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FOOD INTAKE IN A MONTAGU'S HARRIER ESTIMATED BY TWO METHODS OF PELLET ANALYSIS

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KEY WORDS: *Montagu's Harrier*; Circus pygargus; *diet*; *digestion*; *feeding experiment*; *pellet.*

Dietary studies reveal important information on the ecology of raptor populations (Newton 1979). Field studies of raptor diets use direct and indirect methods (Rosenberg and Cooper 1990, Marti et al. 2007). Observations and videography at the nest are used as direct methods (Rutz 2003, Lewis et al. 2004), but have some drawbacks. Prey consumed away from the observer/camera is not recorded (Lewis et al. 2004), and many prey items cannot be identified to the species level (Redpath et al. 2001, Huang et al. 2006). The large investment in time and resources associated with direct methods often prohibits gathering representative samples (Lewis et al. 2004).

Researchers using indirect techniques (analyses of regurgitated pellets and pluckings) infer diets from evidence collected at or near nest sites and perches (Marti et al. 2007). Raptors often pluck their prey before consumption and only a portion of the indigestible part of the prey is ingested (Rosenberg and Cooper 1990, Lewis et al. 2004). Furthermore, the strong gastric acids of raptors leave relatively few clues to identify prey species from pellets (Duke et al. 1975) and many soft-bodied prey species, such as some invertebrates and amphibians, are absent or underrepresented in pellets. Identification of prey species from pellets alone is thus biased (Rosenberg and Cooper 1990) and should be corroborated with results from remains. Prey remains, however, are biased toward large and conspicuous prey items (Schipper 1973, Simmons et al. 1991, Redpath et al. 2001, Lewis et al. 2004). Combining analyses of pellets and prey remains is thus recommended and appears to yield good results for some raptor species (Simmons et al. 1991, Lewis et al. 2004). Nonetheless, indirect methods usually underestimate the daily prey capture rate of raptors and preferably should be calibrated with direct observations (Rosenberg and Cooper 1990). Regardless of the shortcomings, indirect methods are widely used because they are cost-effective and provide large samples with little disturbance to the birds (Lewis et al. 2004, Marti et al. 2007).

Montagu's Harriers (*Circus pygargus*) have a diverse diet, including small mammals, birds, reptiles, and insects (Schipper 1973, Millon et al. 2002, Arroyo and García 2006), and are considered ''opportunistic specialists'' (Arroyo 1998). Prey choice between different populations within Europe differs considerably (Leroux 2004) and has changed locally over time with changing environmental circumstances (Schipper 1973, Koks et al. 2007).

Observations and videography (Maurel and Poustomis 2001, Koks et al. 2007), as well as analyses of pellets and prey remains, have been used to study the diet of Montagu's Harriers (Schipper 1973, Underhill-Day 1993, Sánchez-Zapata and Calvo 1998, Arroyo and García 2006). Food intake has been estimated on the basis of pellet analyses, calculated by multiplying prey numbers found in pellets with mean prey weights from literature or local data (Hartley 1947). However, the reliability of this numerical method has been rarely tested in harriers (*Circus* spp.; see Newgrain et al. 1993 for Swamp Harrier [*Circus approximans*] and Craighead and Craighead 1956 for Northern Harrier [*Circus cyaneus*]), as in other raptors in general (Lowe 1980 for Tawny Owl [*Strix aluco*] and citations therein for other owl species, Wijnandts 1984 for Long-eared Owl [*Asio otus*], Yalden and Yalden 1985 for Eurasian Kestrels [*Falco tinnunculus*]).

In this study, we tested whether pellet mass was a reliable indicator of food intake in Montagu's Harriers, by performing a feeding experiment with a captive bird. We investigated whether this method should be favored above the numerical method.

METHODS

During 21–27 February 2008, we experimentally fed an eight-month-old captive male Montagu's Harrier kept at a room temperature of 15°C. Its body mass of 260 g was below-average compared to free-living Montagu's

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Table 1. Mouse diet of a captive Montagu's Harrier during days 1–7 reflected in pellet contents and pellet weight. The prediction of food intake from pellet weight was based on the regression equation from Fig. 1. The estimate of food intake was based on the number of individuals identified in pellets (in this study all set to one) multiplied by the average mass of mice fed during the experiment (23.7 g).

Day	Diet	Pellet Number	Pellet Weight (g)	Pellet Content	Number of Individuals Identified in Pellet	Number of Individuals Actually Ingested During Previous Day	Food Intake: Prediction from Pellet Mass (g)	Food Intake: Estimate (Number of Individuals in Pellets * Mean Mouse Mass (g)	Actual Food Intake During the Previous Day (g)
0	Chicken								
1	Mouse	1	0.90	Chicken					
1	Mouse	2	0.50	Chicken					
2	Mouse	1	1.40	Mouse	1	0.5	39.0	47.4	30.3
2	Mouse	2	0.35	Mouse	1				
3	Mouse	1	0.30	Mouse	1	3.0	39.6	47.4	41.2
3	Mouse	2	1.50	Mouse	1				
4	Mouse	1	0.90	Mouse	1	1.0	27.4	23.7	31.3
5	Mouse	1	0.70	Mouse	1	1.0	24.7	23.7	19.9
6	Mouse	1	0.70	Mouse	1	1.0	31.5	47.4	25.8
6	Mouse	2	0.50	Mouse	1				
7	Mouse	1	0.20	Mouse	1	1.0	17.9	23.7	24.1
8	Chicken	0				0.5	0.0	0.0	22.4
9	Chicken	0							
10	Chicken	1	0.70	Chicken					
Mean							**25.7**	**30.5**	**27.9**

Harrier males during the breeding season (on average 285 g; C. Trierweiler unpubl. data). The harrier was hatched in farmland in Northrhine-Westphalia (Germany) and housed in a rehabilitation center because of wing damage that occurred shortly after its fledging in mid-July 2007.

The harrier was typically kept on a diet of dead day-old chickens (*Gallus domesticus*). During the experiment, we fed the bird with known quantities of dead laboratory house mice (*Mus musculus*), a substitute for common voles (*Microtus arvalis*), the latter being the main prey in Germany and The Netherlands (Hölker and Wagner 2006, Koks et al. 2007). After 7 d on the house mouse diet, the harrier was fed day-old chickens again.

The harrier had been kept in a large aviary (3.5 × 3.5 × 3 m) during its rehabilitation, but was kept in a small cage (55 × 70 × 85 cm) under veterinary supervision during the experiment. Dead mice with known weights were offered *ad libitum* daily. We collected excess food and pellets once every day, and weighed discarded mice. We calculated ingested prey mass by subtracting the mass of uneaten prey (not corrected for possible dehydration) from offered prey mass.

We dried pellets in paper envelopes and weighed pellets digitally to the nearest 0.01 g after they had been stored at room temperature for one month. We dissected the dry pellets and identified prey species. The bone content of the pellets was negligible, and we could not determine the number of individuals per pellet, so the number was set to one per pellet (Clarke et al. 1993, Arroyo 1998). Raptor diet based on biomass is often calculated by multiplying prey numbers found in pellets with average prey weights taken from literature. We tested the robustness of this method by comparing actual food intake of the harrier with (a) estimated food intake from prey numbers found in pellets (set to one per pellet) multiplied by the average known body mass of mice eaten and (b) estimated food intake from prey numbers found in pellets multiplied by a literature estimate of mouse mass.

We used Microsoft Office Excel 2003 and paired-samples *t*-tests in SPSS 16 (SPSS Inc.) for calculations and tests. Averages are presented ±1 SE.

RESULTS

During the 7 d of the experiment, the harrier ate 195 g of 831 g (24%) of food offered (28 ± 3 g/d, wet weight). The bird produced 18 pellets (in total 7.95 g dry weight), ranging from 0.2–1.5 g dry weight per pellet (Table 1). One day after starting the mouse diet, the Montagu's Harrier produced the first pellet containing exclusively hair (Table 1). After the diet was switched back to chickens on day eight, it took 2 d before any pellet that contained chicken remains was produced. We concluded that, on

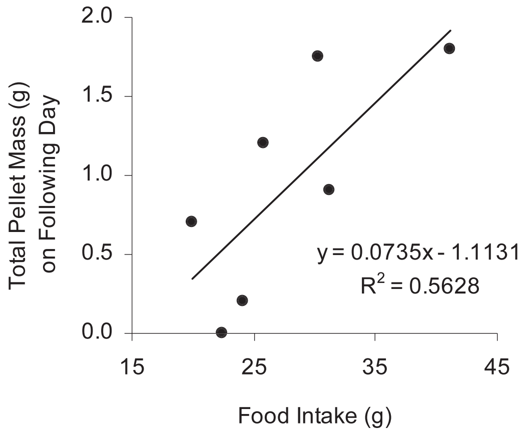

Figure 1. Linear regression of food intake of ingested house mice and mass of all pellets produced the following day ($P = 0.052$).

average, pellets best represent the previous day's food intake. Pellet dry weight represented $3.1 \pm 0.2\%$ ($n = 7$) of the previous day's wet weight food intake.

Using a linear relationship (food intake = [pellet weight on the following day + 1.1131]/0.0735; Fig. 1), we estimated food intake from pellet weight. Predicted food intake (Table 1) did not differ significantly from actual food intake on the previous day (paired sample *t*-test, $t = -0.543$, df = 6, $P = 0.607$).

We also derived an estimate of food intake from the number of individuals found in pellets (which in the absence of other clues was set to one), multiplied by the average mass of mice offered as food (23.7 g; Table 1). These estimates did not differ significantly from actual food intake the previous day ($t = 0.466$, df = 6, $P = 0.658$). Differences between these estimates and the prediction from pellet weight were not significant ($t = -1.859$, df = 6, $P = 0.112$).

In the field, collecting data on prey masses is often difficult, which is why data from the literature are sometimes used instead. We simulated this approach by using 22 g as an estimate of body mass for free-living house mice (Macdonald and Barrett 1993). The resulting estimates of food intake did not differ significantly from actual food intake (*t*-test, $t = -0.083$, df = 6, $P = 0.937$).

DISCUSSION

During our experiment, the Montagu's Harrier had low food intake, presumably because it was a relatively small individual, restricted in its movements, and with low thermoregulatory costs. The production of small light-weight pellets was consistent with the low food intake. Montagu's Harriers' pellets found in the field are usually much larger than the pellets we collected in captivity, as recorded in Long-eared Owls (Wijnandts 1984). Our findings and conclusions should be considered preliminary, as we used only one young bird that was captive most of its life and was fed a simple diet.

Our study indicated that a dietary shift was accurately reflected in pellet composition with a delay of 1–2 d, as found for Eurasian Kestrels by Yalden and Yalden (1985). In Barn Owls (*Tyto alba*), the interval between food intake and pellet production is not fixed, but depends on food quantity, time of feeding, and availability of a subsequent meal (Smith and Richmond 1972).

The relationship we found between dry pellet weight and food intake was based on small mammal prey. Yalden and Yalden (1985) showed that various prey species were represented in Eurasian Kestrel pellets with different fractions of their wet weight: 1.0% in wood mice (*Apodemus sylvaticus*), 1.4% in House Sparrows (*Passer domesticus*), and 1.6% in brown rats (*Rattus norvegicus*). The proportion of house mice recovered from pellets of our Montagu's Harrier was 3.1% on a daily basis, similar to the 3.3% documented for American Kestrels (*Falco sparverius*) and lower than the 6.9% for Rough-legged Hawks (*Buteo lagopus*; Duke et al. 1975). As digestive rates are known to show seasonal variations (Wijnandts 1984), we recommend that feeding experiments with larger mammals, birds, and insect prey should be undertaken to examine seasonal variations and to refine the relationship we determined in this study.

In many raptor dietary studies, quantifying prey found in pellets is difficult because more than one prey item can contribute to a single pellet when the interval between two successive meals is short (Wijnandts 1984, Marti 1974 in Lewis et al. 2004), and also because a single prey item may be distributed among two or more pellets (Rosenberg and Cooper 1990, Lewis et al. 2004). The number of prey individuals contained in one pellet is usually estimated by counting jaws, skulls, or feet (Schipper 1973, Bijlsma 1997, Arroyo 1997, 1998). If only hair (mammals) or feathers (birds) from one species are found in a pellet, the number of individuals for that species is usually set at one (Clarke et al. 1993, Arroyo 1998).

Our estimates of food intake, using the numerical method, closely resembled actual food intake, even in the absence of clues to the number of individuals in pellets. Equating the number of individuals per pellet to one yielded satisfactory results in the laboratory setting of our experiment. For Eurasian Kestrels, Kochanek (1990) suggested setting the number of individuals in small pellets to one and in large pellets to two. This also may be a useful approach in harriers, because the average number of prey per pellet in Hen Harrier was almost two (Redpath et al. 2001) and only 69% of the number of rodents fed to a captive Northern Harrier was retrieved from pellets (Craighead and Craighead 1956). To use estimates from the numerical method reliably, estimated prey weight must accurately reflect real prey weight. This suggests that data be collected locally rather than using means from published sources (Steenhof 1983). We found no evidence that this method performed more poorly than predictions from pellet weight (*contra* Wijnandts 1984), although results should be corrected for biases inherent in pellet analyses when used in the field, for instance, by including correction factors based on prey remains, direct observations, or videography.

INGESTA DE ALIMENTO EN UN INDIVIDUO DE *CIRCUS PYGARGUS* ESTIMADA MEDIANTE DOS MÉTODOS DE ANÁLISIS DE EGAGRÓPILAS

RESUMEN.—Los estudios sobre dieta revelan información importante sobre la ecología de las poblaciones de aves. La dieta de las aves rapaces frecuentemente se investiga mediante el análisis de egagrópilas. Usualmente, la ingesta de alimento se estima multiplicando el número de presas encontradas en las egagrópilas por el peso promedio de las presas obtenido de la literatura o de datos locales (método numérico). Sin embargo, la confiabilidad de este método rara vez ha sido evaluada en especies del género *Circus*. Hicimos un experimento de alimentación con un individuo cautivo de la especie *Circus pygargus* para evaluar si la masa de las egagrópilas es un indicador confiable de la ingesta de alimento y si este método debe ser preferido en relación con el método numérico. Encontramos que un cambio en la dieta se reflejó con exactitud en la composición de las egagrópilas, con un retraso de 1–2 días. El peso seco de las egagrópilas representó el 3.1 ± 0.21% del peso fresco de alimento ingerido durante el día anterior. Nuestros estimados de la ingesta de alimento basados en el método numérico se asemejaron bastante a la ingesta real, incluso en ausencia de pistas acerca del número de individuos incluidos en las egagrópilas. No encontramos evidencia de que este método arrojara peores resultados que el método de estimación de la ingesta de alimento basado en la masa de las egagrópilas.

[Traducción del equipo editorial]

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LITERATURE CITED

ARROYO, B.E. 1997. Diet of Montagu's Harrier *Circus pygargus* in central Spain: analysis of temporal and geographic variation. *Ibis* 139:664–672.

———. 1998. Effect of diet on the reproductive success of Montagu's Harrier *Circus pygargus*. *Ibis* 140:690–693.

——— AND J.T. GARCIA. 2006. Diet composition influences annual breeding success of Montagu's Harrier *Circus pygargus* feeding on diverse prey. *Bird Study* 53:73–78.

BIJLSMA, R.G. 1997. Handleiding veldonderzoek roofvogels. KNNV Uitgeverij, Utrecht, The Netherlands.

CLARKE, R., A. BOURGONJE, AND H. CASTELIJNS. 1993. Food niches of sympatric Marsh Harriers *Circus aeruginosus* and Hen Harriers *C. cyaneus* on the Dutch coast in winter. *Ibis* 135:424–431.

CRAIGHEAD, J.J. AND F.C. CRAIGHEAD. 1956. Hawks, owls, and wildlife. Dover, New York, NY U.S.A.

DUKE, G.E., A.A. JEGERS, G. LOFF, AND O.A. EVANSON. 1975. Gastric digestion in some raptors. *Comparative Biochemistry Physiology* 50A:549–656.

HARTLEY, P.H.T. 1947. The assessment of the food of birds. *Ibis* 90:361–381.

HÖLKER, M. AND T. WAGNER. 2006. Nahrungsökologie der Wiesenweihe *Circus pygargus* in der ackerbaulich intensiv genutzten Feldlandschaft der Hellwegbörde, Nordrhein-Westfalen. *Vogelwelt* 127:37–50.

HUANG, K.-Y., Y.-S. LIN, AND L.L. SEVERINGHAUS. 2006. Comparison of three common methods for studying the diet of nestlings in two *Accipiter* species. *Zoological Studies* 45:234–243.

KOCHANEK, H.-M. 1990. Ernährung des Turmfalken (*Falco tinnunculus*): Ergebnisse von Nestinhaltsanalysen und automatischer Registrierung. *Journal of Ornithology* 131:291–304.

KOKS, B.J., C. TRIERWEILER, E.G. VISSER, C. DIJKSTRA, AND J. KOMDEUR. 2007. Do voles make agricultural habitat attractive to Montagu's Harrier *Circus pygargus*? *Ibis* 149:575–586.

LEROUX, A. 2004. Le busard cendré. Editions Belin, Paris, France.

LEWIS, S.B., M.R. FULLER, AND K. TITUS. 2004. A comparision of 3 methods for assessing raptor diet during the breeding season. *Wildlife Society Bulletin* 32:373–385.

LOWE, V.P.W. 1980. Variation in digestion of prey by the Tawny Owl (*Strix aluco*). *Journal of Zoology* 192:283–293.

MACDONALD, D. AND P. BARRETT. 1993. Collins field guide. Mammals of Britain and Europe. HarperCollins Publishers, London, U.K.

MARTI, C.D., M. BECHARD, AND F.M. JAKSIC. 2007. Food habits. Pages 129–151 *in* D.M. Bird and K.L. Bildstein [EDS.], Raptor research and management techniques. Hancock House, Surrey, BC, Canada.

MAUREL, C. AND S. POUSTOMIS. 2001. Study of the diet of Hen *Circus cyaneus* and Montagu's *Circus pygargus* Harrier chicks at the nest using video recording. *Alauda* 69:239–254. (In French.)

MILLON, A., J.L. BOURRIOUX, C. RIOLS, AND V. BRETAGNOLLE. 2002. Comparative breeding biology of Hen Harrier and Montagu's Harrier: an 8-year study in north-eastern France. *Ibis* 144:94–105.

NEWGRAIN, K., B. GREEN, P. OLSEN, N. BROTHERS, AND N. MOONEY. 1993. Validation of 22-sodium turnover for the estimation of food consumption and energy requirements of some captive Australian raptors. Pages 285–294 *in* P.D. Olsen [ED.], Australian raptor studies: Proceedings of the 10th Anniversary Conference Australasian Raptor Association, Canberra. Australasian Raptor Association and Royal Australasian Ornithologists Union, Moonee Ponds, Australia.

NEWTON, I. 1979. Population ecology of raptors. T. and A.D. Poyser, Berkhamsted, U.K.

REDPATH, S.M., R. CLARKE, M. MADDERS, AND S.J. THIRGOOD. 2001. Assessing raptor diet: comparing pellets, prey remains, and observational data at Hen Harrier nests. *Condor* 103:184–188.

ROSENBERG, K.V. AND R.J. COOPER. 1990. Approaches to avian diet analysis. *Studies in Avian Biology* 13:80–90.

RUTZ, C. 2003. Assessing the breeding season diet of goshawks *Accipiter gentilis*: biases of plucking analysis quantified by means of continuous radio-monitoring. *Journal of Zoology* 259:209–217.

SÁNCHEZ-ZAPATA, J.A. AND J.F. CALVO. 1998. Importance of birds and potential bias in food habit studies of Montagu's Harriers (*Circus pygargus*) in southeastern Spain. *Journal of Raptor Research* 32:254–256.

SCHIPPER, W.J.A. 1973. A comparison of prey selection in sympatric harriers (*Circus* sp.) in western Europe. *Le Gerfaut* 63:17–120.

SIMMONS, R.E., D.M. AVERY, AND G. AVERY. 1991. Biases in diets determined from pellets and remains: correction factors for a mammal and bird-eating raptor. *Journal of Raptor Research* 25:63–67.

SMITH, C.R. AND M.E. RICHMOND. 1972. Factors influencing pellet egestion and gastric pH in Barn Owls. *Wilson Bulletin* 84:179–186.

STEENHOF, K. 1983. Prey weights for computing percent biomass in raptor diets. *Raptor Research* 17:15–27.

UNDERHILL-DAY, J.C. 1993. The foods and feedings rates of Montagu's Harriers feeding in arable farmland. *Bird Study* 40:74–80.

WIJNANDTS, H. 1984. Ecological energetics of the Long-eared Owl (*Asio otus*). *Ardea* 72:1–92.

YALDEN, D.W. AND P.E. YALDEN. 1985. An experimental investigation of examining kestrel diet by pellet analysis. *Bird Study* 32:50–55.

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