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Temperature has been found to affect the living organisms in various ways, for example it has significant role on the cells, morphology, Physiology, behaviour, growth, ontogenetic development and distribution of plants and animals.

Some of well-studied effects of temperature on living organisms are following:

1. Temperature and cell:

The minimum and maximum temperatures have lethal effects on the cells and their components. If too cold, cell proteins may be destroyed as ice forms, or as water is lost and electrolytes become concentrated in the cells; heat coagulates proteins (Lewis and Taylor, 1967).

2. Temperature and metabolism:

Most of metabolic activities of microbes, plants and animals are regulated by varied kinds of enzymes and enzymes in turn are influenced by temperature, consequently increase in temperature, upto a certain limit, brings about increased enzymatic activity, resulting in an increased rate of metabolism.

For instance, the activity of liver arginase enzyme upon arginine amino acid, is found to increase gradually and gradually, with the simultaneous increase in the temperature from 17°C to 48°C. But an increase in temperature beyond 48"C is found to have an adverse effect on the metabolic rate of this enzymatic activity which retards rapidly.

In plants, the absorption rate is retarded at low temperature. Photosynthesis operates over a wide range of temperature. Most algae require lower temperature range for photosynthesis than the higher plants. The rate of respiration in plants, however, increase, with the rise of temperature, but beyond the optimum limit high temperature decreases the respiration rate. The rate of respiration become doubled (like in animals) at the increase of 10°C above the optimum temperature, provided other factors are favourable (Vant Hoff's law).

However, optimum temperature for photosynthesis is lower than that for respiration. When temperature drops below the minimum for growth, a plant becomes dormant even though respiration and photosynthesis may continue slowly. Low temperatures further affect the plant by precipitating the protein in leaves and tender twigs and by dehydrating the tissues.

3. Temperature and reproduction:

The maturation of gonads, gametogenesis and lib.-ration of gametes takes place at a specific temperature which varies from species to species. For example, some species breed uniformly throughout the year, some only in summer or in winter, while some species have two breeding periods, one in spring and other in fall. Thus, temperature determines the breeding seasons of most organisms.

Temperature also affects fecundity of animals. Fecundity of an animal is defined as its reproductive capacity, i.e., the total number of young ones given birth during the life time of the animal. For example, females of the insect, acridid Chrotogonus trachyplerus became sexually mature at 30°C and 35°C than at 25°C, and the highest number of eggs per female was laid at temperatures of 30°C. The number of eggs decreased from 243 to 190 when the temperature was raised to 30—35°C (Grewal and Atwal, 1968).

Likewise, in grasshopper species—Melanoplus sanguinipes and Camnula pellucida when reared at 32°C produce 20—30 times as many eggs than those reared at 22°C (see Ananthakrishan and Viswanathan, 1976). On the other hand, the fecundity of certain inseets such as cotton stem weevil (Pempherulus affinis) was found to decline with an increase in temperature beyond 32.8°C (A Jyar and Margabandhu, 1941).

4. Temperature and sex ratio:

In certain animals the environmental temperature determines the sex ratio of the species. For example, the sex ratio of the copepod Maerocyclops albidu is found to be temperature dependent. As the temperature rises there is a significant increase in number of males. Similarly in plague flea, Xenopsylla cheopis, males outnumbered females on rats, on days when the mean temperature remains in between 21—25°C. But the position becomes reverse on more cooler days.

5. Temperature and ontogenetic development:

Temperature influences the speed and success of development of poikilothermic animals. In general complete development of eggs and larvae is more rapid in warm temperatures. Trout eggs, for example, develop four times faster at 15°C than at 5°C. The insect, chironomid fly Metriocnemus hirticollis, requires 26 days at 20°C for the development of a full generation, 94 days at 10°C, 153 days at 6.5°C, and 243 days at 20°C, (Andrewartha and Birch, 1954).

However, the seeds of many plants will not germinate and the eggs and pupae of some insects will not hatch or develop normally until chilled. Brook trout grows best at 13°C to 16°C, but the eggs develop best at 8°C. In the common forest ground beetle Pterostichus oblongopunctatus development from egg to mature beetle takes 82 days at 15°C, whereas at 25°C it takes only 46 days. In pine lappet, Dendroliniuspini rate of development and mortality of various developmental stages are effected by temperature.

6. Temperature and growth:

The growth rates of different animals and plants is also influenced by temperature. For example, the adult trouts do not feed much aid do not grow until the water is warmer than 10°C. Likewise, in the oyster Ostraea virginica, the length of the body increase from 1.4 mm to 10.3 mm when temperature is increased from 10°C to 20°C. The gastropod Urosalpinx cinerea and sea urchin Echinus esculcntus show maximum size in warmer waters. Corals flourish well in those waters which contain water below 21°C.

7. Temperature and colouration:

The size and colouration of animals are subject to influence by temperature. In warm humid climates many animals like insects, birds and mammals bear darker pigmentation than the races of some species found in cool and dry climates. This phenomenon is known as Gioger rule.

In the frog Hyla and the horned toad Phrynosoma, low temperatures have been known to induce darkening. Some prawn (crustacean invertebrates) turn light coloured with increasing temperature. The walking stick Carausius has been known to became black at 15 C and brown at 25°C.

8. Temperature and morphology:

Temperature also affects the absolute size of an animal and the relative properties of various body parts (Bergman’s rule). Birds and mammals, for example attain a greater body size when they are in cold regions than in warm regions, and colder regions harbour larger species. But poikilotherms tend to be smaller in colder regions.

Body size has played a significant role in adaptation to low temperature because it has influenced the rate of heat loss. According to Brown and Lee (1969), larger wood rats have a selective advantage in cold climates, apparently because their surface to air ratio and greater insulation permit them to conserve metabalic heat. For opposite reasons small- sized animals are favoured in deserts.

The extremities of mammals like tail, snout, ears, and andlegs are relatively shorter in colder parts than in the warmer parts (Allen's rule). For example, there occurs difference in the size of ears of arctic fox (Alopex lagopus), red fox (Vulpes Vulpes) and the desert fox (Megalotis zerda) (Fig. 11.17).

Since heat is lost through the surface, the small ears of the arctic fox help to conserve the heat; while, large ears of the desert fox help in heat loss and evaporation. Similarly, Gazella picticanda of Himalayas has shorter legs, ears and tail than Gazella benetti found in the plains of Himalayas, though both of them are of the same body size.

Likewise, Eskimos have shorter arms and legs in proportion to their trunk size, which is comparatively larger than in any other contemporary group. The mice reared at 31°C to 33.5°C have longer tails than those of the same strain reared at 15.5°C to 20°C. All these examples of Allen's rule are clearly showing adaptive significance of short extremities in reducing heat loss from body in cold climate.

The races of birds with relatively narrow and more acuminate wings tend to occur in colder regions, while those in warmer climates tend to be broader (Rensch's rule). Temperature also influences the morphology of certain fishes and is found to have some relation with the number of vertebrae (Jordon's rule). Cod which hatches off New Foundland at a temperature between 4° and 8°C has 58 vertebrae, while that hatches East of Nantucket at a temperature between 10° and 11°C has 54 vertebrae..

Heads of arctic fox (Alopex lagnpus), red fox (Vulpes Vulpes) and desert fox (Megalot's zerda) showing gradation in size of ears and illustrating Allen's rule (after Clark, 1954).

9. Temperature and cyclomorphosis:

The relation between seasonal changes of temperature and body form is manifested in a remarkable phenomenon termed cyclomorphosis exhibited by certain cladocerans like Daphnia during the warm months of summer (Fig. 1118). These crustaceans show a striking variation in the size of their helmet or head projection between the winter and summer month (Coker, 1931).

The helmet develops on the Daphnia head in spring; it attains its maximum size in summer and disappears altogether in winter to provide usual round shape to the head. Such a kind of cyclomorphosis in the terms of size of the helmet is clearly showing a correlation to the degree of warmth of different seasons.

These prolongations of the helmet have been interpreted as an adaptation aiding flotation since the buoyancy of water becomes reduced as the temperature increases (the buoyancy hypothesis). According to other interpretation (viz., stability hypothesis), the helmet acts like the rudder and gives greater stability to the animal. Besides temperature, such structural polymorphism can be caused by other environmental factors including the food.

10. Temperature and animal behaviour:

Temperature generally influences the behavioural pattern of animals. In temperate waters the influence of temperature on the behaviour of wood borers is profound. For example, in the winter months in general, both Martesia and Teredo occur in smaller numbers in comparison with Bankia campanulaia whose intensity of attack is maximum during the winter months.

Further, the advantage gained by certain cold blooded animals through thermotaxis or orientation towards a source of heat are quite interesting. Ticks locate their warm blood hosts by a turning reaction to the heat of their bodies. Certain snakes such as rattle snake, copper heads, and pit vipers are able to detect mammals and birds by their body heat which remains slightly warmer than the surroundings.

Even in the dark these snakes strike on their prey with an unnerving accuracy, due to heat radiation coming from the prey. The arrival of cold weather in temperate zones causes the snakes to coil up and huddle together.

Cyclomorphosis in Daphnia cucullata due to seasonal change in temperature (after Clarke, 1954).

11. Temperature and animal distribution:

Because the optimum temperature for the completion of the several stages of the life cycle of many organisms varies, temperature imposes a restriction on the distribution of species. Generally the range of many species is limited by the lowest critical temperature in the most vulnerable stage of its life cycle, usually, the reproductive stage. Although the Atlantic lobster will live in water with a temperature range of 0° to 17°C, it will breed only in water warmer than 11°C.

The lobster may live and grow in colder water but a breeding population never becomes established there. Not only temperature affects on breeding in the geographical distribution but also temperature affects on survivality (i.e., lethal effect of temperature), feeding, and other biological activities are responsible in geographic distribution of animals.

As noted earlier in this article, the animals from colder geographic regions are generally less heat tolerant and more cold tolerant than those animals from warmer regions; for example, member of Aurelia, a jelly fish from Nova Scotia dies at a water temperature of 29-30°C, while Aurelia from Florida can tolerate temperatures upto 38.5°C. Thus, lethal limit of temperature may regulate the range of distribution of Aurelia.

Generally, the distribution of shallow-water marine species can be assigned to four types of zonation. In the first type, northward distribution is dependent on thermal lethal limits during the winter months, and southern distribution is dependent on summer temperature limits. In a second type, the thermal limits required for population determine the north to south distribution.

In the third type of zonation, the thermal requirements for repopulation deter
mine the poleward habitat in summer, and the maximum temperature determines the equatorward survival area. Finally, the minimum temperature for survival determines the poleward limit in winter and temperatures limiting repopulation determine the southward range.

Ex. Terrestrial invertebrates, particularly arthropods generally are distributed in all thermal environments where life is found. Many arthropods that have invaded the colder areas have one stage in their life cycle which is very resistant to cold, enabling them to over-winter until warmer weather returns (Salt, 1964). Birds and mammals are also adapted to live in nearly all thermal environments.

The distribution of amphibians and reptiles, however is limited to the relatively warmer thermal climates. Mock (1964) has listed three factors that limit the invasion of reptiles into cold environments: the daily ambient temperature must be high enough to allow activity, the daily ambient temperature must be high enough and long enough to allow breeding and to allow adults and young to acquire food for “over-wintering” and there must be adequate sites for hibernation.

12. Temperature and moisture:

The differential heating of the atmosphere resulting from temperature variation over the earth’s surface produces a number of ecological effects, including local and trade winds and hurricanes and other storms, but more importantly it determines the distribution of precipitation.