BIOLOGICAL CLOCK

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Biological Clock

Definition

- Repetition of same activity of an organism in a definite time is called rhythmicity or periodicity of behavior. Many organisms show some rhythmic behavior. Rhythmic behavior shown by organisms is known as Biological rhythm or Biorhythm or Biological Clock.
- Chronobiology (first used by F Hallberg, Gk *Chronos* means related to time) - Study of rhythmicity in behavior of organisms related with time.

Examples of Biological Clock

- Flowers of some plants (lotus, daisies etc.) open in the morning and close in the evening.
- The polychaete *Arenicola* live in U –shaped burrow in and carries out feeding movements every 6 to 7 minutes.
- Mosquitoes become active in the evening and go rest in the morning.
- Housefly become active in the morning and go rest in the evening.

Examples of Biological Clock

- Most species of moths , bats and owls are nocturnal but butterflies & human beings are diurnal .
- Most of the birds sing at sunrise . Most of the birds migrate annually.
- We feel fresh in the morning and feel asleep when night falls.
- Menstrual cycle is a monthly sequence of changes in human female body (not in childhood, after menopause and pregnancy)

Types of Biological clock

- 1. **Epicycles** (variable) : Lugworm – Feeding every 6-7 minutes.
- 2. **Tidal** (about 12 hrs.): Oyster- Opening of shell valves.
- 3.**Lunar** (about 30 days) : Grunion fish (marine fish) – Mating / Egg laying
- **Circadian** (about 24 hrs.) : Fruit fly – General activity
- **Circannual** (about 365 days): Robin- Migratory
- **Intermittent** (variable –days up to several yrs.) : Lions- Feeding (triggered by hunger)

EPICYCLES

- Biological clocks of short duration are generally termed as epicycles.
- Lugworms , living in U shaped burrows in sand in the intertidal zones , feed every 6 to 7 minutes.
- In true sense , epicycles do not fit the definition provided for biological rhythms .

LUNAR RHYTHM

- Lunar rhythm coincides with the rotation of the moon around the earth . This cycle is of about 29.5 days having two phases: Full moon and New moon phase. Each phase is of about 14.7 days.
- The lunar orbit of about twenty eight days is the basis of lunar periodicity , in which the moonlight grows to full light and fades into darkness again, requiring about two weeks for each of these two phases.

Lunar Rhythm

- A marine alga *Dictyota* produces gametes only on full moon days.
- Guppy fish has a rhythm of change of spectral sensitivity which corresponds to the lunar cycle.
- The terrestrial beetle has cycles of phototaxis responsiveness which corresponds to the lunar cycle.

TIDAL RHYTHM

- Tides are water movements of the ocean which are caused by gravitational pull of moon and sun. They represent a rhythmic rise and fall of water and often waves of long wavelengths characterize the process. Some organisms exhibit tidal rhythm in their activities. . Tidal rhythm is also called circa tidal rhythm.

Tidal Rhythm

Tidal rhythms are common in marine animals and have periods extending between two tides (12.4 hr. apart) and occur in animals exposed to tidal floods. Any organisms living in the intertidal zone of the sea shore are alternately submerged by water and exposed to air. This results in change of several types of environmental factors such as pressure, salinity, food supply, temperature, predation risk etc.

CIRCADIAN RHYTHM

- The term “Circadian “ (*circa* means ‘about’ , *dies* means ‘day’) is used to describe endogenous rhythm that usually fall short of a 24 hours periodicity (Mc Farland , 1985).
- Circadian rhythm enabled animals to adjust to the day-night cycle in an anticipatory manner and to develop daily routines which make the most of the prevailing opportunities.
- Animals are of three types- **Crepuscular**(sand fly) , **Nocturnal**, **Diurnal**

Examples of Circadian Rhythm

- Intertidal Crab change body color .
- Body temp. is high in day time and low during night .
- Blood is less acidic in daytime .
- Adrenal secretes smaller amounts of corticoids by night .
- Kidney excretes less urine during night.

Circadian rhythm and exogenous factors

- Some feel pleasure to get up in the morning.
- Fishes respire more oxygen in the morning.

Biological Clocks may be reset or re-entrained

- Lady in New York (sleeps at 3 pm) and her time is shifted gradually .
- Jet lag

Circadian rhythm and role of genes

- In Drosophila , several genes have been identified for foraging.
- In many social insects including honeybees, circadian rhythm of foraging is influenced by some genes named as per gene or per mRNA (Konopka and Benzer, 1971; Kyriacou et al, 1990; Robinson, 1992; Robinson et al, 1999; Toma et al, 2000, Dugatkin, 2004).
- Recently, researchers at the Univ. Pennsylvania School of Medicine has identified a new protein required for the circadian response to light in fruit flies . The discovery of this protein named JET brings one step closer to understanding the process by which the body's internal clock synchronize to light. It will likely open doors to future treatment of Jet lags.

Circadian rhythm and Biochemical Reactions

- Temperature affects greatly the rates of chemical reactions .
- 10 degree Celsius increase in body temp. can double the rate of many biochemical reactions. But it does not double up the speed of an internal clock.

Site of Biological Clock

- In lower organisms , lower part of brain has the site of biological rhythm. In higher vertebrates , it is the pineal body which controls the circadian rhythm.
- It is possible that the substance responsible for rhythmicity may be a proteinous neurohormone released through axons.

Theories about Biological Clock

- There are two theories: 1. Pendulum theory 2. Relaxation theory
- **Pendulum theory**: suggests that an organism is an independent oscillator with its own intrinsic timing equaling one day of a fixed time.
- **Relaxation theory**: Suggests that organism possesses no such timing but acquires a rhythmic timing from rhythmic and cyclic geophysical events going on all the time. Ex Heart beat

Circadian rhythm is truly endogenous

- There are various ways in which we can say that circadian clock is endogenous.
- 1. The rhythm may exhibit a frequency that is not exactly synchronous with any environmental periodic factors such as light , temperature or other geophysical variables. (Weihaupt, 1964).
- 2. The period of the endogenous rhythm usually deviates from the natural rhythm when studied under constant laboratory condition.
- 3. The rhythm may persist when the animal is removed from one part of the world to another.

CIRCANNUAL RHYTHM

- Endogenous biological clock.
- The term circannual is used to refer the endogenous rhythm that is usually less than 365 days (Mc Farland , 1985).
- It also be represented in terms of seasonal rhythms.
- Many aspects. 1. Reproductive physiology and reproductive behavior including breeding cycle 2. Migration 3. Hibernation and Aestivation 4. Diapause etc.

Migration

- Migration is movement of animal from home to a new place and returning back from that place to home .
- It may classified by various ways:
- (A) 1. Long distance 2. Short distance 3. Middle distance
- (B) 1. Seasonal 2. Periodic
- (C) 1. Exploratory (Norway Lemmings- *Lemmus lummus* *2. Colonization or Progressive (European dove- Steptopolia decaoto)*

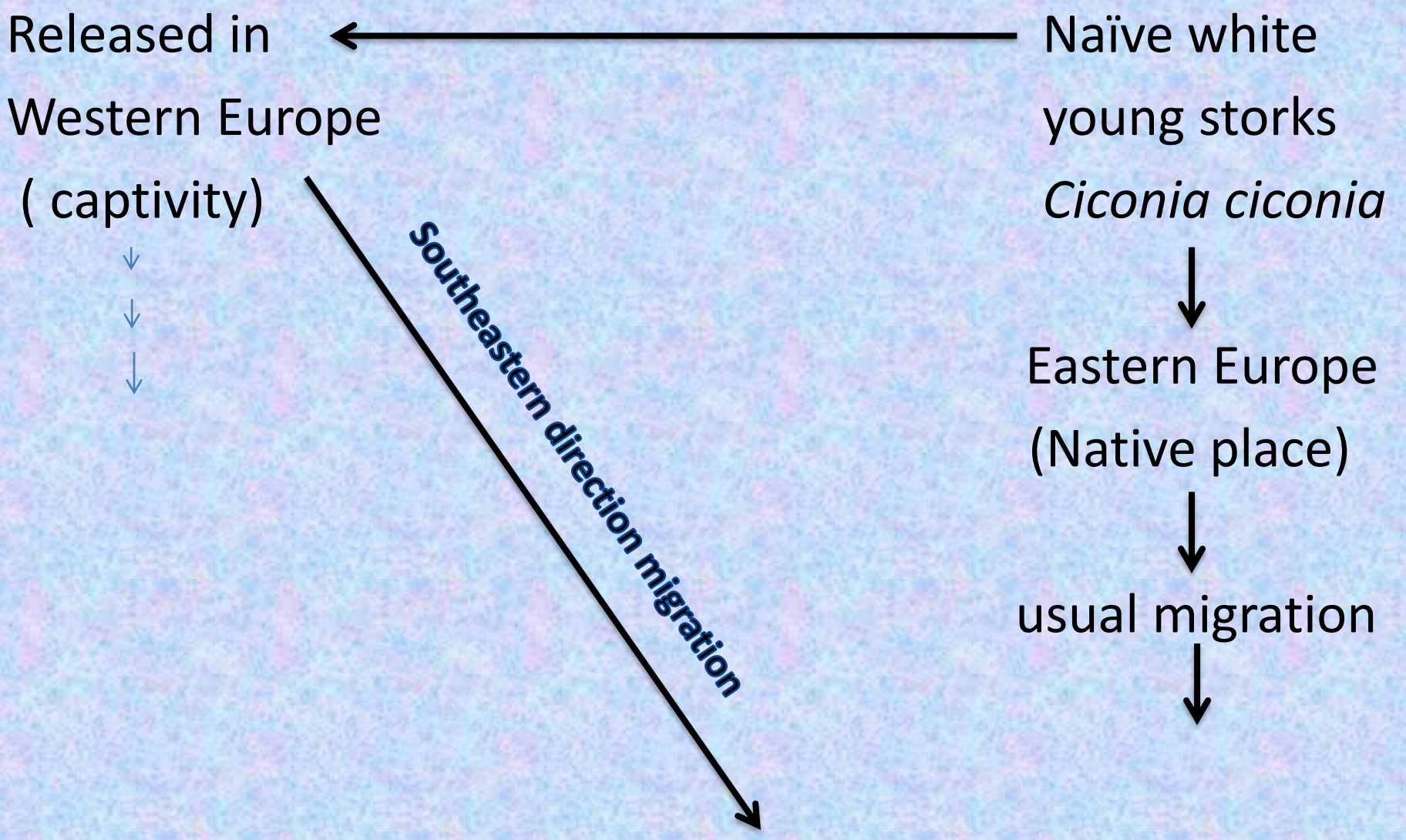
Migration

- During migratory habits there is **marked change** in body wt., molt , testes size and nocturnal restlessness and food preference in typical **long distant** migrants- Garden warbler (*Sylvia borin*, Subalpine warbler (*S. cantillians*) –reported by Berthold , 1971 as well as Willow warbler *Phylloscopus trochilis* -reported by Gwinner,1971.
- **Moderate change** in body wt. & other migratory indices in **middle distant** migrants such as Blackcap (*S.atricapilla*) and Chiffchaff (*P. collybitta*) .

Migration

- Endogenous factors not only impels the onset of migratory activity but also its pattern.

Experiment of Schliz,1963



Migration

- Migratory direction , correct distance , correct time, numbers of hours of migratory restlessness is controlled by biological clock.

Reproductive Behavior & Physiology

- Seasonal climate changes in temp. and precipitation exert powerful influence upon the reproductive success.
- Breeding cycle of several species is controlled by circannual biological clock . Ex. Two estrous in dog /annum, Only one in red fox (*Vulpes vulpes, more in others. Reproductive pattern of many species is influenced by photoperiod factor and endogenous circannual clock.*

Hibernation and Aestivation

- To overcome or adjust prolonged periods of unfavorable weather - hibernation or aestivation .
- If blood serum from a hibernating ground squirrel is injected into a non- hibernation animal , hibernation is induced (Pengalley and Asmundson. 1974)

DIAPAUSE

- A period of dormancy in response to unfavorable climate also occurs among insects and is named as **diapause.**
- In spring season , when diapause is over , they start to metamorphose to be adult. Location of water in the body.

Circadian Clock

Conclusion

- 1. Changes in ambient temperature , day length or other environmental factors induce physiological changes at a particular time or year
- Physiological changes are programmed on seasonal basis by means by an endogenous circannual clock.

You may delay , but time will not

-Benzamin Franklin

Suggested Readings

- Lee Alan Dugatkin.2004.*Principles of Animal Behavior*. W. W. Norton & Company Ltd. London. pp 595.
- John Alcock.2005. *Animal Behavior*. Sinauer Associates, Inc. U. S. A. pp 363.
- David Mc Farland.1985. *Animal Behaviour*. Pitman Publishing Limited , London. Pp 576.
- Satguru Prasad.2009. *Ethology*. Ahead Publications. Pp 269.
- Reena Mathur.2005.*Animal Behaviour*. Rastogi Publication. pp 688.

THANK YOU