

Interactions between parasites and hosts

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Interactions between exploiters and victims can result in various forms of adaptations and counter-adaptations

Exploiters try to make use of their victims while the victims try to escape from being exploited

Models of avian brood parasitism

What is avian brood parasitism?

Avian brood parasite exploits parental care of host and usually reduces the reproductive success.

Host defense against brood parasitism is adaptive and some host have evolved an ability to recognize and reject parasite eggs in response to parasitism.

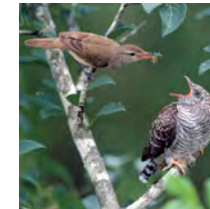
The host defense, in turn, should select for egg mimicry by parasite.

The relationship between host and parasite is expected to result in coevolutionary arms race.

The common cuckoo



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Other cuckoos



ホトトギス



ジュウイチ



ツツドリ

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The brown-headed cowbird



<http://www.mbr-pwrc.usgs.gov/id/framlst/44950id.html>



http://animaldiversity.ummz.umich.edu/site/accounants/information/Molothrus_ater.html

And others

About 1% of 9672 bird species are obligate brood parasites

Inter-specific and intra-specific brood parasitism

Adaptations and counter-adaptations

Host adaptive behavior/trait

Parasite adaptive behavior/trait

Attack toward parasite nearby nest

Cryptic & quick behaviors when parasitizing



Egg recognition and rejection



Egg mimicry

Chick mimicry



Chick recognition and rejection

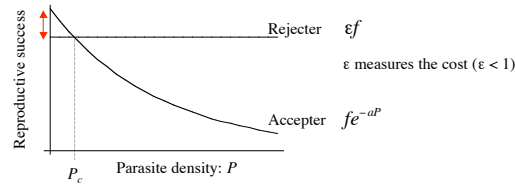
Rothstein and Robinson 1998, Davies 2000

Model assumptions

- Host behavior toward parasitism is genetically determined.
- Host population consists of accepter and rejecter individuals.

Genotype RR, RA : Rejecter
AA : Acceptor

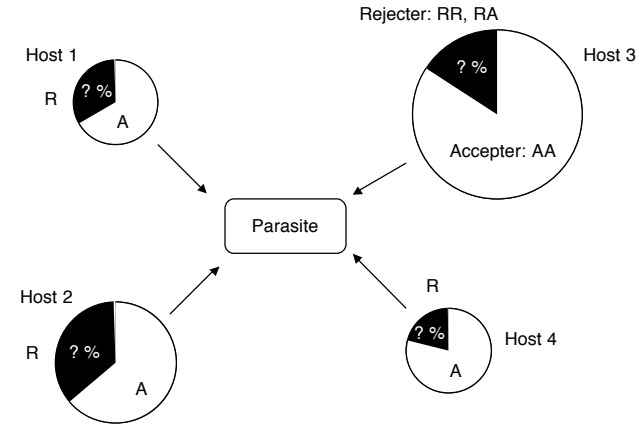
- Recognizing and rejecting parasite egg entails cost to perform.



Rejecting parasitism is more adaptive when severely parasitized ($P > P_c$), while accepting parasitism is more adaptive when no or few parasitism occurs ($P < P_c$).

Model diagram

Parasite exploits N host populations ($N = 4$)



Model equations

Parasite density: P Host i density: H_i $i = 1 \dots N$

Frequency of genotype RR of Host i : x_i

RA of Host i : y_i AA of Host i : $z_i = 1 - x_i - y_i$

$$P' = s_p P + \sum_{i=1}^N (1 - e^{-a_i P}) H_i z_i^2 \Gamma_i$$

$$H_i' = \frac{k_i}{k_i + H_i} [s_{H_i} + (1 - z_i^2) \epsilon_i f_i + z_i^2 f_i e^{-a_i P}] H_i$$

$$x_i' = \frac{s_{H_i} x_i + \epsilon_i f_i (x_i^2 + x_i y_i + y_i^2 / 4)}{s_{H_i} + (1 - z_i^2) \epsilon_i f_i + z_i^2 f_i e^{-a_i P}}$$

$$y_i' = \frac{s_{H_i} y_i + \epsilon_i f_i (x_i y_i + 2x_i z_i + y_i^2 / 2 + y_i z_i)}{s_{H_i} + (1 - z_i^2) \epsilon_i f_i + z_i^2 f_i e^{-a_i P}}$$

s_p : Parasite survival rate

a_i : Searching efficiency of host i

Γ_i : Survival rate of parasite egg

k_i : Density effect of host i

s_{H_i} : Host i survival rate

Specialist case: $N = 1$

There is a stable equilibrium frequency of rejecter individuals, that is always less than 1 (<100%). Host rejection is never fixed in the population!

When freq. of rejecters is small,
parasite density becomes large and

freq. of R increases.

$P > P_c$



When freq. of rejecters is large,
parasite density becomes small and

freq. of A increases.

$P < P_c$



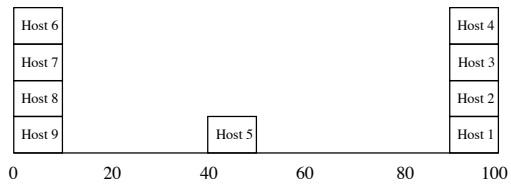
After a long run, the frequency of R reaches an equilibrium state.

The equilibrium frequency critically depends on the host abundance.

Generalist case: $N > 1$

Among N host populations, there exists a unique population that exhibits stable coexistence of rejecter and acceptor individuals at equilibrium. All the other populations consist either of only rejecter or acceptor individuals.

Example of the distribution of host defense level at stable equilibrium derived from the model



N hosts are distributed in the ascending order of the critical parasite density P_{ci} .
The equilibrium distribution depends critically on the N host abundances.

Real world

Cuckoo hosts show various levels of defense against unlike model eggs

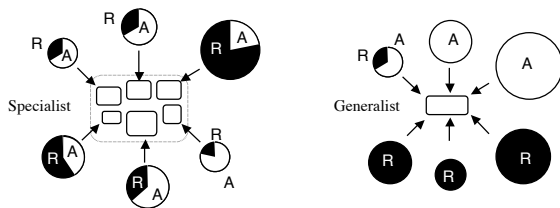


Cowbird hosts show a bi-modal distribution of 100% acceptor and 100% rejecter



Suggestion from the model

Breeding strategy of parasite – specialist or generalist – reflects the difference in the distribution of host defense level



The various defense levels the cuckoo's hosts show and the bi-modal distribution the cowbird's hosts show can be stationary.