Overwintering Mosquitoes

Michael T Riles

Regional Sales Manager

Vector Biologist

48th Annual Meeting Georgia Mosquito Control Association
University of Georgia
Athens, Georgia

Date: October 15, 2025

CENTRAL
LIFE SCIENCES

Overwintering Agenda

Biology of Mosquitoes-

- **Life Cycle**
  - **Egg**
  - **Larva**
  - **Adult Female**

Habitats

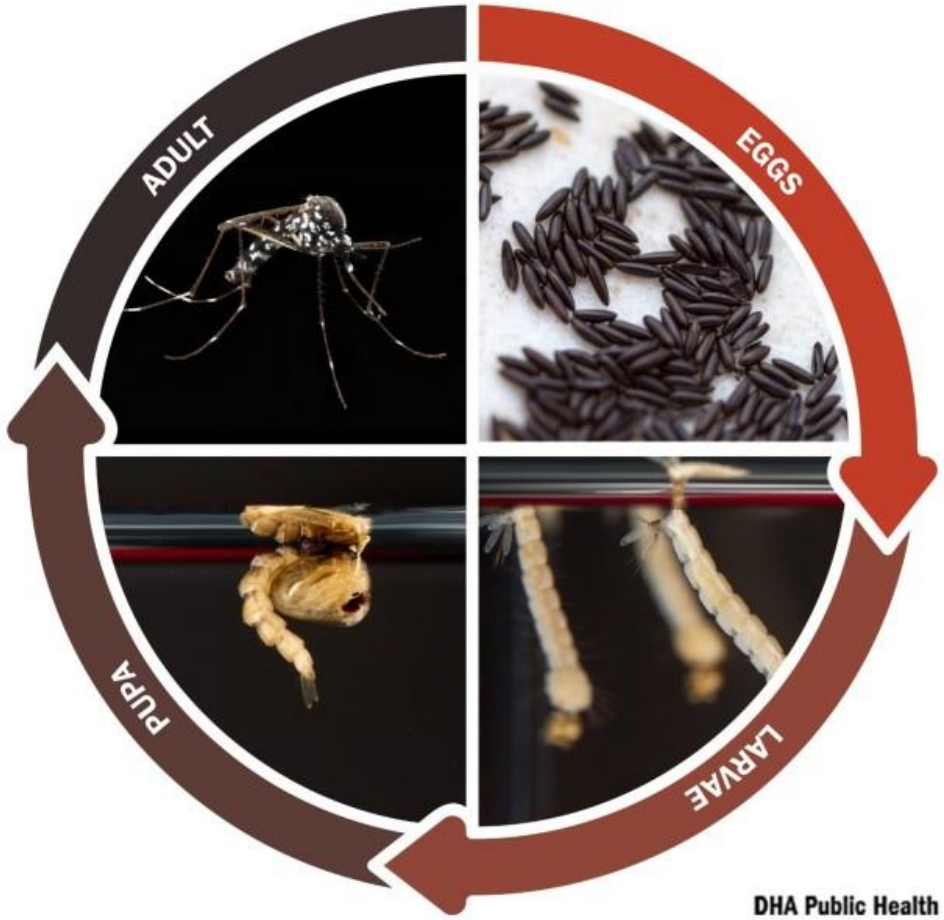
Dormancy

Quiescence

Diapause

CENTRAL LIFE SCIENCES

Mosquito Biology-Life Cycle



Mosquitoes are holometabolous

- Complete metamorphosis

4 distinct life stages

- Egg, larva, pupa, adult

Egg: Oviposits single eggs or grouped into floating egg rafts

- Multiple habitat types
- Species specific

Larva: 1,2,3,4 instar stages

Pupa: Resting stage; undergoes significant transformation

Adult: M/F, Emerges, Flies, Feeds and Reproduces

Mosquito Biology-Egg

Some mosquitoes can overwinter as egg

- Multiple habitats
- Genus & Species Specific
- Oviposition habitats can range:
  - Mud
  - Sandy soil
  - Saline environments
  - Muck
  - Containers (Natural & Man-Made)

Eggs can remain dormant for several years

Mainly *Aedes* & *Psorophora* overwinter in this life stage

Photo Credit: Jake Bova, Emory and Henry College, Virginia

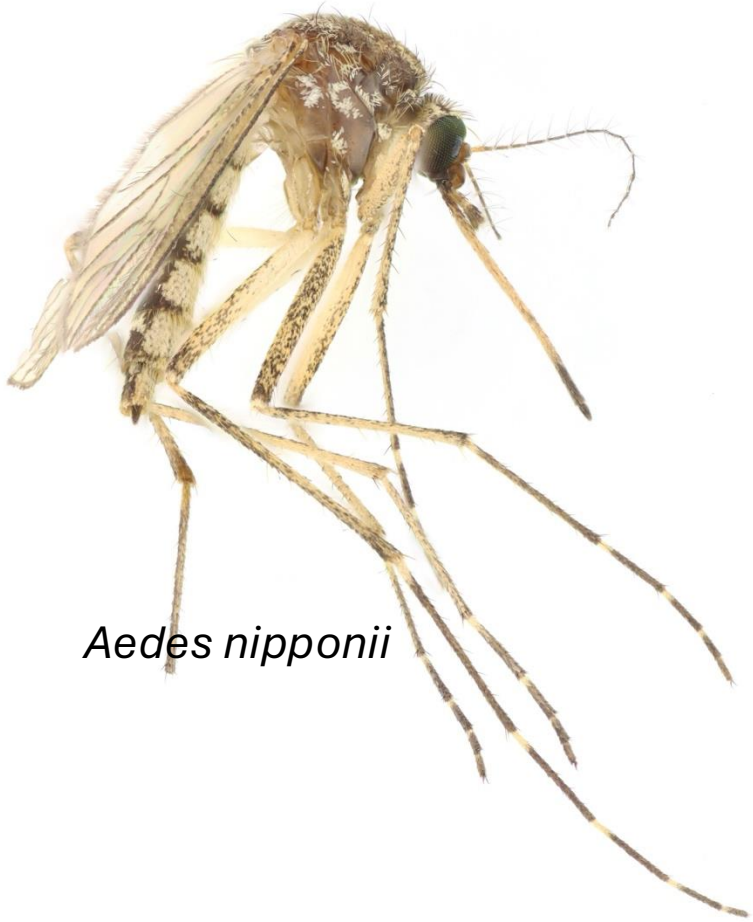
Mosquito Biology-Larva

Some mosquitoes can overwinter as 4th instar larvae

- Most species DO NOT overwinter as larvae
- Overwintering as larvae is species specific
- Diapause can occur in some species
  - Hormonal regulated
  - Ecdysone

Photo credit: M. T. Riles

Mosquito Biology-Adults



Aedes nipponii

Photo Credit: Woo Jun Bang University of S. Korea

Mosquitoes can have differences in seasonal generations

- Univoltine: Only one brood
- Multivoltine: multiple broods

Mosquitoes are cold-blooded

- Cannot regulate body temperature
- Lower temperatures most species become lethargic
- In some instances, stop activity all together

Ovipostion can occur near freezing temperatures

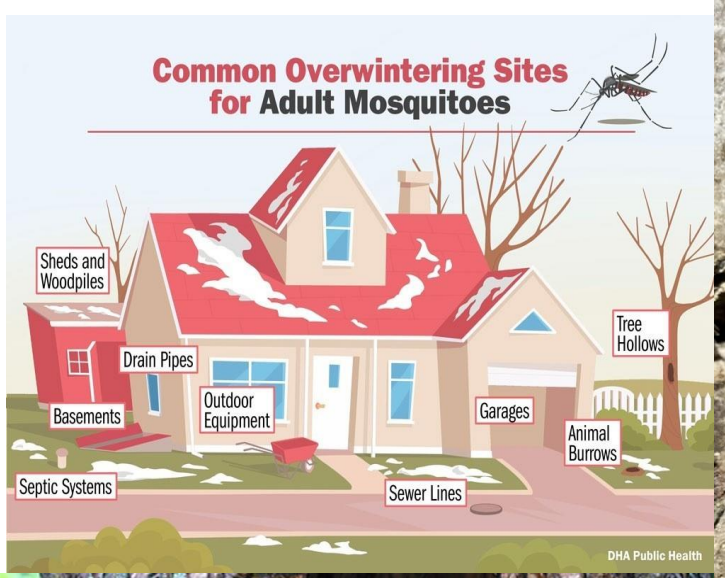
- Focus for overwintering
- Diapause

Resting areas targeted for some species

- Warm, sheltered areas

Overwintering occurs as the adult with *Culiseta, Culex* & *Anopheles*

Place Mosquitoes can Overwinter



Dormancy

Dormancy is a state of reduced metabolic activity

Considered a survival strategy

Temporarily cease growth and development, either in response to adverse conditions or as part of a normal biological cycle

Allows to conserve energy & resources until favorable conditions return

Dormancy

Highly Complex!!

- Hormonal & Physiological processes
- Are species-specific
- Can occur in all life stages except for the pupa

Types of Dormancy:

Maternal pre-diapause stage

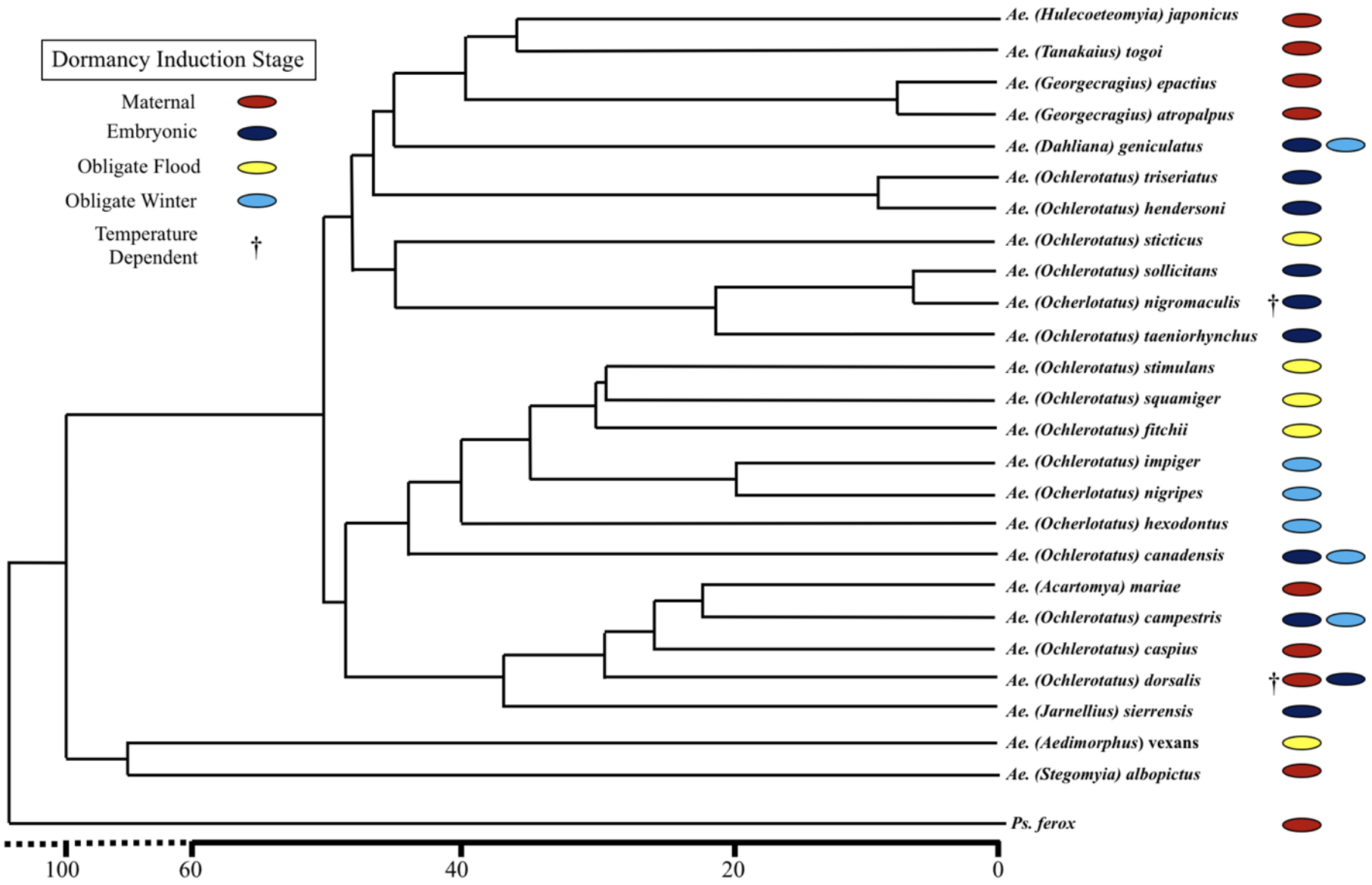
Embryonic pre-diapause stage

Obligate flood stage

Obligate winter stage

Temperature dependent

Dormancy



Maternal pre-diapause stage:
The Fn maternal female is sensitive to environmental cues needed to induce diapause (Figure 1), while the Fn+1 embryos enter diapause.

Embryonic pre-diapause stage:
The embryo is sensitive to environmental cues needed to induce diapause and is the overwintering diapause stage

Obligate flood:
These mosquitoes lay eggs that enter into an obligate aestivation to avoid dry seasons

Obligate winter:
These mosquitoes lay eggs that enter into an obligate diapause to avoid harsh low temperatures and are located more poleward

Temperature dependent:
Induction of diapause is dependent more upon sensing low temperatures and not photoperiods

Bova, 2018

Dormancy

Diniz et al. Parasites & Vectors (2017)

Mosquitoes can experience two major stages during periods of dormancy

<u>Contributes to the possible</u>:
- Establishment
- Maintenance
- Natural spread of species

<u>Synonymous in literature</u>
- But very distinct signaling pathways
- Similar results

Diapause: A biologically controlled process based on environmental cues

Quiescence: An immediate response to environmental factors

These stages of dormancy can be confusing
- Phenotypic effects
- Similar mechanisms

Quiescence

A type of irregular dormancy

- Non-seasonal
- Slowed metabolism
- Less complex than diapause

Direct result from unfavorable environmental conditions:

- Temperature and low humidity

Differs from diapause:

- Not a previously programmed event
- Not hormonally controlled
- Stimulus that induces process ends
- Mosquito activity is restored

Diniz et al. Parasites & Vectors (2017)

Quiescence

Primarily observed in the egg stage
- Desiccation resistance
- Surviving dry conditions

Unfavorable environmental conditions
Impede larval hatching

Processes begin from rapid drops in:
- Humidity
- Temperature

Can be immediately reversable with change
- Considered temporary
- Contact with water will induce hatching

Species that exhibit embryonic quiescence:
- *Aedes aegytpi*
- *Aedes albopictus*

Diniz et al. Parasites & Vectors (2017)

Quiescence

Egg desiccation resistance (EDR)

Depends on several factors to physiological changes:

- Eggshell composition
- Eggshell structure

The biology of the process of EDR is complex

- 3 layers of the egg shell
  - Exo-&endo-chorion
- The serosal cuticle likely secretes an impermeable layer of chitin
- Protecting the embryo from desiccation

Associated w/ water loss regulation in habitats

- Fundamental to determine egg dehydration

Diniz et al. Parasites & Vectors (2017)

Diapause

Diapause: A biologically controlled process based on environmental cues

Influenced by many factors:

- Species specific ecological interactions
- Biogeography
- Life history
- Physiology

A dynamic state of low metabolic activity

Diniz et al. Parasites & Vectors (2017)

Diapause

Genetically determined

Mediated by neurohormones

- Affecting:
  - Decreasing morphogenesis
  - Blocking reproduction
  - Blocking metamorphosis
  - Increasing tolerance to extreme conditions

This process seeks to reactivate development

- via external signals
- controlling genetic factors
- underlying the dormant phenotype

Most only one life stage enters diapause

- Some exceptions occur

Diniz et al. Parasites & Vectors (2017)

Diapause

Environmental cues that induce changing:

- Photoperiod (short days/long nights)
- Gradual decreases in temperature

Species that use photoperiod to signal diapause:

Aedes albopictus
Aedes atropalpus
Aedes taenioryhnchus
Aedes sollicitans
Culex pipiens
Culex restuans

Determining life stages are thought to be:

- Adult females
- Pupae

Diniz et al. Parasites & Vectors (2017)

Diapause

Diniz et al. Parasites & Vectors (2017)

Pupae and adult females

Stimulated by exposure to seasonal changes

- Favorable season
- Unfavorable season

Examples by species:

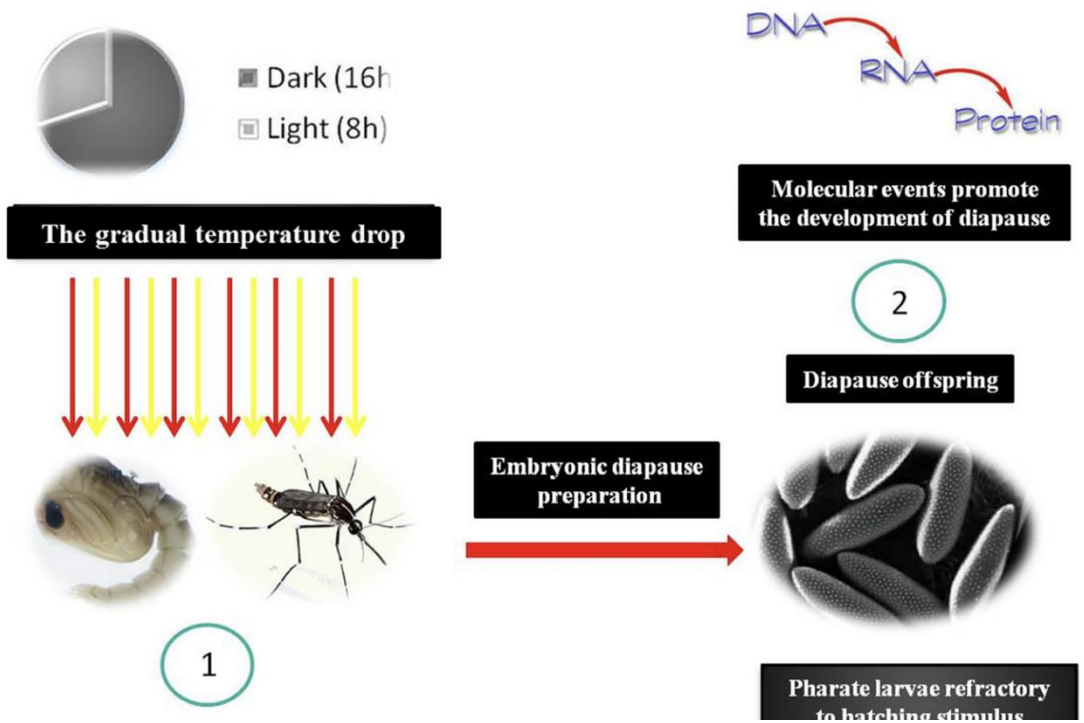
- ***Aedes albopictus***-induced females develop their offspring for diapause
- This presents low metabolism in each life-cycle stage during winter months

- ***Culex pipiens*-** induced pupae express diapause when they become adults; larvae tend to have longer time spans between molts

This ecological adaptation coordinates:

- Growth
- Development
- Reproduction

Diapause



Diniz et al. Parasites & Vectors (2017)

3 phases: eco-physiological stages

Pre-diapause: Preparation

- The sensitive stage
- Exposed to environmental stimuli: Photoperiod
- Triggering diapause seasonally

Responsive: Development Interruption

- The ebb and flow of metabolism
- Based on genetic diapause programming
- Environmental stimulus plays significant role

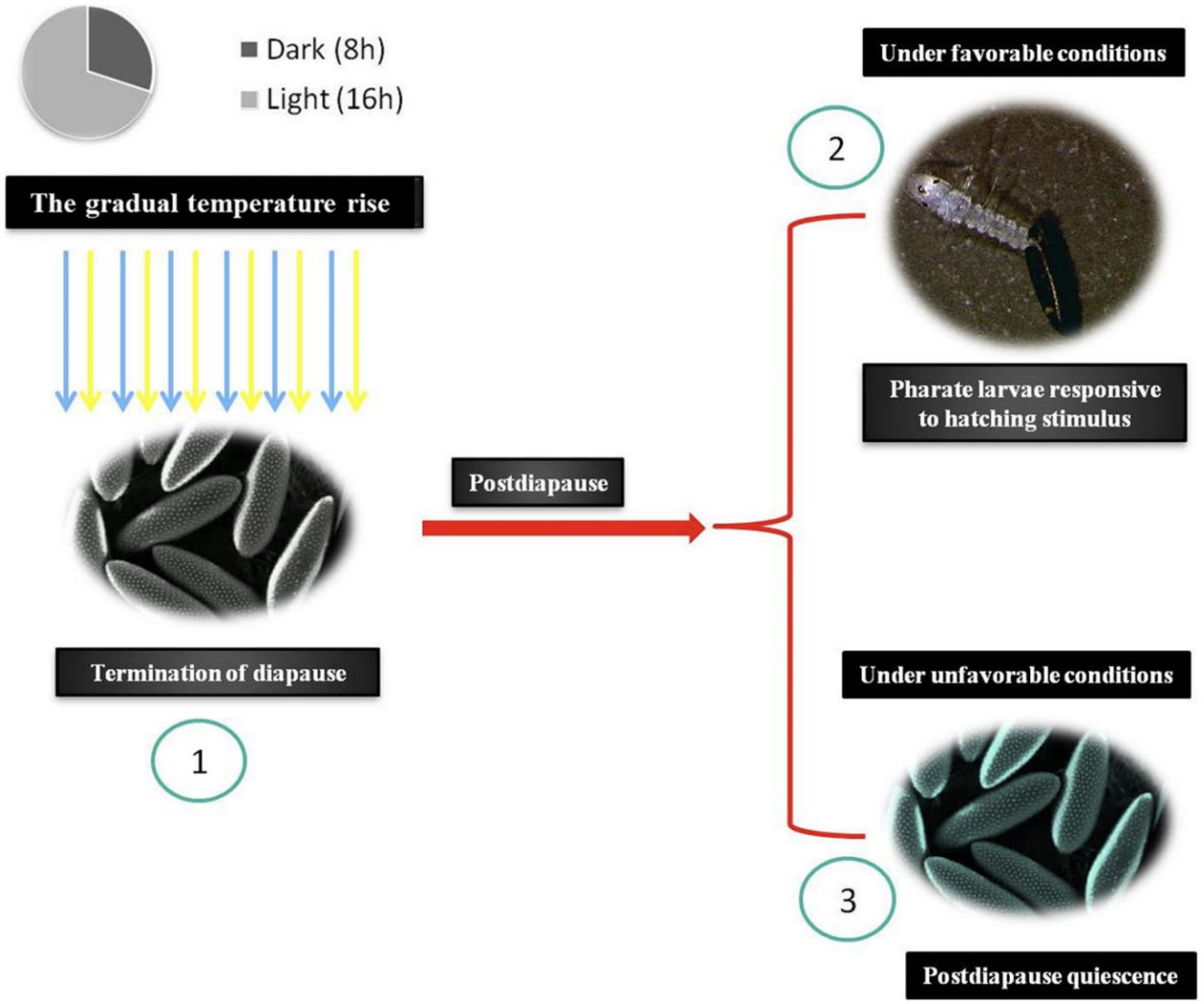
Post-diapause-Complete reactivation

- Photoperiod is less used in this phase
- With species specific exceptions

Example: ***Wyeomyia smithii***

- Photoperiod can cause diapause to end

Diapause



Diniz et al. Parasites & Vectors (2017)

Diapause throughout the life-cycle

- Pharate larvae: larva inside the egg
- Larval
- Adult

This usually occurs by species-specific parts of the life-cycle

Although in some instances some species can perform two stages:

- Between embryonic and larval stages

Most common is the embryonic diapause

Genus reported: *Psorphora, Aedes, Anopheles, and Ochlerotatus*

Larval Diapause

- Prolonged 3rd & 4th instar
- Slower metabolism saving resources
- Ecdysone not released
- Molting is slowed considerably

Diapause

Koenraadt et al. Parasites & Vectors (2019)

Diapause in adult females

Involves a set of characteristics:

- Interruption of the gonadal development
- Reduced biting behavior
- Negative phototaxis
- Metabolism changes with accumulation of body fat

Resting areas are sought out:

Caves, soil cavities, burrows, catacombs, basements, tree hollows, and other structures that are dry and warm

Reproductive diapause begins

- Delays the need for blood feeding & Host seeking

Example: *Culex pipiens*

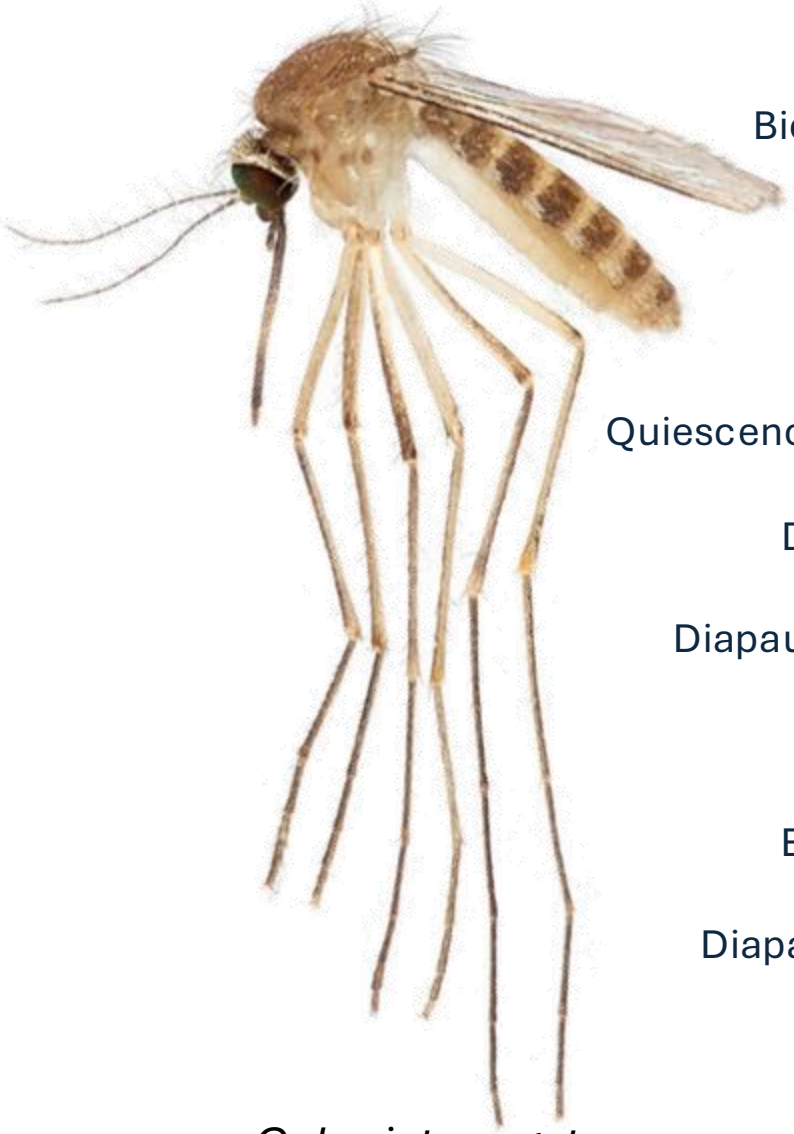
Genus: *Anopheles* & *Culex*

Males do not overwinter-

- They sexually inseminate females then die

Diniz et al. Parasites & Vectors (2017)

Reflection



Culex interrogator

Overwintering is a survivorship mechanism

Biology of the mosquito is the baseline-Life Cycle!

Dormancy can be considered complex

Quiescence is not hormonally controlled

Quiescence can be reactivated quickly and related to photoperiod

Diapause more complicated form of dormancy

Diapause is genetically driven, genus, and species specific

Diapause is geographical + physiological

Embryonic diapause is the most common form

Diapause in adult females mainly *Culex* and *Anopheles*

Aedes scapularis

Photo credit: L. Reeves, University of Florida

References

Bova, J., Paulson, S. and Paulson, G., 2016. Morphological differentiation of the eggs of North American container-inhabiting *Aedes* mosquitoes. *Journal of the American Mosquito Control Association*, *32*(3), pp.244-246.

Bova, J.E., 2018. Overwintering Mechanisms of La Crosse Virus Vectors.

Diniz, D.F.A., de Albuquerque, C.M.R., Oliva, L.O., de Melo-Santos, M.A.V. and Ayres, C.F.J., 2017. Diapause and quiescence: dormancy mechanisms that contribute to the geographical expansion of mosquitoes and their evolutionary success. *Parasites & vectors*, *10*, pp.1-13.

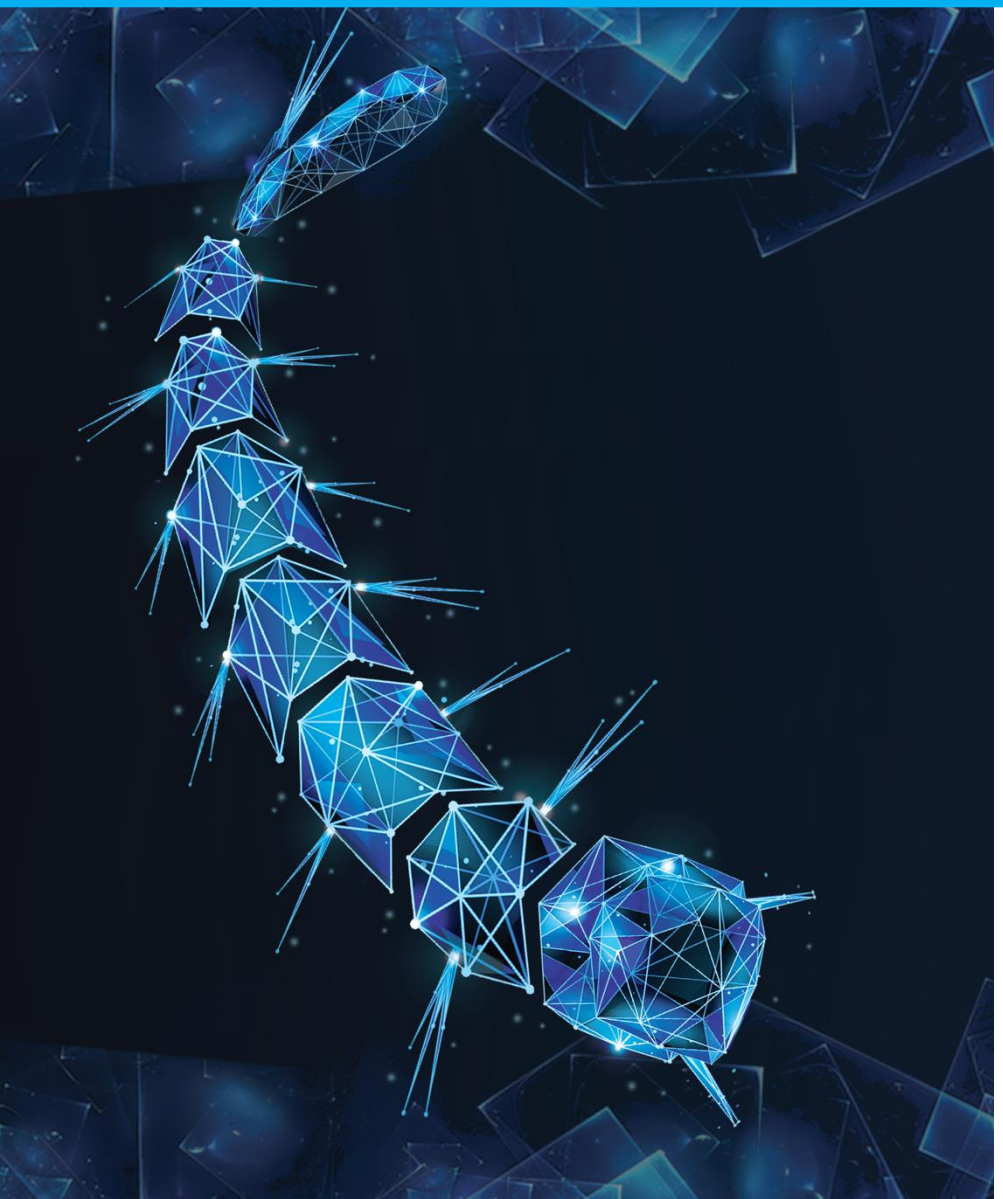
https://www.army.mil/article/283270/where_do_mosquitoes_go_during_the_winter

https://onehealthentomologygroup.nl/2021/08/05/scientists-in-the-field-overwintering-ecology-of-mosquitoes/

Koenraadt, C.J., Möhlmann, T.W., Verhulst, N.O., Spitzen, J. and Vogels, C.B., 2019. Effect of overwintering on survival and vector competence of the West Nile virus vector *Culex pipiens*. *Parasites & vectors*, *12*, pp.1-9.

Vinogradova, E.B., 2007. Diapause in aquatic insects, with emphasis on mosquitoes. In *Diapause in aquatic invertebrates theory and human use* (pp. 83-113). Dordrecht: Springer Netherlands.

THANK YOU!



Michael T. Riles
850.628.0091
mriles@central.com