The Seventeen-year Locust or Periodical Cicada

The Two Races and When They Appear

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ONE of the most interesting insects in the world is the American periodical Cicada, or so-called seventeen-year locust. Every seventeen years in given localities in the Northern States, and every thirteen years in given localities in the Southern States, this sizable but rather frail insect comes out of the ground in great numbers—sometimes in incredible numbers—and for a few weeks pierces the air with its shrilling. It sometimes happens that in certain localities it will appear at more frequent intervals. Thus in 1902 it appeared in parts of Maryland, New Jersey and Eastern Pennsylvania, and in the present year (1911) it will again appear in the same general region. But this does not mean that those which will appear this year are the children of those that laid eggs in 1902; they belong to a different brood, and their immediate parents were flying and singing and laying their eggs in 1894, while the children of the 1902 brood will not issue as adults until 1919.

There are many of these so-called broods, all accurately mapped, and their appearance from time to time can be predicted with certainty. The seventeen-year brood of the present year, for example, running from North Carolina up to Albany, New York, and occurring also in Connecticut, has been reported every seventeen years since 1724 in Connecticut, and in New Jersey since 1775. Many changes have occurred in the 187 years elapsing between 1724 and 1911. Many a generation of Cicada larvæ have gone into the ground for their long years of larval life, emerging at last to the surface only to find in many instances that in the seventeen years a house or a paved street or possibly a whole town has covered the surface.

There are thus two distinct races of the periodical Cicada. The northern, or seventeen-year race stays under ground seventeen years, except for a few weeks. The southern, or thirteen-year race occupies only thirteen years in its subterranean growth. And occasionally, as will happen the present year, a brood of each race will make its appearance. On the whole, for one reason or another, most of the great broods are growing smaller. This is due in part to the gradual change in the face of the country through civilization, and partly, in our cities, to the work of the English sparrow now become so annoyingly abundant. Exact records of the appearances of the Cicada have been kept for many years, and it is therefore possible to predict their appearances with exactitude for many years to come. In 1912 they will come out over most of Iowa; in 1913 in Southwestern Iowa and southward through Eastern Kansas and Western Missouri into the Indian Territory and possibly into Texas. In 1914 a compact brood will appear all through Eastern Ohio and over most of West Virginia, and in 1915 a scattering brood will be found through Wisconsin, Michigan, Illinois, Indiana, Ohio, West Virginia and south.

The alarm always caused by the appearance or announced appearance of this insect is largely unjustified. They take practically no food, and injure trees only by the unfortunate way in which they lay

their eggs. They begin to come out about the end of May or early in June, and are active as adult Cicadas for four or five weeks. After mating, the female lays her eggs by working her strong ovipositor into tender twigs of many different kinds of trees, inserting her

eggs under the bark and in the sapwood in a line along the axis of the twig.

Twigs thus attacked usually die, and where the Cicada is numerous these terminal twigs with dead leaves are frequently so abundant as to make it appear as if a patch of woodland had been seriously injured. The eggs begin to hatch late in July, and the active little larvæ drop to the ground and burrow beneath the surface, where they remain until the end of May of the seventeenth year thereafter. These larvæ are not grub-like, but are active, four-legged creatures, and burrow readily through the soil by means of enlarged forelegs. They do not seem to injure the roots of plants, but to derive their sustenance from the organic matter contained in soil moisture.

In the late spring of the seventeenth year, they have passed through their last molt and have become pupæ, but in this stage they are as active as before. Sometimes reaching the surface of the soil, they will build little cones or chimneys of earth above the surface of the soil, building upward continually for several weeks before the time of issuing. Why they should build these chimneys or turrets or huts, as they have been called, has been a puzzling matter for the people who have written about it. They seem to be made when the soil is shallow or when there is some unusual warmth which brings the pupæ to the surface in advance of the normal time and also sometimes when the soil is excessively moist. The conditions, in other words, must be somewhat abnormal or the chimneys are not constructed.

When the proper time arrives, the pupæ leave the ground almost with a rush. They all come out nearly together and scramble for some tree trunk or fence or bush. On such base they climb upward for a considerable distance and then seize hold firmly and rest. This scramble from the ground begins always just at sundown and continues until nine or ten o'clock in the evening. About an hour after they have risen and fixed themselves, the skin begins to burst along the back of the thorax and the adult Cicada slowly crawls out. In from twenty minutes to an hour or more the issuance is complete, and the newly issued adult, white in color with red eyes, clings either to the pupa shell or to the bark of the tree or to the other object upon which the pupa may be fixed, and gradually the wings

expand and dry, and during the night the dark brownish color of the insect becomes evident.

The Cicada has not many natural specific enemies, and this is quite to be expected from its rare appearances. Nevertheless, many birds feed upon it with avidity, and the English sparrow, rather contrary to its normal habits, seems to begin a prolonged feasting whenever the Cicada comes. So generally are the Cicadas destroyed in the neighborhood of cities by this city nuisance that each year the broods have become smaller since this sparrow was brought to this country. One of the natural enemies is the largest of the digger wasps, *Sphecius speciosus*. This wasp stores its burrows with Cicadas. The periodical Cicada as a rule appears too

1. Pupa. 2. Adult issuing from pupa shell. 3. Later step in the same process. 4. Adult just after leaving pupa shell. 5. Mature adult cicada.

Earth cases of larvæ.

Earth tubes of larvæ coming to the surface too soon.

Holes in the ground from which cicadas have issued.

Pupa cases of cicada.

A PERIODICAL INSECT PEST

early for the wasp, which finds the bulk of its prey in the common dog-day harvest fly that comes out after the seventeen-year locust has disappeared, but many of the late-flying seventeen-year Cicadas are captured by the earliest of the wasps to issue, are stung by them and carried away and packed in the long wasp burrows beneath the ground.

The eggs of the Cicada are preyed upon by certain mites, and there is a little internal parasite which destroys them as well.

It sometimes happens that orchards located on cleared lands or in the vicinity of standing forests are very seriously injured by the Cicadas laying their eggs; but on the whole they do little damage. Where damage of this kind is feared, the remedies consist in destroying the pupæ as they arise from the ground and while they are more or less torpid and sluggish. A very strong solution of kerosene emulsion has also been used with excellent effect. It should be sprayed over the pupæ and newly formed adults in the early evening. A heavy coat of whitewash on the trees will keep them away to some extent when there are other trees in the neighborhood. Bordeaux mixture seems to have some effect of the same kind. Owners of young orchards, forewarned of the coming of a brood of Cicadas, should neglect all pruning operations during the winter and spring in order that their trees may be pruned for them by the Cicadas, thus distributing the damage over a larger surface. Another precaution when a Cicada year is expected is to defer the planting of orchards, especially in the vicinity of old forest land, until the danger is past.

Forests and Water Supply

By Russell L. Dunn

THE source of all the water on the land surface of the earth and beneath it is the water vapor diffused or held in solution in the atmosphere. The condensation of the water vapor results in the change of the water from the gaseous to the liquid state, in which condition it is heavier than the atmosphere, and gravity operating it falls to the land surface, arriving there, dependent on the temperature and relative dryness of the atmosphere it falls through, either in liquid form as rain or in solid form as snow.

That portion of the water precipitated on the land surface which runs off from the surface by gravity to the sea is "water supply," and the other portion is "water waste." The latter includes water which is evaporated directly back into the atmosphere from the surface of snow, water which is evaporated directly back into the atmosphere from the land surface, water which is evaporated back into the atmosphere indirectly from the land surface passing on the way through the leaves of trees and vegetation generally, and water which becomes fixed in the structure of vegetation, the trunks of trees particularly. Water supply includes water which runs off the land surface by gravity without passing through the land beneath the surface and water which passing first beneath the surface subsequently comes to the surface by gravity and then runs off of the surface by gravity.

It has been maintained that the forestation of land in comparison with its non-forestation increases the quantity of "water supply" and decreases the quantity of "water waste."

Consider first the case of water precipitation which comes on to the land surface as rain. Obviously, if rain falls on impervious rock or earth surface it runs off from that surface undiminished in quantity, substantially all of it becoming water supply except the quantity evaporated directly from the surface of the water as it runs off by gravity. On the other hand, if the rain falls on a pervious surface, that is a surface composed of rock or soil particles with voids between the particles, the water seeps or percolates into the surface by gravity until it has filled the voids and thereby made an impervious surface over which any additional precipitation of water runs off precisely as it would from an impervious rock surface.

Obviously, the forestation or non-forestation of the pervious land surface does not determine the quantity of water which enters that surface. The quantity of water entering the land is determined by the cubic space quantity of the voids between the soil particles. That is, no more water enters the land when it is forested than when it is not forested. Also, the quantity of that part of the water supply which is run off of water by gravity without entering the land at all is the same quantity whether the land is forested or is not forested.

But, of the quantity of water which percolates into the soil voids from the precipitation, only that portion is water supply which reappears from the discharge of the voids by gravity, the remainder being water waste. The question of forests increasing the water supply thus becomes limited down to the propo-

sition of whether or not the voids in the soil discharge more water by gravity through springs back to the surface when the land is forested than when it is not forested.

As between land forested and land not forested, the larger water waste quantity made by direct evaporation from the land surface is from land not forested. The shade of the forest keeps the surface of the land beneath it from receiving as many heat units from the sun's direct rays as the unprotected surface would receive. But the heat units which the land surface shaded by the forest does not receive directly are nevertheless received indirectly by the land surface through the leaves of the forest trees. The heat units of the sun's rays are neither more nor less in quantity by reason of the forested condition of the land, but are the same quantity. Those heat units

Members of the staff of the Bureau of Entomology digging for cicada larvæ on the Agricultural Department grounds at Washington.

Eggs of the cicada as deposited in the twigs of trees.

Cicadas laying their eggs in twigs and twigs showing egg-punctures.

PHASES OF THE 17-YEAR LOCUST'S LIFE

that impinge directly on the land surface become conserved into work which can be expressed in terms of water evaporated directly from the soil voids. The heat units that impinge on the tree leaves become conserved into work which can be expressed in terms of water evaporated from the tree leaves and in terms of the water fixed into the tree structure, both quantities of water being obtained from the soil voids. The total quantity of water waste evaporated from the soil voids bears a direct relation to the number of heat units received from the sun, the more heat units the more water evaporated, and it is quite obvious that whether these heat units become conserved into work directly in the soil voids where there is no forest cover, or indirectly through the tree leaves where there is forest cover, the total quantity of work conserved from heat and expressed in terms of water removed from the soil voids is the same.

Obviously, if the quantity of water percolating into

the soil voids is the same quantity whether there be forest on the land or no forest, and the quantity of water waste deducted from it by the sun's heat units conserved into work is the same quantity whether there be forest on the land or no forest, then the quantity of water supply which remains after the deduction of the water waste to reappear through the gravity discharge of the soil voids is the same quantity whether there be forest on the land or no forest.

Consider now the case of water precipitation which comes on to the land surface as snow. After the snow has melted and become water the preceding analysis applies. The forestation or non-forestation of the land does not affect the quantity of water supply from melted snow water.

Before the snow melts, during the period of temperature below the melting point of snow, there is a water waste from the snow by direct evaporation from it, but, as the temperature when below the snow melting point is, if different at all, higher outside of the forest shelter than under it, the water waste from unmelted snow may be a larger quantity where the land is not forested than where it is forested. The difference of quantity of water waste from unmelted snow outside of forest cover and unmelted snow within forest cover is, however, so relatively small that the effect of the forest is practically nothing on the quantity of water supply provided from snow precipitation.

It has been maintained that the forestation of land in comparison with its non-forestation retards the melting of snow, that snow melts slower where it is precipitated on forested land than on non-forested land, and that therefore flood stages of run off of water from melting snow are not as high where the melting snow is under forest cover as where the melting snow has no forest cover.

The melting of snow bears a direct relation to the heat units which the snow receives. Where there is no forest cover, the heat units reach the surface of the snow, and, absorbed by it, become conserved into work expressed in terms of water melted from snow. As the water is produced at the surface of the snow, it leaves the surface by gravity, exposing an unmelted surface of snow, which in turn melts and passes from the surface by gravity. But all of the melting time there is only one surface of the snow, the top, receiving heat units and melting.

Where there is forest cover a less number of heat units reach the surface of the snow, the top, but the bottom of the snow also receives heat units and melts. The heat units which reach the bottom of the snow are heat units collected by the tree leaves and carried by the descending sap to the tree roots, where they become released in effecting chemical changes in absorbing plant food from the soil along with their water carrier. The released heat units raise the temperature of the soil above the melting point of snow where the two are in contact, and the snow melts on the surfaces of contact, the water produced passing away from the snow by gravity leaves an unmelted surface against the warmed soil and the process is repeated.

In the forest during the period of greatest rate of growth of the trees the heat units released and becoming sensible heat in the soil are a larger quantity than the difference between heat unit quantities received by the top surface of the snow where there is no forest cover and where there is forest cover. The increase is due to the conservation of heat from chemical combination in the soil in the process of digestion of plant food. The increase is not a large quantity, but it is sufficient to cause the melting of snow from beneath a forest cover at a more rapid rate than when there is no forest cover. This phenomenon is a matter of very ordinary observation. The observed fact agrees with the conclusion of a deductive analysis concerning it. Instead of the foresting of land retarding the melting of snow as compared with the melting of snow on non-forested land the fact is the reverse, the forest cover of land accelerating the melting of snow beneath it and thereby causing higher flood stages of run-off water than the run-off from melting snow where there is no forest.

Let us study two fields of similar surface lying contiguous, one of the two being planted with a clover, for example, alfalfa, the other being clear of vegetation of any kind. The snow cover will become melted from the alfalfa field sooner than from the barren field. The alfalfa will begin growing before the snow is entirely melted, and will disengage heat in growing which will start melting the snow at the bottom. Both fields receiving the same heat on the top surface of the covering snow would become cleared by the melting of the snow at the same time except for the heat received by the snow on the alfalfa field at its bottom surface accelerating the rate of snow melting.