

WLF 419 - Waterfowl Ecology and Management
Lecture 5: Egg Production
Next Time: Incubation

Lecture will be broken into 3 parts: 1) the physiology of egg formation and the energetic costs, 2) techniques used to address research questions on egg production, and 3) present level of understanding in the field.

I. Physiology of egg production (review)

A. Ovary

1. Recall left ovary is active - right ovary rarely so (handout [Fig 2-9](#))

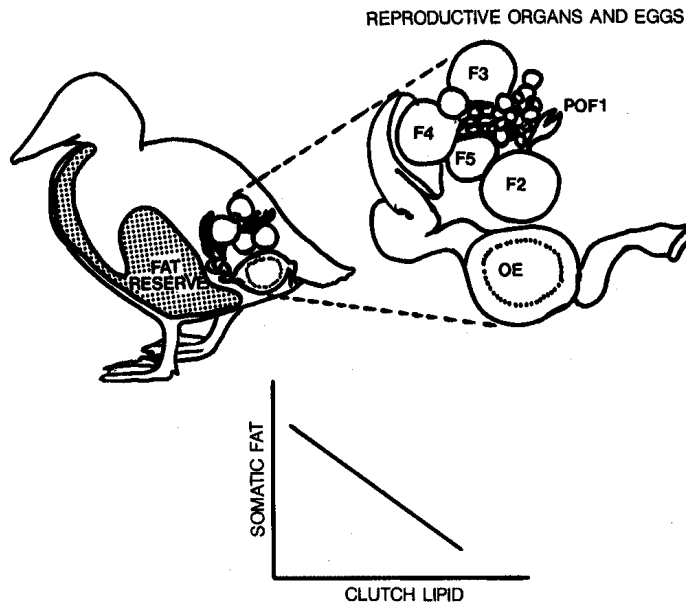


Figure 2-9. Schematic representation of somatic and nonsomatic tissues, and a hypothetical relation between somatic fat and lipid deposited in waterfowl ova. POF = postovulatory follicle; F2-F5 = developing follicles; and OE = oviducal egg.

From Alisauskas and Ankney (1992)

2. Prior to onset of egg production ovary extremely small (resembles a group of pin heads)
3. Process of egg production starts with follicles going through rapid follicle growth (RFG)
 - a) RFG is initiated by release of follicle stimulating hormone from the pituitary
 - b) FSH is released principally in response to increasing photoperiod, but other factors such as temperature, rainfall and social interactions affect this.

c) follicles develop in a hierarchical manner

(1) the largest follicle is the oldest, the next oldest follicle is 24 hrs older than that when ovum matures, follicle ruptures to release ovum into body cavity (looks like a burst balloon)

B. Oviduct - think of in 4 parts....infundibulum, magnum, isthmus, shell gland (or uterus)

1. As follicles mature in the ovary, oviduct correspondingly enlarges
2. Ovum enters oviduct via the infundibulum and gets fertilized during the ~30 minutes it spends there
3. Albumen gets deposited around yolky ovum in the magnum
4. Eggs moves into isthmus where majority of shell laid down
5. Shell is hardened in the uterus, or shell gland and spends most time there until oviposition (20.5hrs)

~24-25 hours

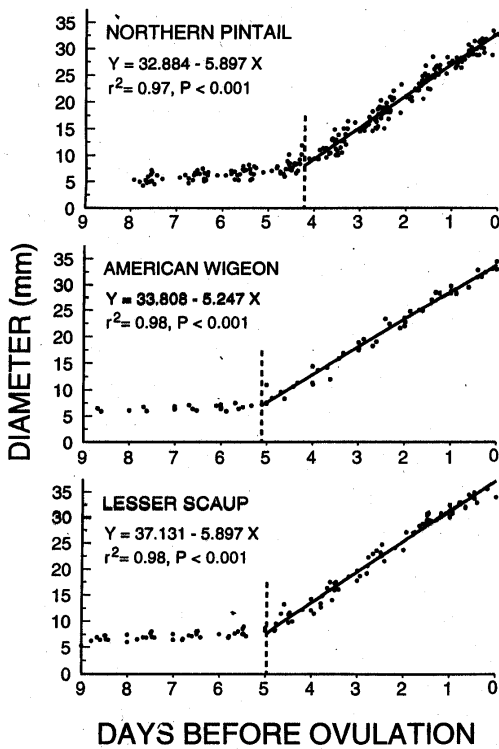


FIG. 1. Rapid follicle growth of three duck species based on ovarian follicle diameters. Vertical dashed lines represent estimates of beginning of rapid follicle growth.

Growth curves of follicle dry masses were best fit with second-order polynomial expressions (Fig. 2). Follicle dry masses at ovulation were estimated to be 8.2, 8.3, and 11.0 g for pintails, wigeon, and scaup, respectively. Predictive models of RFG (Table 2) estimated CORRDAY

II. Energetics of Producing Eggs

A. Waterfowl eggs physically larger and calorically more dense than other bird eggs

1. Young are precocial, hatching in an advanced state of development (within 24 hrs can swim, walk, feed selves)
 - a) female influences where ducklings feed, and may "brood" them, but most energy spent in the production of eggs
2. Great variation in egg mass is observed in waterfowl (Table 2-3)
 - a) tree ducks lay eggs about 5% of body mass while Ruddy duck eggs about 10% of body mass
 - b) patterns for geese more geographic - arctic nesting eggs relatively heavier than temperate nesters

Table 2-3. Characteristics of energy produced as eggs by waterfowl as summarized from Table 2-2

	Mean body mass (g)	Mean egg mass (g)	Mean eggs /day	Mean daily BMR (kcal)	Mean egg energy (kcal)	Mean egg energy (% BMR)	Mean RFG (days)	Mean clutch size	Mean maximum daily production of egg energy (% BMR)	Mean deviation from lower line in Fig. 2-7 (kcal)
Dendrocygnini	788	47	1.00	62	107	175	6	10	174	-2.0
Swans	6500	283	0.52	285	647	234	12	5	103	2.0
Geese	2518	127	0.75	142	290	210	12	5	132	4.6
Cairinini	565	43	1.00	48	97	201	7	11	201	3.8
Anatini	673	43	1.00	54	99	186	6	9	185	-0.3
Aythini	831	58	1.00	64	131	208	6	9	207	20.4
Somaterini	1846	96	0.75	114	219	195	6	4	136	-11.1
Mergini	835	64	0.62	64	146	236	8	9	152	-14.4
Oxyurini	653	88	1.00	54	202	375	12	7	286	52.7

*BMR = $73.5 \text{Body Mass}^{0.73}$ (Aschoff and Pohl 1970).

From Alisauskas and Ankney (1992)

3. Some of most interesting questions arise from the *intraspecific* variation in egg size
 - a) are females producing large eggs the most fit, or are they nesting in the best areas, or do they have the best partners. do the young they produce survive better?
 - b) for example, Black brant that produce large eggs have larger fledglings than females that produce small eggs

B. Females face tradeoff between producing eggs quickly at high energetic cost, or producing eggs slowly and incurring exposure to predation (Figs. 2-4, 2-5)

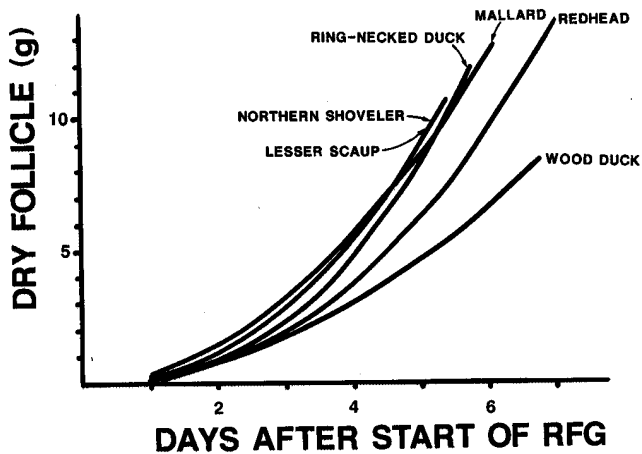


Figure 2-4. Pattern of rapid follicle growth for Lesser Scaup (A. Afton, unpubl. data), Northern Shoveler (D. Ankney and A. Afton, unpubl. data), Ring-necked Duck (R. Alisauskas et al. 1990), Mallard (A. Young, unpubl. data), Redhead (R. Sayler and D. Ankney, unpubl. data), and Wood Duck (Drobney 1980).

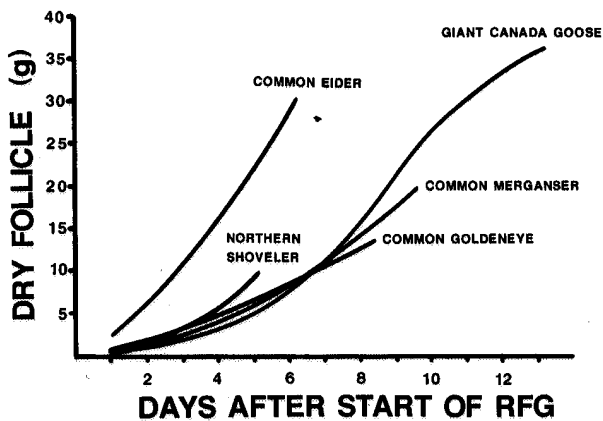


Figure 2-5. Pattern of rapid follicle growth for Common Eider (p. Hicklin, unpubl. data), Giant Canada Goose (S. Mainguy, unpubl. data), Common Merganser (H. Lumsden, unpubl. data), and Common Goldeneye (H. Lumsden, unpubl. data). RFG for Northern Shoveler is also shown in for comparison with Figure 2-4.

1. Prairie nesting females tend to have higher rates of RFG - possible response to high resource availability and high rates of nest predation
2. Cavity nesting species (Wood Ducks) have longer duration of RFG and have lower rates of nest predation

C. Egg laying intervals

1. Temperature nesting *Anas* spp., *Aythya* spp., tree ducks and Wood Ducks lay 1 egg/day
2. Other species have longer intervals - swans ~ 0.5 eggs/day, geese ~ 0.7 eggs/day

III. Nutrients for Egg Production

A. Exogenous

1. Temperate nesting ducks (and it appears for subarctic species also) have seasonal pattern of food availability
 - a) **abundance of aquatic inverts in early spring**
 - b) **decline in seed biomass from spring - midsummer**
 - c) **increase in green aquatic veg BUT less digestible**
 - d) **decline in tuber abundance**
2. Eiders, scoters, mergansers feed on animal matter year round

B. Endogenous - 3 classes of nutrients: lipid, protein, mineral

Remember these are large bodied birds relative to most passerines - therefore do not observe the daily patterns in mass dynamics and research focus has been on seasonal dynamics

1. Lipid
 - a) **Highest energy density - originates from biosynthesis of fatty acids or esterification of fatty acids**
 - b) **1g of metabolized lipid = 0.78g body fat; 1g protein = 0.33g body fat, 1g carbohydrate = 0.34g body fat**
2. Protein
 - a) **Dietary protein assimilated less efficiently into egg protein if 1 essential amino acid is missing**
 - b) **Green vegetation is better balance of amino acids for egg production than animal matter (but green veg. has proportionately less protein than animal food)**
3. Mineral
 - a) **medullary bone is the obligate storage tissue for minerals**
 - b) **medullary bone in hollow long bones and formed under hormonal influence associated with ovary activity**

IV. **Female nutrient reserves and egg production (Fig. 2-9)**

A. Methodology used

1. Females randomly collected on breeding grounds
2. Somatic body constituents determined via proximate composition analysis - sequential removal of components
 - a) **carcass is homogenized & weighed (without feathers)**
 - b) **homogenate is dried & weighed**
 - c) **lipid is extracted from homogenate using petroleum ether & weighed**
 - d) **protein is burned from homogenate in muffle furnace @ 550C & weighed**
 - e) **remaining material is mineral**
3. Procedure is conducted in same manner for reproductive tissue and eggs, if necessary
4. What about variation in body size of birds?
 - a) **absolutely bigger birds will always have larger somatic reserves - obscures detecting patterns across females**
 - b) **use Principal Components analysis to control for variation in body size**

B. How is the relationship examined? (Figs. 2-10, 2-11)

1. Regression analysis traditionally used - regress the somatic tissue of interest against the reproductive tissue of interest
 - a) **answers the question "Is variation in reproductive nutrient X explained by the variation in somatic tissue X?"**
 - b) **see from the species studied thus far, that lipid is used by many species during egg production while protein use is variable (due to food habits)**
 - c) **somatic mineral generally not used to produce eggs except in Ruddy Ducks**
 - d) **generally accepted that nutrient reserve use by females in prairies controlled by food habits during RFG, abundance of food during RFG, and maximum daily rate of egg production**

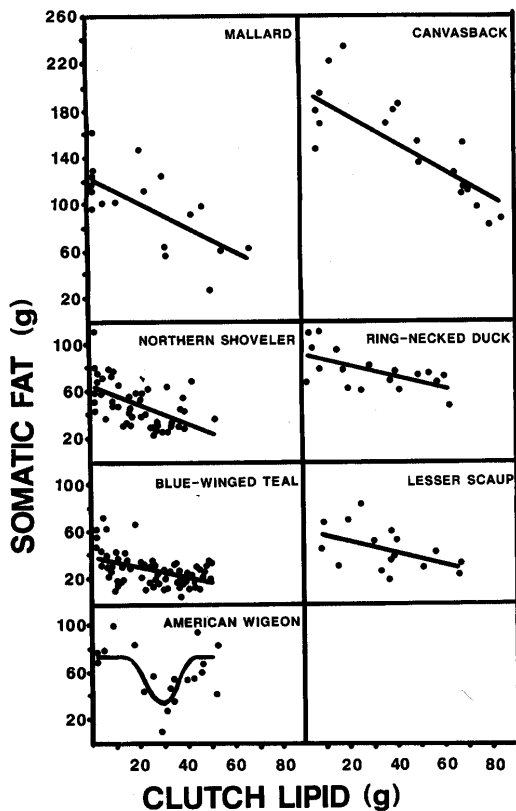


Figure 2-10. Relation of fat in the somatic tissue to lipid deposited into egg yolks of Mallard (G. Krapu, unpubl. data), Canvasback (Barzen and Serie 1990), Northern Shoveler (Ankney and Afton 1988), Ring-necked Duck (Alisauskas et al. 1990), Blue-winged Teal (F. Rohwer, unpubl. data), Lesser Scaup (Afton and Ankney 1991), and American Wigeon (R. Wishart, unpubl. data). See Table 2-6 for further details.

From Alisauskas and Ankney (1992)

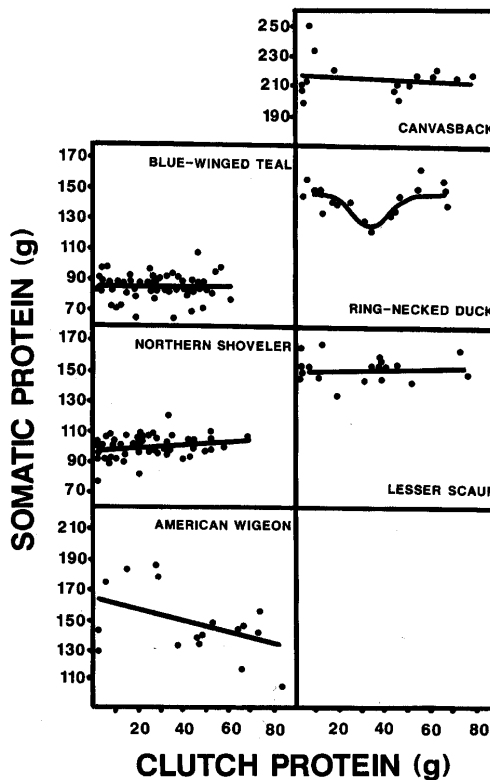


Figure 2-11. Relation of somatic protein to protein deposited into egg yolks and albumen in Canvasback (Barzen and Serie 1990), Blue-winged Teal (F. Rohwer, unpubl. data), Ring-necked Duck (Alisauskas et al. 1990), Northern Shoveler (Ankney and Afton 1988), Lesser Scaup (Afton and Ankney 1991), and American Wigeon (R. Wishart, unpubl. data). See Table 2-7 for further details.

itively apparent (and see American Wigeon fat reserves

C. Historical focus on the "duck factory"

1. All of the above studies conducted in the mid-continent - generally considered the primary site of duck production for North American
2. High densities of breeding ducks occur in other locations across N.A. - interior Alaska is one
3. Presents interesting question about whether all females do the same thing, or is there geographic variation in nutrient reserve dynamics?

D. Subarctic studies of nutrient reserve dynamics

1. Northern Pintails breeding at Minto Flats, AK
 - a) Study showed that Pintails here use protein and lipid to produce eggs
 - b) No data from Pintails in the midcontinent with which to compare
2. Northern Shovelers breeding at Minto Flats, AK (Fig. 1)

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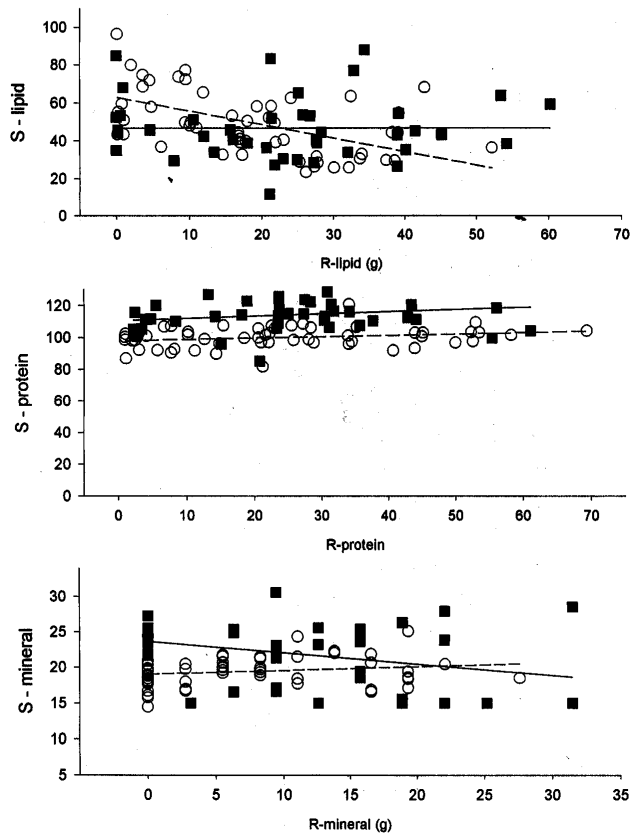


FIG. 1. Commitment of somatic nutrients (protein, lipid and mineral) during egg production for Northern Shovelers in Alaska (closed squares, solid lines) and Manitoba (open circles, dashed lines). Equations for Alaska: S-lipid = $49.27 - 0.02(R\text{-lipid}) - 0.76(\text{standardized nest initiation date}) + 1.83(\text{body size})$; S-protein = $108.84 + 0.13(R\text{-protein}) + 0.42(\text{standardized nest initiation date}) - 0.46(\text{body size})$; S-mineral = $24.88 - 0.30(R\text{-mineral}) - 0.11(\text{standardized nest initiation date}) + 1.56(\text{body size})$. Equations for Manitoba (Ankney and Afton 1988): S-lipid = $63.0 - 0.72(R\text{-lipid})$; S-protein = $98.3 + 0.07(R\text{-protein}) + 3.22(\text{body size})$; S-mineral = $19.10 + 0.04(R\text{-mineral}) + 0.72(\text{body size})$.

From MacCluskie and Sedinger (2000)

- a) **Shovelers use neither lipid, protein, nor mineral to produce eggs**
 - b) **large contrast to study from the prairies that showed that shovelers stored protein and used lipid to produce eggs**
3. Explanations for these results?
- a) **Pintails earliest nesting species at Minto. Initiate nests soon after arrival and often before ice is off of lakes - food is limiting**
 - b) **Shovelers are mid-season nesters, arrive on breeding grounds 10-14 days prior to nest initiation and also initiate nests as invertebrate abundance is increasing**
 - c) **other research conducted simultaneously shows primary production at Minto is similar to midlatitude wetlands (Wisconsin)**
4. Suggests that egg production of females in places like Minto Flats may be ultimately controlled, as opposed to the proximal control suggested in prairie species.

Literature Cited

Alisauskas, R. T.; Ankney, C. D. 1992. The cost of egg laying and its relationship to nutrient reserves in waterfowl. Pages 30 -61 in B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds. Ecology and management of breeding waterfowl. Univ. Minnesota Press, Minneapolis. 635pp.

Esler, D. Dynamics of ovarian follicles in breeding ducks. *Wilson Bulletin* 106:679-688.

MacCluskie, M.C, and J.S. Sedinger. 2000. Nutrient reserve and clutch -size regulation of northern shovelers in Alaska. *Auk* 117:971 -979.