Economics of Sociality

Recall 2-Player Game

Actions {A, B, C}, Symmetric Competitors

PL 1 / PL 2	A	B	C
A	2	5	1
B	6	1	3
C	3	2	6

By Diagonal Dominance, Pure C is ESS

p(C) = 1 Cannot be Invaded by Rare A or Rare B

C Not Tempted to Switch: Nash Equilibrium

Consider Pair (A, B): Nash Equilibrium

Neither Tempted to Switch Strategy, Not ESS

N-PLAYER GAME

Player i $\quad\quad i = 1,2 \ldots, N$

Hypothesize Currency of Fitness: Payoff Function w_i

$w_i = f_i(a_1, a_2, a_3, \ldots, a_i, \ldots, a_N)$

w_i: Action by i and actions of other (N - 1) players

1. Nash Equilibrium: As long as other (N - 1) players continue with their Nash Strategy, no individual tempted to switch strategy

   Neutral Stability

2. Nash Equilibrium: As long as other (N - 1) players continue with their Nash Strategy, any individual changing strategy suffers reduced payoff

   Stable Equilibrium

3. Nash equilibrium with Equal Payoffs to all N identical players: ESS

Proceed to Social Foraging

Group Foraging: ***Ideal Free Distribution***

Resource: Distinct Patches Only

Assume:

1. **Individuals *FREE* to Enter Any Patch**
2. **Individuals *IDEAL*, Each Moves to Patch Where Its Feeding Rate Maximal**
3. **Individuals Identical**
4. **Feeding Rate Declines with Local Consumer Density**
5. **Fitness Increases with Feeding Rate**

m Patches (Habitats) where Resource Found

N Total Consumers (Mobile)

$\mathbf{K_i}$ Resource Availability in Patch *i* (*i* = 1, 2, …, **m**)

K_i Constant, Total Resource in *i*-th Patch

$\mathbf{n_i}$ Number of Consumers in Patch *i*

$$N = \sum_{i=1}^{m} n_i$$

Individual Fitness Increases with its Resource Consumption

Individual's Resource Consumption, Hence its Fitness, Decreases with Consumer Density in its Patch

Specify Fitness (Local Density)

$w(n_i)$: Fitness, Each Consumer, Patch i

$$w(n_i) = K_i / n_i \; ; \forall i$$

Fitness Increases with K_i

Fitness Decreases with n_i

{Same Result for Any Bounded, Single-Valued, Function

Increases Monotonically in (K_i / n_i)}

Individuals Move Freely to Max (K_i / n_i);

When Stop? When Does System Equilibrate?

Equilibrium: Equal Fitness across Patches;

No Player Tempted to Move

Habitat Matching

$$K_i / n_i = K_j / n_j \text{; } all\ (i,\ j)\ pairs$$

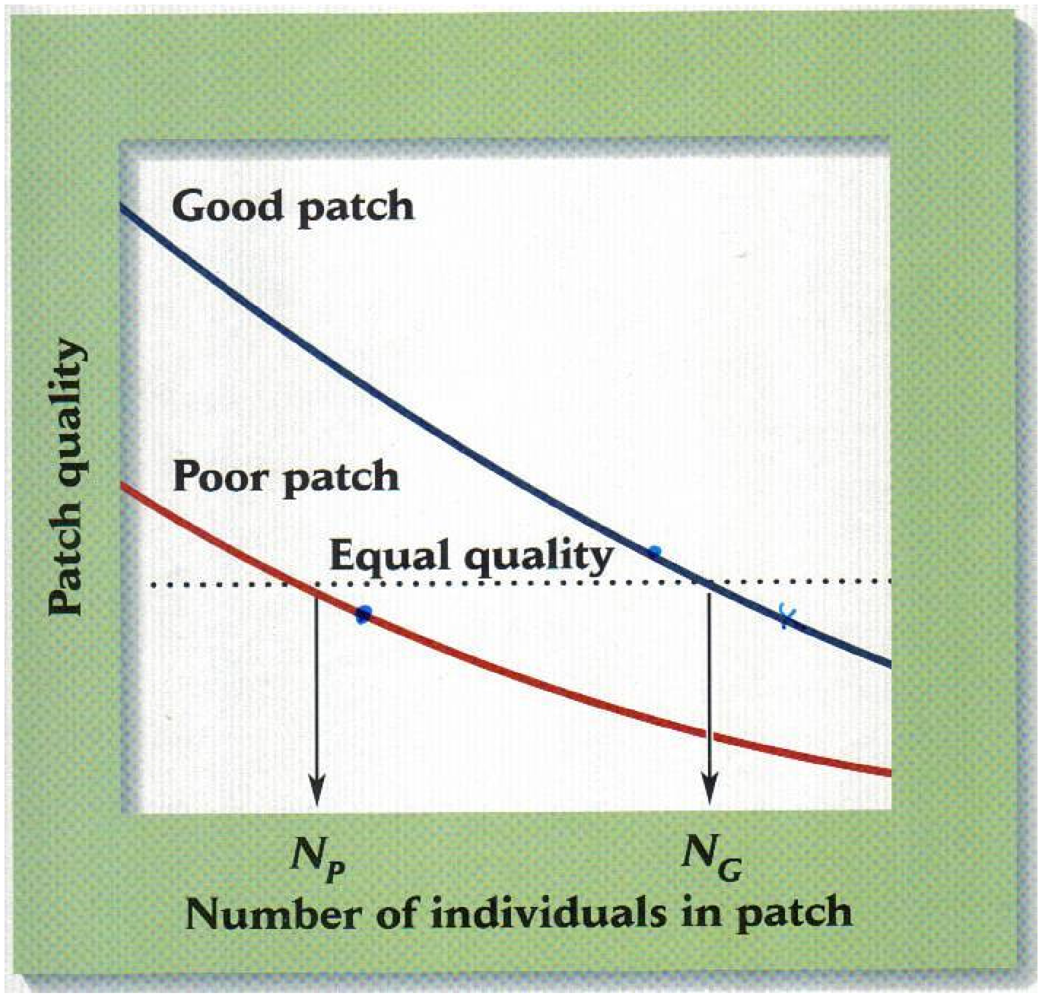
$$\Leftrightarrow n_i / n_j = K_i / K_j \text{; } all\ (i,\ j)\ pairs$$

Input Matching

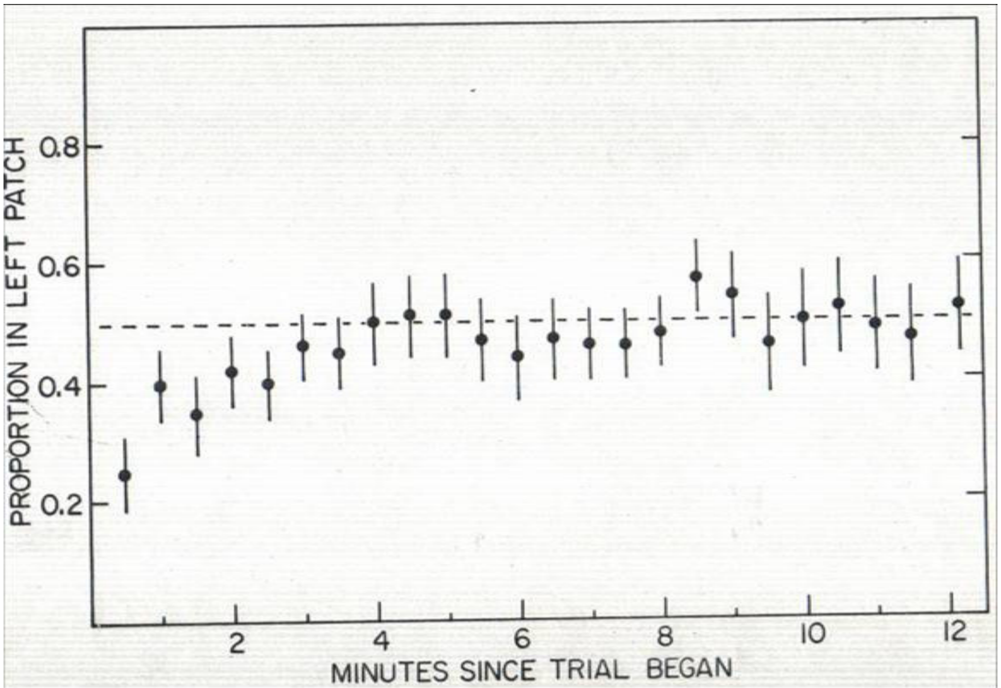
$$\frac{n_i}{\sum_j n_j} = \frac{K_i}{\sum_j K_j}$$

Fraction of Consumers = Fraction of Resources

IFD General

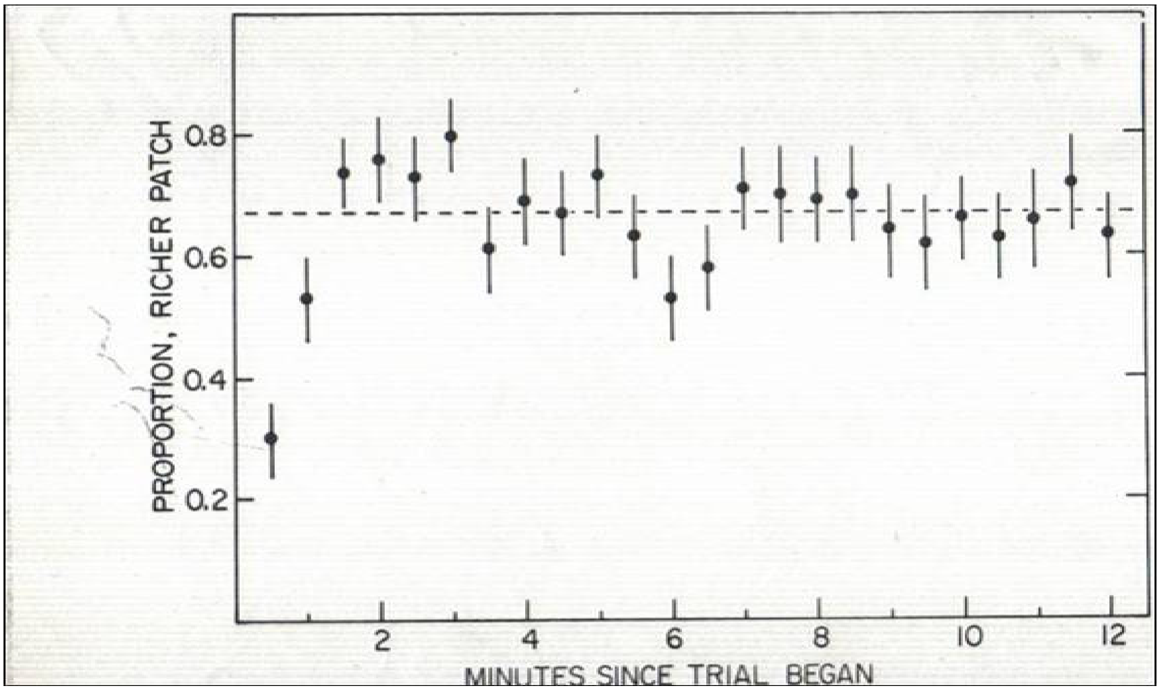

Good patch
Poor patch
Equal quality
Patch quality
N_P
N_G
Number of individuals in patch

UAlbany Ducks $K_1 = K_2$



Habitat Matching?

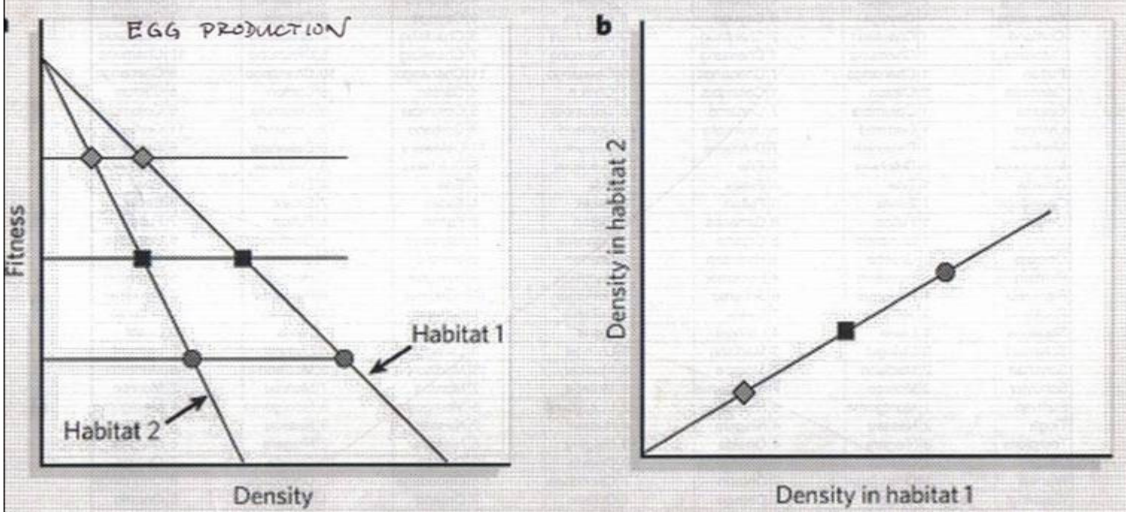
$K_1 = 2\ K_2$



PROPORTION, RICHER PATCH
0.8
0.6
0.4
0.2
2
4
6
8
10
12
MINUTES SINCE TRIAL BEGAN

HAUGEN ET AL (2006) PROC. ROY. SOC. B

PIKE : LAKE 2 BASINS, BREEDING POPULATION DISPERSION



$$n_2 = (K_2/K_1)\, n_1$$

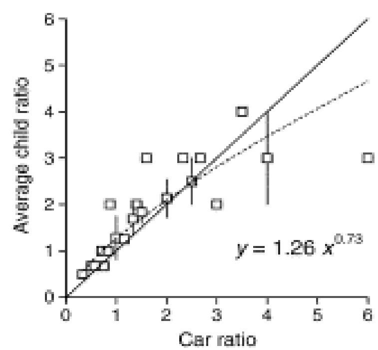
Disma et al. (2011, Evolution Human Behavior)

Istanbul: Children (8 – 11 yr old) sell 500-ml water bottles
to automobile drivers topped for traffic signal

Different traffic lanes (“patches”)
Different numbers of drivers ($k_1 \neq k_2$)

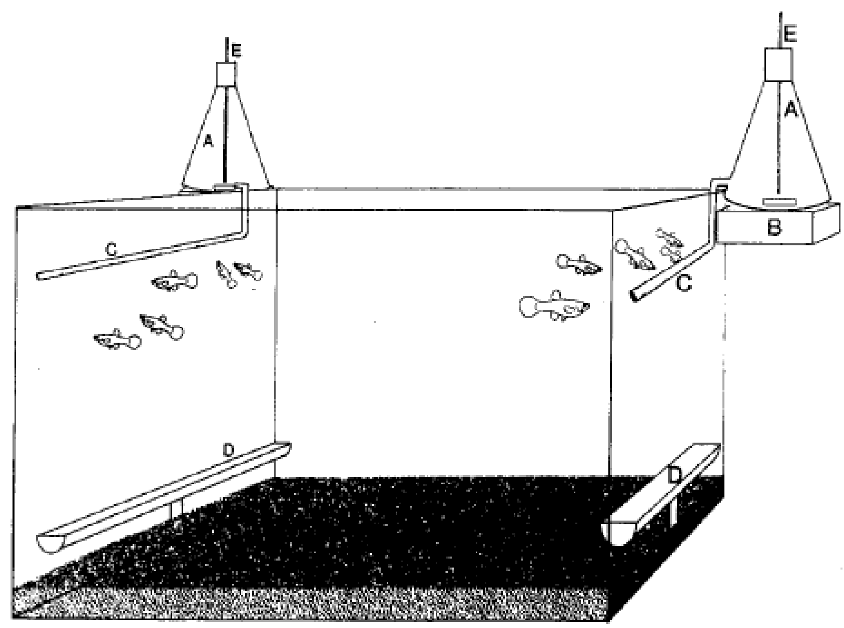
Authors applied logic of IFD
N_i: Number in lane i at IFD

$$N_1/N_2 = K_1/K_2$$



Match IFD Until “Saturated” by Customers

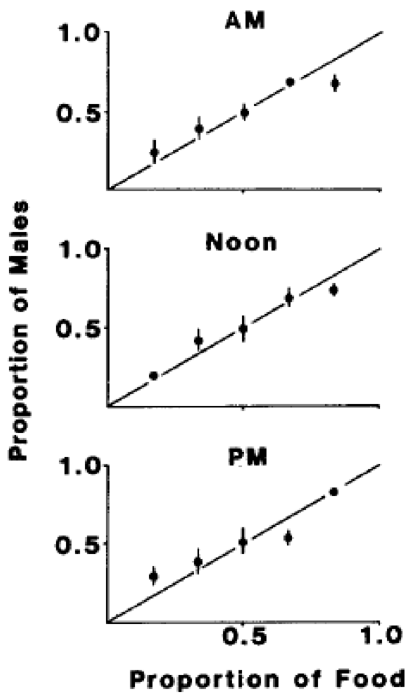
Fish in Aquarium (Abrahams, 1989, Ethology)



10 Male, 10 Female Guppies

Continuous resource input

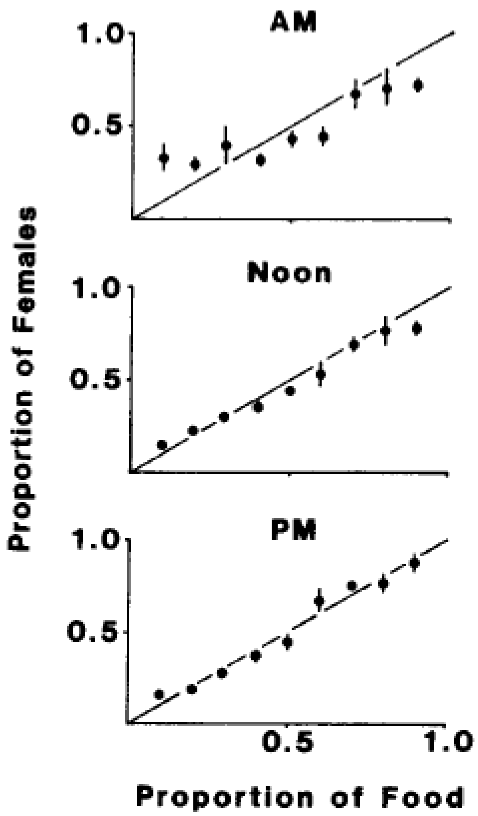
3 Trials/Group per Day



Males:

Input Matching Strong (IFD prediction)

Individuals Moved Between Patches Frequently



Females:

Under-matched First Trial

Individuals Tended to Remain at Feeder Selected

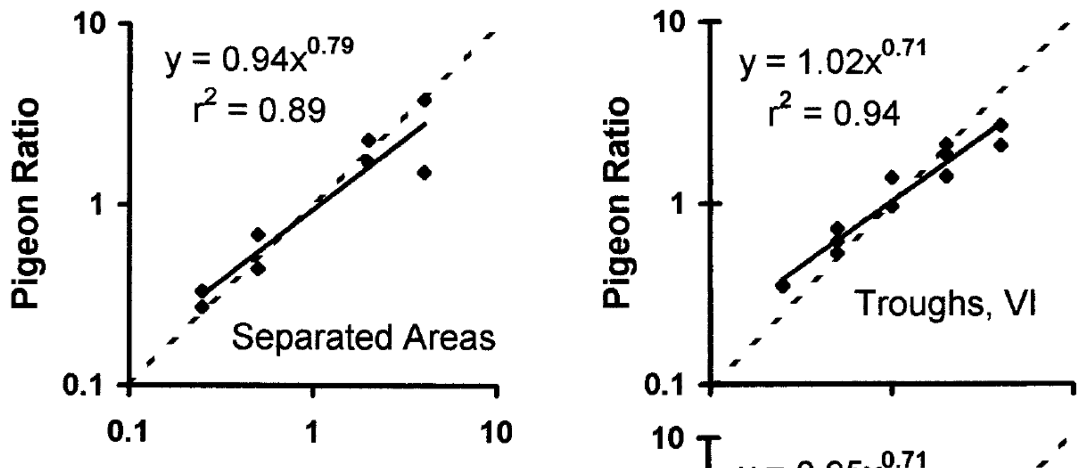
Baum and Kraft (1998, J Experimental Analysis of Behavior)

Domesticated Pigeons

Flock 30 Individuals

2 Patches; Each 1.2 m^2

Some Crowding: Violate “Free” Assumption



Broken line: $N_1/N_2 = k_1/k_2$ (IFD)

“Undermatching”

Few than predicted in richer patch

$\Leftrightarrow$

More than predicted in poorer patch

Violate assumption; Detect Experimentally