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Robin's egg blue: does egg color influence male parental care?

Philina A. English & Robert Montgomerie

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Abstract A recent hypothesis suggests that bird blue-green egg colors may be a sexually selected signal of female (and potentially nestling) quality that males use to make parental investment decisions. While there is some empirical support for this idea, both theory and observations question.5(bot3dng)-9.aliditha5atesecis idea, suggpF1 -2462 TD [(make)-450.9-2.8

to those species in which males actually provide these services.

The sexually selected egg color hypothesis (SSEC; Moreno and Osorno 2003) requires (a) that the intensity of blue-green eggshell color is an honest signal of female and potentially offspring quality, (b) that variation in egg color is detectable by birds, and (c) that males gain a fitness advantage by adjusting their investment in response to that variation. Certainly, blue egg color is variable within species (Moreno et al. 2005; Siefferman et al. 2006; Cassey et al. 2009) and is well within the bird-visible spectrum (Burkhardt and Finger 1991). A recent experiment also demonstrated that birds can discriminate among experimental eggs that span the natural range of variation in color (Soler et al. 2008). Finally, egg color can be readily observed by the male parent whenever the female is off the nest, even if the male does not incubate.

Moreno and Osorno (2003) also argued that, because it has antioxidant properties (Kaur et al. 2003), biliverdin would be valuable to the female and thus its deposition into eggshells potentially costly. Therefore, only high-quality females should be able to deposit large quantities of biliverdin in their eggshells. Female gray catbirds (*Dumetella carolinensis*), for example, laid bluer eggs when they had higher antioxidant levels in their bloodstream (Hanley et al. 2008). In the European pied flycatcher (*Ficedula hypoleuca*), a

exterior MF Porticobase D; Parade of Paints, Kingston, ON, Canada) and various pigments. The dried clay eggs (11.70–12.07 g, n=20) weighed more than natural eggs (5.44–8.28 g, n=450) and were close to the extremes in natural coloration but did not reflect in the UV (Fig. 1b). All females resumed incubating the artificial eggs within minutes after we left the nest vicinity.

For each experimental treatment, we used three synchronous nests within a few kilometers of each other that were located on, or prior to, their second full day of incubation. We required three synchronous nests for each experimental manipulation because high predation rates meant that more than one possible source nest was required to ensure the availability of foster nestlings of the correct age. The

tend to have paler head plumage than males (Sallabanks and James 1999), but sex was confirmed by presence/absence of a brood patch, which is present only on females.

Nestling provisioning by the parents was video-recorded when the nestlings were 3 days [mean (95% CI): experimental, 3.24 days (3.00–3.49), N = 13; unmanipulated, 2.90 days (2.65–3.14), N = 34], 6 days [experimental, 6.37 days (5.87–6.87), N = 9; unmanipulated, 5.83 days (5.61–6.05), N = 37], and 9 days old [experimental, 9.37 days (9.07–9.70), N = 9; unmanipulated, 8.87 days (8.58–9.15), N = 27]. High definition video cameras (DCR-SR100 HDD Handycam; Sony, San Diego, CA, USA) were placed about 5 m from each nest beginning 1–5 h after sunrise [experimental, 3.42 h (2.80–4.04), N = 31; unmanipulated, 3.29 h (3.02–3.55), N = 98].

Videos were reviewed using Sony Vegas Platinum 8 software. Both the number of visits where at least one nestling was fed and the total time each adult was present at the nest were calculated as an hourly rate for each parent. All experimental nests contained three nestlings, while unmanipulated nests contained one to four nestlings (

total time spent by the female at these unmanipulated nests also decreased from an average of 39 min/h on days 3 to 23 min/h on day 9, even though her feeding visit rate increased.

Males rarely visited the nest without food and were never observed brooding. As a result, the total time that males spent at the nest averaged only 5.9 min/h on day 3, declining to 3.2 min/h on day 9. Although males were occasionally observed coming to the nest while the female was brooding, they more often arrived shortly after her departure and thus may have delayed a feeding visit when she was on the nest. Despite this, the male made more feeding visits when the female spent more total time feeding and brooding (Table 2).

To simplify and increase the statistical power of further analysis of male provisioning rates, we performed a separate analysis for each nestling age (3, 6, and 9 days), using the predictors described above (no. of chicks, female

American robin egg cannot be ruled out. For example, blue-green pigmentation due to biliverdin might sometimes be cryptic (Underwood and Sealy 2002; Langmore et al. 2009), may provide some protection from solar radiation (Lahti 2008), or could help to strengthen the eggshell (Solomon 1997). These potential roles for biliverdin in the eggshell have so far received the least attention and provide some interesting possibilities for further discovery.

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References

Anderson DR (2008) Model based inference in the life sciences: a primer on evidence. Springer, New York

Burkhardt D, Finger E (1991) Black, white and UV: how birds see birds. Naturwissenschaften 78:272–280

Cassey P, Ewen JG, Blackburn TM, Hauber ME, Vorobyev M, Marshall NJ (2008) Eggshell colour does not predict measures of maternal investment in eggs of *Turdus* thrushes. Naturwissenschaften 95:713–721