OVERWINTERING INSECTS: ADAPTION FOR SURVIVAL

Insects inhabit almost every part of the earth, experiencing widely varying conditions of light, temperature, precipitation and of kinds and amounts of vegetation. Over most of the continental land masses seasonal changes such as winter or long droughts limit insect activity to certain favourable times of the year. Insects must, therefore, be able to endure somehow the unfavourable periods. In our northern temperature regions the unfavourable period is winter; how do insects survive the low temperatures and the deep snows of Canadian winters?

A great many insects can stop their growth and activity at some stage in their life cycle by entering a kind of dormancy which entomologists call diapause. Insects in diapause have an altered body chemistry which permits them to survive food scarcity and fat depletion. Any stage of the life cycle may be used for diapause in different species, but any one species will always enter diapause in the same stage of development each year. For many aphids, that stage is the egg; for some moths, like the European cornborer it is the larva; for other moths, such as the cecropia, it is the pupa; for still other insects the adult stage is utilized.

While the diapause itself is a complex physiological event as yet not well understood, its onset is preceded or accompanied by specific behavioral patterns. Eggs are deposited in favourable locations; cocoons are spun; larvae, pupae and adults enter the soil or find shelter in appropriate places, as though knowing of hard times ahead, and preparing for them. However, it is quite clear that insects do not anticipate the conditions (cold temperatures; lack of food) which diapause enables them to survive; rather, the insects respond to a biological "clockwork" mechanism which matches the insects' behaviour to the seasonal cycle. In latitudes such as ours, the "clock" is run by the photoperiod, or changing day length; as days shorten in autumn, the insects' behaviour and body chemistry change towards that of the dormant state. These changes are brought about in many insects by the secretion of a dispausing hormone from nerve cells in the insect's "throat".

While the cocoon may protect against drying out, and while shelters in soil, under stones, in rotten logs or amongst plant debris may help the diapausing insect to avoid extremes of cold, few of our local outdoor insects can evade temperatures that drop below 0°C. The basis of insect body fluids is water; water freezes at 0°C and ice formation in living cells is normally fatal. How, then, can insects whose body temperatures follow that of the environment, survive long periods of subzero temperatures? Studies related to this question of cold hardiness have shown two interesting phenomena. Firstly, it is clear that the body fluids of many insects can be supercooled; that is, they can remain liquid at temperatures well below the freezing point in the absence of suitable "nucleating centres" at which crystallization into ice is initiated. Secondly, and perhaps not unrelated to the first observation, hibernating insects have glycerol in their body fluids. We have learned to add glycerol to human blood to preserve it frozen in hospitals. Insects add it to their blood by manufacturing it from their stored food, in time for winter. In effect, they provide their own antifreeze. Not to be wasteful, they convert it back to food again when post-diapause activity is resumed.

Insect physiologists ask, "Is there a causal relationship between diapause and cold hardiness?" In general, they tend to answer themselves in the negative. Insofar as the phenomena are now understood it is believed that diapause has the attributes (inactivity, cessation of feeding) for favor survival, whereas the factors that confer cold hardiness are the supercooling potential and the presence of glycerol. The concurrence in timing of these phenomena allow insects to pass the long northern winters unharmed and to greet the succeeding spring in the fall vigour of their species.

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