

Anomalous Double-Clutch Laying in the Black Vulture (*Coragyps atratus*): Replacement Eggs or Biochemical Alterations of the Breeding Cycle?

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Abstract - We describe the first documented case of anomalous double-clutching behavior in *Coragyps atratus* (Black Vulture) in northeastern North America. The female laid 2 eggs, which hatched successfully, and laid an additional clutch of 2 eggs, probably post-hatching, which it did not incubate, but were eventually consumed by the adults. Although we cannot determine the reason for this rare nesting behavior, the possibility of a double-brooding attempt was unlikely due to the timing of egg laying and the eggs not being incubated, yet we are not able to discard the possibility of an event of intraspecific nest parasitism. Since egg-laying is expensive in terms of energy, and may compromise adults' future reproduction and survival, this redundant expenditure suggests that (1) this pair of Black Vultures may have a resource-rich environment, and/or (2) the food availability derived from anthropogenic byproducts might be altering the biochemical cycles of reproduction timing. Further research is needed to ascertain whether the recent range expansion of Black Vultures in North America due to human activity may hide a threat that could compromise its populations in the future.

Introduction. Understanding the breeding biology of raptors is critical for building baseline knowledge to address potential conservation issues. In the case of scavenging raptors, studying the processes of their reproductive cycle can aid at better evaluating the crucial ecosystem services that they provide (DeVault et al. 2016). *Coragyps atratus* (Bechstein) (Black Vulture) is an obligate scavenger and largely resident bird whose range spans from southern South America to the southern and eastern US (Buckley et al. 2022). Since the 1980s, this species has expanded its range in North America, breeding as far north as Vermont (Buckley et al. 2022), Massachusetts (Petersen and Meservey 2003), and New York (McGowan 2008), and has increased its abundance in these areas (McGowan 2008, Rucker 2021, Wilson et al. 2012). Although the causes of this range expansion are unknown, some possibilities include climate change, the discontinued use of certain pesticides in some of these areas (Kiff 2000), and increased food availability as a result of habitat modification (Hill et al. 2022). From these, the latter poses a potential and hidden risk for vulture populations, since it is known that garbage consumption can have adverse impacts on their health (Plaza and Lambertucci 2018).

The nesting behavior of the Black Vulture is mostly well known. Females lay 2 eggs per clutch, with 24–72 hr between laying (Buckley et al. 2022, Monsalvo et al. 2020), which are incubated over 38–39 d followed by a prolonged nestling period of 80 days after hatching (Jackson 1983, Stewart 1983). These behaviors are associated with biochemical cascades of sex steroids in female raptors that determine timing of egg laying, incubation, and brooding, with estradiol peaking during the egg-laying period and subsequently inhibited by the

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progesterone peak during incubation periods (Blas et al. 2010). In the case of nest failure, renesting can occur some weeks after (Jackson 1983). Despite the Black Vulture's distribution range and abundance, some aspects of its biology have little information available. One of them is the laying of additional eggs before, or after, the original clutch hatches. This behavior is different from double brooding, which is the production of a second brood after having a successful first one (Morrison 1998). To date, there have only been 2 reports of Black Vultures laying an additional egg after the original clutch hatched (Kavouriaris et al. 2023). Here, we describe a case of a breeding pair that laid 2 additional eggs, both within 10 days of the first clutch hatching in Pennsylvania.

Case study. We found the active Black Vulture nest on 2 April 2022, with an adult and 2 eggs (Fig. 1A), in a rocky cavity at Hawk Mountain Sanctuary, PA (40° 38' N, 75° 59' W).



Figure 1. Pictures of the *Coragyps atratus* (Black Vulture) nest found at Hawk Mountain Sanctuary, PA, on (A) 2 April 2022, with 2 eggs on it (photograph © M.J. Bowers), and (B) 9 May 2022, with 2 nestlings and 1 egg (photograph © D. Gallego-García).

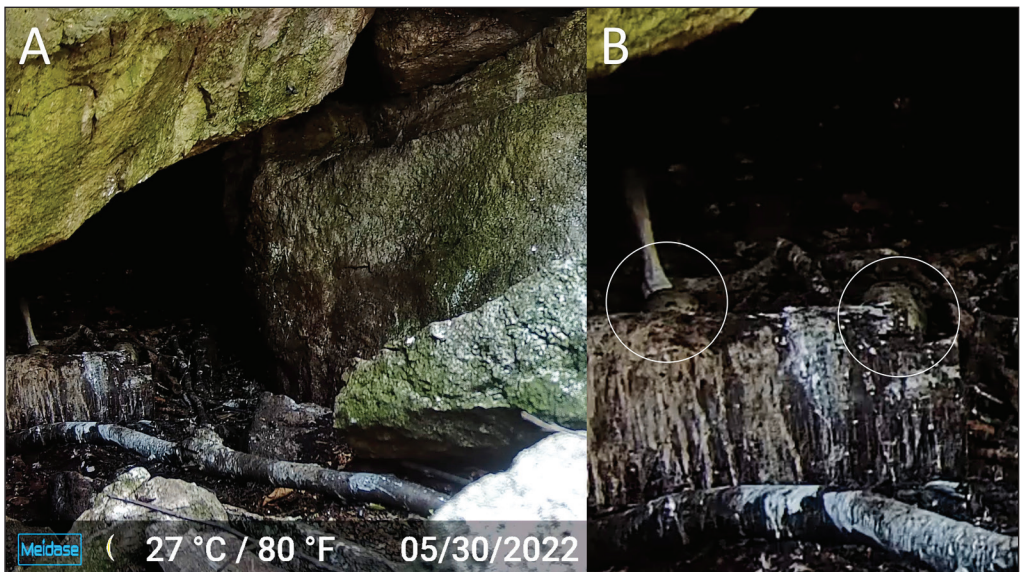
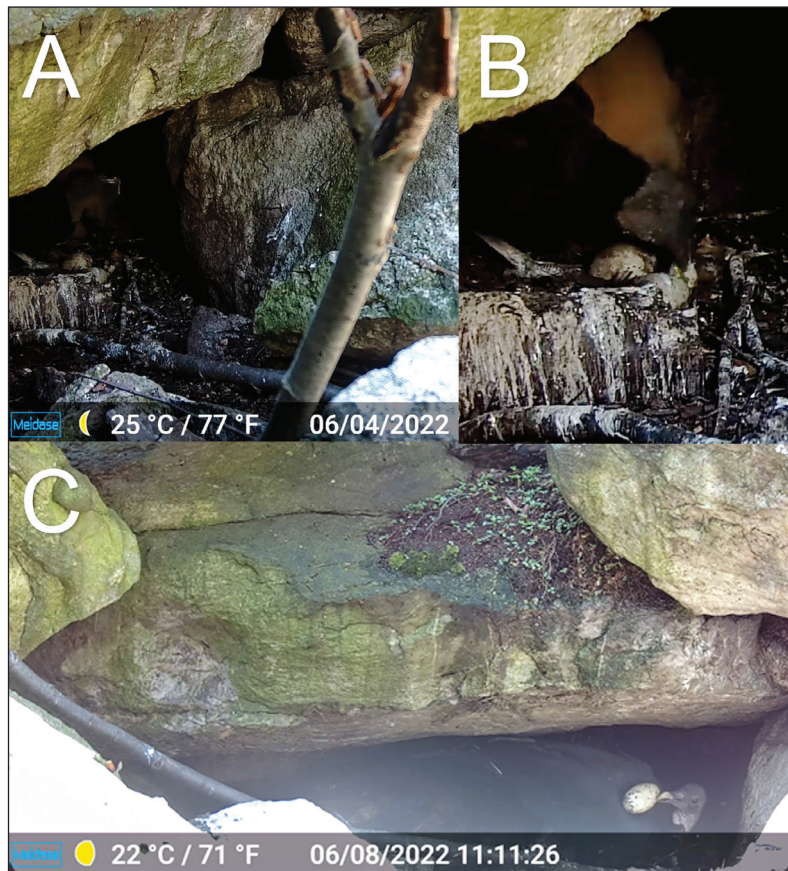


Figure 2. Screenshot of the trail-camera videos of the *Coragyps atratus* (Black Vulture) nest found at Hawk Mountain Sanctuary, PA, on (A) 30 May 2022, with the 2 additional eggs laid after the original ones hatched (see Fig. 1). (B) Zoomed-in close up of image (A).

Hawk Mountain is located in the Central Appalachian Broadleaf Forest ecoregion (Bailey et al. 1994) and is dominated by mixed deciduous forests interspersed with small stands of *Tsuga canadensis* (L.) Carrière (Eastern Hemlock) or *Pinus strobus* L. (Eastern White Pine). An additional visit on 16 April confirmed that the nest still had 2 eggs. On 8 May, the nestlings had hatched and were ~4–5 days old (based on guide of nestling growth and development by McHargue [1981]), and there was an additional egg at the nest (Fig. 1B). We could not ascertain that the first additional egg was laid pre- or post-hatching of the original eggs. On 20 May, the 2 nestlings were at the nest and there were 2 eggs, a situation that was reconfirmed on 30 May, when a camera trap was installed near the cavity (Fig. 2). On 6 June, 1 of the adults was recorded eating from 1 of the additional eggs (Fig. 3A, B) beside 1 of its nestlings (the other nestling was not seen after 2 June). On 8 June, 1 of the adults was recorded eating the remaining egg (Fig. 3C). The breeding season ended successfully, with one fledgling that was seen out of its nest on 15 July by B.M. Brown. When the nest was again checked, we found anthropogenic waste in it, such as cans, aluminum foil, and small plastics (B.M. Brown, pers. observ).

Discussion. The reasons for this unusual nesting behavior remain unclear. As noted in the other reported cases for this species (Kavouriaris et al. 2023), we do not know if the additional eggs laid were infertile because the eggs were consumed by the adults. Also, the chicks overall appeared healthy (Fig. 1B), so it is improbable that the vultures were trying a replacement clutch or renesting attempt (Becker and Zhang 2011, Hipfner et al. 1999). There were no indications of a mate replacement, or a third adult attending the nest

Figure 3. Screen-shots of the trail-camera videos of the *Coragyps atratus* (Black Vulture) nest found at Hawk Mountain Sanctuary, PA, on (A) 4 June 2022, with an adult feeding on 1 of the additional eggs. (B) Zoomed in close up of image (A). (C) The same nest on 8 June 2022, with an adult feeding on the remaining egg.



to account for the additional clutch during observations; yet, we cannot fully discard the possibility of intraspecific nest parasitism, which has no prior evidence in vultures to our knowledge. Additionally, Black Vultures are known to be monogamous, only replacing mates when a member of the pair dies (Decker et al. 1993, Rabenold and Decker 1989). This behavior has been widely documented in other old world vultures (Bertran et al. 2016). Thus, the likelihood of an atypical pair formation is unlikely based on our field observations and camera-trap footage. The possibility of an event of multiple brooding, uncommon in large raptors inhabiting temperate zones (Curtis et al. 2005), is unlikely because we did not see any attempt of incubation of the additional eggs by either of the adults after the installation of the trail camera. Also, given the parental-care demands of the nestlings, it seems improbable that an adult would be able to properly incubate these additional eggs (Kavouriaris et al. 2023). The fact that egg laying is costly in terms of energy expenditure and can eventually compromise future reproduction (Nager et al. 2001) and that the timing of egg laying is associated with biochemical cascades that in theory do not allow females to relay a clutch when they are already incubating the hatched nestlings (Blas et al. 2010) suggests 2 possible explanations for our observations: (1) the female vulture had spare resources to cycle back into egg laying towards a second (or replacement) clutch, and/or (2) the Black Vulture's diet, derived from anthropogenic land uses and byproducts (e.g., garbage, livestock carcasses; Hill et al. 2022), could be altering the functioning of their hormone systems, and thus their reproductive processes, hinting at hidden dangers for this scavenging species (Plaza and Lambertucci 2018). Furthermore, these hypotheses are not mutually exclusive, since there is already evidence linking the production of additional eggs with greater food resource availability as a result of anthropogenic habitat modification in birds and some raptors (Morrison 1998, Toland 1985), although not in vultures. Both of these hypotheses should be carefully examined in future studies, along with the possibility that this rare event is due to intraspecific nest parasitism. Overall, this case is consistent with the idea that the expansion of the Black Vulture's range of distribution during recent decades may be influenced by anthropogenic land-use changes (Hill et al. 2022), a fact that has been especially true in the northeastern US (Rucker 2021, Wilson et al. 2012).

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