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# ANNUAL CHANGES IN GIZZARD SIZE AND FUNCTION IN A FRUGIVOROUS BIRD[1]

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*Key words: Frugivory; gizzard;* Phainopepla nitens; *stomach.*

Frugivory often entails substantial adaptations of the digestive tract, associated with the presence of indigestible seeds and a comparatively low concentration of nutrients in the diet. Species consuming mistletoe berries face the added complication of manipulating the viscous, adhesive pulp characteristic of this bird-dispersed fruit and commonly exhibit extreme adaptations of digestive anatomy and function (Forbes 1880, Wetmore 1914, Desselberger 1931, Steinbacher 1935, Walsberg 1975). An example is the Phainopepla (*Phainopepla nitens*), a small songbird resident in the Sonoran Desert from October through April. During this period, the bulk of the Phainopepla's diet consists of berries of the desert mistletoe (*Phoradendron californicum*) (Walsberg 1975, 1977). The pericarp of this fruit (its "pulp") is mucilaginous, which aids in adhering the seed to host plants but also makes it more difficult for a consuming animal to manipulate. The Phainopepla's digestive apparatus is highly specialized to process large numbers of these berries by rapidly removing the exocarp (the berry's "skin") within the digestive tract (Walsberg 1975). A foraging bird typically fills its crop with berries, then passes them singly to the gizzard (ventriculus). The small gizzard averages only 1.5% of body mass and will contain a single 3- to 5-mm diameter mistletoe fruit. The gizzard apparently contracts and extrudes the seed and semiliquid pulp out of the exocarp into the small intestine. The exocarp is retained in the distal portion of the gizzard. This process is repeated for 12–24 berries, then the accumulated mass of exocarps is ejected from the gizzard into the small intestine. As little as 12 min elapse between ingestion and egestion and at least 1,100 berries may be consumed per day with caloric digestive efficiencies averaging 49% (Walsberg 1975, 1977).

Desert mistletoe, however, is consumed only during the period between October and May. From late spring until fall, Phainopeplas occupy semiarid habitats to the north, east, and west of the Sonoran Desert (e.g., oak woodland, riparian woodland in chaparral areas) (Walsberg 1977). Compared to the period in the Sonoran Desert, the diet is more generalized and a wide variety of small berries are consumed (e.g., *Lycium* spp., *Rhamnus crocea, Rhus* spp., and *Sambucus mexicana*). We report here a major seasonal change in gizzard size and function correlated with this dietary shift. Data were collected incidental to a larger analysis of this species' annual cycle of reproduction, molt, and body composition. Because the annual shift in gizzard structure was noted only late in our study, comparisons are limited to samples collected between August and December.

## METHODS

Phainopeplas were collected by shooting and preserved by freezing. Samples were collected in summer habitat at Sunflower (August) or New River (September), both in Maricopa County, Arizona. November and December samples were collected in the winter habitat of the Sonoran Desert, either at Fort McDowell, Maricopa County, Arizona (October and November samples) or 8 km west of Chiraco Summit, Riverside County, California (December samples). December samples were previously reported in Walsberg (1975). The contents of the gizzard were noted upon dissection, then the gizzard was emptied, blotted dry, and weighed to the nearest 1 mg on an Ainsworth 300DR balance. Data were analyzed using a Tukey test, with $P < 0.05$.

## RESULTS AND DISCUSSION

Gizzard size varies markedly over the annual cycle in Phainopeplas, with gizzard mass in August equalling 2.2 times that in December (Fig. 1). In contrast to the single berry processing observed in Phainopeplas feed-

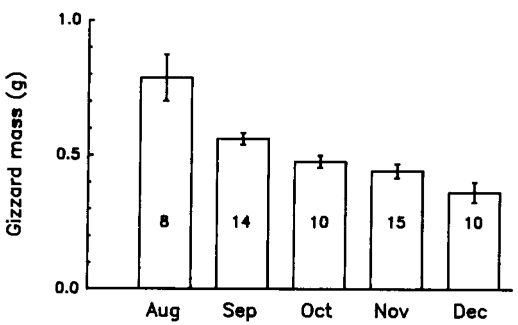


FIGURE 1. Seasonal variation of gizzard mass in the Phainopepla. Values are means ±95% confidence limits. Sample sizes are listed within each bar. Values for October and November are statistically indistinguishable ($P > 0.05$); values for all other months differ significantly ($P < 0.05$).

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ing on mistletoe in their winter range (Walsberg 1975), the much larger gizzards of Phainopeplas collected in their summer range (August and September samples) all held multiple fruits. This method of fruit processing is similar to that of nonmistletoe-specializing frugivores that typically use the gizzard to mechanically reduce multiple fruits at a time (Walsberg, unpubl. data). This presumably is associated with the easier handling characteristics of fruit without the adhesive qualities of mistletoes.

Major restructuring of body components is characteristic of the annual cycle of many bird species. This restructuring can include alteration in plumage, fat reserves, and locomotor muscles (King and Murphy 1985). The alteration in gizzard size observed in the Phainopepla reinforces the view that the avian digestive tract also can exhibit substantial seasonal restructuring (e.g., Davis 1961, Ankney 1977, Al-Dabbagh et al. 1987). Although digestive efficiency and rate during summer months have not been measured, the altered gizzard morphology does suggest that adaptations for seasonal dietary specialization may not entail substantial reduction in the effectiveness of food processing at other times of the year.

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# COMMUNAL ROOSTING IN A VERY SMALL BIRD: CONSEQUENCES FOR THE THERMAL AND RESPIRATORY GAS ENVIRONMENTS[1]

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*Key words:* Auriparus flaviceps; *Black-tailed Gnatcatcher; communal roosting; energetics; microhabitat selection;* Polioptila melanura; *roost-site selection; thermal ecology; Verdin.*

Communal roosting within a cavity represents an extreme in microhabitat selection that has been described for several bird species (e.g., Knoor 1957, Frazier and Nolan 1959, White et al. 1975, Pitts 1976). Although such dense and enclosed aggregations of endotherms have the potential to importantly alter their local environment by elevating temperature, depleting oxygen, and generating carbon dioxide, the physiological consequences of such behavior are not well-known (Reinertsen 1988). Such communal roosting can result in individuals being directly warmed through contact with others as well as experiencing indirect warming associated with heating the air within the cavity and reducing convective heat loss through the cavity entrance. I report here observations of the thermal and gaseous environment within the first reported communal roost of Black-tailed Gnatcatchers (*Polioptila melanura*), a small (about 5 g) Sonoran Desert insectivore.

## METHODS AND MATERIALS

The roost was located along a wash in Vekol Valley, Maricopa County, Arizona, at 570 m elevation. The wash is a normally dry watercourse passing through a desert valley dominated by bursage (*Ambrosia dumosa*) and creosote bush (*Larrea tridenta*) with a scat-

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