King Eiders in northern Alaska depend on food from breeding grounds for egg production

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Background

Birds breeding in the arctic must produce eggs at a time when food availability may be low. The use of body reserves ("capital breeding") for reproduction has therefore been assumed to be a common feature for many arctic species. Large sea ducks like eiders have been shown to rely mostly on body reserves during incubation, and have thus been assumed to also rely on body reserves for egg production. This assumption has not been tested yet for King Eiders.

Understanding to what extent birds rely on exogenous nutrients for reproduction is important as rapid climatic changes in the arctic may alter the spring break-up and emergence timing of invertebrates in arctic tundra ecosystems and could thus affect the food availability for migratory birds arriving in spring.

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Study species

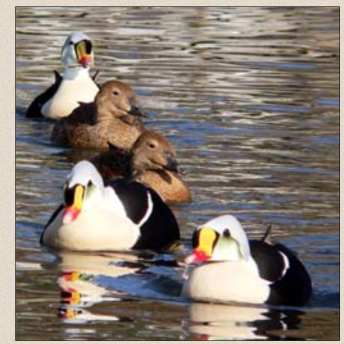
King Eiders (*Somateria spectabilis*) breed in arctic tundra ecosystems around the world. Birds breeding in northern Alaska winter in the Bering Sea and return to breeding grounds in early June. Clutches of 4-7 eggs are generally laid in the second half of June, giving the birds approximately two weeks on their breeding grounds to prepare for egg formation. An adult female King Eider weighs approximately 2000g before incubation, her clutch may weigh up to 400g.

King Eiders feed on freshwater invertebrates on the breeding grounds, a food source that has a markedly different isotopic signature than food consumed during the remainder of the year when the birds are at sea. This isotopic difference can be employed to trace nutrient allocation to eggs.

Female King Eider on a nest in the tundra of northern Alaska (left) and with duckling (right). Females incubate the clutch for 24 days before chicks hatch. Ducklings leave the nest within 24 hours and start foraging independently.

Question

To what extent do King Eiders breeding on the North Slope of Alaska rely on body reserves acquired at sea for egg production?



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Methods

Field sampling

- captured King Eiders (n = 31) on breeding grounds near Teshekpuk Lake (70° 26' N, 153° 08' W) in June 2006 and 2007 to collect blood samples
- separated blood into plasma and red blood cells and froze in liquid nitrogen
- searched for King Eider nests, collected one egg per nest, and collected all eggshell membranes remaining after hatch or predation

Laboratory analyses and calculations

- separated eggs, freeze-dried both yolk and albumen, and extracted lipids from egg yolk using a chloroform-methanol rinse
- analyzed blood, albumen, membranes, and lipid-free yolk for stable carbon isotope ratios ($\delta^{13}C$) at the Alaska Stable Isotope Facility
- isotope ratio of red blood cells was taken to reflect isotope signal of body reserves (capital endpoint)
- average of eggshell membrane isotope ratios from each nest was taken to reflect isotope signal of the female's diet (income endpoint)
- simple linear mixing model with two endpoints (blood, membranes) to quantify source contribution to albumen and lipid-free yolk (Figure 1)

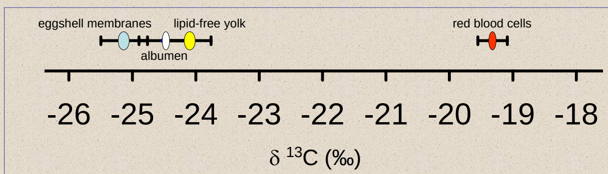

Figure 1. Two-source single isotope mixing model indicating endpoints (red blood cells represent capital endpoint, eggshell membranes represent income endpoint) and albumen and lipid free yolk of King Eider eggs collected on the North Slope of Alaska in 2006 and 2007 (all ± 95%CI). The proportional contribution of body reserves (capital) and tundra food (income) to albumen and lipid-free yolk is calculated from the distance of egg components to either endpoint.

Results

- body reserves contributed ~ 50% to lipid-free yolk
- body reserves contributed <20% to albumen
- large individual variation, with some individuals using 100% and many others 0% body reserves for yolk formation

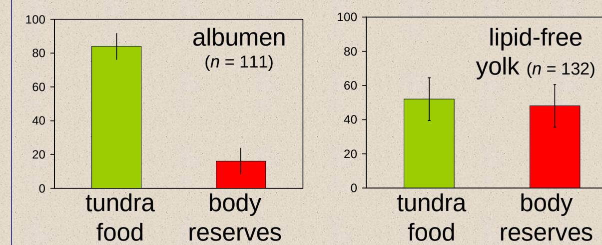

Figure 2. Proportional (mean ± SD) contribution of nutrients from tundra food (green) and body reserves (red) to King Eider albumen and lipid-free yolk from 132 eggs collected on the North Slope of Alaska in 2006 and 2007.

Discussion

King Eiders rely mostly on nutrients from food sources on breeding grounds to produce eggs in northern Alaska. However, the amount of exogenous nutrients used for egg production varies considerably among individuals, and different nutrient allocation strategies appear viable. Females require body reserves for incubation, and may try to retain these reserves by producing eggs mostly from nutrients obtained on the tundra.

Changes to the arctic tundra ecosystem could potentially affect food availability for King Eiders during egg formation. This may reduce productivity and should be considered to assess consequences of climatic changes and industrial development on King Eider reproductive performance.

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