Incubation behavior of common goldeneye and common eider under endocrine disrupting chemicals and environmental pressure

<u>PhD thesis project:</u>

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Part of the Academy of Finland project DISRUPT (Ducks as models for assessing endocrine disrupting chemicals in the aquatic environment, 2020-2025) led by Dr. Céline Arzel.

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Overview

During the recent decades, several waterbird populations have declined in Europe. In parallel the male-biased sex ratio has increased in several waterbird species, including duck species of the Baltic Sea (e.g., common eider *Somateria mollissima*, and common goldeneye *Bucephala clangula*).

Local population decline

+

Male-biased sex ratio

→

Why?!

Potential explanations:

- Endocrine disrupting chemicals (EDCs)
- Predation
- Temperature variation linked to the climate change

Study species

Common goldeneye (*Bucephala clangula*)

- Cavity-nesting income breeders
- Recesses happen mostly during the day
- Mainly feeding on mussles, crustaceans, amphipods,...
- Breeding time: May-April
- Breeding area: boreal forest of north Europe, north Asia and north America
- Wintering area: northern archipelagoes, Baltic Sea, Denmark, Netherlands, Britain and Ireland
- Incubation: 27-33 days, 6-12 eggs per clutch

Study species

Common eider (*Somateria mollissima*)

- Ground –nesting capital breeders
- might lose up to 46% of their weight during incubation
- Short recesses normally for preening, drinking water or eating snow
- Feeding cycle depends on tide, day length, time
- Mainly feeding on mussles, crustaceans, echinoderms,…
- Breeding time: May-April
- In the Baltic Sea, breeding and wintering lands are both along the costal regions
- Incubation: 22-28 days, 4-7 eggs per clutch
- Joint incubation has also been reported in dense colonies

Study area

Baltic Sea region:

- One of the most important areas for sea ducks which mostly nest in Arctic tundra and boreal forest
- One of the most polluted seas in the world as a result of human activities.
- Finnish wetlands are polluted by a wide range of contaminants among which EDCs
- significant temperature increase in April-May (i.e., incubation period of these species) has been recorded in Finland during the recent decades.

Study questions

Incubation/ hatching success

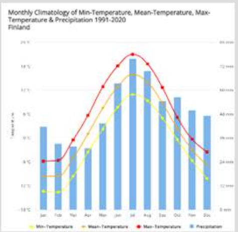
I. Link with EDC contamination:

- Is the contamination level of females affecting the hatching success and the hatchling sex ratio?

II. Link with predation

- What are the impacts of predation risk and disturbances on the incubation behavior of female waterbirds under EDCs pressure?

III. Link with surrounding temperature

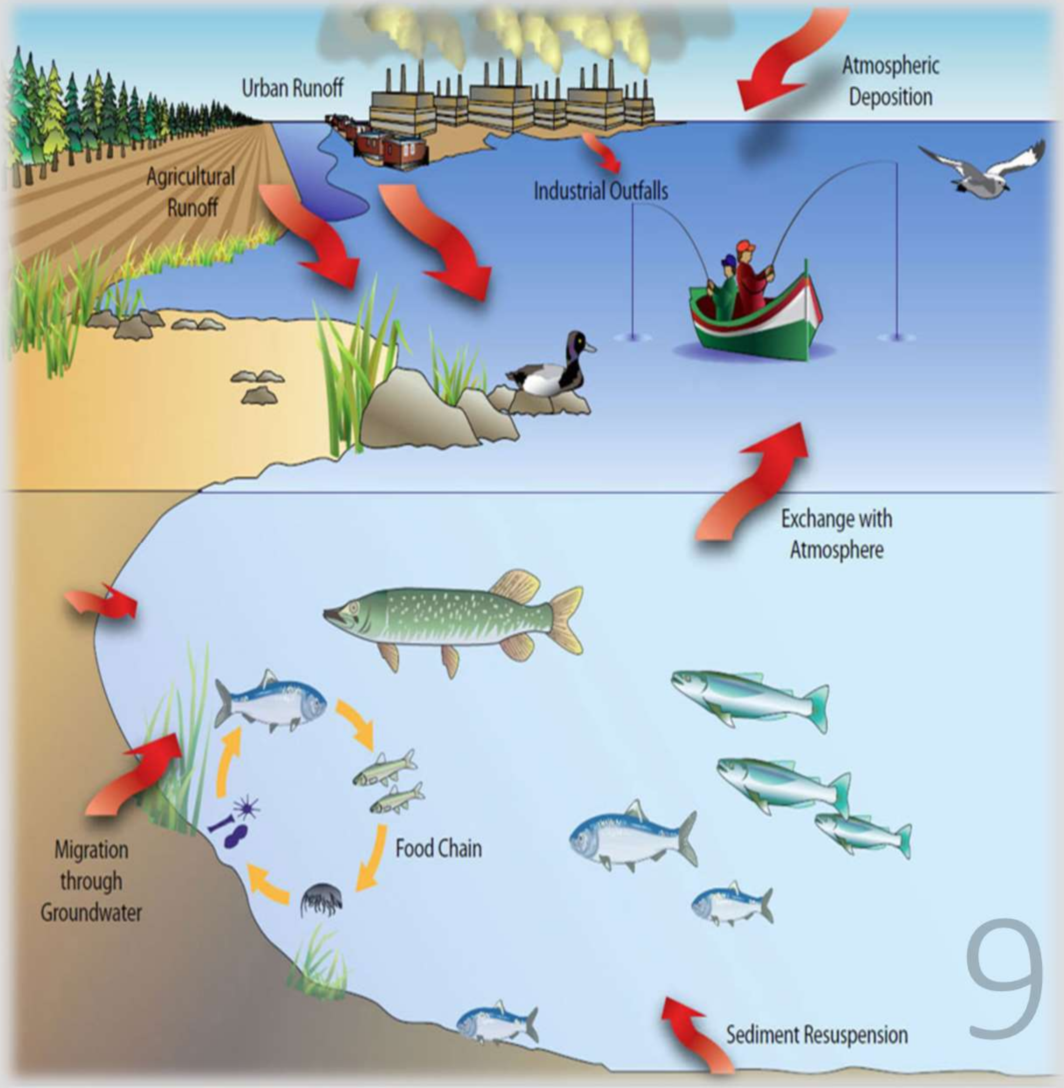


- What's the relation between nest attendance and egg handling with the temperature variation inside and outside the nest (and finally linking it with contamination with EDCs)

Endocrine disrupting chemicals (EDCs)

✓ Endocrine-disrupting chemicals (EDCs): resembling to endogenous hormones in structure

✓ byproducts of technology, as well as industrial products, herbicides, pesticides, and endocrine-active phytochemicals



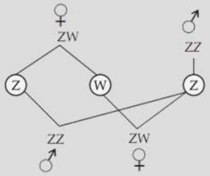
Origin in the Baltic Sea:

- ✓ Agriculture and industrial activities, wastewater from fire-fighting activities, and atmospheric deposition polluting Finnish wetlands and ultimately the sea.
- ✓ The current water browning phenomenon occurring all over Finland, contributes to an increased bio-availability of environmental pollutants.

Endocrine disrupting chemicals (EDCs)

Embryo development and sex differentiation in birds:

Genetic + Hormones (Especially, the hypothalamus-pituitary-adrenal system)



- But unlike mammals, it could be modified through behavioral and environmental processes
- For instance, in geese increase in the holding period (time gap between laying egg and onset on incubation) has led to elevated male- sex bias, as well as reduced hatchability

Reference to EDCs in declining waterbird species have been reported in several species. However the mechanisms by which these chemicals could lead to population decline are not yet clearly defined.

calling for investigating their role on sex differentiation and parental care during incubation

Predation

Males do not take part in incubation; thus, predation has been presented as an important driver of the increased sex ratio bias towards males

Especial danger in conspicuous colonial breeders (e.g., common eider).

Female's response against this risk depends on the type of danger, animal's experience, personality, starting distance of approaching to the nest, stage of incubation

Changing the breeding site, decreased clutch size, or producing smaller eggs are reported against nest predation

Predation

From the endocrine point of view: corticosterone and prolactin mediate parental care under predation risk

Flight initiation distance (FID) in response to predation or observer disturbance: depending on the costs and benefits of the decision on incubation outcome and female survival.

One hypothesis: females take more risk as the incubation goes by

- ✓ Here, we will study the impact of predation risk and disturbance on nest attendance in link with EDCs exposure of the females and the surrounding temperature

Heat stress and temperature variation

In open environment: females are exposed to larger temperature variation, compared to females in protected environments such as wooded lands.

The increased body stress to cope with temperature variation might result in a faster body weight loss and reduced clutches as compared to more stable environments

heat stress linked to the climate change:
Affecting body condition of the incubating females, as well as the energetic cost of incubation

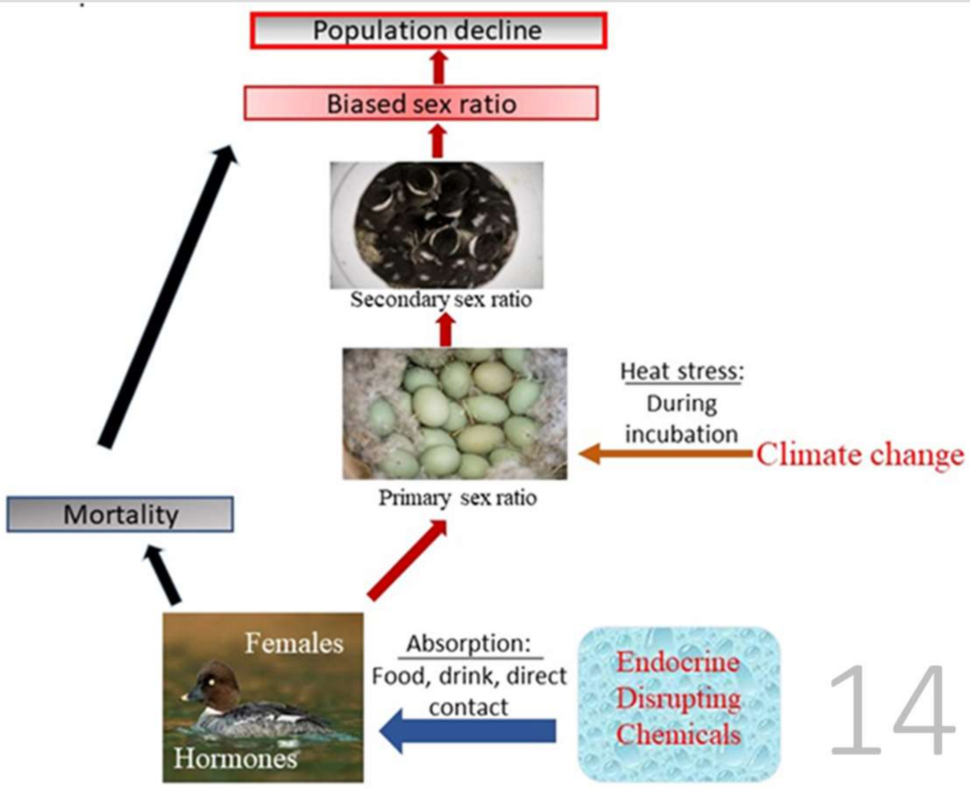
Heat stress and temperature variation

- ✓ Temperature-related hatching sex ratio bias during incubation (e.g., Galiformes)

- ✓ Incubation temperature (at both lower and higher than optimum threshold) can modify the stress hormones, immunology and growth,… in offspring which directly affect their vulnerability against environment and increases early life mortality rate.

- ✓ Some contaminants have been related to the incubation temperature [e.g., chlordane substances lowering minimum incubation temperature and brood patch size.]

- ✓ Ducklings form females in better body condition have higher survival chance in the first week after hatch



Heat stress and temperature variation

Studies on passerines demonstrated that incubating females can respond to the temperature variation between individual eggs by moving and repositioning them across the nest

- ✓ I will investigate the relation between the habitat in the immediate vicinity of the nest (vegetation type, height and density, nest orientation…), the temperature outside and inside the nest, and the incubation behavior of the females.

- ✓ I hypothesize that the effect of female exposure to EDCs on incubation parameters (nest attendance and hatching success) is more significant in areas with higher temperature or exposed to more temperature variations, due to the impact on the female metabolic rate.

2022 field work

- May 2022
- Goldeneye
- Maaninka, Kuopio
- 400 nest boxes
- I will collaborate with Pentti Runko, bird ringer who has followed this population for 38 years.

Methods

I. Detecting the EDCs present in incubating females and evaluating its effect on incubation behavior

✓ Blood sample collection and serum acquisition (28 females)

✓ Exposome/metabolic analysis at Arhus University (AU):
- Identifying biologically hazardous chemicals regardless of their absolute levels

✓ At Norwegian University of Science and Technology (NTNU):
- Analyzing the contaminant concentration

Amalie Ask is in charge of contaminant analyses as part of her PhD.

- the relationship between contamination, hatching success, duration of incubation and hatchling sex ratio will be investigated

- Sex ratio: DNA extraction from egg remains as well as buccal swabs from ducklings

Methods

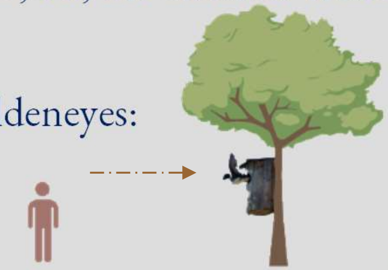
II. Examining the relation between nest attendance and egg handling with the temperature inside and outside the nest

- ✓ Artificial eggs are provided by Scott Shaffer, San Jose State University, US
- ✓ 1-2 artificial egg containing data loggers in each nest of females (20 nests in Kuopio) for which we will have sampled blood
- ✓ These eggs are equipped with temperature thermistor, triaxial accelerometer and magnetometer
- ✓ State-of-the-art data loggers will provide information on incubation behavior (including nest attendance, egg temperature, repositioning, and rotation)
- ✓ Temperature loggers (iButtons) inside and outside nests to measure temperature variation over the incubation period

Methods

III. Assessing the predation rate and anti-predation behavior of females during incubation

- ✓ Wildlife cameras for detecting parasitism, and potential predation
- ✓ During Pentti's regular visits of the nest, we asked him to measure the FID, i.e., the distance from the nests reached by him at which the female flushes away
- ✓ Based on his experience, Pentti has been using a modified method for goldeneyes:



1) Females that flush away when he is approaching the nest box.

2) Females that flush away following scratching the nest box by his fingers.

3) Females that need to be touched to fly away!

Data from the method III+ data from artificial eggs:
nest-defense energetic cost through the risk taken by incubating females in defending their nest throughout the incubation.

We will relate these results to contaminant exposure based on the blood samples collected in these females

Hormonal analyses

Hormone	Type	Route of secretion	Role	Possible link with contamination/ temperature variation/ predation	Route of sampling
Thyroid (T3-T4)	Peptide	Thyroid gland	Onset of puberty, Adrenal responsiveness, relationship with the HPA axis (thyrotropes), Negative relationship with growth hormone (affecting IGF-1),	Role in metabolism (heat stress and EDCs) -H1: females in weaker body condition have higher rate of nest abandonment against predation and temperature variation	Blood
CORT	Steroid	Adrenal cortex	Stress hormone, metabolism	Increases acute response due to PCBs, important under the risk of predation and human disturbance	Blood (under 3 mins! Not possible here!) Faecal Feather


Thank you for your attention!

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Websites used:

https://www.visitkimitoon.fi/

White-tailed Eagle – eBird

Finland - Climatology | Climate Change Knowledge Portal

PowerPoint Presentation (csic.es)

Jackdaw | The Wildlife Trusts

Egg predation by an adult Lesser Black-backed Gull –

Pine Marten (Martes martes) on roof of Goldeneye nesting box (imago-images.com)

American Mink | Government of Yukon

Graphical abstract