UNIT 3. ECONOMIC DECISIONS AND THE INDIVIDUAL

SOURCES

required: Chapter 3 in Krebs & Davies (1993)
remedial: "Foraging & Storing" in Halliday 1994; "Finding Food" in The Trials of Life video series
supplement: Chapter 6 in in Blumstein, D.T. and Fernandez-Juricic, E. "A Primer of Conservation Behavior"

PARTS OF THIS LECTURE OUTLINE

1. Decisions
2. Currencies
3. Constraints

---

1. DECISIONS *(see also Table 3.1 in Krebs & Davies 1993:75)*

1.1. **Starlings: decide when, what, how, where?** *(Krebs & Davies 1993:48-49; Fig. 3.1)*
- 1.1.1. When? brood rearing season- feeding nestlings
- 1.1.2. How? probe in grass=>get a beak full=>fly to nest
- 1.1.3. What? worms: larvae called leatherjackets
- 1.1.4. Where? longer distances from nest are more costly (energy and time)

TIP: For other examples of foraging decisions that have been tested using optimality models, see Table 3.1 on page 75. This is also a good table because it clarifies how different currencies were used to test each decision rule. The constraints for each study are also listed. This table helps to integrate the information in each part of this lecture outline. These three concepts," decisions", "currencies" and "constraints" are the keyword concepts you should think of when you hear the words "optimality model".

1.2. **Optimality model:** graph foraging in starlings *(Krebs & Davies 1993:49-51; Fig. 3.2)*
- 1.2.1. Benefits: optimal load size- diminishing returns (benefits)
  - 1.2.1.1. with each additional worm, less likely to catch another
  - 1.2.1.2. decision: when to give up and deliver worms?
- 1.2.2. Costs: optimal travel time- increasing costs with distance from nest
- 1.2.3. theoretical prediction of optimum from graph of costs:benefits
  - 1.2.3.1. short distance=>smaller load
  - 1.2.3.2. long distance=>larger load

1.3. **Test of alternative models** (hypotheses) *(Kacelnick 1984 cited in Krebs & Davies 1993:52-53)*
- 1.3.1. starlings were fed meal worms under controlled conditions
  - 1.3.1.1. benefit: diminishing returns=rate of delivery (through tube to table)
  - 1.3.1.2. cost: varied distance from nest (8- 600m)
- 1.3.2. predictions were based on alternative models
  - 1.3.2.1. Model 1: currency= time
  - 1.3.2.2. Model 2: currency= energy
- 1.3.3. observations matched Model 1 (time) not Model 2 (energy)

1.4. **Take-home message: Decisions**
- 1.4.1. foraging decisions: when, what, how, where?
- 1.4.2. compare alternative models: currencies used to predict costs and benefits
- 1.4.3. test re. starlings: disproved energy model, accepted time model

Part 1	**Study Questions for Chat & Quiz 3 "Testing hypotheses: comparative approach"**
1.1	In a species of your choice, what are the foraging decisions? (TIP: explain when, what, how, where for starlings)
1.2	What are the costs and benefits influencing optimal load size for a species of your choice? (TIP: compare short vs. long distance in starlings)
1.3	What definitive data were used to test the validity of alternative hypotheses for foraging in a species of your choice? (TIP: time vs. energy models in starlings)
1.4	Does natural selection shape only one type of foraging decision, or all types? (TIP: V in VHDP)

CURRENCIES ***(see also Table 3.1)***

1.5. How to measure the cost:benefit ratio predicted by optimality models? *(Krebs & Davies 1993:50-58,60-63)*
- 1.5.1. rate of food intake (starlings, great tits, woodpeckers)
- 1.5.2. efficiency: energetic cost to carrying heavy load (bees)
- 1.5.3. risk sensitivity: starvation (juncos) and predation (sticklebacks)

1.6. **Alternative models** of risk sensitive behavior in variable environment *(Krebs & Davies 1993:63-70)*
- 1.6.1. Myth: "Eat, for you never know when will be the next meal!"
- 1.6.2. Science: predict when birds will switch options depending on conditions
  - 1.6.2.1. Decision 1: Risk-aversive (snack on small predictable meals)
  - 1.6.2.2. Decision 2: Risk-prone (wait for unpredictable large meals)
- 1.6.3. Currencies: risk of starvation; risk of predation

1.7. **Currency 1. Risk of starvation:** yellow-eyed juncos *(Caraco et al. 1990 cited in Krebs & Davies 1993:64-65)*
- 1.7.1. choice of food delivery in an aviary: 2 feeder options
  - 1.7.1.1. **Decision A.** fixed delivery (medium payoff everytime; 3 seeds)
    - 1.7.1.1.1. Prediction: if juncos were **risk-aversive**, they would choose this feeder
  - 1.7.1.2. **Decision B.** variable delivery (50% gamble; 0 or 6 seeds)
    - 1.7.1.2.1. Prediction: if juncos were **risk-prone**, they would choose this feeder
- 1.7.2. varied external conditions (temperature) to test whether juncos decided based on the weather condition
  - 1.7.2.1. Condition A Warm (19C): low risk; juncos chose the Risk-adverse Option (3 seeds)
  - 1.7.2.2. Condition B. Cold (1C): high risk; juncos chose Risk-prone Option (0-6 seeds)

1.8. **Currency 2. Risk of predation:** stickleback fish *(Milinski & Heller 1978 cited in Krebs & Davies 1993:68-69)*
- 1.8.1. choice of food delivery in aquarium (water flea density at 2, 20, 40)
  - 1.8.1.1. **Decision A. Risk-aversive**: fed in low density patch (high vigilance for predator)
  - 1.8.1.2. **Decision B. Risk-prone**: too busy feeding to watch for predator at high density
- 1.8.2. varied internal state: hungry fish chose dense over less dense patch
- 1.8.3. varied external condition: with or without predator (kingfisher image)
  - 1.8.3.1. hungry fish with predator=> Risk-aversive
  - 1.8.3.2. hungry fish without predator=> Risk-prone

1.9. **Currency 2. Risk of predation**: bluegill sunfish *(Werner et al. 1983 cited in Krebs & Davies 1993:69-70)*
- 1.9.1. choice of patch within habitat (pond bottom, pond top, pond edge)
  - 1.9.1.1. **Decision A. Risk-aversive**: feed at pond edge with protective reeds, little food
  - 1.9.1.2. **Decision B. Risk-prone**: feed at pond bottom with lots of worms (chironomids)
- 1.9.2. varied external conditions: ponds with and without bass (predators)
- 1.9.3. observed variation based on size: small fish more vulnerable
  - 1.9.3.1. small bluegills=> risk-aversive ("the kids stay in the nursery")
  - 1.9.3.2. large bluegills => risk-prone ("the big-guys can afford to gamble")

1.10. Take-home message: currencies
- 1.10.1. alternative models based on: rate, efficiency, risk sensitivity
- 1.10.2. risk-sensitivity: e.g. starvation (juncos, sticklebacks), predation (sticklebacks, bluegills)

Part 2	**Study Questions for Chat & Quiz 3 "Testing hypotheses: optimality approach"**
2.1	What are 3 types of currencies used to test the cost:benefit ratios predicted by optimality models?
2.2	What are 2 alternative decisions and 2 currencies used to examine risk sensitive foraging behavior?
2.3	How was variation in risk sensitive behavior tested in a species of your choice? (TIP: e.g. juncos, sticklebacks, sunfish)
2.4	How does "currency" relate to differential fitness in the logic of natural selection? (TIP: D in VHDP)

2. CONSTRAINTS *(see also Table 3.1)*

2.1. **Hidden assumptions** of optimality models need testing
- 2.1.1. P: perfect knowledge of the costs and benefits (e.g. sampling)
- 2.1.2. E: external conditions do not change during the study (e.g. temperature)
- 2.1.3. I: internal state of the animal does not change during study (e.g. hunger)
- 2.1.4. C: constraints; physiological limits (e.g. small stomach, salt need)

2.2. **Dietary constraint**: sodium and rumen constraint in moose (Belovsky 1978)
- 2.2.1. Myth: moose choose a high energy diet (sugar maple over pond weeds)
- 2.2.2. Science: moose choose a mixed diet that meets their need for salt
  - 2.2.2.1. best model was based on sodium, rumen size and energy
  - 2.2.2.2. due to small rumen, moose can't fill all energy needs with aquatic plants

2.3. **Dietary constraint**: digestive capacity of Columbian ground-squirrel (Belovsky 1986a)

- 2.3.1. Myth: ground-squirrels choose most digestible plants ("cheerios over bran")
- 2.3.2. Science: ground-squirrels=> mixed diet (energy, time, digestive capacity)
  - 2.3.2.1. general model: herbivores optimize energy given constraints (bulk, time)
  - 2.3.2.2. critique: bulk should be measured in terms of dry, not wet matter

2.4. **Take-home messages: Constraints**

- 2.4.1. assumptions about physiological processes should be tested
- 2.4.2. e.g. digestive capacity, handling time, scarce nutrient needs (moose, ground-squirrels)

Part 3	**Study Questions for Chat & Quiz 3 "Constraints"**
3.1	What hidden assumptions of optimality models need testing to determine the validity for each study? (TIP: PEIC)
3.2	How were constraints on optimal foraging identified in a study of your choice? (TIP: scarce nutrient, digestive capacity; see outline 3.2-3.3)
3.3	If physiological constraints limit the validity of optimality models, what is the value of the optimality approach? (TIP: test assumptions; see outline 3.4)

3. SUMMARY

3.1. **Decisions:** when, what, how, where?
- 3.1.1. optimal foraging models: tradeoffs between costs (travel) and benefits (load size)
- 3.1.2. test re. starlings: disproved energy model, accepted time model

3.2. Currencies
- 3.2.1. alternative models based on: rate, efficiency, risk sensitivity
- 3.2.2. risk-sensitivity: e.g. starvation (juncos, sticklebacks), predation (sticklebacks, bluegills)

3.3. Constraints
- 3.3.1. assumptions about physiological processes should be tested
- 3.3.2. e.g. digestive capacity, handling time, scarce nutrient needs (moose, ground-squirrels)

TIP: This chapter lays the foundation for how models of behavioral ecology will be tested throughout the book. This is the simplest model related to finding food. It shows how animals change their decisions based on changes in body condition and in the variability of when and where resources are available in their environment. The models will get more complex!

Summary	**Study Questions for Chat & Quiz 3 "Economic Decisions, Currency & Constraints"**
4.1	What were 3 take-home messages re. individual economic decisions?
4.2	How do optimality models of foraging decisions, currency and constraints relate to the functional approach?