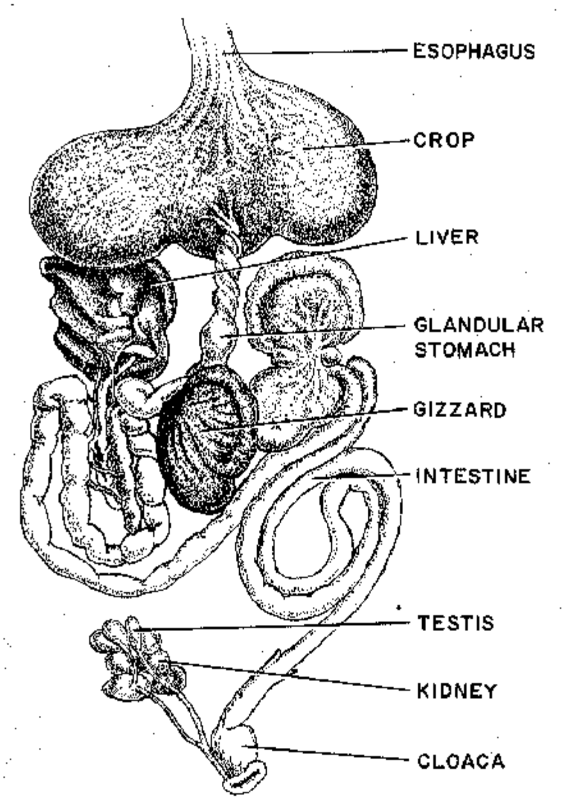
WLF 419 - Waterfowl and Wetlands Ecology and Management
Lecture 4 - Foraging Ecology
Next Time - Nutritional Ecology

- Long History of Studies of Waterfowl Feeding Ecology
  - Early interest from economic impacts on agriculture
  - 1885 Section of Economic Ornithology in Department of Interior
    - field feeding of geese in 1880's in Manitoba
    - Economic Ornithology precursor to US Fish and Wildlife Service
  - Pre 1960's
    - studies largely limited to hunter shot birds
    - did not frequently distinguish between age, sex, and reproductive classes
    - relied heavily on gizzard content
  - Post 1970 (Swanson and Bartonek 1970)
    - esophageal content used to interpret:
      - food use relative to sex
      - reproductive status
      - nutrient dynamics
      - site-specific food abundance



IGURE 6–1. The digestive tract of a pigeon. After chimkewitsch and Stresemann.

From Welty (1982)

- How?
  - Analysis of esophageal content
  - Some fecal analysis for grazing species when collection is not possible

- " Metrics
  - Frequency of occurrence
    - # What % of the sample (birds) had food item X?
    - # food selection when combined with data on availability
  - Aggregate weight (dry) or volume
    - # Aggregate volume (or weight):

$$\frac{\textit{volume of food } X}{\textit{Total volume of foods in sample}}$$

    - # Nutritional relationships
    - # Potential bias
      - * Rare foods in high volume in few individuals may unduly influence estimates
      - * No replication?
      - * most appropriate when time spent searching for prey limits food intake
  - Aggregate percentage
    - # Aggregate weight or volume for each bird averaged over all birds
    - # Equal weighting for each bird
    - # Assumption: Composition of diet is unrelated to size distribution of food sample
      - * most appropriate when food-processing rates limit food intake
    - # Nutritional relationships
    - # Most commonly used method today

! Why?
- " Maintenance
- " Energy Demands
  - Migration
  - Wintering
- " Reproduction

! Properties
- " Determined from proximate analysis
- " Water
- " Dry Matter

- Ash, Inorganic Mineral (e.g., calcium, phosphorus)
    - # Important for proper function of several systems
- Organic
    - # Protein
        - * Growth and Maintenance tissue
        - * Composed of Amino Acids
            - + Nonessential - synthesized by body
            - + Essential - dietary source
        - * Low energy
    - # Lipids
        - * Energy storage
    - # Carbohydrates
        - * Quick energy (glycogen)
        - * Excess stored as fat
    - # Fiber (e.g., cellulose)
        - * Some energy from fiber

" Gross Energy, Metabolizable Energy, and True Metabolizable Energy

Table 1. *Chemical composition of some common waterfowl plant foods. Values represent averages from the literature.*

Common name[a]	Gross energy (kcal/g)	Fat	Fiber	Ash	NFE	Protein
Sticktights	5.177	16.0	19.7	7.2	27.5	25.0
Schreber watershield	3.790	2.9	36.7	4.8	46.9	9.3
Pecan hickory	7.875	40.8	19.0	12.6	35.1	8.4
Chufa flatsedge (tubers)	4.256	6.9	9.0	2.5	55.4	6.7
Hairy crabgrass	4.280	3.0	11.1	9.7	59.4	12.6
Barnyardgrass	3.900	2.4	23.1	18.0	40.5	8.8
Rice cutgrass	3.982	2.0	10.6	9.5	57.8	12.0
Fall panicum	4.005	3.1	16.8	16.1	50.1	12.3
Smartweed	4.423	2.8	22.0	7.5	—	9.7
Pennsylvania smartweed	4.315	2.3	21.8	4.9	63.3	9.0
Pin oak	5.062	18.9	14.7	1.8	58.6	6.4
Willow oak	5.296	20.6	14.0	1.7	55.3	5.1
Curly dock	4.278	1.2	20.4	6.9	—	10.4
Duck potato	4.736	9.0	10.8	4.9	55.5	20.0
Milo	4.229	3.1	6.0	3.5	72.2	10.2
Corn	4.435	3.8	2.3	1.5	79.8	10.8
Common soybean	5.451	20.5	5.4	6.2	27.1	39.6
Common duckweed	4.235	3.5	11.3	10.7	49.8	25.7
River bulrush (rhizomes)	4.010	—	—	—	—	—

[a]For alternative common names and scientific names consult Appendix.

Table 2. *Chemical composition of some common waterfowl invertebrate foods.*

Invertebrate	Gross energy (kcal/g)	Protein (%)
Water boatmen	5.2	71.4
Back swimmers	5.7	64.4
Midges	4.6	61.2
Water fleas	4.0	49.7
Amphipods (*Hyalleia azteca*)	4.9	47.6
Amphipods (*Gammarus* spp.)	3.8	47.0
Cladocera (unclassified)	2.7	31.8
Pond snails	1.0	16.9
Orb snails	1.0	12.2

***Fish and Wildlife Leaflet* 13 • 1988**

Table 3. *Metabolizable energy of some common waterfowl foods.*

Taxon	Test animal	Metabolizable energy (kcal/g)
Water flea	Blue-winged teal	0.82
Amphipod (*Gammarus* spp.)	Blue-winged teal	2.32
Pond snail	Blue-winged teal	0.59
Coast barnyardgrass	Duck (male)	2.63
Coast barnyardgrass	Duck (female)	2.99
Rice cutgrass	Duck (male)	3.00
Common duckweed	Blue-winged teal	1.07
Pennsylvania smartweed	Dabbling duck (male)	1.12
Pennsylvania smartweed	Dabbling duck (female)	1.10

***Fish and Wildlife Leaflet* 13 • 1988**

Note: 1kJ = 0.239 kcal

From Fredrickson and Reid (1988)

! What?

- " Ducks (mostly Aythyini and Anatini)
  - \- Fall and Winter
    - # Meet energy demands of migration and weather
    - # Heavy use of plant material, particularly seeds (including crops)
      - * Source of carbohydrates

Table 15.1. Aggregate percent, percent aggregate volume, and percent occurrence of food items in the diet of 50 canvasbacks on the upper Mississippi River[a]

Food item	Aggregate percent	Percent aggregate volume	Percent occurrence
Plant			
Vallisneria americana winter bud	39.0	42.5	44.0
Sagittaria rigida tuber	49.6	56.0	46.0
Potamogeton crispus winter bud	4.8	0.2	6.0
Vallisneria americana leaf	3.1	0.9	8.0
Ceratophyllum demersum leaf	2.2	T[b]	2.0
Potamogeton pectinatus tuber	0.1	0.1	2.0
Scirpus fluviatilis seed	T	T	2.0
Potamogeton richardsonii seed	T	T	2.0
Potamogeton pectinatus seed	T	T	2.0
Other seeds and tubers	T	T	8.0
Total	98.8	99.7	
Animal			
Oligochaeta	0.7	0.2	2.0
Hexagenia spp.	0.5	0.1	2.0
Hyalella azteca	T	T	2.0
Other invertebrates	T	T	12.0
Total	1.2	0.3	

[a]Total food volume was 243.9 cm^3.
[b]T = trace.

From Korschgen et al. (1988)

    - # Agricultural foods
      - * High Availability
      - * Switch from natural sources based on foraging efficiency?
      - * Complete (balanced diet)
      - * Some economic conflicts
      - * Permanent food source?
      - * Switch to more profitable crops
      - * Harvest efficiency
  - \- Spring
    - # Major shift to macroinvertebrates during laying
      - * Highlighted importance of seasonal wetlands
    - # Surprising, given previous emphasis on fall diet and gizzard content

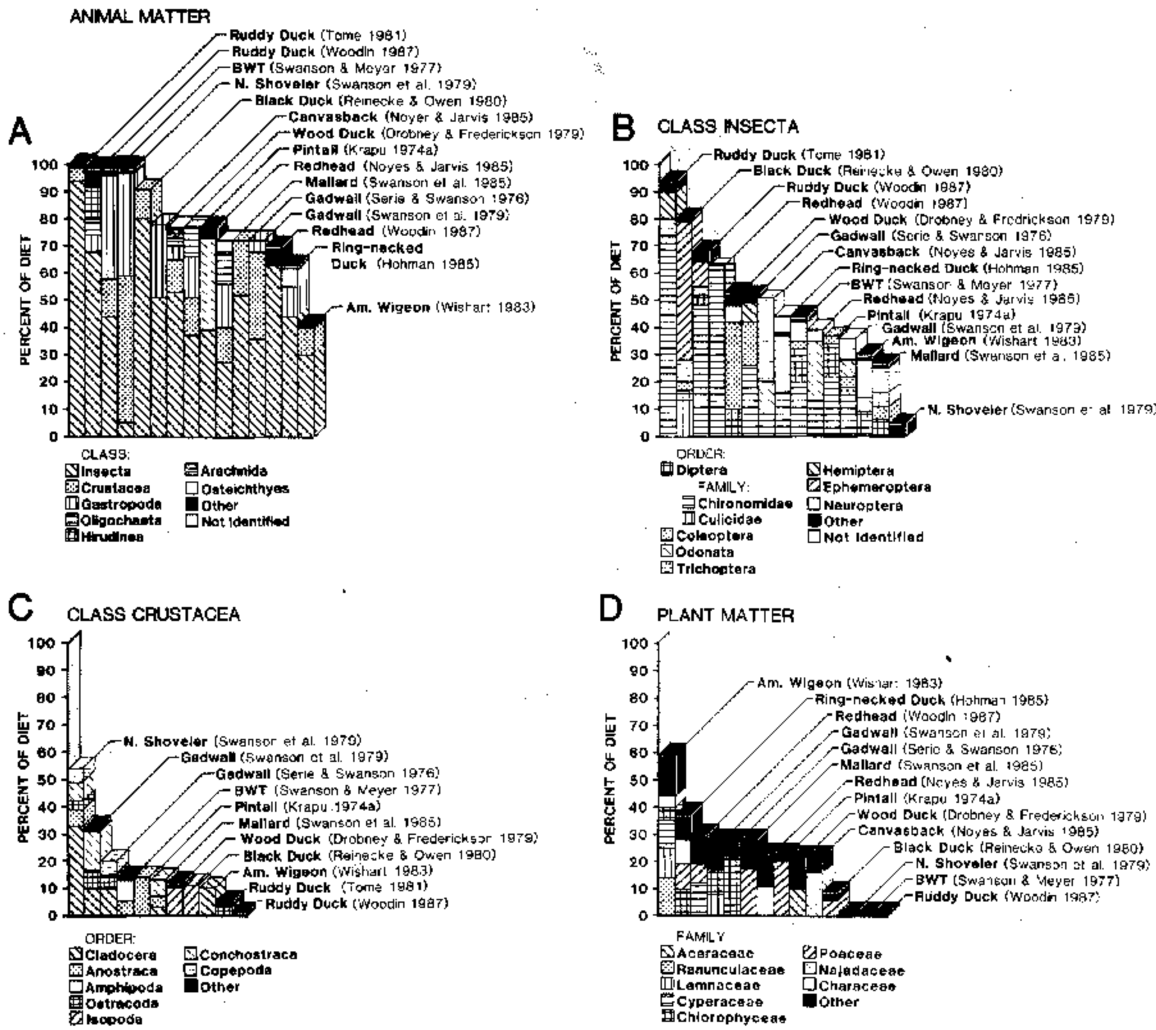


Figure 1-1. Composition of the diet of female ducks (Subfamily Anatinae) during the laying stage of the reproductive cycle. Prelaying and laying stages are combined for the Ring-necked duck.

Much less foraging time for males

Table 1-3. Diurnal foraging effort (%) of ducks during the breeding season

	Female				Male				
Species	Arrival	Pre-laying	Laying[a]	Incubation[a]	Arrival	Pre-laying	Laying	Incubation	Reference
Anas strepera[b]	72	69	74	–	70	52	26	–	Dwyer (1975)
Anas platyrhynchos	–	18	55	38	–	15	20	9	Dwyer et al. (1979)
Anas fulvigula	–	49	62	62	–	50	54	56	Paulus (1984)
Anas rubripes	95	89	91	>90	84	75	75	33	Seymour and Titman (1978)
Anas acuta	25	43	40	60	24	36	30	–	Derrickson (1977)
Anas discors	–	52	66	78	–	29	39	29	Stewart and Titman (1980)
Anas clypeata	69	58	57	68	64	54	35	–	Afton (1979)
Melanitta fusca	–	60	61	61	–	57	49	–	Brown and Fredrickson (1987)
Oxyura jamaicensis	–	63	89	69	–	–	–	–	Tome (1981)

[a]Excludes time spent at the nest by females.
[b]Estimated from Figure 1 in Dwyer (1975).

From Krapu and Rienecke (1992)

- Summer
  - # Limited feeding by breeding female during incubation
  - # Adults rely heavily on animal foods during brood rearing

From Krapu and Rienecke (1992)

- # Ducklings
  - * Mostly invertebrates during early development

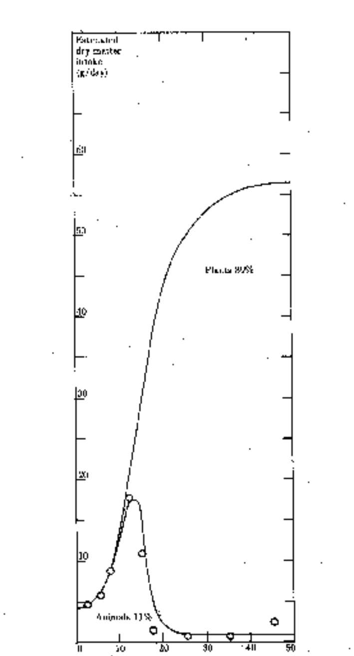
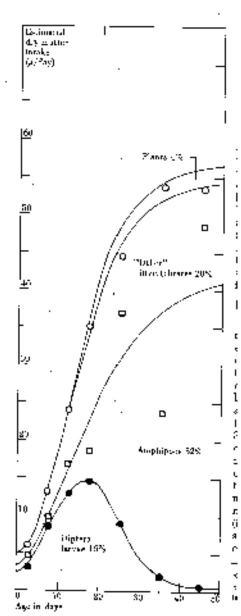


Fig. 3. Changes in plant and animal food intake by young American Widgeons.



Lesser Scaup

From Krapu and Rienecke (1992)

" Swans and Geese

- Mostly herbivores
- Limited data on esophageal content in some cases
- Fall and Winter
    - # Heavy reliance on agricultural crops
        - * Exception; brant, emperor geese, and swans
    - # Change in winter distribution and migration corridors

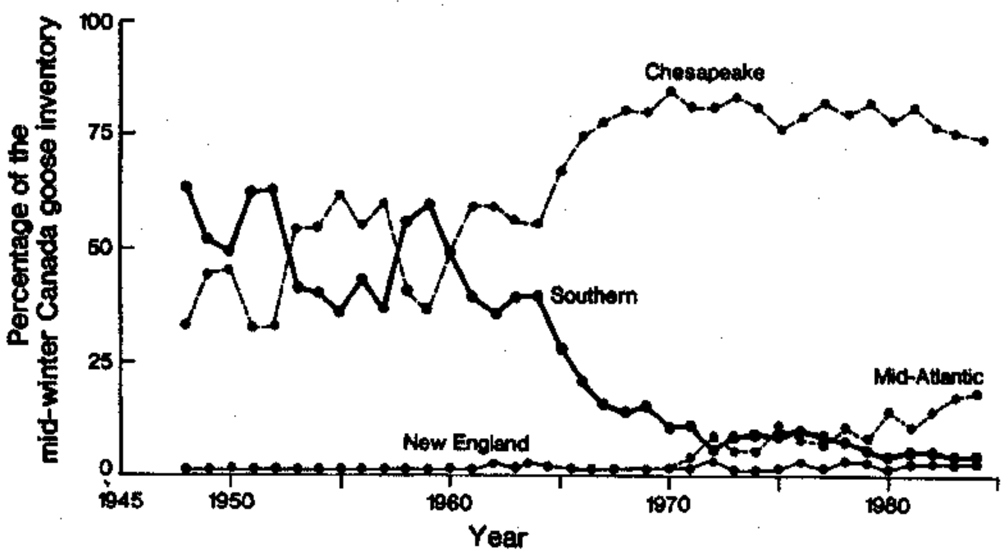


Fig. 3. Changes in the proportional distribution of Canada geese wintering in 4 regions of the Atlantic Flyway, 1948–1984. Proportions were calculated by dividing the total mid-winter estimate for each region by the total mid-winter estimate for all of the states in the Atlantic Flyway.

From Trost and Malecki (1985)

- Spring and summer
    - # Swans
        - * Heavy reliance on plants
    - # Geese
        - * Most species rely on agricultural grains in spring

Table 1-4. Principal foods of North American geese during the breeding season

Species	Location	Reproductive stage: Prenesting	Laying	Incubation	Brood-rearing	Reference
Anser albifrons	Y-K Delta,[a] Alaska	*Hippuris* spp. "Grasses" "Sedges"	–	–	–	Ely (1979)
		Arctophila fulva *Triglochin palustris*	–	–	–	Budeau (1989)
Anser caerulescens caerulescens	McConnell River, N.W.T.	Poaceae Cyperaceae Juncaceae	Poaceae Cyperaceae Juncaceae	Poaceae Cyperaceae Juncaceae	Poaceae Cyperaceae Juncaceae	Harwood (1977)
Anser canagicus	Y-K Delta, Alaska	*Elymus arenarius* *Potamogeton pectinatus*	*Carex rariflora* Cyperaceae	*Carex rariflora* Cyperaceae	–	Eisenhauer and Kirkpatrick (1977)
Branta canadensis minima	Y-K Delta, Alaska	"Grasses" "Sedges"	"Grasses" "Sedges"	*Carex* spp. "Grasses"	"Craneflies, midges" *Carex* spp. *Calamagrostis* sp.	Mickelson (1975)
Branta canadensis occidentalis	Cop-R Delta,[b] Alaska	*Equisetum* sp. *Carex* spp.	*Equisetum* sp. *Carex* spp.	*Carex* spp. *Salix artica* *Equisetum* spp.	–	Bromley (1984)
Branta bernicla	Southampton Island, N.W.T.	–	*Puccinellia* spp. *Carex* spp.	*Puccinellia* spp. *Carex* spp.	–	Ankney (1984)

[a]Yukon-Kuskokwim River Delta.
[b]Copper River Delta.

From Krapu and Reinecke (1992)

* Nutrients gathered during spring (and winter) imported to breeding grounds

Use of Nutrient Reserves - CAGO

From Raveling (1978)

M CAGO	*PRE*	*POST*		
Mass	1871	1530		
Fat	386	56	= 330 g x 9.45 kcal/g x 4.18 kj/kcal	= 13047.8 kj
Protein	382	370	= 12 g x 5.65 kcal/g x 4.18 kj/kcal	= 283.7 kj
				13331.5 kj

From Time Budgets

PRE - POST Expend

1398 kj/day x 3 days = 4194 kj
1342kj/day x 6 days = 8052 kj
12246 kj

Therefore endogenous reserves account for:
13331.5kj/12246kj = 100% of energy expenditure

From Raveling (1978)

F CAGO	*PRE*	*POST*		
Mass	1890	1387		
Fat	532	171	= 361 g x 9.45 kcal/g x 4.18 kj/kcal	= 14273.5 kj
Protein	352	272	= 80 g x 5.65 kcal/g x 4.18 kj/kcal	= 1891.2 kj
				16164.7 kj

From Time Budgets

PRE - POST Expend

1371 kj/day x 3 days = 4113 kj
11277 kj/day x 4 days = 7662 kj
11775 kj

Therefore endogenous reserves account for:
16164.7kj/11775 kj = 100% of energy expenditure

↑ what's the difference per 1.0. Energy for eggs?

Use of Nutrient Reserves - Brant

From Ankney (1979)

M Brant	*PRE*	*POST*		
Mass	1297	1269		
Fat	97.1	66.1	= 31g x 9.45 kcal/g x 4.18 kj/kcal	= 1225.7 kj
Protein	106.4	102.8	= 3.6g x 5.65 kcal/g x 4.18 kj/kcal	= 85.1 kj
				1310.8kj

From Time Budgets

PRE - POST Expend

1874 kj/day x 3 days = 5622 kj
1624kj/day x 4 days = 6496 kj
12118 kj

Therefore endogenous reserves account for:
1310.8kj/12118kj = 10.8% of energy expenditure

From Ankney (1979)

F Brant	*PRE*	*POST*		
Mass	1384	1143		
Fat	123.5	81.2	= 42g x 9.45 kcal/g x 4.18 kj/kcal	= 1672.5 kj
Protein	99.0	79.0	= 20g x 5.65 kcal/g x 4.18 kj/kcal	= 472.8 kj
				2145.3kj

From Time Budgets

PRE - POST Expend

948 kj/day x 3 days = 2844 kj
807kj/day x 4 days = 3228kj
6072 kj

Therefore endogenous reserves account for:
2145.3kj/6072kj = 35% of energy expenditure

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