A MODEL PROBLEM IN INSECT ECOLOGY

KENNETH GRAHAM
University of British Columbia

During the course of its life cycle, every insect encounters a number of crucial trials which it must pass if the species is to survive. These trials concern three important life activities, namely, reproduction, development and survival. A species must maintain a sufficient reproductive output, develop at a sufficient rate, and have enough survivors if it is to remain in existence. Ordinarily a species occurs in somewhat greater abundance than the mere minimum for its survival. It exists in dynamic balance, decreasing under adversity, and increasing when conditions are especially favorable. Different environments provide conditions ranging from those which prohibit the existence of a given insect species, to those permitting great outbreaks.

Among the problems of insect ecology are those concerned with explaining why certain insects produce outbreaks, yet others in the same locality and even feeding on the same host do not. Another problem concerns the reason why certain areas experience the increase in insect population while others do not. The lodgepole pine needle miner (*Recurvaria milleri* Busck) provides an excellent opportunity for enquiry into these outbreak problems.

The lodgepole pine needle miner had not been known in the Canadian Rockies until 1942. In that year, its injury to the needles resulted in discoloration of a small area of forest near Banff. This heralded the beginning of an outbreak which increased in extent and severity until it covered an area of about 400 square miles, involving Banff, Kootenay, Yoho and Jasper National Parks. Great concern arose over the possible extension of the infestation into the pine stands of the East Slope watershed. The loss of those stands could be calamitous to communities far along the rivers that have their origin in the mountains.

Certain basic questions arise over this problem. Why did the outbreak develop where and when it did? Can the infestations spread from epidemic centres, or do they develop autochthonously from endemic populations? Are the East Slope forests really in danger from spread of outbreaks or build-up from endemic populations? These problems are all open to investigation by considering the particular crucial trials that the needle miner must encounter. And now, what are these trials?

The crucial part in the life of a needle miner begins in the food reserves carried into the pupal stage from the larva. The ultimate egg output depends firstly upon the quantity and quality of the food on which the larvae feed. The quality of food must vary according to numerous factors affecting the growth of the tree. Age of trees, soil, soil moisture, aspect, altitude, injuries, all varying locally and regionally, may have an influence on the food quality of foliage, and thereby affect the storage of materials for eventual egg production in the insect.

The next trial in the life of the insect-to-be is the successful pupation of the larva containing the future egg-forming substances. Conditions of environment determine the proportion of individuals that can complete the transformation. Of these conditions, temperature and humidity are probably the most important. Some seasons and some areas may be more favorable or less so than others. The needle miner in the Canadian Rockies passes through a long pupal period during the hottest and driest part of the year. In the dry hollowed-out needle the pupa, though partially protected, is nevertheless exposed to desiccation and high temperature, for a period of up to six weeks. This stage is important in many Lepidoptera as the period when the ovaries are developed and oogenesis takes place. Desiccation during this period can greatly reduce the egg potential. It is conceivable that only certain areas, in certain years, provide conditions favorable to this process. This suggests the problem of determining the effect of environments in the non-infested areas to find whether or not they provide conditions favorable to egg formation.

The pupal stage is beset with other hazards to survival at that time, the principal ones in the needle miner being parasites and birds. As another obstacle at the time of emergence, the adult may be unable to free itself from the pupa or needle containing it. Here again atmospheric moisture conditions may be influential.

The eggs developed in the female must be fertilized if they are to hatch. The process of mating in Lepidoptera meets with maximum success only within rather narrow limits of temperature, humidity, light and air movement. Under adverse environmental conditions, low fertility may result. Here is another problem for study.

Next, the fully formed, fertilized eggs, contained in the female, must be successfully laid. For this, the female must live a sufficient length of time and she must experience suitable environmental conditions in order to lay them. Adverse temperature, and humidities during this period may cause a failure of the population in most areas and in most years. The eggs of the needle miner in the Canadian Rockies are almost exclusively laid within the cavity of the dry needles mined out during previous larval feeding. Here the delicate eggs are moderately well protected from mechanical damage, but not entirely from desiccation and heat. The success in hatching may thus vary locally, regionally and seasonally.

When the larva has issued from the egg, it must crawl from the old mined-out needle to seek the foliage of the current season's growth. Then, having found suitable needles, it must bore through the epidermis to find food and relative security. In this process of locating its food, the larva must overcome the trials of establishment during late summer and early fall. In the needles, the larva feeds during autumn as long as temperature permits. Under continually falling temperatures it apparently enters an induced diapause, in which state it does not respond readily to warming. During the winter months it is subjected to intense cold, sometimes of considerable duration, depending on the locality, altitude, and inflow of Chinook winds. Towards spring it may be subjected to early warming and partial activation, followed by sub-zero temperatures. Severe conditions between autumn and spring result in drastic reductions in needle miner populations. The degree of mortality varies according to locality and altitude. There appears to be less mortality in valleys where premature spring warming does not occur. There is also less killing at a certain elevation above the valley floor, the reason probably being the presence of a warmer thermal layer during winter cold. It is probable that certain areas never provide winter conditions permitting population build-up of this insect.

Finally, during a first summer of larval development, the needle miner is attacked by parasites, diseases and birds. Then it is exposed to a second winter of cold and a second summer of attack by natural enemies before it finally pupates. It is evident that the needle miner must pass the test of numerous critical conditions if it is to increase or even merely survive. Some areas, we know, provide conditions which, on occasion, permit population increase. Other areas probably are always unfavorable in at least one respect. In those areas, epidemics may never occur, regardless of the presence of an endemic population, and despite contagious tendencies of populations in adjacent areas. It may well be asked if perhaps the East Slope of the Rockies is too dry and hot during the reproductive period of the insect, and too cold or changeable during the overwintering stage of the larvae.

The needle miner therefore offers many interesting and productive ecological problems. It is especially convenient for study because, in the needle, the larva possesses relative fixity of abode, and thereby is amenable to refined sampling methods. With pine as a host, it is possible to estimate the number of miners per branch tip, the number of branch tips per tree of various heights, and the number of trees of various sizes per acre. From these data a population census of the insect has been possible. Applying percentage figures for parasitism, it has been possible to determine the number of parasites per acre.

This insect is therefore an eminently suitable one for developing population sampling statistics. The acquisition of reliable procedures for taking stock of populations will be of material assistance in measuring the influence of various factors. Nevertheless, after many decades of entomological progress, in this case we cannot do better than turn to the insect itself for the real answers to some of the most far-reaching problems.

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