Status of blood mercury concentration in twenty-four bird species in Northwest Greenland

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Birds are useful bioindicators of environmental contamination around the globe, but avian studies in the high Arctic have been primarily limited to a few abundant species. Previous Hg studies of Arctic avian species have focused largely on marine seabird species that occur in high abundance (e.g. Thick-billed Murres (*Uria lomvia*) and Black-legged Kittiwakes (*Rissa tridylacta*)). Tissues such as liver, kidney, and muscle have largely been used for analysis (e.g. Dietz et al. 1997; Riget et al. 1997, 2004), acquisition of which is lethal to sampled birds. Non-destructive techniques have predominantly focused on sampling whole eggs (e.g. Braune et al. 2016; Akearok et al. 2010) or feathers (e.g. Bond and Diamond 2009; Fort et al. 2014). Quantification of Hg using these tissue types provides measures of long-term Hg exposure (AMAP 2011). Whole blood sampling has recently become more common which allows for non-destructive sample collection. Blood is considered the best tissue for evaluating short-term dietary uptake of Hg, and can provide insight into Hg exposure during specific life-history stages or geographic locations at time of sampling (i.e. breeding or wintering grounds) (Evers et al. 2005; Wayland and Scheuhammer 2011). Furthermore, using non-destructive blood samples allows for sampling of rare and threatened species, for which little to no information on Hg exists (Boertmann 2007; Eisler 2010). Studies of blood Hg concentrations for Arctic bird species during the breeding season are relatively uncommon, and recent research has highlighted the overall lack of knowledge of Hg exposure on the breeding grounds of Arctic birds, particularly post egg laying (Braune et al. 2016; Mallory and Braune 2017).

The aim of our study was to establish baseline measurements of avian blood Hg during the post-egg laying period in northwest Greenland and examine differences across passerine, shorebird, waterfowl, seabird, and bird of prey species, many of which represent knowledge gaps in contamination studies (Mallory and Braune 2012). Twenty-four migratory avian species (n = 625) were sampled over a three year period (2010–2012) along 750 km of coastline near Thule Air Base (77° N, 68° W). Whole blood samples were analyzed for total Hg along with $\delta^{13}C$ and $\delta^{15}N$ to estimate food web position. Similar to Hg, stable isotopes measured from the blood reflect short-term dietary intake (Hobson and Clark 1992).

Adult mean blood Hg concentrations ranged from 11.4 ng g^{-1} in Hoary Redpoll to 1164.85 ng g^{-1} wet weight in Peregrine Falcon (*Falco peregrinus*) (Fig. 1). Birds of prey had the highest Hg concentration (Least Squares mean = 1164.85 ± 368 ng g^{-1}) followed by seabirds (413.87 ± 97 ng g^{-1}), shorebirds (359.68 ± 152 ng g^{-1}), waterfowl (86.85 ± 29 ng g^{-1}), and passerines (35.25 ± 30 ng g^{-1}).

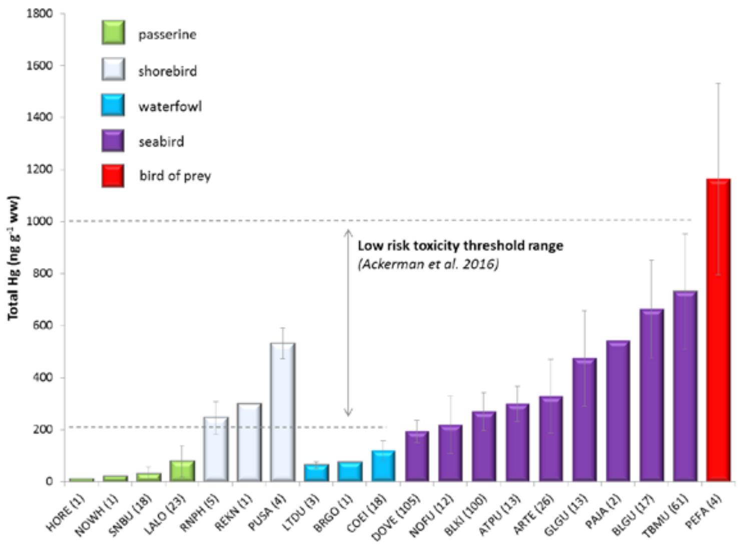

Figure 1. Whole blood total mercury (±SD) for adult birds ranked by mean Hg concentration grouped by bird type. Species not included had juvenile only samples.

Concentrations of Hg in blood of marine and terrestrial species were positively correlated with $\delta^{15}N$ ($r^2 = 0.51$, p = 0.004, slope = 0.089, n = 346) (Fig. 2). Thick-billed Murres (pelagic and benthic fish-feeding seabird) had the highest Hg concentration (mean = 731.35 ± 223 ng g^{-1}) and second highest trophic level (Peregrine Falcons had highest overall Hg concentrations, but isotopic data not available for comparison). The highest trophic position for Glaucous Gulls (coastal scavenger and predator) corresponded to the fifth highest Hg concentration.

Our study documents low to moderately high levels of Hg in bird populations in northwest Greenland. Although there are relatively few comparative blood Hg studies of the same Arctic species on breeding ground, our compared mean Hg results were mixed. Concentrations of blood Hg in Arctic Terns (*Sterna paradisaea*) and Atlantic Puffins (*Fratercula arctica*) measured in our study were 2× higher than breeding birds

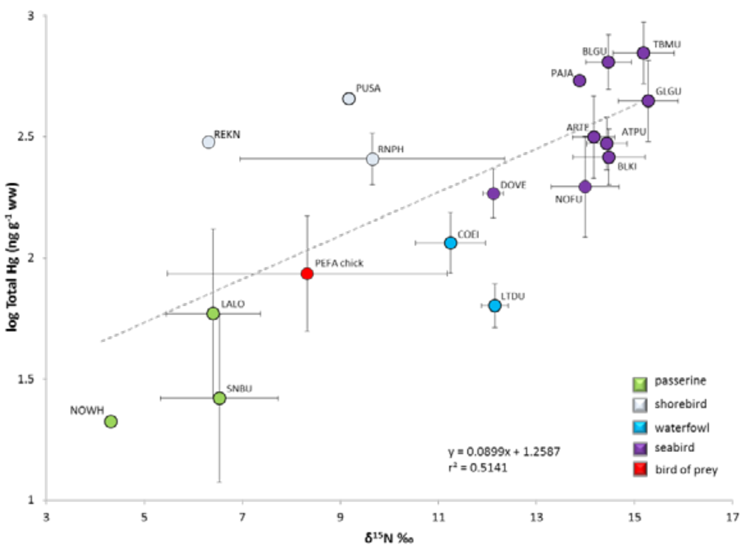

Figure 2. Mean and standard deviation for $\delta^{15}N$ and Hg in all adult birds. Higher $\delta^{15}N$ values indicate higher trophic positions. Data shown are only for samples run for both Hg and isotopes. Hatch year Peregrine Falcons (PEFA chicks) shown, but not included in linear regression statistic.

reported at a more southern latitude (New Brunswick, Canada, 44° N) (Bond and Diamond 2009). Studies of Black-legged Kittiwakes nesting in Svalbard (similar latitude) reported both lower and slightly higher mean Hg levels than were found in our study (Goutte et al. 2015; Tartu et al. 2015; respectively). Dovekies nesting farther south in east Greenland had a lower Hg concentration (Fort et al. 2014). These results are similar to those found by Braune et al. (2002, 2006, 2014), who suggested that Hg concentration in Arctic seabird populations increase with latitude (although blood samples were not the method of comparison). Among non-seabird species only Common Eiders and Red-necked Phalarope had comparable blood Hg data published. Wayland et al. (2001) and Provencher et al. (2016) studied Common Eiders nesting farther south in eastern Canada and reported mean Hg concentrations nearly 2× higher than in our study, which is similar to the decreasing latitudinal pattern reported for Common Eider in the eastern Canadian Arctic by Mallory et al. (2004; not blood samples). A single Red-necked Phalarope sample in coastal northern Alaska was substantially higher (1210 ng g^{-1}; Perkins et al. 2014) than our reported values (246 ng g^{-1}). While concentrations of Hg in other tissue types have been published for a number of the species studied here, useful comparisons with blood tissue are challenging due to differences in heavy metal retention between tissue types and demethylation rates between tissue type and species (Eagles-Smith et al. 2008).

Broadly speaking across latitudes and species, total Hg concentrations of 200–1000 ng g^{-1}have been observed to pose low fitness risks, 1000–3000 ng g^{-1} moderate risks, and values exceeding 3000 ng g^{-1} pose high and severe risks (Ackerman et al. 2016). The mean Hg concentration of all but one of our studied species falls at or below the low toxicity impact level. The Peregrine Falcon was the only species with mean Hg concentrations > 1000 ng g^{-1}indicating moderate risk from Hg exposure (mean = 1164 ± 368 ng g^{-1}). However, 8 of 61 (13.1%) Thick-billed Murres and 1 of 17 (5.9%) Black Guillemots had Hg concentrations > 1000 ng g^{-1} suggesting that all three species may warrant further investigation concerning its potential fitness effects. Eleven species had mean concentrations associated with low risk of Hg toxicity (including Thick-billed Murres and Black Guillemots) while an additional four species had individuals in this range. Avian species of concern listed in Greenland's Red List (Boertmann 2007) as vulnerable (Common Eider, Thick-billed Murre, and Black-legged Kittiwake) and near threatened (Atlantic Puffin, Gyrfalcon (*Falco rusticolus*), and Arctic Tern) may also warrant special attention and continued monitoring. Special attention may also be warranted for three species designated by The Arctic Council Working Group, Conservation of Arctic Flora and Fauna (CAFF), as species of circumpolar concern: Long-tailed Duck, Dunlin, and a Red Knot subspecies (*C. c. islandica*) (Johnston et al. 2015).

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