PSYCHE.

INSECTS IN WINTER.

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The condition of our vertebrate animals in winter, and also the functional condition of their organs, have been well studied and are pretty well understood. That most of them require more carbonaceous food at this season, as this ministers to the special kind of nutrition which supplies animal heat, is a well recognized fact. It has long been known that some vertebrates hibernate, in which state they respire very slowly, and so are able to live even though the heart does circulate unoxidized blood.

The functional activity of the organs in this case is reduced to the minimum, and so nutrition is almost abated, and no food is required other than that stored up in the adipose tissue. But even though these animals do live so slowly, with too severe and long continued cold they often lose even this little vitality and perish.

Physiologists have determined that tissues and organs, whether *in situ* or removed from the body, will maintain their vitality for a long time, and often indefinitely, if kept in a cold atmosphere, though all functional activity is for the time held in abeyance. I myself have exposed hens' eggs, while in the process of incubation, to a temperature but little above 0° C., until I had good reason to believe that the hearts of the embryo chicks had ceased to beat. I then replaced the eggs under the brooding hen, when with the return of heat came also a resumption of development. Very likely the same explanation may rightly account for the retarded development in many tadpoles that pass the winter in an immature state. Most frogs develop fully in summer, and pass the winter in a mature state. Yet we not infrequently find tadpoles in mid-winter, or large ones at the very dawn of spring.

If all animals have had a common origin (and can any biologist doubt it?), we may expect that the phenomena observed among invertebrates will closely resemble the peculiarities which we note in our study of the higher forms.

The effects of cold to stay or retard development among insects, though perhaps not so long and closely studied as have been the same influences as they worked to modify development among the vertebrates, will be found, I feel quite sure, to act in a very similar way.

The winter of 1874–75 was one of the most severe ever experienced in the northern United States. In the month of February of that year, the temperature fell below zero of the Fahrenheit scale (—17.°8 C.), at Lansing, Michigan, twenty-one times. The mercury showed —20° F. (—28.°9 C.) on eight different days, and —30° F. (—34.°4 C.) twice. Surely this was a good time to study the effects of cold upon insect life.

The codling moth insect (*Carpocapsa pomonella*), as is well known, passes the winter, in the larval state, protected only by a slight silken cocoon, and some bark scale, crevice, or similar covering. The

spring following the severe season just referred to I found that nearly all these larvae that had passed the winter out doors about the apple trees were dead, a circumstance I have never observed at any other time. The fact that this mortality was not due to parasites, that there was no climatic peculiarity during that winter other than the cold, especially as the larvae in cellars and kitchens were healthy and lively, points strongly to the severe cold as the cause of this welcomed mortality. If this inference is correct, we must conclude that insects which freeze up in winter may succumb to very severe cold.

Farmers long since observed that clover sward ploughed in autumn, and planted to corn the following spring, was less liable to be attacked by cut-worms, than when ploughed in spring, and immediately planted. This has led to the very general belief among farmers, which view is adopted by several noted entomologists, that exposure to the cold, especially to alternate freezing and thawing, is what destroys the cut-worms. During the very severe winter already referred to, I subjected some cut-worms— larvae of species of *Agrotis* — to intense cold, and to alternate cold and heat, which seemed in no wise to injure them. Others were exposed very much as they would be by fall ploughing, and yet passed the winter in safety. The farmers are doubtless correct in thinking that fall ploughing is a protection against these marauding cut-worms; but wrong in their explanation. Exposure to insectivorous birds and not to cold is the more probable solution, especially as frequent cultivation of the land in autumn and spring, when birds are plenty, is found to greatly augment the destruction of insects.

The late Mr. Quinby, in his work on bee keeping, states that the larva of the bee-moth, *Galleria cereana*, cannot survive exposure to the cold; that if these larvae are removed from the hive and its genial heat, during the winter, they surely die. Mr. G. M. Doolittle reports that he has observed these bee-moth caterpillars in exposed positions, and that they have survived even the present rigorous winter of 1880 and 81. I have often noticed these larvae and the chrysalids, which have passed the winter in cold rooms outside the hives. Still from the natural surroundings of these insects we may easily believe that they have developed a constitution more susceptible to the cold than insects whose habits bring more exposure.

Mr. W. H. Edwards has shown how the development of butterflies may be retarded by the cold. The bearing of these experiments upon the formation of different broods of a species and characteristic markings of each brood is of very great interest.

Among honey bees of the genus *Apis*, we note peculiarities in respect to cold, which, like their habits and instincts, seem to separate them widely from most other insects, and strongly remind us of the vertebrates. Most insects freeze up in winter, so that all their functional activities are held in abeyance, ready to start into action at the touch of revivifying warmth, which ever comes with returning spring. A few of the higher ones really hibernate. There is slight activity of the tissues which is sustained

by the stored-up fat cells of the body. The species of *Apis*, on the other hand, remain active, take food, and resemble more closely the higher vertebrates. In a nearly uniform temperature of from 3° to 8° C. the domestic honey bees remain very quiet, take but little food, and only move as the cold at the outside of the cluster impels them to crowd towards the centre, or as the absence of food in any part of the hive impels the whole cluster to change its position. If the temperature outside the hive is maintained within the limits mentioned above, the bees will eat so little, and there will be so little dis-assimilation in the body, that all the excrementitious substances, except such as pass off with the breath, — and this last is very slight at such times — are easily and safely held in the intestines for so long a space as five or six months. But if the temperature immediately without the hive is for any considerable period lowered much below the point mentioned above, the bees attempt to increase the animal heat by action, and by increased consumption of honey, which among vertebrates is typical as a heat producing food. This leads to an excessive accumulation of fecal matter within the intestines, which consists of the undigested food and the waste products which are the resultant of functional activity. In this condition, bees must soon fly forth to void their feces, which in normal circumstances they only do while on the wing, or soon they will be attacked by fatal dysentery. The above is undoubtedly the rightful explanation of the exceeding mortality among bees the past winter. In many parts of the more northern states, bees have been confined to their hives for five months, and in almost all cases where they have not been protected from the severe cold, they have died. Those wintered in suitable cellars are safe and healthy, and many protected out doors by a thick wall of chaff about their hives are saved from death. I have found by weighing the honey in the fall and in the spring, that bees kept in the right temperature during the past winter have consumed never more than ten pounds (4 Kg. 5) of honey to the colony, while all colonies exposed to the severe cold have taken more than twice that amount. The former have wintered well, the latter have sickened and died.

If bees are confined in winter, and the temperature be raised much above 10° C., the heat becomes a serious irritant, and the bees, unless their hives are very well ventilated, and unless they are soon enabled to fly out from their hives, will speedily die.

It is an interesting fact that bees require only the carbo-hydrates for food in winter. They will winter better on clear honey or even pure cane sugar than when well supplied with the nitrogenous pollen. I think the reason of this is, that in the first case they are prevented from the activity which follows upon brood rearing, and breeding can only be carried on when there is pollen in the hive.

We see then that our honey bees are not dormant in winter, but that, in our colder climates they are Othello-like, and with their occupation gone ; and shut in by the rigor of the season, they only eat the small amount necessary to the bated activity of their bodily functions.