1 **Foraging Decisions: Context**
- 1.1 Importance: consequences for survival, reproduction
- 1.2 Foraging decisions:
  - abundance vs. quality
  - pursue vs. ignore
  - exposure to predation risk
- 1.3 Economic reasoning: maximize gain or minimize cost of some currency
- 1.4 Simple rules: simple organisms need not make complex decisions
- 1.5 3 kinds of foraging behavior:
  - (i) active search
  - (ii) sit and wait
  - (iii) mixed strategies

2 **Example 1: Maximizing Energy Gained**
- 2.1 Simple case: 2 prey types, 1 & 2
- 2.2 3 possible strategies
- 2.3 Equations for $E_1$ & $E_{12}$
\[
E_1 = \frac{T a_1}{t_1} \quad \quad E_{12} = \frac{T (a_1 + a_2)}{t_1 + t_2}
\]
- 2.4 Apply to demonstration:
\[
T = 5 \text{ sec} \quad a_1 = 10 \quad a_2 = 1 \quad \text{suppose } t_1 = 3 \quad t_2 = 1
\]
\[
E_1 = \frac{5 \times 10}{3} = 16.67 \quad E_{12} = \frac{5(10 + 1)}{3 + 1} = \frac{55}{4} = 13.75 \quad (E_2 = 5)
\]
Conc: eat type 1 only; ignore 2
- 2.5 Best strategy: ignore 2 if $a_1/a_2 > t_1/t_2$

3 **Example 2: Minimizing Foraging Time (what to eat when in a hurry)**
- 3.1 Intuition: when prey rare, eat all prey types
  - when prey abundant, selective
- 3.2 Simple case: 2 prey types
- 3.3 3 possible strategies
- 3.4 Compare strategies: Equations for $T_1$ vs. $T_{1&2}$:
\[
T_1 = \frac{1}{a_1} + t_1 \quad T_{1&2} = \frac{1}{a_1 + a_2} + \frac{a_1 t_1}{a_1 + a_2} + \frac{a_2 t_2}{a_1 + a_2}
\]
- 3.5 Best strategy: ignore prey type 2 if
\[
a_i > \frac{1}{t_2 - t_1}
\]
- 3.6 Conclusion: foragers should be more selective when overall prey abundance high
  - foragers should be less selective when overall prey abundance low

4 **Diet Breadth**
- 4.1 If increase variety in diet:
  - a) decrease search time ($T_s$) (more prey available)
  - b) increase handling time ($T_h$) (include difficult prey)
- 4.2 Optimal diet breadth = min($T_s + T_h$)
- 4.3 Increase environmental productivity $\rightarrow$ decrease $T_s \rightarrow$ increase specialization
5 Optimal Foraging Theory

5.1 Theory to predict behavior of efficient forager

5.2 Basic argument: optimality results from natural selection for efficient organisms
   5.2.1 survival & reproduction require energy (food)
   5.2.2 food resources are limited
   5.2.3 efficient foragers have more energy for survival & reproduction
      ⇒ have more offspring ⇒ higher fitness
   5.2.4 optimal foraging evolves because natural selection favors efficient foragers

5.3 Approach
   5.3.1 Identify currency that forager should optimize.
      2 primary currencies: time (minimize foraging time)
      energy (maximize energy gained)
   5.3.2 Develop models of foraging strategies in terms of currency
   5.3.3 Determine strategy that optimizes currency; predict animals will use it

5.4 Other Currencies
   5.4.1 Maximize rate of energy gain
   5.4.2 Maximize efficiency (max gain / min time)
   5.4.3 Minimize starvation risk
   5.4.4 Maximize survival

5.5 Critique of Optimal Foraging Theory
   5.5.1 Assumptions often violated in the field
   5.5.2 Often contradicted by observations & difficult to test
   5.5.3 “Adaptationist Programme” (cf, S.J. Gould)

6 Limitations of Optimal Foraging Theory
   6.1 Nutritional considerations ignored
   6.2 Predation risk may affect foraging
   6.3 Ignores learning
   6.4 Ignores efficiency of experience (search images)

7 Marginal Value Theorem
   7.1 Decision: when to change foraging area
   7.2 Assumptions: knowledge of environment
      7.2.1 know rate of food capture in current patch
      7.2.2 know projected rate of food capture in other patches
      7.2.3 know travel time to other patches
   7.3 Marginal Value Theorem:
      Leave current patch when food capture rate = average yield of entire habitat.
      Equivalently, “leave when can do better elsewhere.”
Derivation:

\[ F(t) = \text{amount food obtained in a patch during time } t; \text{ assume } F(0) = 0. \]
\[ R(t) = \text{rate of food gathering, including travel time between patches, } \tau. \]

\[ R(t) = \frac{\text{food/visit}}{\text{time/visit}} = \frac{F(t)}{t + \tau} \]

Determine \( t^* \), time to leave patch that maximizes \( R \).

\[ R'(t^*) = 0 \text{ and } R''(t^*) < 0, \text{ for some time } t^* > 0 \]

\[ \Rightarrow F'(t^*) = R(t^*) \]

Example: \( F(t) = bt - at^2 \); \( F'(t) = b - 2at \)

\[ b - 2at^* = \frac{bt^* - at^*^2}{t^* + \tau} \]

\[ at^*^2 + 2a \tau t^* - b \tau = 0 \]

Apply quadratic formula:

\[ t^* = -\tau \pm \sqrt{\tau(\tau + b/a)} \]

7.4 Prediction: optimal Giving Up Time (GUT) decreases as travel time betw/ patches decreases

7.5 Implications for various taxa

7.6 Few tests of Marginal Value Theorem

8 Learning and Foraging Behavior

9 Foraging Theory: different philosophical approach to science

– primacy of individual agenda vs. primacy of mechanism

10 Behavior in Groups

Complex group behavior emerges from simple individual rules.

References:


