LITERATURE CITED

CHEBEZ, J.C. 1994. Los que se van. Especies argentinas en peligro. Editorial Albatros.

COLLAR, N.J, L.P. GONZAGA, N. KRABBE, A. MADROÑO, L.G. NARAUJO, T.A. PARKER AND D.C. WEGE. 1992. Threatened birds of the Americas. The ICBP/IUCN red data book. Smithsonian Institution Press, Washington, DC U.S.A.

DE LA PEÑA, R.M. 1992. Las aves argentina. Editorial L.O.L.A.

DE LUCCA, E.R. 1992. El águila coronada, *Harpyhaliaetus coronatus,* en San Juan. *Nuestras Aves* 26:25.

———. 1993. Rapaces Amenazadas. El águila coronada. *Nuestras Aves* 29:14–17.

FULLER, M.R. AND J.A. MOSHER. 1987. Raptor survey techniques. Pages 37–65 *in* B.A. Giron Pendleton, B.A. Millsap, K.W. Cline and D.M. Bird [EDS.], Raptor management techniques manual. Natl. Wildl. Fed., Washington, DC U.S.A.

GIAI, A. 1952. Diccionario ilustrado de las aves argentinas. 1. Aves Continentales. Revista Mundo Agrario, Editorial Haynes, Buenos Aires, Argentina.

GIL, G., E. HAENE AND J.C. CHEBEZ. 1995. Notas sobre la avifauna de Sierras de las Quijadas. *Nuestras Aves* 31: 26–28.

SALVADOR, S.A. AND P.G. EROLES. 1994. Notas sobre aves de Santiago del Estero. *Nuestras Aves* 30:24–25.

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# A COMPARISON OF METHODS TO EVALUATE THE DIET OF GOLDEN EAGLES IN CORSICA

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Identification of prey remains, pellet analysis and direct observation of prey deliveries are the principal methods used to study the diets of nesting raptors (Marti 1987). Although it is often best to observe or film nests for long periods to quantify prey deliveries, this is not always possible due to time and logistical constraints. To assess the validity of using prey remains and pellets as a means of determining diet, several authors have compared data from collections of nest contents with data obtained from direct observation for various raptor species (Collopy 1983, Simmons et al. 1991, Mersmann et al 1992, Mañosa 1994, Real 1996). Overall, they have found that by combining remains and pellets, collected with the same level of effort, it is possible to determine diet. Previous studies of the diet of Golden Eagles (*Aquila chrysaetos*) in the Mediterranean area have been based on the collection of prey remains, without taking into account any possible biases in the data collected using only this technique (Handrinos 1987, Cheylan 1983, Fasce and Fasce 1984, Fernandez 1991, Grubac 1987, Huboux 1984). Considering that the variety of food resources on Mediterranean islands is limited (Seguin and Thibault 1996) with a moderate spectrum of potential prey, we conducted this study to determine the best methods for monitoring the diet of Golden Eagles on Corsica.

## STUDY AREA AND METHODS

Corsica (42°N, 9°E) is one of the major islands in the western Mediterranean covering an area of 8750 km$^2$. It supports a breeding population of 32–37 pairs of Golden Eagles (Torre 1995). Our study area, in the Verghello

Table 1. Minimal Number of Individuals (MNI), percentage of different prey according to different diet analysis methods and correction factors (c.f.) for a Golden Eagle nest in Verghello Valley (Corsica), 1992, 1994, and 1995

| | DELIVERED PREY $N = 79$ | | REMAINS $N = 52$ | | | PELLETS $N = 50$ | | | REMAINS + PELLETS $N = 72$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | c.f. | MNI | % | c.f. | MNI | % | c.f. |
| Mammals | | | | | | | | | | | |
| Large mammals | 31 | 39.2 | 30 | 57.7 | +1.47 | 25 | 50.0 | +1.28 | 32 | 44.4 | +1.13 |
| Small mammals | 6 | 7.6 | 1 | 1.9* | −4.00 | 3 | 6.0 | −1.27 | 4 | 5.6 | −1.36 |
| Birds | | | | | | | | | | | |
| Corvidae | 10 | 12.7 | 11 | 21.2 | +1.67 | 2 | 4.0* | −3.37 | 11 | 15.3 | +1.20 |
| *Alectoris rufa* | 3 | 3.8 | 6 | 11.5* | +3.03 | 2 | 4.0 | +1.05 | 6 | 8.3* | +2.18 |
| Others | 2 | 2.5 | 1 | 1.9 | −1.32 | 3 | 6.0* | +2.4 | 4 | 5.6* | +2.24 |
| Reptiles | | | | | | | | | | | |
| *Coluber viridiflavus* | 27 | 34.2 | 3 | 5.8* | −5.9 | 15 | 30.0 | −1.14 | 15 | 20.8 | −1.64 |

* Significantly different from the frequencies of delivered prey.

Valley, included one breeding pair that had been monitored by the Parc Naturel Régional de Corse since 1981.

We observed prey brought to this nest by adult eagles from mid-May to late July in 1992, 1994, and 1995. During the three years, hatching occurred between 15–24 May and fledging occurred between 28 July–4 August. We made observations using a 20–60× spotting scope from a blind located 200–250 m from the nest. Observers came to and left from the blind at night in order not to disturb the adults. Observations were made for 1 d every 2.5 d with observation days evenly distributed between hatching and fledging for a total of 1271 observation hr spread over 82 d (1992—27 d, 1994—23 d, and 1995—32 d). Whenever possible, prey items were identified to species and the identification was relatively easy because the number of mammalian species likely to be taken by Golden Eagles was low (15 taxa included eight domestic, Saint-Girons 1989, Raveneau 1993). However, not all prey could be identified due to poor visibility during observation periods caused by heat, haze, and aggressive behavior of the young as they took prey from adults. Domestic goat (*Capra hircus*) and sheep (*Ovis aries*) could not be differentiated in any cases, so they were grouped as Caprini.

In each of the three years, remains were carefully collected in and under the nest in late August after fledging. Pellets were dissected and separated into bone fragments, feathers, reptile scales, and hair. Bones collected in the nest or extracted from pellets were identified by comparison with osteological collections (Muséum National d'Histoire Naturelle, Paris, France) following methods of Payne (1985), Barone (1986), and Vigne (1995). Feathers (both from the nest or extracted from pellets) were identified by comparison with a reference collection. Hair was identified by comparison with Spillmann (1991). Because adults spent most of the time away from the nest after the young were 4-wk old, we assumed that most pellets we collected from the nest were from the young. Each species identified in a pellet was counted as an individual.

Quantification of food remains was based on minimum number of individual estimates (MNI) (Poplin 1976, Vigne 1991) based on the number of the most frequent anatomical part in food remains or the pairing of anatomical parts (e.g., jaws). The drawback of this method is that it is impossible to be totally objective in the pairing of bone pairs. Also, the most frequent species are underestimated in comparison to rare species (Poplin 1976). Prey were separated into six categories: large mammals (Caprini, boar [*Sus scrofa*] and red fox [*Vulpes vulpes*]), small mammals (weasel [*Mustela nivalis*], European hedgehog [*Erinaceus europaeus*], and black rat [*Rattus rattus*]), birds (Corvidae, Red-legged Partridge [*Alectoris rufa*] and other birds), and snakes. Differences between taxa, years or prey categories obtained by both methods were tested with Chi-square contingency tables.

## RESULTS AND DISCUSSION

Of the prey delivered to the nest, 86% ($N = 79$, Table 1) were whole. The remainder consisted of portions of large mammals (Caprini, boar and unidentified mammals). Altogether, 39% of the prey delivered to the nest was large mammals, 8% was small mammals, 19% was birds including Red-legged Partridges, Common Kestrels (*Falco tinnunculus*), an unidentified raptor nestling, pigeons (*Columba* spp.), Common Raven (*Corvus corax*), and Eurasian Jay (*Garrulus glandarius*), and 34% was snakes (western whip snake [*Coluber viridiflavus*]). No significant difference appeared among the three years in the amount of these different prey that was delivered to the nest ($\chi^2 = 3.23$, df = 6, $P = 0.78$). Analysis of prey remains collected at the nest showed the diet consisted of 44% large mammals, 6% small mammals, 29% birds, and 21% snakes. Again, no significant difference was found in the diet among the three years ($\chi^2 = 4.44$, df = 6, $P = 0.67$).

Bones contributed most data for the quantitative as-

Table 2. Minimal Number of Individuals and number of species (in parentheses) obtained from bone identification and complementary data by pellet and feather examination from material collected in a Golden Eagle nest in Verghello Valley (Corsica), 1992, 1994, and 1995.

| | BONES | PELLETS | FEATHERS |
|---|---|---|---|
| Large mammals | 30 (4) | 3 (0) | — |
| Small mammals | 1 (1) | 3 (1) | — |
| Large birds | 10 (2) | 0 (0) | 4 (1) |
| Small birds | 0 (0) | 1 (1) | 9 (3) |
| Reptiles | 3 (1) | 12 (0) | — |

sessment of MNI for large mammals and large birds (Table 2). Pellets provided little additional information for large mammals, but added additional data for estimating MNI for small mammals and snakes. Feathers provided supplementary data on bird numbers, especially on smaller species. Analysis of bones yielded the most information on the number of species while pellet analysis better predicted occurrence of small mammals and birds (Table 2). Feathers provided the best estimate for small bird species.

Comparison of data obtained for prey delivered to the nest with that of prey remains showed a significant difference between the six categories of prey ($\chi^2$ = 19.43, df = 5, $P$ = 0.002). The number of mammals and reptiles in the diet was underestimated, while birds are overestimated in samples of prey remains. In fact, the frequency of small mammals was four times lower in remains than in prey delivered. Red-legged Partridge, in contrast, were three times more frequent and western whip snakes were six times less frequent. The small mammals, the Red-legged Partridge and the western whip snake contributed to the significant difference between prey delivery and remains. The comparison between prey delivered and pellets was not significant among the six prey categories ($\chi^2$ = 4.51, df = 5, $P$ = 0.48). Nevertheless, the Corvidae were three times less frequent in pellets than in prey deliveries. On the other hand, the frequency of birds (except the Corvidae and the Red-legged Partridge) in pellets was 2.4 times greater than in prey deliveries. The comparison between prey delivered and remains plus pellets was not significant among the six prey categories ($\chi^2$ = 5.03, df = 5, $P$ = 0.41). Nevertheless, the Red-legged Partridge and other birds were two times more frequent than in the prey delivered.

Using all methods, 15 species of prey were identified (Table 3). Here also, there was no significant difference in the species composition of the diet estimated by direct observation or by analysis of remains and pellets ($\chi^2$ = 6.51, df = 2, $P$ = 0.99).

One might expect that food habits data collected once at the end of the nesting season would be biased in favor of large prey species. However, when adult Golden Eagles clean nests, females often eliminate the larger remains which could result in an underestimation of large prey species (Mathieu and Choisy 1982, Tjernberg 1981). This bias has been noted for other species (Real 1996).

Several sources of bias exist in the results of prey analysis based on remains only that are related to prey size and factors affecting fragmentation of remains such as removal when remains are taken out of nests by females, difficulties in identification owing to wear, differences in the size of prey, and destruction of osteological remains. These factors probably explain the differences we observed between the prey delivery and prey remains methods. One of the more important biases we found in the collection of prey remains of Golden Eagles was the underestimation of the small prey items, in particular small mammals and reptiles, because most of the time they were completely eaten. This bias has been previously observed in Golden Eagle dietary studies (Delibes et al. 1975, Mathieu and Choisy 1982, Tjernberg 1981), and of other raptors (Simmons et al. 1991, Mersmann et al. 1992, Mañosa 1994, Real 1996). Birds such as Red-legged Partridges are overestimated because of the abundance of sterna and feathers. Pellets overestimated birds other than corvids and Red-legged Partridges in the diet because they were eaten entirely. Assuming that the occurrence of a prey species in a pellet corresponds to an individual can also overestimate the number of large mammals in the diet since several pellets could contain the remains of the same individual of a prey taxon eaten

Table 3. Overall number and percentage of species identified by the different diet analysis methods (prey delivered, remains, pellets, and remains + pellets), at the Golden Eagle nest in Verghello Valley (Corsica), 1992, 1994, and 1995.

| | DELIVERED PREY | | REMAINS | | PELLETS | | REMAINS + PELLETS | |
|---|---|---|---|---|---|---|---|---|
| | $N$ | % | $N$ | % | $N$ | % | $N$ | % |
| Mammals ($N$ = 6 species) | 5 | 83.3 | 6 | 100.0 | 4 | 66.7 | 6 | 100.0 |
| Birds ($N$ = 8 species) | 5 | 62.5 | 6 | 75.0 | 5 | 62.5 | 7 | 87.5 |
| Reptiles ($N$ = 1 species) | 1 | 100.00 | 1 | 100.0 | 1 | 100.0 | 1 | 100.0 |
| Total ($N$ = 15 species) | 11 | 73.3 | 13 | 86.7 | 10 | 66.7 | 14 | 93.3 |

over several days. No method gives a perfect estimate of the nesting diet but combining remains and pellets seems to be the least biased estimator of diet available if deliveries cannot be recorded. The complementary nature between these two types of prey analysis has been shown in previous studies on raptor diet (Simmons et al. 1991, Mersmann et al. 1992, Mañosa 1994, Oro and Tella 1995, Real 1996).

The comparison of direct observations and collection of prey remains to determine the diet of Golden Eagles was studied by Collopy (1983), but in a region where the largest prey was jackrabbits (*Lepus californicus*). Our study was the first to compare the different analytical methods in an area where prey are larger than Leporidae. While either method gave similar results for the percent frequency of prey in the diet of Golden Eagles, periodic observations of food delivered to nests are necessary if the main objective is estimate prey biomass (Collopy 1983), or to obtain information on selection of prey (Real 1996). Our data indicate that the combination of prey remains plus pellets collected on only one visit after the breeding season would enable the study of several pairs of eagles over a large area and a short period of time.

RESUMEN.—Numerosos estudios sobre el régimen alimenticio del pollo de Aguila real (*Aquila chrysaetos*) están basados en el análisis de los restos óseos o de las egagrópilas. Pero, dado que dichos restos sufren una degradación diferencial, los resultados pueden quedar sesgados. Desde esta optica hemos comparado durante cuatro periódos de reproducción, en una isle mediterránea, los restos de huesos, de egagrópilas y de plumas encontrados en un nido a los datos obtenidos por observación directa. Queda comprobado que los diferentes tipos de restos se complementan, y que por consiguiente su recogida y análisis con el mismo esfuerzo son necesarios pare que la descripción del regimen alimenticio del pollo de Aguila real se acerque en lo posible de la realidad.

[Traducción de Pedro Arrizabalaga]

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LITERATURE CITED

BARONE, R. 1986. Anatomie comparée des mammifères domestiques. Tome 1. Ostéologie. Vigot, Paris, France.

CHEYLAN, G. 1983. Note sur l'alimentation de l'Aigle royal *Aquila chrysaetos* en Basse Provence. *Bull. Centre de Recherches Ornithologiques de Provence* 5:56–57.

COLLOPY, M.W. 1983. A comparison of direct observations and collections of prey remains in determining the diet of Golden Eagles. *J. Wildl. Manage.* 47:360–368.

DELIBES, M., J. CALDERON AND F. HIRALDO. 1975. Seleccion de presa y alimentacion en España del Aguıla real (*Aquila chrysaetos*). *Ardeola* 21:285–303.

FASCE, P. AND L. FASCE. 1984. L'Aquila reale in Italia. Lega Italiana Protezione Uccelli, Parma, Italy.

FERNANDEZ, C. 1991. Variation clinale du régime alimentaire et de la reproduction chez l'Aigle royal (*Aquıla chrysaetos*) sur le versant sud des Pyrénées. *Rev. Ecol.* (*Terre Vie*) 46:363–371.

GRUBAC, R. 1987. L'Aigle royal en Macédoine. Actes du premier colloque international sur l'Aigle royal en Europe, Arvieux 1986. Maison de la Nature, Briançon, France.

HANDRINOS, G.I. 1987. L'Aigle royal en Grèce. Actes du premier colloque international sur l'Aigle royal en Europe, Arvieux 1986. Maison de la Nature, Briançon, France.

HUBOUX, R. 1984. Contribution à une meilleure connaissance du régime alimentaire de l'Aigle royal en période de reproduction pour les Alpes du Sud et la Provence. *Bull. Centre de Recherches Ornithologiques de Provence* 6:30–34.

MAÑOSA, S. 1994. Goshawk diet in a Mediterranean area of northeastern Spain. *J. Raptor Res.* 28:84–92.

MARTI, C.D. 1987. Raptor food habit studies. Pages 67–80 *in* B.A. Giron Pendleton, B.A. Millsap, K.W. Cline and D.M. Bird [EDS.], Raptor management techniques manual. Natl. Wild. Fed. Washington, DC U.S.A.

MATHIEU, R. AND J.-P. CHOISY. 1982. L'Aigle royal dans les Alpes méridionales françaises de 1964 à 1980. *Le Bièvre* 4:1–32.

MERSMANN, T.J., D.A. BUEHLER, J.D. FRASER AND J.K D SEEGAR. 1992. Assessing bias in studies of Bald Eagle food habits. *J. Wildl. Manage.* 56:73–78.

ORO, D. AND J.L. TELLA. 1995. A comparison of two methods for studying the diet of the Peregrine Falcon. *J Raptor Res.* 29:207–210.

PAYNE, S. 1985. Morphological distinctions between the mandibular teeth of young sheep, Ovis, and goats, Capra. *J. Archeol. Sci.* 12:139–147.

POPLIN, F. 1976. A propos du nombre de restes et du nombre d'individus dans les échantillons d'ossements. *Cahier du Centre de Recherches Préhistoriques* (*Univ. Parıs I*) 5:61–74.

RAVENEAU, A. 1993. Inventaire des animaux domestiques en France. Nathan, Paris, France.

REAL, J. 1996. Biases in diet study methods in the Bonelli's Eagle. *J. Wildl. Manage.* 60:632–638.

SEGUIN, J.-F. AND J.-C. THIBAULT. 1996. Ajustement de l'alimentation de l'Aigle royal (*Aquila chrysaetos*) à la disponibilité saisonnière des proies pendant la période de reproduction en Corse. *Rev. Ecol.* (*Terre Vıe*) 51:329–339.

SAINT-GIRONS, M.-C. 1989. Les mammifères en France. Sang de la Terre et La Manufacture, Paris, France.

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

SPILLMANN, P.-L. 1991. Atlas des pois des mammifères sauvages terrestres de Corse. Mém. Maitrise Sci. Tech., Université de Corse, Corté, Corsica.

TJERNBERG, M. 1981. Diet of the Golden Eagle *Aquila chrysaetos* during the breeding season in Sweden. *Holarct. Ecol.* 4:12–19.

TORRE, J. 1995. L'Aigle royal (*Aquila chrysaetos*) en Corse: répartition et biologie de la reproduction. *Trav. Sc. Parc Nat. Rég. Rés. Nat. Corse* 51:87–90.

VIGNE, J.-D. 1991. The meat and offal weight (MOW) method and the relative proportion of ovicaprines in some ancient meat diets of the north-western Mediterranean. *Rivista di Studi Liguri* 57:21–47.

———. 1995. Critères de détermination des onglons d'artiodactyles de Corse pour une contribution à la connaissance du régime alimentaire du Gypaéte. *Rev. Ecol. (Terre Vie)* 50:85–92.

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# A RECORD OF A HARPY EAGLE FROM EASTERN PARAGUAY

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KEY WORDS: *Harpy Eagle;* Harpia harpyja; *Paraguay; sight record.*

On 2 August 1995, I recorded an immature Harpy Eagle (*Harpia harpyja*) in rainforest at Reserva Privada Itabó (24°20′S, 54°35′W), Departamento Canindeyú, Paraguay. The Harpy Eagle is poorly known in Paraguay and has not been previously recorded at this site.

I first sighted the perched eagle in an emergent tree beside the main road through the reserve. It had been forced into the tree by a flock of seven White-eyed Parakeets (*Aratinga leucopthalmus*). After 10 min, the bird was again mobbed by the parakeet flock, causing it to fly off into the adjacent forest canopy.

There was no question that the bird was a Harpy Eagle. Its most obvious feature was its large, completely creamy-white facial disc. Its bill was dark grey and its eyes large and black. Several completely white feathers formed a crest on its head. Its breast and belly were a uniform creamy white except for a pale grey area across its breast. The undertail appeared dark brown and the underwings appeared pale with some dark barring. I hardly saw the upperparts but they appeared to be largely grey, at least on the back, scapulars and wing coverts, with black lower on the wings. I did not see the upperwings or uppertail in flight.

Not all of the salient characters, notably the enormous tarsi and the divided crest could be seen due to the angle of observation. However, nothing about the bird indicated that it was a Crested Eagle (*Morphnus guianensis*). Immature Crested Eagles are distinguished from immature Harpy Eagles by their slimmer bodies, long tails, smaller bills, dark lores, black-tipped crests and long, relatively small tarsi. Light phase Crested Eagles also have white underwing coverts contrasting with barred remiges (Hilty and Brown 1986). Crested Eagles have not been recorded in Paraguay (Hayes 1995), although they have been historically recorded in Misiones Province, Argentina (Narosky and Yzurieta 1987).

I excluded other large raptors such as Mantled Hawk (*Leucopternis polionota*), Black-and-white Hawk-Eagle (*Spizastur melanoleucus*), Black Hawk-Eagle (*Spizaetus tyrannus*) and Ornate Hawk-Eagle (*S. ornatus*) based on the size and bulk of the bird alone and the plumage of the bird I observed did not match the plumages of any of these species (Narosky and Yzurieta 1987). The latter three species are known from Reserva Privada Itabó (Lowen et al. 1996).

The Harpy Eagle is rare throughout its range from Mexico to Argentina. It was considered Globally Threat-

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