OBSERVATIONS ON THE EFFECT OF DROUGHT IN INSECT POPULATIONS WITH ESPECIAL REFERENCE TO HETEROPTERA HOMOPTERA AND LEPIDOPTERA

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For many years entomologists have speculated on the causes of fluctuation in insect abundance, some of which are readily explained and others mysteriously obscure. Diseases, predators, parasites, destruction of host plants, storms and drought all play a part in regulating the number of insects. Some observations on the effect of drought on Vancouver Island form the subject of this paper.

The south-eastern part of Vancouver Island has an extremely light summer rainfall, similar to that of the interior dry belt south of Penticton. During the months of June, July and August the area around Victoria is probably the driest part of the Province, the total average rainfall for those months being 1.98 inches; this is a 65-year average. At Sidney the average for 37 years is 2.62 inches. Summer rains of any consequence are unusual and the country becomes dry and parched. This lack of summer moisture may account partly for the scarcity of diurnal lepidoptera on the island. Except for the ubiquitous cabbage butterfly and the small ringlet, *Coenonympha inornata insulana* McD., which is probably the most abundant butterfly on the island, few butterflies are seen during June, July and August. This scarcity of butterflies compared with the numbers which may be seen in the northern Okanagan Valley where summer rains frequently occur is very noticeable. The difference is not only in the number of species, but in the number of individuals of any species. In further comparison, although in Great Britain are found only 68 species of butterflies, some of them rare or occasional visitors, the abundance of butterflies is one of the features of the countryside and no doubt is due to the moist climate and high humidity which enable the food plants to remain lush and green.

Vancouver Island has 49 species of butterflies out of 155 species occurring in British Columbia. The proportionate number of moths is somewhat greater. The comparatively small number of species found on the island is not entirely due to climatic conditions but also to the nature of the country and its vegetation. Whereas the interior of the Province has large areas of open country interspersed with park-like spaces and low-lying ground, affording support for a long list of grasses and plants, Vancouver Island and the coast in general have no such terrain. Formerly several thousand acres of park-like land existed at the southern tip of Vancouver Island, much of which is now covered by the city of Victoria. There is a small area of a similar nature at Duncan and one at Comox and a few wide open patches on some of the islands in the gulf. Elsewhere the forest reaches to the water's edge, so that the area suitable for the growth of herbaceous plants is restricted. Of the 49 species of butterflies on Vancouver Island, 32 are herb or grass feeders, 13 are tree or shrub feeders and the hosts of four are unknown. Thus, drought conditions, by drying up the herbaceous plants and grasses, could well account for the small number of butterflies to be seen. This hypothesis becomes more probable in the light of what happened to insect life during the dry summer of 1951.

In that year the southern portion of Vancouver Island and the adjacent mainland were subject to the longest period of drought that had been recorded for fifty years. On Vancouver Island a continuous period of 95 days occurred, from May 25 to August 27, with not more than a

Average relative humidity and average temperature for 1951 compared with 1950 at Langford Forestry Station during June, July, and August.

	Average Relative Humidity per cent		Average Temperature degrees Fahr.	
	1950	**1951**	**1950**	**1951**
June	68.2	66.5	62.3	65.5
July	66.2	66.4	66.1	68.3
August	69.3	67.2	65.7	64.2

trace of rain. The drought could be said to have started earlier than that, however, since from May 13 to May 25 only .08 of an inch was recorded, an amount so small as to be negligible. Unfortunately it was not evident until the season was well advanced that a disastrous drought was upon us. Therefore no provision was made for anything resembling a quantitative survey or accurate recording of populations and the fragmentary data which I have been able to assemble result from observations made in the course of collecting trips at various times from May to September.

Through the courtesy of the Provincial Department of Forestry I was allowed to examine the meteorological records of the forestry stations. Those of the Langford Forestry Station, six miles inland, as summarized in the table, were selected as most typical of southern Vancouver Island. Such records are not necessarily representative of the places where insects were collected but reflect conditions in a general way. Relative humidity was unusually low, averaging during the three critical months about two per cent less than the previous year, while the average temperature was about two degrees higher. Moreover, during the hours from 8 p.m. to 4 a.m., the period during which humidity is highest, there was an unusual lag in the increase of relative humidity, the recordings in the first part of the period being exceptionally low. The prevalence of drying, northeast winds was a contributing cause. Also, inversion of humidity was observed. Whereas humidity should be higher on the lower levels and lower on the high levels; the reverse was often the case. These conditions were disastrous to vegetation and to the insects dependent on it. Arboreal species generally suffered less than those which feed on grasses and herbaceous plants but the number of species present on trees and bushes was generally much lower than normal. The effect of the drought conditions was to cause insects to concentrate on small patches of vegetation in shady places where a little moisture remained. Those species which inhabit swampy areas maintained their usual numbers along the banks of streams and estuaries but were killed-out where swamps had dried up. As the season advanced the moisture content of willows and other trees and shrubs, which normally support large numbers of insects, became too low and very few, even of common species, were found on them.

On the other hand, in valley bottoms and alluvial flats, alder trees and willows had the benefit of abundant moisture. Alder trees at the mouth of Goldstream creek were found to have an enormous population of a species of *Empoasca* and a fair number of *Psylla alni* Crawford. On the open grass flats at the mouth of the creek small leafhoppers concentrated on a few square feet of *Poa pratensis* which remained green. At a slightly lower level in a swamp grass and sedge association near tidewater, species of *Cicadula, Macrosteles* and *Sorhoanus* were found in their usual numbers and large numbers of tarnished plant bug nymphs were present with them.

On the river flats at Cowichan Bay a very large and luxuriant bush of *Salix scourleriana* growing close to the Cowichan river, where the water table could have been only a short distance below, was found to be swarming with a species of *Empoasca* and a considerable number of Nabidae and other insects. Less than twelve sweeps of the net secured 206 Homoptera. By contrast, the same species of willow growing at a higher level out of reach of the influence of

the water, yielded only 53 specimens of several species in about a hundred yards of sweeping. Thus, the survival of species and the extent of population was governed by the amount of moisture available. Insects were found to concentrate on any small oases formed by seepage from springs or on the banks of lakes or rivers with Homoptera predominating. Generally very few Heteroptera were found in proportion to Homoptera, except in some moist shaded spots where herbage remained green, Miridae being exceptionally scarce everywhere.

Having had long experience with the Heteroptera and Homoptera of this region I made an attempt to estimate the population of 64 species in terms of per cent of normal numbers. I found that of 42 grass and herb feeders, 30 species had decreased 70 to 95 percent, 8 species had decreased 30 to 50 per cent, and 4 species were in normal numbers. Of 16 tree and shrub feeders, 6 had decreased 70 to 95 per cent, 3 species had decreased 30 to 50 per cent, 5 species were in normal numbers, and two species of *Empoasca* showed an increase of 200 to 400 per cent. However, these estimates were made in localities favourable for insects. A properly organized quantitative survey over the entire district would have produced much lower averages. The two species of *Empoasca* on alder and willow, one of which was present in twice and the other in four times their usual numbers, were abundant only in exceptionally favourable spots and their numbers were probably augmented by migrants from trees on land where less moisture was available.

Predaceous species were similarly affected and the few that were obtained appeared to have decreased 50 to 80 percent. Several species of leafhoppers which are usually abundant seemed to have disappeared altogether. Of these *Aceratagallia sanguinolenta* Prov., a very small leafhopper which is usually abundant on grasses, was not found at all and had not reappeared three years later. However, the disappearance of this formerly very common species is linked with other causes, for it was found to be scarce in other parts of British Columbia not affected by drought in 1951. In three days of collecting at Kamloops by Mr. E. R. Buckell in 1954 only one specimen was obtained; collecting by myself at the same spot a few weeks later produced two, and one was taken at Spence's Bridge. None was found in the Fraser Valley or on Vancouver Island in 1954. The additional factor of drought at the coast appears to have reduced this species to such an extent that it may take many years to recover its numbers in that region. Others of the same group also were absent. Several species of small leafhoppers which feed on grasses were reduced to negligible numbers but were locally abundant the following year. The small ringlet butterfly which is usually abundant was scarcely seen at all. In fact, the number of species of various orders which were reduced by the drought would make an extensive list.

On the other hand, a few species either were unaffected or were benefited by the weather conditions. A heavy infestation of the aphis *Myzocallis punctatus* Monell occurred on Garry Oaks throughout the southern end of Vancouver Island, in fact, the worst that had occurred in recent years. This infestation did not result from an exceptionally favourable supply of moisture but from other conditions which could have been a decrease of parasites and predators due to drought or other causes. Many other species of aphids were abundant. It is worth noting in this connection that Hemerobiids and Chrysopids were exceptionally scarce that year and very few Coccinellids and Syrphids were seen. The *Myzocallis* infestation was greatly reduced in 1952, was still less in 1953, and in 1954 the species had nearly disappeared, which suggests that if drought was responsible for the decrease of predators they required three years to recover their numbers. Also on Oak trees a small moth, *Gelechia trichostola* Meyr, occurred in

unusual numbers. This species was heavily reduced during the next two years. The codling moth was abundant on Vancouver Island and the long period of warm weather and higher average temperature induced a partial second generation which is unusual at the coast. Other economic species which showed an increase were the apple leaf skeletonizer, *Anthophila pariana* (Clerck); the cherry fruit flies, *Rhagoletis cingulata* (Loew) and *R. Fausta* O.S.; the European earwig, *Forficula auricularia* L.; *Typhlocyba ariadne* McA. and *T. tenerrima* H.S. on loganberries; *Lecanium coryli* (L.); *Polyphylla perversa* Csy. in strawberries; the strawberry crown moth *Ramosia bibionipennis* (Bdvl.); cutworms and wasps.

In the lower Fraser Valley insects appeared to be affected in much the same degree as on Vancouver Island. Most species were greatly reduced in numbers. During the latter part of the summer very few insects were present on trees and shrubs, except where abundant moisture was available as in the case of poplars or other species growing near water or where watering was carried out in cities.

It is fairly obvious that the principal cause of the high mortality among Heteroptera, Lepidoptera and most of the Homoptera was the destruction of food plants. The reason that a number of species were able to increase and others maintained normal numbers is not clear, although most of them were tree or shrub feeders, which have a distinct advantage over grass and herb feeders in a dry season. But the factors governing insect populations are tremendously involved and include the presence or absence of predators, parasites and diseases. These in turn may be affected by temperature, moisture and humidity. The tolerances of insects with regard to temperature, moisture and humidity vary according to the species and although rains may fall in an otherwise normal season, it is important that they fall at the right time to provide sufficient humidity at the critical period of development for any individual species. Writers on the subject have suggested various results from the lack of sufficient humidity. Ludwig (1945, p. 107) states: "Ludwig and Anderson (1942) observed that, when the eggs of Saturniid moths were exposed to low humidity, many more larvae developed than emerged. In dry air many larvae pierced the shells but died without emerging. Hence, in these eggs the chorion is very efficient in preventing evaporation, retaining this function until pierced by the emerging larvae. Thereupon the larvae lose water so rapidly in dry air that very few of them are able to hatch." . . . "In some cases the limits of humidity which permit hatching are narrower than those which permit development, indicating that at the lower humidities, death occurs because the larvae are so weakened by loss of water that they cannot emerge or because desiccation hardens the chorion to such an extent that the larvae are unable to escape", (Pyenson and Sweetman, 1931).

The degree of humidity definitely influences the reproductive capacity of insects. "Low humidity may reduce the number of eggs laid by interfering with the mechanism of oviposition". (Ludwig 1945, p. 110). A combination of heat and dryness may cause desiccation of the pupae of insects. This is evidenced in the well-known case of the Hessian fly, for which drought conditions are unfavourable, since the larvae and pseudopupae are easily killed by dryness. The adults also die prematurely without realizing their productive abilities. Eggs do not hatch successfully, or young larvae are unable to reach the tender parts of the stem.

The recovery of Heteroptera and Homoptera after the year of drought was, for a large number of species decidedly slow. In 1952, except for those species which are always reasonably abundant, few insects were collected even in favourable spots, although the summer rainfall was slightly above the average. In 1953

there was an increase in numbers although still not up to the average. What I would consider normal conditions were not reached until 1954, although even then certain species were still absent. Those species which I mentioned as occurring in abnormal numbers in 1951 were reduced to minimum populations the following year, which is usually what happens following over-abundance. To correctly assess the effect of weather variations on insects is a most difficult matter for, apart from the direct effect of destruction of food plants, intolerance to excessive heat and low humidity, the actions of predators, parasites and diseases have to be taken into account, and as these vary with each species, the problem becomes exceedingly complex. Periods of abundance may be long or short according to the species, and weather cycles may have a direct effect on the length of these periods. Thirty-five years ago many species of Heteroptera and Homoptera were much more abundant than they are now. I have not seen some of the species which were abundant then, for twenty years or more; and some have re-occurred only occasionally. But eventually when favourable conditions return, each species will regain its former abundance.

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NOTES ON THE LIFE HISTORIES OF FOUR SPECIES OF MOTHS (LEPIDOPTERA: PHALAENIDAE) INDIGENOUS TO VANCOUVER ISLAND, BRITISH COLUMBIA

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Among several life histories and partial life histories, worked out during the year 1954 the following are submitted as a contribution to our knowledge of local entomology.

Ulosyneda subtermina Sm.

This is a Western American species, occurring from British Columbia to California. In British Columbia it seems to be confined to Vancouver Island, wherever its food plant the Garry Oak (*Quercus garryana*) grows. Information regarding the early stages is not readily obtainable, at any rate I am not aware of any published records.

Although not a conspicuously coloured moth it is quite distinctive, with shades of ashy brown dotted with black at tip of forewings, and etched with darker lines, unlike any other moth of similar size and appearance. It measures one and one half to one and three quarter inches (40-47mm.) in wing expanse. It is a night flier, and is readily attracted to artificial light in the vicinity of the Garry oak during the months of April and May.

Material for the present account was obtained in a light trap. A female taken on May 11 was confined