THE TETRANYCHIDAE OF OKLAHOMA

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PREFACE

While a member of the staff of the Mississippi Agricultural Experiment Station, a leave of absence was granted the writer to attend the Oklahoma Agricultural and Mechanical College for work toward the Doctor of Philosophy degree. Dr. D. E. Howell, Professor of Entomology and Head of the Department of Entomology, Oklahoma A. & M. College, suggested that a study of the spider mites of Oklahoma be undertaken. Since so little was known of the family Tetranychidae in Oklahoma, a taxonomic study and survey appeared in order.

My sincere appreciation is expressed to Drs. D. E. Howell, my major adviser, whose kind and patient assistance have been invaluable; D. E. Bryan, Assistant Professor of Entomology; F. A. Fenton, Professor of Entomology and Head Emeritus of the Department of Entomology; R. R. Walton, Associate Professor of Entomology, and H. I. Featherly, Professor of Botany and Plant Pathology, for their constructive criticism and suggestions.

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CHAPTER I

INTRODUCTION

Only a few of the families of mites now known contain plant feeding species and the most outstanding family in this respect is the family Tetranychidae.. All the known species of tetranychids are plant feeders and because some spin spider-like webs, they are called "red spiders", or has been suggested by Ewing (1914) to be more nearly correct, "spider mites".

Baker and Wharton (1952) have asserted that there is scarcely a plant that does not have at least one species of this family which will attack it and all species are potential threats to plant life.

In this country our first extended accounts of serious injury from spider mites came from some of the oldest sections of the country, New England and the North Atlantic States. Here they became serious pests of horticultural crops.

Some species of this family have been known for a long time. Ewing (1914) gives Linnaeus credit for describing the "common spider mite" in 1761. Later Schimer (1869) made reference to a spider mite but his description was most vague and the species cannot be accurately determined from it. Many of the early descriptions will fit almost any species of today because stable characters had not been discovered. For many years all species of a red color were considered to be one species and Worsham (1910) stated that "the popular name red spider seems to be applied generally to all species of the genus Tetranychus".

Simmons, Reed, and McGregor (1913), in work concerned with fig insects, found that what they had thought to be one species was actually another. This led them to believe that most investigators who in the past had dealt with the economic aspects of spider mites had been uncertain as to the species concerned. This seemingly accurate observation, therefore, limits the value of the earlier economic literature on these pests.

It is only within recent years, due to the research and publications of Banks, Ewing, Hirst, Oudemans, Trägårdh, Geijskes, McGregor, Womersley, Pritchard and Baker, that our systematic knowledge of the spider mites has acquired an importance commensurate with their economic status. As deOng (1922) has indicated, red spiders were responsible, at that time, for an annual crop loss in orchards in California varying from $100 to over $400 per acre. It is further attested by deOng that spider mites are among the most persistent and injurious pests of horticultural plants, yet they are very often allowed to go unchecked. McGregor and McDonough (1917) estimated that two million dollars yearly is the amount of damage done by spider mites to cotton alone.

Compton and Kearns (1937) estimated from five year's data that the greenhouse red spider caused losses in excess of one-half million dollars annually to greenhouse roses in Illinois.

The necessity for accurate determination of the species involved in economic investigations is exemplified by the fact that some species are more tolerant to one acaricide than others and these differences extend over a range of several species. Metcalf (1948) gave data which emphasized the importance of specificity in acaricides and pointed to the necessity of testing new materials on species of economic importance. It was found that large differences in the toxicity of the same chemical

existed between Paratetranychus citri and Tetranychus bimaculatus.

Melvin and Earle (1948) found a species of Paratetranychus feeding on raspberry approximately five times as resistant to tetraethyl pyrophosphate as greenhouse grown Tetranychus bimaculatus.

Gaines, King, and Fuller (1952) found Tetranychus desertorum more susceptible to sulfur compounds than T. bimaculatus while phosphorus compounds were more nearly equal in effectiveness against both species.

Garman (1950) investigated parathion resistant spider mites and concluded that greenhouse red spiders may become resistant to parathion, but this resistance was not necessarily carried over to chemicals in the same group.

Chapman and Lienk (1950) blamed reinfestation as the reason why the two-spotted mite proved more difficult to control than the European red mite and clover mite, because all three species exhibited essentially identical responses to the immediate effects of the various acaricides used.

Neiswander, Rodriguez, and Neiswander (1950) conducted experiments with two-spotted spider mite populations and found wide variations existed among them. Mites feeding on roses were usually more resistant to acaricides than those on beans. Likewise, a population feeding on beans was more resistant than one feeding on tomatoes. It is further stated by these authors that when subjected to a dilute acaricide over several generations a population may develop a partial immunity to that chemical.

Compton and Kearns (1937) showed great variation in the susceptibility of red spiders to certain sprays to be closely correlated with the species of plant infested.

Smith and Bryan (1951) found differences in the reaction of spider

on cotton in California to various acaricides tested.

Spider mites definitely rate as some of our most important pests. During the first six months of 1954 the Cooperative Economic Insect Report of the United States Department of Agriculture gave reference to spider mites attacking plants 183 times. Eight of 21 states reported spider mites among their 10 most important pests of the year.

For reasons not definitely established, spider mites have increased in importance since the organic pesticides have come into widespread use. Therefore, it has become increasingly important to know what species of spider mites are to be found within each state, their distribution, and their range of host plants in order that proper control measures may be taken to abate the problems when they arise.

This thesis is the result of a systematic study of spider mites collected in Oklahoma from the fall of 1953 to the spring of 1955. Included in the following pages are keys, descriptions, host plants and illustrations of 22 species of spider mites, 18 of which are new State records including 3 new species.

An effort has been made to give a practical and usable guide to the more important and common species of Tetranychidae in Oklahoma. The nomenclature used is that being proposed by A. E. Pritchard and E. W. Baker in their revision of this family now in press.

The author is aware that this study is not complete, just as most taxonomic studies are not complete, and it is the sincere hope that this study will stimulate others to continue the work on the problem in Oklahoma.

CHAPTER II

MATERIALS AND METHODS

Collection

The collection of spider mites for study has been done in several ways. McGregor (1950) gives two methods, the first of which was picking the mites off the host plant with a fine-pointed brush or needle and placing alive in a liquid preservative, the second was whipping the infested plant foliage sharply against a window screen secured to a shallow box-like frame held above white or black paper, the mites then being gathered from the paper.

Baker and Pritchard (1953) suggested that infested leaves be placed in plastic refrigeration bags, ice cream cartons, or paper bags for laboratory examination. Such containers, under refrigeration, may be used a week or two for the preservation of live mites on the foliage. If samples of adult males and females were to be preserved immediately, portions of infested leaves were immersed directly into vials of 60 to 85 per cent ethyl alcohol.

Boudreaux (1953) gave a method permitting the sampling of large amounts of plant material. An apparatus consisting of a piece of screen wire fastemed over the large end of a funnel was employed. Infested plant portions were beaten vigorously on the screen, the mites passing through the screen were caught at the small end of the funnel in a vial of 70 per cent alcohol fastened to the short funnel stem. This method is also suitable for making population counts during experiments for the

for the evaluation of acaricides.

Harvey (1954) investigated chemical control measures of Paratetranychus pratensis on wheat and employed a more elaborate method of collecting spider mites. Plant material was collected into pint ice cream cartons and carried into the laboratory. The lids were removed from the cartons and replaced by funnels fitted with screens, and small vials were attached to the funnel stem. These units were then placed in suitable holders around a wheel turned by an electric motor. Thus, a method of centrifuging was employed which was apparently very effective.

Various other methods of collecting spider mites for taxonomic or economic studies have been employed. The most essential point to remember in collecting spider mites for taxonomic study is to choose a method which assures the collection of males as well as females. The use of a fine-pointed brush for picking mites directly off infested plant material will yield surprisingly few males which are most necessary in specific determination of spider mites.

The method employed in the present study was simple, economical, and effective. Vials, 26 x 70 mm., were filled about one-third full with liquid preservative. Infested leaves, or portions thereof, were placed in the vial and the lid replaced. After a few vigorous shakes the leaves or portions were removed, leaving the mites at the bottom of the vial. Several leaves could be processed in the same vial. If time were a factor during collecting, leaves were placed in the vials, labeled, and carried to the laboratory for examination. An excess of infested foliage in the vials was avoided so that the specimens would not be crushed.

Preservatives

Probably the most widely used preservative for spider mites is ethyl alcohol, normally in concentrations from 60 to 85 per cent. After remaining in alcohol for a period of time, specimens shrink or harden and are difficult to properly mount on slides. To avoid this hardening, McGregor (1950) collected mites directly into Berlese's fluid.

A five per cent solution of chloral hydrate was found to be satisfactory for preserving spider mites, leaving them in a relaxed position which facilitated proper mounting. One difficulty encountered in using chloral hydrate as a preservative was the excessive clearing of the specimens when mounted in Hoyer's mounting medium. This excessive clearing was not evident when specimens were preserved in chloral hydrate for less than three weeks before mounting on slides.

Staining

In order to overcome excessive clearing and to aid in projection of specimens used in making illustrations, several biological stains were tried. Those tried were: Giemsa's, fast green, methyl blue, and aqueous acid fuchsin. It was found that the aqueous acid fuchsin was the most satisfactory. A 0.2 per cent solution was added to the Hoyer's mounting medium at a ratio of 1 to 20. The specimens were soaked in this solution for a period of 12 to 24 hours and then mounted in Hoyer's medium containing the fuchsin. If clear Hoyer's was used, there was a tendency for the mounting medium to bleach the stain from the specimen.

Mounting Media

The perfect mounting medium for tetranchid mites has not yet been

found. Workers in California have devised a methyl cellulose medium which has been used for mounting spider mites, but probably the most satisfactory and widely used medium for tetranychids is Berlese's fluid or various modifications thereof. The modified Berlese's formula used in this investigation for mounting specimens of spider mites is Hoyer's medium. As a matter of convenience the formula as taken from Baker and Wharton (1952) is as follows:

50 grams distilled water
30 grams gum arabic (clear crystals)
200 grams chloral hydrate
20 grams glycerine

The above ingredients should be mixed in the order listed. Stirring is necessary over a period of several days for complete blending. Baker and Pritchard (1953) suggest warming the mixture carefully over a water bath to hasten the solution, but it is not known if this affects the lasting quality of the medium.

An electric blender was used to mix the media employed for mounting most of the specimens in this study. The ingredients were placed in the blender in their proper sequence and blended until all materials were in solution. A Seitz filter, with a filter pad made of a thin layer of cotton between two pieces of cotton muslin, was used in a clean, sidearm Erlenmeyer flask to filter the solution. A vacuum pump attached to the arm of the Erlenmeyer flask speeded filteration and rapidly removed air bubbles from the Hoyer's solution. Slides, using media thus prepared, have been kept almost two years without any signs of deterioration or crystallization even though no ringing compound was employed.

Mounting Techniques

The practice of mounting specimens from alcohol or alive directly

into Hoyer's has been followed by this author, although some workers prefer to clear specimens in lactic acid before mounting.

Spider mites are best mounted one to a slide, using 1-inch by 3-inch microscope slides, and covered with 12 mm. circular cover glasses. McGregor (1950) and Baker and Pritchard (1953) gave techniques which they use to obtain lateral mounts of male mites. McGregor prefers to place a generous drop of medium on a slide, arrange the specimen, then allow the slide to "age" for several days before capping with a cover glass. In applying the cover glass, McGregor places a drop of medium on the cover glass then inverts it onto the slide.

Baker and Pritchard gave a more desirable technique. They suggest warming the slide over a desk lamp before the cover glass is placed, making it easier to compress the male with small needles to get a lateral position. Then, by rolling the cover slip, a perfect lateral view of the aedeagus may be obtained.

Very satisfactory mounts of males in profile may be made by placing a drop of Hoyer's in the center of a slide and placing the specimen in the center of the medium. Then, while observations are made using a binocular dissecting microscope of 20X magnification, the male mite is placed in a lateral position, legs away from the observer with the head towards the right. By using minuten nadeln set in appropriate holders the specimen should be depressed into the drop of medium. A clean cover glass may now be placed on the top of the drop of medium with a pair of sharp-tipped forceps. Place the cover slip, quickly look into the dissecting microscope and by using the forceps hold the cover glass down with sufficient pressure so that the specimen will not roll from its lateral position while the medium spreads toward the edge of the

cover glass.

Normally, female mites are mounted dorsal side up; however, the palpi may be more easily seen if they too are mounted laterally. If only a few specimens are available, females should always be mounted dorsally, using the same technique as employed with the males. In mounting the females, the head should point toward the observer when using the dissecting microscope to orient the specimen.

In most cases during this investigation, a total of ten females and fifteen males were mounted from each sample taken from the field.

After the mites from each sample were mounted they were labeled and placed in a constant temperature oven set at 52 degrees centigrade for 12 to 24 hours to harden the medium and clear the specimens.

Illustrations

Since the configuration of the aedeagus of the male is very important in specific determination, a method of projection was employed to make the illustrations of it and other diagnostic parts. In this method a compound monocular microscope fitted with a 15X ocular and a high dry (43X) objective was used. The microscope was placed in a horizontal position then a Bausch and Lomb 18A6V adjustable spot light microscope lamp was focused on the condenser of the microscope from a distance of 8 inches. A glass prism was fitted on the monocular tube of the microscope 1/4 inch from the ocular to direct the image downward at a right angle to a drawing board. The microscope and lamp were placed on a box so that the distance from the prism to the drawing board was 18 1/2 inches. By placing a piece of white drawing paper on the drawing board with masking tape, a mounted specimen in the microscope could be focused on the paper and the outline of the specimen traced directly onto the paper

paper. This method proved most satisfactory and all illustrations, except Plate I, are made to the same scale.

CHAPTER III

THE FAMILY TETRANYCHIDAE

Taxonomic Position

The following outline provides information on the systematic position of the family Tetranychidae:

Phylum Arthropoda

Subphylum Chelicerata

Class Arachnida

Order Acarina

Suborder Tromibidiformes

Family Tetranychidae

Family Characteristics

Spider mites of the family Tetranychidae are soft-bodied, oval to elliptical in outline in the females and rather pointed in the males. The chelicerae are reduced to a pair of needle-like elements sharply recurved proximally and embedded in a heart-shaped plate, the stylophore, or mandibular plate, of some authors, from which they may be extended while feeding. Near the mouth, one on either side, lie the palpi, each of which has a thumb-like distal segment which is somewhat ventral of a rather strong claw arising dorsally from the penultimate segment, the so-called "thumb claw" complex. The eyes are usually noticeable as red spots lying on either side of the anterior dorsal part of the body. A pair of collar tracheae, or peritremes, lie beneath the stylophore.

Biological Features

Coloration

There are many variations in the color of spider mites. The color may be light green, dark green, orange, red, purple, or nearly black. Perkins (1897) noted that color depended to a large degree on the food plants. The males are usually lighter than the females and the older the adult the deeper the color. Color was considered by many early workers in the family to be of taxonomic significance. Ewing (1914) was able to obtain several colors of the common spider mite from the first and second generation descendants of a single female. Color was at first used to separate many species or varieties within a genus, but when it was discovered that color depended to a large extent on the host plants, there was a tendency to lump together many species. Without doubt, color has been a great factor in the confusion which has existed in spider mite taxonomy, and should not be relied upon as a distinguishing characteristic.

Webbing

As mentioned in the introduction, many species of spider mites have the ability to spin spider-like webs. The ability to spin this webbing varies with the genus and even with species in the genus. Most of the species of Tetranychus spin freely, producing sometimes an enormous amount of webbing on their host plants, completely enclosing leaves, twigs and branches. Mites of the genera Oligonychus, Eotetranychus and Schizotetranychus spin some, and those of the other genera found in Oklahoma spin little, if any at all.

There has been much speculation about the purpose of this webbing. Ewing (1912) in a study of the molting process of a common spider mite,

asserts that one of the chief uses of the web is an aid to the molting process, basing this conclusion on the fact that the cast skins are nearly always found fastened to some threads of the web. Most certainly this webbing does afford protection from enemies and excessive moisture conditions for the adults, eggs, and young.

Ewing (1914) speculates that it is possible that spider mites spin strands of silk by means of which they are carried through the air, as is done by the young of true spiders.

Feeding

All stages of spider mites, other than the egg, feed upon the foliage, stema, or fruits of their food plants. Feeding is accomplished by means of the stylets which are used to pierce the plant tissue, releasing the plant juices to be sucked up through the oral aperture. The extraction of the juices from the plant causes a characteristic "stippling" of the plant tissue. Intensive feeding may lead to discoloration, stunting, or complete defoliation of the host plant. Lathrop and Hilborn (1950) in a study of the European red mite found an apparent direct relation between the weight and size of harvested apples and the amoung of chlorophyll in the leaves. They further reported that apples harvested from trees severely injured by mites were noticeably inferior in color as compared to apples from trees protected from severe mite injury.

Certain species of spider mites have little preference as to hosts and possibly only a few, if any, are host specific. In general, it may be said that the genus Tetranychus contains species which show a decided preference for woody shrubs while the other genera in Oklahoma seem to be primarily found on conifers, other trees, and members of the grass family. This, however, is only a generalization as there is much over-

lapping at the species level.

Mating and Reproduction

On many occasions mites have been observed prior to, and during the actual act of mating. As a general rule, the male usually completes its development several hours earlier than the female. The male then awaits the emergence of the female from the last quiescent stage. As many as four males have been seen near a single female. The males act very excited and run around the female occasionally pausing beside her and placing their forelegs on the back of the female. As soon as the female emerges from the last deutonymphal skin, one of the males crawls under the female from the rear, clasping his forelegs around her abdomen. The abdomen of the male is then curved upward and forward until the tip of the abdomen of the female is met. The pair remained in this position less than five minutes in several matings that were timed.

A variety of methods of reproduction are found in the family Tetranychidae. Parthenogenesis was noted by Perkins (1897) who observed that unfertilized females of the common red spider produced only male progenies. When these males matured and mated the female, both males and females were produced. Some species, such as Petrobia latens, are entirely parthenogenetic, no males have ever been found. Other species in this genus, such as Petrobia harti, evidently produce males only during a short period of time after the emergence from hibernation. McGregor (1950) asserted that the males of P. harti are not known, but Garman (1940) gave a description of the male. Males of this species have been taken by this author on several occasions early in April and May but no later in the season.

In the genus Bryobia there have been males reported, but it is not

generally accepted that B. praetiosa does produce males. However, McGregor (1950) recorded that they may be produced seasonally.

Species of the other genera found in Oklahoma, as far as is known, produce both males and females as in the genus Tetranychus; males only from unfertilized females and both sexes from fertilized females.

Life Cycle

The life cycles of the species of Tetranychidae which have been studied in detail conform, more or less, to a single pattern. There are five stages in the life cycle. These are as follows: egg, larva, protonymph, deutonymph and adult. The egg upon hatching gives rise to a six-legged larva, approximately the same size as the egg. In fact, it may be very adequately described as an egg with legs. The larva, after a period of feeding, enters into a period of quiescence and after a single molt becomes a protonymph. The protonymph differs from the larva in that it has eight legs, but as yet no genitalia are evident. After a second period of feeding the protonymph becomes quiescent and another single molt occurs from which a deutonymph emerges. In the deutonymph stage the males may be readily distinguished from the females by their pointed abdomen, smaller size, and usually their lighter color. The latter part of the deutonymphal stage is again spent in a period of inactivity, after which the adult emerges. The adults are distinguished from this and other stages by their well developed genitalia. It has been observed by Cagle (1949) and Ubertalli (1955) that males usually pass through the last two molts in one day thus emerging as adults in a shorter time than the female. It had earlier been the opinion that the male cycle was one stage shorter than the female.

Hibernation

The ability to overwinter or oversummer, as the case may be, is also well developed in the family Tetranchidae. Species of the genera Tetranychus and Eotetranychus overwinter as adult females. Their overwintering quarters appear to consist of any protected place near their host plant. Some females of T. desertorum were found beneath the bark of apple trees as well as among the litter on the ground beneath the trees. During warm, favorable periods, even in mid-winter, these overwintering females will feed and reproduce if food is available. Hibernating females of the genus Tetranychus are usually orange in color and the dorsal striations of the integument appear as unbroken, wavy lines. On the other hand actively feeding females are normally red or green and the dorsal integumentary striations appear as broken lines.

Species of the genus Oligonychus pass the winter in the egg stage in protected places on their hosts. These eggs have been noted in the case of O. coniferarum to hatch during warm winter periods.

Petrobia latens, the brown wheat mite, according to Fenton (1951), lays two kinds of eggs; one red in color called the summer egg and one white called the winter egg.

Bryobia praetiosa in most cases appears to pass the winter as adult females in protected places. Weldon (1909) recorded B. praetiosa as passing the winter principally in the egg stage in Colorado. These overwintering eggs are deposited before the end of the summer season on the trunk and limbs of trees, the crotches being favorite places.

Thus it may be seen that different methods of hibernation may be encountered in different geographic locations.

Dispersion

Probably man has been the most important factor in spreading spider mites. Because of their small size, they often go undetected as man travels from place to place. McGregor (1912), during an investigation of spider mites on cotton, reported that dispersion is due chiefly to the efforts of the mites themselves. In a most careful and detailed study McGregor found that these mites could travel on the ground at the rate of 1 inch per 15 seconds, which if maintained would give 480 feet in 24 hours.

Wind, rain, and running water are also important in the dispersion of tetranychid mites. Infested leaves may be blown into streams where they are carried many miles from their original plant. Apparently immersion of all developmental stages in water for periods of 2 hours daily is easily withstood by these mites as reported by Linke (1953) in an investigation of the biology of T. althaeae.

An interesting case of phoresy was noted between T. canadensis and the house fly in 1954. Uninfested and infested plants were isolated in the same room. Flies were noted to visit the plants for nectar, and soon all the plants were infested with mites. The mites had been carried by the flies to the uninfested plants.

Natural Enemies

From time to time various investigators have noted enemies of spider mites. A partial list by McGregor and McDonough (1917) included species of Coleoptera, Lepidoptera, Diptera, Neuroptera, Hemiptera and Thysanoptera.

McGregor (1948) listed the following predacious mites as feeding on Tetranychidae: Seinlus sp., Anystis agilis Banks, Scirus longirostris Hermann, and Cheletognes ornatus Canestrini and Fonseca.

Taxonomic Characteristics

Body (Plate 1, Fig. A)

The body of a tetranychid mite is divided into four regions, the gnathosoma, propodosoma, metapodosoma, and the opisthosoma. The first two regions are collectively known as the proterosoma while the latter two regions are termed the hysterosoma.

The dorsal integument of the female has various types of striations. On the proterosoma these generally run longitudinally, while the hysterosoma they are usually transverse. The direction these striations run between the inner lumbar and inner sacral setae is most important in specific separation of the genus Tetranychus.

Between the inner and outer scapular setae on the dorsum are found eye corneas, one or two in number with the second cornea often incomplete. These eye corneas often appear as striking red spots and have been used taxonomically.

Setae (Plate 1, Fig. A)

The setae in lateral rows on the dorsum are named anteriorly to posteriorly as follows: verticals, scapular, humeral, dorsal, lumbar, sacral, clunal, and post anal. Setae may be of various types, simple, fan-like, clavate, setose and may or may not be set on tubercles, or elevations of the dorsum. Type, presence or absence of setae, as well as the length of dorsal setae are important taxonomic characters. Many early taxonomists placed much emphasis on the number of dorsal setae. The number of setae has been found to be the same for several species and consequently the number of setae has decreased in value as a taxonomic characteristic.

Mouthparts

According to Ewing (1913), Tozzetti in 1877 called attention to the taxonomic value of the mouthparts. The most important constituents of the mouthparts taxonomically are the palpi. The palpi are typically 5 segmented, each segment, proceeding distally, being named as follows: palpcoxa, palptrochanter, palpfemur, palptibia, and palptarsus. The palptarsus forms a "thumb" to the palptibia which bears dorsally a strong claw (Plate 1, Fig. C). The palptarsus bears from 5 to 8 appendages, usually 7. Typically, there is a terminal bullet-shaped structure, the terminal sensillum, or "finger" of some authors, and a similar smaller organ dorsally termed the dorsal sensillum. There are usually five additional setae on the palptarsus, the apical pair often being nail-like.

The terminal and dorsal sensilla of the palpi vary to a large extent within the family and their shape is considered to have taxonomic significance.

The shape of the stylophore or mandibular plate and its size possess some taconomic value (Plate 1, Fig. A).

Beneath the stylophore lie the peritremes or collar tracheae. Trägårdh (1915) noted the utility of these tracheae as an aid in the differentiation of species. In certain species this organ is U-shaped and both arms are of equal caliber; in some, U-shaped but with one arm much larger than the other; while in other species the peritremes are straight with a bladder-like enlargement at their ends.

The stylets are the vestiges of chelicerae and apparently have little taxonomic value below the family level, but are quite important as a family characteristic.

Legs

Eight legs are present in all adult Tetranychidae. The legs in most species of tetranychid females are shorter than the body, however, there are notable exceptions among Bryobia and Petrobia. The legs of the male are normally longer than in the female. In the past, the relative lengths of the leg segments were considered to have an important taxonomic value.

A typical leg is divisible into six well defined segments as follows: coxa, trochanter, femur, genu or patella, tibia, and tarsus. Often the distal end of the tarsus is termed the pretarsus. There is great variation in the structure of the tarsus and particularly the pretarsus. According to McGregor (1948) it has been necessary in the taxonomy of spider mites to select, in addition to other characteristics, one characteristic for particular use in the separation of the genera, and the pretarsus with its claw and related appendages is well suited for this purpose. There is often great variation between the pretarsus of males and females and generic keys are usually based on tarsus and pretarsus I of the female. The terminal end of the tarsus, or the pretarsus, bears a pair of true claws and a central empodium. The tarsal claws may be claw-like as in Bryobia (Plate 2, Fig. C), but are usually reduced to a pair of knobbed hairs (tenent hairs) in other genera. The empodium may be claw-like with ventral hairs at its base as in Oligonychus, or it may consist of two simple diverging claw-like hairs as in Schizotetranychus, or the claw-like hairs may be diverging and six in number as in Tetranychus and Eotetranychus. The genera Eutetranychus, Petrobia and Aplonobia possess other arrangements which will be discussed later.

The foretarsus bears two pairs of closely associated setae, duplex

setae, whose position or relative lengths of the members of each pair are often important characteristics. In the genus Eotetranychus the duplex setae are adjacent while in Tetranychus they are widely separated, an important characteristic in the separation of these two genera.

Genitalia

The genital opening of the female is pre-anal in position and surrounded by many tortuous striations, with a genital plate anterior to the aperture. As far as is known the genitalia of the female possess no taxonomic significance.

The copulatory organ of the male, the aedeagus, is most important for specific differentation. Geijskes (1939) considered the aedeagus to be more important for separation of genera than species. Ewing (1913) elucidated the structure of the aedeagus, which he called the penis, and indicated its taxomonic significance. The term aedeagus was suggested by Pierce in 1919 to McGregor (1920) because of the resemblance of this chitinous organ to the aedeagus of insects, especially the Strepsiptera. Dr. Pierce believed, and it has now been generally accepted, that the penis is a delicate extrusible tube found within this chitinous organ.

Trägårdh (1915) also recognized the taxonomic value of the variation shown by the aedeagi of various species.

The aedeagus is made up of several component parts, (Plate 1, Fig. B), which may be defined as follows according to Ewing (1913) with certain modifications:

Inner lobe--The embedded or attached part of the aedeagus, less chitinized than the aedeagus proper.

Shaft--The free part of the aedeagus, more strongly chitinized than the inner lobe.

Basilar lobe—The enlarged proximal part of the shaft, not always present.

Hook—The curved part of the aedeagus, sometimes absent.

Barb—The flattened, knob-like or bent tip of the aedeagus, frequently absent.

CHAPTER IV

OKLAHOMA TETRANYCHIDAE

The tetranychid fauna is represented by eight genera which may be separated by the following key:

1. True tarsal claws present, unmodified, with tenent hairs mediolaterally; body setae short and fan-like; anterior edge of propodosoma with four projections, each bearing a fan-like seta....Bryobia Koch.

   True tarsal claws absent, or represented only by pads or lobes ending in two tenent hairs; body setae not foliaceous; anterior edge of propodosoma without projectious .....2.

2. Empodium absent; without appendiculate or spike-like proximoventral hairs.....Eutetranychus Banks.

   Empodium present or rudimentary; appendiculate, spike-like proximoventral hairs present.....3.

3. Empodium claw-like, long, with appendiculate hairs.....4.

   Claw-like empodium rudimentary with paired, spike-like hairs present .....6.

4. Empodial claw with two series of ventrally directed knobbed hairs along its length.....5.

   Empodial claw with only proximoventral, spike-like hairs..... .....Oligonychus Berlese.

5. Anterior legs longer than body, often 1 1/2 to 2 times as long as body to fore edge of propodosoma.....Petrobia Murray.

   Anterior legs shorter than or not greatly exceeding body length.... .....Aplonobia Womersley.

6. Proximoventral hairs bifurcate, simple, uncleft and widely diverging .....Schizotetranychus Trägårdh.

   Proximoventral hairs bifurcate, each division split into three subequal appressed divisions.....7.

7. Duplex setae of fore tarsus adjacent; clunal setae present..... .....Eotetranychus Oudemans.

   Duplex setae of fore tarus separated; clunal setae absent..... .....Tetranychus Dufour.

Genus Bryobia Koch

Body broadly oval, flattened dorsally, and truncate caudally. Integumentary striations pronounced and irregular. Propodosoma with four prominent anteriorly directed lobes each bearing a single foliaceous seta. Body with 28 leaf-like setae dorsally. Forelegs longer than the other legs, somewhat longer than body to front of propodosoma. All tarsi with two true claws; claws of leg I bearing two tenent hairs; empodium consists of two tenent hairs, empodium of other legs with two ventral, pectinate series of tenent hairs. Frontal tracheae often protruding teat-like.

This genus is represented in Oklahoma by a single species.

Bryobia praetiosa Koch

(Plate 2)

This species is easily distinguished from other species of this family by the flattened body, developed true claws, foliaceous setae, four anterior projections of the propodosoma each with a single leaf-like seta and their brownish to olive green body with reddish legs. The young do not possess the characteristic leaf-like setae but have instead lanceolate to clavate setose setae and the anterior projections of the propodosoma are merely rounded lobes. For this reason, many times the young have been thought to be a different species.

Hosts

B. praetiosa has been recorded from many hosts, among which are the following: apple, barley, burr clover, cantaloupe, Capsella sp., cherry, citrus fruits, clover, flax, peach, pear, prune, sweetpea, sycamore, walnut, wheat, wild oats, and mustard.

In Oklahoma specimens were taken from morning glory, Oxalis sp., and henbit (Lamium amplexicaule).

Distribution

This species is cosmopolitan throughout North America and Europe.

Collections were made in Oklahoma from the following counties: Payne, Grady, Logan, Noble, McIntosh, Pittsburg, Lincoln, and Pawnee; also should be expected to occur throughout the state.

Discussion

B. praetiosa is most abundant during the spring, particularly in April and May. Occasionally it causes annoyance by entering homes. Many control and life history studies have been made on this mite, Weldon (1909) (1910); Lienk, Chapman, and Myburgh (1952); Lienk and Chapman (1951); Webster (1912); and deOng (1922). There appear to be from three to five generations in most localities. Adults of the first generation are found from the middle of March to early April, the second generation matures about the middle of April, and the third generation the latter part of May.

Genus Eutetranychus Banks

(Plate 3)

This genus is included in the present study only in an effort to make this report as complete as possible. Only one mutilated specimen was taken, that being from a grass, Uniola latifolia, in the Wichita Mountains Wild Life Refuge, Comanche County, Oklahoma. The female specimen collected unquestionably belongs to this genus, but structures other than the fore tarsi and palpi were so deteriorated as to be unfit for further identification.

McGregor (1950) gives the generic characters as follows:

> Spider mites usually oval, somewhat flattened bodies in the female, with 18 to 26 lanceolate to clavate dorsal body setae. Tarsi with onychium devoid of claws, bearing only 4 knobbed tenent hairs. Palpus, in those species studied, with terminal segment ("thumb") rather long, its terminal sensilla elongate, "thumb" bearing a dorsal sensilla and 4 or 5 additional setae. Aedeagus (known for only one species) with a dorsal basilar lobe, the shaft narrowing abruptly backward, and bent strongly upward, terminating in as acute unbarbed tip.

Illustrations of the palpus and fore tarsus of the female are given on Plate 3 as an aid to others who may encounter this genus in Oklahoma.

Genus Oligonychus Berlese

The genus Oligonychus was proposed by Berlese in 1886 but he failed to mention the presence of the proximoventral hairs of the empodial claw, or the straight collar tracheae in his description. When Zacher (1910) described a genus, Paratetranychus, he used these characterisitics and Paratetranychus has been accepted as the proper name by many authors. Banks (1917) pointed out that Oligonychus was the older name and should be used instead of Paratetranychus. Pritchard and Baker (1955) are using the name Oligonychus in their revision of the family and their nomenclature is followed in this paper.

Species of this genus are easily separated from other genera found in Oklahoma. The strong claw-like empodium and the series of 6 to 10 proximoventral hairs arising from its base are characteristic. The collar tracheae consists of straight tubes, not U-shaped internally, terminating in slightly swollen chambers.

Six species encountered in Oklahoma may be separated by the following key; (males only)

1. Aedeagus of male with hook bending upward from shaft.....2.

   Aedeagus of male with hook bending downward.....4.

2. Aedeagus with a pronounced barb distally.....3.

   Aedeagus without pronounced barb.....indicus.

3. Barb large, longer than the external shaft of the aedeagus.....propetes.

   Barb small, less than 1/2 length of external shaft.....pratensis.

4. Hook portion of aedeagus less than half as long as shaft; tip of aedeagus conspicuously truncate.....coniferarum.

   Hook portion of aedeagus at least half as long or subequal to length of shaft; tip of aedeagus pointed.....5.

5. Shaft of aedeagus curving upward from point of basilar lobe forming a "bow"; hook portion bending strongly downward at an angle of about 115 degrees.....*milleri*.

Shaft of aedeagus proceeding straight from basilar lobe; hook bending downward at about 90 degrees.....*aceris*.

Oligonychus indicus (Hirst)

Plate 4

Originally described from India by Hirst (1923) this species may be distinguished from other species of *Oligonychus* found in Oklahoma by the upturned hook of the aedeagus and the apparent absence of a barb. Under oil immersion, however, the barb may appear as a short, posterior projection. Terminal sensillum of palptarsus of female short and wide; dorsal sensillum approximately three times as long as wide; collar trachea normally ending in a single elongated terminal chamber. Empodium of tarsus I of female claw-like with 3 pairs of proximovental hairs.

Hosts

Hirst recorded this species from sorghum in India. Rahman and Sapra (1940) recorded *O. indicus* as a pest of sugar cane and described larval and nymphal stages. Feeding on sorghum it is found in large colonies under the surface of leaves, the attacked portion turning a bright red.

Oklahoma specimens were taken from crab grass, *Digitaria* sp., on which they cause stippling of the leaves.

Distribution

Europe, Asia, and North America.

Collections made in Oklahoma from Payne and Hughes counties.

Discussion

O. indicus spins very little webbing; eggs are clear to pearl-like and found near the mid-rib of leaves. Hirst (1923) described the adults

as being grayish green in India, but in Oklahoma specimens are red.

Apparently this species is not widespread in this country, and has not yet aroused economic interest. The absence of literature pertaining to this species in this country is conspicuous.

Adequate descriptions of males and females are given by Hirst under the name Paratetranychus indicus.

Oligonychus propetes P & B [1]

Plate 5

This species is being described as new by Pritchard and Baker in their family revision. O. propetes may be distinguished by the barb of the aedeagus of the male being as long as the shaft. The shaft, concave dorsally, rises to an acute angle from which the barb proceeds downward, distally hooking beak-like. Stylophore of female slightly emarginate anteriorly; collar trachea ending in an enlarged chamber. Leg I of female with 3 pairs of proximoventral hairs basal to the claw-like empodium. Terminal sensillum of palptarsus twice as long as wide, somewhat tapering distally.

Hosts

Host records of this species apparently have not been published.

In Oklahoma this species was found only on oak, Quercus sp.. On oak there is a noticeable blotching of leaves.

Distribution

Distribution in the United States as yet unpublished.

Oklahoma specimens have been collected from Payne, Blaine, Dewey, Grady, and Noble counties.

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[1] In manuscript, to be published in 1955.

Discussion

Webbing by this species is not apparent. Colonies are found primarily on the under sides of leaves. The eggs, round in profile, are deposited near the mid-rib. Heavily infested oaks are noticeable from a distance. Life history studies have not been published.

Oligonychus pratensis (Banks)

Plate 6

Banks (1912) originally described this species from Washington and others have later designated this species as simplex. It is now accepted that pratensis and simplex are synonymous.

The basilar lobe of the aedeagus of the male appears as an obtuse prominence; shaft stout, tapering gradually backward and bending upward; hook short, less than 1/2 the length of the shaft; barb bearing a blunt point proximally, and a sharp distal point, the latter usually being slightly upturned. Female stylophore rounded with no emargination; terminal sensillum of palptarsus longer than thick. Three pairs of proximoventral hairs at base of empodial claw on tarsus I of female. Collar tracheae rather short, straight, slightly enlarged terminally.

Hosts

Oligonychus pratensis has been recorded from date, fan palm, grasses, sugar cane, sorghum, and wheat.

This species was collected from the following plants in Oklahoma: grass, Uniola sp.; Bermuda grass, Cynodon dactylon; Elymus sp.; crab grass, Digitaria sp.; and Johnson grass, Sorghum halepense.

Distribution

Arizona, Florida, Missouri, New Mexico, Nevada, Washington, California,

Texas, Utah, and Kansas.

Collections of this spider mite were made from Delaware, Haskell, McIntosh, Payne, and Grady counties in Oklahoma.

Discussion

Harvey (1954) studied this pest on wheat in New Mexico and recorded this species as the most injurious pest to the 1952-1953 crop. O. pratensis was present from September to July in New Mexico. During the fall, when wheat was in the two - to five-leaf stage, the mites were commonly found in small colonies on the leaves. During the winter the mites were found mainly in the crown of the plants near the surface of the soil.

Griffith and Wene (1953) found O. pratensis to be generally distributed throughout the Lower Rio Grande Valley in Texas. They reported sorghum plants were killed before seed heads developed.

Oligonychus coniferarum (McGregor)

Plate 7

McGregor (1950) originally described this species from Florida as Paratetranychus coniferarum.

Aedeagus of male with basilar lobe represented by a rounded swelling dorsally; shaft about five times as long as hook; hook bent downward about 70 degrees from axis of shaft, and terminates, barbless, in a distinctly truncated tip.

Stylophore of female elliptical, not emarginate anteriorly, and longer than wide. Terminal sensillum of palptarsus spatulate in profile; dorsal sensillum tack-like and not conspicuous. Tarsus I of female with five pairs of proximoventral hairs basal to a claw-like empodium. Collar tracheae, short tubes, terminating in an oval chamber.

Hosts

Arborvitae and other conifers.

Specimens from Oklahoma were collected only from cedar and arborvitae, Thuja sp.

Distribution

Florida and Mississippi.

This species was found in Payne, Grady, Kay, Noble, and Logan counties in Oklahoma.

Discussion

Little has been recorded on the life history or economic importance of this species. O. coniferarum was found to cause serious damage to cedars and arborvitae generally around Stillwater, Oklahoma, in 1953 and 1954. Actively feeding females and males were collected when temperatures were as low as 18 degrees F. Observations indicated mature females lay an average of 6 eggs per day which are deposited in forks of leaf petioles amidst a fine, sparse, webbing. This webbing apparently functions to anchor the eggs. Eggs laid in March hatched in five days and generations appeared continuously from that time.

Oligonychus milleri (McGregor)

Plate 8

The original description of this species was given by McGregor (1950) as Paratetranychus milleri.

Aedeagus of male with weakly developed, rounded, basilar lobe; shaft thickest basally, rising gradually to the hook, which is curved strongly downward at an angle of about 115 degrees and terminates in a sharp, unbarbed tip.

Female with short, rod-like, distinctly setose, dorsal setae. Stylophore emarginate anteriorly. Terminal sensillum of palptarsus small, rounded, and inconspicuous; dorsal sensillum clavate, more than twice as long as terminal sensillum. Tarsus I of female abruptly narrowed distally; empodium claw-like with four pairs of proximoventral hairs. Collar tracheae straight, terminating in oval chambers.

Hosts

Pinus ponderosa, P. taeda in California, and Pinus sp. in Oklahoma.

Distribution

Arizona, California, Virginia, Louisiana, and Arkansas. This species was collected only from Payne County, Oklahoma, but probably occurs also in the southeastern part of the State where pines are indigenous.

Discussion

There are practically no data available on this species. The Cooperative Economic Insect Report (1954) recorded damage done to pine trees in Louisiana and Arkansas.

Oligonychus aceris (Schimer)

Plate 9

This species was originally described by Schimer (1869(as Acarus aceris from leaves of the white maple. Unfortunately this description was vague and doubtless many synonyms have occurred.

Aedeagus of male with inconspicuous dorsal basilar-lobe; shaft with dorsal and ventral sides in profile tapering slightly caudad to hook; hook deflexed about 90 degrees tapering to a terminal, sharp, unbarbed tip.

Empodium of tarsus I of female claw-like with 3 pairs of proxi-

moventral hairs basally. Stylophore emarginate anteriorly. Terminal sensillum of palptarsus nearly as thick as long; dorsal sensillum inconspicuous. Collar tracheae typical of the genus.

Hosts

This species has been recorded from oak, maple, and hickory. One infestation was found in Oklahoma on maple, Acer sp..

Distribution

Connecticut, New Jersey, New York, North Carolina, and Washington. Adair County in Oklahoma.

Discussion

Details of life history, biology or economic importance have not been recorded.

Genus Petrobia Murray

Petrobia was described by Murray in 1877 with only one species, P. latens (Muller). Later Banks (1917) described a genus Tetranychina differing from Petrobia only in the dorsal setae arising from tubercles and the tarsi of the forelegs shorter than the tibiae, the pretarsal claw complex being the same. Womersley (1940) described a genus, Tenuicrus, with a similar claw arrangement. McGregor (1950) placed Tenuicrus in synonymy with Tetranychina and Pritchard and Baker (1955) in their revision are placing Tetranychina in synonymy with Petrobia.

In this genus the forelegs of the adult female are much longer than the body, often from 1/2 to 3 times body length. Palpi four segmented; third segment with a strong dorsal claw; palptarsus bearing a conspicuous dorsal sensillum and 6 other setae. Tarsi I of female with a claw-like empodium bearing ventrally two rows of numerous tenent hairs. Collar tracheae may or may not protrude anteriorly, terminating in complex sausage-shaped or oval chambers.

Two species of this genus are found in Oklahoma:

Forelegs of adult female twice or more body length; dorsal satae longer than intervals between them, setose, borne on conspicuous papillae..... .....harti.

Forelegs of adult female slightly longer than body length; dorsal satae shorter than intervals between them, setose, not on turbercles....latens.

Petrobia harti (Ewing)

Plate 10

This species was originally described by Ewing (1909) as Neophyllobius harti.

Aedeagus of male apparently not worthy of specific significance; a straight, rapier-like shaft tapering posteriorly to a thin truncate tip.

Empodial claw of tarsus I of female characteristic of the genus. Stylophore emarginate anteriorly with minute papillae anterio-dorsally. Dorsal body setae long, setose, borne on conspicuous tubercles. Collar tracheae terminating in a rather large oval chamber.

Hosts

Petrobia harti has been recorded from clover, moss, and Oxalis. Oklahoma specimens were collected only form Oxalis sticta.

Distribution

Connecticut, Illinois and Virginia. Payne, Grady, and Kay counties in Oklahoma.

Discussion

Garman (1940) made observations on this species feeding on Oxalis in Connecticut and reported this mite caused a fine stippling to appear on leaves which sometimes turn almost white with heavy infestations.

Eggs of this species are bright red in color, circular and placed near leaf veins, typically in groups of three. These eggs hatch in about three days in early May in Oklahoma and two or three generations are produced before the weather becomes hot. With the onset of hot weather this species disappears. More than likely, over-summering eggs are produced. Observations were not made during the fall.

The literature is inadequate on the biology of this mite.

Petrobia latens (Müller)

Plate 11

This species was originally described as Acarus latens and has had many name changes since its description in 1776.

Males have never been found of this species. As far as has been

ascertained females produce parthenogenetically.

Empodim claw-like with tenet hairs typical of the genus. Stylophore slightly emarginate anteriorly. Dorsal body setae short, setose, not reaching to next preceding setae; not borne on tubercles. Collar tracheae terminating in large sausage-shaped segmented cells.

Hosts

Petrobia latens has been recorded as feeding upon alfalfa, barley, burr-clover, gladiolus, grass, moss, rye grass, sorghum, wheat and wild onion. Specimens were collected only from wheat in Oklahoma.

Distribution

Europe, Australia, and the following States in the United States: Arizona, California, Idaho, Kansas, New Mexico, Oregon, Texas, Utah, Virginia, and Washington. In Oklahoma, P. latens occurs in western and central counties, collections being made from the following: Kingfisher, Dewey, and Major.

Discussion

Fenton (1951) observed this species in Oklahoma and found active eggs hatched in about a week at 75 degrees F. Adults developed from these eggs in 8 or 9 days. Female mites deposited eggs in one or two days after the last molt, and laid 70 to 90 active eggs or 30 dormant type eggs over a three week period.

Petrobia latens is found predominately in the western United States on grass type plants. Baker and Pritchard (1953) reported this species flourishes during periods of winter rains and infestations disappear with hot, dry weather whereas the opposite was found by Fenton in Oklahoma.

Serious injury has resulted to wheat crops from this spider mite in the western United States where it is considered to be a pest of great economic importance.

Genus Aplonobia Womersley

The genus Aplonobia was originally described from Australia by Womersley (1940) with one species, Aplonobia oxalis. The original generic description is as follows:

> Rounded, very convex species, dorsum furnished with strong, blunt and serrated setae arising from strong papillae, arranged in seven rows: 2, 4. 4 (6). 4. 4. 4. 2., ie., setae clunals present. Mandibles styliform, mandibular plate present, palpi stout with distinct tibial claw. Peritreme ending externally in a sausage-shaped chamber. Eyes, two on each side. Legs only slightly, if at all, longer than body, except I which is distinctly longer. Claws modified as pads ending in two tenent hairs, empodium claw-like with series of tenent hairs.

Pritchard and Baker are including at least one species of this genus in their manuscript. Baker (1955) has examined two species of this genus found in Oklahoma confirming them both to be new species, differing from known species by the dorsal setal pattern.

Herewith follows a description of these two new species with manuscript names which should be validated in 1955.

The two Oklahoma species may be differentiated by the following short key:

Inner humerals minute, not distinctly clavate.....kantacki.

Inner humeral setae distinct, clavate, 1/2 the length of outer humerals.....helianthus.

Aplonobia kantacki Furr [1/]

Plate 12

Female.---Body flattened dorsally, elliptical in outline, in profile deepest in region of coxae IV, distinctly truncate caudally. Legs I longest, scarcely as long as body; legs II and III subequal in length; legs IV longer than II and III, but shorter than I. Thirteen pairs of

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1/ In manuscript

dorsal body setae as follows: verticals conspicuous, the length of the interval between them, setose, borne on weak papillae; outer and inner scapular setae, conspicuous, clavate, setose, subequal to vertical setae, borne on papillae; outer humeral setae large, clavate, setose, arising from distinct papillae; inner humeral setae inconspicuous, short, weakly setose, not on papillae; one pair short, setose, clavate setae slightly ventrad between outer scapular and outer humeral setae; outer dorsal setae large, rod-like, setose, arising from papillae, reaching base of outer lumbars; inner dorsal setae, inconspciuous, shorter than interval between them, not arising from tubercles; outer lumbar setae large, rod-like, setose, arising from tubercles reaching base of outer sacral setae; inner dorsal setae short, inconspicuous, not on papillae; outer sacral satae long, rod-like, setose, arising from prominent papillae; inner sacral setae adjacent, rod-like, setose, borne on conspicuous papillae; clunal setae present, rod-like, setose, arising from prominent posterior projecting papillae. Stylophore longer than wide, rounded anteriorly. One perfect eye cornea each side. Collar tracheae straightish tubes, slightly curving inwardly, terminating in complexly branching elongate cells. Penultimate segment of palpus with a strong claw; last palpal segment longer than wide; terminal sensillum sword-like; dorsal sensillum about four times as long as wide, slightly setose; four additional setae on segment. Fore tarsi, dorso-distally with two adjacent sets of duplex setae; about fifteen setae proximad of proximal set of duplex setae; empodium claw-like with two series of ventrally directed tenent hairs; true claws represented by four tenent hairs fused basally into a pedicel.

Male.—Body much smaller than in the female. Legs I slightly longer than body. Dorsal setal arrangement similar to that of female. Aedeagus

with basilar lobe not pronounced; shaft lanceolate, slightly concave dorsally, tapering distad to a thin, unbarbed, rather sharp tip.

Type material: In possession of author, to be deposited in the U. S. National Museum.

Type locality: Paradise, Payne County, Oklahoma.

Type host: Helianthus sp.

Aplonobia helianthus Furr [1/]

Plate 13

Female.--Body flattened dorsally, elliptical in outline; in profile, deepest in region of coxae IV; distinctly truncate caudally. Legs I longest, scarcely as long as body; legs II, III and IV subequal in length. Thirteen pairs of dorsal body setae; verticals clavate, setose, as long as the interval between their bases, borne on weak papillae; outer and inner scapular setae conspicuous, clavate, setose, inner scapular slightly longer than outer scapular, arising from weak papillae; outer humeral setae clavate, setose, subequal in length to outer scapular, arising from indistinct papillae; inner humeral setae conspicuous, clavate, setose, about one-half the length of outer humerals, basal papillae not evident; outer dorsal setae clavate, setose, arising from papillae, not reaching base of outer humerals; inner dorsals short, clavate, setose, about one-fourth length of outer dorsals, not arising from papillae; outer lumbar setae rod-like, setose, arising from papillae, scarcely reaching base of outer sacral setae; inner lumbars minute, clavate, setose, not arising from papillae; outer sacral setae rod-like, setose, arising from prominent tubercles; inner sacrals

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[1/] In manuscript

adjacent, similar, and equal in length to outer sacrals, borne on papillae; clunal setae present, similar to sacrals, arising from prominent posteriorly projecting papillae. Stylophore longer than wide, rounded anteriorly. One perfect eye cornea each side. Collar tracheae straightish tubes, curving inwardly, terminating in elongated many-chambered cells. Palpi similar to A. kantacki . Tarsi I with two adjacent sets of duplex setae dorso-distally, about twelve setae proximad of proximal set of duplex setae; empodium claw-like with two series of ventrally directed tenent hairs; true claws represented by pedicels bearing two long knobbed, tenent hairs each.

Male.--Body smaller and narrower than female. Legs I about as long as body to front of propodosoma. Tarsi I bearing four pairs of duplex setae dorsally. Aedeagus with basilar lobe indistinct; shaft lanceolate, dorsal edge straight, ventral edge tapering gradually dorso-distally to an unbarbed sharp tip.

Type material: In possession of author, to be deposited in U. S. National Museum.

Type locality; Quartz Mountain State Park, Greer County, Oklahoma.

Type host: Helianthus annuus.

Genus Schizotetranychus Trägårdh

Schizotetranychus, described by Tragardh (1915), is easily distinguished from other genera of tetranychid mites in Oklahoma. The empodial claw of tarsi I of the female is absent, while a single pair of proximoventral hairs appear claw-like, uncleft, and widely diverging Y-shaped. The usual two pairs of tenent hairs are present. The collar tracheae are not U-shaped as in Tetranychus, but slightly hooked inwardly.

This genus was found to be represented in Oklahoma by two species, one of which is being described by Pritchard and Baker (1955) and the other confirmed by Baker to be new. The two species may be separated as follows:

Tarsi I fo female abruptly truncate distally; aedeagus of male tapering gradually from basilar lobe to hook.....camur.

Tarsi I of female gradually tapering distally; aedeagus gradually curving into hook from basilar lobe.....uniolae.

Schizotetranychus camur Pritchard & Baker [1/]

Plate 14

This species is being described by the above authors in their pending revision. In order that this species may be separated from the other mite in this genus found in Oklahoma, the following descriptive characters are given:

Legs I of female shorter than body; tarsi I short and abruptly truncate distally; two sets of duplex and other setae crowded distally. Dorsal body setae well developed, linear-lanceolate, weakly setose, not arising from tubercles.

1/ Manuscript name

Stylophore emarginate anteriorly, longer than wide. Palptarsus thicker than long; terminal sensillum scarcely longer than wide, rounded distally; dorsal sensillum clavate and weakly setose; five additional setae on segment. Collar trachese straightish, curved inwardly terminating in short hooks.

Aedeagus of male with slightly developed basilar lobe, tapering gradually to the hook, which in turn is bent upward at about 75 degrees terminating in a barb projecting posteriorly and sharp tipped.

Hosts

Unpublished. In Oklahoma this species was collected from cane, Andrunaria sp..

Distribution

Unpublished. McIntosh and McCurtain counties, Oklahoma.

Discussion

As this is an unpublished species, no literature is available on its economic importance. Biological studies have not been made.

On cane in Oklahoma, S. camur spins little tents of webs under which eggs are laid and the adults hide. These little spots of webbing appear as light colored spots on the leaves. Feeding produces the characteristic spider mite stippling.

Schizotetranychus uniolae Furr [1]

Plate 15

Dr. E. W. Baker (1955) [2] has graciously pointed out the following differences between this species and its close relatives, S. eremophilus and S. elymus: Differs from eremophilus in the dorsal setal length; the sensory setae on female tibia I are twice as long as in eremophilus; and the peritreme is hooked. The male aedeagus is similar to that of eremophilus but more slender distally; the tarsal I sensory setae are slender and long; the tarsal setal pattern differs from elymus, and the peritreme differs from elymus. The female palps differ from elymus.

Female.--Body elliptical, compressed dorso-ventrally. Legs shorter than body to front of propodosoma. Thirteen pairs of dorsal body setae, mostly failing to reach base of next setae behind. Stylophore longer than wide, rounded anteriorly. One perfect eye cornea each side. Collar tracheae with main tube long and narrow, bending upward and slightly forward to form internally, short, sepate, cresent-shaped chambers. Tarsus I with two sets of duplex setae adjacent, three or four setae borne proximad of proximal set; empodium characteristic of the genus. Last segment of palpus thicker than long; terminal sensillum longer than thick, rather truncate distally; dorsal sensillum inconspicuous, rod-like, short and weakly setose; five additional setae on segment as usual.

Male.--Smaller than the female; body from above narrowly sagittate. Legs shorter than body to front of propodosoma. Palptarsus with apparently no terminal sensillum; dorsal sensillum rod-like and slender.

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[1] In manuscript

[2] Personal correspondence

Aedeagus with a rather well developed basilar lobe; shaft narrowing and tapering backward and upward about 75 degrees to form a rather slender hook which, in turn, is bent slightly posteriorly near the tip to form a sharp tipped pseudo-barb.

Type material: In possession of author, to be deposited in U. S. National Museum.

Type locality: Wichita Mountain Wild Life Refuge, Comanche County, Oklahoma.

Type host: Uniola latifolia.

Genus Eotetranychus Oudemans

McGregor (1950) reported that Oudemans proposed this genus in 1931 to include mites, otherwise similar to Tetranychus, having dorsal integumentary striations on the abdomen entirely transverse, except for a few, marginal areas. McGregor considered this group of mites to be deserving of subgeneric rank only. Pritchard and Baker (1952) called attention to the possession by this group of an extra pair of setae, the clunals, at the posterior end of the dorsum as well as the adjacent position of the duplex setae of the foretarsus of the female. Pritchard and Baker considered these latter differences to be worthy of generic rank.

Four species of this genus were collected during this investigation and may be separated by the following key:

1. Aedeagus with a barb.....2.

   Aedeagus without a barb.....3.

2. Hook portion of aedeagus slightly deflexed; barb acutely pointed at each end of its axis.....perplexus.

   Hook portion of aedeagus stongly deflexed; barb weakly developed and pointed only at caudal tip.....hicorie.

3. Collar tracheae with inner portion anastomosing into two branches forming a closed loop.....populi.

   Collar tracheae not forming a closed loop, ending in an enlarged bulb.....carpini.

Eotetranychus perplexus (McGregor)

Plate 16

This spider mite was originally described by McGregor (1950) as Tetranychus perplexus but following the classification of Baker & Pritchard (1953) it should now be Eotetranychus perplexus.

This species is rather easily distinguished from other members

of this genus found in Oklahoma by the structure of the aedeagus of the male. Basilar lobe not conspicuous; upper face of shaft with proximal half rather concave; distal half with face straight, under face of shaft convex; distally narrowing strongly and deflexed weakly to form a short hook. Barb conspicuous, flange-shaped, acutely pointed at each end of its longitudinal axis.

Hosts

Cercocarpus sp., Prunus sp., and Salix sp. A single infestation was found on hackberry, Cletis sp. in Oklahoma.

Distribution

Southern and central California and Idaho. Oklahoma specimens only from Beckham County.

Discussion

Literature records no economic or biological studies of this species.

This species on hackberry spins little webbing and has a tendency to concentrate along mid-ribs of leaves where their feeding causes a noticeable yellowing. Heavily infested trees are visible from a distance.

Eotetranychus hicorie (McGregor)

Plate 17

Eotetranychus hicorie was included as a new species by McGregor (1950) as Tetranychus hicorie. As with the preceding species this species has been changed to E. hicorie. This is a small species, light in color with a characteristic aedeagus found in the male. Basilar lobe of the male aedeagus not greatly pronounced, rounded; shaft narrowing gradually and evenly to the hook; hook portion bent downward strongly and anteriorly about 125 degrees from the axis of the shaft, and then bent again backward slightly to form a short, thin, barb which is pointed distally.

Hosts

Pecan is recorded as the type host. Pecan and walnut in Oklahoma.

Distribution

Mississippi, Florida, Georgia, Louisiana, and Texas. Oklahoma: Payne, Pushmataha, Pittsburg, and McCurtain counties.

Discussion

Since the description of this mite, little has been written on biology or control. Nickels (1942) mentioned this species along with another species attacking pecan and carried out acaricide tests for its control.

Eotetranychus populi (Koch)

Plate 18

Described as Tetranychus populi in 1838, this species should also be placed in the genus, Eotetranychus. Like many species of spider mites, the male aedeagus is characteristic. The aedeagus of E. populi is long, lanceolate, slightly curved and terminates distally in a distinctly blunt tip. The collar trachea of the female are also an aid in identification as they form complex closed loops at the somewhat hooked inner ends.

Hosts

Lombardy popular, Populus sp., and Salix sp. Salix sp. in Oklahoma.

Distribution

Germany and Connecticut. Payne County in Oklahoma.

Discussion

This species is apparently not generally distributed in Oklahoma. Only two infestations were discovered, both of which were in Payne

County. An infestation on the campus of Oklahoma A. & M. College built up to proportions sufficient to completely defoliate large limbs of willows near Theta Pond. Eggs of this species are pearl-like with an apical stalk as long as the height of the egg. Colonies are found near the mid-ribs of leaves and are found as abundant on the upper as the lower leaf surfaces. The infestation in 1954 built up slowly during April and May and reached serious proportions by mid-July.

Eotetranychus carpini Oudemans

Plate 19

Originally described by Oudemans in 1905, this spider mite has caused quite a confusion taxonomically, because of its close resemblance to E. willamettti and E. uncatus (not collected in Oklahoma). Pritchard and Baker (1952) gave adequate descriptions and pointed out differences between these closely related species. The aedeagus of the male of E. carpini consists of a long undulating, gradually acuminate structure, terminating in a sharp, unbarbed tip.

Hosts

Apples, pears, cherry, raspberry, blueberry, spirea, alder and willow. Elm and hackberry in Oklahoma.

Distribution

California, British Columbia, Connecticut, Oregon and Washington. Delaware, Caddo, Payne, Beckham, and Woodward counties in Oklahoma.

Discussion

Due to the confusion in taxonomy, biological and control studies appear unreliable as to which species was concerned. An excellent life history study has recently been completed by Ubertalli (1955) on .

E. uncatus, one of the closely related species. Similar results would be expected from studies of E. carpini and E. willamettii. Ubertalli found incubation of eggs to occur in 2 days at 82 degrees F. and 9 days at 69.8 degrees F.; larval stage from 2 to 6 days for males and 1 to 6 days for females; protonymphal period ranged from 2 to 6 days for males and 2 days for females; deutonymphal period from 1 to 3 days for males and 2 days for females; minimum time from hatching to adult was 5 days at an average temperature of 80.5 degrees F.; maximum life span of adult females was 14 days at 70.1 degrees F.; maximum life span for adult males was 8 days at an average temperature or 66.7 degrees F.

Genus Tetranychus Dufour

When Dufour created this genus in 1832 he thought the appendiculate empodial hairs were split into four divisions. In fact, the genus and family name was based on this conception of the pretarsal structure. Harvey (1892) stated that Tetranychus bimaculatus had its tarsal claw split into six divisions. Banks (1900) and (1915) asserted that in many cases the claw is split into four divisions. Ewing (1914) figured the claw as being six cleft. Trägårdh (1915) also reported the empodial claw is split into from 4 to 6 spines. McGregor (1917) demonstrated in three species of Tetranychus, the claw as being six-cleft. It has now become generally accepted by acarologists that in all species of Tetranychus, the tarsal claw of the female is split into six sub-equal spine-like divisions.

Only a few characteristics of adult females are necessary to place spider mites in this genus. True tarsal claws represented by pads, each bearing two tenent hairs; proximoventral hairs bifurcate, each division split into three sub-equal divisions; clunal setae absent; dorsal cuticular striations not entirely transverse in region of inner sacrals and inner lumbars; two pairs of dorsal duplex setae of tarsi I separated; collar tracheae consisting of tubes which loop back internally, U-shaped.

This genus is represented in Oklahoma by at least four species. Those found in this investigation may be separated with the aid of the following key:

1. Female dorsum between inner lumbar and inner sacral setae with striae transverse and surrounded by a rhomboidal area of striae; striations longitudinal between both inner lumbar and both inner sacral setae.....2.

   Female with transverse integumentary striae between inner lumbar setae.....3.

2. Tarsus I of female with proximal duplex setae in line with other proximal setae.....desertorum.

   Tarsus I of female with proximal duplex setae distad of other proximal setae.....bimaculatus.

3. Aedeagus of male with barb strongly enlarged, about one-half as long as external portion of shaft.....schoenei.

   Aedeagus of male with barb much smaller, about one-fourth as long as external portion of shaft.....canadensis.

Tetranychus desertorum Banks

Plate 20

Originally described by Banks (1900), this common species has been known under several names, one of the more recent ones being, Septanychus texazona, McGregor. McGregor (1919) set up the genus Septanychus on the basis of a small empodial spur, but Pritchard and Baker (1952) do not consider the presence of this spur to be worthy of generic distinction, as this tiny spur is characteristic of all species of the genus.

Tetranychus desertorum differs from other members of the genus found in Oklahoma in that the proximal duplex setae of tarsus I of the female are more or less in line with other proximal setae. The aedeagus of the male is rather characteristic in that the dorsal margin of the barb is sigmoid and the posterior angulation is sharply hooked downward beak-like (visible under oil immersion). The hook of the aedeagus usually bends upward at an angle of less than 90 degrees.

Hosts

Literature records of hosts of this species are very long and only some Oklahoma hosts will be given here: morning glory, cotton, Solanum sp., ragweed, spinach, bean, milkweed, cockle bur, croton, wild onion, wild lettuce, compositae, fern, primrose, cucumber, squash, chrysanthemum,

field peas, apple, sunflower, jimson weed, sweet potato, goldenrod, tomato, and marigold.

Distribution

South America, California, Arizona, New Mexico, Texas, Louisiana, Mississippi, Georgia, South Carolina and North Carolina. Collections were made in the following counties in Oklahoma: Payne, McIntosh, Pushmataha, Grady, Caddo, Greer, McCurtain, Pittsburg, Cimmaron, Kiowa, Haskell, Blaine, Ellis, Latimer, Tulsa, Pottawatomie, Leflore, Harmon, Ottawa, Noble, Kay, Lincoln, Canadian, Kingfisher, Woodward, Major and Dewey.

Discussion

It is the author's opinion that this species has been reported and economic investigations carried out on it many times under the name bimaculatus. The two species are close, but entirely distinct. Iglinsky carried out life history studies on this species and Iglinsky and Rainwater (1954) reported the time from egg to adult averaged 8.3 days ranging from 5.8 to 11.2 days. The optimum conditions for development were 85 degrees F. and 80 per cent humidity. Cross mating experiments between desertorum and bimaculatus failed to produce females, indicating strongly that the two species are distinct.

Tetranychus desertorum is probably the most frequently encountered species in Oklahoma, being distributed generally throughout the State.

Tetranychus bimaculatus Harvey

Plate 21

Tetranychus bimaculatus, generally admitted by nearly all acarologists, is not the oldest name applicable to this mite, there being older names

in current use in Europe. According to Harvey (1893) the name T. bimaculatus was not established because of any demonstrated structural differences between his specimens and T. telarius (L.) in Europe, but on account of supposed differences in habits. However, McGregor (1942) asserts that telarius in Europe is not the same as the American mite known under the name bimaculatus. McGregor (1950) concluded that T. telarius, the "common spider mite" from Europe belongs to the sub-genus Eotetranychus Oudemans, whereas the American "common spider mite" falls into the sub-genus Tetranychus. The name, T. bimaculatus is therefore provisional and will probably have to be changed at a later date after examination of sufficient European material.

The only mite with which T. bimaculatus could be confused, encountered in this study, is T. desertorum. Tetranychus bimaculatus has four or five setae proximad of the proximal set of duplex setae on tarsus I of the female and the male aedeagus hooks upward at 90 degrees, the barb being rounded dorsally with an indistinct anterior and posterior projection parallel to the axis of the shaft.

Hosts

Recorded hosts of this spider mite number in the hundreds, only a few of the Oklahoma hosts are listed below: violet, rose, hollyhock, horse nettle, Elymus sp., gladiolus, dahlia, persimmon, cotton, bindweed, elderberry, lespedeza, watermelon, apple, sweet pea, castor-bean, sorghum, cucumber and bois de arc.

Distribution

Widespread throughout North America. Oklahoma counties include: Payne, Caddo, Grady, Hughes, McIntosh, Latimer, Delaware and McCurtain. It is interesting to note that this species was not collected in north-

west Oklahoma.

Discussion

There have been many biological and economic studies of T. bimaculatus. Among the best biological studies done in the United States are: Ewing (1914), Cagle (1949), Wilson (1911), Perkins (1897), McGregor (1912), and McGregor and McDonough (1917).

Basically there are two forms of actively feeding females to T. bimaculatus, red and green. McGregor (1950) established a new species, multisetis, for a female, red in color, possessing five or six setae (instead of four) proximad of the proximal set of duplex setae on tarsus I, otherwise identical to T. bimaculatus. At least a part of the red color forms posses this chaetotaxy (not found in Oklahoma). Keh (1952) observed this chaetotaxy of the offsprings to be entirely dependent upon the chaetotaxy of the mother, regardless of the chaetotaxy of the mother of the male parent. Davis (1952) also found this to be true in his breeding experiments. Baker and Pritchard (1953) therefore, considered multisetis only worthy of subspecific rank. Green colored forms of T. bimaculatus are found primarily in the more northern United States, there are exceptions however, in Mississippi, Louisiana, and other southern states. Several workers have demonstrated a differential susceptibility between green and red color forms of T. bimaculatus to various acaricides.

Tetranychus schoenei McGregor

Plate 22

Originally described by McGregor (1941) as T. schoenei, this species was later transferred to the genus Septanychus by the same author (1950).

Since Septanychus is no longer considered valid this species reverts back to the genus Tetranychus.

Adult females are rather easily separated from most other species in this genus by there being longitudinal dorsal striae only between the inner sacral setae, while the striae are transverse between the inner lumbar setae. The aedeagus of the male has an enlarged barb, rounded anteriorly and pointed posteriorly, with the tip being somewhat deflexed; the length of the barb is about one-half the length of the external shaft.

Hosts

Tetranychus schoenei has been collected from apples, black locust, cotton, beans, deciduous and ornamental trees. Oklahoma specimens were taken from persimmon, plum, balckberry, cotton, sumac, wild rose, locust, cottonwood, mulberry, apple, red bud, lantana, elm, bois de arc, pecan and hackberry.

Distribution

This species is known from Maryland, Virginia, West Virginis, Pennsylvania, Louisiana, Mississippi, Alabama and Georgia. Oklahoma counties are: Latimer, Grady, Caddo, Sequoyah, Craig, McCurtain, Payne, Kiowa, Choctaw and Adair.

Discussion

Tetranychus schoenei is one of the more common and widely distributed species of spider mites in central and eastern Oklahoma. Considerable webbing accompanies large infestations as is common with many species of this genus.

Cagle (1943) has done an excellent life history study of this

species. He found nine generations to occur annually in Virginia, with some hibernating forms appearing in the sixth generation. Maximum number of eggs per female; 106, at a rate of 3.7 per day. Developmental period from egg to adult was 5 days at 80.7 degrees F., but 34 days at 51 degrees F.

Tetranychus canadensis (McGregor)

Plate 22

McGregor (1950) described this species in the genus Septanychus, but Pritchard and Baker (1952) also placed this mite in Tetranychus.

The females of T. canadensis and T. schoenei are identical, in that they both possess transverse, parallel striae immediately behind and between the inner sacrals.

The aedeagus of T. canadensis is different from that of T. schoenei, in that it is comparatively small, the axis of the barb being about one-fourth the length of the external shaft.

Hosts

This spider mite is known from apple, cotton, rose, elm, linden, plum, horse chestnut and bois de arc. In Oklahoma specimens were collected from elm, cotton, maple, mulberry, plum, apple, poison ivy, ragweed, locust, bois de arc and blackberry.

Distribution

Canada and the United States: New York, New Jersey, Washington, D. C., Maryland, Virginia, Indiana, Ohio, Kansas, Texas, Louisiana, Mississippi, and Tennessee. The following counties in Oklahoma: Payne, Woodward, Kay, Pushmataha, Greer, Grant, Blaine and Beckham.

Discussion

Tetranychus canadensis is found in the field early in the spring and later it is usually accompanied by T. schoenei. Apparently no life history studies have been published. Lienk and Chapman (1951) have made a few observations in connection with control studies. T. canadensis is a serious pest of elm trees in Payne County, Oklahoma. Severe damage and premature defoliation was caused by this species during the spring and summer of 1954. Little webbing is spun by this species and many infestations go entirely undetected.

CHAPTER V

SUMMARY

Spider mites are plant feeding species and may cause serious damage to a wide range of plants. Every species is a real, or represents a potential threat to plants of its host range. Some speices have developed a resistance to chemical control measures and it has become necessary to know the species involved in order to select proper control measures.

The tetranychids of Oklahoma have been almost entirely unknown with the exception of the following species: Petrobia latens, Tetranychus bimaculatus, T. desertorum, and Bryobia praetiosa. Therefore, it was desirable to investigate the species present, their host plants, their distribution, and to formulate a guide for the determination of the species of this family of mites in Oklahoma.

Collections of spider mites were made from the fall of 1953 to the spring of 1955, which included material from over one-half of the counties in Oklahoma. When sufficient material was available, slides were made of ten females and fifteen males from each collection. One mite was mounted per slide using Hoyer's medium. Some specimens were stained with acid fuchsin for purposes of projection to make illustrations. All illustrations except those of Plate 1 are made to the same scale, one-half inch equal .01 mm.

Oklahoma, with its great differences in altitude and climatic factors, was found to be rather ideal for many species of Tetranychidae. The tetranychid fauna was found to be represented by eight genera which

included the following species: Bryobia praetiosa, Eutetranychus sp., Oligonychus indicus, O. propetes, O. coniferarum, O. milleri, O. aceris, Petrobia harti, P. latens, Schizotetranychus camur, Eotetranychus perplexus, E. hicorie, E. populi, E. carpini, Tetranychus desertorum, T. bimaculatus, T. schoenei, and T. canadensis. The following were determined as new species and are in manuscript: Aplonobia helianthus, A. kantacki, and Schizotetranychus uniolae. Eighteen new state records are included in the above including the three new species. Keys to the genera and species are given for all the species found during this investigation and appropriate illustrations are provided for their determination.

It is a sincere hope that others may be benefited by this investigation and that this work be continued in Oklahoma. This author is inclined to believe there are other species of this family in Oklahoma which will be found to be entirely new to acarology.

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APPENDIX

Plate 1
Morphology of a Tetranychid

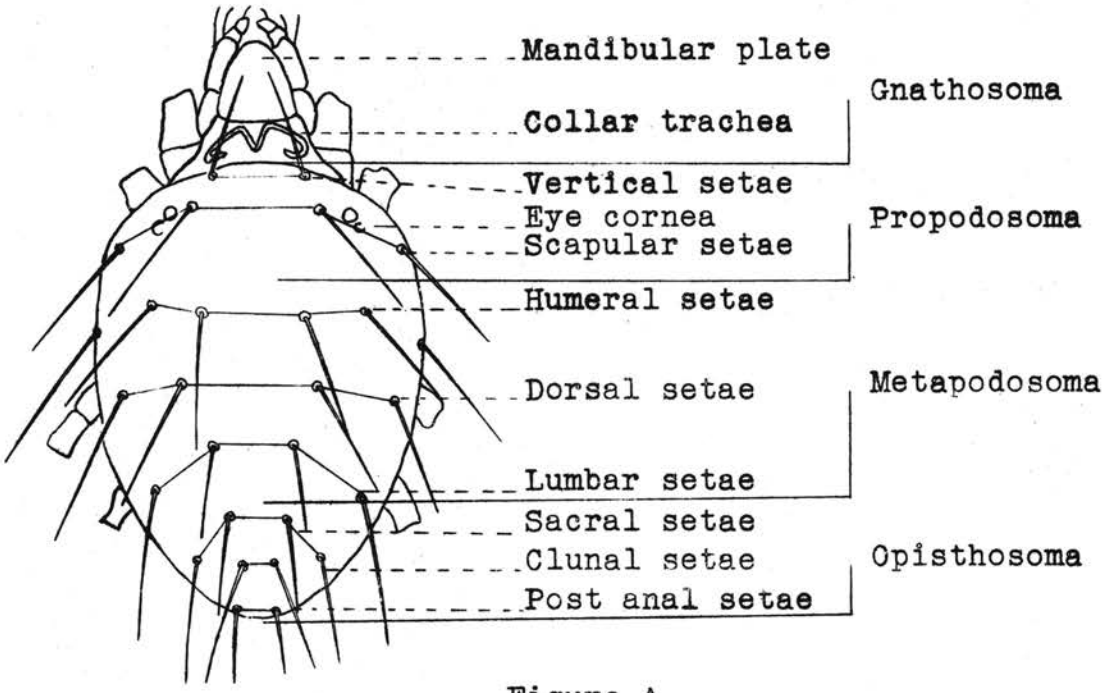

Figure A

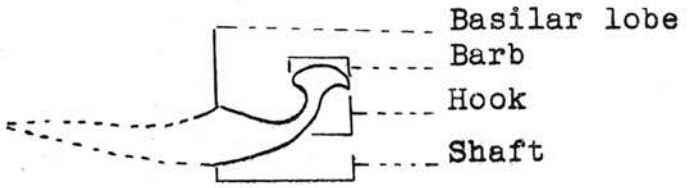

Figure B

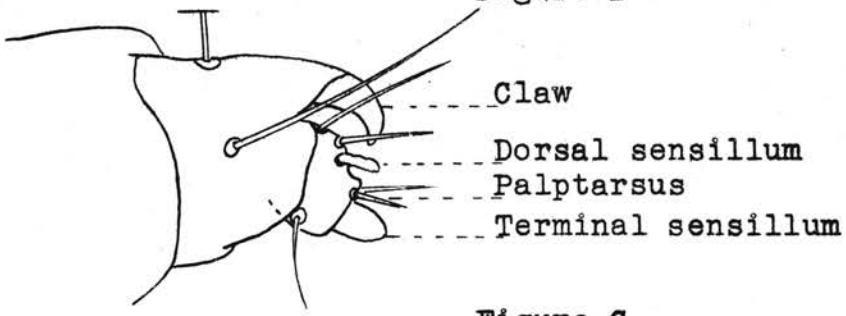

Figure C

Figure A, body, dorsal view; B, aedeagus of male, lateral view; C, tip of palpus of female, lateral view.

Plate 2
Bryobia praetiosa

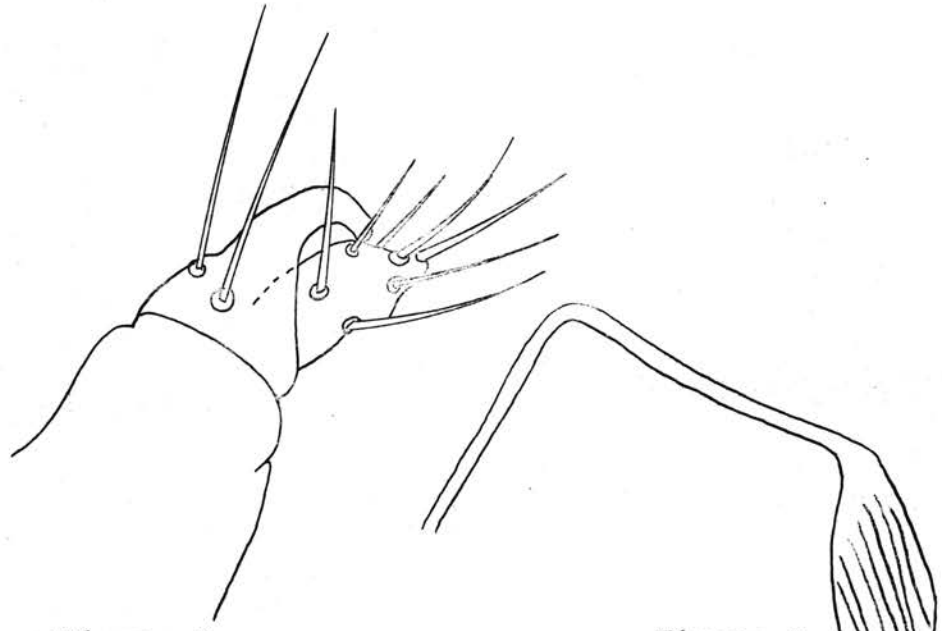

Figure A

Figure B

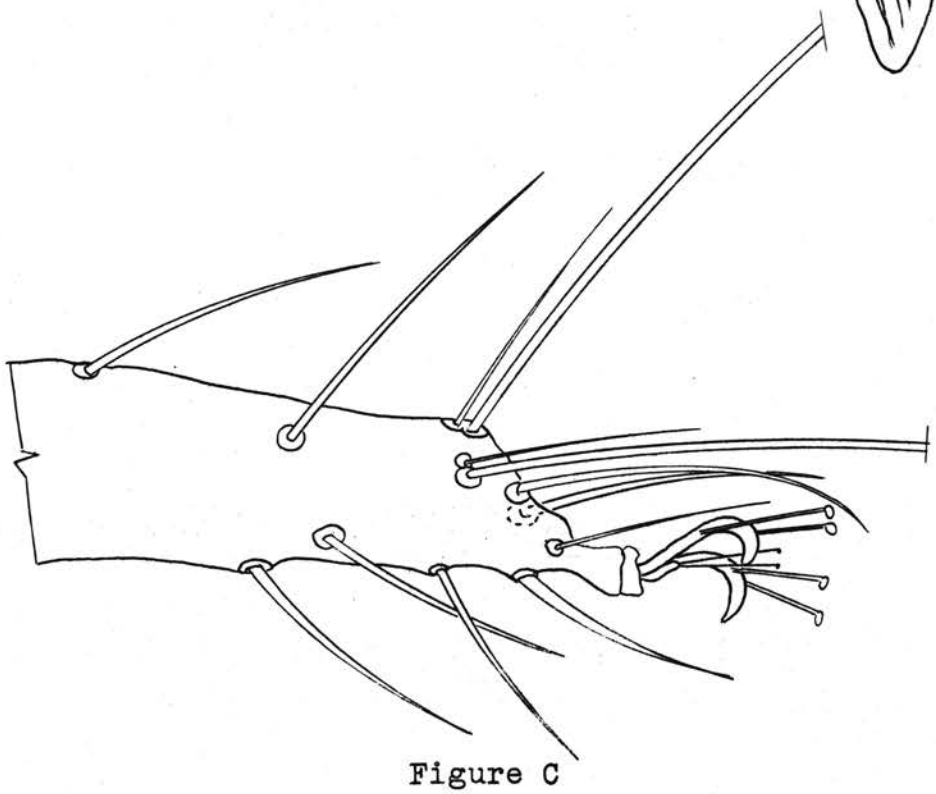

Figure C

Figure A, tip of palpus, female; B, collar trachea; C, tip of tarsus I, female.

Plate 3
Eutetranychus sp.

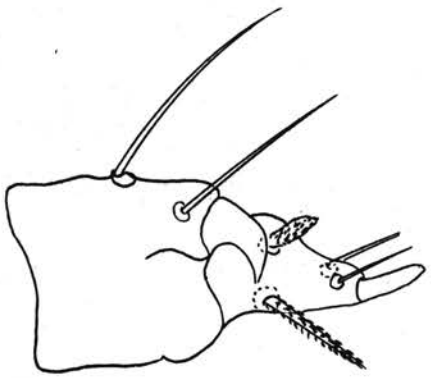

Figure A

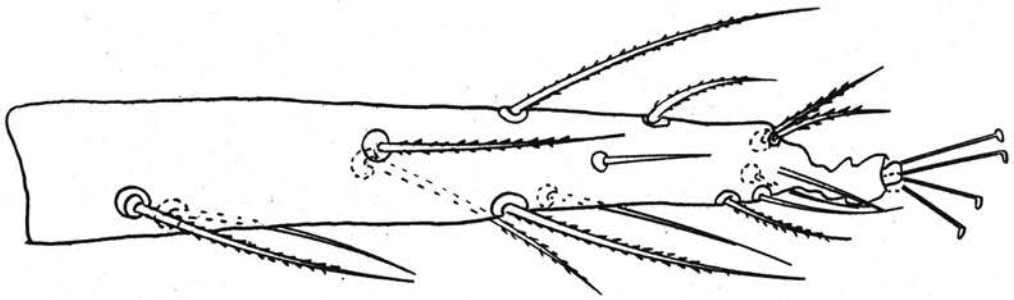

Figure B

Figure A, tip of palpus, female; B, tarsus I of female.

Plate 4
Oligonychus indicus

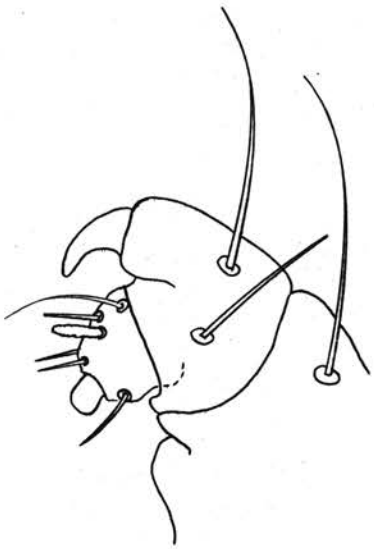

Figure B

Figure A

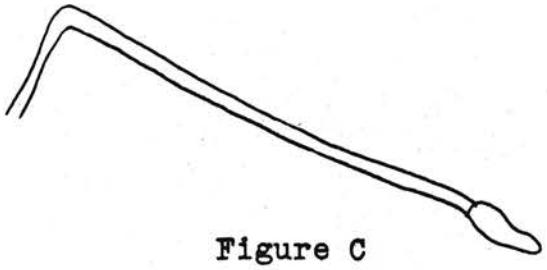

Figure C

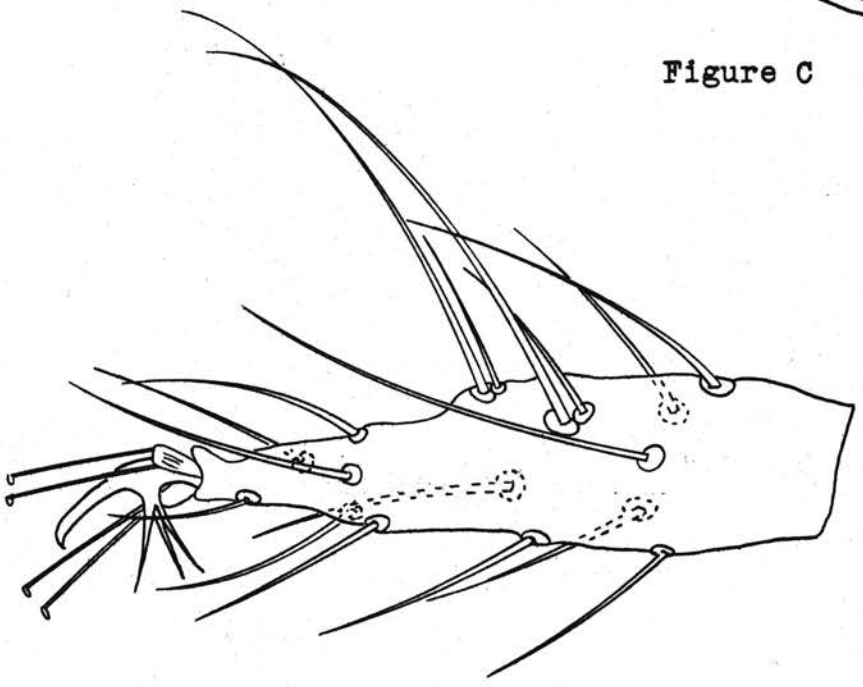

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 5
Oligonychus propetes

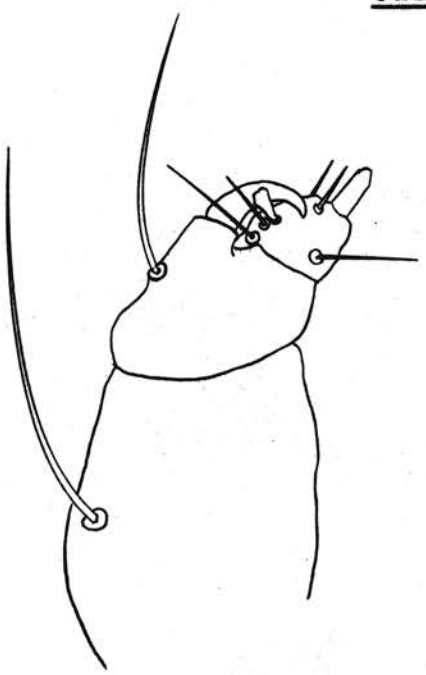

Figure B

Figure A

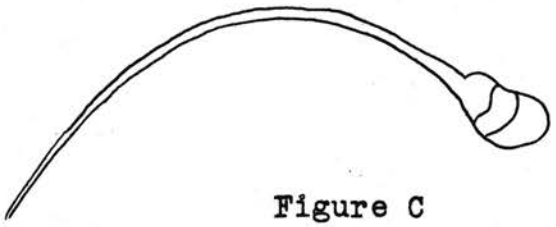

Figure C

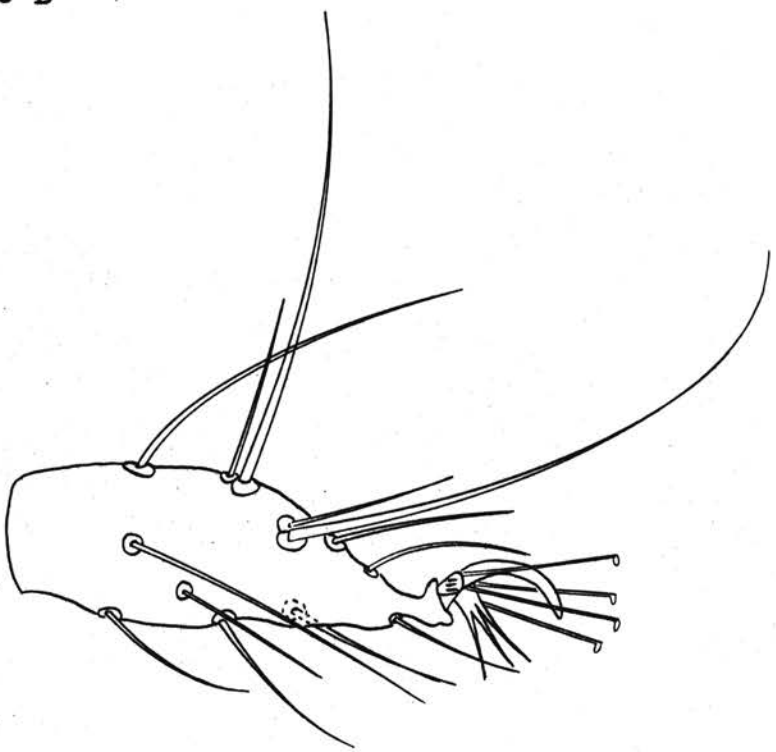

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 6
Oligonychus pratensis

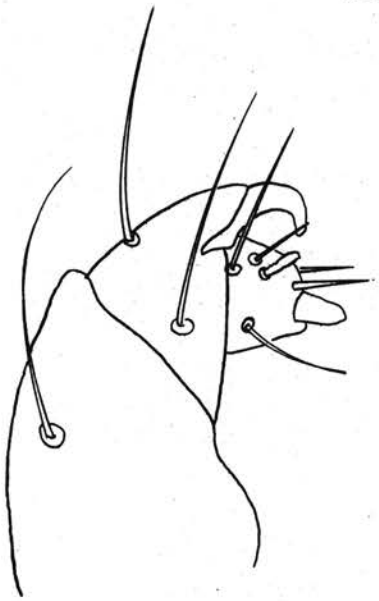

Figure B

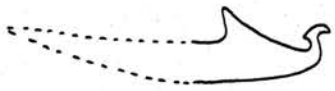

Figure A

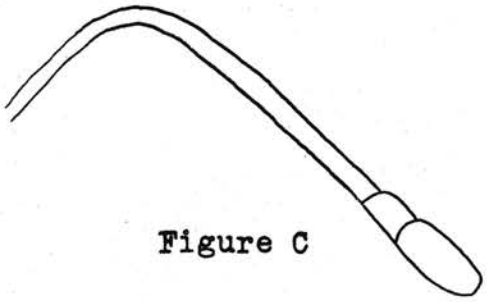

Figure C

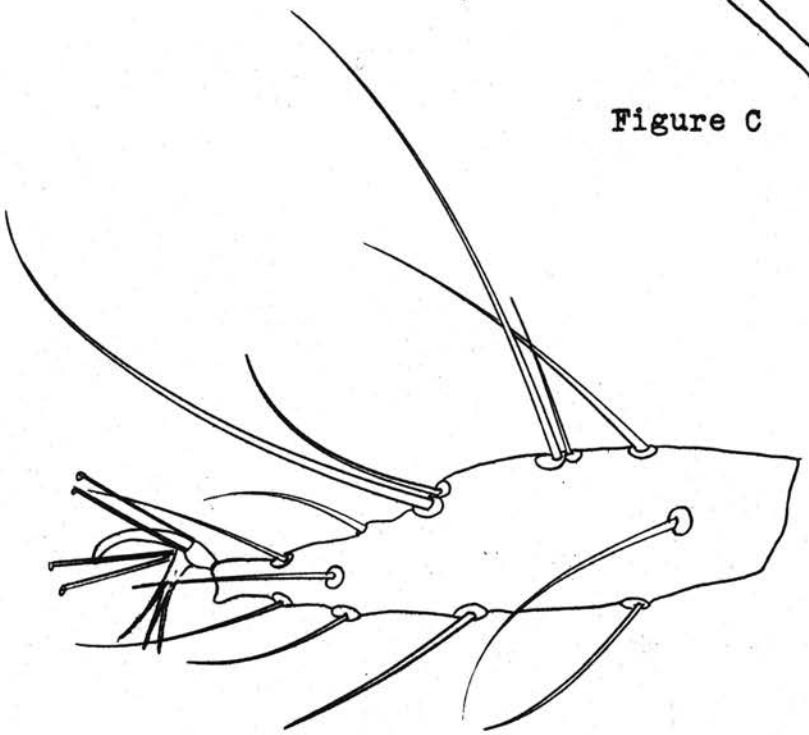

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 7
Oligonychus coniferarum

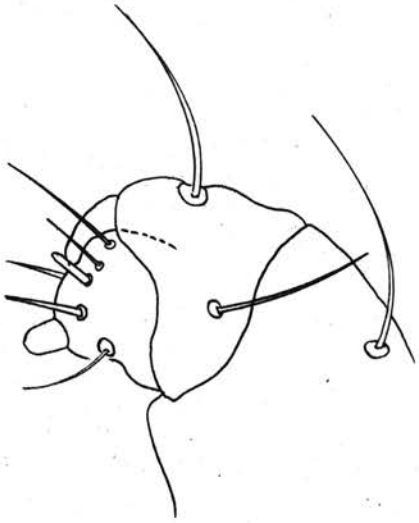

Figure B

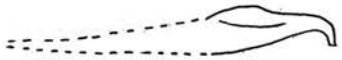

Figure A

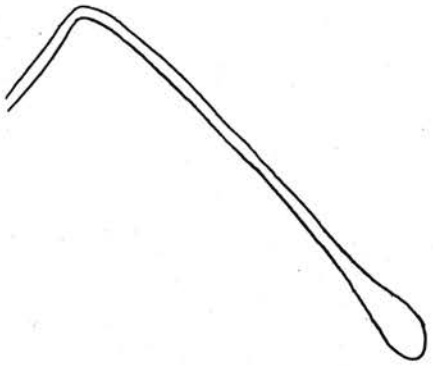

Figure C

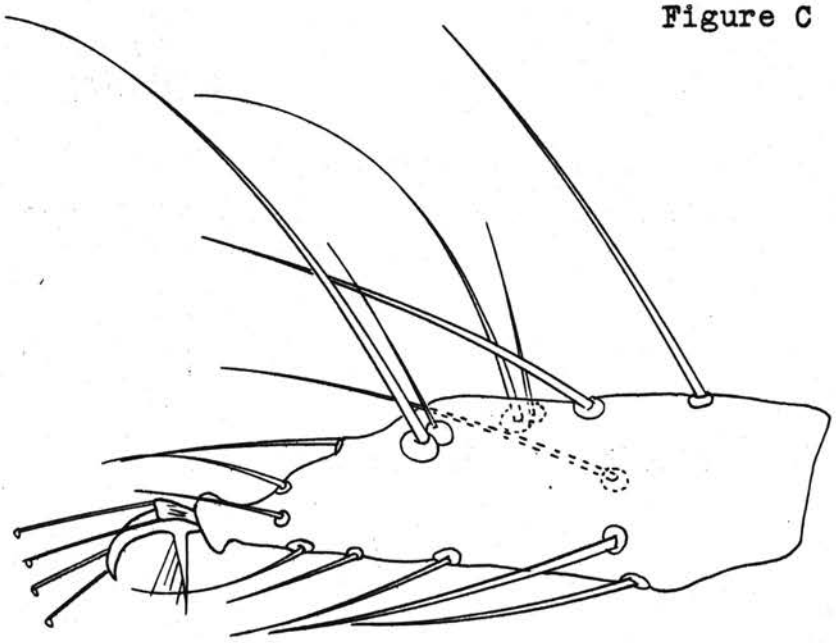

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 8
Oligonychus milleri

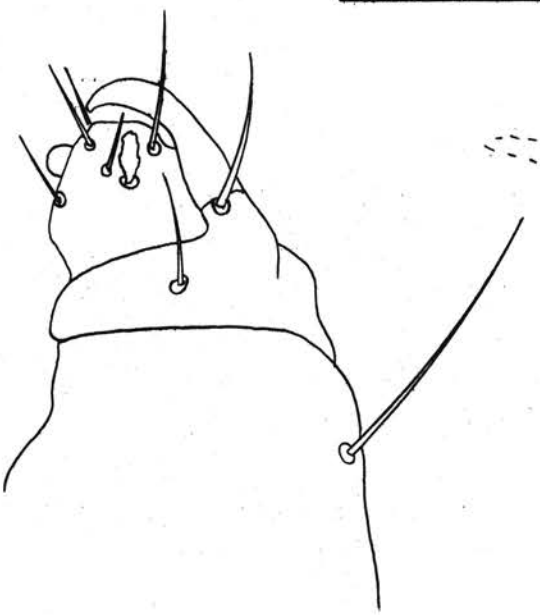

Figure B

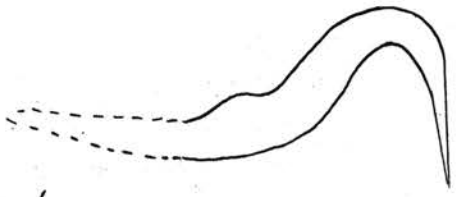

Figure A

Figure C

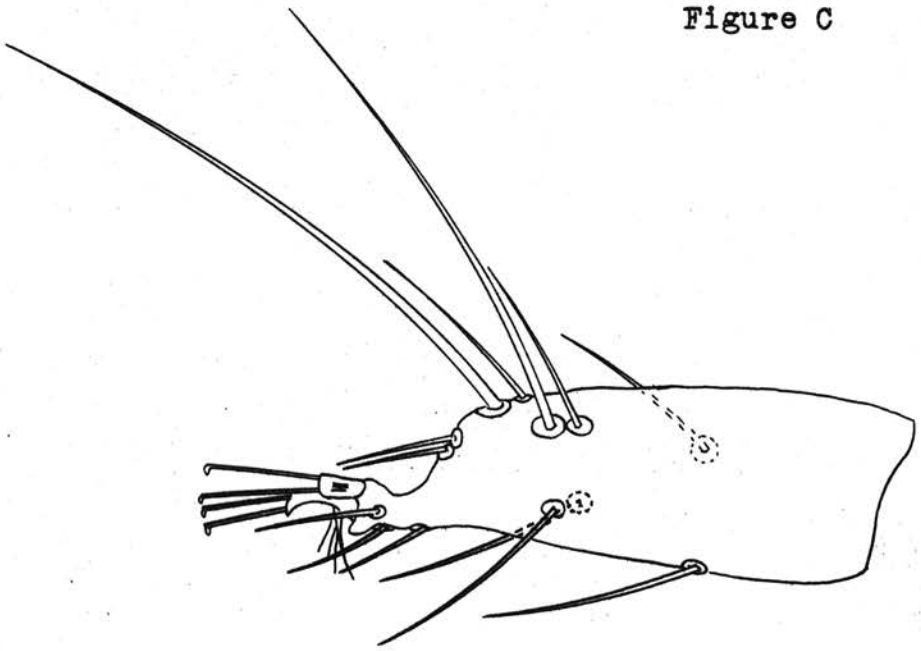

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 9
Oligonychus aceris

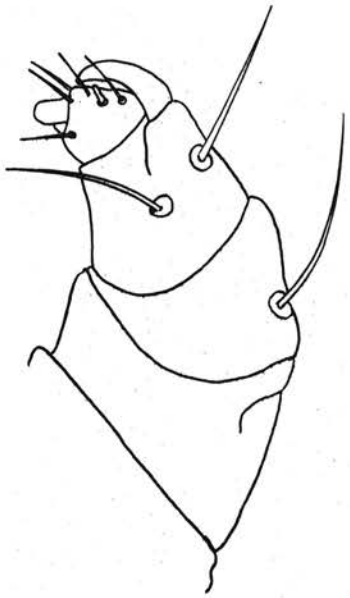

Figure B

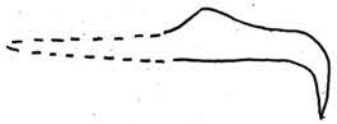

Figure A

Figure C

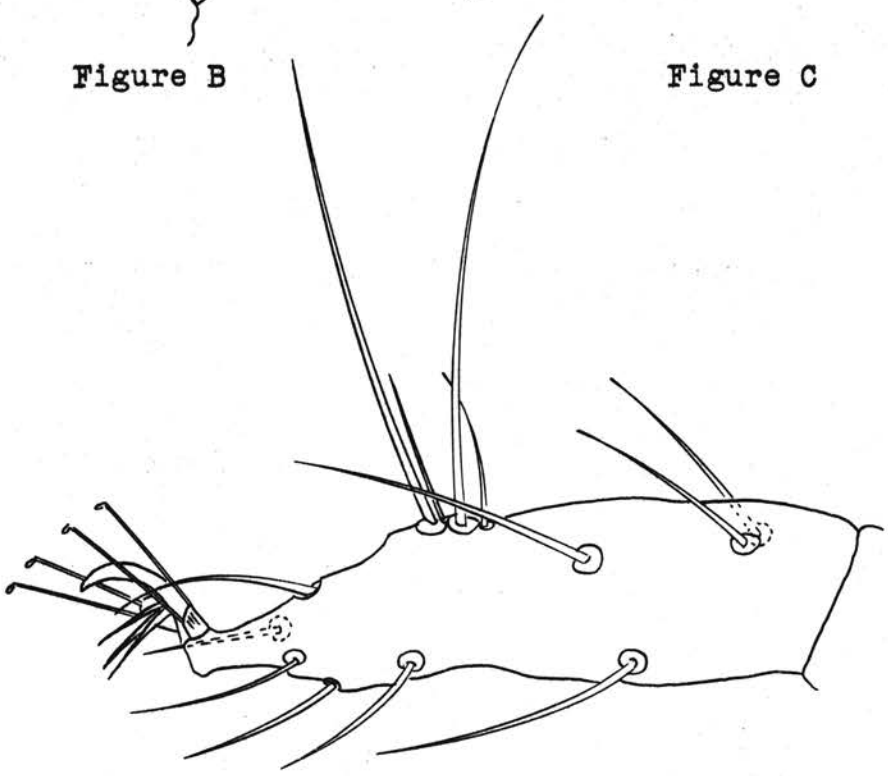

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 10
Petrobia harti

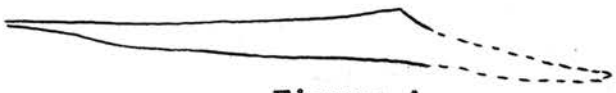

Figure A

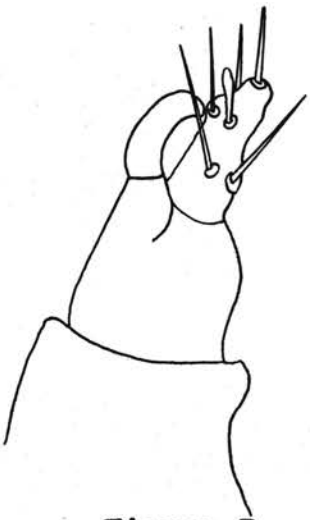

Figure B

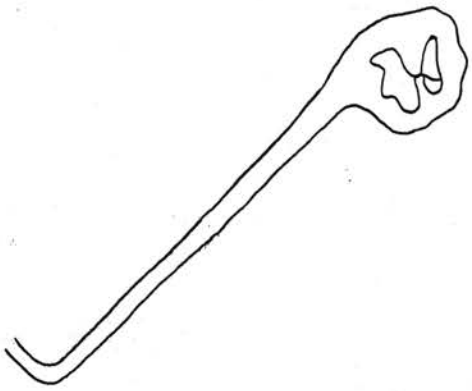

Figure C

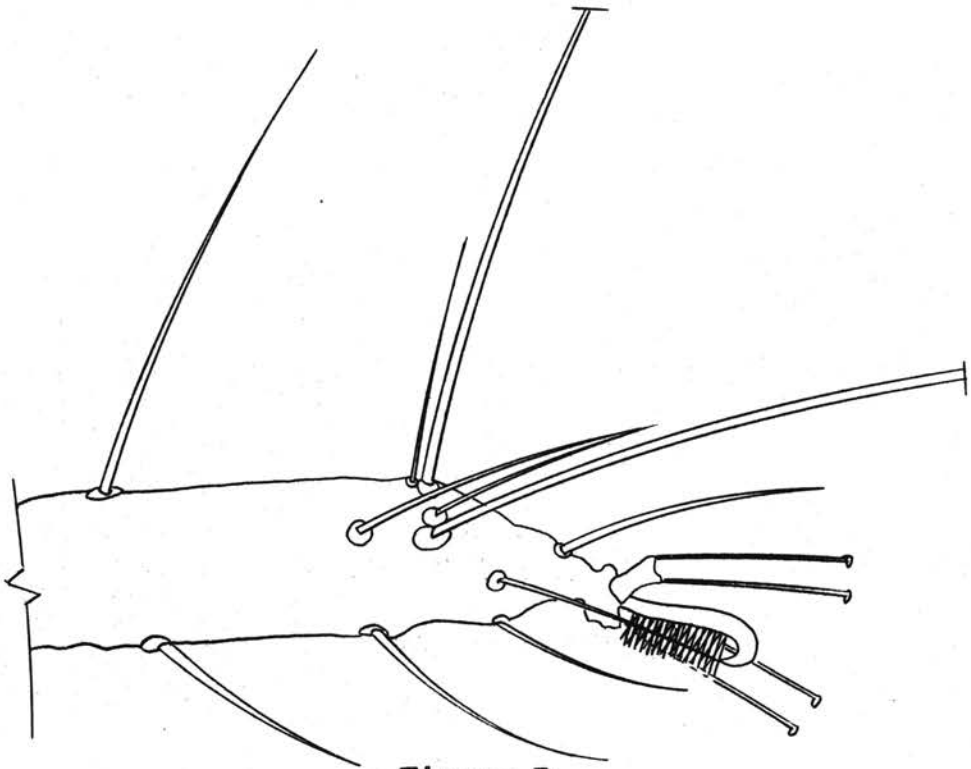

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 11
Petrobia latens

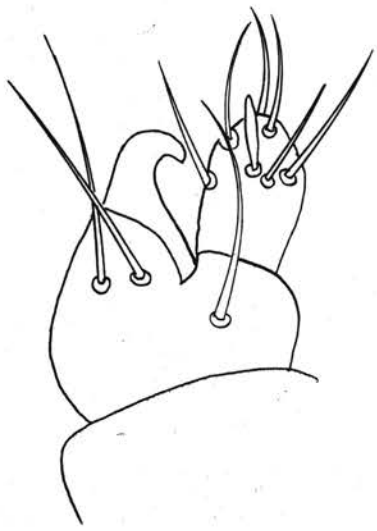

Figure A

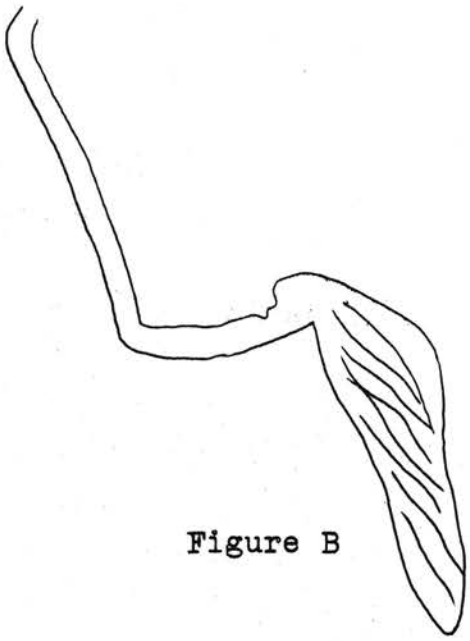

Figure B

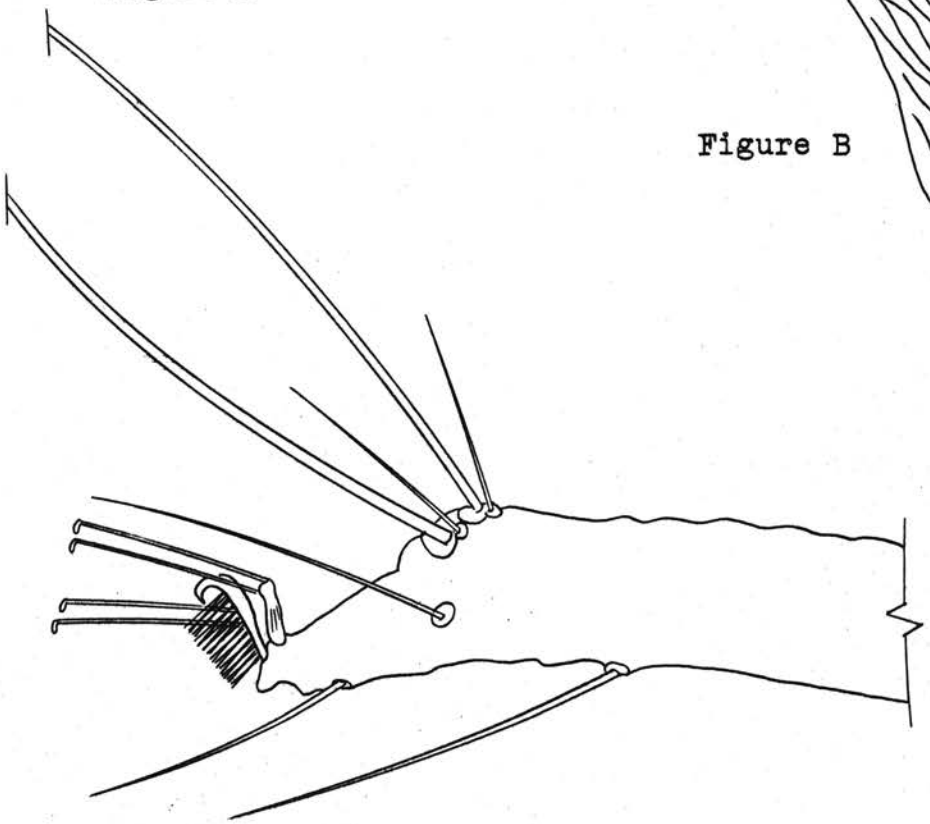

Figure C

Figure A, tip of palpus, female; B, collar trachea; D, tarsus I, female.

Plate 12
Aplonobia kantacki

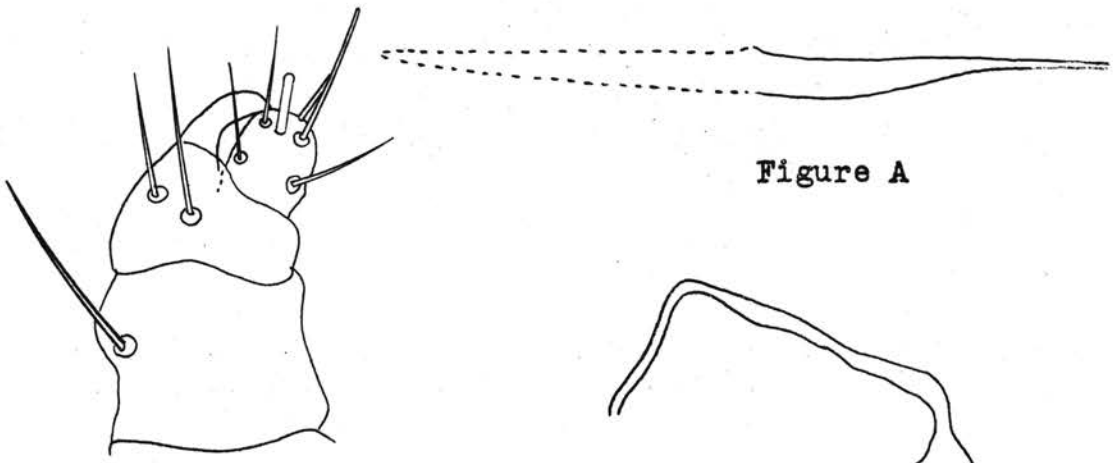

Figure A

Figure B

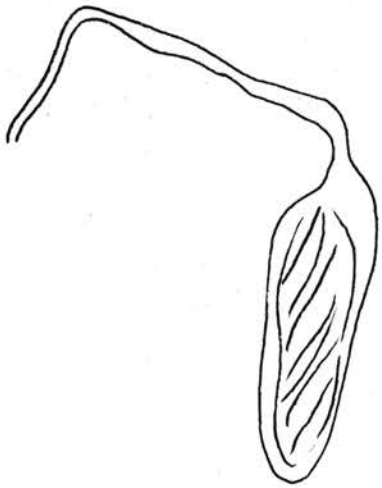

Figure C

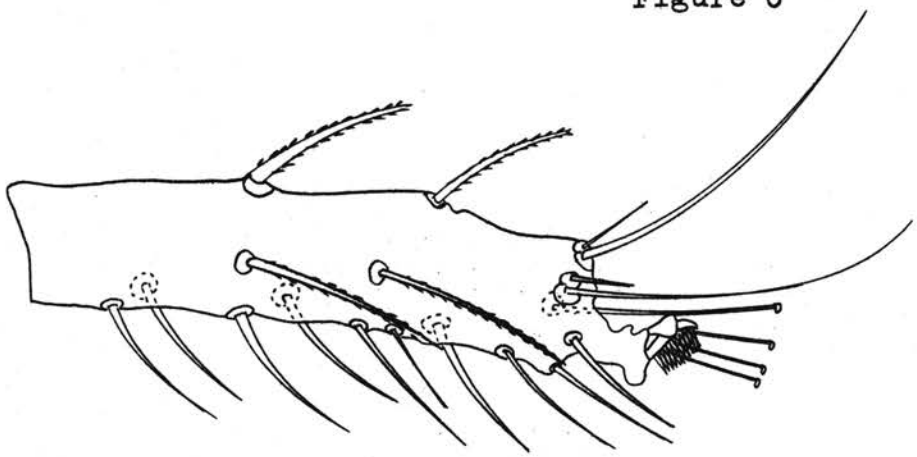

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 13
Aplonobia helianthus

Figure A

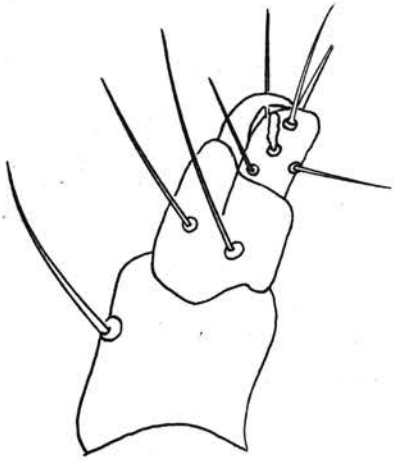

Figure B

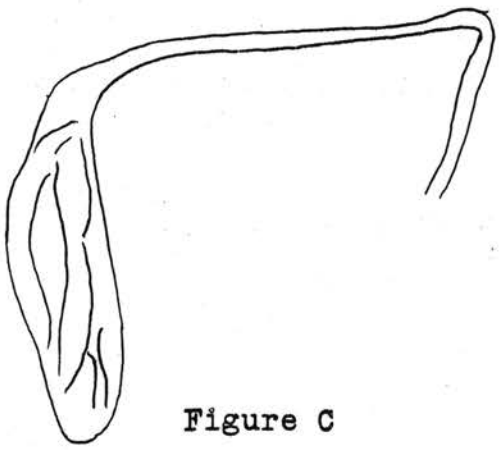

Figure C

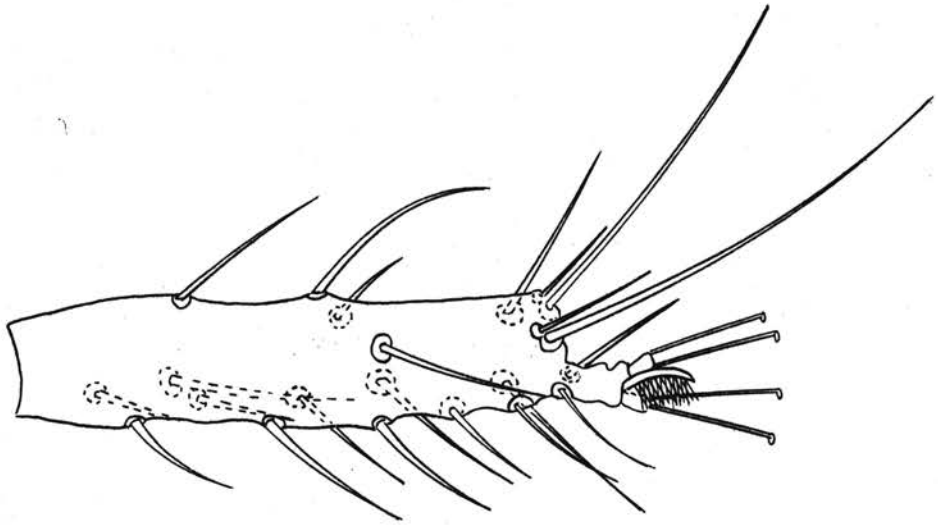

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I female.

Plate 14
Schizotetranychus camur

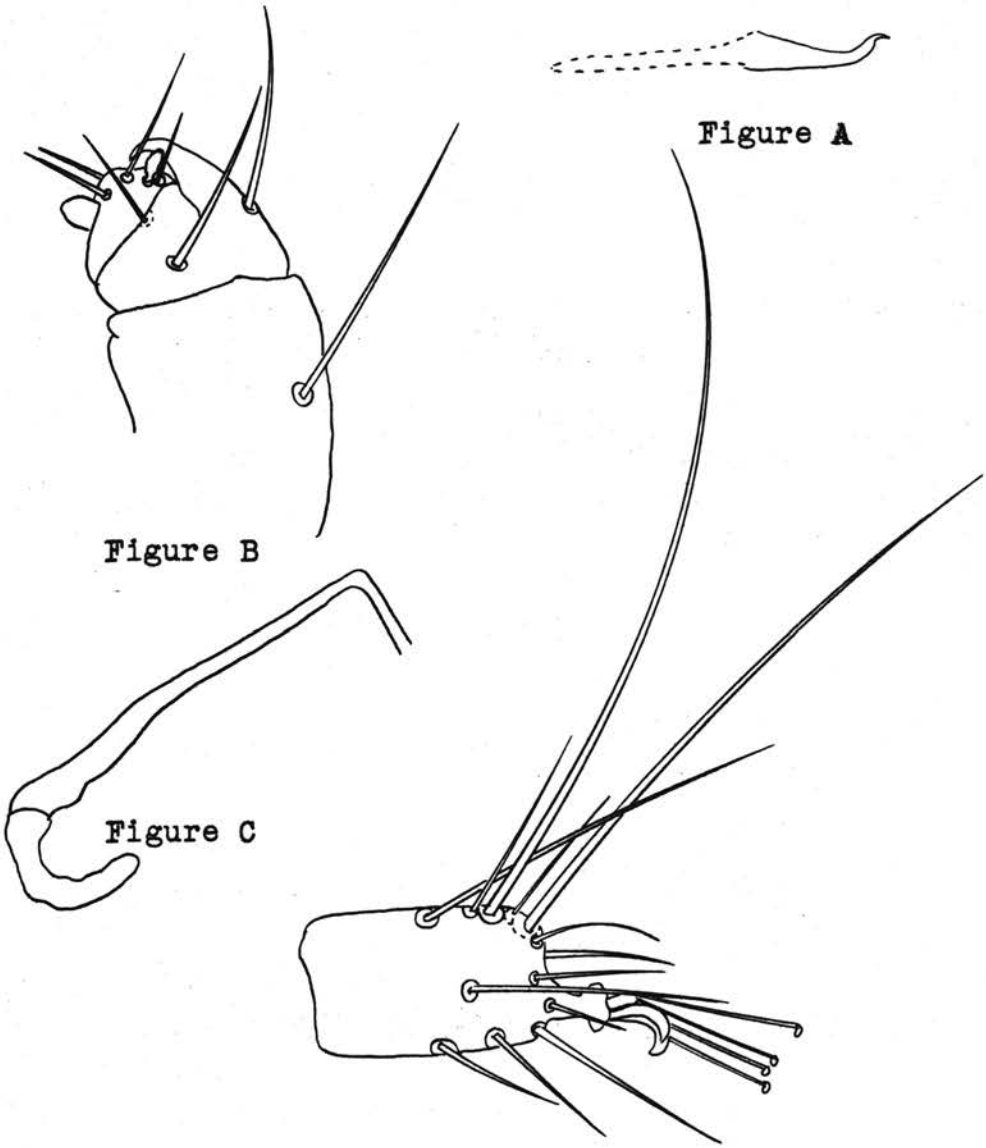

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 15
Schizotetranychus uniolae

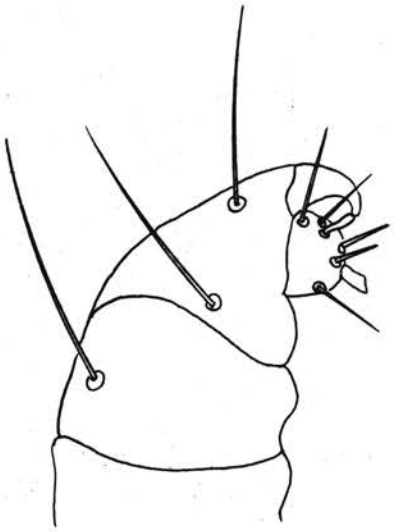

Figure B

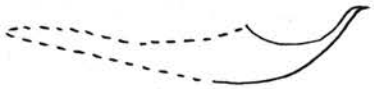

Figure A

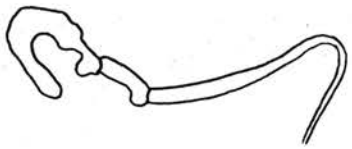

Figure C

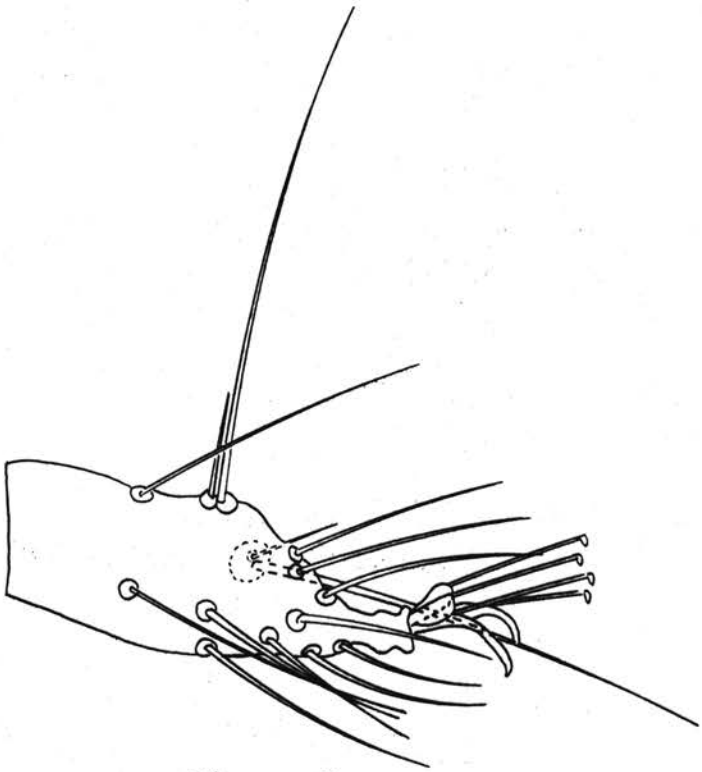

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 16
Eotetranychus perplexus

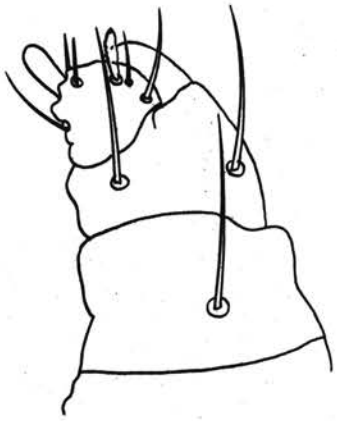

Figure B

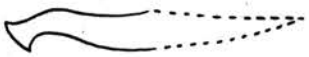

Figure A

Figure C

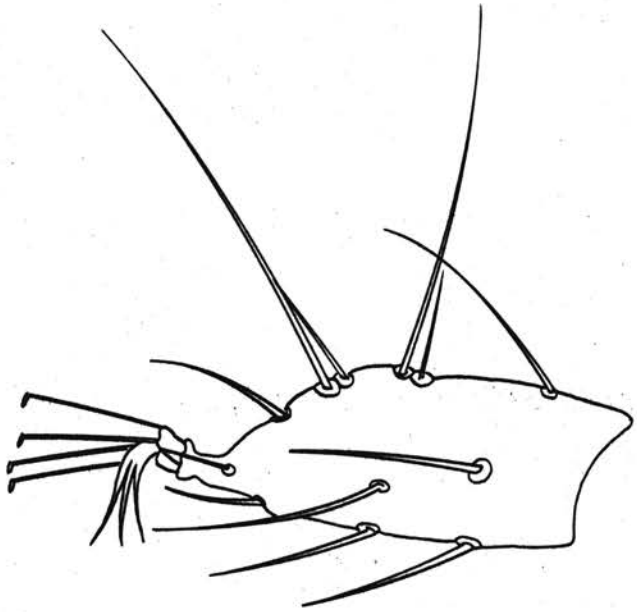

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 17
Eotetranychus hicorie

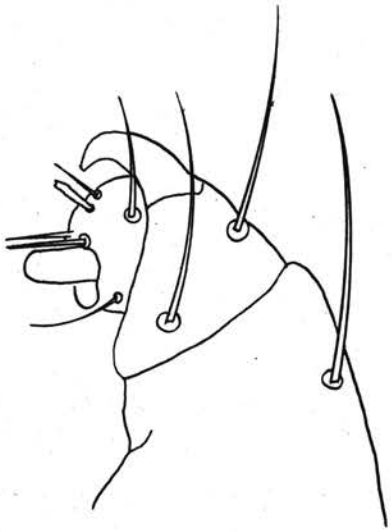

Figure B

Figure A

Figure C

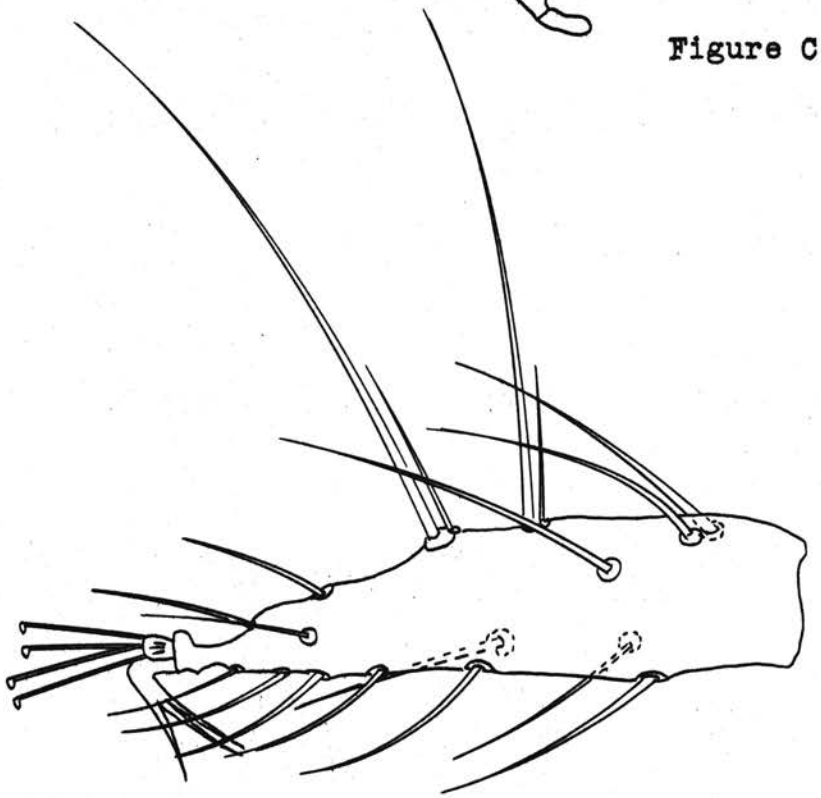

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 18
Eotetranychus populi

Figure A

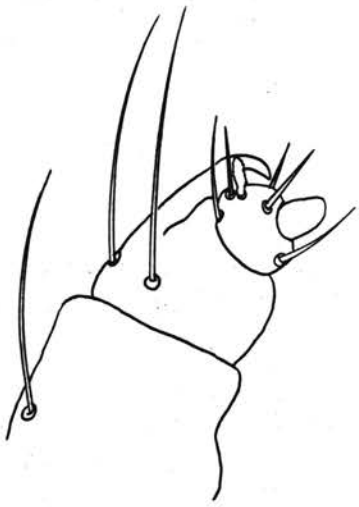

Figure B

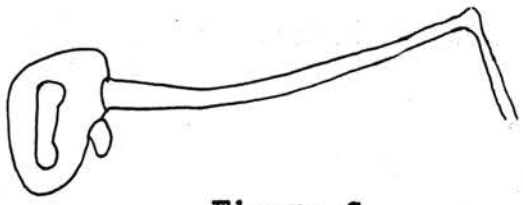

Figure C

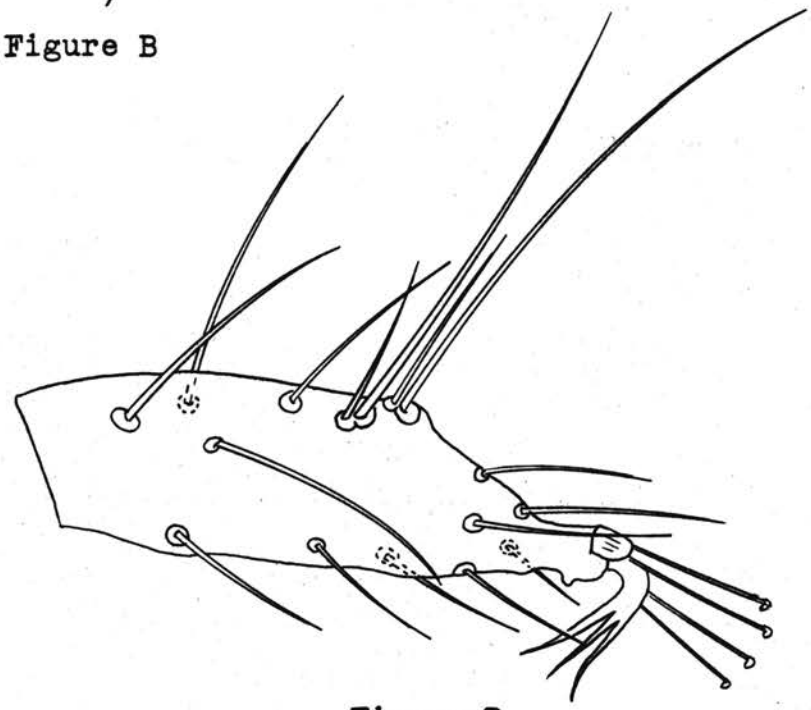

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 19
Eotetranychus carpini

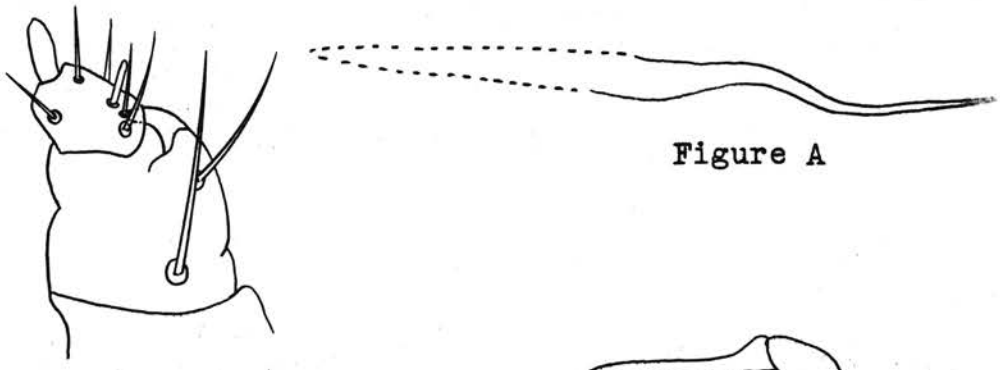

Figure A

Figure B

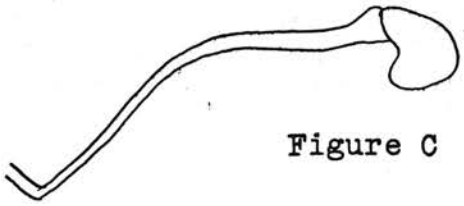

Figure C

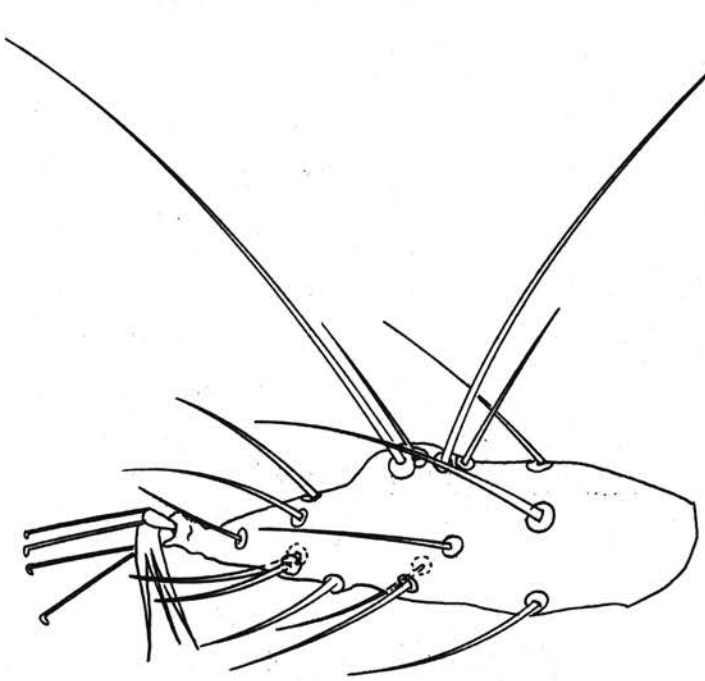

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 20
Tetranychus desertorum

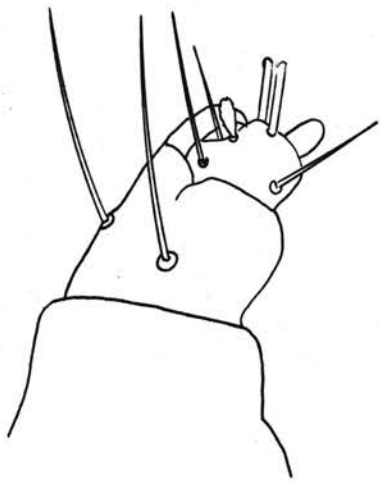

Figure B

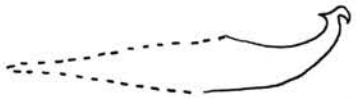

Figure A

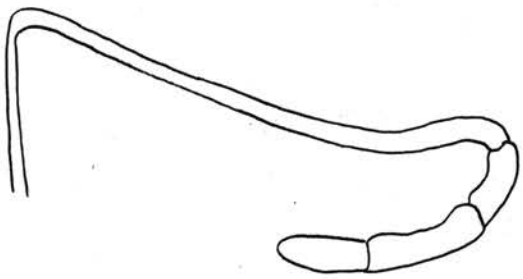

Figure C

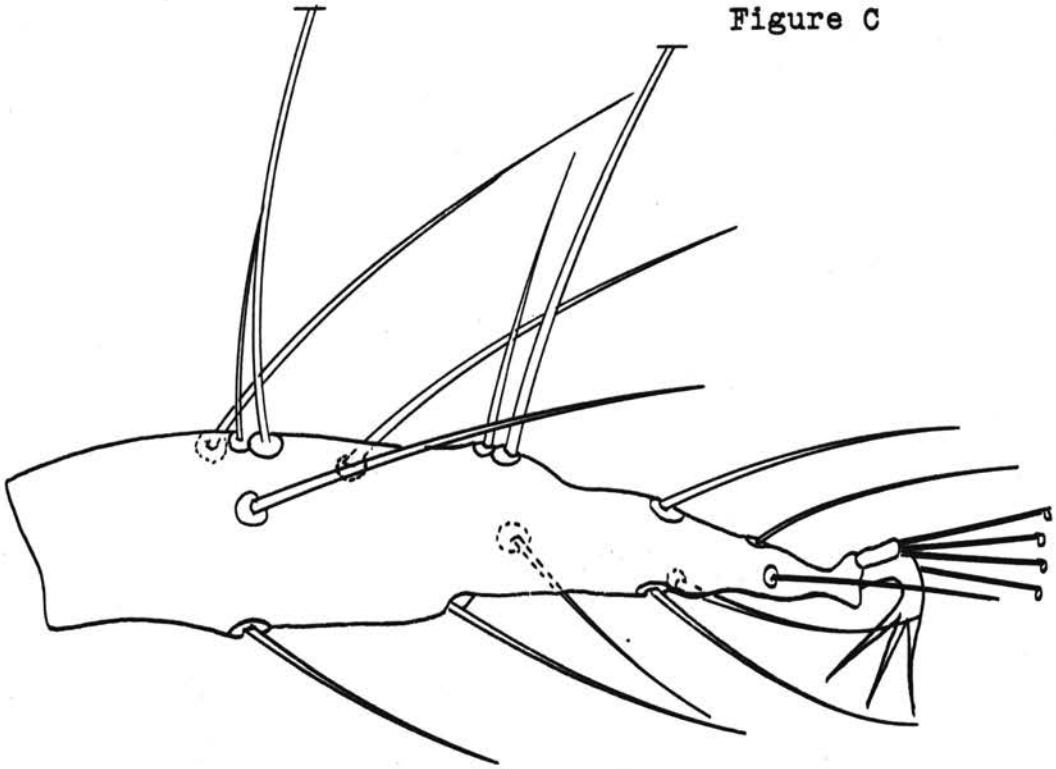

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 21
Tetranychus bimaculatus

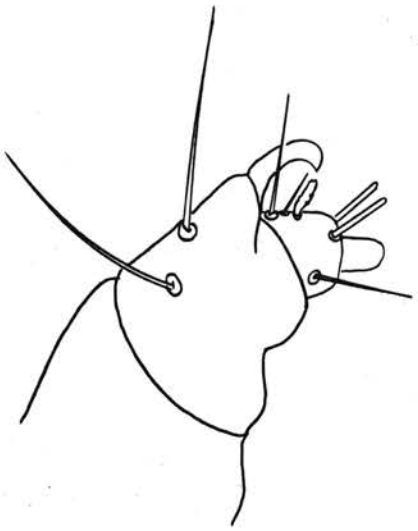

Figure B

Figure A

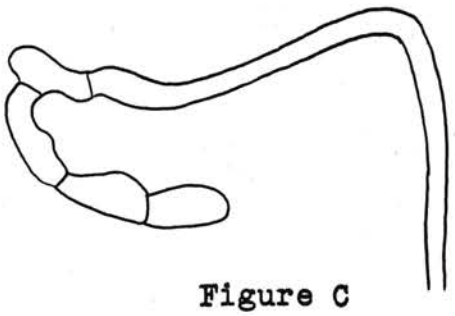

Figure C

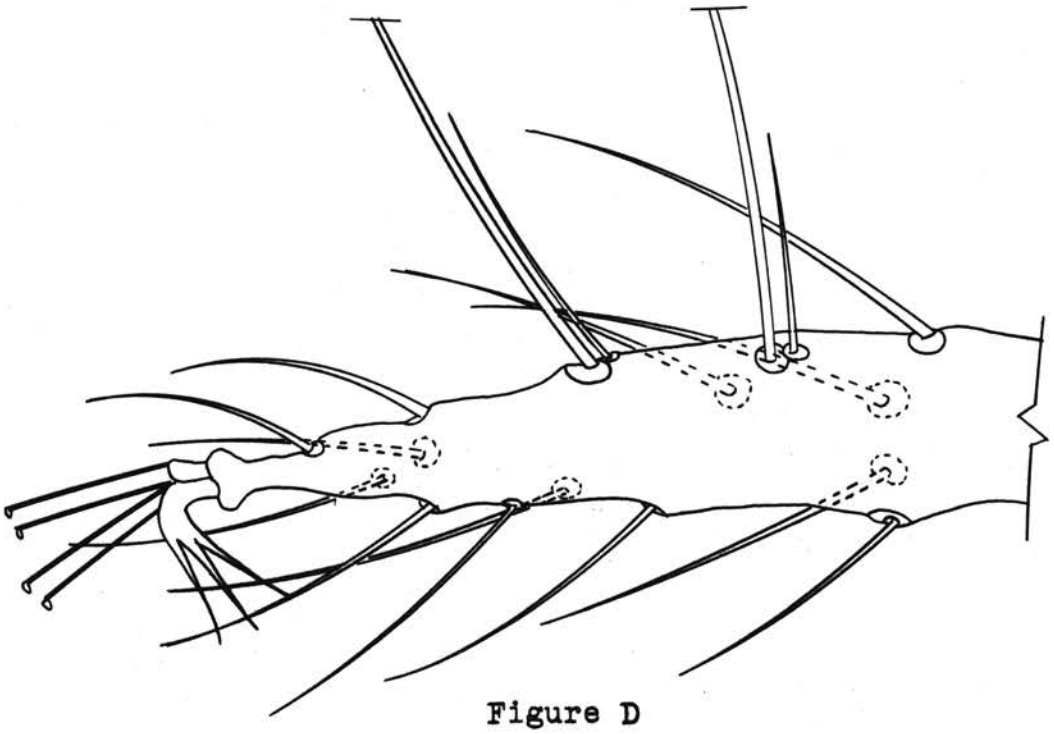

Figure D

Figure A, aedeagus, lateral view; B, tip of palpus, female; C, collar trachea; D, tarsus I, female.

Plate 22
Tetranychus canadensis
&
Tetranychus schoenei

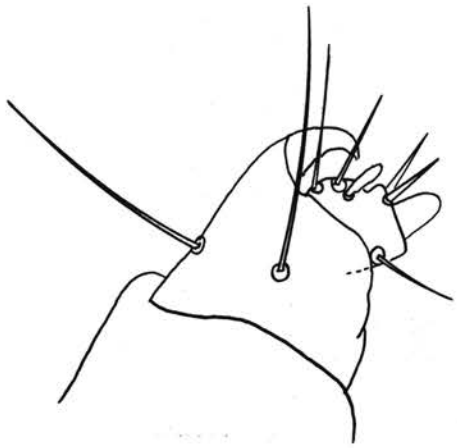

Figure C

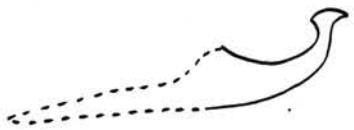

Figure A

Figure B

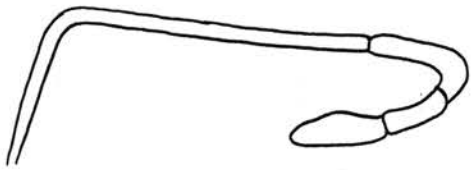

Figure D

Figure E

Figure A, aedeagus, canadensis; B, aedeagus, schoenei; C, tip of palpus, female; D, collar trachea; E, tarsus I, female.

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