Incorporating Female Reproductive Development Into Voltinism Studies

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How can we best predict the number of generations?

- DD requirements for development (538, base 14^{o}C)
- DD requirements of reproductive maturation? (148 DD)

- Complicated phenology:
  - Long lifespan
  - Overlapping generations
  - Diapausing adult stage
  - Need an appropriate biofix

Describing Seasonality

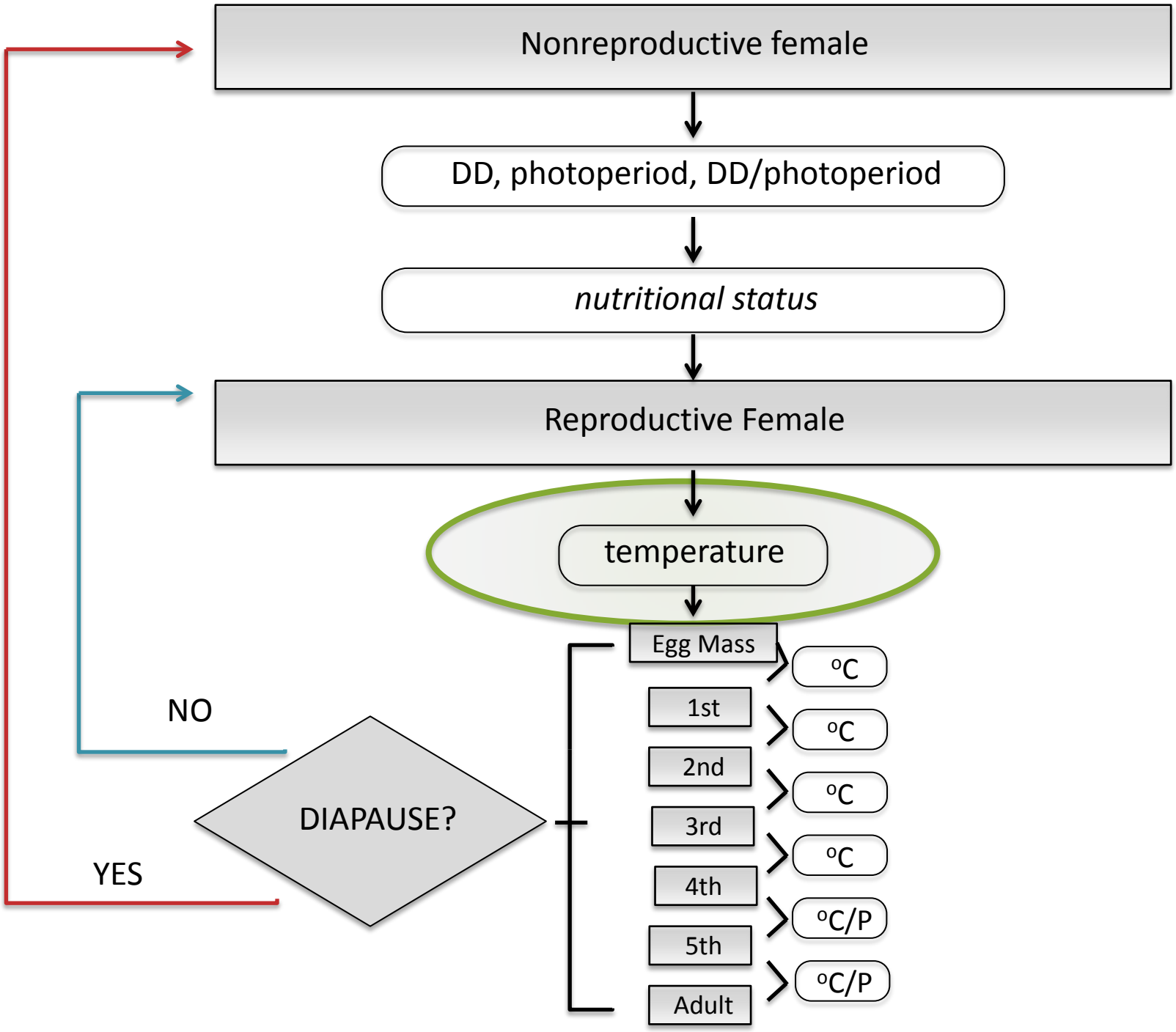
- Seasonality through direct sampling methods
  - Visual or beat samples
  - Blacklight traps
  - Pheromone traps

- Investigate female reproduction
  - Reproductive ranking system
  - Field collected individuals

Project Number of Generations

- *Halyomorpha hal*ys voltinism is both temperature and photoperiod dependant
- Chen et al. 2011 utilized Mont Carlo approximations for grape berry moth
  - Voltinism is influenced by degree day accumulations prior to photoperiod conditions for diapause induction
- Assumes that development and diapause are functions of temperature and photoperiod
- Individual based
  - Diapause termination
  - Degree day development
  - Diapause induction

S. Chen, P. C. Tobin, M. C. Saunders, and S. J. Fleischer. 2011. Projecting insect voltinism under high and low greenhouse gas emission conditions. Environ. Entomol. 40: 505-515


Nonreproductive female
DD, photoperiod, DD/photoperiod
nutritional status
Reproductive Female
temperature
Egg Mass
1st
2nd
3rd
4th
5th
Adult
°C
°C
°C
°C
°C/P
°C/P
DIAPAUSE?
NO
YES

Model Testing and Validation

1. Refine the DD requirements for female maturation
   - 16:8 photoperiod
   - Temperatures 20-33^{o}C

2. Field collection of females from April – October
   - Bridgeton, NJ; Allentown, PA; Kearneysville, WV; Biglerville, PA
   - Rough dissections of females from diapause and host plants
   - Assign to a ranking system

3. Cage studies

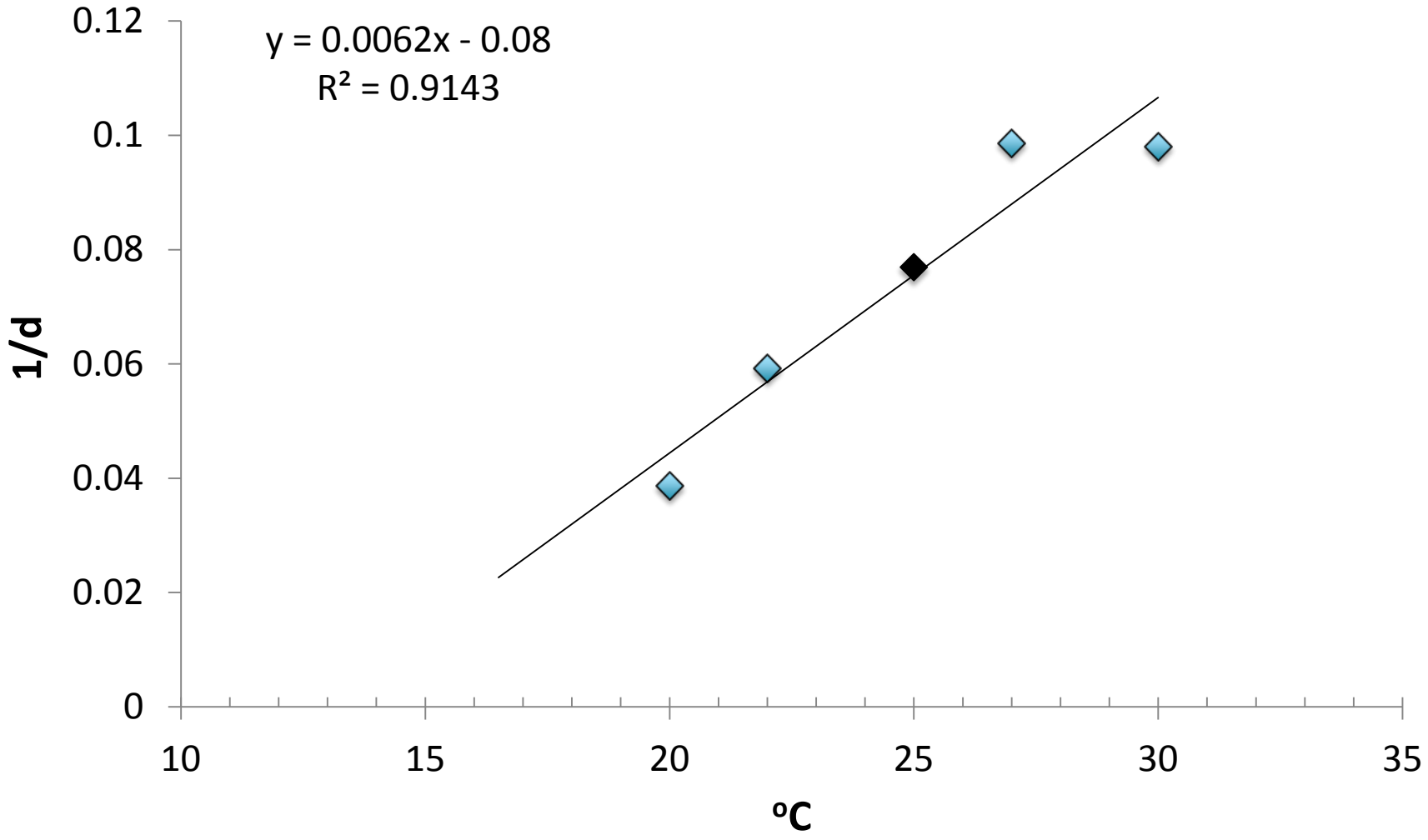
Time to Oviposition

- Original study performed at 25^{o}C suggested 13.35 day preoviposition period

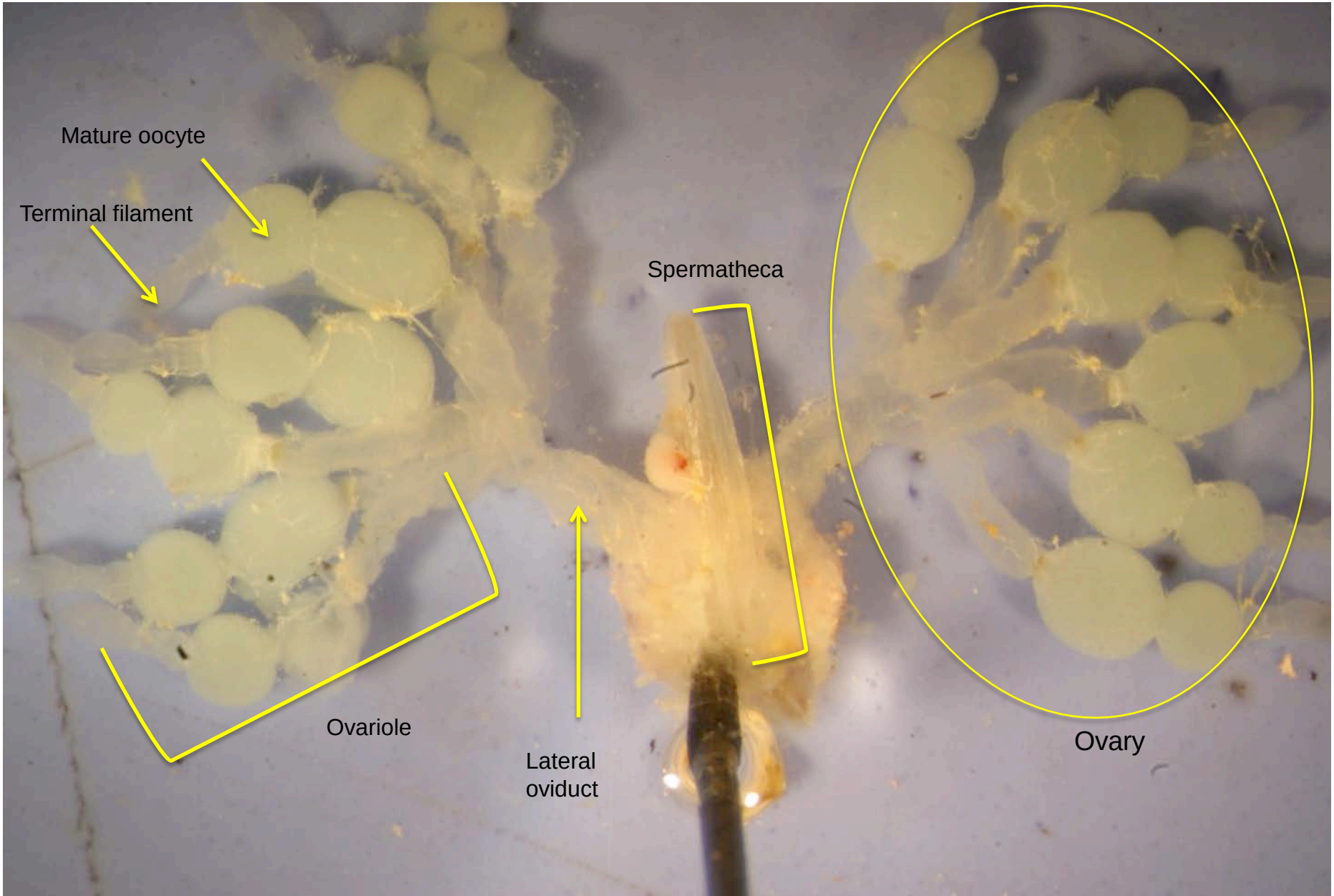
- 148 DD

- Evaluate the accuracy of this by studying time to oviposition at multiple temperatures

“Preliminary” Pre-Oviposition Data 2012



BMSB Female Reproductive System



Reproductive Ranks

1 = Previtellogenic, oocytes are undifferentiated or differentiated without oocyte development

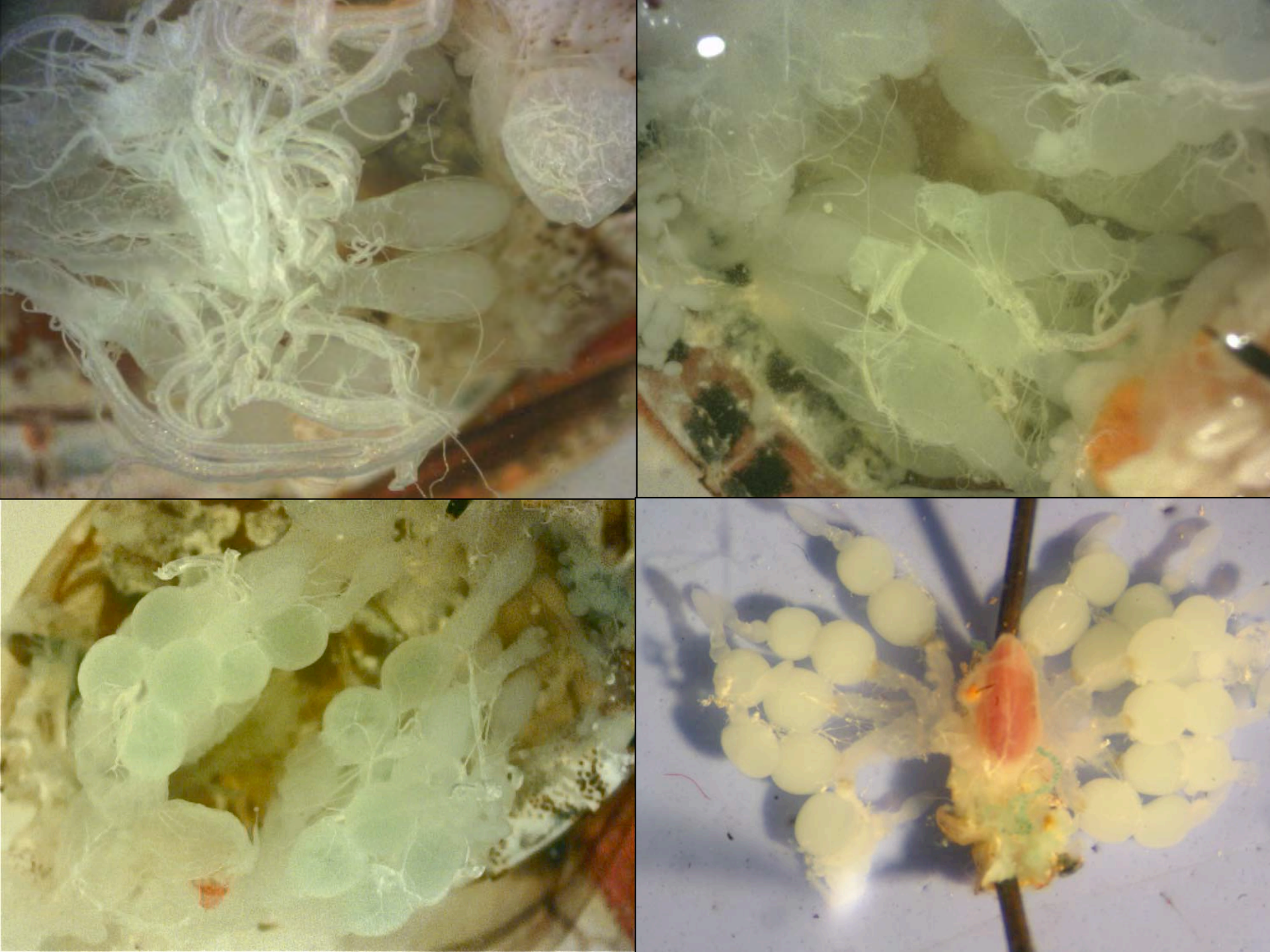
2* = Previtellogenic, one or more oocytes are developed

3 = Vitellogenic, proximal oocyte is developed

4 = Vitellogenic, oocytes are developed, at least one lateral oviduct has a descended oocyte

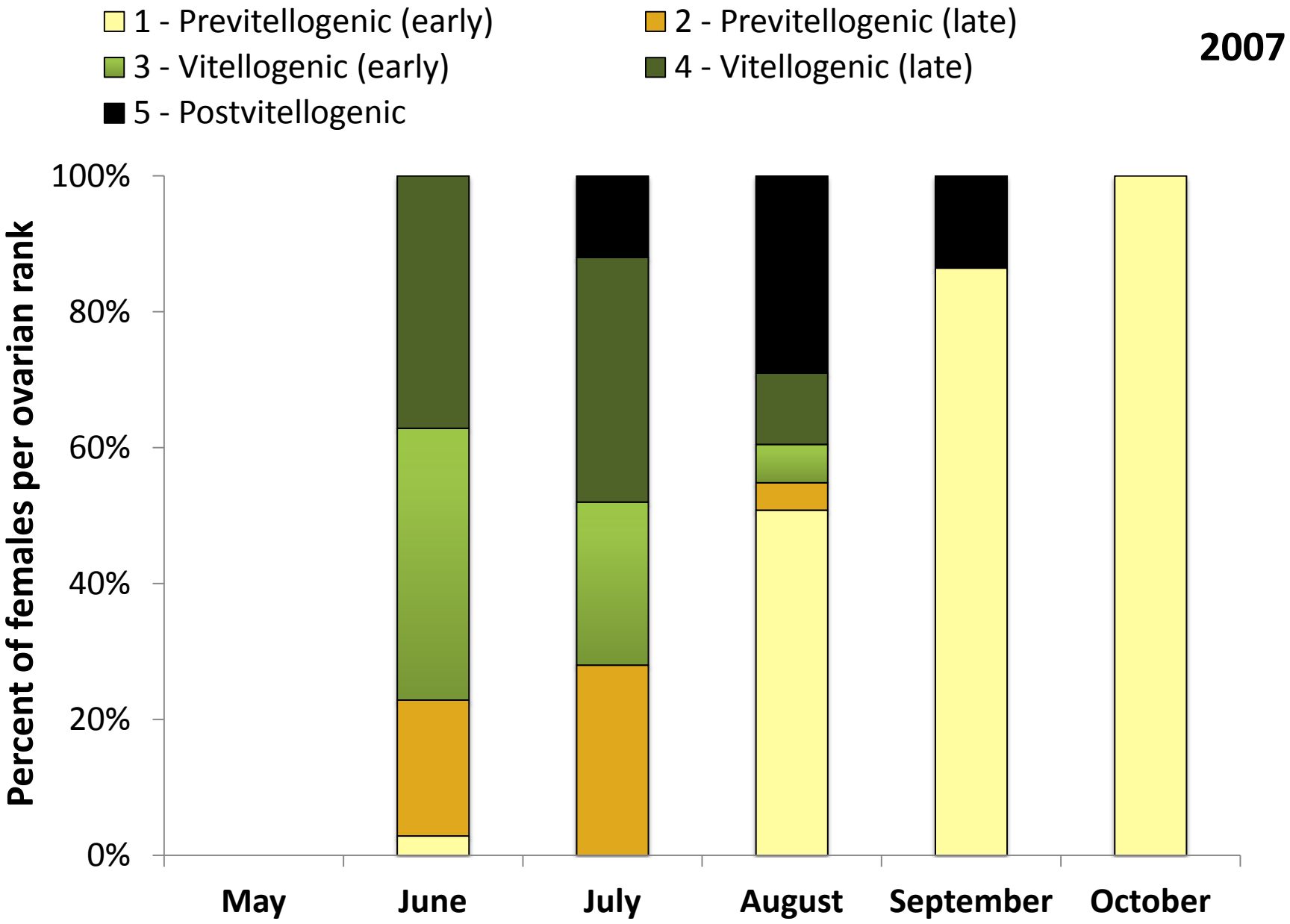
5 = Post-vitellogenic, oocytes are degrading, oocytes distended

* *a female that has oviposited previously (i.e. CL present) cannot be previtellogenic, if oocytes/follicles are (re)developing she is a 3.*

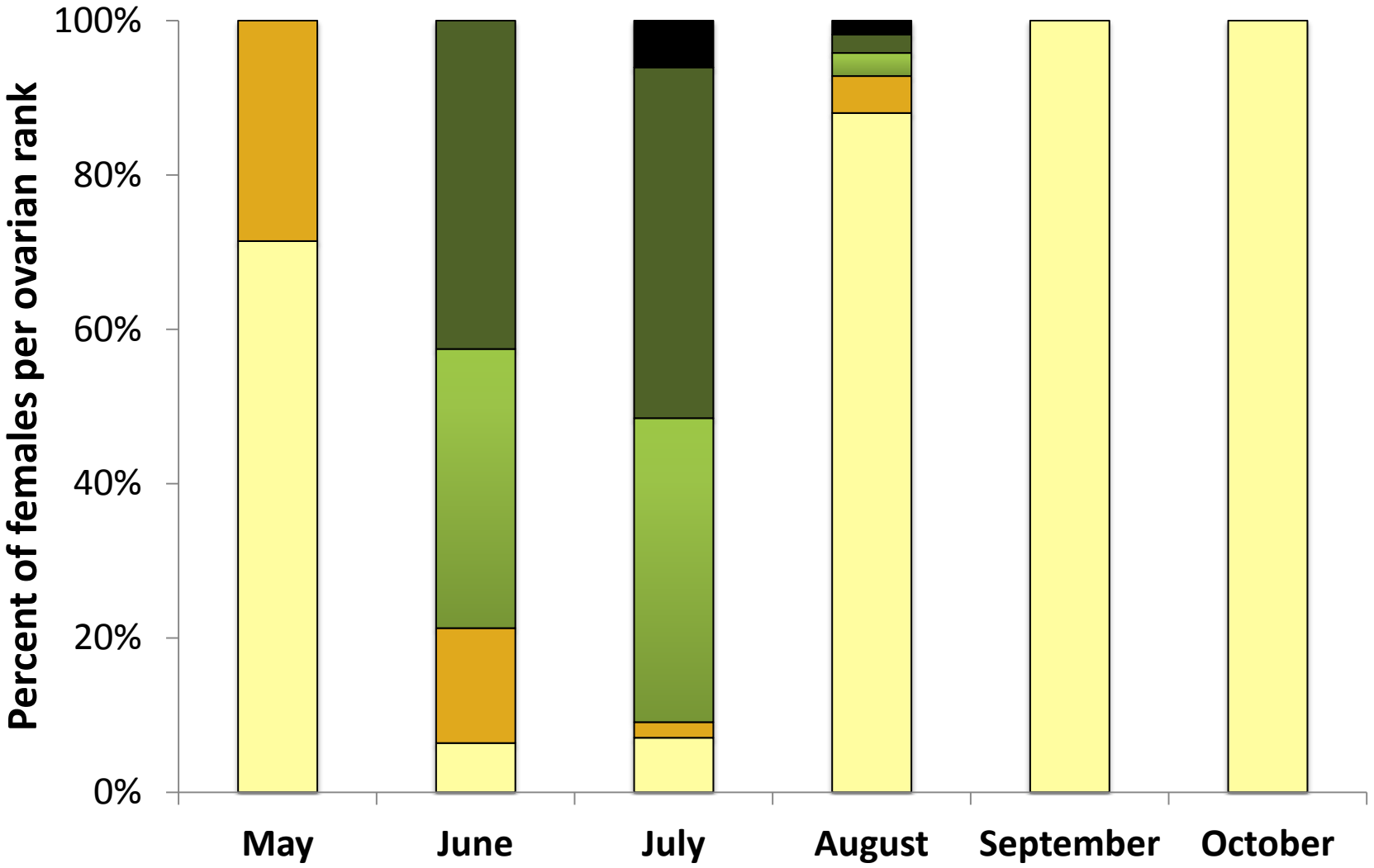


Katayama et al. 1993 ranking system

Nielsen ranking system (in red)


1 - Previtellogenic (early)
2 - Previtellogenic (late)
3 - Vitellogenic (early)
4 - Vitellogenic (late)
5 - Postvitellogenic
2007
Percent of females per ovarian rank
100%
80%
60%
40%
20%
0%
May
June
July
August
September
October

2008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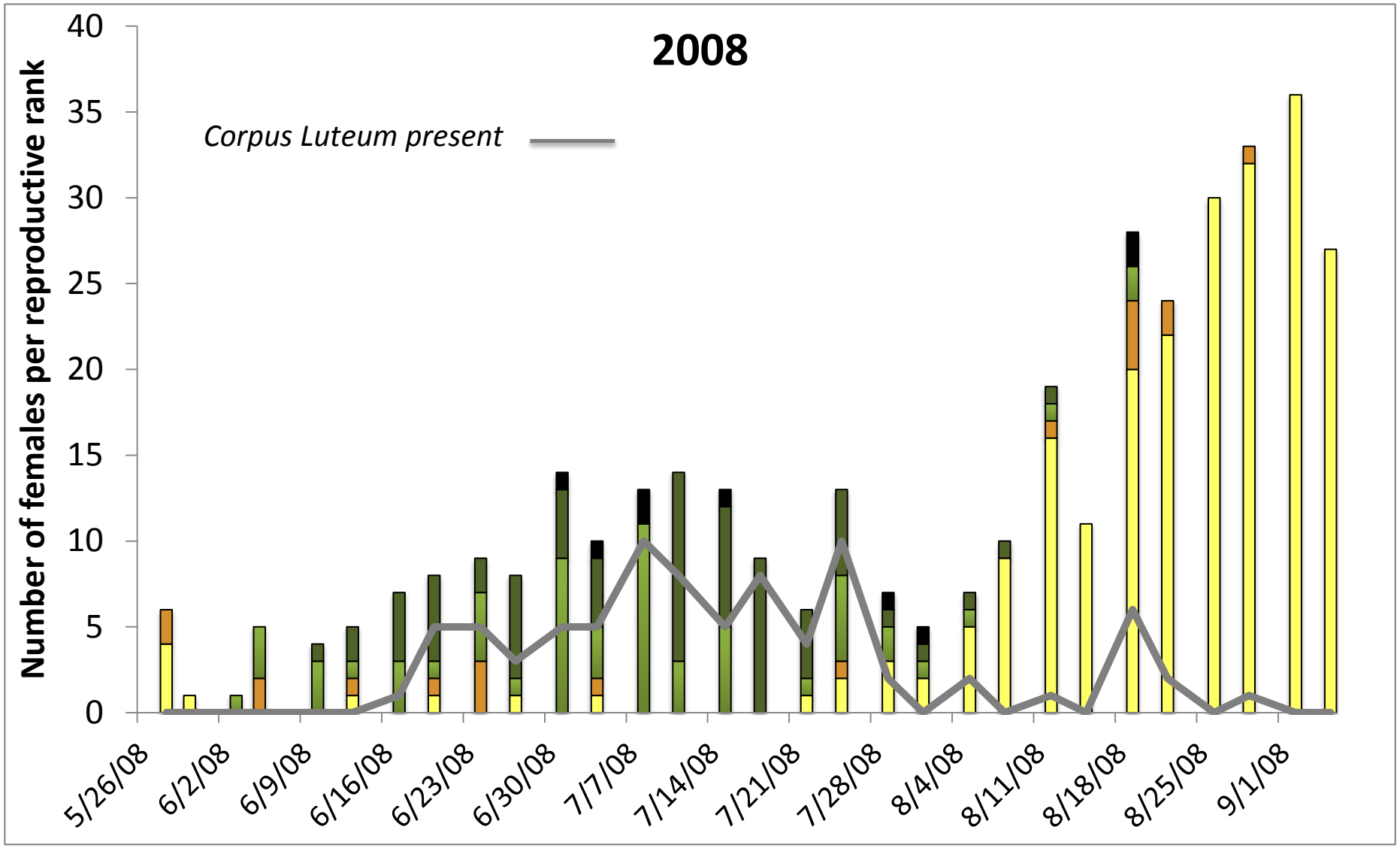
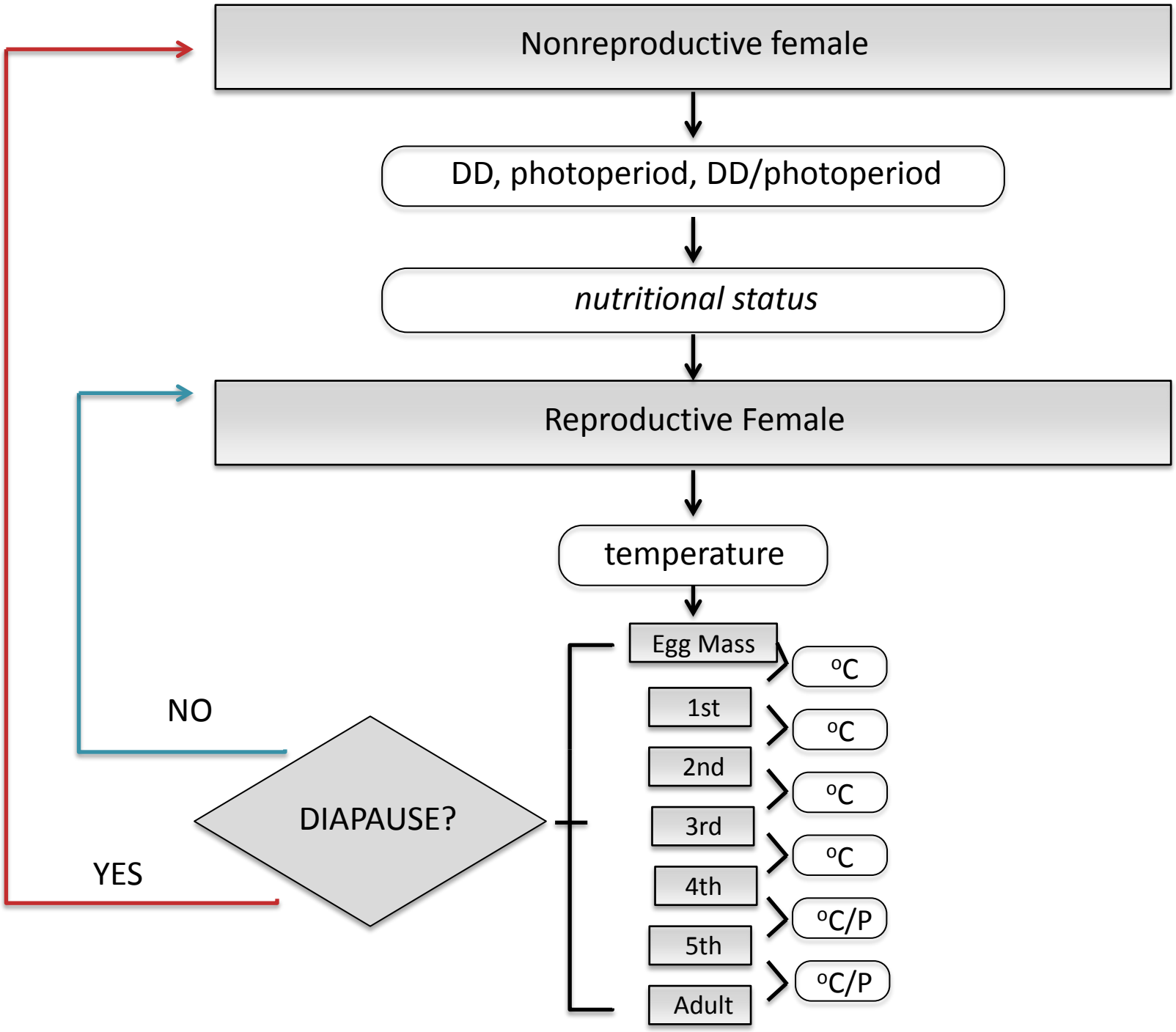

2008
Corpus Luteum present
Number of females per reproductive rank
40
35
30
25
20
15
10
5
0
5/26/08
6/2/08
6/9/08
6/16/08
6/23/08
6/30/08
7/7/08
7/14/08
7/21/08
7/28/08
8/4/08
8/11/08
8/18/08
8/25/08
9/1/08

Expected Outcomes

- Refine the pre-oviposition period
- Identify appropriate biofix
- Identify number of generations based on female reproductive physiology
- Model the number of generations to predict BMSB generations in each area and as populations spread or temperatures warm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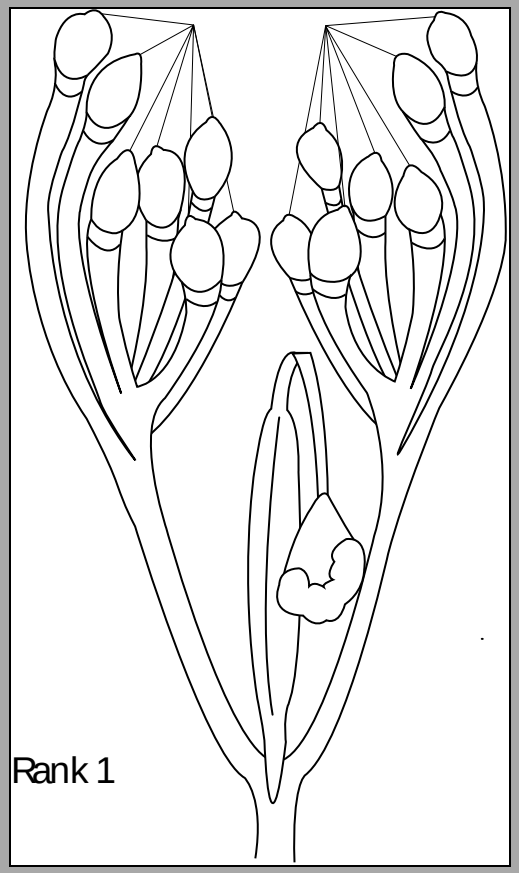
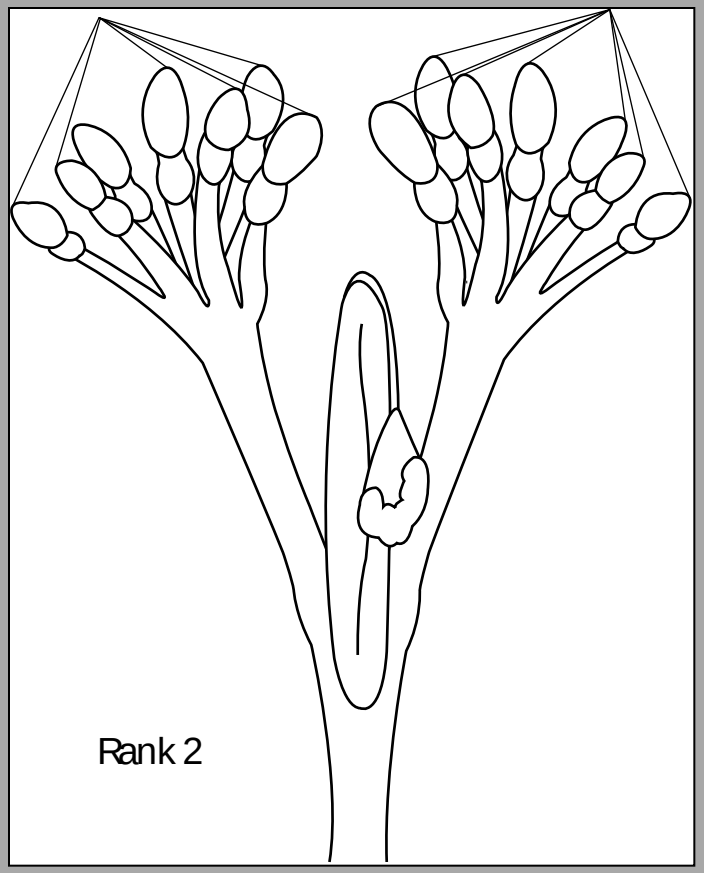
Seasonal Reproductive Development

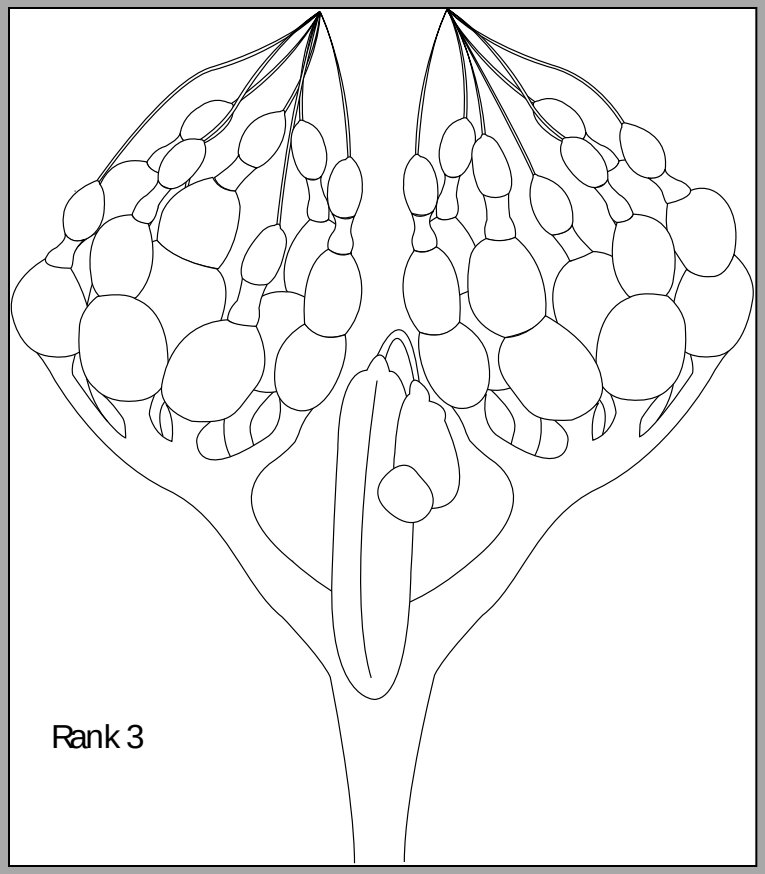


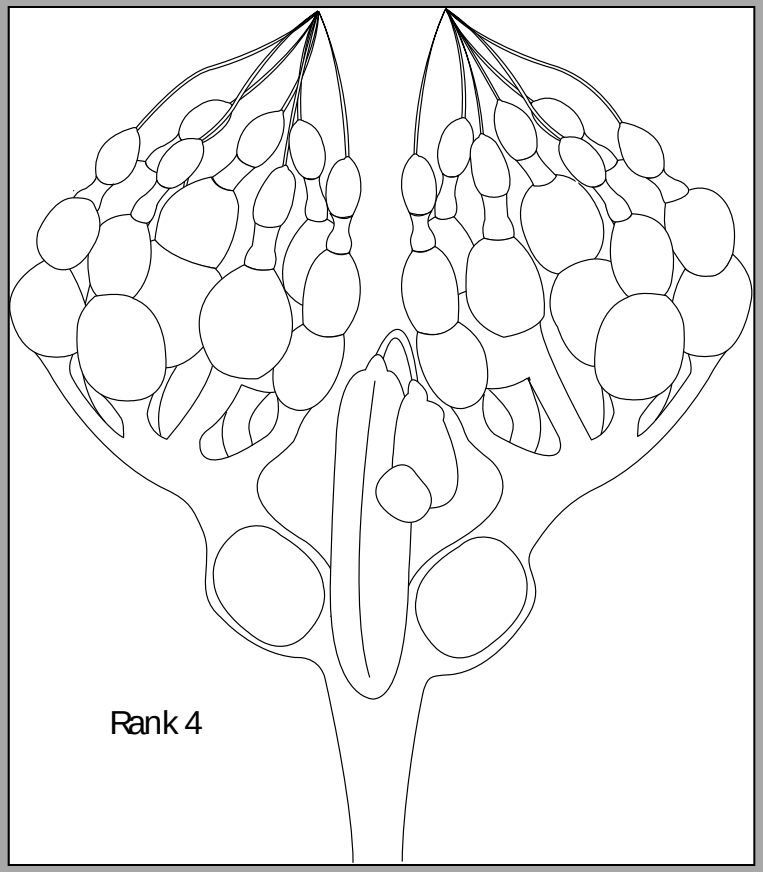


Rank 1: undeveloped oocyctes or one immature oocyte per ovariole

Rank 2: >1 Immature oocyte per ovariole

Seasonal Reproductive Development



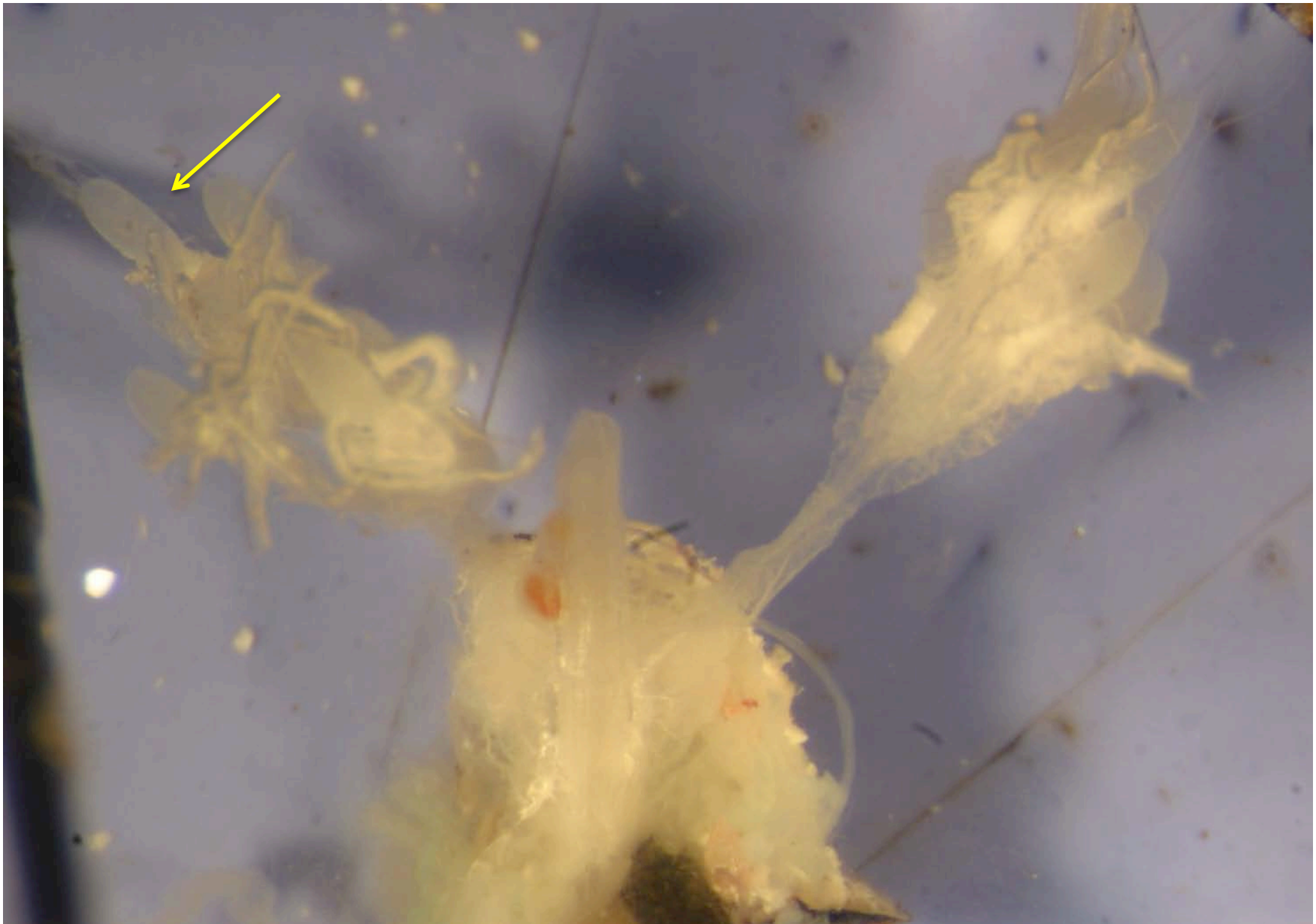


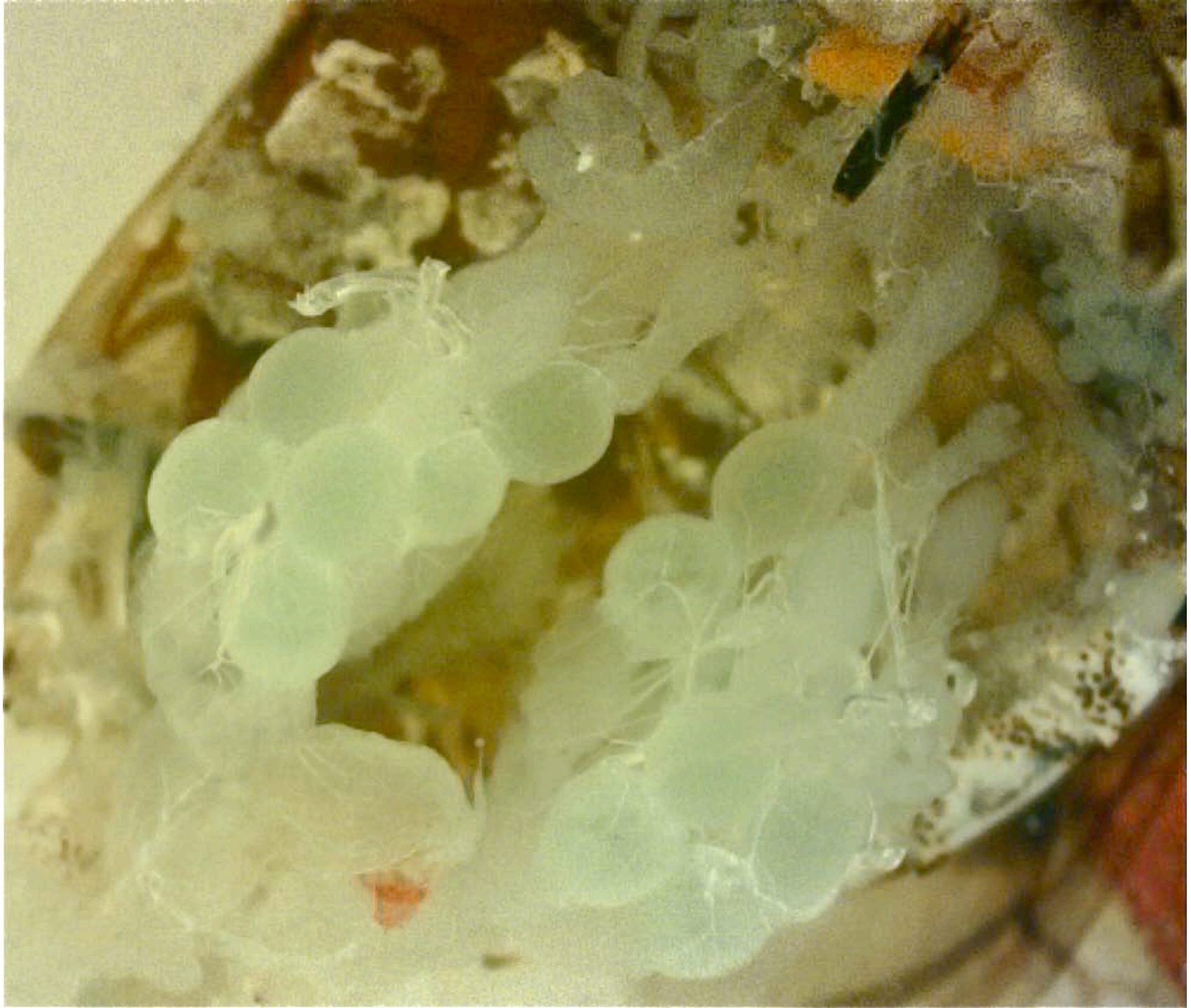
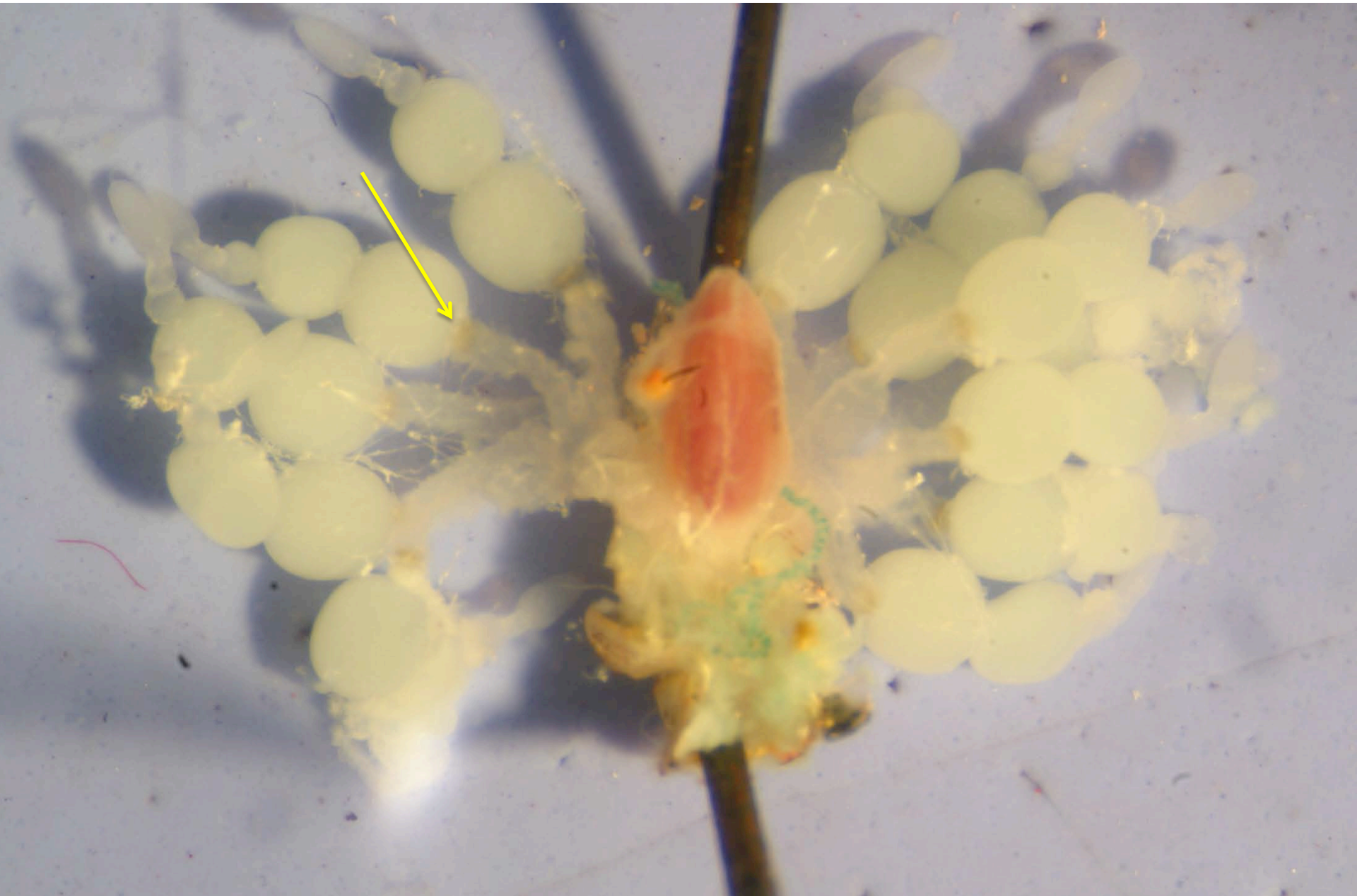
Rank 3: At least 1 mature oocyte per ovariole

Rank 4: Mature oocytes + 1 oocyte in lateral oviduct

Rank 5: Post-vitellogenic females, ovaries distended, oocytes degenerating

Stage 1 – immature oocytes, unmated, spermatheca is clear and skinny





Stage 3 – 2 mature oocytes per ovariole, mated, CL present