Bird migration and circannual rhythm

Sem 6 DSE B3

In birds, migration means two-way journeys—onward journey from the 'home' to the 'new' places and back journey from the 'new' places to the 'home'. This movement occurs during the particular period of the year and the birds usually follow the same route. There is a sort of 'internal biological clock' which regulates the phenomenon. Migration is more or less regular, extensive movements between their breeding regions and their wintering regions.

Circadian Rhythm and Biological Clock that control Migration

Circadian rhythms are physical, mental, and behavioural changes that follow a 24-hour cycle. These natural processes respond primarily to light and dark whereas biological clocks are organisms' natural timing devices, regulating the cycle of circadian rhythms. They're composed of specific molecules (proteins) that interact with cells throughout the body. A master clock in the brain coordinates all the biological clocks in a living thing, keeping the clocks in sync. In vertebrate animals, including birds, the master clock is a group of about 20,000 nerve cells (neurons) that form a structure called the suprachiasmatic nucleus, or SCN. The SCN is in a part of the brain called the hypothalamus and receives direct input from the eyes. In many bird species locomotor activity occurs exclusively in the light portion of the light: dark (L: D) cycle. In autumn and spring, however, the seasons corresponding to natural migratory activity, the birds exhibit additional locomotor activity at night. Under constant condition the period of the rhythm is longer or shorter than 12 months attesting to its endogenous circannual nature. Similar to the annual repetition of migratory activity, its diurnal recurrence is also under the control of an endogenous circadian clock. In bird migration both the annual and the daily pattern of the 'migratory drive' that expresses itself in nocturnal activity and in a series of concomitant physiological and behavioural changes are primarily based on endogenous (circannual and circadian) clock mechanisms.

In vertebrates including birds, pineal gland –a unpaired appendage of brain produce a hormone Melatonin which mediate the adaptation to the day night(light: dark L:D) cycle of the environment. Melatonin is secreted only during night. Two major role of melatonin are first, melatonin is involved into circadian system. The retinal and the pineal clocks control their circadian output via melatonin rhythm. Thus absence of melatonin leads to arrhythmicity. Second, melatonin is critical for photoperiodic system and operates accordingly. In birds the circadian system is highly complex as it composed of several independent clocks. Each clock has its own input and output pathways
Melatonin can also provide seasonal signals with higher levels in the fall and winter months and lower levels in the spring and summer correlating to the changing hours of daylight. Melatonin in birds mediates the entrainment of circadian activity rhythms, and thus helps to time hatching of eggs and facilitate migration. Twice a year, signals provided by the circannual clock mechanism cause alterations in the circadian system leading to the development of nocturnal activity. The changes in the daily pattern of locomotor activity resulting in the development of Zugunruhe are associated with concomitant changes in the diurnal pattern of melatonin secretion.

Onset of Migration and directional changes

Circannual rhythms have been convincingly shown to provide important stimuli triggering the onset of migration in both autumn and spring. This timing function of circannual rhythms is particularly evident and of high biological significance in birds wintering close to the equator. In these regions, photoperiod is constant over the year and other environmental factors such as temperature, precipitations and food abundance are too variable from one year to the next to be suitable for serving as external timing cues. In such birds with equatorial wintering grounds, processes preceding or accompanying spring migratory restlessness (e.g. winter moult and spring migratory fattening, respectively) are also under circannual control. Many species of migratory birds, including sparrows, finches and warblers, maintained in captivity under natural photoperiodic conditions spontaneously exhibit two bouts of migratory behaviour in which normally diurnal birds express nocturnal activity called *Zugunruhe* or "migratory restlessness" at the same times of year that coincide with natural migration. Drastic reductions of migratory restlessness caused by severe interference, e.g. exposure to complete darkness at night, exposure to a combination of complete darkness at night, high humidity and rain, reduction of food intake to levels slightly below those required for the maintenance of fat-free body mass. Although all of these treatments reduced nocturnal activity, the birds did not compensate for the reduced activity during the intervals following treatments. Zugunruhe is controlled by a time programme that is little affected by a bird's actual performance or its energy turnover. When birds are maintained for more than a year in a constantly equinoctial photoperiod (LD 12:12), they express two bouts of *Zugunruhe* approximately 6 months apart, strongly indicating an internally generated temporal program produces these migratory behaviours. Circannual rhythms might control not only the timing of the onset of migration and the timing of changing migratory direction but, in addition, the temporal course and the duration of the migratory flight. The internal clock may thereby provide the distance component required for 'vector navigation', a process in which direction and distance are integrated such as to bring the animal to its specific goal. By endogenous control of flight duration, the birds would arrive at their wintering area even if they possessed no more than directional information. Migratory birds**,** in addition to being confronted with problems of spatial orientation, have to solve various problems of orientation with respect to time. The success of their migrations depends, among other factors, upon proper timing of the onset and end of their daily and seasonal migratory activity. Environmental changes in day length are of overwhelming significance for the timing of migrations in birds. Many bird species have been shown subsequently to depend strongly on environmental changes in photoperiod for the timing of their migratory activities.