Short notes

NEST-BUILDING BEHAVIOUR OF THE BEARDED VULTURE *GYPAETUS BARBATUS*

ANTONI MARGALIDA & JOAN BERTRAN

Margalida A. & J. Berttan 2000. Nest-building behaviour of the Bearded Vulture *Gypaetus barbatus*. Ardea 88(2): 259-264.

Bearded Vultures *Gypaetus barbatus* began supplying material to their nests on average 111 d (range 91-126 d) prior to laying. Males were significantly more active that females. Heavy material (branches) was transported indistinctly in the talons or in the bill while lining (wool) was generally transported in the bill. 71% of the wool was recycled from remains fallen from other nests, probably due to the scarcity of this material in relation to its importance for insulating the egg and chick from the low winter temperatures. No inter-sexual differences were observed with regard to the type of the material selected or how it was carried to the nest. The early nest-building behaviour and the fact that the males were the most active builders are discussed in the context of maintenance of the pair-bond and female selection. After laying, material for nest-maintenance was only rarely supplied, suggesting high solidity of the structure at its location at protected sites.

Key words: *Gypaetus barbatus* - female mate selection - nest-building - Pyrenees

Group of Study and Protection of the Bearded Vulture (GEPT), Apdo. 43, E-25520 El Pont de Suert, Lleida, Spain. Email: margalida@inf.entorno.es

Nest-building in birds includes the building and maintenance of the nest. Both activities may be an important part of parental care, given that the investment by the birds may represent a considerable effort and that nest-building behaviour is associated with courtship and mate choice (Collias & Collias 1984; Hoi *et al.* 1994). In raptors information on this aspect of their biology is scarce (Newton 1979; Fernández 1992; del Hoyo *et al.* 1994). In vultures for example, only general information on the reproductive biology is usually available (see Mendelssohn & Leshem 1983; Mundy *et al.* 1992; Donázar 1993). Nevertheless, considerable differences in nest-building behaviour between species may be expected. For instance, Griffon Vultures *Gyps fulvus* breed colonially and use only one nest structure which practically disappears towards the end of reproduction. In contrast, the Bearded Vulture *Gypaetus barbatus* is territorial and has several nests available which it uses alternately between years (see Brown *et al.* 1988; Margalida & García 1999). These structures are maintained in good condition over long periods of time (Brown *et al.* 1988, Donázar 1993).

In the Pyrenees, Bearded Vultures begin egg-laying in mid winter (December-February), at a time when temperatures regularly drop below 0°C. This implies that both the location of the nest and the materials selected for its construction may play an important role in the ultimate reproductive success.

Parental behaviour of the two sexes over the season has been discussed recently (Margalida & Bertran 2000). However, there is no detailed information on nest-building behaviour. The aim of this paper is to describe the type, distance from the nest and importance of materials selected by Bearded Vultures for nest building and to analyse

inter-sexual differences in nest-building behaviour and their relationship with nest structure and female mate selection.

The study was carried out on a total of eight pairs of Bearded Vultures in NE Spain (Catalonian Pyrenees) during 1991-1996. The physical and climatic characteristics of the study area are detailed in Bertran & Margalida (1996). Six pairs were monitored intensively and partial data were obtained from the remaining two pairs. Visits to the nest-site were undertaken in order to document different aspects of the breeding biology of the species (Bertran & Margalida 1999, Margalida & Bertran 2000). The monitoring of pairs began in September and ended when the chicks fledged (Jun-Jul). During this period, the nests were checked every 7 to 10 d, except during the egg-laying (Dec-Feb), incubation (Feb-Apr) and fledging periods (Jun-Jul), when the monitoring was carried out daily. A total of 2626 h of observation (Table 1) were carried out using 20-60x telescopes from distances not greater than 900 m from the nest. The observations covered all daylight hours (5:00-20:00 h, solar time), the shortest period of observation being 6 h and the longest 14 h d^{-1}. For individual identification of the birds (in flight and perched), variations in moults were noted (Margalida & Bertran 2000) and coloration of feathers of the head, neck and ventral parts, because females tend to be more intensely coloured than males (Negro *et al.* 1999). The sex of the birds was attributed based on their positions during copulation (Bertran & Margalida 1999).

It was noted whenever possible whether or not a given individual supplied nesting material, how this was carried (bill or talons) and the distance at which the material was collected (< 1 km or > 1 km from the nest). It was possible to identify the material on the majority of occasions as either: hard material (mainly branches used for building the nest structure) or soft material (used for lining the interior of the nest). The hard material of three nest was collected and measured with a accuracy of ± 0.05 cm (length and diameter at the mid-section of the branch), selecting 20 branches at random of each nest.

For analytical purposes, the reproductive season was divided into three periods: pre-laying, incubation and chick-rearing. Pre-laying includes the time between the first pre-dispersal flights of the young of the previous clutch (Sunyer 1991) and the beginning of nest-building somewhere else within the territory in September and the moment of egg-laying (December-February, pers. obs.) which, between pairs, may vary by more than two months (Heredia 1991). During this period, nest visits (birds landing at the nest) were noted, regardless whether the birds landed with or without nest material. Incubation starts with egg-laying and ends with hatching (February-April). Chick-rearing lasts until fledging (June-July). The pre-laying period (which includes the supply of material) was further subdivided into 15 d intervals counting backwards from the moment of egg-laying Laying dates were recorded with a maximum error of ± 1 d. Seven intervals of 2h

Table 1. Variation in the frequency of supplies (sums of all observations, $n = 8$) and the type of material supplied to the nest by Bearded Vultures throughout the reproductive cycle.

Period	Male		Female		Hours of observation
	hard	soft	hard	soft	
Pre-laying	69	52	30	26	859
Incubation	0	10	0	6	399
Chick-rearing	1	13	0	6	1368
Total	70	75	30	38	2626

each were used to compare the hourly activity patterns. Mean of means of each pair were used to avoid pseudoreplication problems. Non-parametric tests were used for the analysis of the data (Sokal & Rohlf 1995).

During the pre-laying period, the supply of material to the nest began 111.2 ± 10.65 d prior to egg-laying (range 91-126 d, n = 6). The peak of construction activity took place during this period (Table 1) and males were significantly more active than females (males: 0.265 ± 0.089 visits h^{-1}, range 0.13-0.43, n = 182 visits; females: 0.110 ± 0.006 visits h^{-1}, range: 0.03-0.178, n = 106 visits; Mann-Whitney U = 33, $P < 0.02$). In males, the frequency of nest visits (Fig. 1) showed a peak between 30 and 16 d prior to egg laying (0.361 ± 0.319 visits h^{-1}) while in females such a peak was not found. Nevertheless, there were no significant differences between periods (males: Kruskal-Wallis H_7 = 5.798, n.s.; females: Kruskal-Wallis H_7 = 2.708, n.s.). The average time used for nest construction at the cavity or ledge (n = 2 pairs) was similar in both sexes (males: 9.7 ± 16.6 min per visit, range 1-120 min, n = 92; females: 10.0 ± 13.1, range 1-63 min, n = 61; Mann-Whitney U = 366, n.s.). During the day, males tended to initiate nest-building activity, with an activity peak between 09.00-10.00 h. Females on the other hand, showed a progressive increase with a maximum activity later in the day (13:00-17:00 h), but these differences were not significant (χ^2= 3.95, df = 6, n.s.).

The supply of material to the nest continued after egg-laying but in much lower quantities (Table 1). The construction of new nest structures or the supplying of material to the nest after egg-laying were observed throughout incubation and chick rearing periods, the majority following a breeding failure, as described for frustrated nests (Newton 1979). Only on 2 occasions (n = 48 breeding attempts) was the initiation of the construction of a new nest observed during chick-rearing when the pair still had a chick in the old nest.

The material used for the construction of the nest was composed principally of branches gathered on the ground that were used for the base of the structure itself and sheep's wool for lining the interior, although other soft materials such as grass, moss and pieces of unidentified animal hide were also supplied. The average length of the branches was 83.7 ± 14.05 cm, (range 65.8-100.1 cm, n = 3 nests) and the diameter 1.65 ± 0.22 cm (range 1.15-1.9 cm, n = 3 nests). Each sex placed the material in the nest and there was no sexual division concerning the supply or placement activities. 56.3% of the hard and heavy materials were transported in the talons (n = 87) whilst the bill was mainly used for the softer items (70.5% , n = 78; χ^2 = 10.97, df = 1, $P < 0.001$). Males and females supplied similar proportions of the material with the talons (41.3% vs. 48.9%; χ^2 = 0.96, df = 1, n.s.). Of the two most common materials (branches and wool), there was no inter-sexual difference observed concerning a greater supply of one or other type of material (χ^2 = 0.31, df = 1, n.s.), nor was there any difference between the sexes in the form of transport (branches: χ^2 = 1.06, df = 1, n.s.; wool: χ^2 = 0.037, df = 1, n.s.). The majority of all items was found at distances within 1 km from the nest sites: 91% (n = 75) and

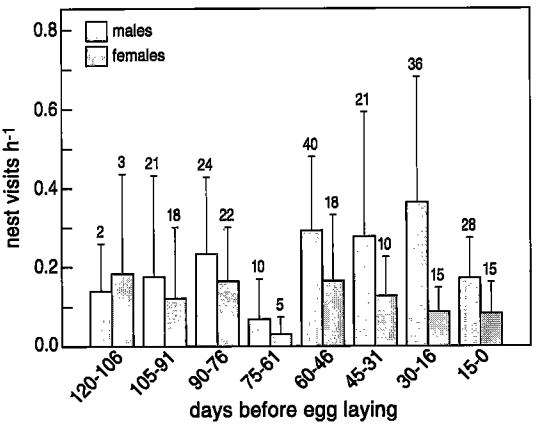

Fig. 1. Seasonal distribution of nest visits (with or without material) in males and females of Bearded Vultures (n = 6) during the pre-laying period (broken up into 15 d periods). Bars give means ± 1 SD; figures give numbers of observations.

97% (n = 30) of all hard and heavy items in males and females respectively, and 83% (n = 63) and 70% (n = 27) of all soft materials in males and females, respectively. 70.6% (n = 68) of the wool brought to the nest was gathered from the fallen remains of other nests. During the pre-laying period, the proportions of hard and soft materials showed no temporal variation either in males (comparison by month: χ^2 = 3.95, df = 3, n.s.) or in females (χ^2 = 1.61, df = 3, n.s.). During the post-laying period 97.2% of the material supplied (n = 36) to the nest by the Bearded Vulture was soft material (Table 1).

Bearded Vultures select their nest site and begin supplying material up to three months before other vultures do (see Mundy *et al.* 1992; Donázar 1993). Given that this species has several nests at its disposal within the territories, which are maintained in good condition over long periods of time (Brown *et al.* 1988; pers. obs.), the early initiation of visits to the nest and start of nest building might be related to factors such as advertising occupancy of the territory (Newton 1979) or the maintenance of the pair-bond, rather than the need of restoring the nest. Several studies in passerines have shown that nest-building behaviour may indicate parental quality and especially the ability of males to invest in reproduction (Hoi *et al.* 1996; Soler *et al.* 1998a; Soler *et al.* 1998b). The fact that during pre-laying period males of Bearded Vulture are more active builders than females, as well as more active nest defenders (Margalida & Bertran 2000), might reflect a demonstration of their reproductive ability and could also be related to the relative costs and benefits of parental investment (Margalida & Bertran 2000). The nest-building behaviour of males could provide information to the female about the quality of the partner (see Soler *et al.* 1998b). The importance of female selection of mates is probably related to the important parental effort that both sexes invest during post-laying period as a consequence of the long breeding cycle (Margalida & Bertran 2000).

The supply of material may take place simultaneously to various nests, although generally the nest chosen for reproduction is the only one supplied regularly. All nest-material was gathered on the ground (Heredia 1991 pers. obs.), including a large part of the wool used for lining the interior of the nest. Apparently, this material is recycled from the remains fallen from other nests, as a consequence of its scarcity and value, i.e. for insulation during incubation (Margalida *et al.* 1997). For example, observations carried out in three territories where we experimentally left wool in vantage points revealed that this material was localised and transported to the nest a few hours after being left. On another occasion, a female was observed carrying this material of > 17 km from the nest (pers. obs.).

Each sex arranged the material in the nest and the time dedicated to this task was similar in both sexes. Also the frequency of supply of the two types of material does not show temporal variation in either sex. Nevertheless, the males were significantly more active than females. Given that this activity may represent an important effort in time and energy (Collias & Collias 1984), this behaviour would help the females to avoid an excessive drain on energy which would affect the optimal physical condition required for reproduction (Margalida & Bertran 2000).

After laying, the supply of material for the maintenance of the nest, was very low in proportion to that described in other raptors (Brown & Amadon 1968; Newton 1979; Fernández & Leoz 1986; Fernández 1992), almost all of the material supplied being soft. Probably, some extra lining was always wanted, but in short supply. Apart from its function in insulation, a constant renewal of this material may help to lessen effects of ectoparasites coming from prey items stocked in the nest (see Wimberger 1984; Clark & Mason 1985). The continuity in nest-building activity after laying might be associated with internal factors (gonadal hormones) which stimulate this behaviour (Collias & Collias 1984). In the Bearded Vulture, we believe that the continuity of nest-building behaviour may also be related with the strengthening of the pair bond (i.e. the construction of new nest structures after a breeding failure). A decline in reconstruction activity would

make better use of the birds' time and energy for foraging. During this stage of the breeding process, care of the chick and delivery of food would replace nest-building behaviour as display to maintain the pair bond.

Finally, the fact that less activity is spent on nest reconstruction at this stage could probably also be related to the solidity of the nest structure and its location (generally in protected places such as caves, see Brown *et al.* 1988; Heredia 1991 pers. obs.), which minimise its deterioration as a result of adverse weather conditions or due to the increase in the activity of the chick within the nest (see Burger 1978; Elkins 1988).

We thank J. Boudet, J. Feixa, D. García, R. Heredia and P. Romero for their help during field work. M. F. Leopold, J. J. Negro and two anonymous referees improved the manuscript. S. Cahill and S. Hardie translated the text into English. The study was jointly financed by the Departament d'Agricultura Ramaderia i Pesca of the Catalonian Autonomous Government (Generalitat de Catalunya), Fundació Territori i Paisatge, Minuartia Estudis Ambientals and the Life Fund of the European Union (Life Project 94/E/A221/E/01126/ASJ).

REFERENCES

Bertran J. & A. Margalida 1996. Patrón anual de observaciones de Quebrantahuesos (*Gypaetus barbatus*) de diferentes grupos de edad en los sectores de nidificación. Alauda 64: 171-178.

Bertran J. & A. Margalida 1999. Copulatory behavior of Bearded Vulture. Condor 101: 164-168.

Brown C.J., S.E. Brown & J.J. Guy 1988. Some physical parameters of Bearded Vulture *Gypaetus barbatus* nests sites in southern Africa. In: Backhurst G.C. (ed.) Proc. Sixth Pan-Afr. Ornithol. Congr.: 139-152, Nairobi.

Brown L.H. & D. Amadon 1968. Eagles, Hawks and Falcons of the world. Hamlyn, London.

Burger J. 1978. Determinants of nest repair in Laughing Gulls. Anim. Behav. 26: 856-861.

Collias N.E. & E.C. Collias 1984. Nest Building and Bird Behaviour. Princeton University Press, Princeton.

Clark L. & J.R. Mason 1985. Use of nest material as insecticidal and anti-pathogenic agents by the European Starling. Oecologia 67: 169-176.

Del Hoyo J., A. Elliott & J. Sargatal (eds) 1994. Handbook of the Birds of the World, 2. New World Vultures to Guineafowl. Lynx Editions, Barcelona.

Donázar J.A. 1993. Los Buitres Ibéricos: Biología y Conservación. J. M. Reyero (ed.), Madrid.

Elkins N. 1988. Weather and Bird Behaviour. T. & A.D. Poyser, Calton.

Fernández C. 1992. Nest material supplies in the Marsh Harrier *Circus aeroginosus*: sexual roles, daily and seasonal activity patterns and rainfall influence. Ardea 80: 281-284.

Fernández C. & J. Leoz 1986. Caracterización de los nidos de Águila Real *(Aquila chrysaetos)* en Navarra. Munibe 38: 53-60.

Heredia R. 1991. Biología de la reproducción. In: R. Heredia & B. Heredia (eds) El Quebrantahuesos (*Gypaetus barbatus*) en los Pirineos: 27-38. ICONA, Madrid.

Hoi H., B. Schleiner & F. Valera 1994. Female mate choice and nest desertion in Penduline Tits, *Remiz pendulinus*, the importance of nest quality. Anim. Behav. 48: 743-746.

Hoi H., B. Schleicher & F. Valera 1996. Nest size variation and its importance for mate choice in Penduline Tits, *Remiz pendulinus*. Anim. Behav. 51: 464-466.

Margalida A. & J. Bertran 2000. Breeding biology of the Bearded Vulture *Gypaetus barbatus*: minimal sexual differences in parental activities. Ibis 142: 225-234.

Margalida A. & D. García 1999. Nest use, interspecific relationships and competition for nests in the Bearded Vulture *Gypaetus barbatus* in the Pyrenees: influence on breeding success. Bird Study 46: 224-229.

Margalida A., J. Bertran, D. García & R. Heredia 1997. Observaciones sobre el periodo de incubación del Quebrantahuesos (*Gypaetus barbatus*) en los Pirineos. Ecología 11: 439-444.

Mendelssohn H. & Y. Leshem 1983. Observations on reproduction and growth of Old World Vultures. In: Wilbur S.R. & J.A. Jackson (eds) Vulture Biology and Management: 214-241. University of California Press, Los Angeles.

Mundy P., D. Butchart, J. Ledger & S. Piper 1992. The Vultures of Africa. Academic Press, London.

Negro J.J., A. Margalida, F. Hiraldo & R. Heredia 1999. The function of the cosmetic coloration of Bearded Vultures: when art imitates life. Anim. Behav. 58: F14-F17.

Newton I. 1979. Population Ecology of Raptors. T. & A.D. Poyser, Berkhamsted.

Sokal R.R. & F.J. Rohlf 1995. Biometry. The Principles and Practice of Statistics in Biological Research. W.H. Freeman, New York.

Soler J.J., A.P. Møller & M. Soler 1998a. Nest building, sexual selection and parental investment. Evol. Ecol. 12: 427-441.

Soler J.J., J.J. Cuervo, A.P. Møller & F. de Lope 1998b. Nest building is a sexually selected behaviour in the Barn Swallow. Anim. Behav. 56: 1435-1442.

Sunyer C. 1991. El periodo de emancipación en el Quebrantahuesos: consideraciones sobre su conservación. In: R. Heredia & B. Heredia (eds) El Quebrantahuesos (*Gypaetus barbatus*) en los Pirineos: 47-65. ICONA, Madrid.

Wimberger P.H. 1984. The use of green plant material in bird nests to avoid ectoparasites. Auk 101: 615-618.

SAMENVATTING

De nestbouw van Lammergieren *Gypaetus barbatus* werd bestudeerd bij acht paren in de Spaanse Pyreneeën. De paren hadden meerdere locaties binnen hun territorium in gebruik waar zich nesten konden bevinden, maar onderhielden als regel slechts één nest per seizoen. Aan dit ene nest werd echter wel veel tijd besteed: gemiddeld begonnen de paren 111 dagen voor de eileg met de nestbouw, midden in de winter. Ook tijdens de ei- en kuikenfases bleven de vogels het nest onderhouden. De nesten werden opgebouwd uit dode takken, die met de klauwen of snavel werden aangevoerd. De nestkom werd gevoerd met zachte materialen, die vooral in de snavel werden aangevoerd. Het zachte materiaal bestond vooral uit wol, dat veelal werd gerecycled uit de resten van het nest van een eerder jaar. Dit verschijnsel, en de waarneming dat extra aangeboden nestmateriaal in territoria zeer snel werd opgemerkt en gebruikt, doen vermoeden dat dit een schaars en gewild artikel is. Het meeste nestmateriaal werd in de nabije omgeving van het nest gevonden. Mannen waren actievere bouwers dan vrouwen. Na de eileg werd veel minder materiaal aangevoerd dan voor de eileg. De langdurige bouw, voorafgaand aan de eileg, wordt gezien als een gedrag dat bijdraagt aan de instandhouding van de paarband en als een test voor de ouderlijke kwaliteiten van de man. (MFL)

Received: 26 November 1998, accepted: 15 May 2000
Corresponding editor: Mardik F. Leopold