ARCTIC
VOL. 65, NO. 4 (DECEMBER 2012)

InfoNorth

Exploring Health and Disease in Northern Common Eiders in the Canadian Arctic

by N. Jane Harms

> An ecosystem approach to wildlife health requires knowledge of potential pathogens in an environment, as well as the actual disease prevalences in the region.
>
> Munson and Karesh (2002:96)

INTRODUCTION

Research on the ecology of wildlife diseases in recent decades has greatly improved our understanding of the effects of disease on individuals and host populations (Tompkins et al., 2011). It is now apparent that infectious pathogens play a role in the population dynamics of wildlife (Telfer et al., 2002), and infectious and non-infectious diseases have been implicated as causes of marked declines or even local extinctions of wildlife species (Oaks et al., 2004; Frick et al., 2010). In addition to the association of infection and disease with morbidity and mortality, there is mounting evidence that subclinical infections may influence various aspects of individual and population health (Tompkins et al., 2011).

The epidemiological triad, which describes the occurrence of disease as the interaction between host, pathogen, and environment, is a familiar concept in the study of wildlife disease (Wobeser, 2006; Acevedo-Whitehouse and Duffus, 2009). A variety of host factors may be crucial to the host-pathogen interaction and can have an effect on disease outcome. Stress, defined as a behavioural and physiological response by an individual to a stressor, has been shown to be an important determinant of health and fitness in many mammalian and avian species (Bortolotti et al., 2008). The stress response is associated with changes in levels of the stress hormone (corticosterone in avian species) produced through activation of the hypothalamic pituitary adrenal axis (Bortolotti et al., 2008). The physiology of stress and the effect of elevated levels of corticosterone on other physiological functions, such as the immune response and reproduction, are subjects of increasing study and focus in wildlife research (Bourgeon and Raclot, 2006; Bortolotti et al., 2008; Harms et al., 2010). Although the effects of the stress response are complex and dependent on a multitude of additional factors, there are indications that chronically elevated levels of corticosterone have deleterious effects on health.

The role of health and disease in wildlife conservation cannot be overlooked, and indeed Munson and Karesh (2002:96) note that “devising conservation strategies that are practical in the current ‘state of the earth’ will require models that include diseases risks.” Disease emergence has been somewhat ignored as a threat to conservation (Daszak and Cunningham, 2002), but it is clear that the health of wildlife populations is essential to maintaining biodiversity. Understanding disease in wild animals and the role it plays in populations requires a wide range of study, from diagnosing the cause of an outbreak, to measuring the effect of stress on host fitness, to identifying the role of climate in the response or exposure to a pathogen. Increasing knowledge of the health of wildlife populations is essential to the development of effective conservation goals and management strategies for wildlife.

Avian cholera, a bacterial disease caused by infection with *Pasteurella multocida*, has caused substantial mortality in numerous species of waterfowl, such as lesser snow geese (*Chen caerulescens caerulescens*) and common eiders (*Somateria mollissima borealis*), since it was first detected in North America in the 1940s (Samuel et al., 2007). Infection with *P. multocida* in waterfowl can result in acute death, and large-scale avian cholera outbreaks are often detected in places where large aggregations of birds gather, such as stopover sites and breeding colonies (Blanchong et al., 2006). The factors precipitating avian cholera outbreaks are not clear, however. Two hypotheses have been proposed to explain the recurrent pattern of avian cholera outbreaks in specific geographical locations: that *P. multocida* persists within the environment, serving as a reservoir for susceptible birds; or that one or more species of waterfowl can act as carrier of the bacteria and shed *P. multocida* in nasal secretions or feces, resulting in disease outbreaks in groups of susceptible waterfowl (Samuel et al., 2005). A study by Samuel et al. (2005) indicated that lesser snow geese, and possibly other waterfowl species, may serve as a disease reservoir and shed *P. multocida* into the environment, but further investigation into the role of environmental reservoirs of *P. multocida* and carrier birds is needed.

In 2005, avian cholera was detected at the largest northern common eider breeding colony in Canada (East Bay Island, Nunavut). Since then, avian cholera on East Bay Island has caused annual eider mortality, and adult eider survival rates and reproductive success have plummeted since the first confirmed outbreak (Buttler, 2008; Descamps et al., 2009). Inuit residents from communities near affected colonies in Nunavut indicated that large die-offs of eiders had not been seen previously (Henri et al., 2010); however, outbreaks of avian cholera were also detected in common eider colonies in northern Quebec near the communities of Ivujivik, Kangiqsujuak, and Aupaluk in 2004, 2005, and 2006 (Gaston, 2004), as well as in 2011 (S. Iverson and N.J. Harms, unpubl. data).

The northern common eider is a long-lived sea duck that returns to the same nesting colony in successive breeding seasons (Merkel et al., 2004; Mallory et al., 2010). Common eiders that breed in the eastern Canadian Arctic and Greenland winter in Atlantic Canada and on the southwest coast of Greenland. Eiders are a key component of northern ecosystems, as well as being essential to subsistence harvests in some communities, and they are hunted by sport hunters in their eastern wintering sites (Gilliland et al., 2009). Factors such as harvest levels, climate, habitat, disease, and food resources that affect eider populations in northern Canada are being monitored because they will have significant management implications for most eider populations. Avian cholera is an important factor to monitor as it causes high rates of female common eider mortality (Buttler, 2008) and has a negative effect on reproduction and duckling survival (Descamps et al., 2009, 2010) on East Bay Island. The recent emergence of avian cholera in the eastern Arctic in a well-studied eider colony provides an opportunity to investigate the effects of an infectious disease on a wildlife population and to explore the role of stress, climate, and food resources on the host-pathogen dynamics. Through my PhD research project, I am examining several hypotheses related to disease reservoirs and the effects of stress and climate on eider survival in the face of an outbreak, as well as addressing some of the gaps in current understanding of disease dynamics of avian cholera in northern Canada.

OBJECTIVES AND METHODS

The research project has four overarching objectives. The first is to examine the role of *P. multocida* reservoirs in avian cholera outbreaks in the Arctic ecosystem by looking for evidence of carrier birds, environmental reservoirs, or both and exploring the spatial and temporal distribution of *P. multocida* in Canada's eastern Arctic. The second is to use bacterial genotyping to investigate origins of the bacteria causing recent outbreaks in northern Canada. The third objective is to investigate the effect of *P. multocida* carrier status and stress on common eider survival and reproduction. Finally, I will examine the effects of climatic or other environmental variables (e.g., food availability) on stress responses during the moulting period (as measured by feather corticosterone), and determine whether stress responses during moult have carry-over effects on survival and reproduction in the following breeding season.

The majority of samples collected for this project are from East Bay Island, where over 500 eiders are caught and banded each year before the breeding season begins (Fig. 1). Female breeding eiders are followed through the summer to gather data on survival and reproduction (Fig. 2). In addition, common eider colony surveys and sample collections have been conducted in a number of breeding sites throughout the eastern Canadian Arctic. Samples from lesser snow geese have been collected in conjunction with annual Arctic goose banding operations and during community-based harvesting on Southampton Island, near Cape Dorset on Baffin Island, in the Queen Maud Gulf Migratory Bird Sanctuary, and on the Great Plain of the Koukdjuak. In addition to samples collected from live birds, carcasses of dead birds found on colonies or collected by community members or biologists are examined to determine the cause of death. As part of the surveillance for this disease in the Arctic, I attempt to isolate *P. multocida* from any birds that have died of avian cholera.

To investigate the presence and distribution of carrier birds (common eiders, snow geese, or both) and the role of environmental reservoirs in initiating and perpetuating avian cholera outbreaks, samples collected from live or hunted birds and the environment have been screened for *P. multocida* using a polymerase chain reaction (PCR) assay (Corney et al., 2007). All PCR-positive samples have been cultured in an attempt to isolate *P. multocida* for use in further genotyping studies. These *P. multocida* isolates, as well as isolates collected from birds that have died in avian cholera outbreaks in multiple locations across Canada, have been genotyped in order to explore the relatedness among *P. multocida* strains collected from different species, years, and locations. Two genotyping methods are being used for this study: multi-locus sequence typing (MLST), which compares single nucleotide polymorphisms from several housekeeping genes to determine the relationship of *P. multocida* isolates to each other (Maiden et al., 1998), and repetitive-element palindromic PCR (REP-PCR), a PCR-based method that generates distinct genetic fingerprint patterns for each isolate, which can be compared using image analysis software (Amonsin et al., 2002). Serotyping (a classical method of distinguishing among the 16 *P. multocida* strains) already completed on many of these isolates makes it clear that different strains of the bacteria are causing avian cholera outbreaks throughout Canada. In addition, multiple strains of *P. multocida* are responsible for avian cholera outbreaks within and between years on East Bay Island, suggesting more than one introduction of the pathogen into this colony. These results will shed light on the origins and movement of the bacterial strains causing disease in northern birds and will also identify important reservoirs of *P. multocida* in the Arctic.

The final component of this research is exploring the relationships among measures of health and infection status in individual eiders and investigating the role of carry-over effects on the East Bay Island eider population. Carry-over effects are events occurring in one season that have effects

FIG. 1. Jane Harms and Brett Elkin sample a female common eider on East Bay Island, Nunavut.

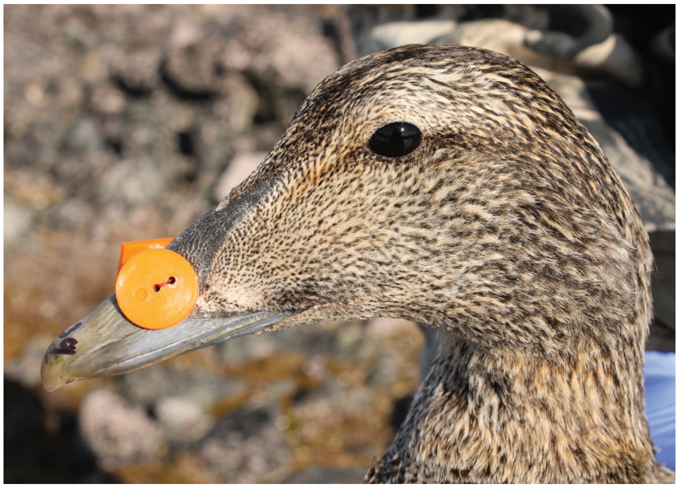

FIG. 2. Female common eider with nasal tags.

on individuals in subsequent seasons (Harrison et al., 2011). Several morphometric measurements, blood, swab samples (oral and cloacal), and feathers are collected from male and female eiders on East Bay Island. These samples provide information on body condition, immune function, carrier status, and stress (feather corticosterone) in individual eiders. Since eiders are followed throughout the breeding season, data are also collected on reproductive success and survival. These data are combined with data on climate and food resources to attempt to explain carry-over effects on eider reproductive success and survival in the face of an avian cholera outbreak.

PRELIMINARY RESULTS

Samples for avian cholera testing have been collected from more than 6000 birds (predominantly common eiders and lesser snow geese, as well as herring gulls, snow buntings, king eiders, and Ross's geese) from various locations in the eastern Arctic. Additionally, more than 1500 environmental samples have been collected from freshwater ponds on East Bay Island and other field sites. Preliminary results of the PCR screening indicate between 3% and 6% of apparently healthy common eiders on East Bay Island carry some strain of *P. multocida*, suggesting that eiders are potential carriers of *P. multocida*. No evidence of *P. multocida* infection was found in samples collected from eider colonies in Nunavik that had experienced previous outbreaks, but PCR-positive samples were detected in just over 2% of eiders collected near Cape Dorset on Baffin Island. In addition, *P. multocida* DNA has been detected in samples from low numbers (< 3%) of lesser snow geese in multiple Arctic locations, including Queen Maud Gulf, Southampton Island, the Great Plain of the Koukdjuak, and Cape Dorset.

MLST and REP-PCR assays have been completed for several hundred *P. multocida* isolates. Preliminary results from the MLST assays indicate that in general, serotypes of *P. multocida* correspond well to genotyping results from MLST analysis (J. Foster, C. Soos, and N.J. Harms, unpubl. data). Within the Canadian *P. multocida* isolates analyzed by MLST, there appear to be two dominant sequence types, 3x4 and 1. Isolates in the sequence type 1 appear to cluster further into two distinct groups, one of which contains many of the East Bay Island isolates along with isolates cultured from an avian cholera outbreak that occurred in Newfoundland in 2007. The second distinct group includes isolates from avian cholera outbreaks that occurred in eiders of the St. Lawrence estuary in 2005 and 2006 (S. Lair and G. Seguin, unpubl. data). The other dominant sequence type, 3x4, shows that isolates from several outbreaks on East Bay Island are related to isolates from outbreaks occurring in eider colonies in Nunavik. Preliminary results of feather corticosterone analysis for eiders on East Bay Island indicate that eider feather corticosterone levels are affected by climatic factors, particularly temperature. We are currently investigating whether feather corticosterone levels are predictive of subsequent reproductive success and survival during avian cholera outbreaks.

SIGNIFICANCE

Monitoring changes in measures of health and disease in wildlife populations and the presence and distribution of pathogens in ecosystems is essential for successful management of wildlife disease (Wasser et al., 2002). The ecological and social changes occurring throughout the Canadian Arctic include both rapidly changing climate and development pressure associated with resource extraction, increasing tourism, and new transportation routes (Mallory et al., 2006; Stephenson et al., 2011). Because there is relatively low biological diversity in the Arctic, it is likely that the Arctic ecosystem will respond rapidly to these alterations, which may include changes in host-pathogen interactions and the presence of new or emerging pathogens and diseases (Kutz et al., 2009). Avian cholera outbreaks in an Arctic wildlife species present an opportunity to study the emergence of an infectious disease that has important ecological and social implications for the North. These outbreaks may have serious consequences for this eider population and will affect conservation and management plans. Models by Descamps et al. (2012) found that avian cholera outbreaks could affect the transient dynamics and long-term growth rates of eider populations, depending on the severity and frequency of the outbreaks. As well, changes in the nature of the outbreaks over time (for example, successive decreases in the mortality of female eiders each year) indicate that there are environmental, host, and agent factors playing a role in how a population responds to disease. The ultimate origin of the *P. multocida* strains causing avian cholera in East Bay Island eiders is still unknown, but our preliminary genotyping results show that some *P. multocida* isolates from East Bay Island are phylogenetically related to isolates from the east coast of Canada, while other isolates appear to be related to *P. multocida* isolates from Nunavik and the St. Lawrence estuary, suggesting connectivity between these locations. A proportion of samples from apparently healthy eiders and snow geese in several Eastern Arctic locations are positive for *P. multocida*, which suggests that they may act as carriers of the bacteria and play a role in initiating outbreaks. The source of bacteria for these carrier birds is unknown, and is a topic of further research.

Our research will help us understand various aspects of the ecology of avian cholera outbreaks, including the effects of outbreaks on eider populations, which is important not only to conservation concerns, but also because common eiders are an important source of food, eggs, and down for subsistence hunters in Nunavut and Greenland (Henri et al., 2010). The results of this study, along with those of other ongoing research projects investigating additional aspects of health and disease in eiders in Canada's North, will encourage conservation decisions that support sustainable eider populations in Canada.

ACKNOWLEDGEMENTS

I am honored to be the recipient of the Arctic Institute of North America's Jennifer Robinson Memorial Scholarship. Funding and in-kind support for my research have also been provided by the Canadian Northern Studies Trust and the W. Garfield Weston Foundation, Environment Canada, Canadian Wildlife Service, Western College of Veterinary Medicine (Interprovincial Graduate Student Fellowship and the Wildlife Health Research Fund), Ducks Unlimited's Institute for Waterfowl and Wetland Research, Nunavut Wildlife Research Trust, Natural Sciences and Engineering Research Council of Canada, Strategic Applications of Genomics in the Environment, Indian and Northern Affairs Canada (Northern Scientific Training Program), and the University of Saskatchewan. I am deeply grateful for the guidance, encouragement, and support from my supervisor, Catherine Soos, and thankful for the guidance from committee members Frederick Leighton, Janet Hill, Grant Gilchrist, and Beverly Kidney, and for the support of my department and the Canadian Cooperative Wildlife Health Center. I am indebted to the students, technicians, and field crew members who have assisted me in the field with sample collection and in the laboratory and in designing portions of this research, including Oliver Love, Holly Hennin, Jennifer Provencher, Samuel Iverson, Wendy Van Dijk, Champika Fernando, and Brett Elkin. I thank Jeff Foster and Christina Allen for essential guidance regarding sample testing and analysis, and Pierre Legagneux and Gary Bortolotti (deceased) for collaboration on corticosterone data analysis. I am also grateful to Makivik Corporation and to the Environment Canada collaborators who have graciously collected samples for this project and to the community members in the North who have participated in many aspects of this research.

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