INTERACCIONES COMO PRESIONES SELECTIVAS

Types of ecological interactions

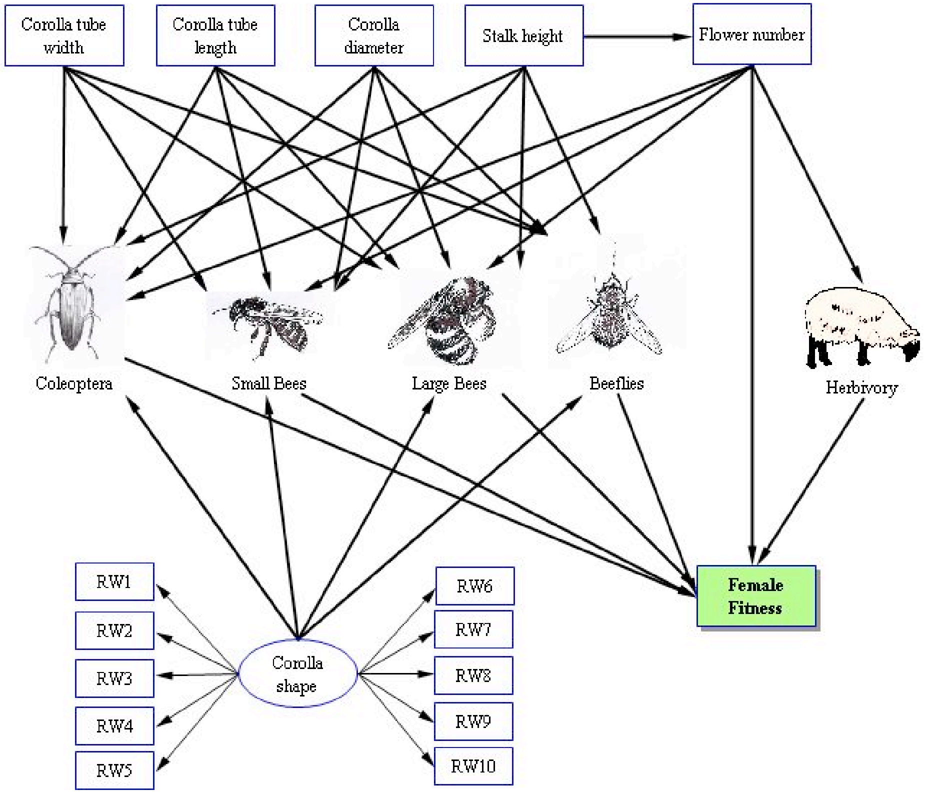
effect on species 1

		+	**0**	**-**
effect on species 2	+	mutualism	commensalism	predation herbivory parasitism
	0	commensalism		competition
	-	predation herbivory parasitism	competition	competition

Una interacción es una presión selectiva si:

Afecta al fitness del organismo de estudio

Provoca una relación entre el valor de un rasgo determinado y el fitness del organismo

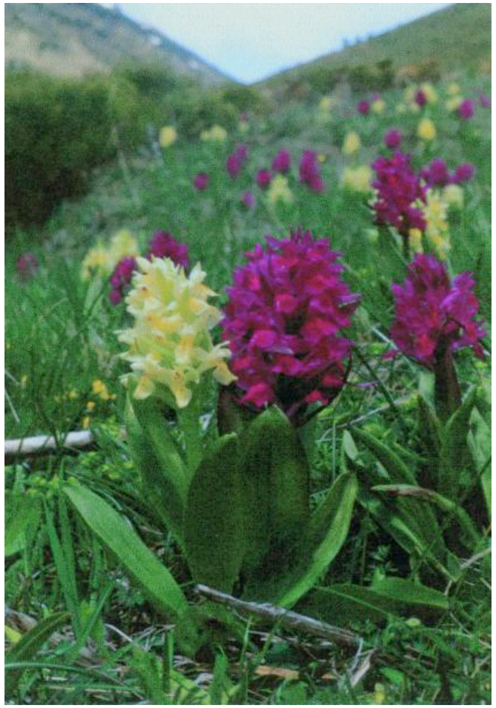


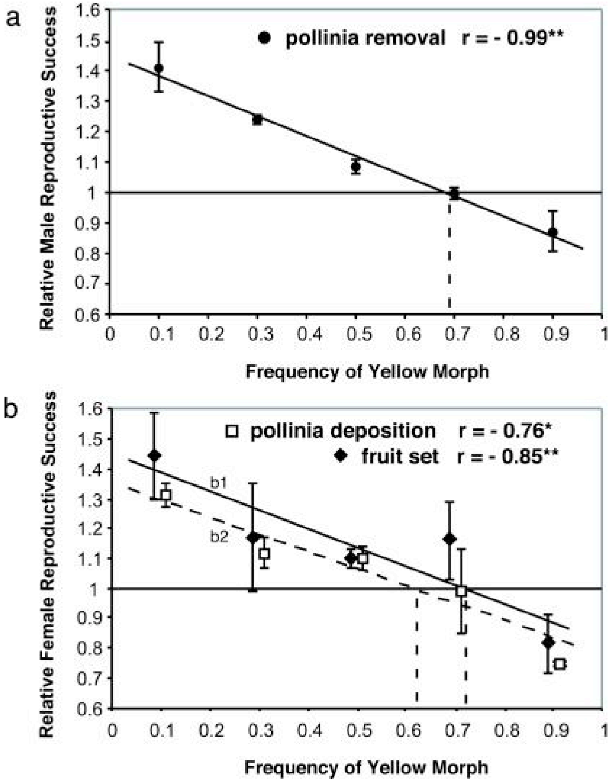
Selección sobre eficacias no constantes

Frequency dependent selection occurs when the fitness of a phenotype is dependent on its frequency relative to other phenotypes in a given population.

Positive frequency dependent selection: the fitness of a phenotype increases as it becomes more common.

Negative frequency dependent selection: the fitness of a phenotype increases as it becomes less common.



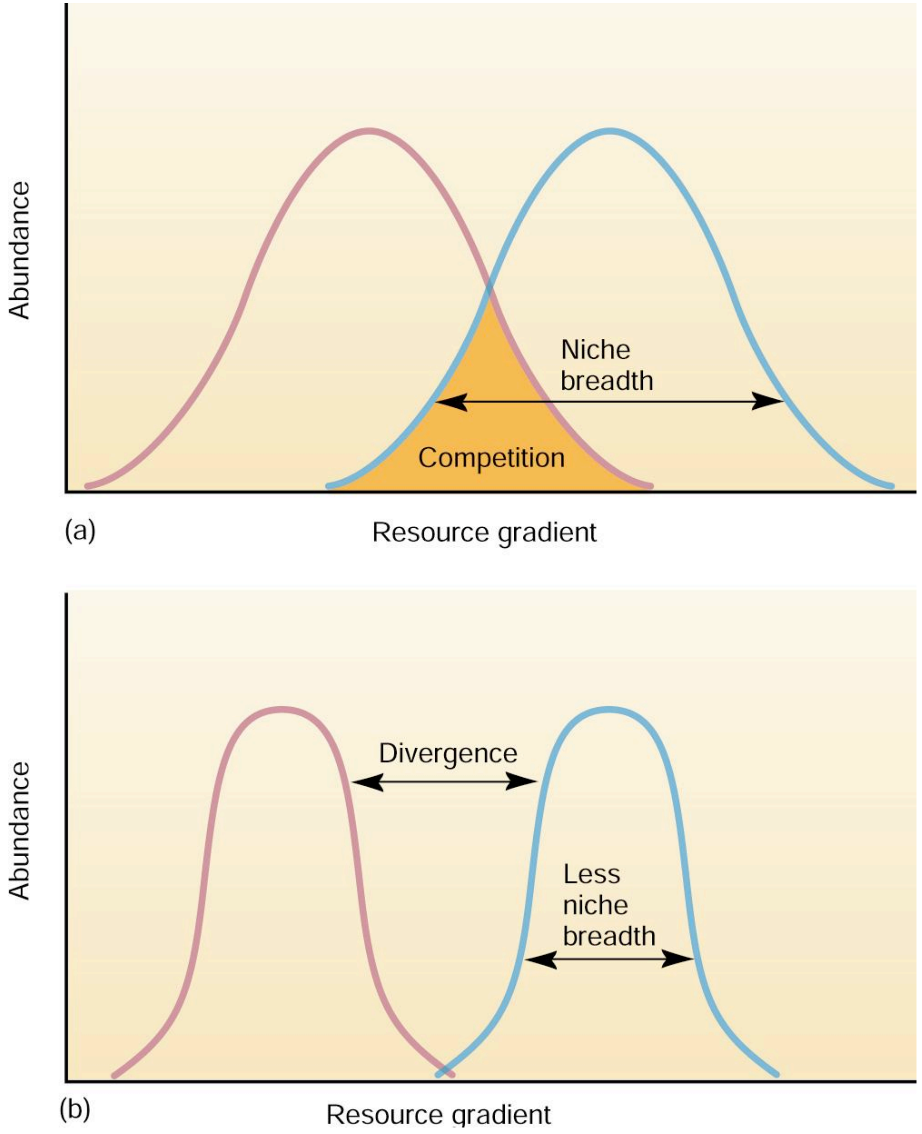


Relative male (a) and female (b) reproductive success of the yellow morph as a function of the relative frequency of the yellow morph in each array.

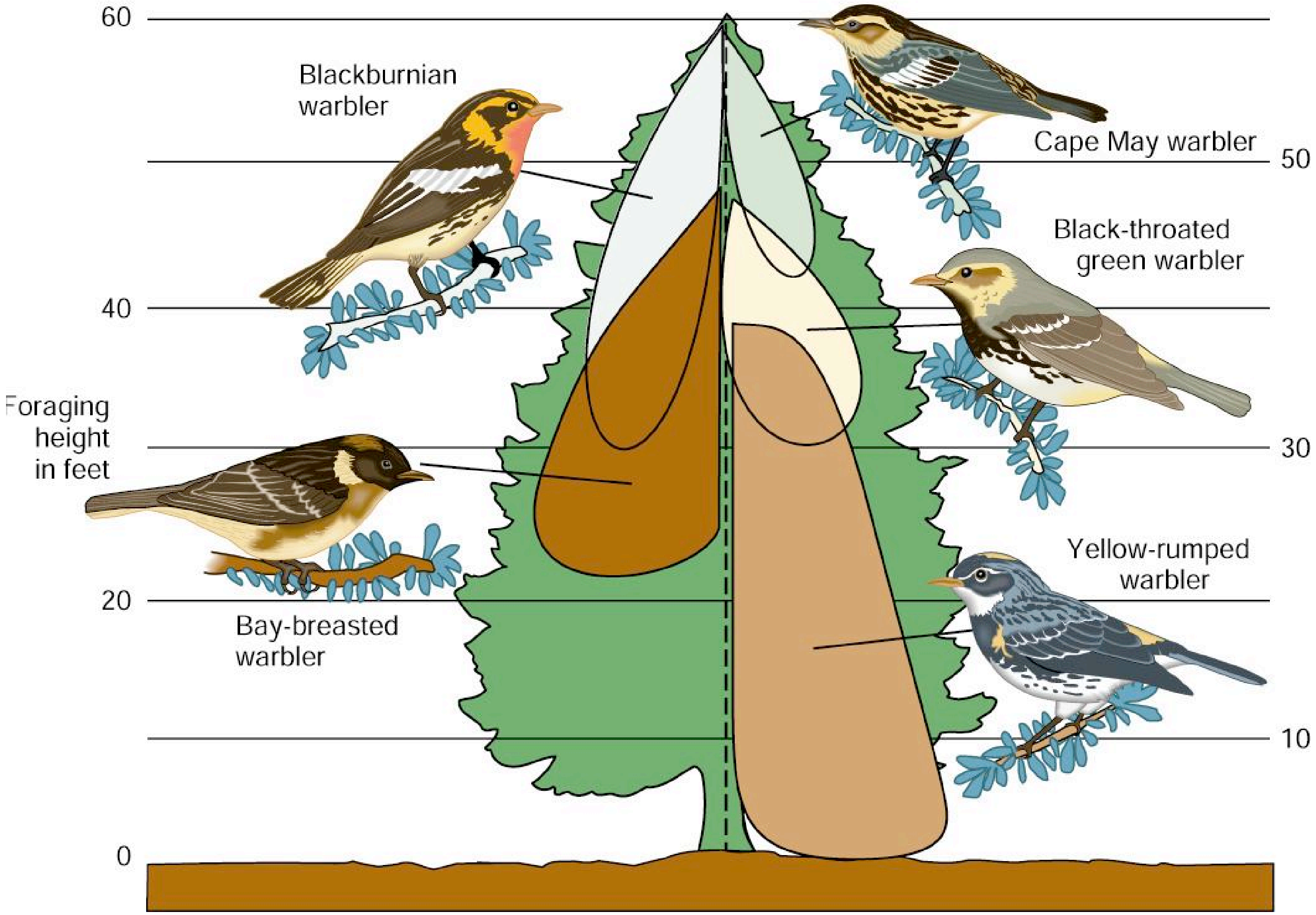
Gigord et al. 2001. Proc Natl Acad Sci U S A. 98: 6253–6255.

El papel de la competencia interspecífica: Desplazamiento de caracteres

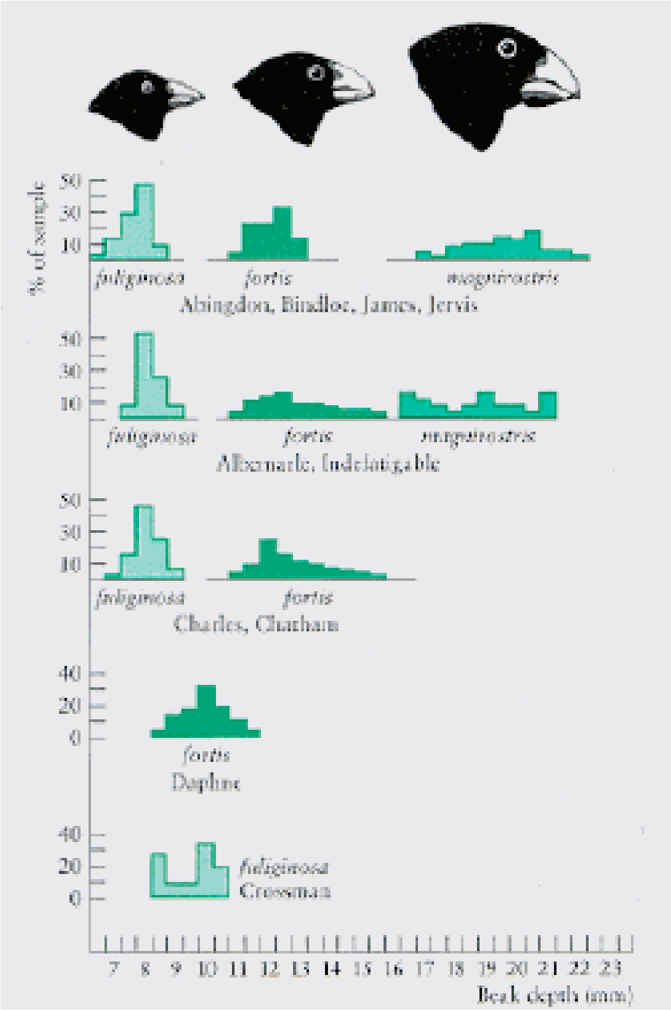
1) Los recursos son sustituibles
2) La abundancia de recursos es el único factor regulando éxito reproductivo
3) Hay competencia a mayor similitud en el valor de un rasgo porque se solapan las curvas de utilización de recursos.



El papel de la competencia interspecífica: Empaquetamiento de nicho



El papel de la competencia interspecífica: Desplazamiento de caracteres



El papel de la competencia interspecífica: Desplazamiento de caracteres

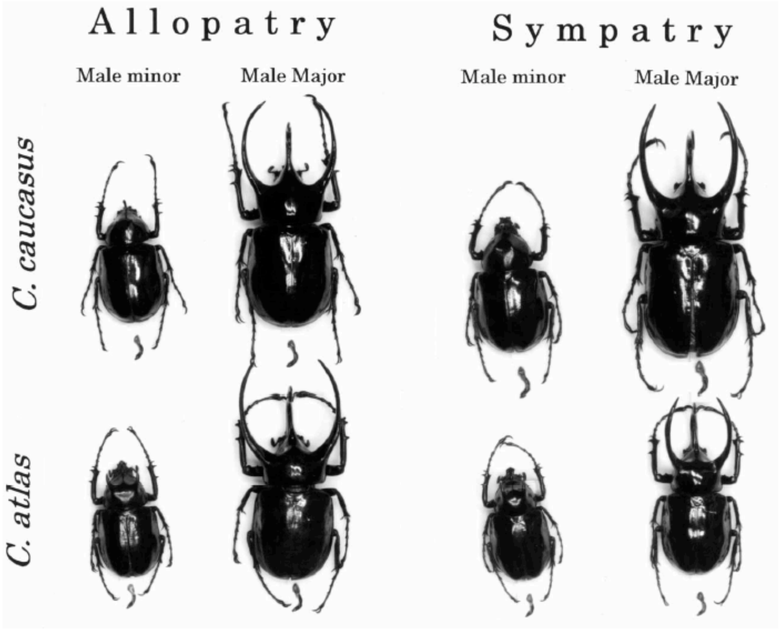


Figure 4: Male *Chalcosoma caucasus* (*top*) and *Chalcosoma atlas* (*bottom*) in allopatric locations (*C. caucasus* from West Java and *C. atlas* from Leyte; *left*) and in a sympatric location (South Sumatra; *right*). Major morph on the right and minor morph on the left side in each location in each species. There is a great difference between the two species, both in body size and genitalia length in the sympatric location. Side view of genitalia from each sample is shown immediately below the body.

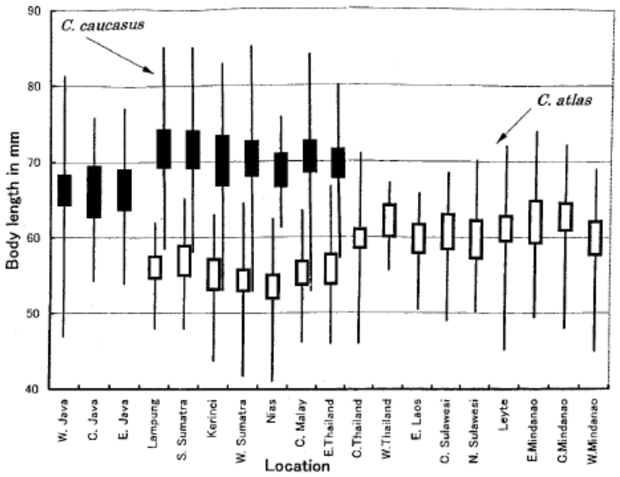


Figure 5: Body length of *Chalcosoma caucasus* and *Chalcosoma atlas* in allopatric and sympatric locations. The 5% reliable range of mean of each population is shown by a rectangular box, and the maximum and minimum values are shown by a vertical line.

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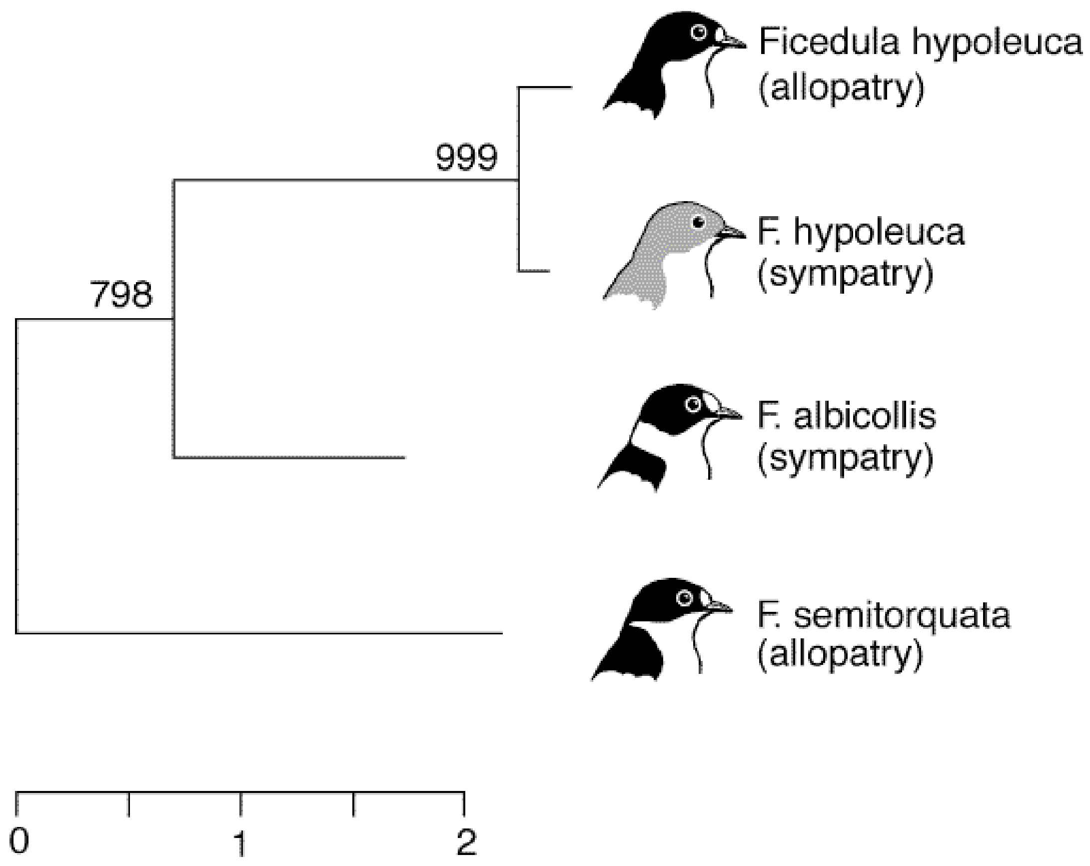
Character Displacement in Giant Rhinoceros Beetles

Kazuo Kawano*

El papel de la competencia interspecífica: Desplazamiento de caracteres



El papel de la competencia interspecífica: Desplazamiento de caracteres

$$f(z) = 1 + r - \frac{r}{K(z)} \int p_i(z)\alpha(z,x)N_i dz$$

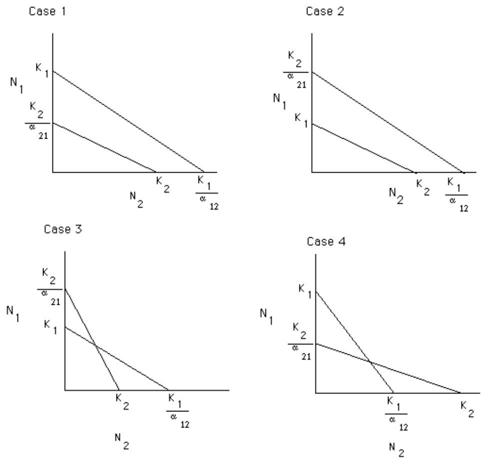
r es la tasa intrínseca de crecimiento,

K(z) es una medida de la abundancia de cada presa, cuantificada como la abundancia de cada fenotipo en el equilibrio, su capacidad de carga (gaussiana, una curva en forma de campana),

p*i*(z) es la distribución de frecuencias de cada fenotipo de la especie i (denominada la densidad efectiva),

α(x,z) es el coeficiente de competencia entre los fenotipos z y x,

Ni es la densidad poblacional de la especie *i*.



$$\frac{dN_1}{dt} = r_1N_1\left(\frac{K_1 - N_1 - \alpha_{12}N_2}{K_1}\right)$$

El papel de la depredación

Las principales preguntas teóricas que se hace un ecólogo evolutivo son:

¿Maximizan los depredadores su virulencia?

¿Maximizan las presas sus defensas?

Carrera armamentística o Reina Roja

¿Maximizan los depredadores su virulencia?: Conflicto o coexistencia

Hipótesis de la virulencia intermedia o "trade-off hypothesis"

$$R_0 = \frac{\beta H}{\alpha + \mu + \gamma}$$

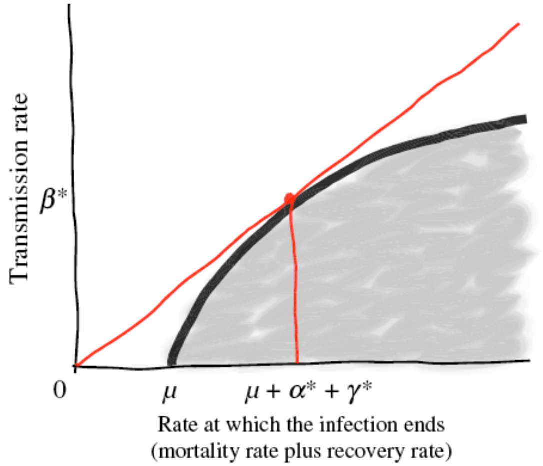


Fig. 1 The trade-off curve. The typical transmission-virulence trade-off is actually the boundary of the set of possible combinations of transmission and inverse of the duration of the infection (the shaded area). If the population starts to evolve at the interior of this set, evolution will favour strains with higher transmission (β) and longer infections (i.e. low virulence, α, and low recovery, γ) until the population 'hits' the boundary (the thick black curve) and increasing rates of transmission can only be 'bought' at the cost of accelerating mortality and/or recovery rates. Adaptive dynamics then can tell us at what point along the trade-off evolution will stop (if at all). If the curve saturates (i.e. is concave), the evolutionary stable strategy (ESS) is given by the tangent of the curve that passes through the origin (diagonal line). This ESS determines the optimal level of virulence (denoted α^*), which coincides with optimal transmission and recovery rates (β^* and γ^*). Note that here the host-background mortality (μ) is assumed to be constant (see Box 1).

R_0 es el fitness del parásito

β es la tasa de transmisión

H el número de hospedadores

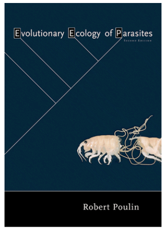
α es la virulencia (tasa de mortalidad del hospedador debido al parásito)

μ es la mortalidad del hospedador no causada por el parásito

γ es la tasa de recuperación

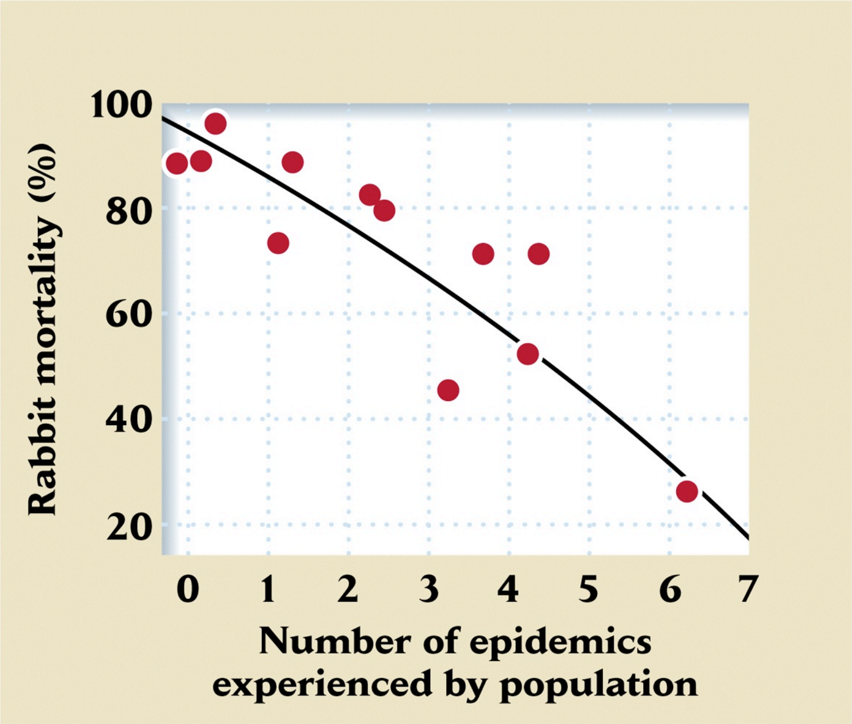
$(\alpha+\mu+\gamma)^{-1}$ puede ser considerado la duración de la interacción

Poulin R. 2006. *Evolutionary Ecology of Parasites*. PUP.

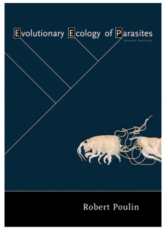


¿Maximizan los depredadores su virulencia?: Conflicto o coexistencia

Parasites that are too virulent may reduce their own fitness by killing their hosts.



Poulin R. 2006. *Evolutionary Ecology of Parasites*. PUP.



¿Maximizan las presas sus defensas?

Defense: *any trait that confers a fitness benefit to the organism in the presence of predator*.

A trait can be viewed as defensive even though defense is not its primary function. For example, the primary role of flavonoids, known deterrents of herbivores, might be to protect leaf tissues from UV damage.

Limitaciones a la maximización de las defensas en las presas

Existencia de costos

Disyuntiva Resistencia-Tolerancia

Existencia de múltiples enemigos

¿Maximizan las presas sus defensas?: Costos

Resistance: *Any prey trait that reduces the preference or performance of predators, reducing the amount of damage*.

IMAGE COURTESY OF IMPOSSIBLE PICTURES/ITV/FRAMESTORE CFC

¿Maximizan las presas sus defensas?: Costos

Benefits of resistance: when the fitness of resistant prey is greater than that of less resistant prey in the presence of enemies.

Costs of resistance: when the fitness of more resistant plants is lower than the fitness of less resistant plants in the absence of enemies.

Direct resistance cost: a tradeoff between fitness and resistance that is not mediated by interactions with other species (e.g. allocation costs, auto-toxicity, opportunity costs, changes in phenology, growth rate, dormancy and other auto-ecological traits, and increased susceptibility to abiotic stresses).

Indirect resistance costs (ecological costs): tradeoffs between fitness and resistance mediated by interactions with other organisms.

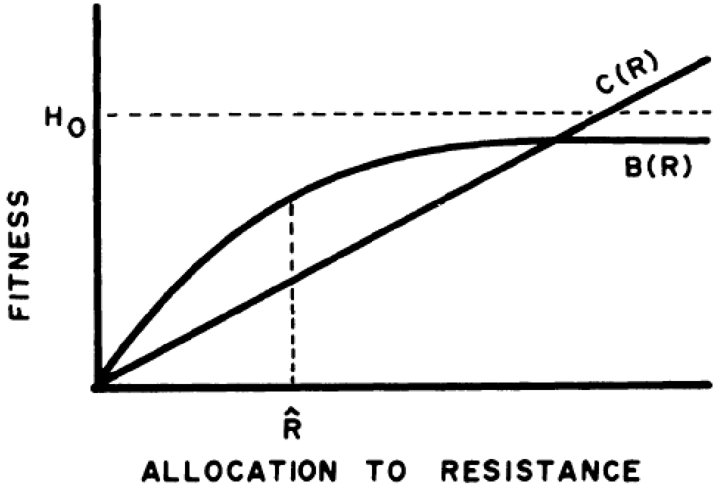


FIG. 1.—The calculation of cost and benefit of resistance, when treated as a quantitative trait. The amount of fitness lost to herbivory by the most susceptible genotype is designated H_0. The fitness cost of resistance, as a function of the amount of resources allocated to resistance, is $C(R)$. $B(R)$ is the fitness benefit of resistance, as a function of allocation. The point $\hat{R}$ corresponds to the genotype with maximum fitness.

¿Maximizan las presas sus defensas?: Costos

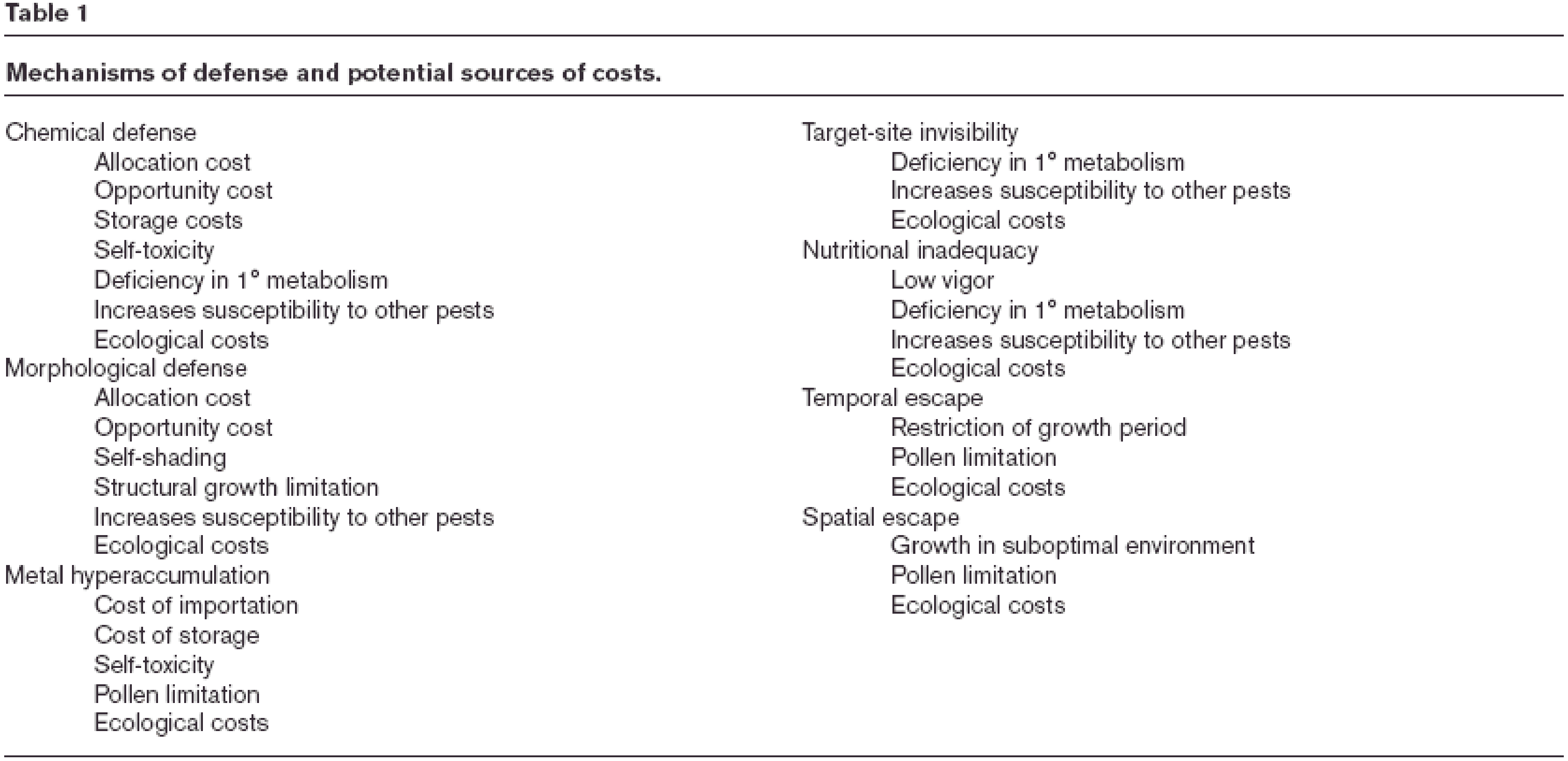


Table 1

Mechanisms of defense and potential sources of costs.

- Chemical defense
  - Allocation cost
  - Opportunity cost
  - Storage costs
  - Self-toxicity
  - Deficiency in 1° metabolism
  - Increases susceptibility to other pests
  - Ecological costs
- Morphological defense
  - Allocation cost
  - Opportunity cost
  - Self-shading
  - Structural growth limitation
  - Increases susceptibility to other pests
  - Ecological costs
- Metal hyperaccumulation
  - Cost of importation
  - Cost of storage
  - Self-toxicity
  - Pollen limitation
  - Ecological costs
- Target-site invisibility
  - Deficiency in 1° metabolism
  - Increases susceptibility to other pests
  - Ecological costs
- Nutritional inadequacy
  - Low vigor
  - Deficiency in 1° metabolism
  - Increases susceptibility to other pests
  - Ecological costs
- Temporal escape
  - Restriction of growth period
  - Pollen limitation
  - Ecological costs
- Spatial escape
  - Growth in suboptimal environment
  - Pollen limitation
  - Ecological costs

¿Maximizan las presas sus defensas?: Costos

Constitutive resistance: resistance that is always expressed in the prey (independent of damage).

Induced resistance: resistance that is expressed only after an organism is damaged.

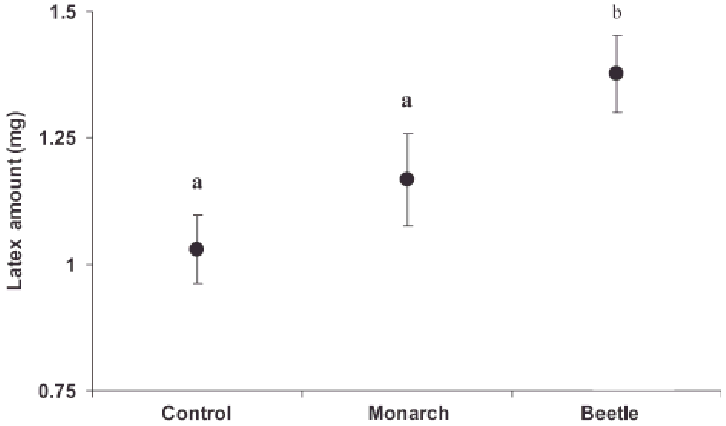


Fig. 1. Plant latex volume from all seven trials where latex volume was assessed for undamaged controls or following damage by monarch, or *Labidomera* larvae (Table 1). Date are least squared means ±1 SE, and unique letters above symbols represent groups that differ significantly following Tukey-Kramer adjusted post-hoc contrasts.

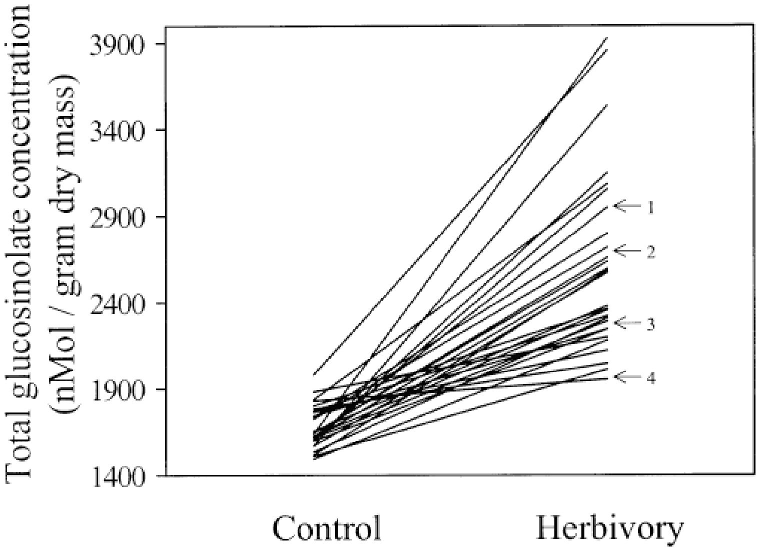
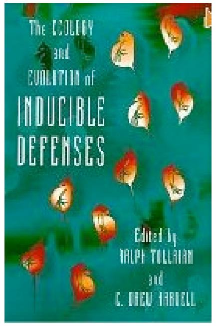


FIG. 1. Reaction norm plot for effects of controlled caterpillar herbivory on total glucosinolate concentration in 28 paternal half-sib families of wild radish. Values are calculated from within each treatment alone using best linear unbiased prediction (BLUP) produced by SAS Proc Mixed (Littell et al. 1996). Lines marked by arrows and numbers indicate the four paternal half-sib families selected for the second induced resistance experiment (Fig. 2). Separate plots of indolyl and non-indolyl glucosinolates are qualitatively similar.



Tollrian, R. and C.D. Harvell 1998. *The ecology and evolution of inducible defenses*- PUP

¿Maximizan las presas sus defensas? : Disyuntiva Resistencia-Tolerancia

Tolerance: response of prey induced after consumption to buffer the negative fitness effect of damage

Degree to which prey fitness is affected by damage relative to fitness in the undamaged state.

Tolerance can be estimated only from a group of related or cloned preys because the fitness of an individual cannot be examined in both damaged and undamaged states. When damage levels are continuous, tolerance is measured as the slope of the line relating the fitness of plants to the level of damage. If damage is qualitative, then tolerance is the difference in fitness between related damaged and undamaged preys (D-U) or the proportional fitness of damaged individuals relative to undamaged ones (D / U).

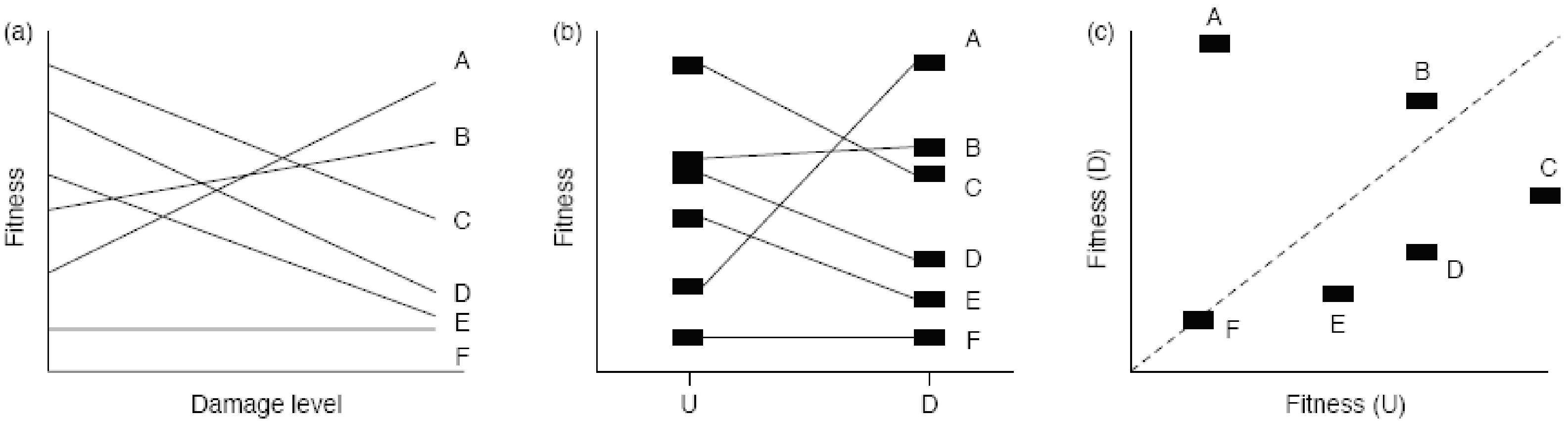


Fig. 1. Tolerance to herbivory has been depicted using a variety of approaches. (a) A reaction norm approach. The slope of the line relating the fitness of related plants to damage level indicates the degree to which plant fitness is affected by herbivore damage. Family F exhibits full compensation for herbivory (slope = 0), whereas families A and B overcompensate (slope>0) and families C, D and E undercompensate (slope<0). (b) Another reaction norm depiction when there are only two levels of damage (U, undamaged; D, some other fixed damage level). In this case, tolerance is estimated as D − U if we assign the difference between categories D and U a unit of 1. (c) Finally, one can plot the fitness of a group of related plants in the damaged versus the undamaged state on the y- and x-axis, respectively. Here, the unity line depicts full compensation (fitness in the damaged state = fitness in undamaged state, slope = 1); plants above the line overcompensate, whereas those below the line undercompensate.

¿Maximizan las presas sus defensas? : Disyuntiva Resistencia-Tolerancia

Trade-offs

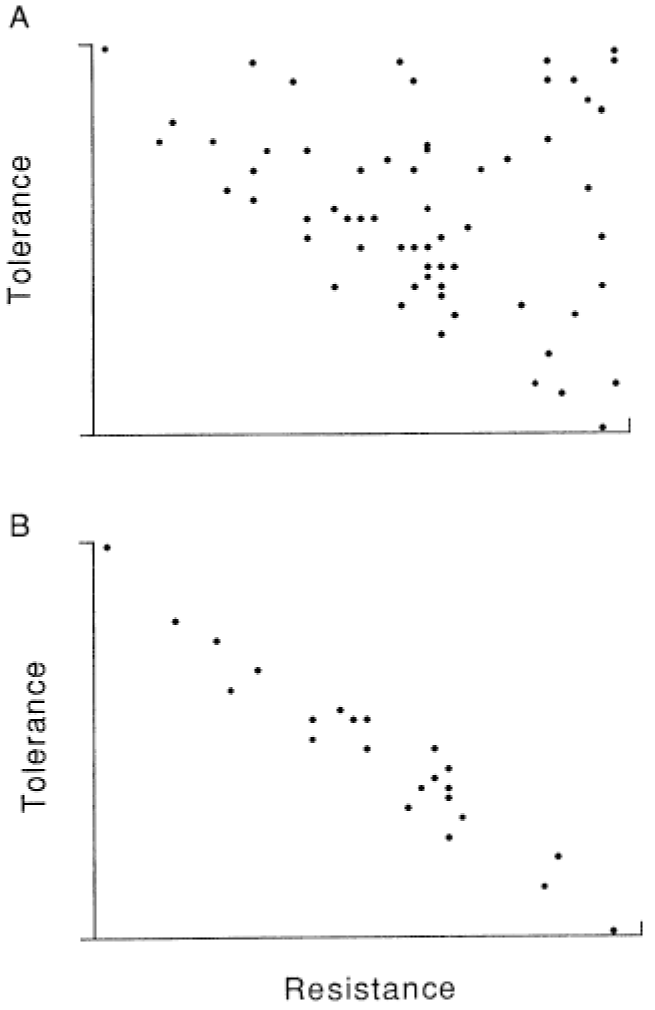
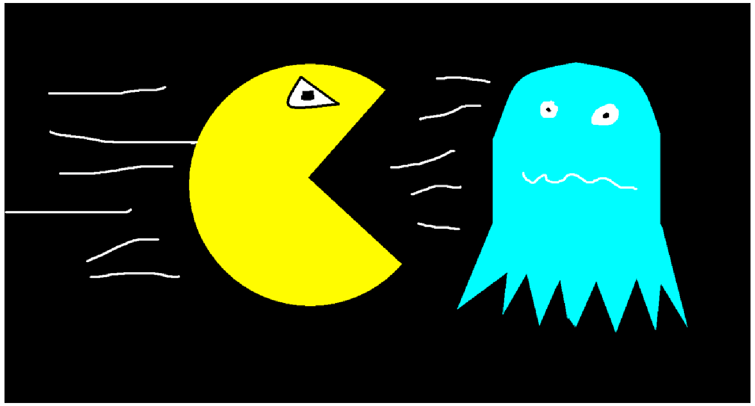
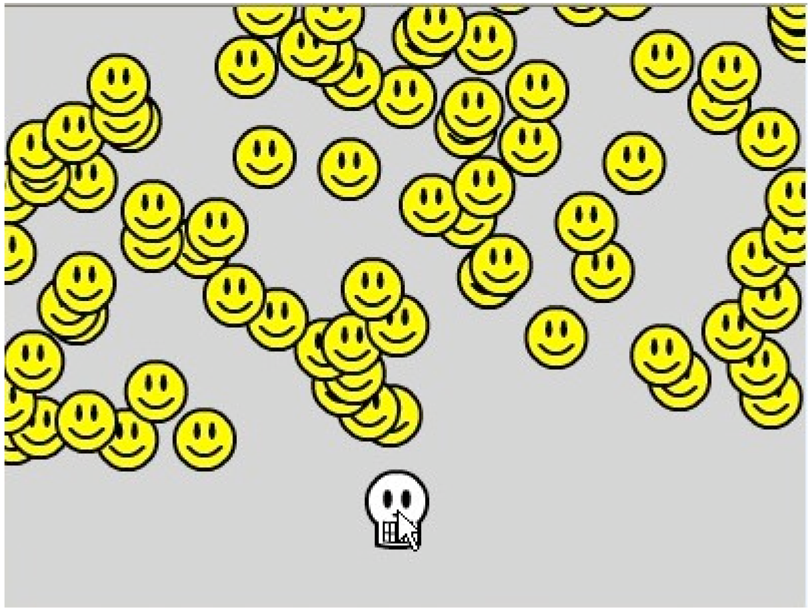


FIG. 1. Postulated genetic correlation between disease resistance and tolerance in the presence of disease (A) in the absence of fitness costs and (B) if both resistance and tolerance are costly (redrawn from Fineblum 1991).

¿Maximizan las presas sus defensas? : Multiples enemigos



vs



¿Maximizan las presas sus defensas? : Multiples enemigos

Multiple predators may produce **diffuse selection/evolution**

Criteria for diffuse selection and evolution:

1 The susceptibilities (resistances) to different predators are genetically correlated. The second species causes correlated responses to selection in the focal trait caused by genetic covariances between traits.

2 The total strength or direction of selection on the trait is altered by the second interacting species, either in an additive or nonadditive manner.

3 The presence of the second species alters the G-matrix; that is, the expression of genetic variance for the focal trait or genetic covariances between the focal trait and other traits under selection change in the presence of a second species.

Evolution is diffuse if the response to selection by one interacting species alone is altered by the presence of a second interacting species.

¿Maximizan las presas sus defensas? : Multiples enemigos

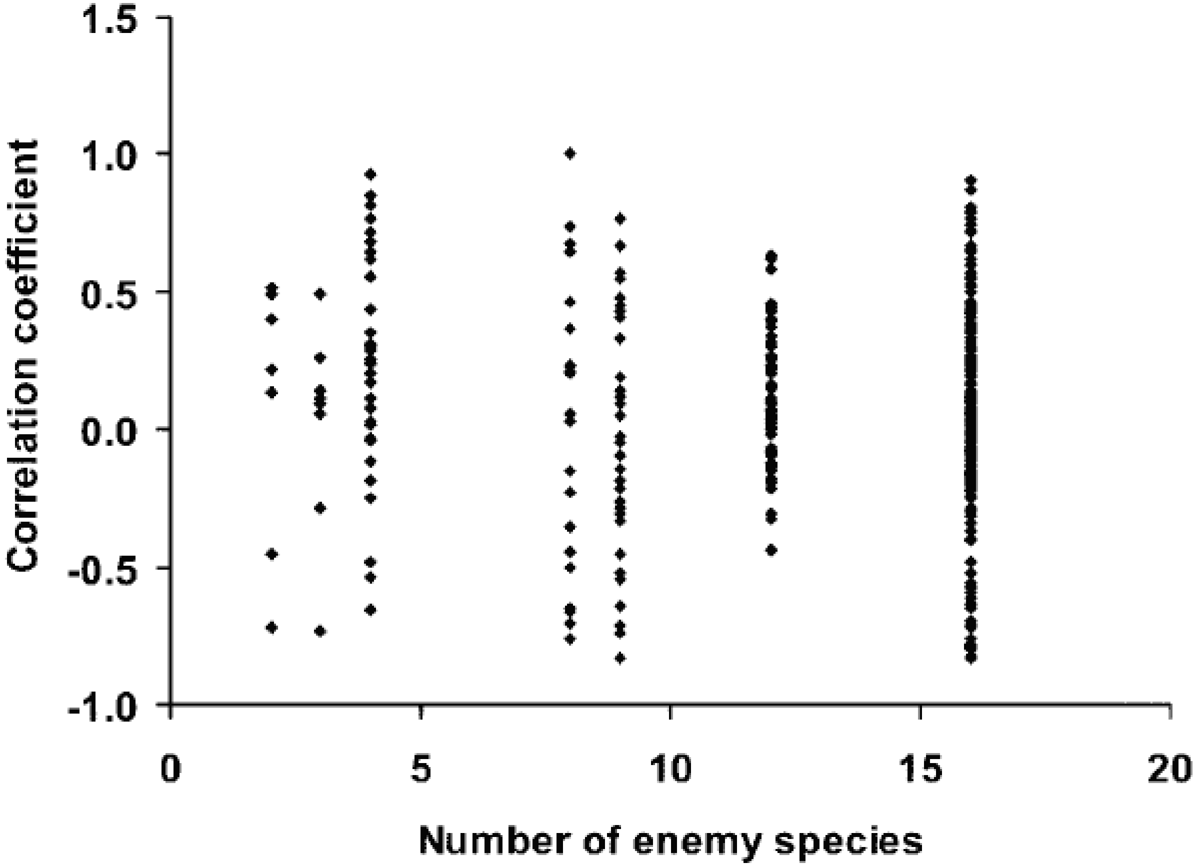


Figure 1: Individual genetic correlations between plant resistances to pairs of natural enemies in relation to the number of natural enemy species examined per study.

¿Qué ocurre si ambos contendientes evolucionan?

Evolutionary arms race

La evolución recíproca de rasgos en depredadores y presas para incrementar la eficacia de depredación y la eficacia de evitación de la depredación

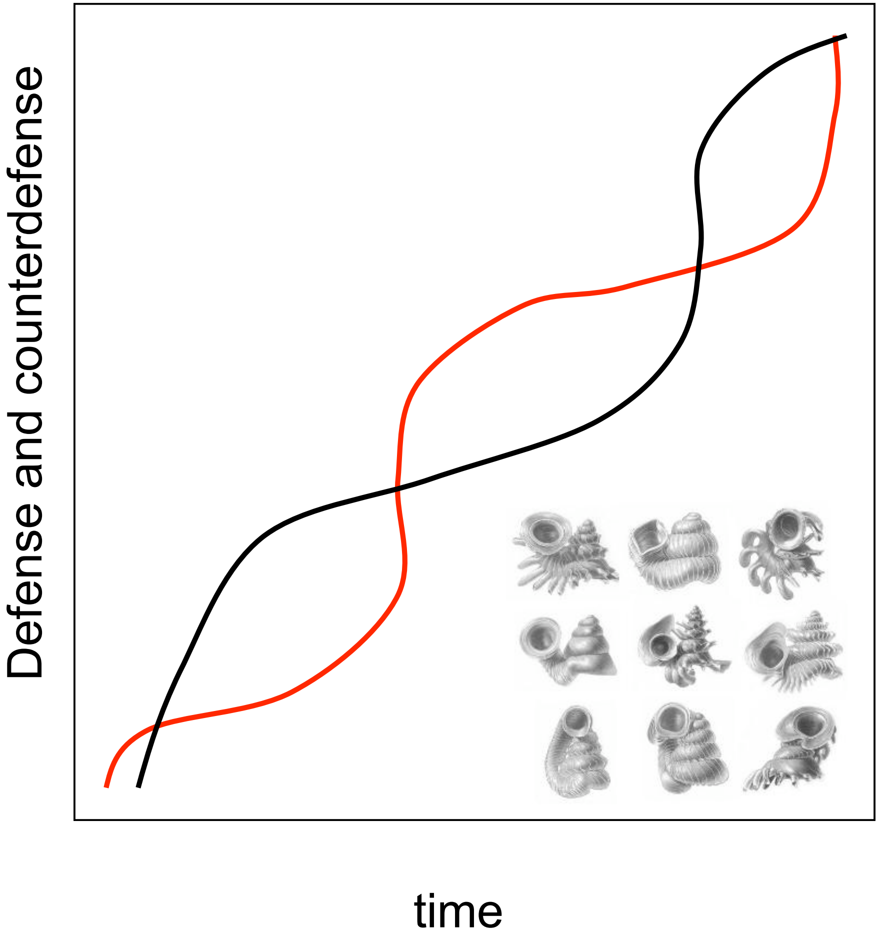
Under this models selection is directional

Arms races can lead to:

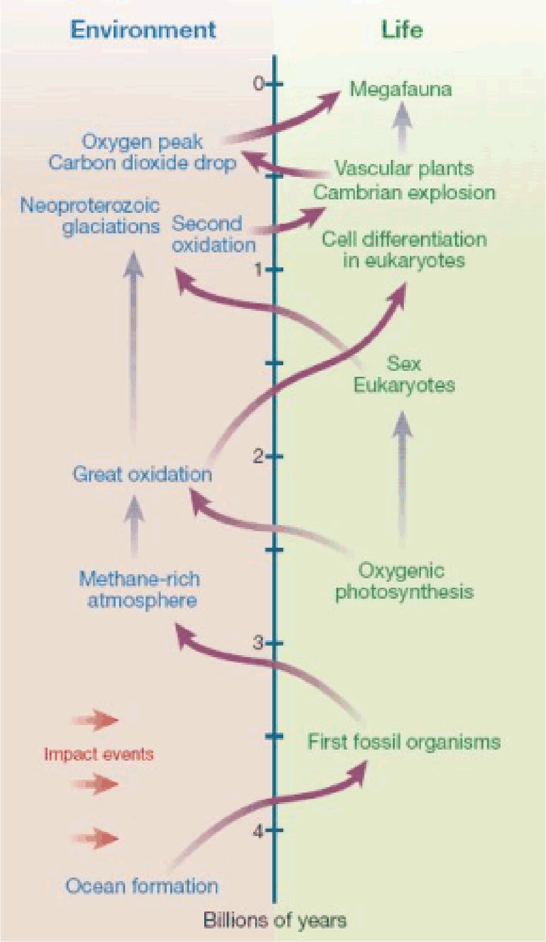
1) rapid evolution of extreme traits

2) high degrees of specialization

3) formation of new species.

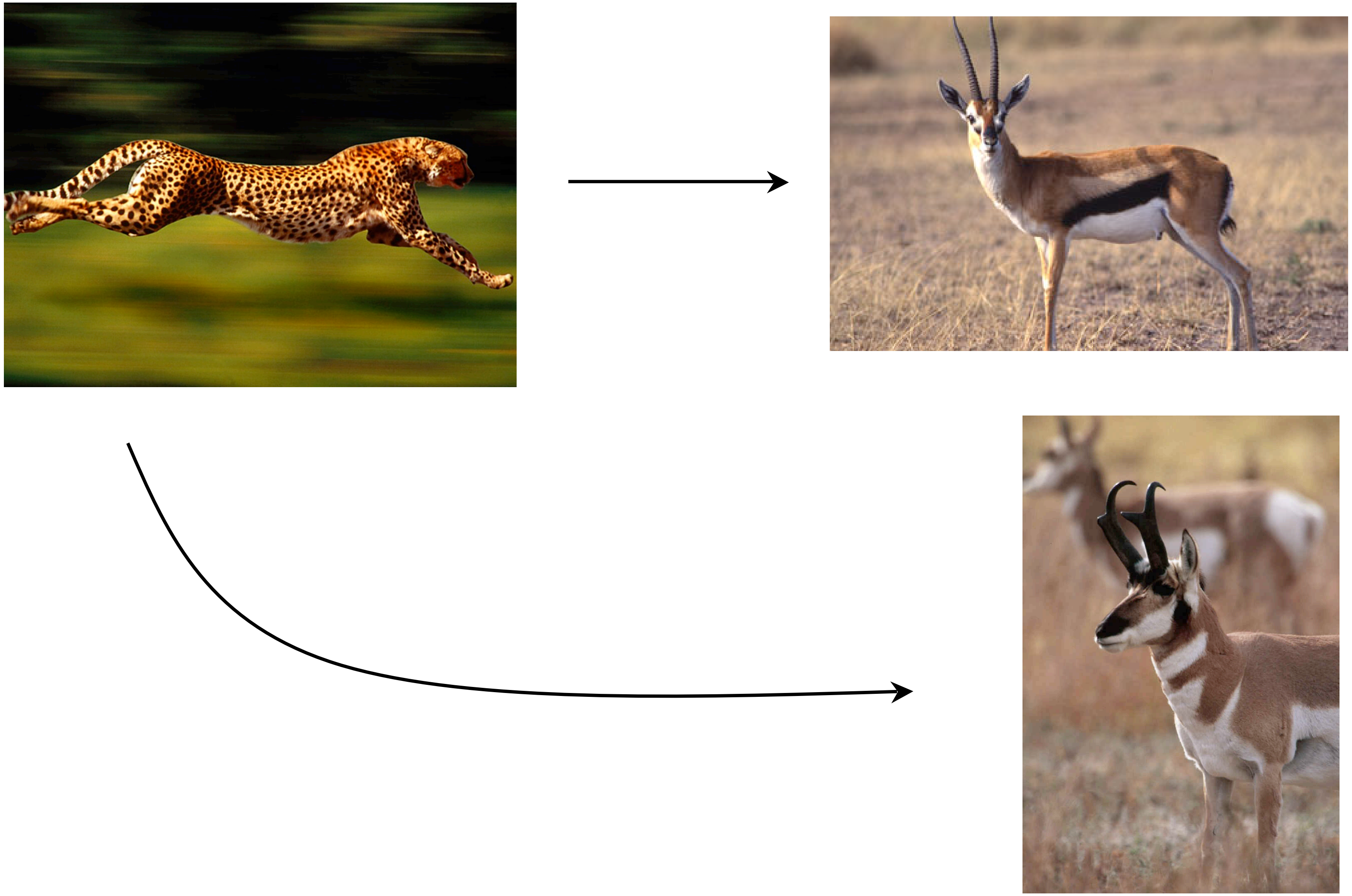


Evolutionary arms race



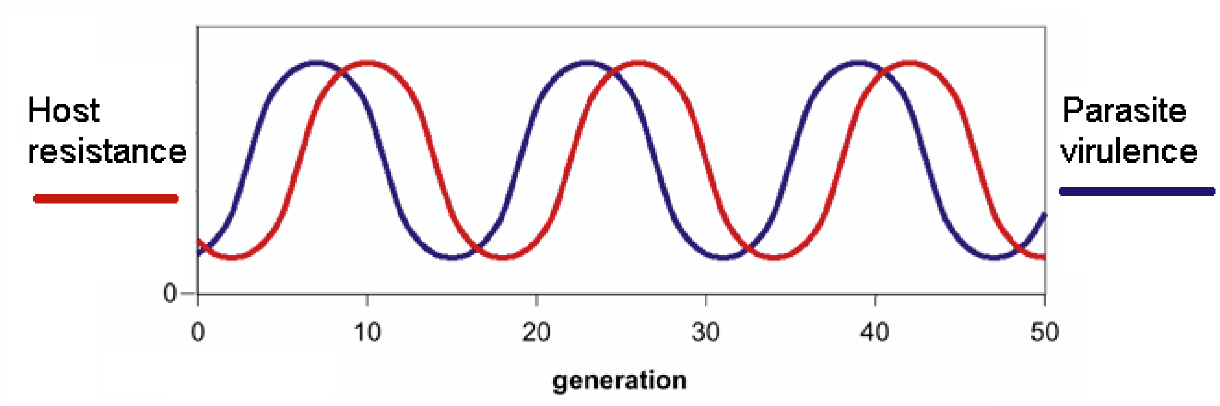
Evolutionary arms race

Applied evolutionary ecology: rewilding America



Red Queen hypothesis

- Both resistance (in the host) and virulence (in the parasite) are costly
  - if the host is susceptible, selection favors virulence
  - this causes selection for resistance in the host…
  - leading to selection for less virulence in the parasite (because virulence is costly)…
  - leading to selection for less resistance in the host (because resistance is costly)…



•Host-parasite interactions are due to genotype-genotype interactions

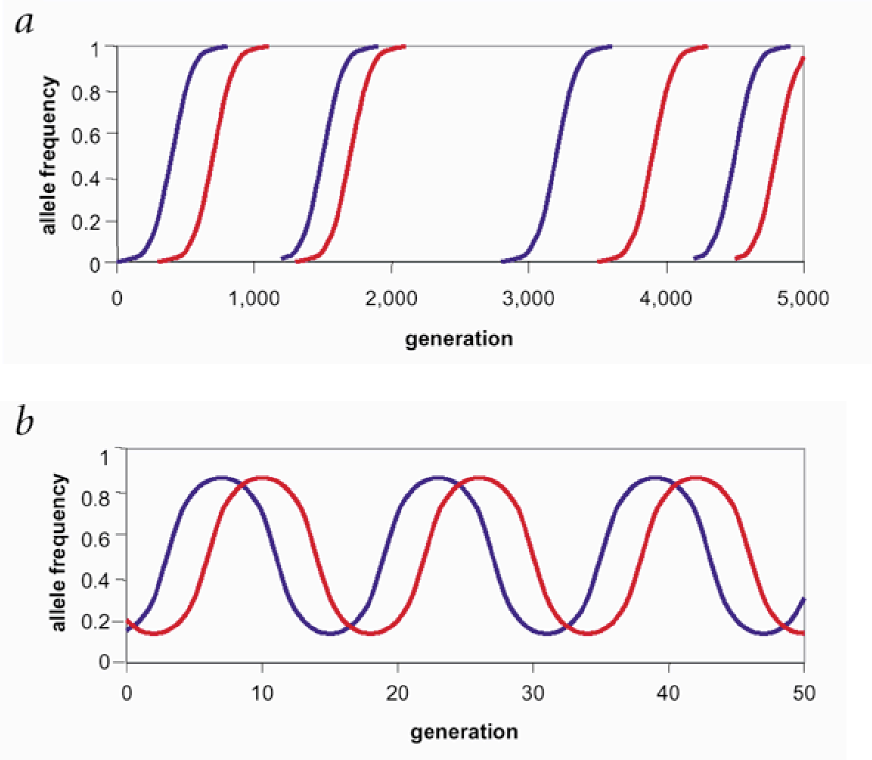
–newly evolved pathogen strains may overcome host resistance

–host resistance may be specific to certain genotypes

Red Queen hypothesis

The Red Queen Hypothesis states:

- Parasites are constantly evolving into new forms to avoid host resistance
- Hosts are constantly under selective pressure to evolve new resistance genes
- Selection is time-delayed negative frequency-depedent selection
- Result is that both parasite and host must constantly evolve just to stay in place…



Red Queen hypothesis

Predicciones:

1- Los parásitos deben expresar mayor virulencia en genotipos alopátricos frente a los que no están adaptados.

2- La virulencia del parásito será subóptima, ya que cada vez que un parásito se adapte a su hospedador, optimizando su virulencia, otro genotipo del hospedador se vverá beneficiado aumentando su abundancia relativa.

3- Diversidad genética del hospedador debe disminuir la virulencia promedio del parásito

4- Parásito debe inducir cambio temporal en la población de hospedadores.