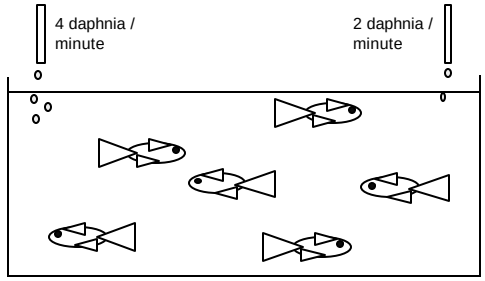
Ideal Free Distribution

Competition by exploitation

1. How should competitors distribute themselves?
2. Assume there are two habitats – one rich with lots of resources and one poor with less resources.
3. Individuals should distribute themselves to maximize their net benefits – in this case the consumption rate of the resource.

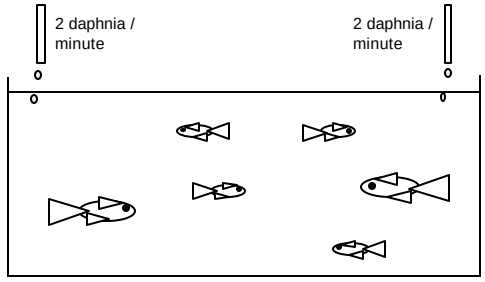
Ideal Free Distribution

Daphnia introduced at a constant rate from delivery tubes
Tube on left has 2× the rate of tube on right



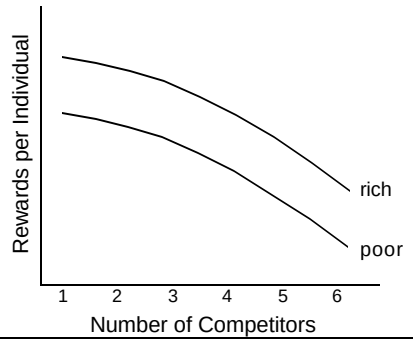
Ideal Free Distribution

Daphnia introduced at a constant rate from delivery tubes
Rate is the same on both sides of aquarium



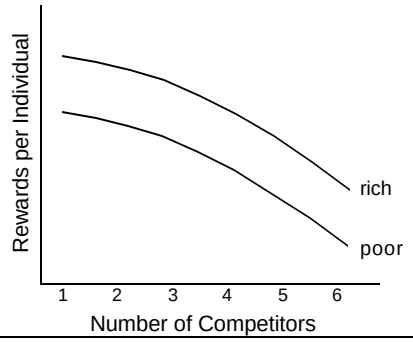
Ideal Free Distribution

Where should a forager go?



Ideal Free Distribution

Suppose there are five competitors on rich territory and two on poor territory. Where should the eighth competitor go?

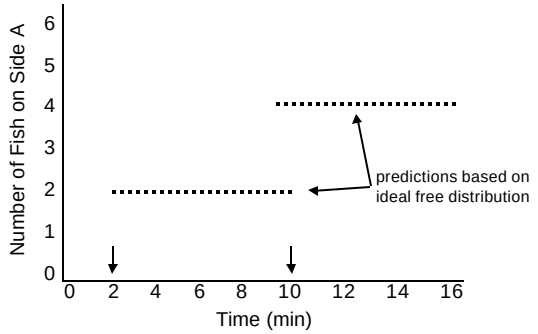


Milinski's Stickleback Experiment

1. Introduced six sticklebacks into an aquarium
2. At 2 min introduced food at twice rate on side B
3. At 10 min switched food source so twice rate on side A

Milinski's Stickleback Experiment

According to ideal free distribution expect 2 fish on side A after 2 min point and then 4 fish on side A after 10 min



Mating Systems: Polygyny Threshold Model

Polygyny: Mating systems in which males may mate with more than one female.

- In birds, usually arises through males monopolizing females indirectly, by controlling scarce resources such as food or nest sites.
- When these resources are patchily distributed, males that are able to defend the best patches can gain the most mates.
- Females may pay no cost to polygyny (sharing a male) or they may pay a cost, but have to accept it.

Cost and Benefits of Polygyny to Females

a) No cost of polygyny to females

- Typical when males provide no parental care, thus females suffer little (if any) from polygyny
- Females may be indifferent to the mating system

Yellow-headed blackbirds

1. Females build nests in marshes, feed in adjacent fields.
2. No costs (or benefits) to settling near other females.
3. Settle 'randomly' in marsh.

Yellow-rumped caciques

1. Males try to make a good impression on females by showing their yellow feathers and flapping their wings.

Yellow-rumped caciques

1. Females nest in colonies in tall isolated trees.
2. The nests hang from branches and have their entrance at the upper side.
3. The females make the nests and raise the young.
4. Benefit from nesting in safe sites and from co-operative nest defence against avian predators.

Cost and Benefits of Polygyny to Females

b) Cost of polygyny to females

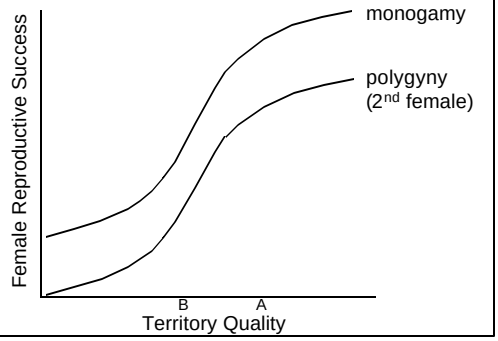
- Typical when males provide parental care or other resources, thus females suffer from polygyny (sharing a male)
- Females may be forced to accept these costs if a fraction of the males control breeding sites and resources
- A female's choice may be "accept polygyny" or "forego breeding"

Red-winged blackbird

1. Males establish territories in marshy areas.
2. Females settle on a male's territory and build nests.
3. Nests are built among cattail shoots.
4. Nests built in deeper water provide better protection from predators.
5. Males defend their territory from predators.

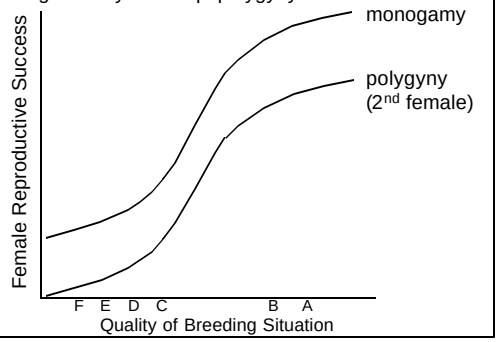
Polygyny Threshold Model

- Suppose that a female has the choice of sharing a male on territory A or mating monogamously with a male on territory B



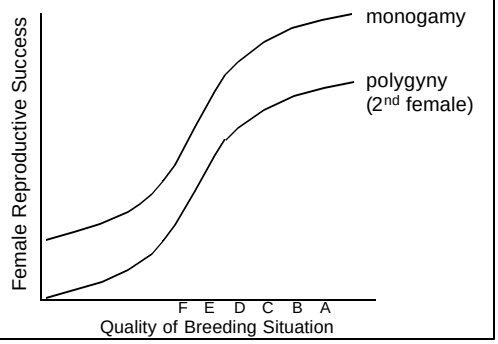
Polygyny Threshold Model

Suppose that six females have to choose among six males on territories A-F. Each female must choose whether to mate monogamously or accept polygyny



Polygyny Threshold Model

Consider a different arrangement of breeding territories



Polygyny Threshold Model

Assumptions:

1. There is a cost to polygyny. A female's reproductive success is lower if there is another female on the territory.
2. Female success is influenced by territory (or male) quality.

Predictions:

1. Females trade off the cost of polygyny against the benefit of obtaining access to a superior territory.
2. A female will settle with an already-mated male only when compensated by obtaining a better territory as compared to that of other unmated males.

Polygyny Threshold Model: An Experimental Test

(Pribil 2000; Pribil and Searcy 2001)

1. Studied red-winged blackbirds in Ontario.
2. Manipulated harem size and quantified male feeding rates and female reproductive success.
3. Manipulated male territory quality by removing cattails and then planting cattails in either the water (high quality) or on the shoreline (low quality).

Red-wing blackbird song

Polygyny Threshold Model: An Experimental Test

(Pribil 2000; Pribil and Searcy 2001)

4. At commencement of the experiment males on high quality territories (those with cattails in the water) were allowed to keep one mate and males on low quality territories were not allowed any mates.

5. Newly arriving females therefore had the choice of mating with an already-mated male on a high quality territory or mating monogamously with a male on a low quality territory.

Polygyny Threshold Model: An Experimental Test

(Pribil and Searcy 2001)

A1: There is a cost to polygyny.

a) Secondary females (those choosing already mated males) receive less help with feeding young than did monogamous females.

b) When harem size was experimentally reduced, females in harems of one produced 1.37 young, while females in harems of two produced an average of only 0.75 young.

Polygyny Threshold Model: An Experimental Test

(Pribil and Searcy 2001)

A2: Female success is influenced by territory (or male) quality.

a) Females nesting in cattails in the water on average lost 1.02 fewer young to predation as compared to females nesting in cattails on the shore.

Polygyny Threshold Model: An Experimental Test

(Pribil and Searcy 2001)

P1: Females trade off the cost of polygyny against the benefit of obtaining access to a superior territory.

a) Cost of polygyny is 1.37 – 0.75 = 0.62 young

b) Thus benefit of nesting over water (1.02 young) outweighs cost of polygyny (0.62 young)

Polygyny Threshold Model: An Experimental Test

(Pribil and Searcy 2001)

P2: A female will settle with an already-mated male only when compensated by obtaining a better territory as compared to that of other unmated males.

a) For 14 high-low quality territory dyads, newly arriving females settled on the high quality territory (accepting polygyny) in 12 (86%) of the cases.

Summary

1. The ideal free distribution predicts that individuals will go to a location (territory) that provides the greatest returns.
2. In the case of feeding, individuals will distribute themselves such that the average consumption rates are equal between locations.
3. When individuals are of different competitive abilities (e.g., small and large fish), individuals will distribute themselves such that the average competitive units are equal between locations.
4. The polygyny threshold model extends the ideal free distribution to mating systems, predicting that females will only accept polygyny when the benefits of the polygynous mating situation outweigh mating monogamously with an unmated male.