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GREAT HORNED OWLS DO NOT EGEST PELLETS PREMATURELY WHEN PRESENTED WITH A NEW MEAL

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In a review of research relating to the physiological mechanism and regulation of pellet egestion in raptors (Duke 1989) it was clear that several aspects of regulation require further study. In particular, the role, if any, of cephalic, or even voluntary control, is very poorly understood. It has been shown recently that in laboratory studies, the meal to pellet interval (MPI, Balgooyen 1971) of captive Great Horned Owls (*Bubo virginianus*) may be influenced by the visual presence of other Great Horned Owls (Duke et al. 1991). Also, in fasted Great Horned Owls with basal gastric contractile and secretory activity, both gastric motility (Duke et al. 1976b) and gastric secretion (Mosher and Duke 1985) were enhanced by the sight of food (dead mice). These findings suggest a cephalic control of gastric function. Since pellets are formed and egested from the muscular stomach (Rhoades and Duke 1977, Duke et al. 1976c) it is possible that cephalic mechanisms could be involved in egestion as well. Hawks fed before mid-afternoon egest at dawn the following day (Balgooyen 1971, Duke 1989). Clearly time, or dawn, is not "sensed" by the stomach, so cephalic input must be involved.

The purpose of the present study was to determine if Great Horned Owls are able to egest pellets slightly before the expected egestion time if presented with a new meal of mice. If digestive efficiency of the new meal is reduced by the presence of undigestible remains of a previous meal in the stomach, owls might stand much to gain if they could prematurely terminate a digestion process (i.e., egest) that was nearly complete to avoid this compromise in digestive efficiency.

METHODS

Four healthy, but permanently crippled Great Horned Owls, obtained from the rehabilitation clinic at The Raptor Center, University of Minnesota, were used. Two were presumably males, and two were presumably females based on their body weights (Table 1). They were trained to eat 40-60 g/kg of thawed mice between 0800 and 0815 H daily. This feeding time was selected for the convenience of the authors. While MPIs for meals fed in the evening are slightly longer than for those fed in the morning, the egestion mechanism and process appears to be constant regardless of feeding time (Duke and Rhoades 1977). The owls were weighed weekly to monitor their health; all maintained, or slightly gained, body weight.

The owls were kept individually in two identical animal holding rooms between 4 December 1991 and 30 April 1992. Lights were automatically turned on in these rooms from 0600-1800 H daily and temperature and relative humidity were maintained at 20-22°C and 45-50%, respectively. Access to the rooms was limited to the authors who regularly fed the birds and maintained the rooms. Chambers in which owls were kept and automatic egestion timing devices have been previously described (Duke et al. 1976a, Duke and Rhoades 1977).

The two smaller owls were tested first. They were fed daily for 3 wk, then a mean (±SD) MPI was determined. This feeding schedule was maintained for the next 4 wk; however, they were fed 1 d per week (selected randomly) at a time equivalent to one SD of the mean prior to the expected pellet egestion time. The two heavier birds were tested similarly.

Assuming that a high meal mass to pellet mass ratio reflects greater digestive efficiency than a low ratio (Duke 1989), we measured pellet masses and meal to pellet intervals (MPIs) in Great Horned Owls given the opportunity to egest the pellet from a previous meal when presented with a new meal. We compared these data with corresponding values for the same individuals fed at 0800 H daily permitting egestion of the "old" pellet some 9-11 hr before ingestion of a new meal.

RESULTS AND DISCUSSION

A pellet was egested only twice in 26 trials involving a new meal being presented prior to egestion from a previous meal. This occurred first with one of the presumed males; the egestion occurred within 2 min of entry of the attendant (G.E.D.) into the room. Because the pellet compaction

Table 1. Mean meal to pellet intervals (MPI) and body masses for four Great Horned Owls. MPI from "experiments" were those in which two feedings resulted in only one pellet.

BIRD NUMBER	BODY MASS (g) START	BODY MASS (g) END	MPI[1] CONTROL (1 MEAL)	N	MPI[1] EXPERIMENT (2 MEALS)	N
1	1102	1180	15.12 (0.66)	56	25.60 (1.71)	8
2	989	1195	14.98 (0.72)	58	28.05 (1.90)	8
3	1670	1710	13.17 (0.20)	30	23.82 (0.47)	5
4	1760	1820	12.48 (1.05)	26	23.37 (2.82)	5

[1] MPI given in decimalized hours (not h:min).

Table 2. Mean daily pellet masses (g) and dry meal mass : pellet mass ratios of Great Horned Owls.

	DRY PELLET MASS (g) CONTROL[a] (1 MEAL PELLET)	DRY PELLET MASS (g) EXPERIMENTAL[b] (2 MEAL PELLET)	MEAL MASS/ PELLET MASS (DRY) CONTROL (1 MEAL PELLET)	MEAL MASS/ PELLET MASS (DRY) EXPERIMENTAL (2 MEAL PELLET)
Males	1.88	3.36		
Females	3.61	6.37		
Both Sexes			8.49 (0.42)	10.00 (0.73)

[a] Pellets collected during control periods are all from one meal.

[b] Pellets collected from experiments in which a meal was fed just prior to the expected pellet egestion represent two meals.

and egestion process averages 12-21 min in duration in Great Horned Owls (Kostuch and Duke 1975, Rhoades and Duke 1977), this pellet was probably not egested in response to entry of the attendant. In the second instance, one of the presumed females refused to eat when food was presented at one SD before expected egestion time. The food was left with her. At approximately 30 min after presentation of the food, she egested a pellet, then immediately ate the new meal. This failure to eat within 15 min perhaps indicated that an egestion process may have been initiated by presentation of a new meal. We were prepared to leave mice with an owl for up to 30 min before removing them to see if egestion followed by eating would occur. On three other occasions, owls had egested prior to our entry to present them with a new meal.

Meal to pellet intervals determined in this study (Table 1) were similar to those determined in previous studies involving Great Horned Owls (Duke 1989, Duke et al. 1991). Dry pellets representing mainly hair and bones from two meals were nearly twice the weight of pellets from one meal (Table 2). The ratio of meal to pellet mass was slightly greater for pellets representing two meals as compared to those from one meal (Table 2). Previous studies have shown that digestion is more thorough (i.e., pellets are relatively lighter), if egestion is delayed (Duke 1989). Also, in Barred Owls (*Strix varia*) whose body weights were experimentally lowered by fasting, MPIs were longer, pellets were lighter in mass and digestion was more thorough (Duke et al. 1980). Presumably in the case of two-meal pellets, digestion of the first meal was considerably more thorough because digestion time for that meal was considerably longer. The MPI for two-meal pellets was slightly less than twice as long as for one-meal pellets (Table 1), so digestion time for the second meal was only slightly less than for a single meal. Thus, eating a second meal before egesting a pellet from an earlier meal is not only not detrimental, but is apparently slightly beneficial in terms of overall digestive efficiency.

We had hypothesized that when presented with a new meal just prior to expected egestion of a pellet from the previous meal, owls would either a) not eat immediately but initiate egestion and eat within about 15–30 min, b) eat the new meal despite the undigested remains of the previous meal still in the muscular stomach, or c) not eat within 30 min, miss the opportunity to ingest the new meal and egest at the expected time. We expected a) but observed b). So, owls don't have to egest the remains of one meal before eating a second meal, and they don't have to miss the opportunity to ingest a new meal if one becomes available. Further, overall digestibility and gain of nutrients is apparently not diminished but is enhanced, by eating the second meal. Of course, a wild owl could also catch the prey, hold it or cache it, then eat it after pellet egestion occurs at the "expected" time. This did not occur during the premature feedings. The latter situation has been observed in Saw-whet Owls (*Aegolius acadicus*) after catching a prey item which was larger than could be ingested in a single meal (Mumford and Zusi 1958, Collins 1963) and in Barred Owls (*Strix varia*) which "incubated" the unconsumed portion of a Ruffed Grouse (*Bonasa umbellus*) to prevent it from freezing (Fuller 1978 pers. observation).

Presumably consumption before egesting the remains of a previous meal is limited by gastric capacity and could only occur once or twice before the stomach is too full of undigestible remains to allow a new ingestion. This remains to be investigated. Whether small owls (e.g., Screech owls *Otus asio*) which eat relatively more per gram body weight per day (Duke et al. 1976a) than large ones would also eat a second meal before egesting the remains of a previous meal should also be investigated.

RESUMEN.—Hipoteticamente se ha sostenido que: 1. La eficiencia digestiva de una nueva comida podría ser disminuída si la que fue previamente ingerida está aún, par-

cialmente digerida, en el conducto digestivo. 2. El Búho Cornado Americano (*Bubo virginianus*) podría prematuramente regurgitar una egagrópila si se le es dada la oportunidad de ingerir una nueva comida.

Se determinó la desviación estandard de la media de los intervalos de regurgitación en cuatro búhos. Luego, en un día (seleccionado al azar) de cada una de las cuatro semanas de estudio, y a una desviación estandard antes del lapso en que se produciría la regurgitación, una nueva comida se les fue presentada. Sólo una regurgitación fue, al parecer, motivada por esta comida anticipada. En todas las demás comidas anticipadas, los residuos no digeribles de dos comidas fueron regurgitados en una egagrópila. El peso de las egagrópilas de dos comidas fue ligeramente menor que el doble del peso de la egagrópila de una comida; y la proporción comida/peso de egagrópila fue ligeramente mayor para egagrópilas provenientes de dos comidas. Así, pues, el ingerir una segunda comida antes de regurgitar la anterior, es no solamente no negativa, sino que, aparentemente, hasta es ligeramente beneficioso para la eficiencia digestiva.

[Traducción de Eudoxio Paredes-Ruiz]

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