Successful replacement clutches in European Bonelli's Eagles (Hieraaetus fasciatus)

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SUCCESSFUL REPLACEMENT CLUTCHES IN EUROPEAN BONELLI'S EAGLES (*HIERAAETUS FASCIATUS*)

KEY WORDS: *Bonelli's Eagle*; Hieraaetus fasciatus; *Europe*; *latitudinal gradient*; *laying period*; *replacement clutch.*

Replacement clutches in birds are laid immediately after the failure of the first clutch. In raptors, this is relatively more common among smaller than larger species (Newton 1979), due to the long duration of the breeding cycle, which in general increases proportionately with body mass (Calder 1984). In the case of the Bonelli's Eagle (*Hieraaetus fasciatus*) only four cases of replacement clutches are known (Mourgues and Lhermitte 1920, Pompidor and Cugnasse 1990, Cabeza and de la Cruz 2001, Bautista et al. 2003), and only two of these were successful (Cabeza and de la Cruz 2001, Bautista et al. 2003). Here we describe a third case of a successful replacement clutch in the Bonelli's Eagle and discuss factors that may influence the success of replacement clutches in this species.

On 23 February 2007, agents of the Wildlife Protection Service of the Spanish Civil Guard seized two Bonelli's Eagle eggs that had been stolen from a nest in the extreme east of the Cadiz Province (southwestern Andalusia, Spain). The eggs were placed in a portable incubator at 37.0–37.5°C and transferred to the Jerez Zoo–botanic Park (Cadiz) and then subsequently to the San Jerónimo Spanish Imperial Eagle Captive Breeding Center (Sevilla, Consejería de Medio Ambiente, Junta de Andalucía). The two eggs hatched on 4 and 5 March. Backdating from 4 March and using an incubation period of 39 d (Arroyo et al. 1995), we calculated that the female of this territory started laying on approximately 27 January.

During the week following theft of the eggs, we visited the territory; the pair of adults was present and the nest (observed from a higher position in a nearby cliff) was empty. During subsequent checks of the nest, a second clutch of two eggs was observed. These eggs hatched and both nestlings fledged during the last week of June. The replacement clutch of eggs was laid between 14 and 18 March, one and a half months after the first, and three weeks after theft of the eggs. This estimated interval between clutches falls between those previously indicated (19–30 d; Pompidor and Cugnasse 1990, Cabeza and de la Cruz 2001, J. Bautista unpubl. data) and is similar to those documented in other large raptors (e.g., 19–29 d for the White-tailed Eagle; *Haliaeetus albicilla*; Fentzloff 1975). Although the identity of the adults was not certain, the replacement of one or both following the egg theft was unlikely given the low likelihood that a new pair would lay eggs in such a short time; in addition, at no time during our visits to the territory was either member of the pair absent.

The success of the replacement clutch was likely facilitated by three factors. First, and probably most importantly, the early laying date of the initial clutch allowed the possibility of a replacement clutch within the normal phenology of the species in the southern Iberian peninsula (Cabeza and de la Cruz 2001); egg-laying there generally occurs between mid-January and late March (Arroyo et al. 1995, Gil-Sánchez 2000, Consejería de Medio Ambiente 2006). Second, the productive ecosystem resources in Andalucía in general, and the Cadiz Province in particular (Consejería de Medio Ambiente 2006, Moleón et al. 2009, in press), may have favored the optimal physiological condition of the adults and the availability of adequate food for the chicks (Cabeza and de la Cruz 2001). Finally, the adult age of both breeders likely enhanced the probability that a second clutch would be laid, given that successful breeding is less likely when one or both of the pair is still in subadult plumage (Gil-Sánchez et al. 2004, Carrete et al. 2006).

The role of latitude in the frequency of replacement clutches in raptors is well known: in the northern hemisphere, the probability of a second clutch being laid after failure of the first increases with decreasing latitude (Newton 1979). This is primarily due to the longer breeding season at lower latitudes. Our results, and those published previously on replacement clutches in Bonelli's Eagle, support this idea. Indeed, the two known cases where replacement clutches failed occurred in France (at the northern limit of the European population; Mourgues and Lhermitte 1920, Pompidor and Cugnasse 1990), whereas the three successful cases were in central (Cabeza and de la Cruz 2001) and southern Spain (Bautista et al. 2003, this study), the warmest region of the Iberian peninsula. Although a larger sample size is necessary to adequately evaluate this hypothesis, it seems plausible to postulate that the probability of producing successful second clutches in the Bonelli's Eagle in western Europe increases with decreasing latitude. This pattern would, in addition, correspond with the availability of greater trophic resources in lower latitudes of western Europe (Moleón et al. in press).

The marked environmental gradient (e.g., temperature) between the most northerly (French Mediterranean coast) and southerly (Cadiz Province) zones of the Bonelli's Eagle range in western Europe is reflected in the phenology

and duration of the egg-laying period (and breeding success; Ontiveros and Pleguezuelos 2003). The average laying date in the southern half of Spain is 2–4 wk earlier and the breeding period extends several weeks longer than in the north (Arroyo et al. 1995, Gil-Sánchez 2000, Consejería de Medio Ambiente 2006). Consequently, the possibility that chicks from a second clutch would develop in the appropriate time period decreases with increasing latitude. Considering this in the opposite sense, successful replacement clutches may be relatively common in the central and southern Iberian peninsula when the failed clutches were laid early (i.e., Jan–Feb). We note that all three successful replacement clutches were laid before mid-February (Cabeza and de la Cruz 2001, J. Bautista unpubl. data, this study).

If our hypothesis is confirmed through future observations, this fact may be of conservation importance for populations in the central and southern Iberian peninsula, already significant for their key role in the conservation of the threatened European Bonelli's Eagle metapopulation (e.g., Gil-Sánchez et al. 2004, Muñoz et al. 2005, Consejería de Medio Ambiente 2006, Moleón 2006), because the failure of a clutch does not necessarily imply total breeding failure in that breeding season.

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