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Behavioural development in young Bearded Vultures *Gypaetus barbatus* reintroduced in the Alps

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Abstract - The behavioural development in young Bearded Vultures released at the Argentera-Mercantour site prior to and immediately after departure from the artificial nest was analysed to provide a detailed description of the development of the main behavioural activities and to check for the occurrence of anomalies. Six individuals released from 1994 to 1996 were continuously monitored using telescopes. Regression analyses pointed out that three vultures during the period at the nest progressively increased the time spent on watching and feeding and hence decreased that spent resting. Then, after leaving the nest, most vultures progressively increased the time spent on feeding and flying and decreased that spent resting and walking. Percentages of significant regressions were lower in the first period (54%) than in the second (72%). This, together with the output of the analysis of covariance, suggests that the period at the nest may be more critical than that after leaving it. However, wing fluttering at the nest progressively and significantly increased in four out of six vultures. Once they have left the nest, most birds showed increased vigilance, selected roosting sites which were protected from terrestrial predators, and successfully interacted with crows at feeding sites. Finally, a few observations suggested that birds were able to drop bones autonomously. Our results, which are in keeping with previous observations, suggest that young vultures are able to overcome the difficulties they meet after release, probably because many behaviours are largely genetically controlled. Hence, we may assume that the final outcome of the reintroduction project of the Bearded Vulture in the Alps will not be significantly affected by the hacking technique employed.

Introduction

The Bearded Vulture *Gypaetus barbatus* disappeared from the Alps between the end of the 19th and the first years of the 20th century. Some authors suggested that the main cause of this disappearance was deliberate human persecution (Géroudet 1974, Hiraldo *et al.* 1979), and analyses of the historical evidence confirmed that such persecution really affected Bearded Vulture populations, at least in the western Alps (Mingozzi and Estève 1997). The decrease of wild ungulate populations was also quoted as a possible cause of local extintion (Coton and Estève 1990), even though cattle, goats and sheep (once largely abundant in the Alps) probably were a much more important food resource to the vulture, as recently demonstrated for the population of Corsica (Thibault *et al.* 1993). The latter hypothesis is also indirectly confirmed by the fact that the species thrives in large numbers when commensal with primitive pastoral cultures (Newton 1979), but, according to Brown (1977), it is rare or fast declining when modern stock-keeping and sanitation prevail.

Whatever the causes of the disappearance of the vulture, an international reintroduction project aiming at the establishment of a breeding population totally independent of human management was started in 1978, and the first four birds were released in Austria in 1986 (Géroudet 1974, Walter 1980, Anderegg *et al.* 1984, Frey 1985, Wackernagel and Walter 1980, Frey and Bijleveld 1993). This project, based upon the falconry technique of "hacking", whereby large young are put out and fed until they become self-sufficient, is now in progress in four Alpine countries, i.e. Austria, France, Italy, and Switzerland (Frey and Walter 1989, Coton and Estève 1990, Frey and Bijleveld 1993). Seventy-two individuals have been released up to date (1997), forty of which are probably still alive (Coton and Heuret 1996, Coton *in verbis*). In 1997 a first case of successful breeding took place in Savoy, thus indirectly supporting certain optimistic expectations based on the supposed high rate of survival of the released individuals (Kurzweil 1994). However, analyses based on computer simulations applied to the population released were not able to predict the final fate of the reintroduction project (Bustamante *et al.* 1994, Bustamante 1996) and simulations applied to the hypothetical historical population in the western

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Alps suggested cautious conclusions (Mingozzi and Balletto 1996).

Wild young are cared for by both parents, both during the nestling and the post-nestling period (Komarov and Veinberg 1981, Brown 1990a and 1990b). The hacking technique implies that, after reintroduction in the wild, young are not reared by parents and might suffer from shortage of parental care. They might also suffer due to unnatural rearing conditions prior to their release (hatching in an incubator, partial hand rearing, rearing by different adult pairs), to the presence of a second nestling placed in the artificial nest (only one nestling survives in the wild) and, maybe, to the presentation of food at libitum (Niebuhr 1996). It is therefore possible that their ontogeny will be affected, and behavioural anomalies could even influence negatively the outcome of the reintroduction project. Even though behavioural data concerning the nestling period were collected at several releasing sites and qualitative reports have been presented (Hegglin 1996, Niebuhr 1996), no quantitative data have been published so far.

The present research analyzes behavioural development in young vultures released at the Argentera-Mercantour site prior to and immediately after departure from the artificial nest. The aim was to provide a detailed description of the development of the main behavioural activities of young and to check for the occurrence of suboptimal behaviours or anomalies, if any.

Materials and methods

Six individuals were reintroduced from 1994 to 1996 in the southwestern Alps. Two (named Topolino, a male and Mercantour, a female) were released in the Argentera Natural Park (Italy) in 1994, two (Geo, a female and Firmin, unsexed) in the Mercantour National Park (France) in 1995, and a third pair (Entraque, a male and Valdieri, a female) again in the Italian Park in 1996. The two protected areas are contiguous, thereby representing the single releasing site of Argentera-Mercantour (Perfus *et al.* 1994).

Artificial nests were prepared at the base of high altitude cliffs (1600- 1950 m a.s.l.) at the limit of the arboreal vegetation. The Italian side is characterized by gneiss and granitic rocks, whereas the French one is characterized by calcareous rocks. Vegetation is also partially different since beeches, *Fagus sylvatica*, larches, *Larix decidua*, Arolla pines, *Pinus cembra*, spruces, *Picea excelsa* and firs, *Abies alba* occur on the Italian slope, and larches, spruces, and Scots pines, *Pinus sylvestris,* grow on the French one.

Individuals, which were released in June, were continuously monitored, apart from periods of bad weather (fog or heavy rain) from 7 a.m. to 8 p.m. To avoid disturbance, observations were carried out from a vantage point at a distance ranging from about 200 to 400 m, using telescopes (Swarovski AT80 20-60X and DT75 30X, Kowa TSN1 20X and 30X). Once released, the birds were nourished by bringing food (carcasses of chamois, rabbits, and sheep) to the nest and, after leaving the nest, at one or more feeding sites. Accordingly, two successive developmental periods were distinguished for each individual: a first period at the nest (until leaving it), and a second one after leaving the nest (until departure from the feeding sites). Ethograms were used to assess the behaviour quantitatively. In particular, five main activities were continuously monitored during both periods: watching (i.e., standing upright), resting (i.e., lying down), feeding, preening, and sunning, and two activities during the second period only: walking and flying. The time spent on each activity was expressed as frequency percentage (i.e. hours regarding a certain activity/ total hours of observation * 100), number of bouts and mean bout duration. The six vultures were released at different ages, from 87 to 104 days (93.3 days, on average). Trends were therefore described as a function of the age of each individual and not, for instance, in relation to the time elapsing since release.

Two more activities, namely wing fluttering (during the first period only) and vigilance, were occasionally displayed for a very few seconds. Accordingly, the former was sampled by counting every wing-beat observed, and the latter by recording the number and duration of every bout for 10-minute periods when vultures were preening or feeding. A vulture was considered to exercise vigilance when it interrupted its feeding (or preening), raised its head, and looked all around for a few seconds prior to beginning feeding (or preening) again.

Activity distributions were studied by correlation and linear regression analyses after data normalization (logarithmic transformation). An analysis of covariance was also carried out to verify whether activity trends covaried among individuals or not (Sokal and Rohlf 1981).

Aggressive interactions between individuals and choices of the roosting site after leaving the nest were also recorded.

Results

At the nest

Chicks at the nest were observed for a total of 158 days, corresponding to 2,054 hours (cumulative data). Linear regression analyses showed that three vultures (i.e., Topolino, Mercantour and Firmin) progressively increased the time spent watching (from a minimum of 20% to a maximum of 50% of daytime), but the other three did not. Analogously, three (Mercantour, Geo, and Firmin) showed also a significant tendency to increase feeding time (from 10% to 40%), but again this pattern was not shown by the other three (Fig. 1 and Table 1). Conversely, four vultures (Topolino, Mercantour, Geo, and Firmin) showed a clear tendency to decrease their resting time (from 40% to 0%); one (Valdieri), however, did not show any trend, and one (Entraque) showed a reversed increasing pattern (Fig. 2 and Table 1). Firmin and Mercantour displayed the expected trends in all activities considered, whereas Valdieri and Entraque did not display any.

The increasing or decreasing patterns may depend upon the variation of the mean duration of bouts or upon the variation in the number of such bouts, or on both. Correlation analyses (P<0.01) showed that, out of the eleven significant regressions quoted above, six prevalently depended upon the variation of the number of bouts, one upon the variation of the mean duration of bouts, and one upon both (with three remaining unexplained).

Analysis of covariance suggested that there was large-scale heterogeneity in percentages of every activity among the individuals considered when age was kept constant (watching: F=4.66, P<0.001; resting: F=12.90, P<0.001; feeding: F=4.36, P<0.001).

Wing fluttering increased for four out of the six vultures (from 0 to about 20 actions per hour, on average) (Fig. 3).

Vigilance was monitored in 1995 and 1996. During the ten-minute bouts, birds looked all around for 1-2 min, on average. No increase or decrease of vigilance as a function of the age of chicks was revealed. Analogously, no trend was shown either for preening (10%-30% of the daytime) or sunning (0%-2%).

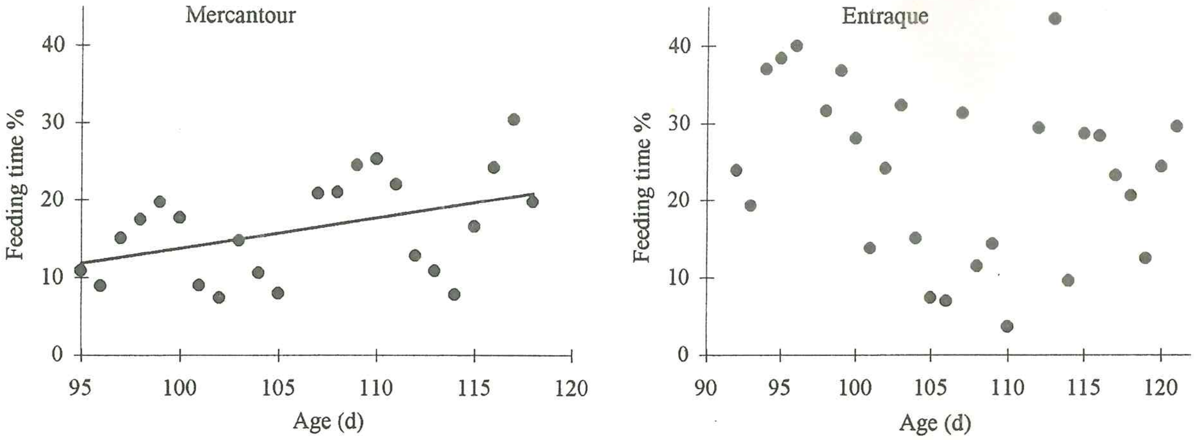

Fig. 1. Percentages of feeding time as a function of age of chicks (in days) for Mercantour and Entraque. Linear regression equation is: y= 0.39 x - 25.66 (P<0.05).

Table 1. Behavioural trends at the nest. Linear regression analyses test the linearity of the relationships between the percentages of behaviours monitored (dependent variable y) and the age of chicks in days (independent variable x). Regression coefficients (*a*), intercepts (*b*), and P values are given. A t-test was used for testing the significance of the regression coefficient. The asterix shows the only case for which the correlation analysis was discordant with the regression analysis: in fact, in this case a significant positive correlation was revealed (r=0.45; P<0.05) in spite of a non-significant regression.

Individual	year	watching			feeding			resting		
		a	*b*	P	*a*	*b*	P	*a*	*b*	P
Topolino	1994	0.88	-54.03	<0.01	0.19	0.30	NS	-1.12	135.64	<0.01
Mercantour	1994	1.32	-109.68	<0.001	0.39	-25.66	<0.05	-1.16	148.03	<0.01
Geo	1995	-0.02	29.28	NS	2.61	-261.67	<0.001	-2.81	332.13	<0.001
Firmin	1995	1.07	-74.86	<0.01	0.58	-33.28	NS*	-1.76	199.11	<0.001
Entraque	1996	-0.28	58.57	NS	-0.29	54.69	NS	0.76	-55.10	<0.01
Valdieri	1996	0.07	29.65	NS	-0.11	34.57	NS	-0.08	27.87	NS

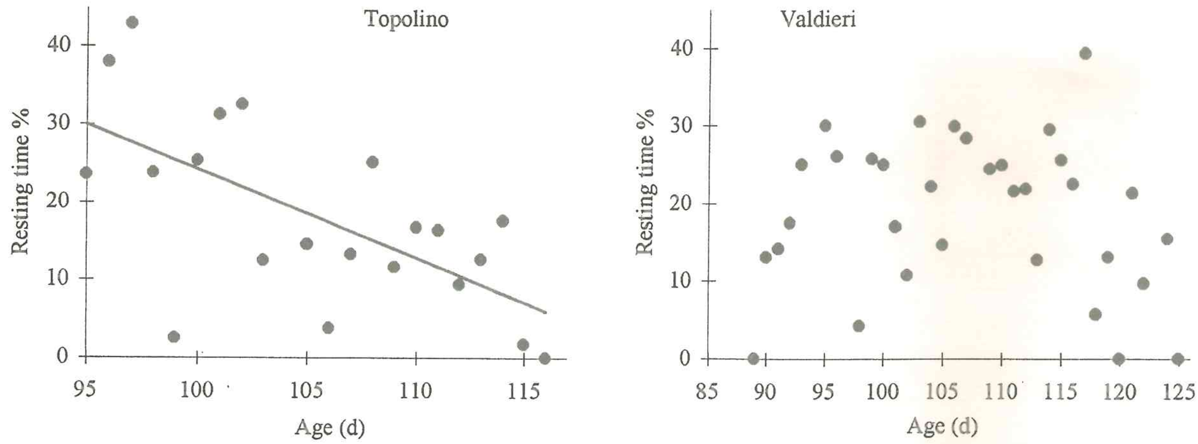

Fig. 2. Percentages of resting time as a function of age of chicks (in days) for Topolino and Valdieri. Linear regression equation is: y= -1.12 x +135.64 (P<0.01).

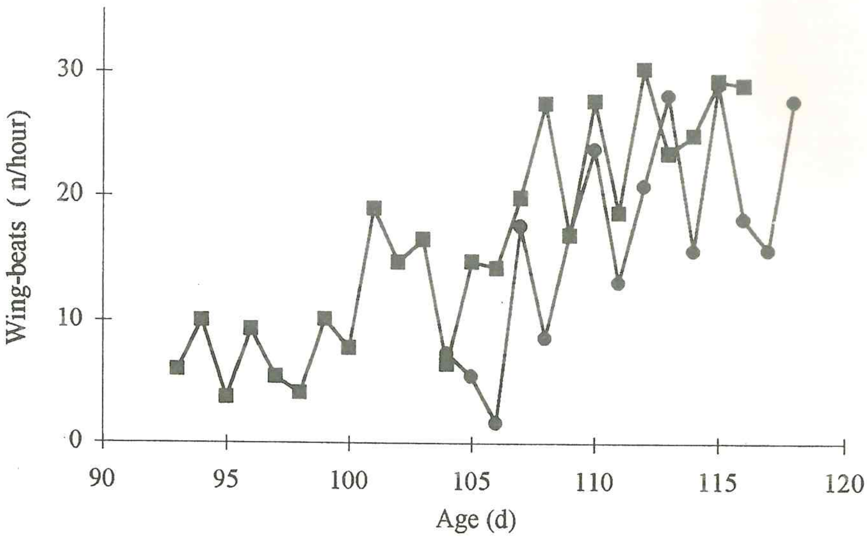

Fig. 3. Number of wing-beats/ hour as a function of age of chicks in days for Geo (•) and Firmin (▪). Correlation analyses showed that the two variables were significantly and positively correlated for Geo (r = 0.69, P<0.01), Firmin (r = 0.85, P<0.01), Topolino (r = 0.67, P<0.01), and Valdieri (r = 0.35, P<0.05). On the contrary, no significant correlation was found for Mercantour and Entraque.

Dominance hierarchies for feeding were evident both in 1994, when 99% of attacks (out of 192) were made by Topolino, and in 1995, when all 180 attacks were by Geo. Only seven attacks were recorded in 1996, all, again, being made by the same individual, Valdieri. Birds left the nest at different ages, from 115 to 125 days (119 days, on average).

After leaving the nest

After leaving the nest, young were observed for a total of 159 days corresponding to 2,067 hours (cumulative data). However, no data are available for one bird (Geo) in 1995, since it dislocated a wing and was therefore taken into care. Also, because the adverse ground orography, it was not possible to monitor the walking activity of the two birds released in 1996.

Linear regression analyses showed that three vultures (Firmin, Entraque, and Valdieri) significantly diminished their watching activity (from a maximum of 40% to a minimum of 10% of daytime), but the other two did not (Table 2). Walking was progressively abandoned by all three birds considered (from about 10% to 0%, on average), even though the trend was not significant in one case (Table 2). Conversely, all birds (Firmin being the only exception) spent more and more daytime on feeding (from 10% to 30%) and all (although Topolino not significantly) progressively increased flying (from 0 to 10%) (Fig. 4 and Table 2). Correlation analyses (P<0.01) showed that, out of the thirteen significant regressions, two mostly depended upon the mean duration of bouts and six upon both the mean duration and the number of bouts (five remaining unexplained).

Analysis of covariance for watching and feeding suggested that there was heterogeneity in percentages of these activities among the individuals considered when age was kept constant (watching: F=2.53, P<0.05; feeding: F=4.24, P<0.01). The same analysis, however, suggested homogeneity in percentages of walking (F= 1.63, N.S.) and flying (F= 2.03, N.S.) among the vultures considered and, accordingly, a single regression line can be assumed for each of these two activities.

No increase or decrease in vigilance as a function of age of young was revealed. The mean duration of vigilance (during the 10-min bouts) of this period was higher than that in the first period: differences were significant for Entraque and Valdieri (t-tests, P<0.01), but not for Firmin. No clear trend was revealed out for preening (5%-30% of the daytime), sunning (0%-2%), and resting (0%-30%). Aggressive interactions at feeding sites were rather infrequent, and the bird which was dominant at the nest was often challenged by the subordinate. In fact, even though 5 out of the 6 attacks in 1996 were delivered by the dominant bird at the nest (Valdieri), only half the interactions (53%, out of 64) in 1994 were won by the vulture which dominated at the nest (Topolino).

A total of 127 interspecific interactions were monitored, mostly at the feeding sites. In particular, Bearded Vultures successfully attacked Crows (*Corvus corone*) 48 times (out of 57), whereas they were attacked by Golden Eagles (*Aquila chrysaetos*) 34 times (out of 36) and by Kestrels (*Falco tinnunculus*) 11 times (no counterattacks observed). Interactions with Alpine Choughs (*Pyrrhocorax graculus*), Ravens (*Corvus corax*), Magpies (*Pica pica*), chamois

Table 2. Behavioural trends after leaving the nest. Linear regression analyses test the linearity of the relationships between the percentages of behaviours monitored (dependent variable y) and the age of young in days (independent variable x). Regression coefficients (*a*), intercepts (*b*), and P values are given. A t-test was used for testing the significance of the regression coefficient.

Individual	year	watching			feeding			walking			flying		
		a	*b*	P	*a*	*b*	P	*a*	*b*	P	*a*	*b*	P
Topolino	1994	-0.17	68.06	NS	0.72	-70.87	<0.01	-0.17	25.64	NS	0.48	-57.00	NS
Mercantour	1994	-0.05	54.74	NS	0.42	-36.25	<0.05	-0.34	50.67	<0.01	0.19	-23.50	<0.05
Firmin	1995	-0.68	138.18	<0.01	-0.21	41.42	NS	-0.31	45.80	<0.01	0.49	-59.28	<0.001
Entraque	1996	-0.66	133.44	<0.001	0.57	-58.92	<0.001				0.33	-39.62	<0.001
Valdieri	1996	-0.66	136.18	<0.001	3.46	-357.68	<0.05				0.25	-30.82	<0.001

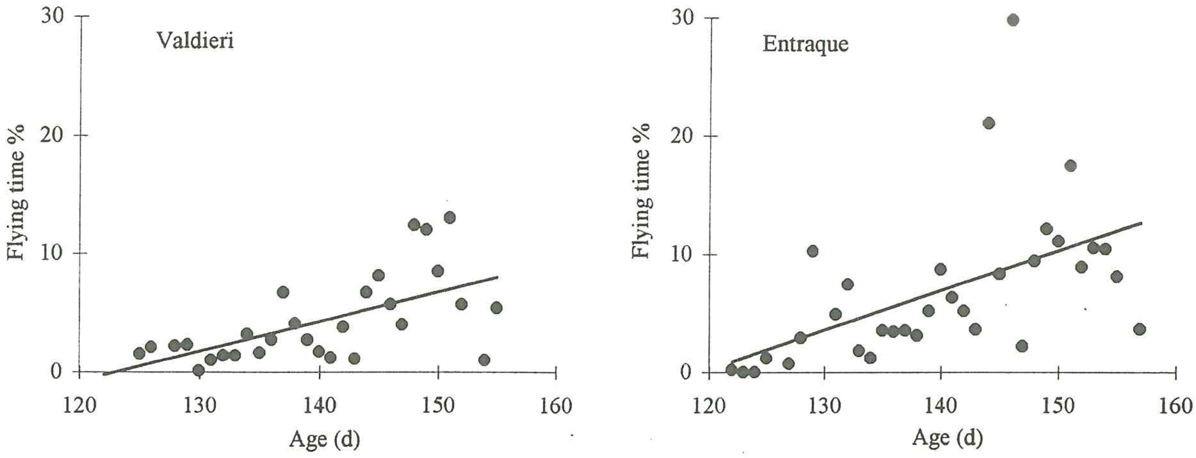

Fig. 4. Percentages of flying time as a function of age of young (in days) for Valdieri and Entraque. Linear regression equations are: y = 0.25 x- 30.82 (P<0.001, Valdieri), y = 0.33 x + 39.62 (P<0.001, Entraque).

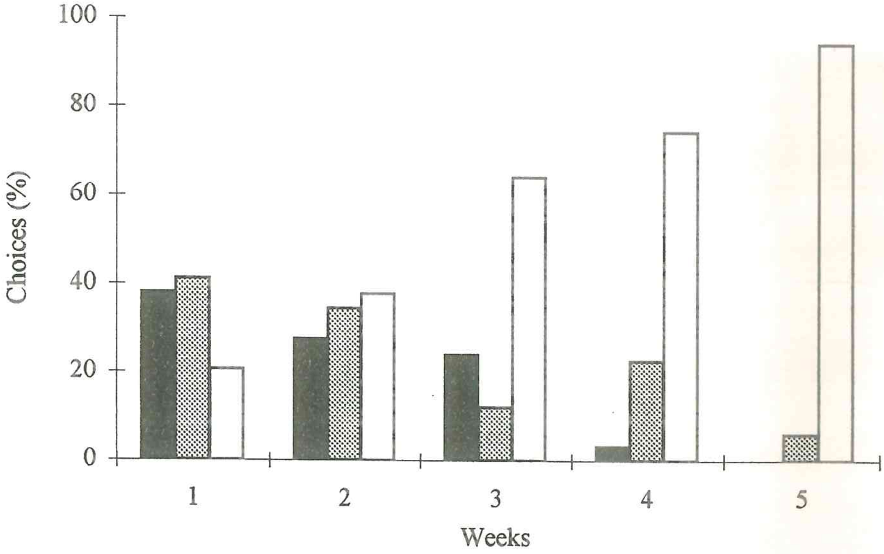

Fig. 5. The choice of the roosting site in relation to the time elapsing since the leaving the nest (in weeks). A total of 136 choices were made by the five vultures. Accessibility and unaccessibility of roosting site were referred to the potential disturbance or predation by terrestrial predators, especially mammals. Black bars: nest; dotted bars: accessible sites; white bars: inaccessible sites.

(*Rupicapra rupicapra*) and foxes (*Vulpes vulpes*) were also occasionally monitored.

Young came back to the nest for roosting during the early days; later on, however, they began to roost in cliffs, selecting more and more inaccessible sites, at least to terrestrial mammal predators (Fig. 5).

The dropping of bones behaviour displayed by Firmin was monitored in 1995. This vulture started to drop bones from the 14th day after the first flight. Until the 50th day, a total of 55 drops was observed of which 69% were concentrated between the 29th and 35th day.

Discussion

In the ontogeny of young birds, two categories of behaviour can be distinguished, i.e.: 1) that displayed in relation to the specific needs of young, and 2) precursors of adult behaviour, which, as a rule, are retained for life (Immelmann 1985). Because of the lack of parents, no typical young behaviour, such as begging for food, was ever observed in the Bearded Vultures monitored. All behaviours displayed by young vultures may therefore be classed in the second category, and, accordingly, any anomalous development of these behaviours might be detrimental to the behavioural performances of adults.

Activities (with the exception of preening, sunning, and resting after leaving the nest) were displayed by some individuals according to increasing or decreasing patterns which seemingly depicted a rather efficient behavioural development. During the period at the nest, the time spent on watching and feeding progressively increased, and, conversely, the time spent on resting tended to decrease. Individuals had to become accustomed to the new nest site, and increasing watching activity was therefore useful. Though wild chicks are fed by complete and incomplete regurgitation, they are also capable of feeding themselves from food brought to the nest from early age (Cramp and Simmons 1980). Released young therefore took full advantage of this capability when, deprived of parents, they were put out at the artificial nest. However, they had to spend more and more time learning how to pick up food autonomously. The decreasing time spent on resting simply depended upon the increase of observation and feeding. The time spent by birds in wing fluttering was quite negligible. Nevertheless, birds were observed to increase this activity, in keeping with the behaviour displayed in the wild (Brown 1990a). After leaving the nest, the time spent feeding and flying progressively increased in some individuals, and, conversely, the time resting and walking decreased. The increase of feeding was probably connected with the energy expenditure associated with the first flights, while the increase of flying suggests that birds were gaining confidence. The decrease in resting and walking depended on the increase in feeding and flying. Walking, for instance, which was displayed when birds were not able to fly, was progressively abandoned when they became accustumed to flying. It should be emphasized that even the vultures which did not show any expected behavioural pattern during the period at the nest (i.e., Entraque and Valdieri) displayed the "right" patterns after their first flight.

The trends discussed so far were statistically significant and regarded 62% of cases (twenty-six out of forty-two), whereas in the remaining ones individuals showed no activity trends or, if any, they were not statistically significant. Percentages of significant trends were lower in the first period (54%) than in the second (72%). Analyses of covariance revealed significant differences among individuals in all activities considered at the nest (watching, resting, feeding) and in two activities after leaving the nest (watching and feeding). The decrease in walking and the increase in flying, however, were shown by all the individuals considered (three and five, respectively). In this case, the analysis of covariance did not show significant differences among vultures and, in fact, a single regression line for each of these activity data can be statistically assumed.

These results suggest that the period at the nest may be more critical than the second period. The recovery of the second period was being prepared already during the first one. Wing fluttering at the nest, in fact, progressively and significantly increased for four out of six vultures, thus suggesting that birds were able to prepare themselves for leaving the nest. Once they had gone, the time spent on vigilance immediately and significantly increased, likely in reply to possible attacks from other birds.

Certain activities did not show any apparent trend. Sunning, which was seldom displayed by vultures (up to 2% of the daytime), evidently depended upon the cloudiness of the sky. Preening was quantitatively much more important, covering up to 30% of the daytime during both periods examined. This comfort behaviour is essential for insulation and flight. Plumage is usually maintained by routine care which is roughly constant over time: the lack of any increasing or decreasing activity pattern is in keeping with this hypothesis.

Despite the theory of "innate behaviour" proposed by Lorenz, it is now recognized that all behavioural traits develop through an interaction between genetic and environmental influences, and that any dichotomy into innate and learned behaviour is therefore artificial (Krebs 1985). In our case, after release, individuals were reared in the absence of parental influence, which, however, likely affected the nestlings during the previous period in captivity. It is known that isolated animals are able to generate their own environmental cues for development, and it is quite possible that young vultures are able to learn from their own trials and errors. Notwithstanding, considering the behavioural performances achieved, it seems unquestionable that vulture behaviour is controlled by a rather strong genetic component. Brown (1990b), for instance, suggested that bone-dropping was a technique learned from parents. However, observations regarding Firmin in 1995 demonstrated that even released individuals are able to drop large bones to break them and extract the marrow, hence suggesting that this behaviour is largely innate, in keeping with other conclusions (Llopis Dell 1996). The selection of sleeping places is probably partly learned by young, as observations from the first breeding in the wild in Haute Savoie confirmed (Heuret *in verbis*). However, our data indicate that, even without parental care, young vultures were able to select roosting sites which were adequately protected from terrestrial predators, again suggesting this behaviour is partly inborn.

On the other hand, it cannot be excluded that parental care serves to accelerate the acquisition of certain behaviours and to improve their efficiency as well. Released vultures seem to leave the nest later than wild ones. Our six individuals did so at 119 days, on average. The mean leaving age of birds released up to date in the Alps is 118 days (Hegglin 1996), whereas wild ones are known to leave at 100-110 days (Cramp and Simmons 1980) or at an average age of 110 days (Fasce and Fasce 1992). Leaving ages reported by Brown (1990a) regarded individuals from South Africa, which are known to belong to the distinct subspecies *G. b. meridionalis* (Hiraldo *et al.* 1984), and were therefore not taken into account. The exact hatching day may be difficult to detect from observations in the wild and, accordingly, underestimation of the leaving age of chicks cannot be ruled out. However, assuming that differences between leaving ages of released and wild chicks are real, the effects of the disturbance caused by researchers who brought food to the nest (nourishing was done at night to diminish disturbance), or of the presence of an artificial nest so different from the natural one made up of a massive pile of branches (Cramp and Simmons 1980), seem not to affect leaving habits. In case of disturbance, in fact, young can fly prematurely, and a shortening of the nestling period was therefore expected. The lack of parental care may be responsible for the delay observed in leaving, since adults in the wild can encourage young to fly. Also, a delaying effect induced by food excess at the nest (Fasce and Fasce *in litteris*) or by a differential food quality (Mingozzi *in litteris*) cannot be ruled out.

Some observations suggest that interactive behaviour did not suffer from the releasing technique used. In the Bearded Vulture, as in many other large birds of prey, the oldest nestling repeatedly and mercilessly attacks its smaller nest-mate in what has become known as the

Cain-Abel conflict (Newton 1979, Thaler and Pechlaner 1980). In the wild, the smallest chick usually dies from starvation so that only one nestling per clutch survives to the third day (Brown 1990a). In captivity, parents are also known to kill the second chick during, or within 24 hours of hatching (Cramp and Simmons 1980). However, the releasing methodology used in the reintroduction project allows the survival of both chicks put out at the artificial nest, maybe creating an unusual and unnatural developmental situation. During all the three years, one chick (usually the oldest and largest) was clearly dominant over the other. After leaving the nest, however, the bird which was subordinate was able to counterattack, hence indirectly suggesting it had not seriously suffered.

Also interspecific interactions suggest that interactive behaviour is quite normal in released birds, since it is well known that wild Bearded Vultures outside the breeding period are usually non-aggressive and can be attacked by other raptors (Cramp and Simmons 1980, Grubac 1991). However, the vultures we observed were also able to drive away Crows, and this, paradoxically, might have been enhanced by interactions at the nest. Moreover, observations of a pair of vultures released in Haute Savoie showed that they were able to defend their reproductive site against Golden Eagles and ravens (Lücker 1997).

All the above reports suggest that, although the period at the nest may be rather critical for some vultures which may be unable to develop the optimal activity patterns, young are able to recover after leaving from the nest. In particular, they can successfully shift from walking to flying, select advantageous roosting sites, be more on the alert, and even successfully break the bones of the carrion they find. Although sample size is small, the present results are in keeping with observations previously carried out at other releasing sites (Hegglin 1996, Niebuhr 1996).

Accordingly, even if some behaviour may be displayed later or less efficiently without parental care, young vultures are able to overcome the difficulties they meet after release, probably because many behaviours are largely genetically controlled. Hence, we may conclude that the final outcome of the reintroduction project of the Bearded Vulture in the Alps will not be significantly affected by the hacking technique employed.

Riassunto - In questa ricerca viene analizzato il comportamento dei sei giovani Gipeti rilasciati al sito dell'Argentera-Mercantour dal 1994 al 1996, distinguendo il periodo trascorso al nido da quello successivo all'involo. Le analisi di regressione hanno evidenziato che tre nidiacei su sei aumentarono progressivamente il tempo dedicato all'alimentazione e all'osservazione diminuendo, complementarmente, quello di inattività. Dopo l'involo quasi tutti i gipeti aumentarono progressivamente il tempo trascorso in alimentazione ed in volo, diminuendo quello dedicato al riposo ed al cammino. Le percentuali di regressioni significative erano minori nel primo periodo (54%) rispetto al secondo (72%). Questi risultati, insieme a quelli ottenuti dall'analisi della covarianza, suggeriscono che il periodo al nido potrebbe essere più critico rispetto a quello successivo all'involo. In ogni caso i battiti alari al nido aumentarono progressivamente in quattro su sei animali. Una volta involati, la maggior parte di gipeti aumentò l'attività di vigilanza, iniziò a selezionare dormitori protetti dai predatori terrestri e interagì con successo per il cibo con le cornacchie. Infine, alcune osservazioni hanno evidenziato che i giovani involati sono già in grado di rompere le ossa autonomamente. I nostri risultati suggeriscono che i giovani gipeti riescono a superare le difficoltà incontrate dopo il rilascio perché molti comportamenti sono in gran parte geneticamente controllati. Possiamo conseguentemente supporre che il risultato finale del progetto di reintroduzione del Gipeto sulle Alpi non dipenda in modo significativo dalla tecnica di reintroduzione impiegata.

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References

Anderegg, R., Frey, H. and Muller, H.U. 1984. Reintroduction of the bearded vulture or lammergeier *Gypaetus barbatus aureus* to the Alps. International Zoo Yearbook 23: 35-41.

Brown, L.H. 1977. The status, population structure, and breeding dates of the African Lammergeier *Gypaetus barbatus meridionalis*. Raptor Research 11: 49-80.

Brown, L.H. 1990 a. Breeding biology of the bearded vulture in southern Africa, part 2: the nestling period. Ostrich 61: 33-42.

Brown, L.H. 1990 b. Breeding biology of the bearded vulture in southern Africa, part 3: the post-nestling dependence period. Ostrich 61: 43-49.

Bustamante, J., Bögel, R. and d'Oleire Oltmanns, W. 1994. Predictions derived from a Population Viability Analysis of the captive bearded vulture population and the population released in the Alps. Gypaetus barbatus Bull. 15: 35-40.

Bustamante, J. 1996. Population viability analysis of captive and released Bearded Vulture populations. Conservation Biology 10: 822-831.

Coton, C. and Estève, R. 1990. La réintroduction du Gypaète barbu dans les Alpes. Rev. Ecol. (Terre et Vie), suppl. 5: 227-241.

Coton, C. and Heuret, J. 1996. Report on the monitoring at the Alpine scale in 1996. Bearded Vulture Ann. Rep. 1996: 70-74.

Cramp, S. and Simmons, K.E.L. (eds.) 1980. The birds of the Western Palearctic, Vol. II. Oxford University Press, Oxford.

Fasce, P. and Fasce, L. 1992. Gipeto. *In*: P. Brichetti, P. De Franceschi and N. Baccetti (eds), Fauna d' Italia, Aves. Edizioni Calderini, Bologna. pp. 480-488.

Frey, H. 1985. Die Verwilderung von Bartgeiernestlingen, über Horste-Detailvorschlag zur Durchführung. Gypaetus barbatus Bull. 7: 13-18.

Frey, H. and Bijleveld, M. 1993. The reintroduction of the bearded vulture *Gypaetus barbatus* (Hablizl 1788) into the Alps. Bearded Vulture Ann. Rep. 1993: 3-8.

Frey, H. and Walter, W. 1989. The reintroduction of the bearded vulture into the Alps. In Raptors in the Modern World, eds. B.U. Meyburg and R.D. Chancellor. Proc. III World Conf. Birds Prey Owls, Eilat: 341-344.

Géroudet, P. 1974. Premiers pas vers la réintroduction du gypaète barbu dans les Alpes. Nos Oiseaux 32: 300-310.

Grubac, R.B. 1991. Status and biology of the bearded vulture *Gypaetus barbatus aureus* in Macedonia. Birds of Prey Bullettin 4: 101-107.

Hegglin, D. 1996. The monitoring of juvenile Bearded Vultures at their point of release: goals and parameters. Bearded Vulture Ann. Rep. 1996: 56-60.

Hiraldo, F., Delibes, M. and Calderon, J. 1979. El quebrantahuesos. ICONA Monogr., No 22, Madrid.

Hiraldo, F., Delibes, M. and Calderon, J. 1984. Comments on the taxonomy of the Bearded Vulture *Gypaetus barbatus* (Linnaeus, 1758). Bonn. zool. Beitr. 35: 91-95.

Immelmann, K. 1985. Behaviour, development of. *In*: B. Campbell & E. Lack (eds.), A Dictionary of Birds. T. & A.D. Poyser.

Komarov, Y. E. and Veinberg, P.I. 1981. Observations on the nestling of the bearded vulture in Central Caucasus. Ornitologiya 1: 170-172.

Krebs, J.R. 1985. Behaviour, history of. *In*: B. Campbell & E. Lack. (eds.), A Dictionary of Birds. T. & A.D. Poyser.

Kurzweil, J. 1994. Survival of released Bearded Vultures: influence on the development of a stable population. Bearded Vulture Ann. Rep. 1994: 31-35.

Lücker, L. 1997. Première tentative de nidification d'un couple de Gypaètes barbus *Gypaetus barbatus:* issus de réintroduction dans les Alpes et remarques comportamentales. Nos Oiseaux 44 : 193-204.

Llopis Dell, A. 1996. Studies on nutrition of released Bearded Vultures (*Gypaetus barbatus*). Bearded Vulture Ann. Rep. 1996: 89-90.

Mingozzi, T. and Balletto, E. 1996. The historical extirpation of the bearded vulture *Gypaetus barbatus* in the western Alps (France-Italy): modelling the impact of human persecution. Ital. J. Zool. 63 : 371-376.

Mingozzi, T. and Estève, R. 1997. Analysis of a historical extirpation of the bearded vulture *Gypaetus barbatus* (L.) in the western Alps (France-Italy): former distribution and causes of extirpation. Biol. Cons. 79: 155-171.

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

Niebuhr, K. 1996. Behaviour of released Bearded Vultures at the release site Rauris and comments on further research topics. Bearded Vulture Ann. Rep. 1996: 53-56.

Perfus, M., Cristini, S., Lequette, B. and Millischer, G. 1994. Réintroduction du Gypaète barbu dans le massif de l'Argentera-Mercantour. Riviéra Scientifique: 67-80.

Sokal, R.R. and Rohlf, F.J. 1981. Biometry, 2nd Edition. W.H. Freeman and Company, San Francisco.

Thaler, E. and Pechlaner, H. 1980. Cainism in the lammergeier or bearded vulture *Gypaetus barbatus aureus* at Innsbruck Alpenzoo. International Zoo Yearbook 20: 278-280.

Thibault, J.-C., Vigne, J.-D. and Torre, J. 1993. The diet of young Lammergeiers *Gypaetus barbatus* in Corsica: its dependence on extensive grazing. Ibis 135: 42-48.

Wackernagel, H. and Walter, W. 1980. Captive breeding and reintroduction of the lammergeier or bearded vulture *Gypaetus barbatus*. A zoo/nature conservation project. International Zoo Yearbook 20: 243-244.