PUC I YEAR SEMESTER-II

UNIT VI: ECOLOGY AND ENVIRONMENT

MODULE 29: CYCLOMORPHOSIS –ECOLOGICAL ADAPTATIONS

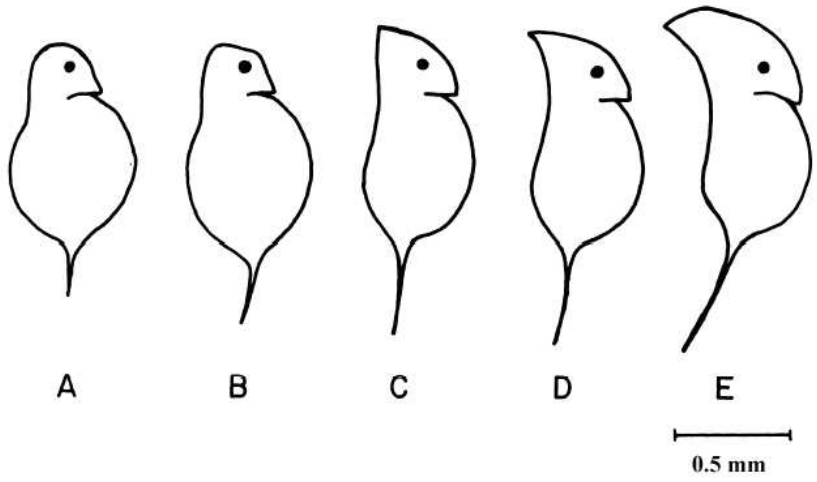
Temperature has many effects on the structure, physiological processes, behaviour and distribution of most of the organisms. Several structural modifications and behaviour patterns are induced by temperature. Animals living in colder climates have a greater longevity than the forms living in warmer zones and are larger in size.

In *Drosophila melanogaster*, temperature affects the position of genes and chromosomes behaviour during crossing over. This brings about the change in the number of facets in the eyes, size of the vestigial eyes and the presence or absence of more or less eggs than the normal number of six.

Various fresh water organisms display characteristic phenotypic changes in time, regular seasonal changes in morphology known as **cyclomorphosis** and relatively rapid changes in morphology, life history and or behaviour in response to predator activity, interpreted as inducible defenses. These two phenomena are not necessarily related but inducible defenses can be cyclomorphic if predators show seasonal changes in abundance.

Cyclomorphosis is a phenomenon where in some animals the body form undergoes different modifications in relation to seasonal changes in temperature. The process of cyclomorphosis was first described by Coker (1939) in certain Cladocerans (e.g., *Daphnia*). Seasonal variation in morphological traits has been reported for a wide range of organisms including dinoflagellates and rotifers, but

most examples have been documented in cladocerans, especially in the genus *Daphnia (*water flea*)*. In winter season the head of Daphnia is round in shape. With the onset of spring season a small helmet or hood starts developing on it. The helmet attains maximum size in summer. In autumn the helmet starts receding. By winter season the head becomes round. Compared to typical morphs, helmeted morphs, helmeted daphnids were thought to be better able to resist water currents, enabling them to stay in preferred water layers containing higher food concentrations.



Seasonal Changes in the helmet shape of *D. retrocurva*. A - C are from early to late spring and D - E are summer forms. Figure modified from Brooks (1965).

Two hypotheses have been put forward to explain the mechanism of cyclomorphosis, namely the **buoyancy hypothesis** and the **stability hypothesis**. The buoyancy hypothesis assumes that helmet aids in floatation in summer, whereas stability hypothesis assumes that protuberances (helmet) act as rudders and hence give greater stability to the animal.

Gloger's rule:

Temperature along with moisture and light affects the colouration of some animals. In warm humid climates many mammals, birds and insects are darker in colour than their counterparts living in cool or dry climates.

Jordan's rule:

Temperature has an apparent control on the number of vertebrae in certain species of fish. Thus fishes of low temperature waters have more vertebrae than those of warm water forms. e.g., cold fish.

Allen's rule:

Tail, ears, bill, neck and other extremities of animals are relatively shorter in the cooler parts than in the warmer parts and are in general characterized by compact structure. Aliens rule can be seen in difference in ear size of three different species of fox – arctic fox, red fox of temperate region and desert fox. A desert fox has larger ears and limbs to facilitate better heat loss from the body compared to the arctic fox.

The adaptive significance of the feature is obvious that short extremities reduce exposed surface which reduces loss of heat from the body.

Bergman's rule:

According to this rule, geographic races of a species inhabiting cold regions are much larger than the forms inhabiting the warmer regions. For example the birds and mammals in the colder regions are much larger than the related forms

inhabiting warmer regions. Penguins which are found in Antarctica attain a body length of 1000 to 2000mm whereas penguins of the equatorial Galapagos Islands are about 400mm long.

Bergman's rule suggested that as the temperature decreases from the equator towards the poles, the body size of the individual living there increases gradually.

Adaptations:

Adaptations help organisms survive in their ecological habitat; adaptations can be anatomical, behavioural or physiological.

Anatomical adaptations are physical features such as an animal's shape. A **behavioral adaptation** is something an animal does – how it acts - usually in response to some type of external stimulus. **Physiological adaptations** include the ability to make venom; but also more general functions such as temperature regulation.

Behavioural adaptations:

Some animals show adaptation to cope with the environment. Desert lizards keep their body temperature constant by behavioural means. They stay in the sunlight and absorb heat when their body temperature drops below the comfort zone. They move to the shade when their body temperature starts increasing. Some species burrow in the soil to escape excessive heat.

Morphological and anatomical adaptations:

In the polar region, penguins have a layer of blubber (fat) beneath their skin which acts as an insulator. This helps them keep warm.

According to **Bergman's rule** the animals living in colder regions have larger body size with greater mass. Mammals from colder climates generally have shorter earlobes and limbs to minimize heat loss from the body. Large earlobes and long limbs increase the surface area which is **Allen's rule**.

Physiological adaptations:

These are those adaptations involving the metabolism of organisms. If you prick your finger, how long does it take for the bleeding to stop? (Three to seven minutes.) Why does it stop? (Platelets cause clotting). Human body has adapted itself to keep from bleeding to death. Some more physiological adaptations of the human body are Enzymes to digest food; secretion of saliva; runny nose as reaction to dust and pollen; muscles contract to make heat. Physiological adaptations for other animals - Secretion of venom in snakes; protein in spider's web; diving response and blow holes in whales; cold water fish carry no oxygen in blood; smooth, thin skin of amphibians to enable respiration; hibernation in some animals.

In most animals physiological functions proceed in an optimal temperature range. (Humans 37^0C). This constancy is in terms of optimal concentration and osmotic concentration of body fluids. The organism should try to maintain constancy of its internal environment (homeostasis) despite varying environmental conditions. This is achieved by the following processes.

Regulate: Some organisms are able to maintain homeostasis by physiological means which enables constant body temperature, constant osmotic concentration etc. For example in summer when outside temperature is more than body temperature we sweat, which brings down the body temperature.

Conform: Most of the animals cannot maintain constant internal environment. Their body temperature changes with the environment. For example in aquatic animals, the osmotic concentration of the body fluids changes with the surrounding water. They are called conformers.

Partially regulate: Camel can be conformer upto certain range of temperature and regulators otherwise. So they are called partial regulators or partial conformers.

Migrate: The journeys taken by animals to escape extremely hot or cold climate is called migration. Many animals particularly birds during winter undertake long distance migration to more suitable areas. Ex: Pulicat Lake in Andhra Pradesh where many migratory birds come from Siberia.

Hibernation: Overwintering in dormant state is called hibernation. This is characterized by reduced metabolic rate, low body temperature and reduced heart beat. Ex: polar bears going into hibernation during winter.

Aestivation: Dormancy in summer when high temperature, excessive dryness or shortage of food may occur is called aestivation. Ex: some snails and fish.

Dispause: Some organisms show delay in development during unfavourable conditions and spend some time in a state of inactiveness called Dispause. Ex: mostly in insects and embryos of some fish.

Check points

- Temperature has many effects on the structure, physiological processes, behaviour and distribution of most of the organisms.

- **Cyclomorphosis** is a phenomenon where in some animals the body form undergoes different modifications in relation to seasonal changes in temperature.
- The process of cyclomorphosis was first described by Coker (1939) in certain Cladocerans (e.g., *Daphnia*).
- Two hypotheses have been put forward to explain the mechanism of cyclomorphosis, the **buoyancy hypothesis** and the **stability hypothesis**.
- **Gloger's rule:** Temperature along with moisture and light affects the colouration of some animals.
- **Jordan's rule:** Temperature has an apparent control on the number of vertebrae in certain species of fish.
- **Alien's rule:** Tail, ears, bill, neck and other extremities of animals are relatively shorter in the cooler parts than in the warmer parts and are in general characterized by compact structure.
- **Bergman's rule:** Geographic races of a species inhabiting cold regions are much larger than the forms inhabiting the warmer regions.
- Adaptations help organisms survive in their ecological habitat; adaptations can be anatomical, behavioural or physiological.
- Anatomical adaptations are physical features such as an animal's shape.
- A behavioral adaptation is something an animal does – how it acts - usually in response to some type of external stimulus.
- Physiological adaptations include temperature regulation.

Questions

Short answer questions

1. Explain cyclomorphosis with an example?
2. What are the effects of temperature in Drosophila melanogaster?
3. Give an account of Gloger's rule, Jordan's rule and Alien's rule?
4. What is Bergman's rule?
5. What is behavioural adaptation?
6. Give an account of morphological and anatomical adaptation
7. Write about physiological adaptation?

Long answer questions

1. Describe in detail the effect of temperature on animals
2. What is adaptation? Describe in detail the various adaptations of animals to extreme temperature?

MCQS

1. Which of the following statements is true?
    a. **Animals living in colder climates have a greater longevity**
    b. Animals living in warmer zones have greater longevity
    c. Animals living in warmer zones are larger in size.
    d. Both a and c are correct
2. In Daphnia
    a. The head is round in shape in spring
    b. The head is round in shape in winter
    c. A hood develops in winter season

d. None of the above

3. Which of the following statements is true
   a. The animals living in cool climates are dark in colour
   b. Fishes of low temperature waters have more vertebrae
   c. Fishes of low temperature waters have less vertebrae
   d. The animals living in warm climates are lighter in colour compared to those living in cool climates
4. According to Bergman's rule
   a. As the temperature decreases, the body size the individual increases gradually
   b. As the temperature increases, the body size of the individual increases gradually
   c. As the temperature decreases, the body size of the individual decreases gradually
   d. None of the above
5. The short extremities in arctic fox
   a. Reduce heat loss
   b. Allows heat to be lost from the body
   c. Allows body to remain cool
   d. Both b and c
6. Bears are able to survive winter months because they do which of the following?
   a. **Hibernate**
   b. Hunt
   c. Fish
   d. Aestivation