association with their elders. Where now are the teachers and exemplars?

THEO. GILL.

PRICE OF THE REPORTS OF THE HARRIMAN EXPEDITION.

I DESIRE to correct an error in my review of volumes three and four of the Harriman Expedition, published in the preceding number of SCIENCE (May 2, 1904). As I have been informed, the price which I quoted from a trade-list of the publisher applies to volumes one and two of the series and not to subsequent volumes. The price of volumes three and four, the ones reviewed, is $5.00 per volume.

ISRAEL C. RUSSELL.

SPECIAL ARTICLES.

AN ENEMY OF THE COTTON BOLL WEEVIL.

SPECIMENS of the cotton boll weevil were obtained in eastern Guatemala in 1902, during a visit made to that country in order to study the culture of coffee and rubber, for the United States Department of Agriculture. The insects, which were collected on the request of the Division of Entomology, were not found on the cotton cultivated by the Indians, but were very common in the flowers of the tree cotton growing spontaneously near a native house, a short distance from the cotton field. The beetles were secured in a rather inaccessible part of Alta Vera Paz, seldom visited by naturalists or other travelers. It lies between Cajapon and Sepacuite, and is inhabited only by primitive Indians and a very few Spanish-speaking 'natives' of mixed blood.

The Indian variety of cotton seemed very small and unpromising, only one or two bolls being borne on a plant; it seemed very strange also that so small a variety should be planted while the large tree cotton was so ready at hand. It was learned, however, from Mr. Kensett Champney, who has a most thorough acquaintance with the agricultural habits of the Indians, that this was the only variety of cotton planted by them in this district, and the one exclusively relied upon to furnish material for their native fibers. The absence of the weevils from the small Indian cotton was reported when the specimens of the beetles were brought back to Washington, but the diminutive size of the plant seemed to forbid any recommendation of profitable utility in the United States.

Later on, with the increasing acuteness of the boll weevil question and the voting of a special appropriation by Congress for the study of means of protection against its ravages, the existence of a variety of cotton in Guatemala which seemed not to be subject to the attacks of the boll weevil was recalled, and it seemed to the authorities of the Bureau of Plant Industry that every clue should be followed up. The Secretary of Agriculture authorized an investigation of the Indian cotton of Alta Vera Paz, to ascertain whether it possessed, in reality, any quality enabling it to resist the boll weevil, or to learn other causes of its immunity from the attacks of the insect. The custom of the Indians to plant their crops every year in tracts of land recently cleared by burning suggested an alternative possibility that if not actually resistant to the weevil the cotton might have an almost equally valuable tendency to quick growth, thus enabling a crop to be obtained before the weevils had time to become injuriously numerous. The importance of securing early varieties has been emphasized as the result of the investigations of the boll weevil in the United States.

In this part of Guatemala the present season has been much more rainy that that of 1902, and the cotton is much larger. Well grown plants bring to maturity from ten to twenty bolls of fair size, and even more. A thorough search shows that the weevil is present and able to injure the cotton, but reveals also an active enemy which keeps it in check. This is a large reddish brown ant which is attracted to the cotton by the food which it secures from three sets of extra-floral nectaries. Each leaf has a nectary on the under side of the midrib, from one to two centimeters from the base. Each of the large bracts of the involucre has a circular or broadly oval nectary close to the stem, and there is a third series of three nectaries at the base of the calyx, between the pair of small bracts alternating with the larger divisions of the involucre, of which

they seem to be, morphologically speaking, the stipules. Nectar is also to be found between the calyx and corolla, but no bees, flies, or other winged insects were observed visiting the flowers except beetles, sometimes the boll weevil, but much more often a small black staphylinid of very active habits. To these and to the very small black ants which are also occasionally present in numbers on the cotton, the large brown ant pays no attention, but the weevil is attacked on sight and becomes an easy prey.

The ant's mandibles are large enough to grasp the weevil around the middle and pry apart the joint between the thorax and abdomen. The long, flexible body is bent at the same time in a circle to insert the sting at the unprotected point where the beetle's strong armor is open. The poison takes effect instantly; the beetle ceases to struggle, and with its legs twitching feebly is carried away in the jaws of its captor. As with many other insects when stung by wasps the paralysis is permanent; even when taken away from the ants the beetles do not recover. The adroit and business like manner in which the beetle is disposed of, in very much less time than even the briefest account of the operation could be read, seems to prove beyond question that the ant is by structure and by instinct especially equipped for the work of destruction, and is, in short, the true explanation of the fact that cotton is successfully cultivated by the Indians of Alta Vera Paz, in spite of the presence of the boll weevil. Instead of congregating in large numbers on the cotton in the immediate vicinity of their nests the ants have, as it were, the good sense to spread themselves through the field, from 2 to 4 or 5 usually being found doing inspection duty on each plant. In some places there seemed to be not enough ants to go around, and here the beetles were more numerous. Rarely, too, certain flowers or branches seemed to have been overlooked, beetles being found on the same plants with the ants. In such instances, indeed, the young flower or boll was generally riddled with punctures as though many beetles had availed themselves of the rare opportunity of feeding undisturbed.

Cotton-growing among the Indians is something of a special art, the community being supplied by a few men aware, as it were, of the secrets of the business. They know nothing about the weevil and its ravages, and ascribe such damage as occurs to other harmless insects, or even to superstitious causes, such as the failure of the owner to abstain from salt at the time of planting. The ant, however, is definitely associated in their minds with cotton, and they do not expect to secure a good crop unless these insects favor the plants with their presence. Some of the Indians give the ant a special name, *kelep,* not applied to any other species, but it is also referred to as 'the animal of the cotton.'

In the neighborhood of Secanquim, on the coffee estate of Messrs. Champney and Company, where the most of our observations have been made, the ants are by no means widely distributed, and the cultivation of cotton is confined to very narrow limits, where it is planted year after year in closely adjacent places, or even on the same ground. In one instance the same Indian has planted cotton on the same hillside for upwards of forty years, with no failure to secure a crop except in one year, as he explained, when he was sick and did not sow! Such facts preclude, of course, any explanation based on the theory of temporary immunity secured from burning over the land or by planting in a new place in which the beetles have not had time to congregate. The cotton is sowed in October or November, a very rainy part of the year, when land can not be cleared by burning, and the weeds are pulled out and thrown with the dead corn stalks and brush into piles, which would protect the beetles rather than destroy them. The perennial tree cotton also furnishes permanent breeding-places, so that the conditions are most favorable to the propagation of the beetles in large numbers. The ants, however, are evidently able to hold them in check, and thus permit the regular cultivation of an annual variety of cotton by the Indians.

Ethnological data show that the weaving of cotton cloth was practised in tropical America for many centuries before the arrival of

Europeans, and the probability is great that the plant itself is a native of this hemisphere. In being carried to other countries it was taken beyond the reach of both the friends and the enemies which had developed with it. The boll weevil has migrated northward with the extension of the area of cotton cultivation into Mexico and Texas, but the ant has not yet followed. The question now is whether it can be induced to do so. The Mexican entomologists seem not to have found the ant in that country, in the northern states of which the weevil has been reported as very destructive.

That the ants are so localized in their distribution in this part of Guatemala has undoubtedly served the better to demonstrate their value as protectors of the cotton plant; it suggests also, with other facts, the probability that they are not native here, but have spread eastward in smaller or larger colonies as the forests were cleared away by the Indians. The present occupation of the eastern districts of Alta Vera Paz by the Indians does not date back more than a few generations, though abundant evidence of much more ancient inhabitants is found in the apparently primeval forests. The ants, like the Indians, probably came from the dry, open interior plateau region, where the center of the aboriginal cotton industry of Guatemala is still located, and where another visit to the ants is to be paid in the next few days. To establish such an origin for this useful insect would greatly increase the probability of its successful introduction into the United States. The acclimatization of a thoroughly tropical animal requiring continuous heat and humidity could scarcely be hoped for. If, however, the cotton ant can survive a long dry season and perhaps cold weather in the table lands of Guatemala it might easily learn to hibernate in Texas, as has the boll weevil. The ant, indeed, is much better able to protect itself against frost, since it excavates a nest three feet or more into the ground. That it is a reasonably hardy insect is shown also by the fact that several individuals have survived confinement for twelve days without food, and seem now to be thriving on a diet of cane juice. To take worker ants to Texas will be, evidently, a very easy matter, but to secure queens and establish permanent colonies may require considerable time and experiment, and a thorough study of all the habits of the species.

Although the cotton seems to be especially adapted to attract the ant by means of its numerous nectaries, the insect is not, like some of the members of its class, confined to a single plant or to a single kind of prey. It was observed running about on plants of many different families, and it attacks and destroys insects of every order, including the hemiptera, and even centipedes. On the other hand, it does not do the least injury to the cotton or to any other plant, as far as has been ascertained, and it can be handled with impunity, having none of the waspish ill-temper of so many of the stinging and biting ants of the tropics. Since where once established it exists in large numbers and seeks its prey actively, it is a much more efficient destroyer of noxious insects than the spider or the toad. It seems, in short, not unlikely to become a valued assistant in the agriculture of tropical and sub-tropical countries, if not in temperate regions. The farmer has a new and practical reason to 'consider the ant.'

An accumulation has been made, of course, of seeds, specimens, photographs and notes bearing on the cotton, beetles, ants and many other collateral matters not to be mentioned here. Even this brief preliminary report should not close, however, without an acknowledgment of the many favors of Messrs. Owen and Champney, owners of the Sepacuite estate, and of Mrs. Owen. Without the kind invitations, hospitality and extensive local knowledge and cooperation of these generous friends, it would have been quite impracticable to visit the Indian cotton district of the interior of Alta Vera Paz in 1902, or to ascertain the existence of the cotton ant in the present season.

O. F. Cook.

Sepacuite, Guatemala,
May 11, 1904.

Zygospore Formation a Sexual Process.

In a paper now in process of publication the writer has given a detailed account of a