What does it mean to say animals optimize? Do they optimize regarding food and habitat selection, and if so, on what bases?

Spiders can customize their webs to make sure they get the diet they need.

if flies are the only food, spiders adjust their web to catch enough flies to get the protein they need by making a web with bigger catching area and smaller mesh size.

If crickets are the main food, the web gets stronger and stickier to withstand the extra force required to keep crickets captive in the web.
Models of Foraging

Some contend red deer select a diet based on protein, others contend they optimize for energy.

Animals exhibit partial preferences. Why?

Based on the Matching Law
Match - distribute efforts with rewards
Undermatch - under-use better sites
Overmatch - over-use better sites

Ideal Free Distribution
Designed to predict the distribution of organisms among patchy resources or habitats, and to link behavioral and population ecology.

Observations
Regional (seasonal migrations) $\rightarrow$ match
Landscape (plant communities) $\rightarrow$ match
Within plant communities $\rightarrow$ over-match
Patch (food selection) $\rightarrow$ under-match

The IFD typically does not correctly predict distributions of foraging animals.

The distribution of animals consistently under-matches the distribution of resources.

Assumption
Animals have good knowledge about resource profitability.

The IFD will be less applicable when patch quality fluctuates rapidly or where it is difficult or costly to sample.
Models of Foraging

Assumption
Preferences for diets and habitats are similar for individuals within a species.

This has implications for all facets of life.

Diet/Habitat

Quality

Time

Body Size

Digestive Capacity

Physiology

Morphology

Body Size

Digestive Capacity

Large herbivores have relatively low metabolic requirements, long food retention times in the gut, and large mouth size. This makes them better able to tolerate fiber and consume lower-quality forage.

Ruminants generally require food of a higher quality than non-ruminants. The rumen reduces the rate of passage of digesta through the gastro-intestinal tract, whereas the ceca do not.
Models of Foraging

<table>
<thead>
<tr>
<th>Body size</th>
<th>Digestive system</th>
<th>Rumen volume (liter/kg)</th>
<th>Mouth size</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>large (1)</td>
<td>rumen</td>
<td>large (.25)</td>
<td>large</td>
<td>cattle</td>
</tr>
<tr>
<td>large (2)</td>
<td>caeca</td>
<td>—</td>
<td>large</td>
<td>zebra</td>
</tr>
<tr>
<td>small (3)</td>
<td>rumen</td>
<td>large (.25)</td>
<td>small</td>
<td>sheep</td>
</tr>
<tr>
<td>small (4)</td>
<td>rumen</td>
<td>small (.10)</td>
<td>small</td>
<td>goat</td>
</tr>
<tr>
<td>large (5)</td>
<td>rumen</td>
<td>small (.11)</td>
<td>large</td>
<td>eland</td>
</tr>
</tbody>
</table>

(1) Cattle: time constrained due to size - tolerate coarse forages.
(2) Zebra (horse): as 1 above, but tolerate coarser forage – not limited by rumen fermentation and rate of passage.
(3) Sheep: less time constrained than 1 and 2 due to small size – can ingest poor quality forage due to large rumen.
(4) Goats (deer): less time constrained than 1 and 2 due to small size – require high-quality forage.
(5) Eland: time constrained due to large size and relatively small rumen volume – requires high-quality diet.

**Body Morphology & Physiology**

This model classifies ruminants as concentrate selectors, intermediate selectors, and roughage eaters based on morphology and physiology.

What are the implications of body size, morphology and physiology for mixed-species grazing?

What are the implications of body size, morphology and physiology for selecting replacement animals that match the landscape?
How do bison from the tall grass prairie differ from bison in the arid southwest?

Models of Foraging

Learning (Behavior)

Optimality (Fitness)

Physiology (Function)

Morphology (Form)

Euphagia

Hedyphagia

Diet Selection

Nutrients

Toxins

Euphagia

Hedyphagia

Euphagia

Animals can sense, through smell and taste, nutrients and toxins in plants. Some distinctive gastrointestinal or systemic stimulation during feeding might also be a cue that the diet contains a particular nutrient or toxin.

Hedyphagia

Animals obtain a nutritious diet by selecting vegetation that is immediately "pleasing" to the senses of smell, taste, and touch and avoiding that which is not.

Evolution progresses such that plant compounds that are nutritious ultimately have come to taste (sweet and salty) good and those that are toxic have come to taste bad (bitter and sour), all through natural selection.
Models of Foraging

We typically discuss nutrient/toxin content of food and palatability as if they are unrelated. Are they related, and if so, how? Does a body know what it needs, and if so, how?

Do animals eat nutritious foods because they taste good?
OR
Do foods taste good because they are nutritious?

How learning about foods and habitats influences the behavior of herbivores and ecosystems.

Functionally Integrating Nutrition and Behavior

Nutrition: processes by which organisms take in and assimilate food to promote growth and replacing worn or injured tissues.

Behavior: furthers the interchange between animals and environments.
Models of Foraging

Respondent (Pavlovian) Conditioning

Responses prepared in advance by natural selection come under the control of new stimuli.

Operant Conditioning

Responses are strengthened by events that follow.

Reinforcement increases rates of responding
Positive – creature wants
Negative – creature wants to avoid

Positive Reinforcement

"This is it, son — my old champin' grounds... God, the memories."

Negative Reinforcement

"Oh, he’s asleep. Pull the wagon, buck, and I’ll start holler my head off — God, I love this."

Punishment decreases rates of responding
Positive – present aversive
Negative – remove positive
Models of Foraging

Temporal Contiguity
The more delayed in time or distant in space the consequences, the less likely the consequences will influence the behavior.

Positive Punishment

Negative Punishment

Changing the Culture of Welfare Elk
Concerns:
costs of feeding 1,000 elk all winter,
spread of brucellosis, chronic wasting disease, wolves

Strategic use of “carrots and sticks” (cattle grazing, supplementation, herding, hunting) changed food and habitat selection behaviors of elk.

Areas grazed by cattle early in summer are attractive to elk in fall and winter due to the combination of re-growth and mature forage.
Models of Foraging

Supplemental energy and protein enable herbivores to eat more sagebrush.

Stopped feeding (negative punisher) to encourage elk not to use feed grounds.

Elk were fed occasionally and only in areas they wanted elk.

Since the project was initiated in 2004, elk have been fed only in 2005 and 2010.

Schedules of Reinforcement
- Continuous (each time)
- Fixed ratio/interval (fixed number/amount of time)
- Variable ratio/interval (variable number/amount of time)

Used stockmanship to move (negative reinforcement) and place (positive reinforcement) elk in desired locations.

Used hunting (positive punisher) to decrease elk use of areas where they were previously fed.
Models of Foraging