THE PRICKLY-PEAR PROBLEM IN AUSTRALIA

By Dr. A. D. Imms, F.R.S.

THE entry of the prickly-pear into Australia dates from about 1787, when the species *Opuntia monacantha* was introduced from Rio de Janeiro. The object was to establish the cochineal industry in that land since prickly-pears constitute the host for this particular kind of insect. Some twenty-five other species of Opuntia have found their way into Australia, but their origins cannot be traced. All have become naturalized either as serious pests, minor pests or as garden escapes. The two major pest species in Australia are *Opuntia inermis* and *O. stricta*. At one time landowners grew hedges of prickly-pear around their homesteads until they got out of hand and then the hedges were cut down. The rapidity with which these pests have increased is one of the botanical wonders of the world. Their original home is the coastal sector of Texas and Florida where the mean rainfall is 40–50 in. Yet in Australia the plants have adapted themselves to a very different environment and with a precipitation of only 20–30 in. annually. In 1900 an area of about 10,000,000 acres was affected in Queensland and New South Wales. The invasion advanced with such celerity that at the peak, in 1925, the affected area must have been greater than 60,000,000 acres: in some years the annual increase in infested territory exceeded 2,500,000 acres. The main distribution takes place by seeds, but every broken-off segment of the plant is liable to take root.

The problem of the control and eradication of the pest has been a matter of cost. The great bulk of the infested territory, stretching 900 miles between lat. 20° S. at Mackay, Queensland, to lat. 33° S. at Newcastle, N.S.W., is natural grazing land generally worth less than £1 per acre. Biological control of prickly-pear was first advocated in Australia in 1899. In 1912 the Queensland Government appointed a Travelling Commission to investigate possibilities of biological control in view of the increasing difficulties facing mechanical and chemical methods of eradication. The Commission comprised Dr. T. Harvey Johnston, professor of biology at the University of Queensland, and Mr. Henry Tryon, Government Entomologist to the State. They visited many countries where prickly-pears were indigenous or had become acclimatized and made valuable recommendations for the introduction of insects and diseases affecting Cactaceæ. During these travels small stocks of the cochineals, *Dactylopius ceylonicus* and *D. greenii*, were forwarded to Australia. The first-named was liberated in the field and in a few years it almost completely eradicated *Opuntia monacantha* and this achievement gave a stimulus to efforts in biological control.

In 1920 the Commonwealth Prickly Pear Board came into being with Prof. T. Harvey Johnston as scientific controller. It was established to investigate the whole question of the biological control of prickly-pear, being supported by the Commonwealth Advisory Council of Science and Industry and by the Governments of Queensland and New South Wales. Mr. Alan P. Dodd's report* is an official record of the campaign and its progress from the Board's inception in 1920 up to the year 1940. The Board, it may be added, has been an independent body from its start, exercising complete control over its investigations, finances and staff. During the nineteen-year period June 1920 to May 1939 the sums actually spent on prickly-pear control amounted approximately to £168,000.

The operations of the Board were governed by the fact that in America insects, diseases and other agencies keep the prickly-pear within reasonable bounds, whereas in Australia such natural controlling agencies are wanting and there is little check on the spread and reproduction of the pest. The Prickly Pear Board was concerned with an attempt to bring about a condition of biological equilibrium by the introduction of insects and diseases likely to provide natural checks. The control aimed at depended upon the introduction of a complex of organisms working collectively in destructive unison. Officers of the Board studied insects affecting Opuntia in many lands, covering widespread areas of cactus growth in North America, South America and the West Indies. In work of this character it is important to study on the spot, not only those insects actually attacking prickly-pear, but also the natural parasites and predators affecting them. The exclusion of such restraining agents from Australia, if their hosts are to multiply freely and vigorously attack the prickly-pear in the new surroundings, is of prime importance.

The Board established a station at Urvalde, Texas, where extensive preliminary biological work has been carried out and the most promising cactus-feeding insects bred under caged conditions. Also, such insects were tested by starvation and other means regarding the possibilities of their attacking cultivated plants of economic value. The selected

* The Biological Campaign against Prickly-Pear. By Alan P. Dodd. Published under the authority of the Commonwealth Prickly Pear Board. Pp. iv+177+37 plates. (Brisbane: Government Printer, 1940.)

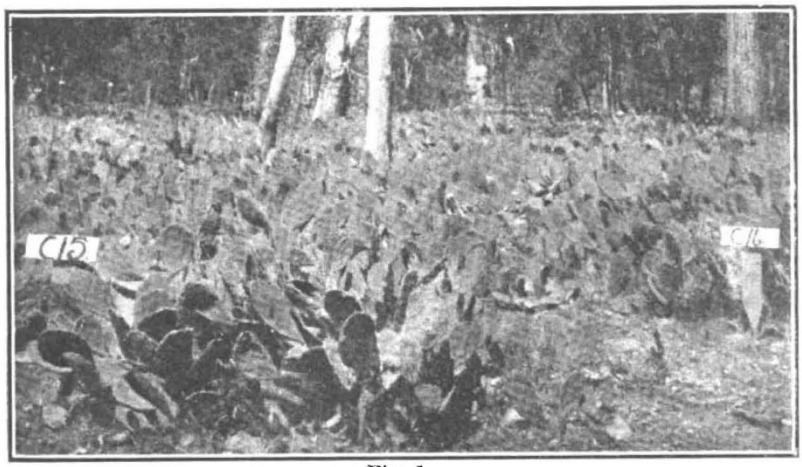

Fig. 1.
DENSE PRICKLY-PEAR, *Opuntia inermis*, PRIOR TO ATTACK BY INSECTS, CHINCHILLA, QUEENSLAND, OCTOBER 1926.

species received from America were shipped to quarantine buildings at Sherwood, near Brisbane. Here they were again bred through one or more generations in order to preclude the escape of any parasites that might have been accidentally introduced at the same time. Also, additional tests were undertaken in order further to explore any possibility that the introduced insects might attack crops or other useful plants and not confine their activities to prickly-pear. From Sherwood, species that were deemed promising and that had withstood the foregoing testing, were eventually forwarded to acclimatizing and breeding centres where the first liberations into the open country were usually carried out.

In all, twelve species of prickly-pear insects were introduced and established in Australia. On the other hand, 150 species of cactus-feeding insects were discovered in America and of these about 50 species were imported into Australia. It will be noted that the greater number were rejected for various reasons. Many were confined to cacti other than Opuntia; others caused too little damage to be of potential value, while some forms were discarded because they did not pass the stringent tests as regards their feeding propensities. Lastly, the unexpected and overwhelming success attending the introduction of a single species of insect rendered further importations of other kinds superfluous.

Of the various species that have become acclimatized to Australian conditions the moth *Cactoblastis cactorum*, the larvæ of which tunnel through the tissues, is the most important. The cochineal became distributed almost everywhere in the prickly-pear country and the plant-sucking bug, *Chelinidea tubulata*, spread in countless millions over various localities. The red spider, *Tetranychus opuntiæ*, said to be only a biological race of the European *T. telarius*, also spread over many thousands of square miles. In his 1929 report Dodd stated that the established complex of insect enemies was already bringing about a considerable degree of prickly-pear control. In the heart of the infested country it was possible to travel for 100 miles without seeing any healthy plants. Thus it would appear that the original conception of a biological association of different enemies working in unison was well justified. It was quite unforeseen, and could not have been foreseen, that the outstanding success in the repression of prickly-pear achieved up to 1936 would have resulted from the activities of a single species of insect. The agent in question is the Phycitid moth, *Cactoblastis cactorum*, from South America. This fact is all the more remarkable because only one small consignment of material was introduced into Australia. It took the form of about 2,750 eggs obtained in the Argentine in March 1935 and, a year later, two generations of this insect had been reared in captivity, the original number multiplying to 2,540,000. Between 1928 and 1930 about three thousand million eggs, laid by the descendants of insects from the original batch, were distributed in the prickly-pear areas. The

Fig. 2.
THE SAME AREA AS IN FIG. 1 THREE YEARS LATER, OCTOBER 1929, AS A RESULT OF THE ONSLAUGHT OF CACTOBLASTIS.

orange-red larvæ are gregarious internal feeders, which tunnel in companies through the tissues of the plant, thus providing also for the ingress of disease organisms. In this manner the prickly-pear ultimately becomes so completely destroyed that it is reduced to a rotting mass of pulp.

The various other insects that were established have either become suppressed, or their activities nullified, owing to competition with the Cactoblastis. It is only locally, and in relation to a few Opuntia species of minor importance, that the Cactoblastis has shown itself to be ineffective. The most serious of these plants is *Opuntia aurantiaca*, but there is good reason to believe that its control by a species of Dactylopius (cochineal), also from the Argentine, seems assured.

The results of the repression programme have led to 22,000,000 acres of former dense pear country in Queensland being selected for settlement. The previous value of this land was almost nothing, but freed from the pest its capital value would average 10*s*. an acre, without taking into consideration the worth of the new improvements in fencing, water facilities, removal of timber, etc. Hence the State has gained an asset of at least £10,000,000 because of the availability for farming of land hitherto useless. The area once under impenetrable prickly-pears, and now converted to dairy pastures, must exceed 1,000,000 acres on which many hundreds of new settlers live. In New South Wales the greater part of the former prickly-pear country has been brought into production, mainly for sheep grazing, and most of it has been utilized to enlarge adjacent pastoral properties.

The present status of Cactoblastis is satisfactory. Concentrated numbers of larvæ are still attacking, reducing and destroying many of the remaining prickly-pear areas of heavier growth. Native parasitic Hymenoptera are not exercising an undue amount of control and their importance is not growing. After an interesting discussion of the future of the problem, Mr. Dodd concludes that, up to date, there is no indication that prickly-pear will not continue to be held in complete subjugation by its remarkably efficient lepidopterous enemy.

THUNDERSTORM PROBLEMS

By Dr. F. J. W. Whipple

On July 20 the London Branch of the Institute of Physics visited the Royal Meteorological Society at South Kensington to take part in a discussion on "Thunderstorm Problems". Sir George Simpson, president of the Royal Meteorological Society, was in the chair—a happy arrangement, for Sir George has been working at thunderstorms for nearly forty years; his classical work in India, which included the experiments on which the breaking-drop theory of the production of electricity is based, was published so long ago as 1909 and his most recent papers on the subject describe work of equal importance.

The discussion was opened by Dr. T. E. Allibone, who spoke on "The Physics of Lightning". His survey began with the year 1889, when Vernon Boys told the Physical Society that a lightning flash consisted of many separate strokes traversing the same path. Later, Hoffert recorded eight strokes on a photographic plate by waggling the camera about a vertical axis, and Walter, by using a camera mounted on a turn-table, was able to show that the strokes might be spread over a period of a second. It was Boys again who constructed a camera incorporating two identical lenses rotating about a common axis. The two images of a flash photographed with this camera were distorted differently and, the rate of rotation of the lenses being known, the speed with which the flash had developed could be determined. The Boys camera has been used effectively by Schonland in his studies of storms in the neighbourhood of Johannesburg.

Schonland and his collaborators demonstrated that a lightning flash to earth is a very complicated phenomenon. There is a preliminary 'leader' which starts from the cloud and sends out a number of branches; when one of these reaches the ground it becomes the channel for the main stroke up which the luminosity travels from ground to cloud. Subsequent leaders and main strokes use the same channel. The first leader alone is branched. Its progress is by jerky steps of about 50 metres. Comparison with electrical records has shown that the current in the main stroke is a hundred or more times as strong as that in the leader stroke. The main stroke removes to the ground the charges lowered from the cloud by the leader and retained for a while as ionization in the channel. It may be noted that in detailed studies the timing of a leader is conveniently reckoned in milliseconds, that of the progress of the main stroke in microseconds, while the intervals between the strokes are a few hundredths of a second.