TYLENCHUS SIMILIS, THE CAUSE OF A ROOT DISEASE OF SUGAR CANE AND BANANA

By N. A. COBB,
Technologist in Charge, Office of Agricultural Technology,
Bureau of Plant Industry

OCCURRENCE OF TYLENCHUS SIMILIS IN FIJI AND HAWAII

A serious outbreak of a disease among bananas (Musa sapientum) in Fiji in 1890–91 caused the planters great uneasiness. At the request of Sir John Thurston, British High Commissioner of the Pacific, the Department of Agriculture of New South Wales, Australia, undertook an investigation, which was conducted by the writer. Most of the banana plants examined grew in the gardens adjacent to Government House at Suva, Fiji, where experimental plantings were made in connection with the disease. During the investigations roots of the banana and the soil about the roots were examined with a view to discovering possible causes of the disease. It was during this particular part of the investigation that a new species of nematode was discovered, to which the name "Tylenchus similis" was applied. Only the male was seen.

Nothing further was discovered concerning this species of Tylenchus until 1907, when, during a visit to sugar plantations on Kauai, one of the Hawaiian Islands, the same nematode was again found by the writer, this time infesting the roots of sugar cane (Saccharum officinarum). Both sexes of the nematode were found in abundance, and to these specimens, which at the time appeared to represent a new species, the name "Tylenchus biformis" was applied. T. biformis proved to be a true parasite and was found to be sufficiently injurious to the roots of sugar cane to justify a careful examination.

The nematode appeared to attack the roots at or near the tips, with the result that the root soon succumbed, thus compelling the plant to throw out new roots, which in turn became infested. The attacks of the nematode resulted in striking lesions, easily discoverable whenever the attacks were of a pronounced character. The tissues of the root lost their white or colorless appearance and took on first a cinnabar-red color, then a reddish purple color. The latter was succeeded by a dark purplish red, and this in turn by a purplish black. The discolored areas were sometimes several millimeters in length. In advanced cases the tissue of the axial part of the root was attacked, and large numbers of the nematodes were readily discovered in the colored cavities caused by their activities. The seriousness of the result was increased by the fact...
that the breach created by the nematodes afforded entrance to fungous and microbic enemies.

It will thus be seen that this Hawaiian species of Tylenchus was found under circumstances conclusively proving its parasitic nature. Every degree of infestation was found in the sugar-cane roots, from those which upon external examination, even with a lens, appeared to be in a sound condition to roots spotted with numerous dark infested areas, each harboring scores of the nematode parasites. Sections of the roots showed that the cavities inhabited by the nematodes were colored or blackened on the inside and that it was this discoloration which gave rise to the outward appearances already described. All stages of the nematode were found in the cavities, including full-grown males and females, and it was plain that this species of Tylenchus lived generation after generation largely in the roots of the sugar cane, though it would undoubtedly be necessary, in the natural course of events, for the progeny sooner or later to remove from one root to another or from one plant to another. It was therefore to be expected that nematodes of this species would be found in soil adjacent to the roots of sugar cane, although the investigations made at the time did not disclose any stage of the parasite living free in the soil.

**OCCURRENCE OF TYLENCHUS SIMILIS IN JAMAICA**

Recently this nematode disease has been reported from the Island of Jamaica. The following are extracts from letters written by Mr. S. F. Ashby, Microbiologist of the Department of Agriculture, Jamaica:

I send you in a carton some fragments of diseased portions of rhizomes and true stems of the Jamaica (Gros Michel) banana preserved in dilute formalin. The disease, locally called "black head," shows as a black rot working into the tissue from the surface usually from around the insertions of diseased roots; the roots when attacked show depressed dark flocks at the surface, and within the cortex a purple rot disintegrating in the older parts.

The disease is widespread here owing to suckers for planting being frequently dug from affected stools; it is responsible for much backward growth and short bunches on land depending on rainfall in moderate or bad seasons.

Dr. Erwin F. Smith, after an examination of the material accompanying Mr. Ashby's letter, was of the opinion that the disease was not caused by *Fusarium* spp.

**DESCRIPTION OF TYLENCHUS SIMILIS**

A comparison of the species of Tylenchus found in Hawaii with the other species known at the time seemed to indicate that it was not identical with any form previously described. It was, however, pointed

---


The illustrations were prepared under the author's personal supervision by Mr. W. E. Chambers.
out that the males and females were so unlike that, had they not been found in conjunction and under such circumstances as to preclude the possibility of error in assigning them to one and the same species, it is probable that they would have been considered to be separate species. The remarkable similarity of the male to those of the species of Tylenchus previously found about banana roots in Fiji did not escape notice, but as the Fijian observations were incomplete, no females of the Fijian species having been seen, the question of the identity of Tylenchus similis and Tylenchus biformis was not raised. The present investigation establishes the identity of these two species. The species should therefore bear the prior name "Tylenchus similis Cobb, 1892."

This nematode is, in the opinion of the writer, clearly proved to be the primary cause of a disease of the sugar cane. Mr. S. F. Ashby, in a recent letter, writes as follows concerning its relation to banana:

I at first attributed the attack [on banana] to the joint action of a Fusarium and a coli-like bacterium frequently isolated from the rot; inoculation of either or both failed to cause a similar rot. Eelworms were always found present, and on going through samples from various sources again I invariably came across the same species in the advance margin of the rot both in rhizomes and roots.

The specimens forwarded by Mr. Ashby contained no other organism that would appear to have caused the lesions.

The following description of Tylenchus similis is derived from specimens forwarded from Jamaica by Mr. Ashby in diseased banana tissues.

Tylenchus similis Cobb. The moderately thick layers of the transparent, naked, colorless cuticle are traversed by somewhat more than 400 transverse striae, which are not further resolvable. The transverse striae are interrupted on the lateral fields by conspicuous wings, the presence of which is indicated by four longitudinal striae taking up a space equal to one-fourth to one-third the diameter of the body. The two outer of these lines are more conspicuous than the two inner, inasmuch as they are somewhat wider and more refractive. The two inner lines are sometimes faint and occupy about one-fourth to one-fifth the width of the entire wing space. The outer margins of the wings are almost imperceptibly crenate, a feature which is associated with the transverse striae of the cuticle; the inner lines are also crenate, but even less markedly so. These wings begin opposite the base of the spear, where, however, they are not so pronounced as along the median regions, and extend backward to near the end of the tail. They maintain their maximum development in a rather uniform way from opposite the nerve ring to a little behind the anus. The posterior portion of the neck is subcylindroid, while the anterior portion is convex-conoid, and ends in a rounded head, which in the

1 Nematodes.
female has a flattish, hemispherical lip region, set off by a more or less distinct constriction. The striae begin to diminish in size in the neighborhood of the base of the spear, and are only about one-third to one-half as wide at the base of the lips as they are farther back. These transverse striae are so pronounced a feature that they give to the contour of the body a crenate appearance, especially toward the posterior extremity. The lip region also is minutely transversely striated, the number of labial striae being about 8 to 10. There are arched radial ceratinous elements in the lip region, but these have not been accurately counted. It seems likely there are about six of them. The mouth opening is very small, and the vestibule is strengthened by ceratinous elements which serve as a guide to the spear. This latter is somewhat longer than the base of the head is wide and in the females at least is a strongly developed and doubtless very efficient organ. It may be divided into two regions the posterior of which is cylindrical, and ends at its hinder extremity in a strongly developed threefold bulb, about one-fourth as wide as the corresponding portion of the head, and to which are attached muscles that pass forward to near the outer portion of the base of the lip region. The anterior half of the spear is narrower, ends anteriorly in a somewhat blunt point, and is hardly half as wide as the larger posterior cylindrical portion. At the base of the spear the cesophageal tube begins. At this point it is about two-fifths to one-half the width of the corresponding portion of the neck. It has this diameter until near the median bulb, where it diminishes in such a way that at the actual junction with the bulb the diameter of the definite constriction separating it from the bulb is only one-fourth to one-sixth that of the neck. The median bulb is fairly well developed in the female, though much deteriorated in the male. In the female it is elongated to ellipsoidal in form, and about two-thirds as wide as the corresponding portion of the neck. It is supplied with a fairly well-developed but somewhat simple refractive valvular apparatus having a diameter nearly one-third as great as that of the bulb itself. Behind the bulb the cesophagus is again narrow—about one-sixth as wide as the corresponding portion of the neck. It soon widens out a little so as to become more than half as wide as the base of the neck. It joins the intestine in a somewhat indefinite manner. The length of the posterior part of the cesophagus may be judged by the fact that the distance from the anterior margin of the median bulb to the end of the cesophagus equals nearly half the length of the neck. In stained specimens the beginning of the intestine is indicated by the special cardiac cells of the intestine, which stain more strongly than the cells immediately behind them (fig. 1). The intestine is made up of cells which are packed with spherical granules of various sizes and of more than one kind. The smallest of the granules of the smaller sort have a diameter considerably less than the width of one of the striae; the larger are two or three times as wide. The fatty granules or accretions of the intestine, the granules
of the larger sort, are of very much larger size and give to the organ its peculiar pearly appearance.

From the inconspicuous anus the rectum leads inward and forward a distance about equal to the anal body diameter. The tail is conoid to the rather blunt roughly conoid terminus, which has a diameter about one-third or one-fourth as great as that of the base of the tail. On each lateral line, a little in front of the beginning of the middle third of the tail, there is a minute pore, which is possibly homologous with the single papilla found in the corresponding position on the tail of the male. The final strie are rather indefinite, so that the terminus appears almost as if not striated. The lateral fields appear to be more than one-third as wide as the body. The excretory pore is rather conspicuous, as is the duct leading to it. Both walls of the duct are distinctly refractive, and its lumen may readily be seen. The pore is located about as far behind the median bulb as the base of the spear is in front of it. The duct leads backward a distance equal to three to four body widths, and there joins the rather small ellipsoidal renette cell located on the left-hand side of the body. The exact details of this renette cell are not yet clear. There is a conspicuous refractive cell of rather uniform granular texture located just behind the excretory pore. This cell is longer than the body is wide, about one-third as wide as long, and has a strongly refractive nucleus about one-fourth as wide as itself. Closely associated with this cell are two others of similar form but somewhat smaller, the three forming a close tandem series twice as long as the body is wide. As a rule, the two posterior cells of this series exhibit peculiarities not shown by the anterior cell; they do not stain so strongly with carmine, and in general are less conspicuous. These three glandular cells empty through a narrow duct which enters the base of the esophagus in the rear of the nerve ring, passes through the median bulb, being diverted to pass around the central valve on its dorsal side, and extends thence onward to near the

Fig. 1.—*Tylenchus similis*: Nearly adult female. a, Lip region; b, spear guide; c, 3-bulbed base of spear; d, ampulla, salivary gland; e, esophageal lumen; f, esophagus; g, median bulb; h, nerve cells; i, nerve ring; j, excretory pore; k, initial intestinal cells; l, anterior salivary gland; m, m, end of ovary; n, ovum; o, renette duct; p, posterior salivary gland; q, fat granule, intestine; r, renette cell (?) ; s, terminus; t, caudal pore; u, vulva; v, anus; w, crenate cuticle; x, x, spermatozoa.
base of the spear, where the duct enlarges to form a distinct, elongated ampulla, emptying into the oesophageal lumen immediately behind the base of the spear. From the somewhat broadly elevated but otherwise not very conspicuous vulva the vagina leads inward at right angles to the ventral surface fully halfway across the body, where it joins the two uteri, one of which extends forward and the other backward. In the females found infesting sugar-cane roots on the Island of Kauai, in Hawaii, the thin-shelled eggs were observed to be about twice as long as the body is wide and fully five-sixths as wide as the body. They begin segmentation before deposition. The blastomeres are rather coarsely granular.

Male formula. \( m^1p^1 \) mm. The male differs in many important respects from the female, not only in the form of the tail end but in that of the anterior extremity as well. The neck of the male tapers rather regularly from the intestine forward, though it decreases rather more rapidly in diameter anteriorly, where it ends in a short, somewhat subcylindrical or hemispherical lip region set off by a deep and distinct constriction. This lip region appears to be composed of about the same number of striae as that of the female, and to have the same general structure in spite of its difference in form and size. The spear of the male, however, is very weakly developed and is nothing like so efficient an organ as that of the female; in fact, at times it is difficult to convince oneself that the male really possesses an oral spear. From the structure of the mouth of the male it appears somewhat doubtful whether he is able to make his way unaided into the tissues of the host plant. It seems more probable that he works his way into the cavities already created by the voracity of the female. The bulbous base of the spear is no wider than one of the nearby annules of the cuticle, and the shaft at its widest part is considerably narrower than any of the annules of the cuticle. It tapers anteriorly to an excessively fine narrow point. The wings of the male are similar to those of the female, but are hardly so strongly developed (fig. 2). The tail tapers from some distance in front of the anus and diminishes in size rather regularly to near the blunt terminus. The posterior portion is subcylindroid and ends in a bluntly conoid terminus, which is about half as wide as the base of the tail, and which, like that of the female, is not provided with a spinneret. The bursal flaps spring from the submedian lines at a point just in front of the proximal ends of the spicula. When the body is seen in profile, the bursa extends beyond the ventral contour from opposite the proximal ends of the spicula to near the middle of the tail and continues almost to the end of the tail. Near the junction of the middle and anterior thirds of the tail there are two ventrally submedian, finger-shaped papillae, which extend into the bursa and appear to reach about halfway to its margin. The bursa, like the cuticle, is striated, and its margin is crenate. The
regular striations of the cuticle extend nearly to the terminus. The two equal, slightly arcuate, or nearly straight, tapering spicula are about one and one-third times as long as the anal body diameter. Their proximal ends are cephalated by constriction. At their widest part, which is near the constriction, they are about one-fifth as wide as the corresponding portion of the body. Distally they taper to a slightly blunt point. The accessory pieces are about half as long as the spicula and are placed parallel to them. Passing inward the accessory piece increases in thickness for some distance and then near the middle begins to taper and at the same time to curve away from the spicula almost imperceptibly. The accessory piece appears to have attached to it muscles which pass backward, but the distal attachment of these muscles has not yet been made out. The single testis extends forward and has its tapering blind end located considerably behind the middle of the body. The proximal portion of the testis is about one-half as wide as the corresponding portion of the body. The males are more rare than the females, the ratio appearing to be about 1 male to every 5 to 10 females.

It is a rather remarkable feature of this species that the young have tails more blunt than the adults, the reverse being usually the case with nematodes.

Habitat. (1) About the roots of bananas (Fiji); (2) in the roots of sugar cane (Kauai, Hawaii); (3) in the roots of bananas (Jamaica).
CONCLUSION

On the basis of our present knowledge it is impossible to suggest the original habitat of this nematode. In view of its habits, its known distribution indicates that it is adapted to tropical and subtropical conditions of widely different character. Its infestation of plants differing from each other so widely as banana and sugar cane leads to the suspicion that it may be another addition to the already formidable list of nematode parasites which adapt themselves to a great variety of conditions. Its presence in Jamaica suggests the possibility of its introduction thence into Porto Rico and the southern portions of the mainland of the United States, where it would probably find suitable host plants in the sugar cane and might be expected to attack other plants.

In one way this investigation of the anatomy of *Tylenchus similis* adds materially to our knowledge of the group of Tylenchi to which it belongs. For a long time observers have noted in this group the presence of puzzling tissues or organs near the base of the neck, and these have been described and figured in a way that indicated a very incomplete and unsatisfactory knowledge of their real nature; in fact, they have always been regarded simply as constituents of the cardiac bulb. These researches prove that in *Tylenchus similis* these peculiarities of the base of the neck are due to the presence of a threefold gland emptying through the lumen of the oesophagus near the base of the spear.

What appear to be homologous organs are known in other genera and are regarded as "salivary glands," admittedly more on the basis of their structure than on the results of physiological tests. However, the morphological evidence is very strongly in favor of the conclusions reached.

The presence of such organs has not hitherto been noted in Tylenchus or any nearly related genus. The details of the organ are difficult to follow, but once they had been demonstrated it became evident that a similar organ exists in other species of Tylenchus, and it is especially interesting to note the presence of a similar organ in the well-known *T. dipsaci* Kühn, or, as it is yet more commonly known, *T. devastatrix* Kühn, the devastating nematode, so often responsible in the past for great damage to bulbous crops, such as the onion and hyacinth. This similarity in structure between *T. dipsaci* and *T. similis* makes it all the easier on structural grounds to suspect *T. similis* of becoming a serious pest whenever it gets an opportunity. Whatever may be the cause, there is no doubt of the ability of this species rapidly to break down the tissues of the plants it attacks. One may now suspect, and on very good grounds, that this ability is due not only to the battering action of the oral spear but to the chemical action of a special secretion. Entirely in accord with these ideas is the absence of this organ in the male of *T. similis*; when the oral spear deteriorates, the gland deteriorates also.