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# Anti-parasite treatment, but not mercury burdens, influence nesting propensity dependent on arrival time or body condition in a marine bird

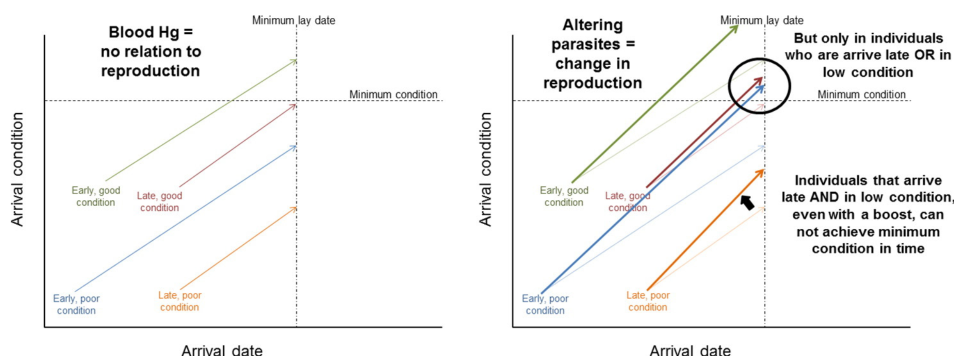
JF Provencher [a,*], MR Forbes [a], ML Mallory [b], S Wilson [c], HG Gilchrist [c]

[a] Department of Biology, Carleton University, Ottawa, Ontario K1S 5B6, Canada
[b] Department of Biology, Acadia University, Wolfville, Nova Scotia B4P 2R6, Canada
[c] Environment and Climate Change Canada, Wildlife Research Division, Raven Road, Carleton University, Ottawa, Ontario K1S 5B6, Canada

## HIGHLIGHTS

- Parasites and contaminants can interact within wildlife to influence survival and reproduction.
- Parasite burdens in wild common eider ducks (*Somateria mollissima*) were manipulated.
- Reproduction and survival were examined in relation to mercury burden and parasite treatment.
- Reproduction nor survival was found to vary with blood mercury concentrations.
- Anti-parasite treatment increased propensity to breed for birds in low condition or late breeders.

## GRAPHICAL ABSTRACT

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## ABSTRACT

Arctic wildlife can be exposed to high mercury (Hg) levels, and are also naturally exposed to gastrointestinal parasites that can reduce condition and negatively affect reproductive output and/or survival in similar ways. Importantly, both Hg and parasites are increasing in wildlife in some Arctic regions. We studied the northern common eider duck (*Somateria mollissima*) to explore how Hg in association with both natural levels and experimentally reduced parasitic infections, affect reproduction and survival. Female eiders were measured, banded, and blood sampled to determine blood Hg burdens, prior to breeding. Propensity to nest, clutch size, nest survival, nest attendance, and return rates were assessed in relation to both Hg burden and parasite treatment. Neither reproduction nor return rates of females varied with Hg concentrations, but females arriving late to the colony, or in low body condition, showed increased nesting propensity when given the anti-parasite treatment as compared to placebo treatment. Our results suggest that parasites can play a critical role in decisions to invest in avian breeding annually, particularly among individuals with a late onset to breeding, and in poor condition.



## 1. Introduction

Schedules of breeding often show marked variation within a population, which may be driven by a number of biotic and abiotic factors. In migratory birds, body condition (e.g., adipose tissue) can be a key driver

* Corresponding author.
*E-mail addresses:* jennifpro@gmail.com (J.F. Provencher), mforbes6@gmail.com (M.R. Forbes), mmallory@acadiau.ca (M.L. Mallory), scott.wilson@canada.ca (S. Wilson), grant.gilchrist@canada.ca (H.G. Gilchrist).

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of inter-individual variation in the likelihood that individuals nest as well as the number of eggs they lay (Ankney, 1992; Descamps et al., 2011b; Steigerwald et al., 2015). Both parasitism and contaminant burdens have been found to independently influence body condition in birds (Daoust et al., 1998; Sheldon and Verhulst, 1996), and therefore may be expected to explain variation in breeding propensity and productivity (Hanssen et al., 2003). Understanding how contaminants and parasites influence individual reproduction, both independently and jointly has been examined only in a few studies to date, but is crucial to understanding their potential as drivers of population dynamics (Bustnes et al., 2006; Marcogliese and Pietrock, 2011; Reed et al., 2008; Wayland et al., 2002).

Contaminants acquired through diet have the potential to deleteriously affect wildlife health and condition in several ways. In both wild birds and mammals, individuals with high mercury (Hg) concentrations may exhibit neurological, physical and hormonal changes (Scheuhammer et al., 2008; Sonne, 2010; Van Hoomissen et al., 2015). This suggests that Hg can potentially influence a range of behaviours, including foraging and migration, which, in turn can lead to an overall decline in body condition. For example, in clapper rails (*Rallus longi*; Ackerman et al., 2012) and common eiders (*Somateria mollissima*; Wayland et al., 2001a), body mass was negatively associated with Hg burdens. Mercury also influences reproduction and survival in wild birds. Black-legged kittiwakes (*Rissa tridactyla*) with higher blood Hg concentrations were more likely to skip breeding than those with low Hg (Tartu et al., 2013). White-winged scoters (*Melanitta fusca*) with higher levels of Hg showed lower annual survival rates (Wayland et al., 2008). Collectively, these findings suggest that Hg can induce changes in physiology, which can then manifest in a bird through reductions in body condition, reproductive output and/or survival.

To assess the manifold effects of Hg on wildlife, it is important to study Hg in concert with other factors expected to affect individual or population health. Parasites can affect an animal's reproduction and condition because they deplete host resources and/or compete for nutrients with their hosts. For example, red-legged partridges (*Alectoris rufa*) in Spain with higher intensities of parasitic helminth infestations (*Capillaria contorta*) had reduced body condition (Calvete et al., 2003). Parasites also can negatively influence the demography of host populations. Female red grouse (*Lagopus lagopus scoticus*) infected with nematodes (*Trichostrongylus tenuis*) had smaller clutches which led to cyclical patterns in grouse population levels (Hudson and Dobson, 1991). In comparison, higher levels of parasitism were associated with lower survival in young female snow geese (*Chen caerulescens*), illustrating that parasites can have long-term effects on host demographics (Souchay et al., 2013). Of note is that parasite infections in wild birds may not be associated with any decline in reproduction or survival (Perez-Orella and Schulte-Hostedde, 2005; Shutler et al., 2012), and reducing parasites has been shown to alter avian survival (Hanssen et al., 2003).

Importantly, the relationships between contaminants and parasites, and their direct and indirect influence on host condition, survivorship and reproduction of fish and wildlife can be complex (Bulté et al., 2012; Marcogliese and Pietrock, 2011). For instance, the host typically mounts an energetically-costly immune response when exposed to parasites, which can vary with parasite exposure rates (Schulenburg et al., 2009). The presence of parasites and their effect on the host immune response can influence how a host responds to contaminant exposure by altering host contaminant uptake and retention (Marcogliese and Pietrock, 2011). Parasites also can alter the energy budget of a host causing an increase or decrease in metabolic and/or foraging rates (Bergey et al., 2002). In turn, this may increase or decrease a host's exposure to trophically-transmitted contaminants such as Hg.

To investigate how Hg affects reproduction and survival in wildlife under conditions of natural and reduced parasitism, we undertook an experimental anti-parasitic manipulation of female eider ducks breeding at a colony in northern Canada. Eider ducks are well-studied in the circumpolar Arctic, and are relatively easy to mark, track and monitor over time and while breeding (Descamps et al., 2009; Goudie et al., 2000; Love et al., 2010). Eider ducks are also useful models for studies that examine parasite and contaminant interaction because the prevalence of parasites is often high (Wayland et al., 2001b). To experimentally broaden the range of parasite burdens in wild eider ducks a sample of breeding females were given either an anti-parasite treatment (PANACUR® Hoechst Roussel Vet GmbH) or a placebo of distilled water. A combination of direct colony observations and remote logging devices were then used to assess female behaviour and productivity throughout the breeding season in relation to their parasite treatment and naturally occurring blood Hg burden.

Our general hypothesis was that variation in intensities of parasite infections and in contaminant burdens would be associated jointly or independently with eider duck reproduction and survival. Such studies of free-ranging wildlife pose challenges for two main reasons: first, one can experimentally manipulate parasitism, but not easily manipulate Hg burden; and second, wildlife come 'pre-packaged' with their contaminant burdens which vary by region and year. From this perspective, we generated several predictions. First, we expected if the range of Hg concentrations was great, higher blood concentrations of Hg in females would be associated with decreased measures of reproduction or survival. Since eider hens go through a fasting period during incubation, losing up to a third of their body mass (Bustnes et al., 2010), we also expected nest attendance to be negatively related to their Hg burden. Mercury can reduce condition so that females take more incubation recesses. Therefore, we expected females with lower levels of blood Hg to have fewer absences from their nests as measured through automated nest data loggers. We also expected individuals given the anti-parasite treatment to have higher measures of reproduction and survival, and fewer absences from the nest as compared with those receiving the placebo. We anticipated that an experimental decline of intestinal parasites would enhance a female's ability to acquire and retain energy as compared with birds only given a placebo treatment. Lastly, we expected that eider ducks with higher levels of both Hg (higher blood concentrations) and parasites (placebo treated birds) would show the lowest measures of reproduction and survival, and have the most absences from the nest during incubation.

## 2. Materials and methods

### 2.1. Capture of birds

Eiders were caught at the East Bay Migratory Bird Sanctuary, Nunavut (64°01′04′N, 82°07′49′W) in northern Hudson Bay as they returned to the Arctic during their spring migration. Hens were caught using monofilament nets as they were arriving at the colony in June 2013 and 2014. More detailed information on capture and handling can be found in Hennin et al. (2014). Birds were caught prior to laying on the island, which continues for several weeks when the weather allows, until most females have arrived and have initiated nesting. The colony is surrounded by sea ice during the pre-breeding season so that all birds are caught in flight as they arrive on the island. Band reading for mark-recapture studies occurs daily during and after the banding season, so that the arrival date of females to the colony can be estimated.

At the time of capture, a metal US Fish and Wildlife Service band was placed on the right tarsus of each bird, as well as individually coded plastic colour bands on both legs. Females were also fitted with a unique combination of nasal disks allowing for individual identification during incubation (Hennin et al., 2016). The disks were attached to the nares using UV-degradable surgical monofilament so that the disks fall off shortly after the breeding season and prior to fall migration (H.G. Gilchrist unpublished manuscript). Upon capture, weight (body mass in g) and total head length (in mm) was taken for each female following banding. Birds captured as pairs were released as pairs.