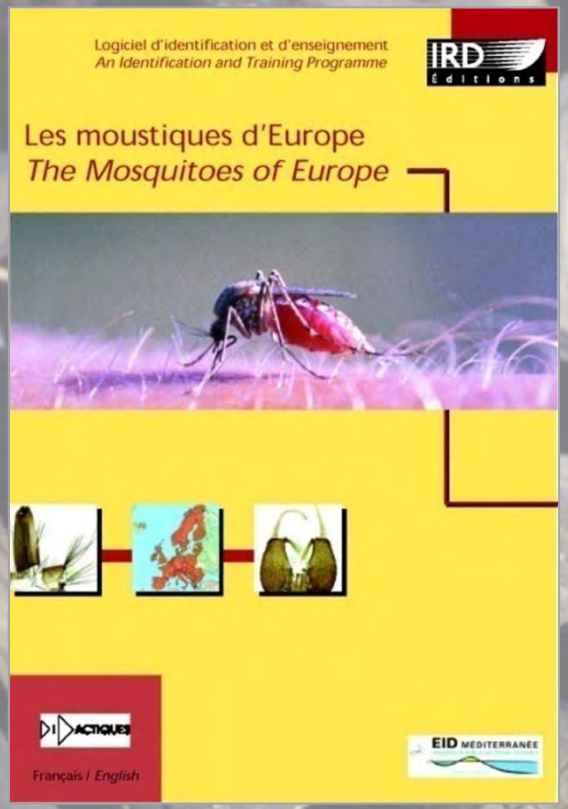


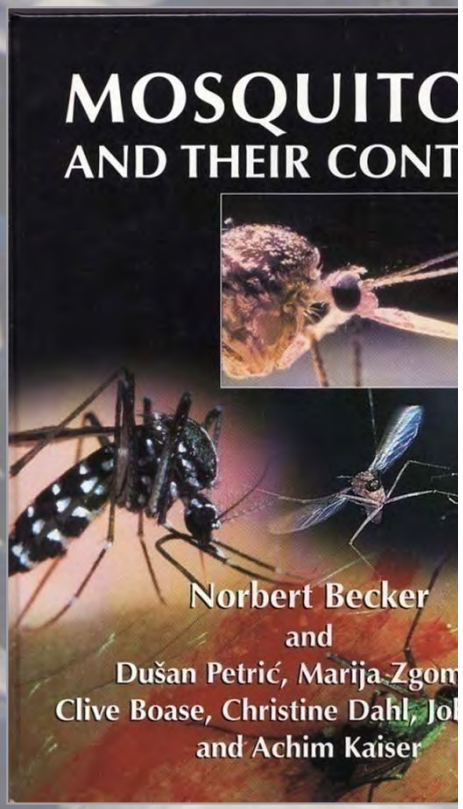




Source: Matsuo et al., 1972; EncinasGrandes-1982

Bibliography





Published in European Mosquito Bulletin, 2003, (16): 7-12. *With some corrections.*

Mosquitoes in used tyres in Europe: species list and larval key

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Biological invasion

Definitions

- Exotic/non-indigenous: shuttled from it natural geographic range to a recipient biotope where it never was before
- Invasive: a non-indigenous species that proliferates in a recipient ecosystem

Risks

- Threat to biodiversity
  - Homogenization of biota with cosmopolitan spp.
  - Restoration of native diversity impossible
- Threat to human and/or animal health
  - Biting nuisance / mosquito-borne diseases transmission

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Invasive *Aedes* container-breeding mosquitoes

- ✓ Container-breeding species
- ✓ Eggs: resistant to desiccation
- ✓ No restrictive host preferences
- ✓ Dissemination by human activities
- ✓ Adapted to temperate climate (+ winter diapause)

(1) Introduction – (2) Establishment – (3) Spread

- Introduced exotic species
- Invasive species
- Intercepted exotic species