

This grass is no doubt a true *Agropyrum*, in spite of its branching rachis and pedicellate spikelets. The species is named in compliment to Mr. Cox, who has done a great deal to advance our knowledge of the interesting flora of the Chatham Islands, where he has long been resident.

ART. XXXVI.—*The Vegetable Caterpillar* (*Cordiceps robertsii*).

By H. HILL, B.A., F.G.S.

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Plate XXI.

THERE is a small company of active scientific inquirers along the east coast of this North Island. In order to put down their thoughts and gain information from others of like tastes to themselves they issue a newspaper in manuscript, known as the "East Coast Naturalist." In one of the numbers of this interesting publication appears a letter signed "W. M.," in which the writer calls attention to an article by James Buckland on the "Vegetable Caterpillar." "W. M." does not say where the article appears, but mention is made of the differences between the generally accepted information concerning the caterpillar (*Cordiceps robertsii*) and the information given by Mr. Buckland. No doubt there is a good deal of misapprehension with respect to this curious product, and it may be that a study of its life-history will even prove of benefit to the students of bacteria in relation to their effects on animal organisms.

Comparatively little appears to be known concerning the vegetable caterpillar beyond the fact that it is found in certain places in the North Island of New Zealand. The first published account of the caterpillar is in the "Tasmanian Journal of Science" for the year 1842. In vol. i., pages 307, 308, there is an account, accompanied by two illustrations, of the bulrush caterpillar (*Sphæria robertsii*), native name "aweto-hotehe," by the Rev. R. Taylor, Waimate, New Zealand. "This singular plant"—so runs the account—"which is a native of New Zealand, may be classed amongst the most remarkable productions of the vegetable kingdom. . . . The aweto is only found at the root of a particular tree—the rata. The female pohutakara (*sic*), the root of the plant which in every instance exactly fills the

body of the caterpillar in the finest specimens, attains a length of $3\frac{1}{2}$ in., and the stem which germinates from this metamorphosed body of the caterpillar is from 6 in. to 10 in. high. Its apex when in a state of fructification resembles the club-headed bulrush in miniature, and when examined with a powerful glass presents the appearance of an ovary. There are no leaves; a solitary stem comprises the entire plant, but if any accident break it off a second stem arises from the same spot. The body is not only always found buried, but the greater portion of the stalk, as well as the seed-vessel, alone is above ground. When the plant has attained its maturity it soon dies away. These curious plants are far from being uncommon. I have examined at least a hundred. The natives eat them when fresh, and likewise use them when burnt as colouring-matter for their tattooing, rubbing the powder into the wounds, in which state it has a strong animal smell. When newly dug up the substance of the caterpillar is soft, and when divided longitudinally the intestinal canal is distinctly seen. Most specimens possess the legs entire, with the horny part of the head, the mandibles, and claws. The vegetating process invariably proceeds from the nape of the neck, from which it may be inferred that the insect, in crawling to the place where it inhumes itself prior to its metamorphosis, whilst burrowing in the light vegetable soil, gets some of the minute seeds of this fungus between the scales of its neck, from which in its sickening state it is unable to free itself; and as a consequence these, being nourished by the warmth and moisture of the insect's body, then lying in a motionless state, vegetate, and not only impede the process of change in the chrysalis, but likewise occasion the death of the insect. That the vegetating process thus commences during the life of the insect appears certain from the fact of the caterpillar, when converted into a plant, always preserving its perfect form; in no one instance has decomposition appeared to have commenced, or the skin to have contracted or expanded beyond its natural size."

The "Transactions of the New Zealand Institute" contain some information on this interesting question, but no experiments seem to have been carried on by any of those who have written on the subject, and the information that contains the first descriptive account of the hotehe is perhaps as full and as correct as anything that has since appeared.

In the "Proceedings of the Wellington Philosophical Society," 14th November, 1894, there is an abstract of a paper on vegetable parasites by the late W. M. Maskell, and some valuable remarks are given as to the action of vegetable parasites on insects. Referring to the house-fly fungus (*En-*

tomophthora muscæ) and various fungi that attack homopterous bush insects, the vegetable caterpillar came under notice. "The grub," said Mr. Maskell, "was stated to be the larva of some large moth, probably of the genus *Hepialus*, and the fungus belonged to the genus *Cordiceps*. The action of the fungus on the insect was practically the same as in the case of the fungus on the house-fly, as it took possession of and destroyed all the internal organs; but, as the caterpillar was subterranean, the fungus, in order to reach the air and scatter its spores, pushed out a long stem through the earth, and at the extremity of the stem the 'asci,' or small bags containing the spores, were developed."

Following Mr. Maskell's remarks, Sir Walter Buller ventured to challenge Mr. Maskell's description of the vegetable caterpillar, because he considered it unscientific and misleading, and he pointed out that in Mr. E. Wakefield's book, "New Zealand after Forty Years," there was an erroneous figure of the vegetable caterpillar, which was represented as lying horizontally, with the stems growing upwards at a right angle with the body. Mr. T. W. Kirk at the same time remarked that specimens of *Hepialus* do not take to the ground, and that the stems of the vegetable caterpillar "grow from either end, and from both ends, of the single specimen."

In the "Transactions of the New Zealand Institute" for 1894, page 155, Sir Walter Buller has a paper on the vegetable caterpillar, but he brings no new facts to bear on the life-history of this interesting insect. He gives, however, the following statement from the late Mr. Skey, then Government Analyst, touching the so-called skin of the vegetable caterpillar: "The skin does not give any indication of the presence of chitine or other animal substance. It burns without intumescence, and does not evolve the odour of nitrogenous matter in combustion." Sir Walter found, however, that it was necessary to correct a statement that he made at the meeting referred to above, to the effect that in every instance that had come under his observation the caterpillar, in the living state, had descended into the ground tail foremost, his subsequent examination of specimens in his collection showing a specimen caterpillar that had evidently buried itself head foremost.

As to where this caterpillar is found, I quite agree with Sir Walter Buller as to the general distribution of the vegetable caterpillar over the whole of the North Island; and, of course, the statement made by the Rev. Mr. Taylor, as quoted above, is erroneous. I have found specimens all over the North Island except on the peninsula to the north of Auckland. Along the Bay of Plenty and in the bush country between Lichfield and Rotorua they are very plentiful. They are

common in the uplands where the soil is porous and pumiceous, as between Napier and the volcanic country, and the specimens vary remarkably in size and general appearance. They are not obtainable at all times of the year. I have gathered them at Tarawera and Te Haroto, in the bush, during October, November, and December, and they were being sold fresh and in good condition by the native children along the railway-line leading to Rotorua late in March two years ago.

The specimens vary from $1\frac{3}{4}$ in. to $3\frac{1}{2}$ in. in length, and the shoots or stems vary from 3 in. to as much as 15 in. I happen to have available for reference two collections of the vegetable caterpillar, one of my own and one belonging to my friend Mr. A. Hamilton. They were collected from different districts, and a careful inspection of them seems to point to the fact that a special study of the vegetable caterpillar will provide some valuable information in the direction suggested by the late W. M. Maskell.

It is not yet known what grub it is that inhumes itself in the earth, but I do not think it is the *Hepialus*, as the segmentation is different, and the mandibles do not agree. I am endeavouring to obtain specimens of the live caterpillar from the natives, who say that it can be got at certain times of the year; but, unfortunately, it is difficult to get a native to proceed into the bush for the mere purpose of gathering a few caterpillars.

In order to show that the prevailing idea about the vegetable caterpillar is an incorrect one, I have photographed a number of specimens, each being different from the others: (1) Caterpillar with a single stem; (2) caterpillar with two stems at the same end; (3) caterpillar with bifurcated growth from the same end; (4) caterpillar with much-branched stem, like a stag's horn; (5) caterpillar with two stems united 2 in. or so from the head, followed by a bifurcation, one with and one without spines; (6) caterpillar with two stems, one at the head and one at the tail. These examples suffice to show that the caterpillar, when it inhumes itself in the ground, is affected by the spores at a different period in its movements, and there seems to me not a shadow of doubt that the caterpillar moves head foremost into the earth. I have quite a number of specimens where it is evident the fungus began to shoot as the caterpillar was head downwards, others where the caterpillar was seemingly preparing to leave the earth when the fungus began its deadly work, and absorbed the whole of the life's-blood of the caterpillar in the nourishment and maintenance of its own organism. The specimen with a shoot at either end is a proof in itself that the animal was in an almost horizontal position when it was attacked by two of

the active spores, that seemingly found a more than ordinary place for nourishment and generation.

The photographs, with the scale of inches beside the specimens, will explain the unusual length of some of the stems. It is a pity they do not show what might easily be shown by means of micro-photographs—viz., how the spores are generated. The spores, it would seem, are caught in a fold of the insect's skin in the process of inhumation, and the moisture of the earth causes the spores, or "asci," to send out a large number of filaments like a fan, and these grip the skin, just like the rata is seen to grip a matai. The skin, or chitine, is subsequently absorbed, and the fine cilia pass within the animal and are nourished by the juices which are undoubtedly kept for use by the fungus until it is wanted in the process of growth, just in the same way as a spider preserves the juices of its prey by wrapping about it a material that takes the place of the skin or integument. Thus the growth of the stem of the fungus depends for its strength and nourishment solely upon the caterpillar which it surrounds, and in a measure replaces, keeping the internal organism for the sustenance of the plant in its growth and reproduction. I have made a number of experiments with the spores, and it appears they easily generate when placed under favourable conditions.

If a few are slightly moistened in a saucer the "asci" are seen to change at a great rate. At the part where they are fixed on the stem a kind of swelling takes place, and fine cilia-like spirules are thrown out in the form of a fan. The swelling represents a gelatinous-like substance of a whitish appearance. The growth takes place at a rapid rate, and I have noticed on several occasions that, if the spores are allowed after moistening to dry, a peculiar smell is given off like that of decaying fish. I am unable to account for the cause. Sir Walter Buller says that the late Mr. Skey could discover no traces of animal matter in any of the remains of the caterpillar. By burning the hardened and shiny portions of the head, claws, and tail a most pronounced animal smell results, and this is more perceptible in the case of specimens just dug from the ground.

Possibly the caterpillars when dug from the ground vary considerably in their structure and condition, and it is certain that until the full development of the spores has taken place and the growth dies there must remain a certain part of the caterpillar's body unused. As long as there is food for the sustenance of the fungoid growth it is evident that the stem continues to grow, and this can be seen whenever an unusually large caterpillar is discovered. The stem of the plant, as shown in the illustrations, extends to as much as

15 in. in the largest specimens, and in the smallest ones the stem is only 2 in. or so.

I have made a number of experiments to discover whether the spores would germinate on other caterpillars, but have been as yet unsuccessful. I believe, however, that it will be possible to trace the effect of the growing spores upon caterpillars when inhumed under favourable conditions, and experiments are now being carried on to test whether such is possible. To me it is evident that we know nothing whatever as to the life-history of the caterpillar known as *Cordiceps robertsii*. How it lives, where it lives, under what conditions it is inhumed and attacked are all questions yet to be decided. That the caterpillar is attacked by a spore externally is evident by a mere examination of the specimens, and I am inclined to the opinion that the mycelium-like growth merely surrounds or envelopes the caterpillar, but does not absorb the juices whilst the animal is living. It is curious that the spores only appear to find a favourite locality for production on the *Cordiceps robertsii*. All the specimens I have belong to the same variety of caterpillar, and, although I can cultivate the spores, all my attempts to get them to grow on other caterpillars have up to the present time failed. But the conditions under which the caterpillars have been placed may account for the failure, and further experiments are necessary before definitely stating that the fungoid growth is special to *Cordiceps*.

In any case, the growth of a vegetable organism upon an animal, from which it obtains sustenance, is suggestive to the scientist. The forms and functions of organized life have gone back, as it were, in these latter days to the study of the lowest known organisms, and the world of intelligence has been moved at the discoveries which scientific men have made in the domain of bacteriology. I make no remark upon the wonders of this noble science beyond suggesting that the vegetable caterpillar supplies a fine illustration of a vegetable organism depending for its life and its development upon an animal; and may it not be that the bacteria which flit here and there, sometimes to destroy and sometimes to renew, act upon animal functions in a similar way, and eventually destroy that upon which they are sustained and are brought to ripeness?

Appended are photographs of the varieties of the vegetable caterpillar referred to in this paper.

EXPLANATION OF PLATE XXI.

Fig. 1. *Cordiceps robertsii*.
 Fig. 2. " asci, showing mode of growth (micro-photo).