COMPARATIVE CROP MILK COMPOSITION IN GRANIVOROUS AND FRUGIVOROUS COLUMBIDAE

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Abstract

Crop milk, a glandular secretion produced by doves, pigeons, and some species of penguins and flamingoes, was collected from five different species of dove squabs at the Memphis Zoo between day 0 and 14 post-hatching. These species (*Ptilinopus jambu*, *Ptilinopus magnificus*, *Gallicolumba luzonica*, *Gallicolumba rufigula*, and *Streptopelia decaocto*), range from primarily frugivorous to primarily granivorous representatives of Columbidae. The samples were analyzed for dry matter, crude protein, and fat in an effort to better delineate the nutrient content of crop milk secretions through the initial feeding period, and subsequent improvement of hand-rearing diets for Columbids. Dry matter and fat content increased significantly with chick age across all species, but crude protein was relatively constant among each species. Data were confounded by the inclusion of varied amounts and ingredients of the adult diet by the parents, but initial observations indicate that nutrient content of crop milk secretions may change regardless of adult diet, through the first 14 days of feeding period. Further collection and analysis of crop milk from squabs fed by parents consuming a consistent diet for the entire collection period will assist in further delineating differences among species of fruit doves with disparate foraging strategies.

Introduction

Several species of pigeons and doves (Columbidae), as well as some species of flamingoes and penguins, share with mammals the ability to produce a glandular secretion for the nourishment of their young. This secretion, produced in the crop, has been termed crop milk. The great diversity which exists in the natural history and origin of birds in the Columbidae family makes feeding these individuals in captivity challenging. The family contains 43 genera made up of about 300 species with 716 geographical races and forms. Beyond the challenges posed by the diversity of members within the family are the challenges posed by attempts to successfully hand-rear individuals of the family.[7] Appropriate formulas to feed squabs of different species within the family have not been established. Crop milk composition has not been well studied, especially in terms of variation between species and over time as squabs age.

The purpose of this study was to characterize crop milk composition between primarily granivorous and primarily frugivorous species within the Columbidae family, and to determine whether there are changes in the nutrient content of crop milk over the first 10 days of squab growth and development. This information, in theory, will assist in developing more appropriate hand-rearing formulas for members of the Columbidae family.

Background

An excellent literature review and summary of the physiology of avian lactation can be found in Kirk Baer.[3] Similar to mammalian milk, the production of crop milk in birds is prolactin mediated. However, unlike mammal milk which is an exocrine secretion only from the female, crop milk in birds is a holocrine secretion produced by both the male and female in response to hormonal stimulation around the eighth day of brooding. Lipid droplets are incorporated into the tissue lining of the crop, which is followed by detachment of cells into the lumen of the crop and, thus, the production of crop "milk."

Squabs are hatched in an undeveloped state, as singletons or in clutches of two.[1] In granivorous and frugivorous species, the adult diet may not be energy dense enough to support the rapid growth required for squab survival. Crop milk represents the major source of nutrition to support the squab during the period of rapid growth from hatching to the end of the first week to ten days of life. Thereafter, the crop milk is gradually mixed with the adult diet until the young birds reach the point of self feeding and consume the adult diet in its entirety. The secretion of crop milk is an important adaptation that allows these bird species to survive and reproduce in almost all environment types.[2]

Previous research indicates that pigeon (*Columba livia*) crop milk is devoid of sugar.[5] The high levels of crude protein (50% on a dry matter basis, DMB) and fat (45% DMB) in pigeon milk support the role of the secretion as an energy dense food source for rapidly growing squabs. More specifically, the nitrogen fraction of crop milk has been reported to contain approximately 17% free amino acids.[6] The amino acid profile suggests that nonessential amino acids may be important in squab development. That fat content of crop milk is primarily in the form of triglycerides and phospholipids,[3] and crop milk appears a good source of essential fatty acids. Immunoglobulins, specifically immunoglobulin A (IgA) and C (IgC), appear to be another important component of crop milk.

Materials and Methods

Consecutive daily crop milk samples were collected from day one (hatching) through day 14 from each squab in close proximity to feeding to ensure a fresh sample was collected. Samples were collected via a massage and manual expression technique.[6] Samples were manually expressed into 1ml cryovials (Nalge Nunc, Inc., Rochester, NY) and stored at -80 degrees F until analysis. A similar diet was offered to adult birds in the free flight aviary, and the adult diet was monitored as closely as possible in the free flight situation, in order to ensure, inasmuch as possible, that the diet was consumed as formulated during the period of rearing the squabs.

A variety of frugivorous and granivorous dove species were used in the Memphis Zoological Society (Memphis, TN) bird collection. They range from more frugivorous species (Jambu fruit dove, *Ptilinopus jambu*; Wompoo fruit dove, *Ptilinopus magnificus*) to more granivorous species (Collared dove, *Streptopelia decaocto*), and several which display intermediate foraging preferences (bleeding heart pigeon, *Gallicolumba luzonica*; golden heart dove, *Gallicolumba rufigula*).

Dry matter (DM) was determined by weight difference after drying in a forced-air oven at 100°C for 3 hours. Nitrogen was determined with a Perkin Elmer CHN elemental analyzer. Crude protein (CP) was estimated as 6.38 times analyzed N.[5] Fat was determined on ground samples by a modified version of the Rose-Gottlieb method with sequential extractions using ethyl and petroleum ether. Care was taken to exclude components of the adult diet from samples. Where available, values from different chicks of the same age and species were averaged.

The relationships between squab age and crop milk composition (dry matter, fat, and protein) were examined using correlation across all species. Analysis of covariance was used to examine differences between species with squab age as the covariate. Statistical analysis was done using SPSS 15.0 (SPSS Inc, Chicago, IL).

Results and Discussion

The crop milk samples generally consisted of small, curd-like material in a mucus matrix. There was often visible adult diet components mixed in, even from the first day with some species. The amount of mucus also varied a great deal. Subjectively, collared dove and golden heart dove crop milk samples tended to have more thick mucus and significant amounts of adult diet components from day one. Jambu crop milk samples had less mucus and only occasionally had adult diet components. Wompoo crop milk samples had no adult diet components (but there were only two samples from the first two days post hatching). The bleeding heart pigeon crop milk samples were variable in terms of containing adult diet components, with samples from one squab usually containing seeds while the samples from the other squab usually contained little adult diet for the first 3 days; thereafter having many seeds and mealworms mixed in. There appeared little consistent inclusion of adult diet components based on species, thus it appeared dependent upon the individual adult feeding the squab. Observations with free-ranging mourning doves (*Zenaida macroura*), a granivorous species, indicated crops of nestlings contained almost no seeds during days 0-3, and increasing proportion of seeds from days 4-8, and almost entirely seeds beginning at day 8.[1]

The components and proportions of the representative diet are listed in Table 1. The nutrient content of the diet (determined using Zoo Diet Analysis Software, Lansing, MI) is provided in Table 2.

Even though the exact diet consumed by the adult birds is not known, the nutrient content of the crop samples differed greatly from the nutrient content of the representative adult diet, indicating significant contribution of the endogenous secretion over and above the adult diet. The samples from the collared doves had the lowest fat of all samples (18.8 ± 2.1% DMB). Although both species are considered the most frugivorous representatives in the study, the wompoo and jambu samples contained the highest (47.7 ± 0.02% DMB) and lowest (26.8 ± 2.1% DMB) crude protein, respectively. The mean values for squab age, DM, CP, and fat for the crop samples are provided for each species in Table 3. Both DM ($r = 0.622$, $p = 0.001$; Figure 1) and fat content ($r = 0.328$, $p = 0.039$) increased with chick age (up to 9 days of age); CP was relatively constant within each species. Both species and squab age were significant factors for DM and fat ($p = 0.001$). Species was a significant factor for CP ($p=.001$) but squab age ($p=.143$) was not. Thus,

DM and fat generally increased with squab age for all species; but protein did not. In this data set species differed from each other after accounting for squab age.

Conclusions

The differences among the species of doves and the foraging strategies exhibited across these species may have been confounded by access to a widely variable adult diet. Dry matter and fat content in the milk increased with day of age, appeared to plateau at around 40% after day 9, although only two species had samples after that day and so this is only a hypothesis. Dry matter and fat content did not vary predictably with foraging strategy of the birds. Protein content varied among species, but not with squab age. It may be that when formulating hand-rearing diets, changes in fat content play a more key role through the formula feeding period than changes in protein. Future studies are recommended in order to more clearly delineate the differences in foraging strategies across these species, with special attention to the consistency of adult diet components.

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LITERATURE CITED

1. Blockstein, DE. 1989. Crop Milk and Clutch Size in Mourning Doves. Wilson Bull 101(1): 11-25
2. Horseman, ND and JD Buntin. 1995. Regulation of Pigeon Crop Milk Secretion and Parental Behaviors by Prolactin. Annu Rev Nutr 15: 213-238.
3. Kirk Baer, C. 1999. Comparative Nutrition and Feeding Considerations of Young Columbidae. In Zoo and Wild Animal Medicine – Current Therapy, Fowler, ME and RE Miller, Eds. WB Saunders Co, Philadelphia, PA. Pp. 269-277.
4. Kirk (Baer), CL and G Romo. 1997. Crop Milk Composition and Squab Growth in the Pigeon. Proc. Dr. Scholl Nutr. Conf., Lincoln Park Zoo, Chicago, IL. Pp 140-144.
5. Kirk Baer, C. 1994. Crop milk composition and squab growth in the Columbidae (Columba livia). MS Thesis, University of Maryland, College Park, MD.
6. Kirk Baer, C and OP Thomas. 1994. Nutrient Composition of Crop Milk and Growth of Squabs: New Noninvasive Techniques for Milk Collection and Body Composition Determination in Columbidae (Columba livia). Proc ARAV and AAZV. Pittsburgh, PA. Pp 302-304.
7. MacLeod, A and J Perlman. 2002. Cream of the Crop: An Improved Hand-Rearing Diet for Hatchling and Nestling Columbids. J Wildl Rehab 25(1): 12-17.

Table 1. Components and proportions of a representative diet offered to adult doves at the Memphis Zoo.*

Item Description	Proportion of Diet (%)
Commercial Parrot Maintenance Pellet	33.0
Apple	8.25
Papaya	8.25
Banana	8.25
Kiwi	8.25
Blueberries	8.25
Honeydew Melon	8.25
Sweet Potato	8.25
Brown Rice	8.25
Total	100

* Birds also have access to a commercial game bird pellet, mealworms, waxworms, crickets, leafy greens, and green vegetables, even though not part of their specific diet.

Table 2. Proximate nutrient content of a representative diet offered to adult doves at the Memphis Zoo (dry matter basis, DMB).*

Nutrient	Representative Adult Diet
Dry Matter, %	42.0
Crude Protein, %	14.3
Fat, %	6.1
Ash, %	4.5
Crude Fiber, %	4.7

* Representative of diet offered in free flight aviary to all adult birds on study, not necessarily consumed in the same proportions.

Table 3. Mean values for crop milk constituents. Fat and crude protein (CP) reported on a dry matter (DM) basis. Because DM and fat increased with squab age those values for Wompoo fruit doves should be considered preliminary. CP did not vary with squab age.

Species	Number of chicks	Number of samples	Chick age Mean (range)	DM % (SEM)	CP % (SEM)	Fat % (SEM)
Collared dove	2	14	5 (1 – 9)	25.3 (1.4)	39.5 (3.3)	18.8 (2.1)
Bleeding heart pigeon	2	14	5 (1 – 9)	37.0 (1.4)	45.7 (0.8)	38.3 (0.9)
Golden-heart dove	1	11	7.5 (1 – 14)	33.6 (2.2)	44.2 (2.7)	27.9 (3.0)
Jambu fruit dove	3	13	5 (1 – 10)	36.9 (3.2)	26.8 (2.1)	42.5 (3.4)
Wompoo fruit dove	1	2	1.5 (1 – 2)	24.5 (5.3)	47.7 (0.2)	19.6 (1.8)

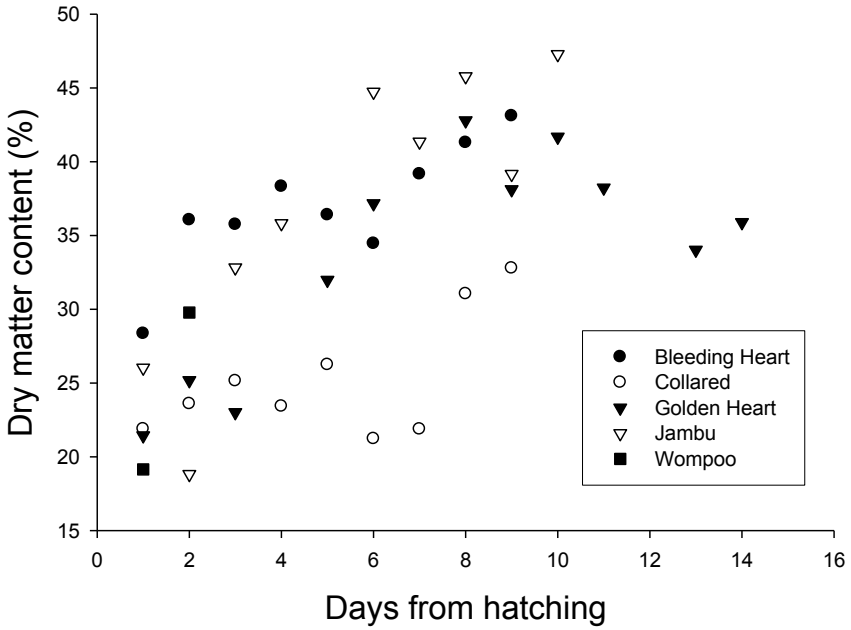

Figure 1. Mean dry matter content of crop milk within day and species. The dry matter content of crop milk generally increased as the squabs got older, possibly plateauing at about 40% after day 9 from hatching, although only two species had samples after that day.