

Biological Clocks in the Wild: how artificial light at night impacts migratory birds?

Biological rhythms help to regulate virtually all aspects of life (biochemistry, cell biology, physiology and behaviour). Among all living things birds' biological clocks are exceptionally conspicuous on many levels. We are all familiar with circadian timings of species-specific bird songs (larks singing at dawn, nightingales or blackbirds in the evening) or annual timing of reproduction and migrations (white stork's appearance is a herald of spring and autumn starts with its departure). Because of this fact birds were among the first animals of interest for early scientists enquiring circadian rhythms. It was soon understood that the regularity of behaviours is governed by endogenous clocks, which are adjusted and synchronised with environmental cues, primarily light. Unfortunately, rapidly expanding anthropopressure largely disrupts these cues. Yet, it is surprising how little we know about the effects of disorders in the functioning of the internal time-keepers in free-ranging animals. Majority of the studies focused either on tracing molecular and biochemical changes in clinical studies of humans or experiments on laboratory animals (often nocturnal) such as mice and rats, largely ignoring the fact that artificial laboratory setups are far from conditions in which natural biological rhythms evolved. On the other hand, studies of free-ranging populations focused on evaluating stress response and sleep patterns disturbance in animals exposed to artificial light at night, without examining circadian clock response, such as levels of clock gene expression or melatonin. As a result, there is a considerable gap in our knowledge of natural circadian rhythms and consequences of their disturbance for important fitness traits i.e. early development or immune response.

This study will aim at understanding the effects of disturbance in environmental cues, i.e. light exposure, on circadian clock of migratory collared flycatcher (*Ficedula albicollis*). We will employ an experimental setup introducing artificial light at night (ALAN) in nest-boxes during breeding season and quantify its effects on circadian clock and physiology of this bird. It is important to study migratory birds, because they may be particularly susceptible to biological clock disturbances, and subjected to ALAN during migration. As a result we will try to understand shifts in circadian rhythms and their consequences in natural populations.

We will measure the levels of circadian clock gene expression (i.e. levels of transforming information relayed in the gene to functional products - proteins and various types of RNA) and relevant hormone profiles (melatonin - sleep hormone, ghrelin - hunger hormone and corticosterone - stress hormone). We will also look into the effects of ALAN on the immune response of birds using immune gene expression levels. To see how the light alters behaviour we will install cameras inside nest-boxes to directly observe young birds' response to light (begging for food). We will also have a chance to establish if the light exposure can influence hatching patterns and subsequent development of birds.

The results of this project can bring wide implications, because the magnitude of anthropogenic impacts on wildlife is unquestionable, yet our understanding of the mechanisms behind these impacts remains elusive. There have been many studies trying to explain the mechanisms governing circadian rhythms, and studies on model vertebrates (mice, rats) or invertebrates (fruit flies) provide invaluable insights, but these may have limited relevance as human clock analogy. Due to their diurnal lifestyle, cognitive abilities, sociality and sensitivity to melatonin, birds represent an excellent model for this purpose. The understanding of circadian mechanisms in real-world settings is fundamental, yet to our knowledge, hitherto not undertaken. Studying multiple related mechanisms such as sleep and hunger hormones can help to understand how light pollution or changes in circadian activities (night shifts) relate with appetite dysfunctions leading to obesity or malnutrition in humans.