Short communication

Corticosterone and stable isotopes in feathers predict egg size in Atlantic PufÞns Fratercula arctica

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Examining factors that operate outside the breeding season may provide new insights into life-history traits such as egg size, in which individual variation has not been fully explained. We measured corticosterone (CORT) levels and $\delta^{15}N$ values (trophic level) in feathers grown several months before egg-laying to test the prediction that a female's physiological state and feeding behaviour prior to the breeding season can inuence egg mass in Atlantic Puf ns Fratercula arctica As predicted, egg mass increased with both CORT and $\delta^{15}N$ values in feathers, suggesting that the ability of female Pufns to meet the nutritional costs of egg production is related to CORT promoting increased foraging effort during moult and to consumption of a higher trophic-level diet.

Keywords: carry-over effects, feather corticosterone, nitrogen stable isotopes.

The tness consequences of egg size have been documented for mothers and offspring in many taxa (Sinervo et al. 1992, Einum & K-52nng 19992nng

c variation. In Macaroni Penguins Eudyptes chrysolophus, for example, physiological processes underlying egg formation, which determine 'reproductive readiness', begin while females are migrating to nesting areas, such that females that lay shortly after returning to the colony produce clutches with greater size variance than clutches from females that spend more time at the colony before laying (Crossin et al. 2010).

Here, we test the prediction that physiological and behavioural factors operating prior to the breeding season in uence the size of the single egg laid by a common North Atlantic seabird, the Atlantic Puf n Fratercula arctica To do this, we measured $\delta^{15}N$ values, which gauge the relative trophic level of feeding, and levels of the steroid hormone corticosterone (CORT) in wing feathers grown several months prior to breeding. CORT levels in avian blood uctuate in response to environmental challenges (Wing eld & Kitaysky 2002), food availability (Kitaysky et al. 1999, 2007) and reproduction (Wing eld & Sapolsky 2003, Goutte et al. 2010). However, it is not possible to collect blood from Puf ns outside the breeding season. Fortunately, CORT circulating in the blood is incorporated into growing feathers, such that CORT levels in feathers are correlated with circulating levels during moult (Bortolotti et al. 2008, 2009). We therefore predicted that $\delta^{15}N$

important prey species for Puf ns in the northwest Atlantic (Nettleship 1972), was extremely low during

RESULTS

The full model including laying date, $\delta^{15}N$ and CORT offered the most parsimonious explanation for intraspecific variation in egg mass (mean mass ± sem = 68.75 ± 3.72 g, range = 63–75 g) in Puffins (Table 1). This model received 95% of the model weight and had very strong explanatory power ($R^2 = 0.82$); no other model received strong support. Egg mass declined with laying date (parameter estimate in the full model = −0.67 g per day, 95% confidence limits: −0.95 to −0.39) but increased with both $\delta^{15}N$ values (1.26 g egg mass per ‰ of $\delta^{15}N$, 95% confidence limits: 0.49–2.03) and CORT levels (0.11 g egg mass/pg/mm of CORT, 95% confidence limits: 0.04–0.18) measured in primary feathers grown during the prebreeding period (Fig. 1). Based on the regression line (Fig. 1b), egg mass peaked as $\delta^{15}N$ values approached that

dynamics of fractionation between the tissues of predator and prey (Hobson 2011). Determining trophic level on a ner scale may require analysis of individual amino acids that show constant isotopic variation with trophic level (Hobson 2011).

Moult is known to be a nutritionally demanding process for birds, requiring large amounts of protein (Mur-

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