MOMIYAMA, T. 1927. Discription of twenty-five new birds and three additions from Japanese territories. *Annot. Orn. Orient.* 1:81–101.

———. 1930. On the birds of Bonin and Iwo-islands. *Bull. Biogeogr. Soc. Japan.* 1:89–186.

NAKANE, M., T. MATSUMOTO, AND K. MIYASHITA. 1980. Status of the birds on Chichi-jima and Haha-jima in the Ogasawara Islands. Pages 43–63 *in* The general survey of natural environment of the Ogasawara (Bonin) Islands research group of Tokyo Metropolitan University [EDS.], Reports of the general survey of natural environment of the Ogasawara (Bonin) Islands. Tokyo Metropolitan University, Tokyo, Japan.

OGASAWARA NATURAL ENVIRONMENTAL GROUP. 1992. The nature of the Ogasawara Islands. Kokin-Shoin, Tokyo, Japan. (In Japanese.)

ORNITHOLOGICAL SOCIETY OF JAPAN. 2002. Check-list of Japanese birds. Ornithological Society of Japan, Hokkaido, Japan.

REIF, V., R. TORNBERG, S. JUNGELL, AND E. KORPIMAKI. 2001. Diet variation of Common Buzzards in Finland supports the alternative prey hypothesis. *Ecography* 24: 267–274.

SELAS, V. 2001. Predation on reptiles and birds by the Common Buzzard, *Buteo buteo,* in relation to changes in its main prey, voles. *Can. J. Zool.* 79:2086–2093.

SERGIO, F., A. BOTO, C. SCANDOLARA, AND G. BOGLIANTI. 2002. Density, nest sites, diet, and productivity of Common Buzzards (*Buteo buteo*) in the Italian pre-Alps. *J. Raptor Res.* 36:24–32.

SHIMIZU, Y. AND H. TABATA. 1991. Forest structures, composition, and distribution on a Pacific island, with reference to ecological release and speciation. *Pac. Sci.* 45:28–49.

SUZUKI, T. 1982. Status of the Ogasawara buzzard on Chichijima: estimation of distribution and abundance. *Ann. Rep. Ogasawara Res.* 6:23–34.

——— AND H. CHIBA. 1995. Distribution and ecology of the Ogasawara Buzzard. Pages 61–93 *in* Tokyo Regional Forest Office [EDS.], The Ogasawara buzzard–report for conservation act of rare plants and animals Tokyo Regional Forest Office, Tokyo, Japan.

——— AND Y. KATO. 2000. Abundance of the Ogasawara buzzard on Chichijima, the Pacific Ocean. *J. Raptor Res.* 34:241–243.

SWANN, R.L. AND B. ETHERIDGE. 1995. A comparison of breeding success and prey of the Common Buzzard *Buteo buteo* in two areas of northern Scotland. *Bird Study* 42:37–43.

TAKANO, S., Y. UCHIDA, N. YANAGISAWA, AND N. SUGIYAMA 1970. The birds of the Bonin Islands and the Volcano Islands. Pages 61–87 *in* Agency for Cultural Affairs [EDS.], Nature of the Ogasawara Islands. Agency for Cultural Affairs, Tokyo, Japan.

TOMIYAMA, K. 1998. Disturbance of island ecosystem by introduced species in Ogasawara Islands. *Jpn. J. Ecol*, 48:63–72.

TRUSZKOWSKI, J. 1976. Role of the Common Buzzard (*Buteo buteo* L.) in agrocenoses of the middle Wielkopolska. *Pol. Ecol. Stud.* 2:103–111.

TSUYAMA, T. AND S. ASAMI. 1970. Nature of the Ogasawara. Hirokawa Publishing Co., Tokyo, Japan.

UEDA, K. AND L. N. DEFOREST. 1988. Food and behavior of male Ogasawara buzzards during the courtship feeding period. *Jpn. J. Ornithol.* 37:34–36.

WILD BIRD SOCIETY OF JAPAN. 1975. Hahajima Islands. Pages 93–136 *in* Wild Bird Society of Japan [EDS.], Survey on special birds requiring protection. Japan Environment Agency, Tokyo, Japan.

YABE, T. AND T. MATSUMOTO. 1982. A survey on the marine rodents on Chichijima and Hahajima, the Ogasawara Islands. *J. Mammal Soc. Jpn.* 9:14–19.

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## THE DIET OF EURASIAN GRIFFONS (*GYPS FULVUS*) IN CRETE

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Between a quarter and half of the global range of the Eurasian Griffon (*Gyps fulvus*) population occurs within Europe (Arroyo 1994). The species is distributed mainly in countries bordering the Mediterranean basin and feeds primarily on livestock carrion (Cramp and Simmons 1980, Donázar 1993). In Crete, the griffon's feeding ecology may be more closely related to pastoralism than anywhere else in Europe. Paleontological findings indicate that all autochthonous-mammal species (apart

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from some rodents) disappeared from the island by the end of the Pleistocene (Sondaar et al. 1996, Willemsen 1996), while the presence of griffons dates back to the upper Pleistocene and Holocene (Rich 1983). Moreover, the introduction of sheep and goats by farmers occurred 7000 years ago (Cavalli-Sforza 1996, Jarman 1996).

Since the last century the main potential food sources for this species on Crete consisted of domestic livestock and one wild species (i.e., the Cretan wild goat [*Capra aegagrus cretica*]). Given that (1) studies of the Eurasian Griffon's diet are completely lacking in Greece, (2) that the most important griffon population in the country is found on Crete (Handrinos 1985, Handrinos and Akriotis 1997), and (3) that the number of species that are available as carrion on the island is low, this study on the griffons' diet should lead to more effective management of the species. Pellet analysis is the most common technique for the study of the diet of carrion-eating species (Hiraldo 1976, Coleman and Fraser 1987, Ceballos and Donázar 1990, Thibault et al. 1993, Larraz, 1999). However, an analytical problem arises due to the low occurrence or even absence of bones and a high concentration of hair or feathers in pellets (Houston 1976). The latter provide information concerning the qualitative composition of the diet, but they do not reveal the number of animals on which the bird has fed upon. Thus, no quantitative data or biomass quantity can be estimated from such pellets (Marti 1987). Here, I report qualitative data on the diet of the Eurasian Griffin on the island of Crete, based on the analysis of regurgitated pellets.

## METHODS

Fieldwork was undertaken in 11 griffon colonies at the end of the 2000 and 2001 breeding seasons. This period was considered to be most suitable, because it offers the opportunity to collect pellets while causing minimum disturbance to the birds. As nests are progressively destroyed by the chicks, a relatively large sample of pellets may be found among the nest material at the bottom of the breeding cliffs. Unfortunately, collection of pellets below roost sites that would account for the diet of the species throughout the year was not feasible. The bases of most cliffs where roosting sites were located were searched intensively but did not provide any pellet material.

Pellets were found below 14 nests in four colonies (two in western and two in eastern Crete, which hosted 90 and 79 individuals in 2000 and 2001, respectively). They were sun-dried in order to remove water (Coleman and Fraser 1987), their mass measured and separated from bones and feathers. They were dissected into small pieces for subsequent identification. The hair was identified through a photonic stereoscope Leica MZ8 (Leica Microsystems Ltd., Heerbrugg, Switzerland), with the aid of an identification-key (Papageorgiou and Sfougaris 1989) and by comparison to reference samples from specimens of local mammal species, which constitute potential prey for griffons (i.e., domestic sheep [*Ovis aries*] and domestic goat [*Capra hircus*], beech marten [*Martes foina*], badger [*Meles meles*], brown hare [*Lepus europaeus*], and the Cretan wild goat).

Table 1. Items found in Eurasian Griffon pellets in Crete (Greece, 2000–01).

| ITEM | *N* (PERCENT) |
|---|---|
| Domestic sheep hair (*Ovis aries*) | 127 (89.4) |
| Domestic goat hair (*Capra hircus*) | 22 (15.5) |
| Rabbit hair (*Oryctolagus cuniculus*) | 4 (2.8) |
| Beech marten hair (*Martes foina*) | 2 (1.4) |
| Bones (Caprines) | 9 (6.3) |
| Gramineae spp. | 61 (42.9) |
| Holm-oak leaves *Quercus coccifera* | 24 (16.9) |
| Dirt | 14 (9.86) |
| Coleoptera (Family Dermestidae) | 8 (5.6) |
| Olive core | 1 (0.7) |

Eurasian Griffons are exclusively carrion eaters, feeding mainly on soft tissues, thus only the frequency of the presence of prey items was estimated (namely the number of pellets containing each prey species × 100/total number of pellets; Ceballos and Donázar 1990). The null hypothesis that sheep and goat remains were found in the pellets in exact ratio to their proportion in livestock numbers was tested by a chi-square test with a Yates' correction (Zar 1996). When the remains of one or more animals were found in the same pellet it was assumed that they provided information on the frequency that griffons fed on them (Hiraldo 1976).

## RESULTS

My field assistant and I collected 811 different items among nest ruins. However, only 142 items were considered as regurgitated material and only 93 (65.5%) had the typical oval shape of the pellets produced by raptors (Fitzner et al. 1977). The rest of the items were tufts of sheep and goat hair, which probably originated from dissolved pellets, and were not included in this analysis. Pellet size was rather small, with a mean diameter of 19.3 mm (SD = 8 mm, range = 5–50 mm), mean length of 57.7 mm (SD = 24.5 mm, range = 18–138 mm), and mean width of 33.5 mm (SD = 14.6 mm, range = 10–105 mm). Their mass ranged from 0.6–15.3 g ($\bar{x}$ = 4.05 ± 2.86 g) and contained 10 different constituents (Table 1).

The dominant species in the griffons' diet was domestic sheep, which was present in almost 90% of the pellets. Domestic goat was the second most important prey item (Table 1). Sheep were represented in the pellets more than goats ($\chi^2 = 16.5$, $P < 0.001$). The rabbit (*Oryctolagus cuniculus*) and the beech marten were the only additional species detected in the analysis, but in a substantially smaller number of pellets. Pieces of long bones or whole vertebra were found in 6.3% ($N = 9$) of the pellets, all originating from adult caprines.

Plant material occurred in 42.9% ($N = 61$) of the pellets and was mainly grass (i.e., Gramineae), while holm oak leaves (*Quercus coccifera*) were found in 16.9% ($N = 24$) of them. Fourteen pellets (9.86%) consisted exclusively of dirt with a few stones, one contained an olive

core (0.7%) and eight (5.6%) contained cocoons of coleoptera of the family Dermestidae.

## DISCUSSION

In Europe, the griffon usually feeds on cattle (*Bos taurus*), equines (*Equus caballus, Equus asinus*), caprines (*Ovis aries, Capra hircus, Rupicapra rupicapra*), red deer (*Cervus elaphus*), pigs (*Sus scrofa var. domesticus*), canids (*Canis familiaris, Vulpes vulpes*), lagomorphs (*Lepus capensis, Oryctolagus cuniculus*), birds and insects (Fernández 1975, Beven 1979, Cramp and Simmons 1980, González et al. 1984), but it prefers large ungulates when these are available (Donázar 1993). Fernández (1975) reports that the species' diet in southern Spain consists mainly of domestic animals such as goats (34.9%), sheep (20.9%), donkeys (11.6%), and cows (7%); while in northern Spain, sheep were found in more than 75% of pellets analyzed (Marco and Garcia 1981). The results of the present study do not differ from relevant ones in other Mediterranean regions in the sense that griffons feed opportunistically on the carrion of the most common species in their foraging range.

The findings of my pellet analysis probably reflect the availability of the different prey species and the way that griffons feed on different types of carrion. Medium sized domestic animals, such as sheep and goats, constitute the majority of livestock (i.e., 95.3%; National Statistical Service of Greece 1991) and the totality of the free grazing livestock of Crete. They are present in the uplands from late April until late October, and suffer greater losses than those that are homebred due to accidents, malnutrition, and sickness. Moreover, they are well represented in the pellets because griffons start feeding on their carcasses from any part of the body, thus consuming lots of hair (pers. obs.). By contrast, large ungulates were completely absent from the pellets. In Crete the number of such animals has decreased by 86% (National Statistical Service of Greece, pers. comm.) in recent decades (i.e., since 1961) and their corpses are buried currently. Typically during the 1960s and early 1970s old equines were left to die in remote upland areas or their carcasses were thrown in a few waste dumps near the villages (primarily in gorges). However, griffons are incapable of tearing the skin of these animals. Instead, griffons access nutrition from carcasses mainly from the natural orifices (e.g., mouth), which produces minimal intake of hair in their food (Houston 1976).

I attributed the high frequency of sheep hair in the pellets to the spatial distribution of domestic animals up to the time that pellet collection took place. Pellets were collected from nest material and account for the period that nests were occupied by incubating individuals or by parent birds attending their young, specifically from early January to late May/early June. The majority of livestock in the vicinity of the colonies during this period was sheep. Small waste dumps that operate illegally near these stockyards also provided dead biomass to the griffons.

The rabbit remains recorded were suspected to have been taken from a Bearded Vulture (*Gypaetus barbatus*) nest. A breeding pair had been supplied with dead rabbits during the chick-rearing period (Xirouchakis et al. 2003) 3 km from the colony where the pellets containing rabbit hair were collected. After the Bearded Vultures' breeding attempt, griffons were observed to visit the nest several times and consume bones and prey remains. In other cases, griffons were observed to take bone fragments from the base of a cliff 4 m below another nest while a Bearded Vulture was incubating. This habit has also been reported in Spain, where griffons occasionally explore the ossuaries of Bearded Vultures, where the latter drop the bones to break them (Bertran and Margalida 1997). Based on the present results, bone consumption seemed frequent in Crete, suggesting that griffons do not suffer from calcium deficiency as some African vultures do in areas where large carnivores are extinct. This substance is not available in large herbivores' carrion if no broken bones are found resulting from the action of large mammalian predators (Houston 1978, Richardson et al. 1986). In contrast, griffons in Crete have been seen to break the bones of small ungulates easily, and thus are not dependent on mammalian carnivores or other vulture species with powerful beaks, which are absent from the island (e.g., Cinereous Vulture [*Aegypius monachus*]).

Vegetation in the griffon's diet was probably consumed accidentally as well as the dirt, or was contained in the ungulates' digestive tract. However, griffons have been observed to eat green plants after feeding bouts, a process that probably facilitates pellet formation (Hiraldo 1976). Finally, the coleoptera prey that was recorded was likely consumed incidentally along with hair as dormestids (Dermestidae) feed on the wool of dead animals.

Overall, irrespective of the source of food used by griffons (i.e., carrion from waste dumps or from transhumance herds), pellet analysis showed that their diet was dominated by small domestic ungulates. Considering the low use of poisoned baits for vermin (due to the absence of large predators) and the dramatic increase in livestock numbers (>70%; National Statistical Service of Greece 1991) promoted by subsidy policies when Greece joined the European Union in 1981, the future of the species seems rather favorable. However, increased food abundance does not necessarily imply higher food availability. The latter is also determined by other factors such as stock-rearing methods, sanitary conditions, closing down of rubbish dumps, or outdoor abattoirs. In the meantime, the strong dependence of griffons on pastoralism means that socio-economic factors may place them at risk of a human-induced food shortage.

## LA DIETA DE *GYPS FULVUS* EN CRETA

RESUMEN.—Recolectamos egagrópilas de 14 nidos de *Gyps fulvus* en Creta al final de las estaciones reproductivas de 2000 y 2001. El análisis mostró que *G. fulvus* se

alimenta casi exclusivamente de carroña proveniente de ovejas y cabras domésticas. Los equinos y bovinos estuvieron ausentes de las egagrópilas, probablemente debido al modo en que los buitres consumen los cadáveres y a la escasez de estos animales como carroña. La deficiencia de calcio en los volantones no fue considerada como un problema porque se encontraron huesos de pequeños ungulados en el 6.3% de las egagrópilas. Se considera que el incremento en la abundancia de ganado de las últimas dos décadas ha sido beneficioso para la especie; sin embargo, los métodos de cría del ganado también pueden afectar su estado de conservación al largo plazo.

[Traducción del equipo editorial]

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LITERATURE CITED

ARROYO, B. 1994. Griffon Vulture *Gyps fulvus*. Pages 156–157 *in* G.M. Tucker and M.F. Heath [EDS.], Birds in Europe: their conservation status. BirdLife Conservation Series No. 3, BirdLife International, Cambridge, U.K.

BERTRAN, J. AND A. MARGALIDA. 1997. Griffon Vultures (*Gyps fulvus*) ingesting bones at the ossuaries of Bearded Vultures (*Gypaetus barbatus*). *J. Raptor Res.* 31: 287–288.

BEVEN, G. 1979. Griffon Vultures apparently feeding on beetles. *Br. Birds* 72:336.

CAVALLI-SFORZA, L.L. 1996. The spread of agriculture and nomadic pastoralism: insights from genetics, linguistics and archaeology. Pages 51–69 *in* D.J. Harris [ED.], The origins and spread of agriculture and pastoralism in Eurasia. Univ. College London Press, London, U.K.

CEBALLOS, O. AND J.A. DONÁZAR. 1990. Roost-tree characteristics, food habits and seasonal abundance of roosting Egyptian Vultures in northern Spain. *J. Raptor Res.* 24:19–25.

COLEMAN, J.S. AND J.D. FRASER. 1987. Food habits of Black and Turkey vultures in Pennsylvania and Maryland. *J. Wildl. Manag.* 51:733–739.

CRAMP, S. AND K.E.L. SIMMONS. (EDS.). 1980. The birds of the western Palearctic. Oxford Univ. Press, Oxford, U.K.

DONÁZAR, J.A. 1993. Los buitres ibericos: biologia y conservacion. J.M. Reyero, Madrid, Spain.

FERNÁNDEZ, J.A. 1975. Consideraciones sobre el régimen alimenticio de *Gyps fulvus*. *Ardeola* 21:209–217.

FITZNER, R.E., L.E. ROGERS, AND D.W. URESK. 1977. Techniques useful for determining raptor prey-species abundance. *Raptor Res.* 11:67–71.

GONZALEZ, L.M., J.L. GONZALEZ, AND C. LLANDRES. 1984 Tree-nesting colony of griffon vultures in Spain. *Vulture News* 11:12–13.

HANDRINOS, G. 1985. The status of vultures in Greece. Pages 103–115 *in* I. Newton and R.D. Chancellor [EDS.], Conservation studies in raptors. World Working Group on Birds of Prey, Salonica, Greece.

——— AND T. AKRIOTIS. 1997. The birds of Greece. Helm–A. & C. Black Ltd., London, U.K.

HIRALDO, F. 1976. Diet of Black Vulture (*Aegypius monachus*) in the Iberian Peninsula. *Doñ. Acta Verteb.* 3:19–31.

HOUSTON, D.C. 1976. Breeding of the White-backed and Rueppell's Griffon vultures, *Gyps africanus* and *G. rueppellii*. *Ibis*. 118: 14–40.

———. 1978. The effect of food quality on breeding strategy in griffon vultures (*Gyps* spp.). *J. Zool. Lond* 186: 175–184.

JARMAN, M.R. 1996. Human influence in the development of the Cretan mammalian fauna. Pages 211–229 *in* D.S. Reese [ED.], Pleistocene and Holocene fauna of Crete and its first settlers. Prehistory Press, Madison, WI U.S.A.

LARRAZ, D.S. 1999. Dumps for dead livestock and the conservation of wintering Red Kites (*Milvus milvus*). *J. Raptor Res.* 33:338–340.

MARCO, J. AND D. GARCIA. 1981. Situation actuelle des populations de nécrophagus (*Gyps fulvus, Gypaetus barbatus* et *Neophron percnopterus*) en Catalogne. *Rapaces Méditerranéens* 1:119–129.

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

NATIONAL STATISTICAL SERVICE OF GREECE. 1991. Statistical year book of Greece, Athens. National Statistical Service of Greece, Athens, Greece.

PAPAGEORGIOU, N. AND A. SFOUGARIS. 1989. Identification of Greek mammals by the morphology of hair. Aristotelian Univ. Salonica, Salonica, Greece.

RICH, P.V. 1983. The fossil history of vultures: a world perspective. Pages 3–54 *in* S.R. Wilbur and J.A. Jackson [EDS.], Vulture biology and management. Univ. California Press, Berkeley, CA U.S.A.

RICHARDSON, P.R.K., P.J. MUNDY, AND I. PLUG. 1986. Bone crushing carnivores and their significance to osteodystrophy in griffon vulture chicks. *J. Zool. Lond.* 200. 23–43.

SONDAAR, P.Y., M.D. DERMITZAKIS, AND J. DE VOS 1996. The paleogeography and faunal evolution. Pages 61–67 *in* D.S. Reese [ED.], Pleistocene and Holocene fauna of Crete and its first settlers. Prehistory Press, Madison, WI U.S.A.

THIBAULT, J.C., J.D. VIGNE, AND J. TORRE. 1993. The diet of young Lammergeier *Gypaetus barbatus* in Corsica: its dependence on extensive grazing. *Ibis* 135:42–48.

WILLEMSEN, G.F. 1996. The Cretan otter *Lutrogale cretensis*.

Pages 153–157 *in* D.S. Reese [ED.], Pleistocene and Holocene fauna of Crete and its first settlers. Prehistory Press, Madison, WI U.S.A.

XIROUCHAKIS, S., C. GRIVAS, M. PROBONAS, A. SAKOULIS, AND G. ANDREOU. 2003. Evaluation des actions pour la conservation du Gypaète barbu (*Gypaetus barbatus*) en Crète. Pages 124–132 *in* J.-F. Sarrazin and J.-M. Thiollay [EDS.], Actes du colloque international: conservation des populations de Gypaète barbu. LPO, Tende, France.

ZAR, J. 1996. Biostatistical analysis. Prentice Hall, Princeton, NJ U.S.A.

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