CHEMICAL ESPIONAGE (PROBLEM C)

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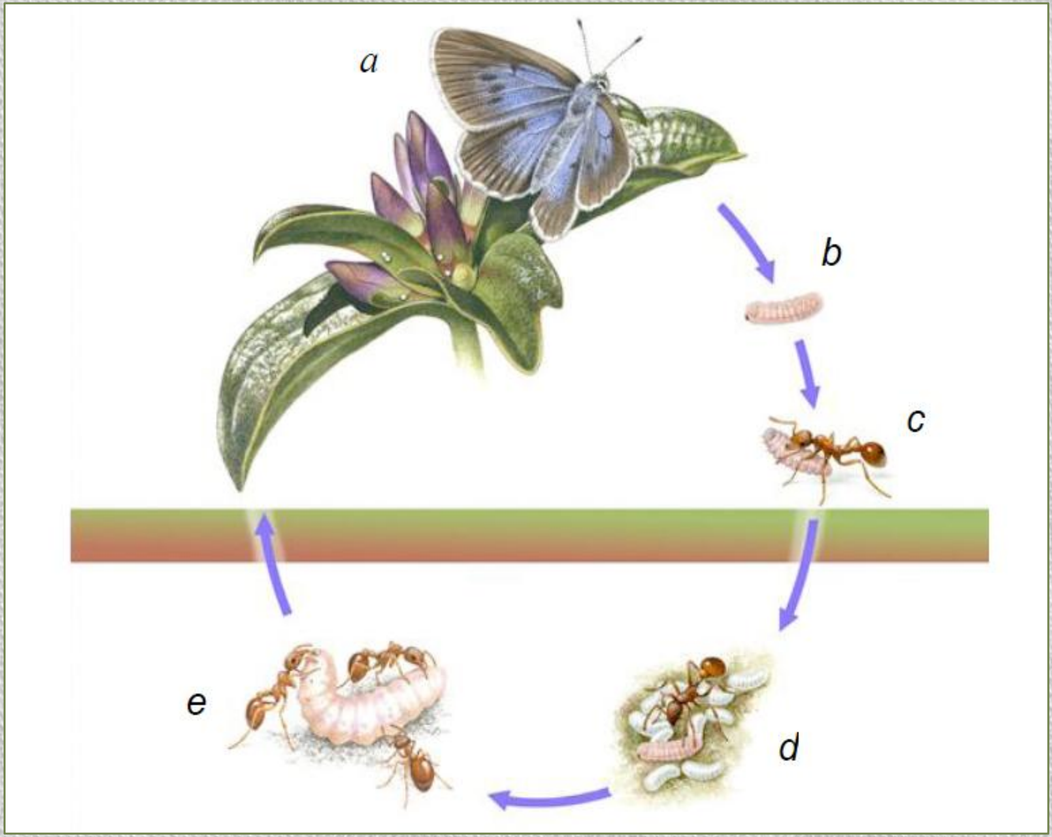
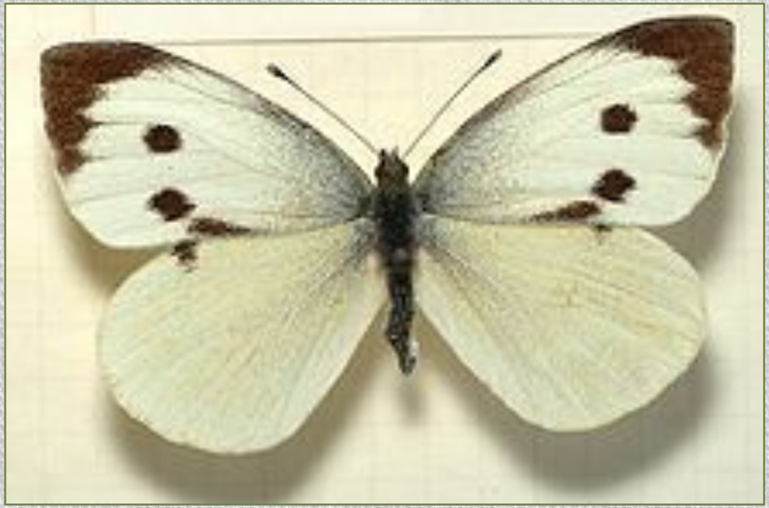
Background

- *Pieris brassicae*
- Chemical Signals
  - Aphrodisiacs
  - Anti-aphrodisiacs
- Parasitic Wasps



Assumptions

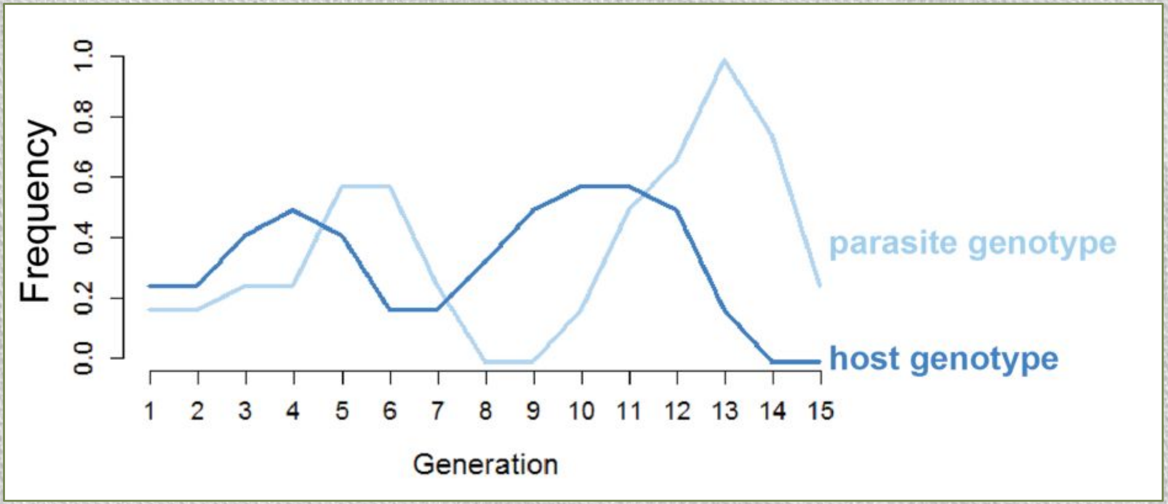


- Y-linked Inheritance
- Presence of Null Male *P. brassicae*
- 1:1 Sex Ratio
- No Variable Population Depressants
  - Weather
  - Predation
  - Starvation
- Total Mortality of Parasitized Eggs

Rationale

- Lotka-Volterra Predator-Prey Equations

- Red-Queen Hypothesis



Variables Definition	Variable	Value
Population of butterflies	P_N	P_0 = 1000
Population of non anti-aphrodisiac (NA) male butterflies	M_{NA}	M_{NA} = 475
Population of non anti-aphrodisiac NA male butterflies	M_{AA}	M_{AA} = 25
Population of wasps	w_N	w_0 = 50
Brood size	b	141
Survival to adulthood of butterfly population	P_s	0.42
Survival ratio of offspring of NA male butterflies	S_{NA}	0.65
Survival ratio of offspring of anti-aphrodisiac AA male butterflies	S_{AA}	0.95
Chance of parasitic wasp finding eggs if female mates with NA male	i_{NA}	0.01
Chance of parasitic wasp finding eggs if female mates with AA male	i_{AA}	0.025
Death rate of butterfly population	d_p	0.5
Death rate of wasp population	d_w	0.7

The System of Equations

$$(dP_N)/(dt)=[(dP_{AA})/(dt)+(dP_{NA})/(dt)]$$

$$(dP_{NA})/(dt)=S_p(S_{NA}*M_{NA(N-1)}*b[1-w*i_{NA}])- dP_{NA(N-1)}$$

$$(dP_{AA})/(dt)=S_p(S_{AA}*M_{AA(N-1)}*b[1-w*i_{AA}])- dP_{AA(N-1)}$$

$$(dM_{NA})/(dt)=(dP_{NA}/dt)*(½)$$

$$(dM_{AA})/(dt)= (dP_{AA}/dt)*(½)$$

$$(dw)/(dt)=w*b*[(i_{NA}*M_{NA(N-1)})+(i_{AA}+M_{AA(N-1)})]-d_w*w_{(N-1)}$$

Reflections & Improvements

- Population Record
- Environmental Factors: flowers, lands, weather
- Oviposition Plant Preference
- Genetic Inheritance

Additional Issues

Problem C1

(Suppose you are asked to add an animal that is a predator of both the butterflies and the wasps, a bird for example. How would you change your model to accommodate this new situation?)

Additional Assumptions

1) Bird finds most advantageous plant (cabbage)
2) Least advantageous plant is sarson
3) To maximize nutritional gain versus energy loss, birds target cabbage plants (double oviposition)
4) The likelihood that the bird encounters/searches for larvae is affected by whether the larvae is on the cabbage
5) Females that mate with AA males have more time to search for cabbage
6) AA-sired larvae are therefore disproportionately represented on cabbage

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New Terms

Variables	Variables Defined
B_{Brb}	Bird population
d_{Brb}	Death by bird
a	likelihood bird encounters larvae
h	nutrition factor
V	Bird breeding factor
e	eggs

$$(dP_{AA})/(dt)=S_p(S_{AA}*M_{AA(N-1)}*e*[1-*w_{(N-1)}*i_{AA}])*(1-d_{Brb}*B_{N-1}*a_{AA})- dP_{AA(N-1)}$$

$$(dP_{NA})/(dt)=S_p(S_{NA}*M_{NA(N-1)}*e*[1-*w_{(N-1)}*i_{NA}])*(1-d_{Brb}*B_{N-1}*a_{NA})- dP_{NA(N-1)}$$

$$(dw)/(dt)=w_{(N-1)}*e*[(1-d_{Brb,w}*B_{N-1}*a_{NA})]+[(M_{AA}*i_{AA})(1-d_{Brb,w}*B_{N-1}*a_{AA})]-d_w*w_{(N-1)}$$

$$(dBrb)/(dt) = v * B_{N-1}* [(h_p*d_b*e*(a_{AA}*M_{AA(N-1)}+ a_{NA}*M_{NA(N-1)})) + (h_w*w_{n-1}*(a_{AA}*i_{AA}+ a_{NA}*i_{NA}))] – (d_{Brb}*B_{N-1})$$

References

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