SUPPLEMENTARY FEEDING AND THE POPULATION DYNAMIC OF THE SPANISH IMPERIAL EAGLE

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SUMMARY.—Supplementary feeding and the population dynamics of the Spanish imperial eagle. Supplementary feeding could be a useful technique to avoid losses of chicks in certain nests under peculiar circumstances, but it could be appropriate to prolong it until the end of the dependence period also. This would prevent the negative effects on breeders clearly pointed out by Blanco (2006). We have serious concerns about the real magnitude of siblicide in this species, as well as about the possible effect on the growth speed of the population that techniques aimed to improve fecundity would have. Consequently, the suggestion of extending this technique to a large proportion of the breeding population must be seriously reconsidered. The idea that breeding populations and their fecundity are the main target for conservation plans must be revised, according to most recent advances on population dynamics of long-lived species and structure of populations

Key words: Aquila adalberti, brood reduction, cainism, management techniques, raptor conservation, Spanish imperial eagle.

RESUMEN.—Alimentación suplementaria y la dinámica de poblaciones del águila imperial ibérica.

La alimentación suplementaria puede ser una técnica útil para evitar la perdida de pollos en ciertos nidos bajo circunstancias especiales, pero puede ser apropiado prolongarla hasta el fi-

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nal del periodo de dependencia. Esto evitaría algunos efectos perjudiciales en los reproductores como los que ponía claramente de manifiesto G. Blanco (2006). Tenemos serias dudas sobre la magnitud real del cainismo en esta especie así como del posible efecto que las técnicas destinadas a aumentar la fecundidad pueden tener sobre la velocidad de crecimiento de la población. En consecuencia, la sugerencia de extender esta técnica a una gran porción de la población reproductora debe ser seriamente reconsiderada. La idea de que los objetivos de conservación deben ser la población reproductora y, en concreto su fecundidad, debe ser revisada a la luz de los conocimientos recientes en dinámica de poblaciones y estructura de las mismas en especies de larga vida.

Palabras clave: Aquila adalberti, reducción de nidada, cainismo, técnicas de manejo, conservación de rapaces, águila imperial ibérica.

Recently, Guillermo Blanco (2006) discussed some possible consequences of supplementary feeding when applied to a large portion of a target population, the Spanish imperial eagle Aquila adalberti. We agree with many of his arguments and in the present note we will report some supplementary shortcomings of the cited technique that affect its effectiveness (in accord with the population dynamic theory). The main idea underlying our note is that the common concept that breeding populations and their fecundity are the main target of conservation plans directed toward endangered raptors need to be revised today, according to our most recent information achieved on population dynamics of long-lived species and structure of populations (Ferrer et al., 2004; Penteriani et al., 2005a, 2005b, 2006).

González et al. (2006) published an analysis of the effectiveness of a supplementary feeding program for the endangered Spanish imperial eagle. According to the authors, this technique decreases siblicide probabilities in a cainism-facultative species such as the Spanish imperial eagle, consequently resulting in population increases. It is always interesting and not very frequent to make an evaluation of the effectiveness of management techniques used in endangered species conservation. In this sense the González et al. (2006) attempt is a valuable study. Nevertheless, some serious limitations in the reported analyses, as well as the erroneous interpretation of several aspects of the population biology of the Spanish imperial eagle, encouraged us to make some reinterpretation of the problem.

Although the authors said that supplementary feeding is an innovative technique for this species, this is not true. Supplementary feeding of this species was first used in the Doñana National Park (SW Spain) in 1988, with the aim of avoiding the high mortality levels detected in certain territories. Eagle feeding was not only carried out during the nestling period, but throughout the dependence period until young were over 140 days old (Ferrer, 1992). Results appeared in the Annual Reports of the Spanish imperial eagle Conservation Plan for Doñana National Park (Cadenas et al., 1988, 1989, 1990). We were very surprised to read in the paper by González et al. (2006) that their program started in 1988, exactly when our program started in Doñana, especially because they only show information from 1990 onwards (as shown in the Table 1 of their paper). 1990 represented the year in which the technique of supplementary feeding, first tried in the Doñana population, began to be used in other subpopulations. It is interesting to point out that the original purpose of this technique was to avoid an unusual high mortality of nestlings/fledglings in those territories located at the south of the National Park. Eagles occupying these territories were traditionally feeding mainly on

waterfowl and waders due to the absence of wild rabbits in this area (Ferrer, 2001). As a result of management decisions by the Park administration starting from 1987, the evacuation of water from the marshes was a priority to avoid the emergence of botulisms. As a consequence, pairs of eagles feeding mainly on waterfowl suddenly suffered a great reduction in food availability when they were in the middle of the nestling period. To avoid this human-induced mortality, supplementary feeding at these nests was implemented with very good results (Cadenas et al., 1987, 1988, 1989). However, the extension of this technique to all or a large fraction of the population has never been proposed until today.

Because the main objective of the supplementary feeding program proposed by Gonzalez et al. (2006) was "…to limit the process of sibling aggression", the frequency of cainism seems to be crucial to determine the maximum expected effect of this program on fecundity. González et al. (2006) cited previous studies on the importance of sibling aggression as a cause of mortality in nestlings of Spanish imperial eagles. They said that in Calderón et al. (1987) and Ferrer (1993), sibling aggression was never detected. Again, this is not true. In Ferrer (1993), as well as in Calderon et al. (1987) and in Ferrer (2001), we can read that 28.6 % of deaths in the nest were due to sibling aggression, affecting 4.8 % of chicks hatched in the population. González et al. (2006) said that because of the discrepancies over the occurrence of siblicide and the technique of chick translocation was considered inefficient, we rejected this latter as a handling technique. Such a statement is true (Ferrer and Hiraldo, 1991), but they omitted that when we decided not to make a translocation of nestlings to avoid siblicide, the hatching rate in Doñana population increased from 45 to 60 % (Ferrer and Hiraldo, 1991). This was because of chick translocation need and an average of 7.7 visits to the nest (Ferrer and Hiraldo, 1991) and, when trying to protect the 4.8 % of the

chicks, we were finally killing the 15 % of the eggs (Ferrer and Hiraldo, 1991).

According to their own published data (González, 1991), however, 26.2 % of the total nestling population died by cainism, i.e. the main factor limiting fecundity in the species. Nevertheless, they did not mention that this data was obtained in a sub-sample of 70 nests, after discounting nests with only one chick and assuming that any partial loss in the brood was due to siblicide (González, 1991). This assumption, which they repeated in the Gonzalez et al. (2006) paper, is obviously an overestimation of this behaviour. It is difficult to assume that the only reason explaining a partial loss of the brood is sibling aggression. Surprisingly, although their own necropsies showed a frequency of 38 % of the deaths attributable to sibling aggression, they decided to account again for all the nestlings disappearing as dieing by siblicide and estimated nestling mortality by this cause as 54.8 %. These exaggerated estimates would put the Spanish Imperial eagle among the group of cainism-obligate raptors (Simmons, 1988).

González et al. (2006) mentioned among the possible factors limiting the species' breeding success " … an increase in the number of inexperienced pairs as a result of high adult mortality (Ferrer et al., 2003)". Again, they are wrong, because in the cited paper there was never any report of a possible effect on fecundity. In fact, density-dependent variation in the age of first breeding is critical to the long-term survival of small populations of long-lived species with deferred sexual maturity (Ferrer et al., 2004). This is because density-dependent variations in the age of first breeding buffer population fluctuations and, consequently, increases the persistence of these populations.

Gonzalez et al. (2006) argued that the results obtained by their supplementary feeding program support the idea of an adaptive regulatory mechanism that facilitates the death of the chicks in situations of reduced availability of food. They seem not to distinguish be-

tween the trivial idea of one or more chicks in a brood that probably died when there was not enough food from the evolutionary based idea of a mechanism generating differences among chicks in the brood, avoiding an unnecessary waste of energy if the available food is not enough. Gonzalez et al. (2006) did not report any information that could be interpreted as a support to the adaptive brood reduction hypothesis.

Last, probably the most serious difficulty in the González et al. (2006) paper arises when the authors said that the supplementary feeding program may have had a great impact on the nearly +4 % of annual population increases recorded in this species during the last ten years. In fact, annual increases recorded have been +4.5 % (from 135 to 210 pairs, data from National Spanish imperial eagle Working Group). But, how important could the real benefit for the conservation of the Spanish imperial eagle be when applying this supplementary feeding program to all the population? Using the Gonzalez et al. (2006) data obtained from 1192 nests, with 319 of them under a supplementary feeding program, they recorded that 209 of the 2252 hatched nestlings died before fledging. Assuming the most positive option for them, that is, that all the chicks that died were in non food-supplemented nests, this gives a nestling mortality for any cause of 11.87 % in the population of nestlings without a supplementary feeding program. If we assumed that all of them died by sibling aggression, again the most optimistic option that could be avoided using this supplementary feeding technique, we can expect an increases in fecundity of +11.87 %. According to the classic theory of deterministic population dynamics applied to bird of prey (Mertz, 1971; Ferrer and Calderón, 1990; Ferrer and Hiraldo, 1991; Ferrer, 2001), the finite index of natural increment "λ" give us an idea of the rate at which the population numerically increases or decreases. This index is defined by the following equation:

$$\lambda^5 - p\lambda^4 - \beta(e/2) = 0$$

where "e" is productivity per pair that is 0.7525 for a stable population (Ferrer and Calderón, 1991), "p" is annual adult mortality rate (6.07 %) and "β" is preadult mortality (83.86 %). The percentage of annual change of the population was calculated as follows:

% of annual change= $100 (\lambda - 1)$

Substituting in the above equations the increases of +11.87 % in fecundity, we obtained a maximum percent of annual change of +0.59 %, far away from the +4.5 % registered in the real population. As a consequence, under the most favourable scenario, food supplementation applied to all the population would explain only a small fraction of the observed increases. Consequently, the authors' assertion about the great impact of this feeding program in the population increases seems incongruent.

On the other hand, as shown by Ferrer and Hiraldo (1991), an increment in adult survival obtained by protecting dangerous power lines would lead to a potential increase of +5.99 % annually, that is closer to the observed one. New legislation on power lines constructions to protect birds was adopted in Andalusia in 1990, and shortly after several programs were implemented to reduce the electrocution of eagles in Spain in all the autonomous communities with eagle populations. A significant reduction in the electrocution of eagles (nearly 87 %; Ferrer et al., in prep) seems a more plausible explanation for the significant increase recorded in the Spanish imperial eagle population.

In conclusion, although supplementary feeding could be a useful technique to avoid losses of chicks in certain nests under peculiar circumstances, it could be appropriate to prolong it until the end of the dependence period also. This will prevent the negative effects on breeders clearly pointed out by Blanco (2006). Usually, mortality during this period is difficult to de-

tect but it exists and would be avoided with this technique. We have serious concerns about the real magnitude of siblicide in this species, as well as about the possible effect on the growth speed of the population that techniques aimed to improve fecundity would have. Consequently, the suggestion of extending this technique to a large proportion of the breeding population must be seriously reconsidered. The idea that breeding populations and their fecundity are the main target for conservation plans must be revised, according to most recent advances on population dynamics of long-lived species and structure of populations (Penteriani et al., 2005a, 2005b, 2006). The floater population is vital for population persistence and their mortality reduction must be a priority in the conservation plans of long-lived endangered species today.

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