MORPHOLOGICAL AND EXPERIMENTAL STUDIES ON

Otodectes cynotis (Hering, 1838)

By

ROBERT JAMES TONN

Bachelor of Science
Colorado State University
Fort Collins, Colorado
1949

Master of Science
Colorado State University
Fort Collins, Colorado
1950

Submitted to the faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May, 1959

MORPHOLOGICAL AND EXPERIMENTAL STUDIES ON

Otodectes cynotis (Hering, 1838)

Thesis approved:

Mendell Krull
Thesis Co-adviser

D. C. Howell
Thesis Co-adviser

F. A. Fenton

Geo. A. Moore

W. S. Newcomer

Robert MacVicar
Dean of the Graduate School

PREFACE

The importance of mites in the world of living things is becoming more evident each year, especially since many modern insecticides seemingly control the action of some economically important insects and this has shifted the emphasis to the mite. Thus, acarology is rapidly becoming established among the basic biological sciences. Because of this growing emphasis on mites, the mite, Otodectes cynotis, found in the ears of dogs, cats, foxes, and ferrets was studied and this thesis prepared from the information gathered.

I am greatly indebted to a number of persons who have discussed with me various phases of the problem or have read portions of the manuscript making valuable suggestions and criticisms. Of especial help in this capacity were Doctors W. H. Krull, D. E. Howell, G. A. Moore, S. W. Newcomer, P. B. Barto, and F. A. Fenton, the members of my graduate committee at Oklahoma State University, Barbara A. Everhart of the Department of Veterinary Parasitology at the same institution, and Doctor E. B. Everitt of the Department of English at Texas Lutheran College. I wish to express my sincere gratitude to Doctor W. H. Krull of the Department of Veterinary Parasitology and Doctor D. E. Howell of the Department of Entomology, the co-advisers of my committee for their personal interest and guidance during the entire project as well as to their respective departments for providing me with the necessary equipment and work space to accomplish the research.

I also appreciate the help given me during the survey studies and the collecting of specimens by Doctors Good, Lessert, and Alexander of Ponca City; Doctor McQueen of Enid; Doctors Corcoran, Devine, Doyle, Faulks, and Wirtz of Oklahoma City; Doctors Ezzell, Gomez, Hoffmann, Irwin, Ritchie, and Todd of Tulsa; and the clinic staff at the Veterinary College, Oklahoma State University.

Special thanks, I believe, should be given to the following persons who allowed me to use their dogs during certain phases of the problem. These men are Messrs. Patton, Smith, Kroutil, Holzer, Owens, Sherman, Berry, Walker, and Taylor of the Stillwater-Perkins area of Oklahoma and the late Mr. Parker of Oklahoma City.

In preparing any thesis it is necessary to rely a great deal on the services of the library for necessary material. Mr. Alton Juhlin and his staff of the Special Services Department of the Oklahoma State University Library preformed a valuable service throughout the problem and I wish to express my sincere gratitude to them for this service.

I also wish to express my appreciation to Miss Barbara A. Everhart of the Department of Veterinary Parasitology and to my wife, Kathleen, for their untiring help in many ways with research, illustrations, and general preparation of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF ILLUSTRATIONS

I. INTRODUCTION

Acarology, which is the study of mites and ticks, has developed largely as an outgrowth of entomology. Even though acarology is relatively new as a formal biological science, mites and ticks have been recognized for a long time. The observers of nature during the early Greek Civilization were familiar with mites and ticks. In fact, the word acari is the Latinized form of the Greek word akari meaning mite. Homer referred to ticks on dogs, and other workers of his time alluded to crushed ticks for treatment of disease, and recommended them as an aphrodisiac in love potions. In spite of this early interest, few mites were named and described. Systematic entomology and acarology are said to have their beginnings with Linnaeus' 10th edition of the Systema Naturae. This edition, although containing many descriptions of insects, included only 29 species of mites, all in the genus Acarus. Even today, the acarologist is not bothered with the volumes of vague literature that plague the entomologist.

Fabricus, Latreille, and Leach, whose interests were primarily in entomology, described some new species of mites and thus helped to create interest early in this field. These men were followed by such workers as Furstenburg, Canestrini, and Trouessert, who became specialists in the taxonomy of the mites. But modern taxonomy in this field probably had its beginning with the work of such men as Berlese in Europe and Banks and Ewing in the United States. Until recently, however, the only good collection of mites, library facilities, and personal guidance for students interested in acarology were located in the Washington, D. C. area.

Today there is a growing demand for research in this field. Several universities and museums offer educational programs for specilization in acarology; for instance, the Institute of Acarology at the University of Maryland does an excellent job of correlating and pursuing research and in encouraging "budding" acarologists. The United States is not, however, the only country with an expanding interest in acarology. All over the world, taxonomists and students of basic research in this field are at work, because acarines and the diseases they help to spread are increasing in importance economically, and considerations of public health have focused attention on the necessity for research. This intensification of research is especially evident in such countries as Russia, where as a result of a cold climate, itch mites become a serious problem among its populace and domestic animals.

Actually, we know very little about the biology of the mites; even such species of economic importance as the chiggers and itch mites have been neglected. Much of this lack of information is due to difficulty in rearing the mites on which such information has to be based, as well as to the indifference of biologists to this area of study when less difficult phases may be pursued. Yet a study of the biology is absolutely necessary for making progress. Results of research are needed to give the taxonomist documented material upon which to base his decisions, relations, and speciations. For instance, even ecological and life history studies may indicate why one species is a disease carrier or producer, while a related species is not, a fact which could be important in public health. Basic biological studies of mites may help us to understand the action of modern acaricides and initiate ideas for the development of more effective ones. Many mites are of great economic importance; through

further study of them, natural biological control of these mites may be accomplished. If the science of acarology is to advance and take its place among the better established basic sciences, the acarologist must devote many hours of research to the study of basic biology of mites.

At the present time, acarology is suffering from growing pains. As a science it is probably a hundred or more years behind entomology in accomplishments and is trying to catch up over night. Much of the taxonomy in acarology is actually in a chaotic state, because some workers are trying to outdo each other in describing new species. The entire Order Acarina is in haphazard condition taxonomically. Far too many students of acarology see the so-called "romance" in describing new species and are blind to the necessity for redefining the earlier named ones.

That Otodectes cynotis is common throughout the world is demonstrated by available information which shows that in many countries the organism has long been considered a pest. It may reduce the vigor and alertness of the host, may be a nuisance to the host as an irritant, and at times probably subjects the ear to secondary invaders. Most of the affected hosts can withstand a large number of the mites without showing apparent symptoms or pathological changes. Extreme infestations appear to be more prevalent in foxes than in other hosts, because surveys and popular literature concerned with fox farming indicate that a very serious problem exists in the fox fur industry. O. cynotis appears to affect not only the health of the ear and of the animal in general but also affects the natural lustre of the pelt, however, any host such as the dog, cat, fox, or ferret may show symptoms of its presence and even pathological changes occasionally. Extremely severe infestations may be fatal, death being caused by either

the mites or secondary infections. Many terms have been used to indicate an infestation of the ear by mites. Among the most common are ear canker, ear mange, otacariasis, auricular scabies, parasitic otitis, and otodectes mange.

All of these terms apparently refer to infestation of a single mite, O. cynotis, the classification of which is discussed. Of the many schemes of classification of sarcoptiform mites, the writer will follow the recent one proposed by Yunker (1955) who determined the taxonomic position of Otodectes to be as follows:

Suborder: Sarcoptiformes

Supercohort: Acaridiae

Cohort: Psoroptidia

Superfamily: Psoroptoidea

Family: Psoroptidae

According to Baker and Wharton (1952) the family Psoroptidae includes four genera.

1. Psoroptes Gervais, 1841 (Dermatodectes Gerlach, 1857: Dermatokoptes Fürstenburg, 1861)

   Type: Psoroptes equi (Hering) 1838

2. Caparina Canestrini, 1894

   Type: Caparina setiferus (Mègnin) 1880

3. Chorioptes Gervais, 1859 (Symbiotes, 1857

   Nom praeoc.: Dermatophagus Fürstenburg, 1861

   Type: Chorioptes caprae (Delafond) 1854

4. Otodectes Canestrini, 1894

   Type: Otodectes cynotis (Hering) 1838

The genus Otodectes was established to include certain ear mites of the cat, dog, and ferret. Usually these mites are referred to as single species, O. cynotis, with host varieties.

Since the science of Acarology in its modern form includes a new and growing field of research, much is yet to be learned about mites and their behavior. The writer decided to investigate some of the phases of the biology and taxonomy of a single species, Otodectes cynotes (Hering, 1838), an ear mite reported from dogs, cats, ferrets, and foxes. In so doing, basic information and techniques for study in the fields of taxonomy, morphology, life cycles, and biological behavior were achieved, thus establishing a foundation for future work.

The principal points considered in this study are these:

1. The number, morphology, and basic biology of the stages in the life cycle of O. cynotis.
2. The external morphology in detail, particularly structures and measurements that may be of taxonomic value.
3. The incidence, abundance, and peculiarities of the infestation in dogs and cats.
4. The specificity of the varieties in cats and dogs.
5. The biology and ecology of the mite.

II. METHODS AND MATERIALS

The materials used in these studies as well as the explanation of the methods employed in the study of the morphology, the life history, and the survey will be discussed in this section. Many of the materials and methods used in the section dealing with the behavior of the mite were quite diverse, consequently they will be included in the discussion of the various phases reported in the respective specific sections.

1) Collection and Morphology of Otodectes: Mites for this investigation were collected from the hosts in the following manner. The investigator restrained the cats and dogs manually, and examined both ears for mites by swabbing them with an applicator stick covered with cotton. The swab was introduced deeply into the external auditory meatus, and was gently twisted to catch the cerumen and mites. The swab was removed and examined for mites with a hand lens. If parasites were present, the swab was transferred to a test tube containing 50 to 70 percent alcohol. The tube was labeled with all the information available, including the kind, sex, and age of the host. These parasites were used later for the morphological studies. When live mites were needed, the same method of collecting was used, except that the swabs were put in petri dishes. These were taken to the laboratory where the mites could be kept under observation.

The investigation in morphology included measurements of the organisms and the detailed study of all stages in the life cycle of the mite. Preserved material, being easier to handle, was used more

extensively than living specimens. The ease of examination was demonstrated by the fact that the specimens mounted well in Hoyer's solution, Hoyer's solution with aceto-carmine, and Hoyer's solution with Giemsa's stain, following the procedure outlined by Furr (1955). The labels on the slides included host, location of host, date, sex and/or stage of development of the mite. The mounted specimens were cleared and dried in an incubator for a few days before they were studied. Phase-contrast and dissecting microscopes were used in the study of the morphology of the mites.

2) Life History and Survey of Otodectes: In the study of the life histo of these parasites, several types of artificial media were tried for rear them, but the mites either died immediately or bogged down in the medium. Because of the failure of the mites to survive on artificial media, it wa necessary to study them directly on the host or to bring them into the laboratory and to keep them in chambers until they died. Mites used in the study of the life cycle were transferred directly from the source animal to an experimental one, or the mites were placed in a refrigerator until they could be utilized on experimental animals. Refrigeration reduced the activity of the mites and made them easier to handle. Since mites that had been refrigerated transferred successfully, it was assumed that this treatment did not alter or influence the normal behavior patterns of the parasite.

Most of the experiments were carried on in a room at approximately 22° C. except during the summer when the temperature approached but seldom exceeded 38° C., the temperature of the ear of the host.

Observations made at known temperatures and relative humidities furnished information on the tolerance of the mite to these conditions. When specific constant temperatures were needed, either a constant

temperature water bath or a bacteriological incubator provided the requisite stability. These were pre-set and checked for a period of at least twenty-four hours before either was used. Each device was equipped with a thermometer, which made periodic temperature readings possible while the experiment was being conducted.

Constant relative humidities for different temperatures were maintained by using KOH solutions of appropriate percentages, or with saturated salt solutions following the procedures recommended by Peterson (1953). Constant humidity chambers consisting of petri dishes or other suitable containers with tight-fitting covers were used. In order to maintain the humidity, these containers had filter paper in the bottom saturated with either the KOH or the salt solutions. Petri dishes or hanging-drop slides were the best receptacles for handling the mites in these experiments. Using these containers under a stereoscopic microscope, rapid observations and counts of specimens were made. The Petri dishes or hanging-drop slides were placed in the humidity chambers, and these, in turn, in the constant temperature incubator. By utilizing such methods many "off the host" observations on all stages of the mite were completed, and the effects of temperature and humidity were determined and recorded. Data were recorded, temporarily, either on the lid of the petri dish or the surface of the slide, and transferred later to permanent file cards.

Large numbers of eggs were needed for both the hatching and embryology experiments. To secure them, female mites were placed in a petri dish, and the eggs collected hourly. This method, although good, was time consuming. Accordingly an egg collecting apparatus similar to that of Camin (1950) was constructed (Plate I) and utilized. With this

apparatus, eggs could be collected over a period of any duration without waste of time. Such eggs went into deep-well, hanging-drop slides, and were observed hourly until hatching occurred. To complete the observations, eggs of known age taken from the hanging-drop slides were submerged in glycerine or glycerine jelly which acted as a preserving agent and made possible a detailed study of the development of mites within the egg.

The biological studies on the larvae, protonymphs, deutonymphs, and adults could not be completed by observing them off the host exclusively, since no suitable culture medium was devised on which the mites would complete the life cycle. Furthermore, it was assumed that artificial conditions would probably alter the development and behavior of the mite.

In order to secure suitable experimental hosts, it was necessary to examine the animals for the presence of mites by using both a swab and an otoscope. If no mites were found by these two methods, the animals were considered to be negative and suitable for experimental work. The ears of such dogs and cats after they were selected, nevertheless, were cleaned and treated with 2 percent Dow ET-57 (0,0-dimethyl O-2,4,5-trichlorophenyl phosphorothioate) in mineral oil or mineral oil alone, which was a further precaution in securing mite-free potential hosts. In a week, these animals were reexamined and re-treated as a further precautio This was repeated even a third time in some instances. All animals lived in isolation in cages or pens during the observations.

Transfers of the mites were made from cat to cat, cat to dog, dog to cat, and dog to dog by swabbing the ear of the host and examining the cotton tipped applicator for mites with a hand lens before placing it in the external auditory meatus of the experimental animal. Experience demonstrated that twenty minutes was sufficient time for the mites to

transfer from the swab to the ear of the animal. The right ear was uniformily used for establishment of the infestations and the left ear maintained as the control. The ears of both the experimental and control animals were examined periodically with both an otoscope and swab to determine if the transfers were successful. If the infestation was established, the left ear, the control, was checked periodically to determine the period of time which was required for the infestation to spread to this ear.

Kittens were used as hosts in studying the details of the life history of the mites. The same procedure as outlined in the transfer studies for securing potential hosts insured mite-free kittens. To obtain experimental infestations for life history studies a known number of mites of a stage were introduced into the right ear of each kitten. The data were accumulat by periodic inspections to determine the duration of time of the individual stages in the life history, the conditions of hatching of the eggs, and the stages of metamorphosis of the mite.

III. SYSTEMATICS OF OTODECTES CYNOTIS

Until recently Otodectes cynotis has been known under many scientific names. Even though Canestrini established the genus Otodectes in 1894 some of these names are still being used. The general literature concerning O. cynotis since 1894 is voluminous, but for the most part unimportant from the standpoint of taxonomy. These references, therefore, are omitted from the synonymy.

Synonymy: Sarcoptes cynotis Hering, 1838

Psoroptes cynotis Gervais, 1841

Sarcoptes auricularum Lucas & Nicolet, 1849

Symbiotes canis Bendz, 1859

Symbiotes felis Huber, 1860

Dermatophagus canis Zurn, 1874

Chorioptes ecaudatus Mégnin, 1876

Symbiotes ecaudatus Perroncito, 1882

S. cynotis auricularum var. canis Railliet & Cabiot, 1892

S. cynotis auricularum var. cati Railliet & Cabiot, 1892

S. cynotis auricularum var. furonis Railliet & Cabiot, 1892

Choriopte auriculaire Railliet, 1893

Chorioptes auricularum var. canis Railliet, 1893

Chorioptes auricularum var. cati Railliet, 1893

Chorioptes auricularum var. furonis Railliet, 1893

Otodectes cynotis Canestrini, 1894

Otodectes furonis Canestrini, 1894

Although the complexity of the synonymy of O. cynotis is confusing, it nevertheless represents a normal trend of development in taxonomy in a fast growing science such as acarology. This complexity is primarily an outgrowth of several circumstances. For instance, the mites were found and described in three of the four known hosts (dogs, cats, and ferrets) at approximately the same time. Further confusion arose when many genera were created with little regard for existing ones; in addition new species were being described in existing genera, a condition which made it advantageous to split many of them. Many descriptions were made even though the individual workers did not have an opportunity to examine some of the literature and others apparently actually lacked the necessary interest to seek out the past history of the mite. Because of this situation, over a period of time the parasite was described by a number of workers, who used different determinations for speciation, and placed the mites in many genera using various names to designate the same species. As more related species were described and better characters of differentiation for species were determined, the clouded taxonomy of Otodectes gradually cleared. Today few workers refer to the mite under any other name than O. cynotis.

The confusion of this past taxonomy and the unavailability of much of the older literature concerning this ear mite makes a complete survey of taxonomic history almost impossible. Because of this difficulty, this discussion is merely an attempt to show what the writer considers to be the highlights of the taxonomy of the mite.

Hering in Germany was apparently the first person to discover Otodectes cynotis in the ears of any host. He found the ear mites in the ears of a dog in 1834 and later (1838) published his findings, giving

measurements for the total length and width of the mite, and describing it superficially. Perhaps the greatest value of his paper is in the reporting of the mite and giving it a scientific name, Sarcoptes cynotis.

In a revision of the genus Sarcoptes, Gervais (1841) placed the ear mite, along with other species, in a new genus Psoroptes. Although it is no longer included in this genus, its close relationship to Psoroptes is evident, since it is considered to be in the family Psoroptidae.

Lucas (1849) was apparently unaware of these publications when he designated the mite as Sarcoptes auricularum. This name led to confusion, for the mite now had two specific names, cynotis and auricularum. Both of these were used well into the twentieth century as species designations for the mite.

With greater emphasis being placed on the taxonomy of mites after 1850, the genus Sarcoptes underwent a period of drastic revisions. It was split into many genera, three of which included this specific mite simultaneously and these are the primary concern of this discussion. They are Symbiotes Gerlach, 1857; Chorioptes Gervais and Van Beneden, 1859; and Dermatophagus Fürstenburg, 1861. Each genus will be discussed separately in chronological order.

Ear mites from the dog were described and designated by Bendz (1859) as Symbiotes canis. A year later a similar mite was collected by Huber (1860) from the cat and called S. felis. Later Perroncito (1882) reported the mite as Symbiotes ecaudatus, using the specific name given it by Mègnin (1876), who described it as Chorioptes ecaudatus. Railliet and Cabiot (1892) in a review of the literature referred in their discussion to the parasite as Symbiotes auricularum, and designated host varieties with respect to the specific mammal hosts. This report included

findings of experimental transfers of the parasite between various species of natural hosts. These experiments later strengthened the observations of Vitzthum (1928) who concluded that all these ear mites belonged to a single species. The generic name Symbiotes was later shown to be invalid because Redtenbacker in 1849 had previously used it as a generic name for a group of Coleoptera.

Mégnin (1876, 1884) described the parasite as Chorioptes ecaudatus and reported it as a cause of an epidemic which he called parasitic otitis of ferrets in France. This apparently was the first report of the ear mite from ferrets. Later Railliet (1887) described another case that he called acariasis in ears of ferrets; however, he differed from Mégnin by calling the parasite Symbiotes ecaudatus. Railliet (1893) added to the confusion of the taxonomy of the ear mite by referring to the mite as Chorioptes auricularum, but in the same paper he also used Choriopte auriculaire, in both cases using the host variety names designated by Railliet and Cabiot (1892).

Zürn (1874) found this mite in the ears of dogs and described it as Dermatophagus canis. His description was good and was accompanied by drawings of the larva, male, and female mites; however, one drawing of what he calls the young female actually appears to be a gravid deutonymph rather than a female. According to Railliet (1893), Hering in 1863 and Schirmer (his reference could not be found in the literature) also placed the ear mite of the dog in this genus.

Canestrini (1894) designated the fundamental taxonomic characters of these ear mites and erected the genus Otodectes to include all forms from the cat, dog, and ferret. In addition, he recognized that the specific name, cynotis, had priority over all existing names and included

in this species organisms parasitizing the cat and the dog. However, on the basis of measurements, he raised the variety furonis, which was used by Railliet and Cabiot (1892) for the mites of the ferret, to specific rank.

Allen (1924) reported he had found species of Otodectes in the ears of the fox in the United States in 1919. This apparently is the first report of the ear mite in foxes. It appears that no variety name ever has been given to the ear mite of foxes, even though several references to the mite appear in the literature. However, later mention of the mite is made in the periodicals from England, Germany, and Canada as well as from the United States. Much of the literature that has been written about the ear mites of foxes has appeared in popular articles in fur trade journals and, therefore, is not used in this study.

Vitzthum (1928) noted the similarity in morphology between O. furonis and O. cynotis, and determined that the only difference was in length and width, and, therefore, he considered furonis to be a variety of O. cynotis.

Gillain (1942) in a study of ear mites of a cat in Africa found a variety of mites, similar to existing ones except for size, which he considered to be O. cynotis var. africana. The establishment of this variety, however, was based on the measurements of a single male and only a few females collected from a single host. Since the material was limited and because it apparently has not been reported by other workers from Africa, the mite is probably O. cynotis var. cati. Further support for this opinion is suggested by two observations: first, O. cynotis var. cati was reported in Africa earlier by Hofmeys and Dutoit (1940), and second, the extremes of measurements of the mites show greater variations

in size of individual specimens of O. cynotis var. cati than in the variety established by Gillain.

The proper name of the mite from ears of dogs, cats, foxes, and ferrets is Otodectes cynotis (Hering) Canestrini, 1894. The variety designation may or may not be used, depending upon the opinion of the writer.

The genus Otodectes is distinguished from other genera in the family Psoroptidae by the following combination of characters: presence of suckers on legs I and II of the female and on all the legs of the male, transverse genital opening in the female, coxal apodemes I and II fused ventrally. Mites found primarily in the ears of the dog, cat, fox, and ferret.

IV. ANATOMY OF *OTODECTES CYNOTIS*

Very few papers on the detailed anatomy of mites have been published. In descriptions of specific mites, most publications mention briefly certain anatomical structures, but do not give enough detail to establish a sound foundation for biological or taxonomical studies of mites as a whole. In *O. cynotis*, the work of Vitzthum (1928) and Grandjean (1937), although restricted to certain phases of anatomical parts, is excellent and contributes much to our knowledge of anatomy. There are, however some conflicts as to terms applied to some parts. In this study the stages in the cycle are described, using modern terminology, and the papers of Vitzthum and Grandjean discussed. The descriptions are based on the study of both living and preserved material and microdissection was used to study both the mouthparts and integument.

Segmentation

Since segmentation in mites is not conspicuous, only arbitrary divisions can be applied to the different regions of the mite. The acarologist, therefore, has had to adopt new terminology because many terms such as head, thorax, and abdomen are not applicable to mites. The terminology of Vitzthum 1940 (as cited by Baker and Wharton, 1952) probably is the most universally used at the present time. Accordingly, the mite is divided into the gnathosoma or region of the mouthparts, propodosoma or region of the legs I and II, metapodosoma or region of legs III and IV, and opisthosoma or posterior region of the body. The gnathosoma usually is set off slightly from the body proper and the remainder

of the mite is sometimes called the idiosoma. In another method of showing arbitrary divisions, the term "proterosoma" is used for the combined region of the gnathosoma and propodosoma while the term "hysterosoma" is used for the posterior region, the metapodosoma and opisthosoma. (See plate 2 & 3). In the species of Otodectes, a definite line of demarcation between all the divisions except the gnathosoma and the idiosoma is lacking. Hence the terms other than gnathosoma and idiosoma will be used only when referring to plates or location of setae.

Integument

The integument of all motile stages of species of Otodectes is composed of a hypodermis and the sclerotized or chitinized exoskeleton which is striated on both the dorsum and venter of the idiosoma. The integument is creamy white except in areas which are heavily sclerotized and these vary from red to golden brown. The apodemes and marginal areas of the segments of the appendages have pronounced sclerotization, thus providing support for the attachment of muscles. Areas with thick sclerotin on the mite are usually referred to as plates. These plates are, for the most part, found in both the genital and anal regions. A punctate, propodosomal plate is present in all life cycle stages. This plate on the dorsal median line is approximately twice as long as wide and setae are lacking. Punctation on the plate increases progressively in the mite from the larval to the adult life cycle stage. A smaller pair of plates occurs on the dorsum of all stages of this species. These plates are located along either side of the base of the propodosomal plate. These plates are tear-drop-shaped and each bears a long whip-like seta arising from the center and each usually has a smaller seta located on the medial edge of the plate (it may be off the plate, but always

present). Another, the hysterosomal plate, occurs only on the male and is located on the dorsal median line and extends from the level of legs III to the posterior tip of the opisthosoma. This plate is punctate, emarginate at the posterior end, and bell-shaped in general outline, being wider at the anterior end. It differs from the propodosomal plate because it has a pair of setae.

Apodemes, which are inward extensions of the integument, are utilized for the attachment of muscles. In the immature stages, these structures are associated primarily with the appendages and anal opening, however, in the adult, additional apodemes are associated with the genital structures. A discussion of the genital apodemes will be included with the reproductive system. The exoskeleton, except the apodemes and the propodosomal and hysterosomal plates, is striated. These striations are particularly prominent in the region of the genital opening especially the female, where they follow the curvature of the genital opening and the internal apodemes.

Various forms of setae are found on the integument of the mite. The majority of these are of the simple type, which is considered to be the most primitive, however; other types are found in association with the genitalia, on the tarsi, and the margins of the body, especially the posterior tip. Perhaps the most noticeable of these are the long whip-like ones which Grandjean (1936) called "acanthoides" and which he believed functioned as tactile organs. These setae are associated with tarsi III and IV; however, one to three pairs of long whip-like setae similar to the acanthoides also are present on the posterior tip of the opisthosoma. There is a single pair of whip-like setae on the margin of the metapodosoma that arise from an elevated area immediately anterior

to the legs III, and another single pair on the small plate on the dorsum. Other setae located on the venter near the median line between coxa II and III occur either as one or two pairs, depending on the stage of development, and are not simple. Vitzthum applied the term "genital-taster" to these structures and assumed them to be rudimentary accessory reproductive organs. Similar setae are found on tarsi I of the male and female. Other non-simple types of setae are located on the appendages and will be discussed in detail with the legs.

In numbering the setae, those on the dorsum are represented by arabic numerals and the numbering begins with the most anterior medial setae of the adult mite. The same procedure is used on the venter but lower case letters are substituted. The marginal setae vary greatly in position due to influences of preserving and mounting techniques, hence, although indicated in the description as marginal, they are lettered as ventral ones. The setae of the legs were counted and their location considered, but no attempt was made to number them individually; however, when possible the terminology of Wharton and Fuller (1950) applied to the setae of the legs of chiggers is used. The following plates (2, 8, 11, 16, 18 & 20) give the position, size, and shape of the setae.

Gnathosoma

Much emphasis has been placed on the potential taxonomic value of the mouthparts in some groups of mites and a few outstanding papers, Brown (1948), on the mouthparts of the chiggers, and Hughes (1949) and Gorirossi (1950), on the mouthparts of the mesostigmatic mites, are noteworthy. However, very little information has been reported on the mouthparts of the species of the family Psoroptidae and apparently none on O. cynotis. These probably have been ignored because of their small

size and the difficulty in dissecting them. In studying these mouthparts some difficulties were encountered, but enough information was secured to describe their general morphology. The small size, in spite of the rather elaborate development, and the lack of sufficient sclerotization made it difficult to observe the outline of the mouthparts. Perhaps the most frustrating situation in this study was the inconsistency in terminology; it appears that each person, who undertook a study of the mouthparts of mites, "coined" his own terminology. For my purpose, the terminology of Gorirossi (1950), Wharton and Fuller (1950), and Baker and Wharton (1952) will be modified and used for similar anatomical structures in this study.

The gnathosoma is easily differentiated by a distinct line of demarkation between it and the ventrocephalic region of the idiosoma. A band of tissue of the idiosoma surrounds the region of attachment of the gnathosoma and forms a camerostome or cavity in the idiosoma from which the gnathosoma can be extended or retracted. The general shape of the gnathosoma is like a cone with the broad end rounded, where it attaches to the body. The region of attachment is called the basi capituli and the narrower terminal region is the beak or rostrum. The combined regions of the basi capituli and beak include the mouthparts which are composed of the pedipalpi, the chelicerae, and some minor structures.

The pedipalpi are situated on either side of the beak, thus forming the lateroventral surface of the gnathosoma. The posterior portion of the palpus and its coxa on either side are fused to form the base of the gnathosoma. Each palpus consists of three segments, but the first one is formed by the fusion of the coxa, trochanter, femur, and genu which are immovable. This segment bears a single, simple seta near the apex

which may be median or lateral in position. This segment is not heavily sclerotized but is covered with a thin punctate plate. The middle segment is movable, shorter and narrower than the proximal segment and has sclerotized bars on the lateral surface and base. The barred area approaches but does not extend the length of the segment. This segment bears four setae, two are situated near the apex of the segment. One of these arises from the tip of the lateral sclerotized area and the other one is more medial, arising from a plate at the margin of the spongy area. The other two are located in the same general relative position but are at the base of the segment. In the sclerotized area on the dorsolateral surface, there are one or two sclerotin spurs or spines. These spurs are usually opposite the apexial setae. The arrangement of setae on this segment is quite constant in all the life cycle stages. The terminal segment articulates with the ventral or median area of the middle segment very much like a thumb on a hand. This structure is a cellular mass capable of pulsating, or elongating and contracting. It is striated and has a single, simple seta near its base. This segment in living specimens may cover the medial mouthparts on the ventral surface, and since the mouthparts are directed downward, it appears that the structure is sensory in function.

The chelicerae arise from the basi capituli and the point of origin is obscured dorsally by the dorsum and ventrally by the palpi and hypostome. Each chelicera terminates in the chela which is composed of a movable ventral arm and a fixed dorsal one. The movable arm is inserted into the base of the fixed chela. Each of the arms is sclerotized and tricuspid, having an apexial and two lateral teeth. All the teeth are sharp except one lateral tooth on the movable arm. This atypical tooth is flattened and much longer than the others. (Plate 5). The base of the

chelicera is sclerotized, devoid of setae, and slightly punctate. structure is broader at the base than at the apex. The chelicera c be extended or retracted by muscles extending from it into the regi the pharynx posterior to the basi capituli.

Minor structures of the gnathosoma (See Plates 4, 5, 6 & 6A)

Dorsal to the chelicerae is a pair of punctate triangular plat called the cheliceral plates which overlap the chelicerae to the le of the chela at the apex of the beak. The basal lateral margins of plates slightly overlap the palpi. They are not extensively sclerc except for a small area on the posteriomedian surface. These cheli plates are attached to the gnathosoma and can be drawn into the can According to some authorities (Snodgrass, 1948) this structure coul called the tectum; however, this term should not be used because th a paired structure and not a continuation of the dorsum of the idic

Ventral and median to the chelicerae is a projection which app arises from the hypostoma and is usually called the labrum. It is tensible and may be seen protruding for various degrees or it may b obliterated by being completely retracted.

At a level slightly ventral and to either side of the labrum i large tube and each runs posteriorly and laterally from the median in the region of the mouth to the coxa of each respective palpi and forms the shape of a U on either side. Here each tube bends poste and laterally again to enter the supracoxal fossa. In the region c gnathosoma, these tubes are easily observed because of the numerous spine-like processes which project outward apparently from it.

On the median line posterior to the labrum and mouth, there is muscular pharynx. It is located at approximately the base of the

chelicerae and from the ventral surface appears to have the shape of a shield. The anterior end is more heavily sclerotized and the posterior end is striated. The sclerotin is deposited to form transverse bars, resembling apodemes, each with a slight posterior bend at the lateral extremity. The labrum may be attached to these apodeme-like structures which may aid in the manipulation of the mouth.

The hypostoma forms the floor of the gnathosoma and is ventral to the labrum. The base of the hypostoma is broad and plate-like and has an anterior projection in approximately the same region as the more dorsal labrum. The area between the labrum and hypostoma, according to Snodgrass (1948) forms the food canal.

Idiosoma

The idiosoma comprises the remainder of the mite and supports the legs. Four pairs are present in the adult, protonymph, and usually in the deutonymph, and only three pairs in the larva.

The idiosoma is usually sub-ovoid in shape, tapering somewhat at both the anterior and posterior ends. A posterior median marginal indentation in the male and a pair of adanal or copulatory suckers are located on the projecting lateral areas, giving the mite a weakly bilobed appearance. The female tapers posteriorly, and the degree of tapering depends largely upon the presence or absence of an egg in the idiosoma.

Dorsum

The dorso-anterior surface has a projection which partially covers the gnathosoma. This projection forms sclerotized "shoulders" in the region of the first pair of legs and also bears the propodosomal plate situated near its median anterior border. This plate is punctate and devoid of setae. No differ[illegible]

can be found in any of the life cycle stages including the male and female, but the degree of sclerotization increases with each advanced life cycle stage reaching the maximum in the adult. In the dorsal sclerotized area above trochanter I are found a pair of supracoxal glands and two pair of setae. The second large dorsal plate in the male, the hysterostomal plate, has been described.

The arrangement of setae is bilaterally symmetrical and the number increases with the progressive stages of development. All of the setae except setae "2" are simple and range from small to medium in size. Unless designated otherwise, the setal arrangement (Plates 2, 8, 11, 16, 18&20) for all stages is as follows. Seta "1" is located either on or bordering a small plate which is lateral to the base of the propodosomal plate. Seta "2" is on this small plate and is long, whip-like, and probably tactile. Seta "3" is located posterior and lateral to coxa II, near the margin of the body. Seta "4" is posterior and median to seta "3", and seta "5" is posterior and median to seta "4"; both setae "4" and "5" are situated at a level between legs II and III. Seta "6" is posterior and lateral to seta "5" being at a level in line laterad to seta "4", in other words, it is situated at the level between legs III and IV. Seta "7" is anterior and median to seta "6", and on the hysterosomal plate of the male, seta "8" is posterior and median to seta "6" and is located in the opisthosomal region of the mite. This setal arrangement is the same in both the male and female, but not all of these setae are represented on the immature stages. In the deutonymph and protonymph, seta "8", and in the larva, setae "7" and "8" are missing. The dorsal marginal setae will be described with the ventral marginal ones.

Venter

An anus is present in all life-cycle stages. This aperture is either terminal or subterminal in position. A pair of lateral plates surrounds the opening with two or three pairs of small apodemes on each inner margin. In the male the anus is indistinct because of the presence of the copulatory suckers and their sclerotized plates. The coxal apodemes are heavily sclerotized, especially in legs I and II, and fused ventrally. Other sclerotized areas are found in association with the reproductive system. In the males, these areas are posterior and lateral to the adanal or copulatory suckers and around the aedeagus. The aedeagus is conical, situated between the coxal apodemes of legs III, and is surrounded, both externally and internally, by heavily sclerotized areas. The second structure which is apparently a reproductive one, consists of a pair of adanal or copulatory suckers, which gives the male its weakly bilobed appearance. These suckers are retractile and are almost completely surrounded by sclerotized plates. There are two pairs of small modified sucker-like setae (e and f), one of each pair being lateral to the aedeagus. These are hollow and mushroom-shaped and may be accessory reproductive structures.

In the female the genital opening is transverse with the anterior lip reinforced with sclerotin. It is situated on the medial plane between legs II and III. The genital aperture and its apodemes mold the pattern of the pronounced striations in this area. Internal apodemes are visible anterior, posterior, and lateral to the opening and two pair of modified sucker-like setae similar in shape to those in the male are present, one of each on the posterio-lateral margin of the aperture. No genital organs are visible in the immature stages, but two pair of

rudimentary suckers may be seen in the deutonymph and a single pair in the protonymph.

The male, female, and deutonymph, each have eight pairs of setae on the venter, however, their position varies slightly due to relative development of the genital structures. In the male, seta "a" is located in the upper region of coxa I, slightly anterior to the position of setae "1" and "2" of the dorsum. Seta "b" is located medial to the coxal apodemes of legs III and might be considered a coxal seta. Setae "c" and "d" are situated medial to coxal apodemes of legs IV. Setae "e" and "f" are the sucker-like structures posterio-lateral to the aedeagus and seta "g" is located posterior to the aedeagus. Seta "h" is located slightly anterior to the copulatory sucker.

In the female setae "a", "b", and "h" are similar in position to those of the male and seta "c" is located posterior to the lips of the genital aperture between legs II and III. Setae "d", "e", "f", and "g" are slightly more anterior than those of the male, but in the same general order of position. The setal pattern of the deutonymph is more like the female than the male, that is, more anterior. In the protonymph only setae "a", "b", "e", "g", and "h" are present and in the larva only setae "a", "b" and "h" are present.

There are seven pairs of marginal setae on the adults and nymphs. The posterior tip of the opisthosoma has five pairs of marginal setae (i, j, k, m and n) which are lateral in position and appear either ventral or dorsal depending on the condition of the preserved specimens. Seta "i" is whip-like, extends posteriorly from the margin of the body and is as long as or longer than legs III. Surrounding this seta are four smaller ones. Seta "j" is the most medial and slightly longer

than seta "k" which is located between "i" and "j". Lateral to seta "i" are setae "m" and "n" in that order, seta "m" being longer than "n". Setae "o" and "p" are located antero-lateral to coxa III; "o" is long and arises from a slightly elevated area and "p" is short and arises from the sclerotized region of the apodeme. The larva bears three pairs of marginal setae, one is on the tip of the opisthosoma and two are above coxa III.

Legs

Legs of O. cynotis are long and slender, but the fourth pair is shorter than the others. Legs IV of the male are longer than the corresponding legs of the female, and in both, the legs are clearly segmented. The deutonymph is atypical in that the fourth legs are reduced to such an extent that the only evidence of them consists of a small granular pit associated with the posterior coxal apodeme which may bear a single minute seta arising from its center. However, in many specimens even the seta is not visible, and it is questionable whether it is always present. In the protonymph these legs are more typical, easily recognized and show signs of segmentation. They have both a long terminal and a smaller subterminal seta. The larva is hexapodous.

With the exception of legs IV, the typical legs of the various stages consist of six segments: coxa, trochanter, femur, genu or patella, tibia, and tarsus. The presence of both the sucker (caruncle or pretarsus) and claw on the apex of the tarsus as well as the distribution of these on the legs, the relative length of the pedicle or stalk, the condition of the pedicle, whether jointed or not, are of taxonomic significance in separating O. cynotis from closely related mites of the family Psoroptidae.

Each segment is highly sclerotized especially along the lateral,

anterior and posterior margins and at the base of the larger setae. The remainder of the segment is usually covered with a punctate plate, on which setae may be present or absent.

The coxae of the first and last two pairs of legs are usually continuous. Coxa II is separated by some distance from coxa III. The coxae of all legs are more or less immovable and attached to the ventral body wall, thus the apodemes form part of the exoskeleton. These apodemes usually are joined on legs I and II of the adult and usually open, on legs of the immature forms. However, there is no consistency as to their condition in this respect. The apodemes are easy to observe on the ventral surface but many extensions from surface apodemes project internally into the mite or are on the dorsal surface of the coxa and obscured because of the idiosoma. The apodemes are jointed where they meet the sclerotized bars of the trochanter thus allowing for greater freedom of movement. Similar joint-like breaks in the sclerotization occur in other segments of the leg, but they are not as pronounced. The greatest amount of movement in the leg takes place at the trochanter-coxal joint. The trochanter may be moved at least 180 degrees in any plane. Membranes permit its extention and retraction.

The setal pattern of the leg segments is quite constant within each stage. However, the number of setae increases with advanced stages and the patterns are different in the male and female. Legs I usually have the most complicated setal pattern, but legs II are very similar. Legs III and IV have a much simpler setal pattern. Since the complexities resulting from position, size, shape, and number are rather extensive, no attempt will be made to discuss them, but Plates 3, 9, 10, 12, 13, 14, 15, 17, 19, 21 and Table 1 will provide this information. The majority of the

setae found on the legs are conventional but they vary greatly in size from long whip-like ones of legs III and IV to the minute ones on many segments.

Certain structures of the leg deserve special mention because of their size, shape, and position. On the dorsal surface of both tarsi I and II, near the joint of the tibia in adults and deutonymphs, there is a deep furrow or groove in the sclerotin of the tarsal plate. This groove is fairly constant in these stages, but apparently is lacking in the protonymph and larva. Immediately anterior to this groove on the lateral margin of tarsi I of the male, female, and deutonymph there is a sucker-like seta which is similar in size and shape to the rudimentary genital suckers. On tarsi II these setae are replaced by a raised area bearing two simple setae, a large and a small one. Near the apex of the segment, on the dorsal surface, on genu I of the adult and nymphs and on genu II of the adult there is a very small seta or microgenuale or famulus which was mentioned by Grandjean (1935). There is a long nude whip-like seta known as the mastigenulae immediately below on the dorso-lateral margin. Other long whip-like setae known as mastifemorala, mastitibiala, and mastitarsala are found on their respective segments. Tarsi I and II have many ordinary setae as well as setae resembling the specialized ones similar to those of chiggers that have been discussed. These are the pretarsala, subterminala; and parasubterminala, however, no structures resembling spurs, which are characteristic in the chiggers, could be found.

All of the tarsi of the male and tarsi I and II of both the female and immature stages terminate in claws and, in addition, have a delicate transparent sucker-like structure which has been called the pretarsus,

caruncle, or sucker, which emanates from a short, nonjointed pedicle or stalk. The claws are curved, sclerotized, and, with the exception of tarsi III of the male, end in a blunt point. The claw of tarsi III is bidentate and each tooth is bluntly pointed. Each sucker is connected to the tarsus by a pedicle or stalk which arises from a pad that acts as a joint, allowing the sucker to bend when the mite walks. These suckers also have an accordian-like pleat in their stalk which permits them to be extended or contracted. The suckers are open at the apex and contain a solid structure which is continuous with two filaments attached to the tarsus. This entire structure is apparently sensory in nature. Legs III and IV of the female and III of the immature stages each terminate in two whip-like setae or acanthoides but in the male the acanthoides attach subterminally instead of terminally to legs III and IV because of the presence of the sucker and claw. These acanthoides in all stages are quite frequently longer than the body of the mite.

Supracoxal Glands and Internal Structures

On either side of the idiosoma, between trochanter I and the chitinized shoulder is a thick rounded depression bordered by sclerotin, which according to Grandjean (1937) is the supracoxal fossa. This structure is present in all stages, but is more easily seen in the immature ones because of the lack of sclerotin. In the adults and deutonymphs there are two setae associated with the fossa while only one is seen in the protonymphs and larvae. One of the setae is simple and very similar to the setae on the palpi and legs, and is usually located on the most anterior border of the pit. The second one projects from the sclerotinized shoulder, median to the pit, and is probably a spur rather than a seta. It is greatly reduced or absent in the immature ones.

There is a series of internal tubules or glands in close association with this fossa. The pit apparently contains the opening of the gland or large sclerotinized tube which runs antero-medially toward the mouthparts In addition to this gland some minute trachea-like tubules originate from the side of the pit. These tubules have an undulating course posteriorly and apparently terminate at the level of the anus. They are nonbranching, have taenidea, and in some cases may terminate in a bulb-like structure. Although these tubules resemble the trachea of insects, no air bubbles were observed when living mites were placed in glycerine, olive oil, or lactic acid and their respiratory function could not be established.

Near coxa II there is a very long chitinized tube which Grandjean also called a supracoxal gland and which Hirst, according to Grandjean, considered to be a trachea. It is connected by small tubules with the supracoxal gland of leg I and there is a small punctate plate on the ventral surface (Plate 7).

The buccal area of the mite has been described. The pharynx is muscular and situated near the base of the gnathosoma. It is visible from the ventral surface of the mite as cylindrical, striated-walled structure arising from the region of the mouthparts. The esophagus continues as a straight tube and in living mites is filled with a coarse, granular material. It may be traced posteriorly to a level between legs II and III. In this region it becomes obscured in a larger mass which is probably the ventriculus and intestine.

Measurements

Measurements have been used as a criterion to determine species in many kinds of animal life. In mites the present trend is to omit measurements, particularily in differentiating new species. This trend

seems to be a logical one for in making measurements to determine varieties of O. cynotis it was evident that there is much variation which even may be influenced by technique. However, they may be of secondary value in determining varieties of O. cynotis. These varieties will be considered in the discussion. An attempt was made to reduce variation by defining the landmarks on the mite very specifically and carefully measuring with a filar micrometer. The body length included the gnathosoma as well as the idiosoma and the body width was measured at the widest point between legs II and III. To determine the size of the gnathosoma, the measurement was made through the widest area for width and this level was used as a base line in determining the length to the apex. It should be understood, however, that this is not the complete length of the gnathosoma. This was done because in many instances the dorsum hid the base of the gnathosoma. The legs were all measured from the apex of the tarsus to the tip of the coxal apodemes.

Discussion

In the papers of Vitzthum (1928) and Grandjean (1937) there are several points of interest concerning the descriptions of anatomical structures. Perhaps of major interest is the basis of determination of sex in immature stages. Vitzthum believed that it was possible anatomically to tell male and female protonymph and deutonymphs. He used the degree of the development of legs IV and the presence or absence of adanal suckers as a basis for sex differences. He stated that these differences are especially evident in the deutonymph. In the male deutonymph, the suckers are absent and legs IV bear two terminal setae, while in the female, adanal suckers are present and legs IV are greatly reduced and without terminal setae. Grandjean, on the other hand believed

that there is no way of distinguishing a male from a female deutonymph on the basis of these structures. In examining over three hundred immature mites in this present study it is apparent that Grandjean is probably correct. Examination showed that deutonymphs with adanal suckers and a single seta for legs IV were either males or females and none with two setae were found. The specimens observed by Vitzthum which lacked the adanal suckers were probably deutonymphs with the suckers retracted into the body of the mite. This conclusion is based on the fact that several living deutonymphs were noted in which suckers could be drawn into the body and became ill-defined to the observer.

In this study, it was concluded that legs IV of the deutonymph are reduced to minute setae and occupy the same position as legs IV in the protonymph. This seta is very small and extends upward from a granular area and in many cases is probably missed because of its small size, direction of projection or because it has been broken off.

Measurements indicate that male deutonymphs are smaller than female deutonymphs and the average size of the deutonymph including both sexes, is slightly larger than the average size of the male adult. This observation would have to be verified by rearing the life cycle stages off the host or in isolation chambers on the host. Neither of these methods was used successfully during this study, and it can only be assumed that this size difference does occur.

Zürn (1874) figured a gravid female mite taken from the ear of a dog and identified as Dermatophagus canis which is believed to be synonymus with O. cynotis even though the species of the genus Dermatophagus are now in the genus Chorioptes. His drawing shows the gravid female with pretarsi on legs III, posterior copulatory suckers at the

tip of the opisthosoma, and no genital opening. Thus, this mite appears to be a "stage" half-way between the deutonymph the adult. Since no mite was found during this study which exhibited similar characters and since the description is different from any known mite which infests the dog, in either the family Sacroptidae or Psoroptidae, the drawing is apparently in error.

The supracoxal glands are interesting from a discussion standpoint. These glands and their accompanying tubes have been described under a variety of names. According to Grandjean (1937) Oudemens called them parastigmata while Mégnin and Troussart referred to the tubes as tracheae. These writers considered them to be respiratory in nature, however, Grandjean did not agree with this conclusion and considered them be be secretory in nature. Although the minute tubules leading from the pit are spiral-shaped and resemble the tracheae of insects, it is considered that Grandjean was right in that the tubes do not branch. However, I disagree with his statement that the tubules are solid because upon dissection, the tubules appeared to be full of fluid and no air bubbles could be detected when they were mounted in media. Furthermore, in tracing the larger tube forward to near the mouth, it appears to be connected with the digestive system and have a secretory function. However, there is the possibility that it may be excretory.

V. REDESCRIPTION OF OTODECTES CYNOTIS (HERING, 1838)

Genus Otodectes: A psoroptid mite without vertical setae. Legs, propodosomal, genital, and anal regions sclerotinized or with plates. Mouthparts minute, chelicerae chelate, with noticeable sclerotinization. Legs I and II with suckers and claws in all stages, leg IV modified depending on sex and life-cycle stage. Legs III and IV with at least one long terminal or subterminal seta.

Otodectes cynotis (Hering, 1838)

With the characters of the genus; usually less than 500 microns long, subovoid to ovoid in shape, white to reddish in color. Idiosoma, with distinct shoulders, transversely striated except posteriorly where striations may run lengthwise. Dorsal propodosomal plate twice as long as wide, a pair of long whip-like setae arising from a plate near the propodosomal plate. Anal opening ventral and sub-terminal. Genital apertures in adult. Six pairs of segments in legs of adult.

Female (Plates 8, 9 & 10 and Tables 1, 5, 6, 14, 20, 21& 22) Larger than male, posterior tip of opisthosoma not bilobed, dorsal hysterosomal plate absent. Setae: dorsal 8 pairs, ventral 8 pairs, marginal 7 pairs, and between gnathosoma and coxa I, 2 pairs. Adanal suckers absent; genital aperture ventral, median, transverse, with sclerotized genital apodemes, and posterior to coxa II. Legs I and II, with tarsi claw-like, possessing short, stalked suckers, III and IV each terminate in two long whip-like setae, claws and suckers absent. Leg I

longest, II longer than III, IV very small and rudimentary. Usual number of setae from coxa to tibia: leg I, 0-1-1-3-2-8; II, 0-1-1-3-2-8; III, 0-1-0-0-2-4; leg IV, 0-0-0-0-1-4.

Male (Plates 11, 12, 13 and 14 and Tables 1, 3, 4, 7, 15, 20, 21, & 22): Posterior tip of opisthosoma weakly bilobed, dorsal hysterosomal plate bell-shaped with widest portion anterior. Setae as in female. Adanal or copulatory suckers retractile, usually on either side of anal opening; aedeagus between coxal apodemes of leg III. Legs with tarsal claws and short stalked suckers; Leg III longest, I longer than II, IV very short, but not rudimentary. Legs III and IV each with two subterminal whip-like setae. Usual number of setae from coxa to tibia: leg I, 0-1-1-2-2-10; II, 0-1-1-3-2-8; III, 0-1-0-0-2-3; IV, 0-0-0-0-3-5.

Deutonymph (Plates 16&17 and Tables 1, 8, 9, 16, 20, 21 & 22) Smaller than female and usually smaller than male; posterior tip of opisthosoma weakly bilobed with adanal suckers. Dorsal hysterosomal plate absent. Setae as in female. Legs I and II like female; III terminates in two long whip-like setae, claws and suckers absent; IV sometimes visible under high magnification. Legs I and II subequal; I usually longer, III approximately 2/3 length of I and II. Usual number of setae from coxa to tibia: I, 0-1-1-2-2-8; II, 0-1-1-2-2-7; III, 0-0-0-0-(0-1)-(4-6).

Protonymph (Plates 18&19 and Tables 1, 10, 11, 17, 20, 21 & 22): Smaller than deutonymph, posterior tip on opisthosoma not bilobed. Dorsal hysterosomal plate absent. Setae: dorsal 7 pairs, ventral 5 pairs, marginal 7 pairs, and between gnathosoma and coxa I, 1 pair. Adanal suckers absent. Legs I and II like female; leg III terminates in two long whip-like setae, claws and suckers absent; IV larger than in deutonymph, segmented, terminates in one long setae. Leg I longest, II slightly

shorter, III 2/3 as long as II, IV 1/3 as long as III. Usual number of setae from coxa to tibia: Leg I, 0-0-1-3-2-7; II, 0-0-1-2-2-7; III, 0-0-0-0-0-4; IV, 0-0-0-0-0-2.

Larva (Plates 20&21 and Tables 1, 12, 13, 17, 20, 21 & 22): hexapodous, smaller than protonymph, subequal to egg, posterior tip to opisthosoma not bilobed, no suckers; dorsal hysterosomal plate absent. Setae: dorsal 6 pairs, ventral 2 pairs, marginal 3 pairs, and others absent. Legs I, II, and III as in protonymph. Leg I longest, II longer than III. Usual number of setae from coxa to tibia: leg I, (0-1)-0-1-2-3-7; II, 0-0-1-2-2-6; III, 0-0-0-0-1-4.

Egg (Plate 22 and Table 19) Length: maximum 243 microns, minimum 160 microns; width: maximum 144 microns, minimum 80 microns; average length 2.1 times the width, pearly white to transparent, usually flattened on one side, sticky. Found in masses even though laid singly.

Remarks concerning the redescriptions of Otodectes cynotis (Hering, 1838)

The family Psoroptidae includes the genera Psoroptes, Chorioptes, Caparina and Otodectes. Of these genera, Psoroptes, Chorioptes, and Caparina are parasites infesting the body of the host, whereas Otodectes although found on the body is primarily a parasite of the external auditory meatus. In differentiating between these genera, Psoroptes can be identified by the species having long, segmented, three-jointed stalks, the posterior tip of the idiosoma of the male with two conspicuous lobes and suckers on legs I, II, and III of the male and I, II, III, and IV of the female. Species of Chorioptes, Otodectes and Caparina have short unsegmented stalks and suckers on all four legs of the male, however, Chorioptes sp. has suckers on legs I, II, and IV of the female while

female. Otodectes sp. differ from Caparina sp. in being found in the ears of dogs, cats, foxes, and ferrets, while the latter occur on goats.

The data given in the descriptions of the genus and species, with the illustrations, should be sufficient for the identification of the mite. As stated in the systematic discussion of Otodectes there are, however, certain intraspecific or variety differences. Because of these differences the single species (O. cynotis) has been separated into four varieties. These are based largely upon host specificity of the mites, except the variety africana, which, if valid, could be referred to as a geographical one. Evidence presented in a later section tends to indicate that host specificity does not seem very marked, at least not in the so-called varieties canis and cati. When comparing specimens from one of these hosts species with those of another, the only apparent morphological difference is size. Using this as a criterion to separate the alleged varieties, size decreases in this order: canis, cati, africana, and furonis.

To show similarities and differences between the alleged varieties canis and cati, specimens were grouped according to the species of the host and measurements taken of certain anatomical structures. Data in tabular form and a discussion on the measurements occur in the section on anatomy. In studying the analyses of the data concerned with these measurements it is noted that in all life-cycle stages, the extremes in size of all stages are greater than those given in previous reports. Two possible reasons for this discrepency may be given. One is that all the data in previous publications were based on specimens from outside the United States and possibly a geographical difference occurs. The other and perhaps the more feasible explanation is that the number of specimens

measured by the writer far exceeds those measured by other workers. Further comparisons on the measurements of mites can be found in Tables 20 and 21 in the appendix.

VI. OBSERVATIONS ON THE LIFE HISTORY OF *OTODECTES CYNOTIS*

In the study of acarology a knowledge is essential of the growth and reorganization that occurs in the development of the mite from the time the egg is laid until maturity. Mites, in general, pass through five stages in their life history: egg, larva, protonymph, deutonymph, and adult. There is no apparent agreement concerning the terms used for the three immature stages. The first stage is usually called the larva and is easily identified by its hexapod condition. Fenseco (1948), however, suggested that the larva should be called the proteronymph. The second stage will be referred to as the protonymph and the third stage, the deutonymph. Vitzthum (1928) and Grandjean (1937) called the third stage the tritonymph, even though they used the term larva for the first stage. Vitzthum used this term because he claimed the deutonymph was missing in parasitic mites. Grandjean used tritonymph because it was in general use, but admitted the term deutonymph was more logical.

In a personal letter to the writer, Strandtmann (1958) stated that in most of the literature the term, tritonymph, is used for the second nymphal stage, and that this term persists in spite of all the evidence which indicates that there is no such thing as a "third nymphal stage". It is apparent that some workers originally believed that there were three nymphal stages occasionally instead of the two that are recognised, and perhaps those who use the term today still think that this is true. There are, however, some mites in which there is a non-feeding *hypopus* stage between the deutonymph and the adult and is called the tritonymph

by some workers. Still others refer to this stage as "deutonympha vagrans" or migrate deutonymph. The latter terms are preferred to hypopus or tritonymph by most modern acarologists because the hypopus stage occurs only occasionally and it is not a necessary stage in the life cycle, consequently it should not be called a tritonymph. On the basis of this information by Strandtmann and because the writer thinks that deutonymph is the more logically defined term for the second nymphal stage in any life history, it will be used in this discussion.

Although the stages have been superficially described, the complete life history of O. cynotis has not been determined. Most of the early investigators dealt only with gross descriptions of the stages and had little interest in their biology, or development. The majority of the observations in this study of the life history were based on the ear mite of the cat, but some attention was given to the mite of the dog.

To secure the data on the life cycle of the mite, experiments both under laboratory conditions, studying mites placed in containers, and under natural conditions, putting mites in the ears of non-infested kittens, were completed. The methods utilized have been described in the Method and Materials section. Four kittens which were infested were from a cat in which no ear mites could be found. These kittens were approximately five weeks old when weaned and isolated from the mother, thus limiting their contact with possible infested animals. They remained free of ear mites until the right ear was experimentally infested with some taken from a male cat. After the mites were placed in the ear of these potential hosts, observations were made periodically, by swabbing the ears, to determine the rate of development of mites and their possible migration to the left ear which served as a control. This experiment was

repeated on two more kittens and a dog, using mites from the same male cat.

The environmental conditions under which these experiments were conducted are as follows: daily maximum temperatures ranged from 30 to 38° C and daily minimums from 13 to 21° C with the relative humidity varying from 50 to 90 per cent.

The approximate time required to complete each stage in the natural life cycle was determined by introducing a known number of mites, usually females, into the right ear of the potential host. Valuable information that could not be duplicated under laboratory conditions was collected on the spread of the parasite and growth rates in normal habitats. However, to verify the life cycle a number of laboratory tests were devised. These observations included the effects of temperature and humidity on certain stages of the life cycle including the embryology, from oviposition to hatching. Other observations made in the laboratory on the life cycle included molting habits, movement and locomotion, and population studies of the mite.

The Egg of Otodectes cynotis

Eggs were first observed within females. They were collected from the cerumen in the ear of the host and from containers in which gravid females had been placed. When first noted, an egg was a round granular, shell-less mass near the posterior tip of the opisthosoma. It gradually assumed its mature shape and shell. When mature, the egg was located posterior to the genital opening on the median line of the idiosoma, but angling and reaching slightly across this line. With the exception of this constant position, little else, including the structural development, could be discerned because the entire egg was filled with a fine grainy

mass of embryo and yolk material. Although the embryo was not clearly differentiated, the embryonic head appeared to be toward the head of the female and the dorsal side was in apposition to the dorsum of the female.

It appears that the female can oviposit within two to seven days after it emerges from the deutonymph stage. Once oviposition has started, it apparently continues as long as environmental conditions remain favorable. However, when female mites were placed in containers, oviposition was limited to twenty-four hours. Oviposition occurs more rapidly during some periods of the year than others. This fluctuation suggests that there may be a definite ovulation cycle among the mites which reaches the possible peak of production in the spring and summer and gradually decreases to a low in the winter. Temperature probably plays the important role in this cycle.

Immediately after oviposition, the eggs were pearly white, oblong, subcylindrical, with one side slightly flattened. An opaque mass filled the egg. These eggs were moist, soft shelled, and very sticky when first deposited. The egg shell soon became hard and the stickiness caused it to adhere to the first object which it contacted in its environment. As a part of this environment, eggs were seen adhering to mites which dragged the egg until it dried and fell off, or theoretically, until it hatched. The eggs also adhered to hairs in the ears of the host or occasionally to hairs on the body, especially in the area between the ear and the eye. Even though females deposited eggs singly in petri dishes, they exhibited a proneness to oviposit near another egg. Many instances were noted where two or more eggs were collected from a single area and it was not rare to see as many as four eggs together. Out of 330 eggs collected during an experiment on hatchability, 217 were found in this

association. Further observations indicate that when swabbing the ears of hosts, it was not uncommon to obtain some pieces of cerumen with a hundred or more eggs adhering to it while other pieces contained no eggs.

In order to study adequately the embryological development of the egg it was necessary to determine the hatchability of eggs, length of time required for incubation, and effects of temperature and humidity upon development. To do this, eggs were collected periodically and put on slides which were transferred to humidity chambers in temperature-controlled receptacles. The eggs were collected within an hour after oviposition and were checked periodically until they hatched. Although a relatively large number of eggs was used in making these observations, exact data could not be collected on all eggs because many of them hatched during the night or at times when observations were not feasible. As the ear of the host has a temperature of 38° C. and maintains a rather high humidity, only temperature-humidity combinations near this range were used. The data in Table 2 indicate that there is considerable variation in the time required for eggs to hatch even when the temperature and humidity are controlled. Hatching occurs in 24 to 102 hours with the mean being about 70 hours, depending on temperature. It is doubtful, however, if humidity is as important a factor as temperature because of the impermeability of the shell of the egg. Other factors such as age and condition of the female at oviposition may play a role in the time required for hatching. Almost 90 per cent egg hatch occurred in some experiments, and the average of all was more than 50 per cent.

The larva usually breaks the shell on the anteroventral surface especially in the region of the mouthparts and legs I and II. The legs become active while the egg is intact and when the shell breaks, the

activity of the first two pairs of legs increases to free the gnathosoma and legs I. Legs II become free soon after the first and the rest of the body follows. Occasionally the body is not completely freed immediately and the mite may carry the shell until it drops off or the mite dies. Mortality of mites under laboratory conditions is quite high because of their inability to free themselves from the shell under conditions of humidities of 90 per cent or more. Under these conditions the larvae were trapped in the water of condensation and died.

Sterile eggs are opaque and white instead of having the characteristic clear, glossy, semi-transparent sheen of fertile eggs. Sterile eggs dry up and collapse in approximately five days.

Embryology of Otodectes cynotis (Plate 22)

Eggs used for studies on the embryonic development were collected in the manner described in the section on temperature and humidity. In order to secure permanent mounts, eggs were put on a slide, which had been ringed with asphaltum and transferred to a dark cabinet maintained at approximately 35° C. At two-hour intervals the eggs were fixed with glycerine or glycerine jelly, sealed with a cover glass, and ringed with finger nail polish. This procedure made it possible to arrange specimens to show the sequential development of the egg. Since some eggs were sterile and great variation in time occurred in the development of fertile ones, it was necessary to study five to ten eggs for each period of incubation. To relate the embryological development of O. cynotis only the gross anatomical characters were studied in each stage.

There were few detectable changes in the development of the embryo during the first sixteen hours. However, in all probability a great deal of internal reorganization occurred because there were changes in the

cellular mass; grossly it was differentiated into a dark central and a light peripheral area.

The development of legs I could be identified as two small antero-lateral projections after 18 hours of incubation. In 22 hours, these legs were more prominent and legs III were detected as similar projections at the posterior end. At this time the embryonic mass was separated from the shell by a vitelline membrane which left a noticeable space on either end of the egg. At 24 to 28 hours of incubation the embryonic mass decreased in size somewhat while legs I and III increased in size, but with little differentiation in shape. These legs continued to grow for several hours thereafter. Legs II appeared ventral to and at the level of legs I in 28 to 34 hours. At this time the gnathosoma and the anterior projection of the dorsum were visible, but not completely differentiated. The legs, especially I and II, were segmented in 38 hours and extended anteriorly, bending medially, and terminating bluntly. At this time the dark embryonic mass within the body, probably a food reserve, was smaller. The periphery of the body and appendages continued to be light. At this stage, 38 hours, the developing embryo exhibited a coarse granulated texture which increased until hatching.

The legs were broader at 40 hours than in hatched larvae. The gnathosoma had increased in size although differentiation of parts was not evident. In 42 hours, legs I, although still visible, had begun to curl under the body. This was the stage in which the setae began to develop. Some of the embryos exhibited two small setae at the tip of the opisthosoma which developed into the long whip-like setae of the motile stages. Because of the four small setae also found in this area of the larva, the identity of those destined to become long had to be

determined in a later stage. In 44 hours the two front pairs of legs had increased their flexion and legs III were not visible because of their position immediately beneath the decreasing, darkened area.

At 46 hours the legs were in the approximate position of a fully developed embryo. They were bent so that legs I and II projected posteriorly while legs III projected anteromedially. The anterior projection of the dorsum was evident and the general outline of the mouthparts could be detected.

After 48 hours of incubation the legs were more typical in shape. The most noticeable structure in association with them was the marginal V-shaped sclerotin bar located between legs I and II in the region of the shoulders and the supra coxal glands. The pair of bars was seen more distinctly during this stage than in any other period of development. Further development of the gnathosoma occurred between 50 and 54 hours and finally it resembled that of a newly-hatched larva. More areas of sclerotization increased on the body, especially the coxal apodemes, while the dark central mass in the body continued to decrease in size. At this time the relative shape of the embryo was very similar to one ready to hatch. At 56 hours, most of the setae had developed and in 60 hours the setal pattern of the legs was easily distinguished. The legs of the embryo showed an increase in segmentation and had the shape of those of the larva. Between 62 and 64 hours, the apodemes of the coxa showed further development and the acanthoides were easily recognized. An outline of what apparently is the anal plate was visible in some specimens. The setae were larger and the striations of the body were more pronounced than in previous stages. General refinement of appendages and gnathosoma, and an increase in definition of striations and setation

had occurred in 64 to 70 hours. At 70 hours of incubation, the shell of the egg was completely filled with the mite and the tips of the chelicerae were in contact with the shell. Between 70 and 76 hours the mite had attained the general shape of the larva and did not change until hatching. At this stage before hatching, the mouthparts touch the shell, legs are folded ventrally, and the acanthoides of legs III are crossed and project anteriorly from the body; the coarse granulation of the embryo is accentuated and the dark central mass is reduced but still visible at the level of coxa III; the anal opening is visible and body striations are pronounced. Eggs began to hatch in 76 hours and continued for a period of 15 hours.

Even though incubation times were given, the stages of development should not be correlated with it because of the extremes in the variation of time necessary for development of individual eggs.

The Larva (Plates 20 & 21 and Tables 12, 13, 18 & 24)

The small hexapod larva, averages 254 microns long and 161 microns wide in forms from the dog, and 235 microns long and 150 microns wide in those from the cat. This is approximately the same size as the egg, and the larva grossly resembles the egg in shape, being glossy white, and semi-transparent. Newly-hatched larvae mounted in Hoyer's appeared grainy which may be due to the presence of yolk material in the gut.

Larvae appeared in one to seven days after female mites were placed in the ear of a potential host. At first these larvae were sluggish and moved only a short distance at a time, but after a few hours they became more active and moved away from the egg shell. Legs I and II were active in locomotion while legs III were inactive and projected behind the mite. After these initial movements, a quiescent period of approximately

twenty-four hours terminated this stage. It was noted, however, that only larvae isolated from the ear of the host and not those reared under laboratory conditions were affected. More than a hundred larvae were reared in the laboratory and checked for possible emergence of the protonymph stage and only once was the exuvium of the larva and the living protonymph recovered. It is possible that either the conditions in the laboratory were not suitable to keep the larvae long enough for ecdysis or they needed to feed before molting. The latter reason appeared the most feasible since mites were kept in the laboratory for periods of time longer than necessary for ecdysis to occur.

The Protonymph (Plates 18 & 19 and Tables 10, 11, 17 & 24)

The protonymph, the first nymphal stage, is somewhat larger than the larva and averages 306 microns long and 214 microns wide in the specimens from the dog and 278 microns long and 184 microns wide in those from the cat. The protonymph may be distinguished from the larva and deutonymph by size and the presence of a small stub-like segmented leg IV, which is absent in the larva and is present, but much smaller in the deutonymph.

Protonymphs were recovered from one to four days after the first larvae were observed in the ears of the experimental hosts. Observations showed the protonymphs to be more active than the larvae, as they were often found on the pinna of the ear and in the area surrounding the ear, while this was not true for the larvae. Locomotion of the protonymph is similar to that of the larva since it uses only legs I and II

The protonymphs could be kept in containers for over a week, compared to several days for the larva, and more advanced stages could be kept even longer. After the period of activity, the protonymph became quiescent and molted. The outline of the developing deutonymphs was never observed

in protonymphs, therefore, molting apparently occurs in a very short time.

The exuviae of the protonymphs were found, but, because of their transparent nature, were not observed as often as those of the deutonymph. In a study of the exuviae that were recovered the mite appeared to have been released by an opening on the median line of the dorsum, usually toward the posterior tip.

The Deutonymph (Plates 16 and 17 and Tables 8, 9, 16&24)

The deutonymph, the second nymphal stage, is larger than the first, averaging 391 microns long and 268 microns wide in those from the dog and 365 microns long and 251 microns wide in those from the cat. It may be distinguished from the other stages by its size, by leg IV, which is very minute (visible only under oil immersion), and presence of a pair of adanal suckers which project from the tip of the opisthosoma.

Molting of the protonymph to the deutonymph took place in the experimental host animal in four to five days after the first appearance of the protonymphs. The deutonymph was active on emergence and the range of habitat was more extensive than that of either the larva or protonymph. It not only frequented the ear, but was found in the areas between the ear and the eye as well as other parts of the body. This and the adult stage are the most active ones; their activity apparently accounts for the spread of the mites to potential hosts. This potential ability to spread to other animals was particularly noticeable in the experimental animals in which only one ear was infested and in which the deutonymphs and adults were the first to migrate to the control ear, where they were recovered in 18 days after the initial infestation.

During the terminal part of this stage, the deutonymph attached itself by its adanal suckers to similar suckers of the male and became

inactive. Movement of the appendages, however, was observed occasionally during the early part of this union. If they were separated manually during the early part of this period, the deutonymph was observed occasionally to search for another male, but if separated in the latter part of the period, it remained inactive. It was during this quiescent period that the deutonymphs developed into either males or females. In the study of the stages, it was noted that males formed unions with deutonymphs that had potential male characters. Therefore, it appears that the act is not necessarily a copulatory condition, since the deutonymph has no genital opening. These observations support those of Grandjean (1937) who stated that apparently the deutonymph did not copulate with the male, but they disagree with Vitzthum (1928) who believed that copulation occurred during this stage. A possible function of this union is to aid the deutonymph in molting, although molting still is possible when the deutonymphs remain separated from the male throughout their development.

The developing adult can be seen readily within the deutonymph if mounted in Hoyer's during the quiescent period. The gnathosoma of this developing adult is posterior to that of the deutonymph and legs I and II are folded within the idiosoma, projecting posteriorly while legs III and IV project anteriorly. The genital aperture of the female and the adanal copulatory suckers of the male are visible on these specimens and can be used to identify the sex. Even though a sex difference is visible in deutonymphs mounted in Hoyer's, nevertheless it is impossible to separate the developing sexes on this basis in living specimens. The duration of the deutonymph stage was two to five days in the experimental host, but evidence on the length of life of the deutonymph in the laboratory suggests that it can live much longer in this stage. In studying

a number of exuviae of the deutonymphs, it appeared that the adults emerge through an opening along the median line of the dorsum. This opening continued to the level of legs III to meet a transverse opening which together form a "T" and from the tips of the cross bar parallel openings extend posteriorly to the margin of the body.

The Adult (Plates 8, 9, 10, 11, 12, 13, 14 & 15 and Tables 3, 4, 5, 6, 14, 15 & 24)

The adult stage is the largest; the gravid female averages 480 microns long and 315 microns wide in those from the dog and 447 microns long and 288 microns wide in those from the cat. It is usually larger than the male which averages 387 microns long and 287 microns wide in the dog host and 333 microns long and 248 microns wide in the cat host. The female can be distinguished from other stages by size, absence of adanal suckers, presence of a short, visible, segmented leg IV, and a ventral, median, transverse genital opening; while the male can be recognized by being about the size of the deutonymphs, presence of adanal suckers, long, visible, segmented legs IV and bilobed posterior end.

The sexually mature male was not observed to molt and probably does not, because the life expectancy is shorter than the female and there is no expansion of the body for sex products. The female molts immediately after copulation, between the pubescent and the ovigerous stages. The halo appearance around the pubescent female which could be the future exuviae is presented as evidence. The actual molting was observed on one occasion and took place in a few seconds, the female was active immediately before and after this ecdysis. The exoskeleton appeared to rupture in the same way as in the protonymph. The exuviae are very difficult to recognize in cultures and on swabs because they are extremely transparent.

Copulation was not observed, but it was evident that it must occur because an aedeagus is present in the male. The deutonymph destined to become a female molts, and immediately after, copulation may occur and it is released then by the male to which it had been attached. It appears that males may infrequently attach to adult females since on one occasion, in spite of the many mites that were observed, one was seen attached to a female that had a fully developed egg.

Female mites under laboratory conditions would not oviposit for more than approximately 24 hours regardless how long they lived. In one experiment, 24 females were isolated and observed individually every two hours until they died. They lived approximately 36 hours and all eggs, two in number, were laid during the first 12-hour period. This limited egg production is probably resulted from abnormal environmental conditions.

Movement and Locomotion of the mites

Locomotion is accomplished by using legs I and II while the hind legs are dragged behind and probably have a function in balance. As the mite moves, the gnathosoma, including the mouthparts, are alternately extended and retracted and move up and down simultaneously. These peculiarities of movement indicate that they probably are sensory in nature. The motility of the trochanter of legs I and II which allows extensive rotation, extention, and contraction is effected by means of a membranous joint between it and the immovable coxa. Muscle attachments extend from the body of the mite to the apodemes of the legs, detectable in moving mites. The exact origin of these muscles of legs I and II and those of legs III are not distinct, but apparently are at the level of the coxal apodemes of legs III.

The mite apparently does not always use the suckers to hold onto the substratum during locomotion, since the suckers bend at the point of attachment and at their accordian-like pleat when it is placed on hard surfaces. When the mites were placed on asphaltum, basal media, or scotch tape, the imprint of the suckers could be observed on the media and apparently aided in traction. The suckers can be inflated and deflated as the mite moves. They are probably sensory as well as ambulatory in nature.

Location of Otodectes cynotis on the host

Even though O. cynotis is called the ear mite it does occur outside of the ear. All stages of the mite, particularly the deutonymphs and adults have been observed on the skin of the head of the host, especially in the region between the ear and the eye, which is in most cats, an area of sparse hair. In order to determine the extent of the range of mites on the body of cats, six of them were brushed with a wire animal brush and the dust and debris examined. This material contained many of the exuviae of nymphs and specimens of the stages of living mites. These observations show that the mites are distributed over the entire body of the host. Further evidence for this and proof that they are not confined entirely to the skin was obtained by cutting hairs from patches of skin on the flanks of kittens. These hairs were examined and exuviae and mites were present. Therefore, it is shown that they are found on both the skin and the hair. Since adults, deutonymphs and protonymphs were more numerous than larvae, it appears that they are probably more motile. Since larvae were observed on the hairs and since they are not as motile as the other stages, it is probable that they hatched from eggs deposited there.

More evidence was obtained by clipping all of the hair from one entir side of an anesthesized male cat and then transferring a number of mites, representing all of the stages, to the flank region of the side that was clipped. The movement of these mites was studied and although the progression was erratic, the general pattern of travel was toward the head and on two occasions mites were observed until they reached the ear of the host.

Preliminary information on some other biological phenomena

Seasonal abundance of Otodectes cynotis: Great differences in numbers of ear mites in cats that were examined were noted over a period of three years. The maximum numbers appeared during the summer when the temperature was warm and the minimum during the winter months. This seems to be substantiated by the veterinarians consulted during this study, many of whom stated they received most of their cases of O. cynotis infestations in the spring or early summer; while others maintained that cases were evenly distributed throughout the year. The area in which the veterinarian practiced apparently explains this difference; those who observed a seasonal difference were in rural communities and had mixed practices, whereas those who did not note a difference were in urban areas and had small animal practices primarily. It can be assumed that the dogs and cats in urban communities were pets and kept indoors during extremely cold weather. Under such conditions of warmer and more constant temperatures multiplication of mites would be favored. Dogs and cats in rural areas are usually maintained outdoors and would be subjected to colder temperatures with greater fluctuations. No doubt such conditions would account for the lesser number of mites during winter and the rise in numbers in spring and summer.

Sex ratio of Otodectes cynotis: Even though no total counts were made by swabbing the ears of the hosts, it was apparent that the females outnumbered the males (Table 23). This could possibly be the result of several interacting factors such as production of a greater number of females, the development of some parthenogenic eggs, or possibly that females live longer than males. However, no studies were attempted which involved the first two conditions, but in the experiments on length of life in the mites the fact was established that females usually lived 24 to 72 hours longer than the males under laboratory conditions.

A case of decrease of population in Otodectes cynotis: A single case was observed in which there was a decrease in population of ear mites in five cats over a period of two years. These five cats were examined in the summer of 1956 and found to be heavily infested and when they were examined in the summer of 1958 only a few mites were found. During this period, the cats were not treated for ear mites, ticks, or fleas and no explanation can be given for this decrease in population.

Experimental transfers of Otodectes cynotis

Although the ear mites of the dog and cat are considered to be varieties canis and cati, respectively, the basis for the varieties appears to be poorly defined. With the exception of size, there is little, if any, evidence of morphological difference in the varieties of O. cynotis, and the physiological distinction between the two forms is even more vague. Many of the writers and veterinarians consulted have assumed and reported that these ear mites can be spread easily from the cat to the dog and vice versa, in fact, many professional people working with these pets have questioned the "variety concept" in the species of O. cynotis. Most of the information reported by these persons is speculative and is not

supported by either observations or analytical data. There is only one reference in the literature which pertains to actual laboratory experimentation, Railliet and Cabiot (1892), who attempted transfers from cat to cat, cat to dog, dog to cat, and ferret to dog. Their results showed that cat to cat and cat to dog transfers were possible but not always accomplished, but their dog to cat and ferret to dog transfers were entirely unsuccessful. They concluded that the mite is readily transmissible from an infested individual to healthy ones of the same species, but more difficult from cat to dog and vice versa, and not possible between the ferret and dog. These results, they stated, are to be expected if one considers the differential in size of the parasite of the dog as compared with that of the cat, and the size of the mite in the dog as compared with that of the ferret. Since varieties in the cat and dog overlap one another in size, certain specimens taken from the cat may be of the same size as specimens collected from the dog. They noted, however, that the difference in size between the mite of the ferret and the one of the dog is always distinct and well-marked. They reasoned on this basis that it is easy to understand how specimens from the cat could live in the dog, but assumed that it would be difficult for specimens from the ferret to adapt themselves to live in the dog. Only four experimental hosts were used in their research. This limited number was not sufficient to form conclusions in regard to either host specificity or individual physiological variation.

In order to determine the time required for O. cynotis to spread from one animal to another, a number of experiments were undertaken to infest the ears of laboratory animals with mites recovered from hosts. The methods used in these transfers were given in the section on material

and methods.

(1) Transfers of mites from cat to cat.

Cerumen with mites from the ear of a naturally infested male cat was placed in the right ear of a young female and two mature male cats. A month later, the ears of these three animals were examined and the female and one male had mites in both ears, whereas, in the other male the mites were confined to the right ear. Two weeks after this examination, this unilaterally infested cat was checked again and mites were found in both ears.

In another transfer, two six-week-old kittens were used to secure information concerning the spread of mites among kittens. Twenty-five eggs were placed in the right ear of each kitten. When the ears were examined a week later, few mites were observed in the right ears and no mites were found in the left ones. Thirteen days after the first examination a second one was made and eggs were present. The infested ears contained cerumen, but the control ears showed very little cerumen and were free of mites. An examination a month later showed the control ears to contain both cerumen and mites.

(2) Transfers of mites from cat to dog.

Two small litters of pups were used in this experiment. The first litter was composed of two long-eared, long-haired puppies about 10 to 12 weeks old and the second one consisted of two short-haired, short-eared puppies and one long-haired, long-eared puppy which were eight weeks old. Cerumen with mites and possibly eggs were transferred from an infested cat to the right ear of each of four puppies and the fifth one was used as a control. These puppies were isolated individually for a month. After this interval of time, all the ears of the puppies were

examined for mites. One of the short-haired pups to which a transfer had been made and the control pup had no mites, two of the long-eared, long-haired pups and the other short-haired, short-eared pup had ear mites in only the right ear. However, a month later another examination showed that both of the ears of the infested dogs had mites while the other two still remained negative.

(3) Transfers of mites from dog to cat.

Four kittens were experimentally infested with ear mites from naturally infested dogs by using cerumen and mites on cotton swabs. These kittens died of coccidiosis before any observations were made. The dead kittens were examined and two of them had a few mites in the ears used for the infestation, but it was not determined if these were the mites that had previously been placed in the ear or if the population had been established.

In another experiment the right ears of two kittens about three months old were subjected to infestation by using the cotton-swab method with mites from dogs experimentally infested in a previous experiment. After these kittens were isolated individually and examined a month later thriving populations of O. cynotis were present in the right ear of each kitten but no mites were found in the control ears.

On the basis of these experiments and additional ones concerned with the life history work a total of 11 cats out of 11 became infested with mites from cats, four out of five dogs were infested with mites from cats, and four out of six cats were infested with mites from dogs. This seems to indicate that transfers between hosts of the same species are easier to accomplish than transfers between different hosts.

Unilateral infestations are very rare in nature, if reports in the

literature can be relied upon. Consequently, unilateral infestations are interpreted to be recent ones. It is assumed that mites remain in the infested ear until population pressure encourages migration and then a bilateral infestation occurs. On the basis of these experiments and observations made during the survey and life history studies, there is reason to assume that an increase of cerumen accompanies an infestation but is not necessarily a prerequisite for infestation.

Measurements of mites taken from animals infested with varieties other than their own showed a consistant variation. Because of this variation it is assumed that size can not be used to separate the varieties of ear mites found in the cat and dog.

Generations of Otodectes cynotis in relation to epidemiology

The potential number of generations during a period of optimum growth conditions is important from the standpoint of epidemiology. The actual minimum time required to complete a generation is unknown and probably varies considerably, because of environmental factors, such as temperature and humidity. The approximate time necessary to complete a generation was determined by using six hosts that were experimentally infested with specific stages of the mite. These data are presented in Table 24. Larvae usually hatched in three to four days after oviposition and lived for one to four days before molting. The protonymph stage lasted four to five days, and the deutonymph two to five days. The ages of the male and female under natural conditions could not be determined. Theoretically, the shortest life cycle based on experimental findings could be completed in ten days, but in no case observed was it completed in less than 15 days. The usual time of completion varied between 18 and

of time under laboratory conditions in petri dish habitats than indicated by these experimental infestations. This evidence could indicate that these life-cycle stages probably live even longer on the host under certain conditions.

The short duration of time to complete the life cycle shows that many mites may be produced in a very limited period and this may be related to the rapid spread. Another condition that may be related to the spread is the degree of confinement of the hosts. This was especially evident in the examination of hounds in which numerous ones were confined in small kennels, for in these the percentage of infestation was high. (See Table 35).

Animals probably become infested in one of two ways. Evidence has been presented that the mites are capable of existing not only in the ear, but on the body or off the host entirely. Consequently, the mite can easily transfer from one host to another, or from a contaminated premise to a host. The likelihood of such transfers should be related to the degree of infestation of hosts. In theory, at least, it is possible for the mites to be transferred by other arthropods. Holz (1955) was successful in using house flies to transfer Psoroptes communis (Hering) to rabbits and Notoedres alepis (R. and L.) to rats. In this study stick-tight fleas, Echidnophaga gallinacea (Westw), and cat and dog fleas, Ctenocephalides felis (Curt), and C. canis (Curt) were capable of carrying both the eggs and motile stages of the ear mite. This was determined by putting fleas in a petri dish containing all stages of the mite and observing them.

Many problems concerning the adequate control of O. cynotis were noted during this study. Mites may be destroyed or killed by liquids.

The density of the liquid, however, seems to be important in this respect. Mites can live even when the entire head of a dog is immersed daily in water for two weeks. By way of contrast, mites placed in liquids such as olive oil, glycerine, mineral oil or lactic acid lived for only three hours, therefore, the base used in acaricides should be a heavy liquid and the dosage ample to reach the depths of the ear of the host. In this way the time element will be reduced and the mites less likely to be able to leave the ear. Another reason for the use of oil, is that cerumen may be dissolved and oil spreads more rapidly than water. Because the mites are found on the entire animal, especially the head, the entire body must be treated. Because of the nature of the life cycle, treatments after the initial one should be administered every four days for twenty days. Another precaution which should be taken into consideration in treatment is the environment, since this may be a source of infestation. Control of flies, fleas, and ticks, which might be a possible avenue of spread, should also be encouraged. Owners should provide an adequate diet for their animals since it is indicated in a survey that dogs which were well fed and had a clean environment did not have as heavy infestations as ones with poorer food and care. To prevent reinfestation, mineral oil or prescribed acaricides should be used periodically in the treatment of the ears.

VII. BEHAVIOR OF OTODECTES CYNOTIS

Intrinsic characteristics of O. cynotis were determined by controlled experiments in the laboratory. Numerous observations of the mites both in the laboratory and on the host indicate that environmental factors have a profound effect on the activity of the mite. These reactions were not studied exhaustively, nevertheless, the mites were subjected to various conditions experimentally and data were gathered on their reaction to stimuli such as temperature, humidity, odor, light, and gravity. Since much of the information was collected in connection with other phases of research, only the additional methods used to study the reaction to environmental conditions will be discussed, but the results of all data concerning intrinsic characteristics will be included.

The experiments were an aid in discovering the factors in the environment which constituted stimuli and how they affected the mite. Each experimental condition was tested independently but, in one experiment a combination of temperature and humidity, was used to better understand the response of the mite. All life history stages were utilized in these experiments.

Temperature

In the life history it is apparent that temperature plays an important role in the behavior of the mite. Some special equipment had to be made to study the reactions of the mite to temperature gradations. The apparatus shown in Plate 23 consisted of a piece of sheet iron one meter long and ten centemeters wide wrapped in Reynold's Aluminum foil.

One end of the sheet iron was fastened securely to an electric, thermostatically controlled heating plate set at 45° C., while the other end was placed in an insulated cabinet containing chipped ice. After approximately 30 minutes, a temperature gradient ranging from 13 to 45° C. was established. The gradient was determined by taking temperatures at two inch intervals along the length of the equipment. Further readings were taken by placing a thermometer in a glass tube, similar to those used in the actual experiment to hold the mites and comparing with the temperature at similar points outside the glass tube. The temperature within the glass tube remained approximately the same as the one recorded on the plate. Because of this similarity all temperatures taken during the actual observations on the mites were with the bulb of the thermometer placed immediately adjacent to the outer surface of the glass tube which rested on the sheet iron.

After determining the temperature gradient, about 25 ear mites representing all the motile stages were placed in a glass tube one meter long and one centimeter wide which was open at the ends. The mites scattered or oriented themselves for about five minutes and then the tube was placed in position on the sheet iron. At least 30 minutes was required for the temperature of the tube to stabilize and for the mites to reach the temperature level they preferred.

After 30 minutes, the tube was checked with a hand lens to determine the temperature that the various mites had selected. After the counts were made, the tube was removed from the sheet iron and the mites were allowed to redistribute themselves under uniform temperature conditions in the tube. It was then reversed and replaced on the plate. This total procedure including the reversal was repeated 21 times using 12

different groups of mites. There was no clear cut response to a specific temperature by any of the stages, but the majority distributed themselves at a level between 23 and 43° C., with the greatest concentration at 38 to 43° C. There were individuals from 19 to 45° C., but mites died at the higher temperature without adjusting to a lower one and those at the lower temperature range became immotile. This absence of movement to avoid extremes of temperature was not due to lack of mobility. For a brief period activity at the temperature extremes was marked. The temperature range of greatest mite concentration with that of its natural environment since it wanders out of the ear of the host and is subjected to extremes in temperature which occur on the body of the host during different times of the day or seasons of the year. The data given in table 25 provide more detailed information on the response of the mites to temperature.

Other observations on mites placed in containers kept at different temperatures indicated that, although 38° C. is the temperature of the normal habitat in the ear of the host, the length of life could be increased considerably by lowering the temperature. Mites placed in a refrigerator at 4° C. lived for 21 days, nine days longer than similar mites living at 32° C. More detailed information on the effect of temperature on the length of life is given in table 26.

Humidity

The humidity preference of O. cynotis was determined by two methods (Peterson 1953) using KOH or inorganic salts to control humidity. The first test allowed the mites to make a choice between two humidities. This was done by fastening a glass rod to the bottom of a petri dish

into two compartments. Filter papers cut to fit the semi-circular chambers were soaked in solutions which produced two specific humidities and were placed on either side of the glass rod on the floor of the chamber. The glass rod and filter papers on either side formed a flat surface. This surface was covered by an intact filter paper. Under the conditions of the experiment it remained dry throughout the test. By covering the chamber, an approximately constant humidity could be maintained in either compartment because of the intimate contact with the solution. This test was repeated several times using humidities from 50 to 90 per cent with different collections of mites at different paired humidities. It was established that the mites adjusted themselves to a range of humidity of 50 to 90 per cent which was the upper limit that could be used in this experiment. These data are presented in table 27.

A second series of experiments was undertaken to show the inter-relationships of temperature and humidity upon the length of life of various stages of mites. The temperature in the ears of the dogs and cats is approximately 38° C. and was used as the theoretical optimum, even though only slight preference was indicated by the mites in the temperature experiments referred to earlier. Two temperatures, 27 and 32, were used with relative humidities ranging from 70 to 100 per cent. These experiments were conducted by putting mites from natural infestations in either a hanging-drop slide or on a slide ringed with asphaltum and covered with a plastic cover glass containing minute holes. The slides were transferred to platforms in fingerbowl humidity chambers which contained the salt solutions to regulate humidity. The finger bowls were sealed with a glass plate ringed with vaseline and placed in

specific temperature cabinets. Periodical examinations of the mites were made without disturbing the covers. Longevity in the sexes and life history stages in descending order are: female, male, deutonymph, protonymph, and larva, the reverse of the sequence of stages in the life cycle. The life span of all stages could be increased considerably by lowering the temperature. The humidity range of 70 to 85 per cent was optimum for any specific temperature tested. The reduction of the life span of the mites in humidities of 90 to 100 RH. was due to the condensation of water droplets which trapped the mites. Humidities below 70 per cent also reduced the life span and the wrinkling of the body indicated a possible deficiency of water in the tissues. Tables 28, 29, 30 and 32 show the reaction of the mites to temperature and humidity.

Odor

To test the ability of mites to detect odor, a two-part experiment was conducted. In the first part, a glass T-tube was used to test the responses of the mites to odor of cerumen of cats and dogs. This tube was 7 mm in diameter, with the stem of the "T" 5.5 cm long and the cross piece 10.5 cm long. One end of the cross pieces had cerumen from the cat while the other end contained cerumen from the dog. Mites from a cat were introduced into the stem of the T - tube, which was then connected by rubber tubing to a suction apparatus on a water faucet. With this apparatus, two streams of air could be drawn at equal rates from the ends of the cross piece, each passing through one of the cerumen areas and meeting at the entrance of the stem of the T-tube. Uniformily distributed light was furnished by a goose neck lamp placed above the tube. The temperature was maintained at about 30° C. with

having been determined to be tolerable to the mite. In running the test about 10 mites, representing all stages of development, were put at the junction of the stem and cross piece, from which they could distribute themselves. Thirteen tests were conducted and each was allowed to run for 30 minutes. Of the mites used in the 13 tests, 45 mites congregated near the cerumen of the cat, 39 near the cerumen of the dog, 15 did not appear to make an adjustment, and 34 merely moved up to the stem of the tube. In a series of five additional tests using cerumen at one end of the "T" only and allowing air to pass through both ends, a total of 49 mites was used and 19 moved to near the cerumen, 11 moved to the other end of the cross piece, 6 did not migrate, and 13 moved up the stem of the tube. These experiments suggest that mites have little response to the odor of cerumen.

The second part of the experiment consisted of placing materials emitting odors into a petri dish which contained mites of all life cycle stages. In one test, a drop of blood from a dog was put in a petri dish containing 50 mites which were observed almost continuously for three hours to determine if they would respond. In the random distribution that followed, only two mites of the 50 approached the blood and neither remained in association with it for over five minutes.

The mites also displayed a similar reaction when subjected to hair and cerumen under the same conditions.

Light

The response of O. cynotis to light was determined by using a petri dish which was divided into equal parts by fitting one half with a hood of black construction paper so that the area was dark, while the other half was not affected. A beam of light from a three battery flashlight

directed straight down onto the center of the petri dish. This beam was focused in such a way that the greatest source of light was in the center with lesser gradation of light toward the periphery. Mites were taken directly from the ear of a cat, placed in the petri dish and allowed to distribute over the bottom before the experiments were started. The experiments were conducted in a darkened room at approximately 30° C. Four observations on approximately 40 mites in the containers were made at half hour intervals. After each observation the paper hood was placed on the opposite side of the petri dish to reverse the light and dark areas. The mites responded by moving toward the center of the light source. It was learned, however, that the half-hour period was not long enough for the mites to complete their adjustments; thereafter, in similar experiments the time was increased to one hour. Three similar one-hour tests were conducted to determine the distribution of the mites. In each test more than 90 per cent of all stages of the mite were concentrated in the center of the beam of light. It was apparent in these tests that neither the stage of development nor the sex of the mite affected the orientation to light.

Another test was undertaken to determine the reaction of mites to a concentrated beam of white light. Instead of dividing the petri dish into equal light and dark areas, the entire area, with the exception of a 2 cm-diameter circle, was masked with a hood of thick dark construction paper. The experiment was conducted in a darkened room. The petri dish was placed under a light source from a flash light and mites were counted at the end of an hour. Over 90 per cent of the 36 mites congregated in the circle of the concentrated light.

To test the response of the mites to different colors of light,

filters were placed between the light source and the mites. Green, purple, red, and blue wratten filters were utilized in these tests. The same petri dish arena was used in which half of the dish was darkened and the other half was not affected. Mites were placed in the dish and were allowed to distribute themselves. The temperature and humidity were approximately the same as in the previous tests. Two observations, each after an hour interval, were made on different batches of mites, using a green filter. The illuminated area attracted over 90 per cent of the mites in each experiment. Similar observations were made using other filters. The results for the red and blue filters were the same as for the green one, but it took a half hour longer for the purple filter to produce similar results. These data are presented in table 32. It will be noted that all mites were not counted in each case as some had migrated to the top of the container.

A second test was conducted to determine if the mites had a preference for a specific color of light. In this experiment a petri dish was divided into four sections each of which was illuminated by a different color of light. The filters used were blue, green, red, and colorless glass. A goose neck lamp with a 60-watt bulb situated above the petri dish provided the source of light. A container of water was placed between this source of light and the petri dish to prevent a rise in temperature. The experiment, carried on in a darkened room, ran for an hour after which the number of mites in each area was recorded. To arrive at a satisfactory distribution, the container with mites was placed in a refrigerator and when body movement stopped the mites were manually distributed evenly over the bottom of the container. Four tests were conducted and it was evident that the mites showed little preference for the color of light,

but they did prefer light to dark areas. The data are presented in table 33.

Gravity

The external auditory meatus of both cats and dogs runs ventrally and inwardly from the pinna of the outer ear to the middle ear. Since mites were found throughout this ear canal as well as on the pinna and in some cases also on the body, experiments were devised to test the reactions of the mite to gravity. Several tests, using about ten mites each, were made. The mites in a glass tube, fastened at a 90-degree angle, and kept at 30° C. under white light was used to determine the direction of movement of the mites at various times. The observations were made periodically and it was apparent that mites initially exhibited a negative geotaxis. However, after a period of time they moved in all directions. The results are presented in table 34.

VIII. SURVEY OF *OTODECTES CYNOTIS*

In the fall of 1956, a survey which produced data on the degree of parasitism of the ear mite, *Otodectes cynotis*, in dogs and cats was completed. The dogs involved were in eight kennels of fox and coon hounds near Stillwater and Perkins, Oklahoma, in one kennel of dogs in Oklahoma City, and another in the Veterinary Clinic at Oklahoma State University. The cats were farm cats from approximately the same territories. Some of this survey work was undertaken in conjunction with a treatment program to test the efficacy of Dow ET-57 on mites, ticks, and fleas.

The examinations made in this survey supplied an opportunity to study the mites in their natural habitat. They also provided an opportunity to secure information on the specific relationships of the parasite and host, as well as the general condition of the ear of the host. A relatively large number of animals was examined and the conclusions resulting from the study corroborated much of the work of other researchers.

Veterinarians from Oklahoma City, Tulsa, Ponca City, and Enid, Oklahoma, cooperated in collecting mites and supplied additional data for this study. From this information, it was apparent that ear mites are definitely a serious problem to the pet owner and the veterinarian. The infestations were very difficult to control efficiently, and therefore, were of economic significance. Although cats and dogs can be treated by veterinarians with excellent results, reinfestation in many

cases takes place soon after treatment, resulting probably from infested animals or from contaminated premises. It appears that this situation could be handled more effectively if a community rather than an individual undertook the project of treatment and control.

The hosts were examined by swabbing both the ears with a cotton-tipped applicator; the presence of mites was ascertained with a hand lens or, in some cases, with an otoscope. For the study of morphology some of the mites were preserved in 70-per cent isopropyl alcohol.

The majority of the dogs examined were hounds. Others included Terriers, Cockers, Boxers, Shepherds, Beagles, Bulldogs, Manchesters, Great Danes, Dalmatians, Dachshunds, Scotties, Greyhounds, Chows, Pekingeses, Pomeranians, Pointers, Weimaranars, and mixed breeds. The ages of the dogs ranged from three months to ten years or more. The cats examined were all mongrels, and varied in age from kittens five weeks old to cats more than four years old. The hair coat in these cats was exceedingly diverse, and ranged from a short coat, like that of the Siamese, to an extremely long one, like that of the Persian. The data given in table 34 will summarize the findings of the survey.

In the Stillwater and Perkins, Oklahoma areas, eight kennels were involved in this study as noted. Most of the hounds ran together occasionally on hunts, thus providing an excellent opportunity for spreading the parasites through close contact. A total of 113 hounds were examined and 87 of them or 77 per cent were infested. Considered on the basis of individual kennels, the range of incidence of infestation varied from 27 to 100 per cent. This wide range was possibly a result of different nutritional conditions and various degrees of

incidence of infestation were small and had dirt-floored pens which provided little chance for good sanitary practices. Fleas in these kennels were exceedingly abundant, and probably were involved in producing the extreme number of cases of mites. It is known that eggs and mites sometimes stick to the fleas, and it is theoretically possible that the mites may be transferred by them. The dogs were given a poor diet and kept very thin, because it was the belief of the owners that the dogs would run better in this condition. The two kennels in which the dogs had the least numbers of mites were large, and their owners handled their kennels more efficiently. These dogs had a good diet of meat and commercial dog food, and were treated periodically for fleas. One of these kennels consisted of a pasture which the owner sprayed occasionally with D.D.T. and other insecticides. The other kennel was a dirt and cement-floored pen with ample room for the dogs, and included water facilities which enabled the owner to keep the area clean. Although the results of the survey indicate that there was a possible correlation between degree of ear mite abundance and environmental factors, it was not feasible to correlate these data because the dogs were traded back and forth and conditions of environment varied too drastically.

The kennel in Oklahoma City was rather unusual in providing an excellent opportunity to study a number of conditions of interest in the overall analysis of the problem. One person owned the kennel which included all varieties and ages of dogs. Comparatively speaking, the management of the kennel was conducted efficiently. All of the dogs had a common area in which to feed and exercise, but each animal was given an individual sleeping area which it used. There were 134 dogs in the seven-acre pasture and 88 of them were examined; 29 dogs or

approximately 33 per cent had ear mites, but in no case was the infestation heavy. All of the dogs had been dipped periodically for fleas in a very strong mixture of crude oil and insecticides; but an examination revealed that a small number of fleas was present on many of them. Several of the dogs which did not have ear mites had other ear infections. These conditions possibly could have had their origin either in an initial infestation of ear mites or in the strong dip used to control the fleas.

The 20 dogs examined at the Veterinary Clinic at Stillwater included those that were being used for research, as well as some clinical patients. Only two dogs, or 10 per cent, were found to be infested with ear mites. These two, probably obtained from an animal shelter, were being used for research. The results of the survey at the Veterinary Clinic are more in accordance with other previously published reports than are those obtained in a survey of the kennel dogs. Pullar (1946) reported an incidence of 3.4 per cent of ear mites for dogs of Australia, Correa (1947) in Porta Alegre, Brazil, determined that less than 3 per cent of dogs in an animal shelter had mites, while Brink (1944) in Sweden found only one infested dog in 131 that were necropsied. All of these surveys showed a much lower degree of infestation than that of the Oklahoma study, in which 50 per cent of the dogs had O. cynotis.

Thirty-six cats examined in this study were either farm or alley cats and of these, 12 cats or 33 per cent had ear mites. No surveys of ear mites infestations in cats has been published apparently, but Stafford (1935) and Schultz (1932, 1938) estimated that 75 per cent of all cats had mites, and intimated that the incidence was higher in cats with long hair.

Many veterinarians tell their clientele that cats spread otacariasis

among dogs and vice versa. The basis of this remark is supported by an observation of Kaufmann and Frost (1949), who wrote that it is probably that cats are a common source of infestation of mites for the dog. This statement was based on the single observation that three dogs closely associated with infested cats had mites. The present survey shows, however, that cats even in close contact with infested dogs can be free of mites. However, since in both this study and that of Railliet and Cabiot (1892) infestation of mites has been produced experimentally by transferring mites between these two species of hosts, it appears that the facts in the spread of ear mites are not completely known.

Turning now to unilateral infestations, the present observations as well as the information supplied by veterinarians, indicate that unilateral infestations are exceedingly rare. In fact not a single animal examined by this investigator had a unilateral infestation. Beresford-Jones (1955) reported these to be rare in dogs of London; however, Kaufmann and Frost (1949) reported 10 per cent of the dogs what they examined had ear mites in only one ear.

The general condition of the ear seems to play an important role in susceptibility of ear mite infestations. The results of this study and those reported by Beresford-Jones indicate that infestations are more prevalent in dirty ears than clean ones. Dirty ears apparently may predispose them to mite infestations, or, on the other hand, their presence may be the predisposing factor to dirty ears. However, when suppuration of the ear is produced by either the ear mites or secondary infections the environment of the ear is altered and the mites either die or migrate.

Sex of the host is apparently not a factor in its susceptibility to

males than in females. His survey was based on dogs from an animal shelter, dogs which had the run of the streets until they were captured; it may be assumed that males would wander more extensively and have more contact than females, and thus have a greater chance to become infested. The present study was of animals confined in kennels; in these the incidence of infestation among males and females was nearly equal.

There was no indication of age resistance to mite infestations in dogs and cats in the current study; this information substantiates similar findings of Beresford-Jones, since in both surveys some of the infestations were observed in old animals. Mohr, quoted by Beresford-Jones, believed that age resistance existed. It appears that this problem can be properly elucidated only by further study.

The question of relative abundance and incidence of mites in dogs and cats has been raised by some investigators. Beresford-Jones found that infested dogs had fewer mites than infested cats. Pullar (1946), however, in six dogs found two that had several hundred mites each, and three more that had at least one hundred each. The present study was limited because none of the animals was necropsied; consequently, no accurate information concerning the number of mites in the ear could be secured. However, it appears that the number of mites in the host may result from environmental influence rather than host species differences. This opinion is based on the observation that pen-mates may show great differences in the degree of infestation, varying from heavy to light, and even to the absence of mites. To further substantiate the conclusion, it was determined that one male cat approximately four years old, even though housed with an infested male cat for more than a year, was never found to be infested. Five of six kittens of the same age which were

confined in a cage for a period of a year had ear mites, while the other remained free. Furthermore, a female cat was checked periodically for over a year and was free of mites; however, her litter of three kittens became heavily infested before it was five weeks old. In comparing dogs and cats, it was noted that dogs were as severely infested as the cats. These observations seemed to indicate that a certain physiological or pathological condition of the ear of the host must exist before an Otodectes infestation can be established. Schulz (1938) stated that the mite is quickly and easily spread from animal to animal. This may be true in many cases, but apparently the host must be susceptible to the mite before any spread, whether rapid or slow, can take place.

Few observations have been reported on the degree of susceptibility to infestation in relation to the breed of the host. In this study, however, long-haired and short-haired animals appear equally susceptible to mites and no difference in infestation was found in dogs, whether they had erect or drooping ears. Pullar (1946) observed no correlation between breed of host and susceptibility to infestation, and found no cases of mites in dogs with drooping ears. He suggested, however, that since only six dogs were examined no conclusion concerning drooping or erect ears could be established.

IX. SUMMARY

1. A systematic study was made on *Otodectes cynotis* and the alleged four varieties.
2. In an attempt to find a basis for the varieties *canis* and *cati* a detailed study of the external anatomy was made and a more complete description of the species prepared.
3. A study of the life history of *O. cynotis* was completed under natural conditions using cats and dogs as experimental hosts and additional observations were made on the egg, larva, protonymph, deutonymph, and adult. Observations relative to the life history included those on:

   Embryological development of the gross anatomical structures.
   The distribution and movement of the mite on the host.
   The relative abundance of the life history stages of the mite.
   Variations in abundance of the ear mites within the ear of the host.
   The possible methods of spread from host to host.
   The transfer of mites from cats to dogs and vice versa.
   Treatment.

4. The effects of such stimuli as temperature, humidity, light, odor, and gravity on the stages of the mite were studied.
5. A survey of the ear mites in the dog and cat was conducted and the results summarized. Additional specific conditions investigated included the effect of hair coat, length of ears, diet, sex, age and

amount of cerumen on infestation. The relative abundance of unilateral infestations was also studied.

X. CONCLUSIONS

The study of Otodectes cynotis revealed a variation in size of the forms in both the cat and dog which overlaps the four alleged varieties. Since the literature stated that size is the only apparent means of differentiation between varieties and the fact that transfers were made of mites from a cat to a dog and from a dog to a cat, the validity of the variety concept is questioned. Even if the variety concept is maintained, the variety africana is not valid as it is based on only one male and a few females from a single cat and the size of these specimens fall within the size range of specimens collected from cats during this study.

The life cycle stages are identified primarily by size, characteristics of legs IV, adanal suckers, and genital structures, but no morphological characters were found to determine the sex of immature stages. There is a difference in size, but the variations within stages are too great to allow for differentiation.

The gross anatomy of all stages of the mite from both the dog and cat were studied in detail and an outline of the major characteristics prepared. The position and number of setae on the body and legs were determined to be fairly constant in mites of each life-cycle stage, but the number of setae increases progressively from the larva to the adult. The major ducts of the supracoxal glands have their origin slightly dorsal to coxa I and extend to a point near the mouth in the basi capituli of the gnathosoma. These occur in other mites, but their

function has never been determined. It is assumed that the major ducts of the supracoxal glands are either secretory or excretory in function. Smaller minor ducts associated with the supracoxal fossae extend from the glands to the level of the anal opening and end blindly. These ducts have taenidea and for that reason may function in respiration. The first detailed account of the minute but complex mouthparts is presented. The major structures include the paired tridentate chelicerae. Punctate cheliceral plates cover the dorsal aspect of the gnathosoma. The pedipalps form the ventro-lateral margins, with the hypostome completing the enclosure. Two pairs of rudimentary accessory genital sucker-like setae occur on the venter close to the genital openings of the male and female; similar ones were noted on the deutonymph, but only a single pair on the protonymph and none on the larva. A structure similar to these genital sucker-like setae as well as a groove in the basal portion of the tarsal plate is located on tarsi I of the male, female, and deutonymph, but these structures were not observed on the other stages. All stages have both an anal and propodosomal plate, but only the adults have genital plates, and only the male has a hysterosomal plate. Internally, a bulbular pharynx and a straight esophagus could be seen. The esophagus was traced to a level between legs II and III where it was obscured by other digestive structures.

It was calculated from experimental data that the cycle could be completed in ten days, but in the actual experimental studies, a period of at least 15 days was necessary before the second generation of mites could be detected. Studies on the embryology showed a great variation in the incubation period of the eggs ranging from 24 to 101 hours. The extremes were very rare but they present a problem in the

efficient control of the mite. The variation is apparently attributable to temperature, but other factors such as humidity may influence it. The study of development of the larvae showed that the legs developed first followed by the appearance of the anterior projection of the dorsum and gnathosoma, then the sclerotized areas and finally the setae.

The study of distribution of the mites showed that they were not confined to the ears but occurred on the skin and hair of the body of the host, especially on areas around the ears and eyes. An experiment with mites released on the rear flank of a cat indicated that they moved almost straight to the ear, some entering it in less than one hour after their release.

A three-year study on the population of mites on hosts showed that they reached a peak in early summer and a low during the winter. Temperature probably was the primary factor influencing these population changes, but the possibility of an inherent factor was not excluded. A few more females than males usually were present in any given population. It was concluded that this difference could be explained by the fact that females live longer than males, as indicated by experimental evidence.

Methods of spread from host to host were determined to be by direct contact of hosts, by arthropods carrying eggs or motile stages of the mite. The dispersal by direct contact is probably the most common. Mites under experimental conditions at room temperatures and humidities could be kept alive off the host for approximately two weeks, and as shown above, mites may wander extensively on the host. Flies have been determined to be a factor in the spread of species of Psoroptes and this research on O. cynotis shows that fleas are capable of carrying mites and eggs.

Transfers of these mites from cats to cats, cats to dogs, and dogs to cats were successful and casts doubt on the validity of the variety concept. It shows that the interspecies transfer is feasible under natural conditions.

The treatment of hosts for ear mites has been discussed. On theoretical grounds it is believed that a heavy oil base should be used in acaricides and that a series of treatments, of each entire animal, instead of a single one should be used. Control would be most efficient as a community enterprise.

A study of a response of O. cynotis to various stimuli, indicated that they reacted to temperature, humidity, and light. The temperature range suitable to the mites was 23 to 43° C., and 38 to 43° was most acceptable. Relative humidities from 70 to 85 per cent were tolerated by the mites. Mites died from being trapped in water droplets of condensation at humidities of 90 to 100 per cent and they died from desiccation in humidities below 70 per cent. These wide variations in temperature and humidity are to be expected since the mites may live out of the ear and off the host.

The mites respond positively to light and in all tests most of them preferred light to dark areas. The response was similar to green, blue, red, and purple light. Authorities consider them colorblind to red light, but experiments conducted did not support this conclusion.

No proof of sensitivity to odor could be secured experimentally when odors from cerumen, hair, and blood were used. Mites exhibited initially a negative response to gravity when transferred to a new environment, but after they are confined for a period of time they moved in all directions.

The results of the survey of ear mites in the dog and cat showed that of 113 hounds examined near Stillwater, 87 had mites, of 88 dogs of mixed breeds in Oklahoma City, 29 had mites, and of 20 dogs at the Oklahoma State University Veterinary Clinic only two had mites. Thirty-six cats were examined and 12 had ear mites. These data indicate a higher per cent of infestation than in most of the previous surveys.

No unilateral infestations were noted during the survey and experimental findings indicate that unilateral infestations probably occur only in newly-infested animals and not in well-established cases. No correlation of infestation was evident between number of mites in long- or short-haired dogs or long- or short-eared dogs. A possible correlation between proper diet and sanitary practices and mite infestations was noted but because of the trading of the dogs among the owners exact data could not be collected.

No difference in the degree of infestation was observed in male and female hosts. This finding was contrary to some reports in the literature, however, the fact that dogs examined in this survey were usually confined in groups, whereas those used in other surveys were animals that had the run of the terrain, could account for this difference.

The literature indicates that a possible age resistance to O. cynotis among animals exists, but findings in this survey did not support this assumption since old as well as young animals were found to be heavily infested. It is thought that resistance is a response of the individual animal rather than age resistance.

It was determined that cerumen increased in the ear of the host as soon as the mites had established themselves, and that it is not

necessarily a predisposing factor in infestation. As evidence to support this conclusion potential hosts infested in one ear only had more cerumen than the uninfested one and only, when the latter ear became infested did any amount of cerumen appear.

LITERATURE CITED

Allen, J. A. 1924. Auricular scabies (Parasitic otitis) in silver black foxes. Canad. Vet. Rec. 5: 12-16.

Baker, E. W. and Wharton, G. W. 1952. An Introduction to Acarology. The MacMillan Co., New York. 1-465.

Bendz, H. C. B. 1862. Parasiter hos hunden, Taenia Echinosoccus og Symbiotes canis. Overs. K. Danske Vidensk. Slesk. Forh. 12-23.

Beresford-Jones, W. B. 1955. Observations on the incidence of Otodectes cynotis (Hering) on dogs and cats in the London area. Vet. Rec. 67: 716-717.

Brinck, P. 1944. Resultatet av en undersökning av parasit-och tuberkulosförekomsten hos hundaran i Malmo Stad. Skand. Vet. Tidskr. 34: 685-694.

Brown, J. R. C. 1949. The anatomy of the gnathosoma of Trombicula (Eutrombicula) affreddugési (Oudemans), 1910. Master's thesis. Duke University, Durham, N. C.

Camin, J. A. 1950. Observations on the life history and sensory behavior of the snake mite, Ophionyssus natricus (Gervais). Chicago Acad. Sc. Special Publ. 10: 1-70.

Canestrini, G. 1894. Prospetto dell' acarofauna italiana. Parte 6: Famiglia dei Psoroptidi (Psoroptidae). Appendici ai filoptidi italiani. varin: Psororgates, Hemisarcoptes, Histiogaster, Psoroptes ovis, Otodectes furonis. Gli Epidermoptini. 723-833. Padova.

Correa, O. 1947. Contribuicão á determinacão dos índices helminthológico e entomologico de Canis familiaris Linnaeus na cidade de Pôrto Alegra, sua impotância para a medician veterinária e a medicini humana. Tése Rio Grande do Sul. 1-86.

Fonseca, F. D. 1948. A monograph of the genera and species of Macronyssidae Oudemans, 1936 (synon. Liponissidae Vitsthum, 1931) (Acari). Proc. Zool. Soc. 118: 249-334.

Furr, R. 1955. The Tetranychidae of Oklahoma. Doctor of Philosophy thesis. Oklahoma State University, Stillwater, Okla.

Gervais, P. 1841. Note sur quelques especes de L' ordre des acariens. Ann. Sc. Nat., Zool. 15: 5-10.

Gillian, J. 1942. Otodectes cynotis var. africana. Un nouvel acarien du chat. Bull. Agric. Congo. Belge. 33: 110-111.

Gorirossi, F. E. 1950. The mouthparts of the adult female tropical rat mite, Bdellonyssus bacoti (Hirst, 1913) Fonseca, 1941 [Liponissus bacoti (Hirst)], with observations on the feeding mechanism. J. Parasitol. 36: 301-318.

Grandjean, F. 1936. Observations sur les acariens (3e série). Bull. Mus. Nat. Hist. Nat., Paris 8: 84-91.

_____. 1937. Otodectes cynotis (Hering) et les pretendues trachees des acaridiae. Bull. Soc. Zool. France. 4:280-290.

von Hering, E. A. 1838. Die kratzmilben der tiere und einige verwandte arten. Nova Acta Acad. Nat. Curios. 12: 575-624.

Hofmeyer, C. F. B. and Du Toit, R. 1940. A note on the occurrence of the ear mite, Otodectes cynotis Hering, in the Union of South Africa. J. Amer. Vet. Med. Assoc. 11: 67-69.

Holz, J. 1955. Untersuchungen über die möglichkeit der übertragung von milben (Psoroptes und Notoedres) und läusen (Polyplax spinolosa) durch Musca domestica. Tierarztl. Umsch. 10: 248-249.

Hughes, T. E. 1949. The functional morphology of the mouthparts of Liponyssus bacoti. Ann. Trop, Med. Parasitol. 43: 349-360.

Huber, J. C. 1860. Notizen uder das vorkommen pflanzlicher und thierischer parasitea in unserm beserk. Ber. Naturh. Ver. Augsburg. 13: 121-229.

Kaufmann, E. and Frost, C. 1949. Otodectic mange in the dog. Vet. Rec. 61: 368.

Kontz, F. R. 1955. Life cycle, diagnosis and treatment of various mites that attack small animals. Vet. Med. 55: 278-281.

Lucas, H. 1849. Sarcoptes auricularum trouve' dans les oreilles d' un chien. Ann. Soc. Entom. France. 7: 34-35.

Mégnin, J. P. 1876. Le parasitisme auriculaire chez quelques animaux domestiques. Rec. Med. Vet. 53: 978-985.

_____. 1881. Sur une affection epileptiforme et contagieuse chez le chien causée par un acarien du conduit auditif. Rec. Méd. Vét. 58: 129-131.

_____. 1884. Otite ulcereuse epidemique grave, aussi chez des furets causée par un autre acarien psorique; le Chorioptes ecaudatus (Megn.). Bull. Soc. Centr. Med. Vet. 38: 70-71.

Perroncito, E. 1882. I parassiti dell' womo e degli animali utili. Delle pio comuni malattie da essi prodotte profilossi e cura relativa. Milane. 1-506.

Peterson, A. 1953. A manual of entomological techniques. Edwards Bros. Ann Arbor, Mich. 1-367.

Pullar, E. M. 1946. A survey of Victorian canine and vulpine parasites. V. Arthropoda. Austral. Vet. Jour. 22: 112-118.

Railliet, A. 1887. Acariases multiples sur un furet. Bull. Soc. Centr. Méd. Vét. 41: 244-246.

_____. 1893. Traite' de zoologie medicale et agricol. Paris. 2 ed. 1-736.

_____. and Cadiot, P. J. 1892. Observations and experiments on "symbiota otacariasis". Vet. Jour. Ann. Comp. Path. 34: 189-193.

Schultz, C. W. 1934. Feline auricular mange. Vet. Med. 29: 324-325.

_____. 1938. Feline auricular mange. Vet. Med. 33: 34-35.

Snodgrass, R. E. 1948. The feeding organs of Arachnida, including mites and ticks. Smiths. Misc. Coll. 110. 1o: 1-93.

Stafford, C. D. 1935. Common parasites of the cat. Vet. Med. 30: 438.

Wharton, G. W. and Fuller, H. S. 1952. A manual of the chiggers. Memoirs of the Ent. Soc. Wash. 4: 1-185.

Vitzthum, H. 1928. Acarologische Beobachtungen. Zool. Anz. 75: 281-295

Yunker, C. R. 1955. A proposed classification of the Acaridae (Acarina: Sarcoptiformes). Proc. Helm. Soc. Wash. 22: 98-105.

Zürn, F. A. 1874. Raüdemilben im ohr der hunden und bei kannchen. Wchnschr. Thierh. u. Viehzucht. 18: 277-283.

APPENDIX

TABLE 1

A COMPARISON OF THE CHAETOTAXY OF THE LIFE CYCLE STAGES OF *Otodectes cynotis*

Setal position	male	female	deutonymph	protonymph	larva
Body:					
Dorsum	8	8	7-8	7	6
Venter	8	8	8	5	2
Marginal	7	7	7	7	3
Legs I					
Tarsus	10	8	8	7	7
Tibia	2	2	2	2	2-3
Genu	3	3	2-3	3	2
Femur	1	1	1	1	1
Trochanter	1	1	1	0	0
Coxa	0	0	0	0	0
Legs II					
Tarsus	8	8	7	7	6
Tibia	2	2	2	2	2
Genu	3	3	2	2	2
Femur	1	1	1	1	1
Trochanter	1	1	1	0	0
Coxa	0	0	0	0	0
Legs III					
Tarsus	3	4	4-6	4-5	4
Tibia	2	2	0-1	0-1	1
Genu	0	0	0	0	0
Femur	0	0	1	0	0
Trochanter	1	1	0	0	0
Coxa	0	0	0	0	0
Legs IV					
Tarsus	3-5	4-6		2	
Tibia	2-3	1		0-1	
Genu	0	0		0	
Femur	0	0		0	
Trochanter	0	0		0	
Coxa	0	0		0	

TABLE 2

EFFECT OF TEMPERATURE AND HUMIDITY ON THE VIABILITY

AND INCUBATION PERIOD OF *Otodectes cynotis*

Number of eggs per individual test	Temperature in °C.	Humidity	Number of eggs hatched	Per cent of hatch	Average incubation in hours	Extremes in incubation in hours
330	38	room	149	45	45	24-76
76	38	100	64	84	69	45-97
18	38	100	13	72	70	46-87
49	38	90	27	55	61	43-78
26	38	90	20	76	60	43-77
19	38	80	14	74	58	48-73
18	38	80	14	77	58	48-73
10	32	90	6	60	95	90-102
14	32	room	10	71	84	76-91

MEASUREMENTS OF PARTS OF THE ADULT MALE

Otodectes cynotis FROM THE CAT

Anatomical part	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	52	333.0	225.0-387.0
width	52	248.0	171.0-297.0
Gnathosoma:			
length	10	63.0	53.0-69.0
width	10	58.0	53.0-69.0
Legs (length):			
I	10	298.0	291.0-307.0
II	10	274.0	250.0-291.0
III	10	312.0	302.0-322.0
IV	10	195.0	187.0-203.0

TABLE 4

MEASUREMENTS OF PARTS OF THE ADULT MALE

Otodectes cynotis FROM THE DOG

Anatomical part	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	75	387.0	270.0-414.0
width	75	287.0	180.0-333.0
Gnathosoma:			
length	10	63.0	54.0-68.0
width	10	60.0	52.0-64.0
Legs (length):			
I	10	325.0	302.0-354.0
II	10	303.0	270.0-317.0
III	10	339.0	322.0-364.0
IV	10	209.0	198.0-229.0

TABLE 5

MEASUREMENTS OF PARTS OF THE ADULT FEMALE

Otodectes cynotis FROM THE CAT

Anatomical part	Number of specimens	Average of part in microns	Range of size in microns
Body:			
length	17	447.0	396.0-495.0
width	17	288.0	234.0-342.0
Gnathosoma:			
length	10	76.0	71.0-83.0
width	10	73.0	64.0-83.0
Legs (length):			
I	10	294.0	276.0-302.0
II	10	272.0	260.0-291.0
III	10	213.0	203.0-224.0
IV	10	97.0	78.0-114.0

TABLE 6

MEASUREMENTS OF PARTS OF THE ADULT FEMALE

Otodectes cynotis FROM THE DOG

Anatomical part	Number of specimens	Average of part in microns	Range of size in microns
Body:			
length	22	480.0	414.0-540.0
width	22	315.0	261.0-369.0
Gnathosoma:			
length	10	73.0	61.0-78.0
width	10	67.0	62.0-70.0
Legs (length):			
I	10	316.0	302.0-348.0
II	10	289.0	280.0-312.0
III	10	231.0	218.0-250.0
IV	10	100.0	94.0-120.0

TABLE 7

A COMPARISON OF THE WIDTH AND LENGTH OF COXA I

OF *Otodectes cynotis* FROM THE DOG AND CAT

Host and Sex	Number of Specimens	Width			Length			Ratio		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Female:										
from dog	10	81	69	75	115	83	96	1.47	1.03	1.28
from cat	10	74	58	66	101	71	86	1.56	1.15	1.30
Male:										
from dog	10	74	62	68	97	85	92	1.44	1.30	1.36
from cat	10	74	58	66	106	81	92	1.57	1.27	1.40

TABLE 8

MEASUREMENTS OF PARTS OF THE DEUTONYMPH

OF Otodectes cynotis FROM THE CAT

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	18	365.0	291.0-437.0
width	18	251.0	198.0-312.0
Gnathosoma:			
length	18	57.0	53.0-62.0
width	18	54.0	48.0-60.0
Legs (length):			
I	18	188.0	177.0-218.0
II	18	183.0	156.0-218.0
III	18	115.0	104.0-125.0
IV (1)			

(1) Not measured

TABLE 9

MEASUREMENTS OF PARTS OF THE DEUTONYMPH

OF Otodectes cynotis FROM THE DOG

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	11	391.0	354.0-447.0
width	11	268.0	250.0-322.0
Gnathosoma:			
length	11	63.0	55.0-69.0
width	11	60.0	55.0-64.0
Legs (length):			
I	11	218.0	177.0-250.0
II	11	199.0	156.0-229.0
III	11	123.0	114.0-135.0
IV (1)			

(1) Not measured

TABLE 10

MEASUREMENTS OF PARTS OF THE PROTONYMPH

OF Otodectes cynotis FROM THE CAT

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	15	278.0	250.0-322.0
width	15	184.0	166.0-218.0
Gnathosoma:			
length	15	51.0	48.0-55.0
width	15	49.0	46.0-51.0
Legs (length):			
I	15	175.0	156.0-198.0
II	15	162.0	146.0-177.0
III	15	104.0	89.0-114.0
IV	15	30.0	28.0-35.0

TABLE 11

MEASUREMENTS OF PARTS OF THE PROTONYMPH

OF Otodectes cynotis FROM THE DOG

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	10	306.0	270.0-364.0
width	10	214.0	166.0-284.0
Gnathosoma:			
length	10	54.0	48.0-58.0
width	10	50.0	46.0-53.0
Legs (length):			
I	10	191.0	177.0-218.0
II	10	180.0	146.0-208.0
III	10	114.0	104.0-125.0
IV	10	30.0	29.0-32.0

TABLE 12

MEASUREMENTS OF PARTS OF THE LARVA OF

Otodectes cynotis FROM THE CAT

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	17	235.0	198.0-291.0
width	17	150.0	125.0-197.0
Gnathosoma:			
length	17	42.0	31.0-52.0
width	17	38.0	31.0-41.0
Legs (length):			
I	17	145.0	125.0-156.0
II	17	133.0	114.0-146.0
III	17	89.0	83.0-94.0

TABLE 13

MEASUREMENTS OF PARTS OF THE LARVA OF

Otodectes cynotis FROM THE CAT

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	20	254.0	208.0-322.0
width	20	161.0	125.0-218.0
Gnathosoma:			
length	20	44.0	41.0-48.0
width	20	41.0	39.0-44.0
Legs (length):			
I	20	159.0	135.0-178.0
II	20	136.0	114.0-166.0
III	20	93.0	83.0-104.0

TABLE 14

MEASUREMENTS OF PARTS OF THE ADULT FEMALE FROM DOGS EXPERIMENTALLY INFESTED WITH *Otodectes cynotis* FROM CATS

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	10	446.0	395.0-486.0
width	10	293.0	252.0-324.0
Gnathosoma:			
length	10	72.0	62.0-78.0
width	10	67.0	62.0-70.0
Legs (length):			
I	10	269.0	252.0-288.0
II	10	254.0	234.0-270.0
III	10	194.0	180.0-216.0
IV	10	86.0	78.0-90.0

TABLE 15

MEASUREMENTS OF PARTS OF THE ADULT MALE FROM DOGS EXPERIMENTALLY INFESTED WITH *Otodectes cynotis* FROM CATS

Anatomical parts	Number of specimens	Average of part in microns	Range of size in microns
Body (total):			
length	10	344.0	322.0-364.0
width	10	255.0	234.0-288.0
Gnathosoma:			
length	10	60.0	53.0-65.0
width	10	56.0	53.0-62.0
Legs (length):			
I	10	259.0	218.0-288.0
II	10	244.0	208.0-270.0
III	10	285.0	270.0-306.0
IV	10	170.0	162.0-180.0

TABLE 16

MEASUREMENTS OF PARTS OF THE DEUTONYMPH FROM DOGS EXPERIMENTALLY INFESTED WITH Otodectes cynotis FROM CATS

Anatomical parts	Number of specimens	Average of parts in microns	Range of Size in microns
Body (total):			
length	10	343.0	302.0-378.0
width	10	239.0	198.0-270.0
Gnathosoma:			
length	10	55.0	45.0-60.0
width	10	53.0	49.0-58.0
Legs (length):			
I	10	203.0	180.0-218.0
II	10	190.0	162.0-208.0
III	10	115.0	107.0-125.0
IV (1)			

(1) Not measured

TABLE 17

MEASUREMENTS OF PARTS OF THE PROTONYMPH FROM DOGS EXPERIMENTALLY INFESTED WITH Otodectes cynotis FROM CATS

Anatomical parts	Number of specimens	Average of parts in microns	Range of Size in microns
Body (total):			
length	10	265.0	216.0-306.0
width	10	180.0	144.0-216.0
Gnathosoma:			
length	10	45.0	41.0-53.0
width	10	45.0	41.0-57.0
Legs (length):			
I	10	161.0	144.0-180.0
II	10	157.0	144.0-180.0
III	10	99.0	86.0-115.0
IV	10	28.0	28.0-32.0

TABLE 18

MEASUREMENTS OF PARTS OF THE LARVA FROM DOGS EXPERIMENTALLY INFESTED WITH *Otodectes cynotis* FROM CATS

Anatomical parts	Number of specimens	Average of parts in microns	Range of size in microns
Body (total):			
length	10	211.0	180.0-252.0
width	10	141.0	114.0-180.0
Gnathosoma:			
length	10	40.0	37.0-45.0
width	10	37.0	33.0-41.0
Legs (length):			
I	10	132.0	108.0-144.0
II	10	116.0	90.0-144.0
III	10	82.0	72.0-90.0

TABLE 19

COMPARISON OF SIZE OF THE EGGS OF *Otodectes cynotis*

FROM THE DOG AND CAT

Type of host	Number of specimens	Average size in microns	Range of size in microns
Dog (1)			
length	22	204.0	189.0-243.0
width	22	107.0	90.0-144.0
Dog (2)			
length	10	198.0	198.0-198.0
width	10	101.0	90.0-108.0
Cat (1)			
length	17	192.0	162.0-216.0
width	17	101.0	81.0-126.0
Cat (3)			
length	22	206.0	198.0-218.0
width	22	97.0	83.0-114.0

(1) Eggs measured within the gravid female
(2) Eggs laid by mites collected from dogs experimentally infested with mites from the cat
(3) Eggs laid by the mite

TABLE 20

A COMPARISON OF MEASUREMENTS OF LENGTH AND WIDTH OF SPECIMENS OF *Otodectes cynotis* COLLECTED DURING THIS STUDY WITH SPECIMENS OF DESIGNATED VARIETIES COLLECTED BY OTHER WORKERS

Variety and stage	Investigator	Length			Width		
		Max.	Min.	Aver.	Max.	Min.	Aver
Male:							
canis	Tonn	414	270	387	333	180	287
canis	Railliet	380	350	___	280	250	___
canis	Gillain	380	350	___	280	250	___
cati	Tonn	387	225	333	297	171	248
cati	Railliet	350	320	___	250	230	___
cati	Gillain	350	320	___	250	230	___
furonis	Canestrini	340	270	___	210	210	210
furonis	Railliet	340	270	___	250	210	___
furonis	Gillain	340	270	___	250	210	___
africana	Gillain	240	240	240	180	180	180
(1)	Canestrini	420	380	___	310	290	___
(1)	Perroncito	300	300	300	200	200	200
(1)	Mégnin	300	300	300	200	200	200
Female:							
canis (2)	Tonn	540	414	480	369	261	315
canis (3)	Tonn	558	414	487	387	206	322
canis (2)	Railliet	530	460	___	350	280	___
canis (3)	Railliet	380	340	___	260	210	___
cati (2)	Tonn	495	396	447	234	342	288
cati (3)	Tonn	495	360	426	351	198	283
cati (2)	Railliet	480	430	___	290	260	___
cati (3)	Railliet	360	310	___	250	200	___
furonis (2)	Railliet	450	380	___	280	240	___
furonis (3)	Railliet	330	300	___	230	180	___
furonis	Canestrini	450	380	___	280	240	___
africana	Gillain	350	300	___	220	200	___
(1)	Canestrini	450	420	___	300	260	___
(1)	Perroncito	450	___	___	250	___	___
(1) (2)	Mégnin	450	___	___	250	___	___
(1) (3)	Mégnin	280	___	___	180	___	___
Deutonymph:							
canis	Tonn	447	354	391	322	250	268
cati	Tonn	437	291	365	312	198	251
(1)	Mégnin	280	___	___	180	___	___

TABLE 20 (CONTINUED)

Variety and stage	Investigator	Length			Width		
		Max.	Min.	Aver.	Max.	Min.	Aver.
Protonymph:							
canis	Tonn	364	270	306	284	166	214
cati	Tonn	322	250	278	218	166	184
Larva:							
canis	Tonn	322	208	254	218	125	161
cati	Tonn	291	198	235	197	125	150
(1)	Megnin	280	180	___	180	120	___
Egg:							
canis	Tonn	243	189	204	144	90	107
canis	Railliet	210	200	___	120	91	___
cati (4)	Tonn	218	198	206	114	83	97
cati (5)	Tonn	216	162	192	126	81	101
cati	Railliet	190	160	___	120	80	___
furonis	Railliet	200	160	___	120	80	___
(1)	Megnin	180	___	___	80	___	___
(1)	Perroncito	180	___	___	80	___	___

___ Measurement not available
(1) No specific variety mentioned in publication
(2) Gravid female
(3) Callow female
(4) Egg measured after oviposition
(5) Egg measured before oviposition

TABLE 21

A COMPARISON OF RATIOS OF WIDTH TO LENGTH OF SPECIMENS OF *Otodectes cynotis* COLLECTED DURING THIS STUDY WITH SPECIMENS OF DESIGNATED VARIETIES COLLECTED BY OTHER WORKERS

Variety and stage	Investigator	Ratio of width to length		
		Maximum	Minimum	Average
Male:				
canis	Tonn	1 to 1.24	1 to 1.50	1 to 1.35
canis	Railliet	1 to 1.40	1 to 1.30	———
cati	Tonn	1 to 1.59	1 to 1.20	1 to 1.33
cati	Railliet	1 to 1.40	1 to 1.39	———
africana	Gillian	———	———	1 to 1.33
furonis	Canestrini	———	———	1 to 1.28
furonis	Railliet	1 to 1.36	1 to 1.28	———
(1)	Megnin	———	———	1 to 1.50
(1)	Canestrini	1 to 1.35	1 to 1.32	———
Gravid Female:				
canis	Tonn	1 to 1.65	1 to 1.39	1 to 1.52
canis	Railliet	1 to 1.64	1 to 1.51	———
cati	Tonn	1 to 1.70	1 to 1.42	1 to 1.56
cati	Railliet	1 to 1.65	1 to 1.65	———
africana	Gillian	1 to 1.59	1 to 1.50	———
furonis	Canestrini	1 to 1.60	1 to 1.58	———
furonis	Railliet	1 to 1.60	1 to 1.58	———
(1)	Megnin	———	———	1 to 1.50
(1)	Canestrini	1 to 1.61	1 to 1.50	———
Callow Female:				
canis	Tonn	1 to 2.27	1 to 1.30	1 to 1.51
canis	Railliet	1 to 1.61	1 to 1.46	———
cati	Tonn	1 to 1.76	1 to 1.24	1 to 1.50
cati	Railliet	1 to 1.55	1 to 1.44	———
furonis	Railliet	1 to 1.66	1 to 1.43	———
(1)	Megnin	———	———	1 to 1.55
Egg:				
canis	Tonn	1 to 2.30	1 to 1.52	1 to 1.90
canis	Railliet	1 to 2.22	1 to 1.75	———
cati	Tonn	1 to 2.18	1 to 1.50	1 to 1.90
cati	Railliet	1 to 2.00	1 to 1.59	———
furonis	Railliet	1 to 2.00	1 to 1.66	———
(1)	Megnin			1 to 2.25

——— No information given in publication to determine the ratio

(1) No specific variety mentioned in publication

TABLE 22

STRUCTURES IMPORTANT IN DISTINGUISHING THE LIFE CYCLE STAGES OF *Otodectes cynotis*

Structure

Stage	Pretarsi	Legs IV	Adanal suckers	Acanthoides	Genital structures	Accessory genital suckers	Hysterosomal plate
Male	all legs	extend posterior from body, segmented	present	subterminal, legs III and IV	aedeagus	2 pair	present
Female	I and II	usually does not extend post. from body, segmented	absent	terminal, legs III and IV	ventral, medial transverse genital opening	2 pair	absent
Deutonymph	I and II	granular area	present	terminal, legs III	absent	2 pair	absent
Protonymph	I and II	stub-like, very small, segmented	absent	terminal, legs III	absent	1 pair	absent
Larva	I and II	absent	absent	terminal, legs III	absent	absent	absent

TABLE 23

THE VARIATION IN THE NUMBER OF INDIVIDUALS OF EACH STAGE OF *Otodectes cynotis* COLLECTED FROM INDIVIDUAL HOSTS BY A UNIFORM SWAB

Host No.	Female		Male		Immature*		Total of all the stages
	Total	Per cent	Total	Per cent	Total	Per cent	
1	11	35	9	29	12	36	31
2	20	30	15	24	30	46	65
3	8	27	4	13	18	60	30
4	9	20	7	16	28	64	44
5	0	0	0	0	2	100	2
6	5	33	1	7	9	60	15
7	1	33	0	0	2	67	3
8	5	42	2	16	5	42	12
9	17	20	11	12	61	68	89
10	9	27	5	15	19	58	33
Total	65	22	43	15	185	63	293

*Includes all immature stages

TABLE 24

THE TIME INTERVAL ELAPSED BETWEEN THE INTRODUCTION OF MITES INTO EXPERIMENTAL HOSTS AND THE RECOVERY OF THE STAGES OF THE LIFE CYCLE

Host number	Stage of mite introduced in ear of host	Time elapsed in days			
		Larva	Protonymph	Deutonymph	Adult
1.	female	7	7	12	18
2.	female	7	12	12	15
3.	female	7	8	—	20
4.	female	6	8	15	18
5.	deutonymph	8	18	—	8
6.	deutonymph	12	13	—	12
7.	larva	—	—	12	14

— Stage not recovered or no record could be kept

TABLE 25

THE RESPONSE OF Otodectes cynotis CONFINED IN GLASS TUBING HAVING A TEMPERATURE RANGE FROM 19 TO 45° CENTIGRADE

Temperature in Centigrade	Number			
	Larva	Nymphs	Adult	Total
45	1	6	9	16 (1)
44	0	0	0	0
43	4	1	6	11
42	13	6	19	38
41	5	8	14	27
40	0	4	10	14
39	3	9	10	22
38	3	3	2	8
37	0	0	0	0
36	1	0	2	3
35	5	2	4	11
34	1	3	7	11
33	2	0	3	5
32	1	1	2	4
31	0	0	3	3
30	3	4	5	12
29	10	7	5	22
28	2	3	7	12
27	4	8	9	21
26	2	1	6	9
25	3	0	3	6
24	1	0	0	1
23	5	3	9	17
22	1	0	0	1
21	0	0	0	0
20	1	0	0	1 (1)
19	4	3	3	10 (1)

(1) Inactive

TABLE 26

THE EFFECT OF VARIOUS TEMPERATURES ON LENGTH OF LIFE

OF THE STAGES OF *Otodectes cynotis**

Stage	Length of life in days of miets at various temperatures (2) 38°C.	32°C.	4°C.
Female	9	12	21
Male	7	8	16
Deutonymph	4	6	(1)
Protonymph	4	6	(1)
Larva	3	4	(1)

* Humidity was not controlled
(1) Not recorded
(2) The day the last mite of the group died

TABLE 27

THE DISTRIBUTION OF *Otodectes cynotis* IN PETRI DISHES WHEN GIVEN A CHOICE OF TWO HUMIDITIES, EXPRESSED IN PERCENTAGES

Test number	50%	90%	Total mites used	50%	80%	Total mites used	60%	80%	Total mites used	70%	80%	Total mites used
1	38	62	87	34	66	59	42	58	40	47	53	40
2	41	59	17	30	70	20	43	57	21	50	50	16

TABLE 28

THE LONGEVITY OF THE FEMALE *Otodectes cynotis* AT DIFFERENT TEMPERATURES AND HUMIDITIES

Temperature in °C.	Relative humidity	Number of mites individually tested	Length of life of mite in hours	
			Average	Range
32	100	15	24	12-48
32	87	15	40	12-71
32	80	15	57	6-95
27	100	15	6	1-12
27	90	15	36	12-57
27	80	15	94	24-165
27	70	15	86	12-112

TABLE 29

THE LONGEVITY OF THE MALE *Otodectes cynotis* AT DIFFERENT TEMPERATURES AND HUMIDITIES

Temperature in °C.	Relative humidity	Number of mites individually tested	Length of life of mite in hours	
			Average	Range
32	100	15	13	9-23
32	87	15	38	9-59
32	80	15	51	6-95
27	100	15	18	6-38
27	90	15	41	24-71
27	80	15	47	24-82
27	70	15	46	23-95

TABLE 30

THE LONGEVITY OF THE DEUTONYMPH Otodectes cynotis

AT DIFFERENT TEMPERATURES AND HUMIDITIES

Temperature in °C.	Relative humidity	Number of mites individually tested	Length of life of mite in hours	
			Average	Range
32	100	15	13	9-23
32	87	15	26	9-46
32	80	15	38	12-71
27	100	15	18	6-30
27	90	15	53	23-71
27	80	15	62	24-96
27	70	15	63	24-96

TABLE 31

THE LONGEVITY OF THE PROTONYMPH Otodectes cynotis

AT DIFFERENT TEMPERATURES AND HUMIDITIES

Temperature in °C.	Relative humidity	Number of mites individually tested	Length of life of mite in hours	
			Average	Range
32	100	15	6	4-12
32	87	15	8	4-24
32	80	15	8	4-24
27	100	15	12	4-28
27	90	15	14	6-32
27	80	15	24	12-36
27	70	15	38	24-71

TABLE 32

THE RESPONSE OF Otodectes cynotis TO LIGHT AREAS OF DIFFERENT WAVE LENGTHS AS COMPARED TO DARK AREAS

Period of elapsed time	Total number of mites counted	Number in light area			Number in dark area		
		adult	immature	per cent	adult	immature	per cent
No filter:							
30 min.	26	8	9	35	6	3	35
30 min.	32	6	7	41	14	5	59
30 min.	37	15	12	73	7	3	27
30 min.	37	15	17	87	3	2	13
1 hour	37	16	18	91	2	1	9
1 hour	37	17	19	97	1	0	3
1 hour	37	17	19	97	1	0	3
Green filter: (1)							
1 hour	28	15	11	93	1	1	7
1 hour	20	12	8	100	0	0	0
Purple filter: (2)							
1 hour	30	6	10	53	7	7	47
1 hour	32	6	7	60	5	4	40
1½ hour	32	12	9	88	3	1	12
Red filter: (3)							
1 hour	46	34	12	100	0	0	0
1 hour	46	34	12	100	0	0	0
1 hour	41	(5)	(5)	70	(5)	(5)	30

TABLE 32 (CONTINUED)

Period of elapsed time	Total number of mites counted	Number in light area			Number in dark area		
		adult	immature	per cent	adult	immature	per cent
Blue filter: (4)							
1 hour	82	42	36	95	3	1	5

(1) 4800 to 6200 A. units

(2) 3200 to 4700 and from 6500 to 7000 A. units

(3) 6100 to 7000 A. units

(4) 4300 to 5400 A. units

(5) No attempt was made to separate mature and immature mites

TABLE 33

A COMPARISON OF THE RESPONSE OF *Otodectes cynotis*

TO LIGHT AREAS OF DIFFERENT WAVE LENGTHS

Period of elapsed time	Total number of mites counted	Per cent of mites in area			
		white (1)	red (2)	green (3)	blue (4)
1 hour	80	27.5	18.7	21.2	32.8
1 hour	77	24.7	27.2	29.7	18.4
1 hour	315	27.6	21.9	24.4	26.1
1 hour	295	29.1	22.4	23.1	25.4

(1) No filter-tungsten bulb
(2) 6100 to 7000 A. units
(3) 4800 to 6200 A. units
(4) 4300 to 5400 A. units

TABLE 34

THE GEOTACTIC RESPONSE OF *Otodectes cynotis* PLACED IN GLASS TUBES AT A 90 DEGREE ANGLE

Interval elapsed	Inches up the glass tube												Total mites used
	1	2	3	4	5	6	7	8	9	10	11	12	
30 min.	2	1	1	2	3	2	3	2	4	3	5	8	36
1 hour	0	0	1	2	0	1	0	2	1	10	8	11	36
2 hour	0	0	0	0	0	0	0	3	1	5	8	19	36
6 hour	6	4	3	1	0	4	2	0	3	6	2	5	36

TABLE 35

THE INCIDENCE OF INFESTATION OF DOGS AND CATS WITH

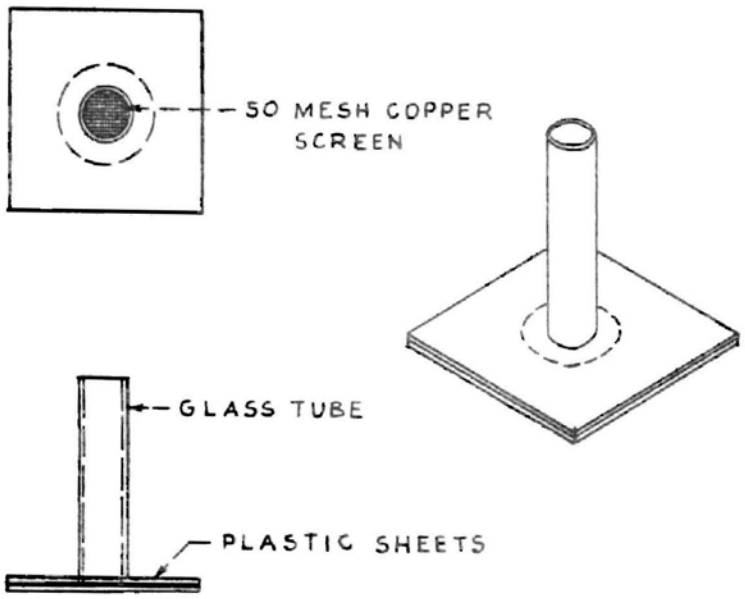
Otodectes cynotis

Location of host	Number of animals examined			Number of animals infested			Per cent of infestation		
	male	female	total	male	female	total	male	female	total
Dogs									
Stillwater									
Perkins									
Kennel									
1	9	4	13	8	3	11	89	75	85
2	9	17	26	5	12	17	56	70	65
3	5	1	6	5	1	6	100	100	100
4	13	9	22	3	3	6	23	34	27
5	6	10	16	6	9	15	100	90	94
6	6	6	12	6	6	12	100	100	100
7	8	6	14	8	6	14	100	100	100
8	7	5	12	6	4	10	86	80	83
Okla. City Kennel	40	48	88	14	15	29	35	32	33
Veterinary Clinic	11	9	20	1	1	2	9	11	10
TOTAL	114	115	229	62	60	122	54	52	53
Cats									
Stillwater									
Perkins	18	18	36	4	8	12	22	44	33

EXPLANATION OF PLATE 1

Egg collecting apparatus modified after Camin, 1950.

PLATE I



EXPLANATION OF PLATE 2

Figure A. *Otodectes cynotis*, dorsal view, to illustrate structural terms and relative position of the setae.

Figure B. *Otodectes cynotis*, ventral view, to illustrate structural terms and relative position of the setae.

PLATE 2

FIGURE A
(DORSAL)

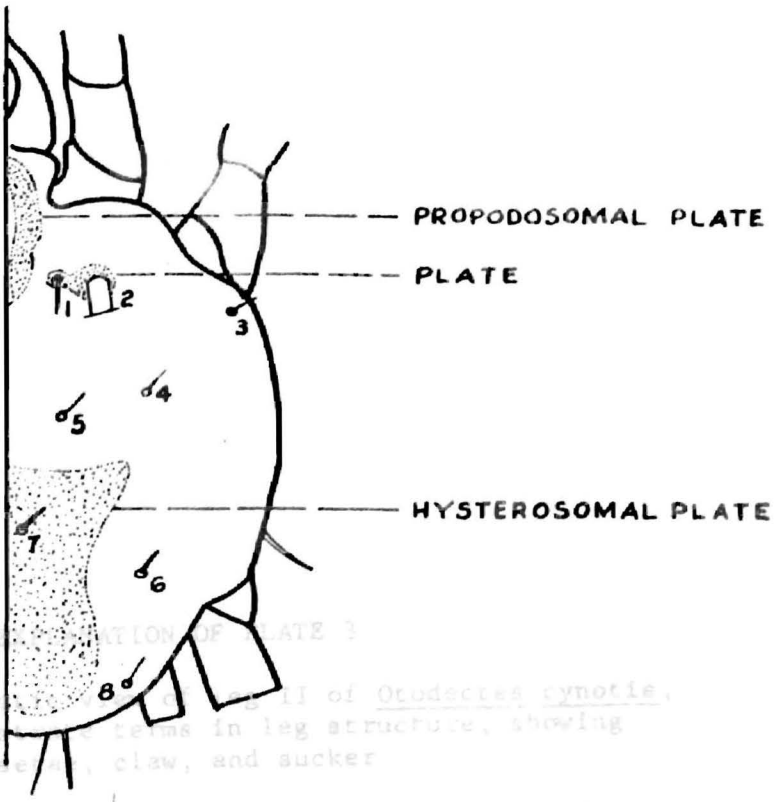
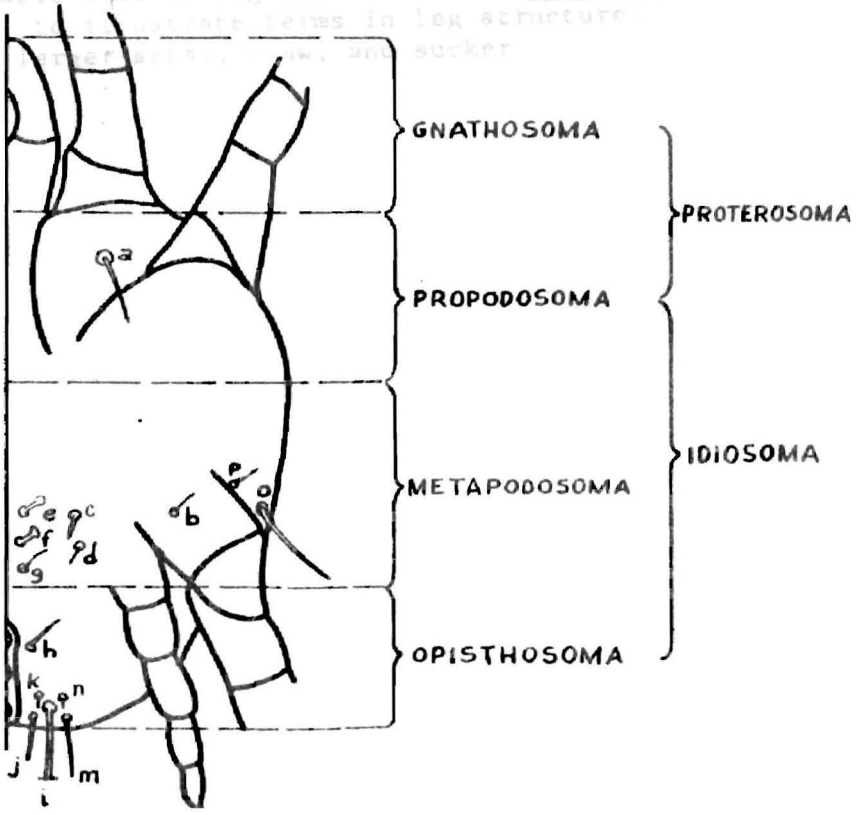


FIGURE B
(VENTRAL)



EXPLANATION OF PLATE 3

Figure A. Diagramatic view of leg II of *Otodectes cynotis*, to illustrate terms in leg structure, showing larger setae, claw, and sucker.

Figure B. Diagramatic view of leg III of male of *Otodectes cynotis*, to illustrate terms in leg structure, showing larger setae, claw, and sucker.

PLATE 3

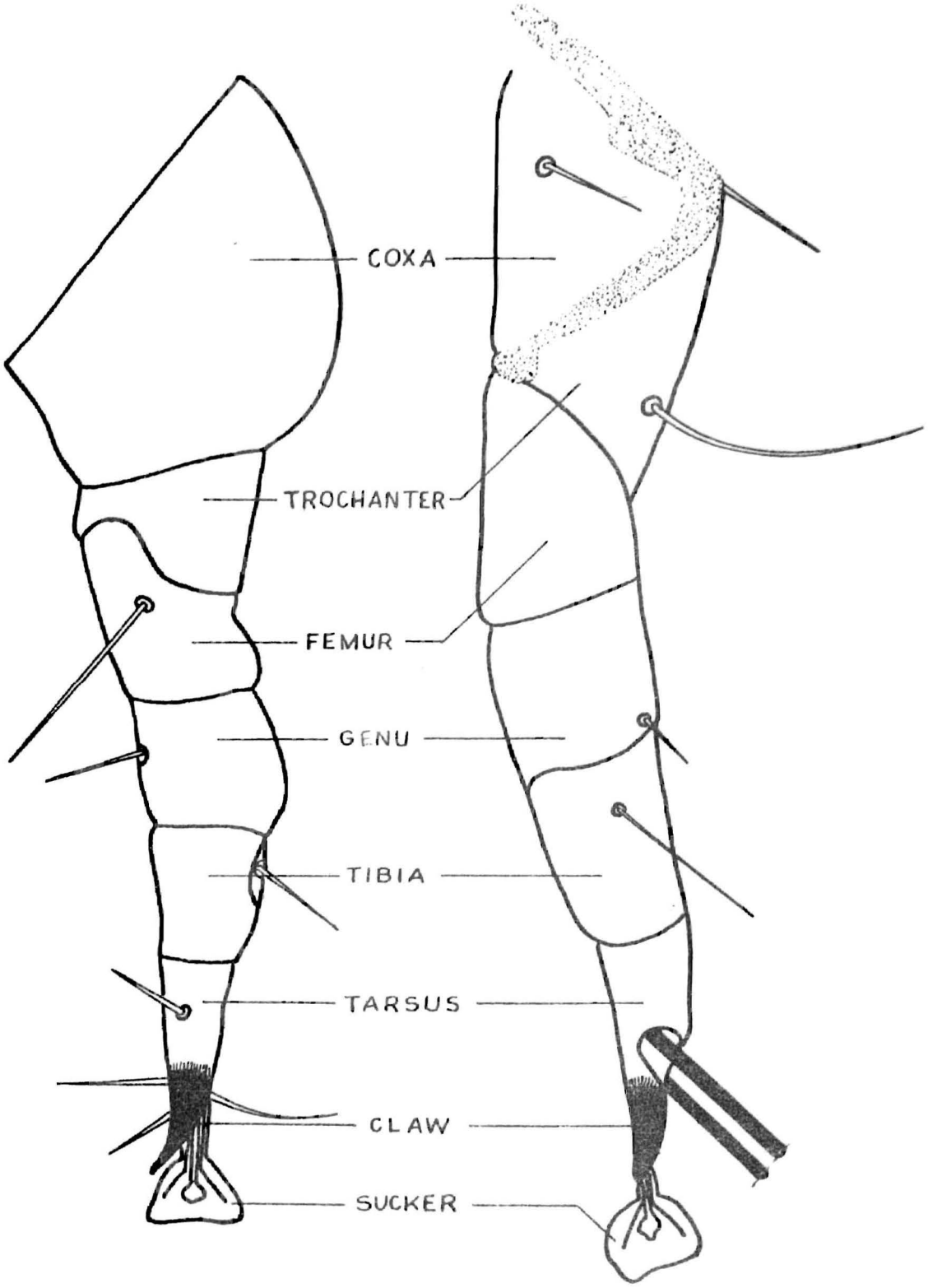
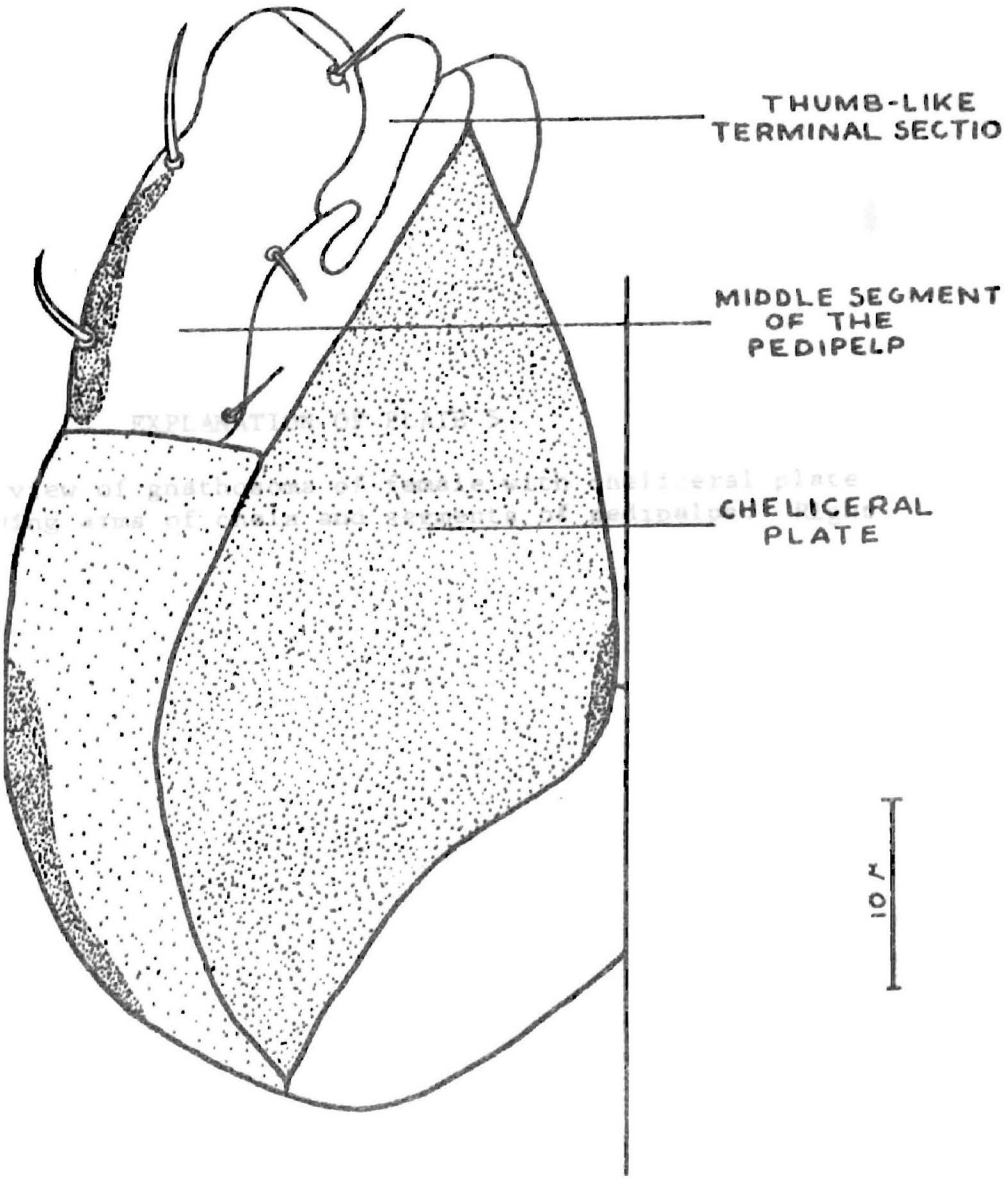


FIGURE A FIGURE B

EXPLANATION OF PLATE 4

Dorsal view of gnathosoma of female showing cheliceral plate and pedipalps. Right side only.

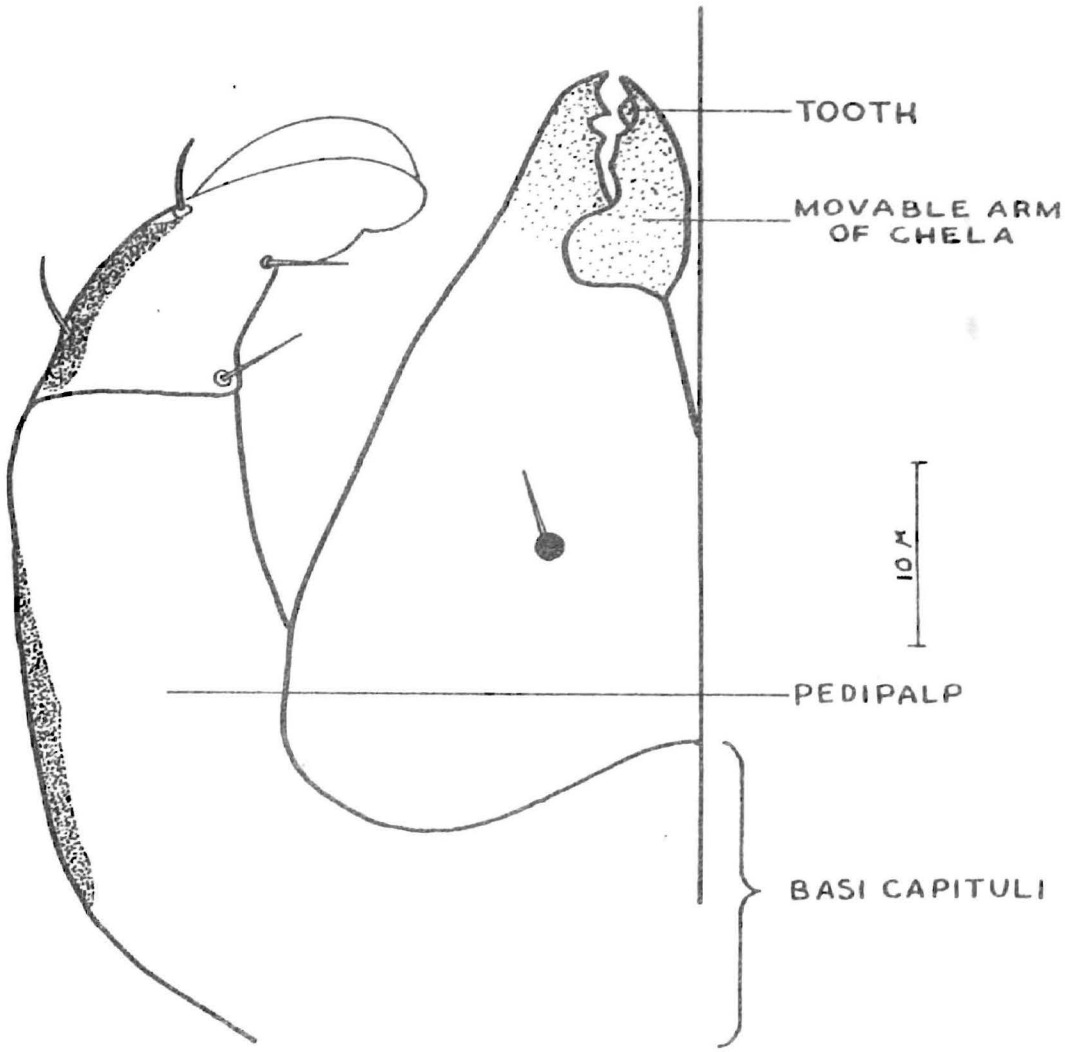
PLATE 4


THUMB-LIKE
TERMINAL SECTIO
MIDDLE SEGMENT
OF THE
PEDIPELP
CHELICERAL
PLATE
10 μ

EXPLANATION OF PLATE 5

Dorsolateral view of gnathosoma of female with cheliceral plate removed, showing arms of chela and segments of pedipalps. Right side only.

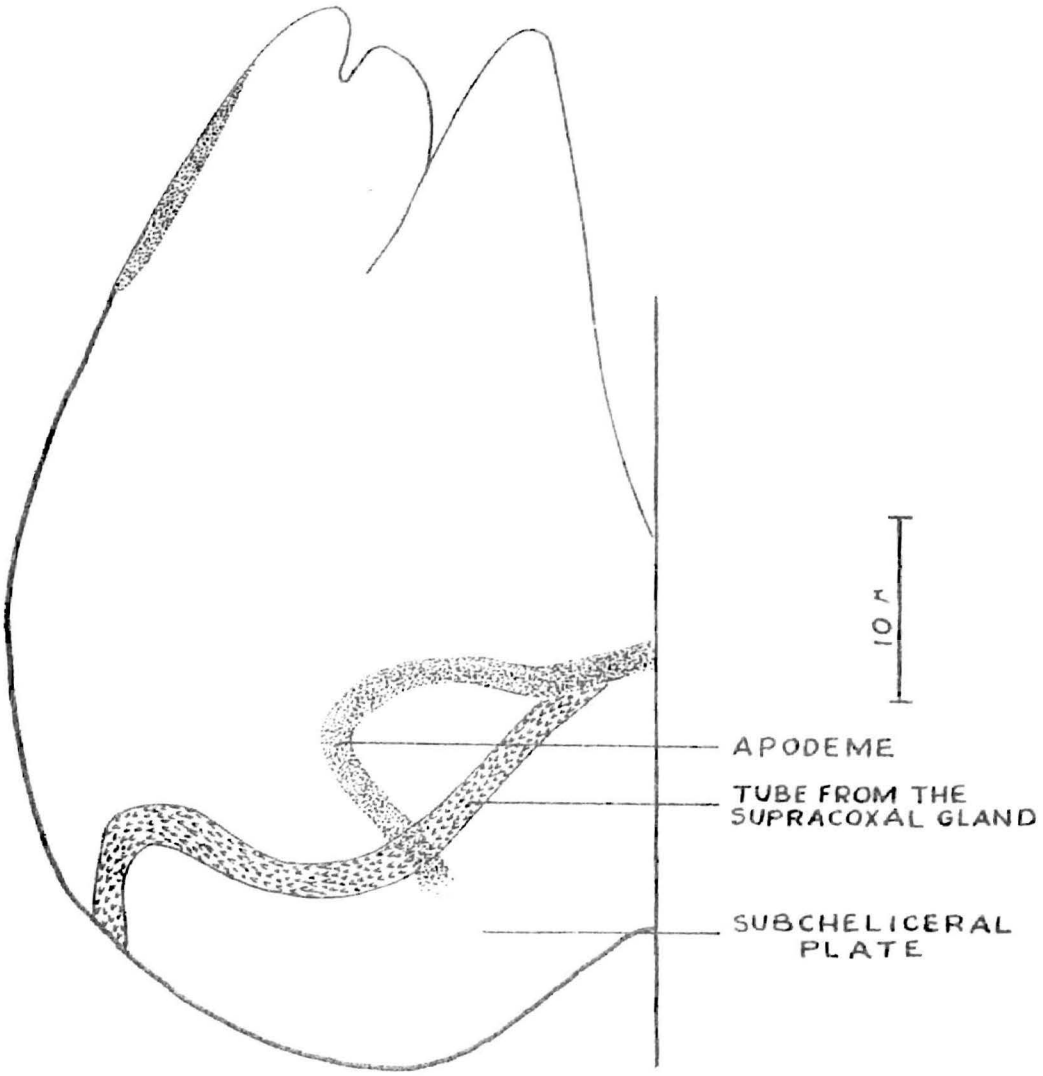
PLATE 5



EXPLANATION OF PLATE 6

Sub-dorsal view of gnathosoma of female with cheliceral plate removed, showing apodeme in phayngeal area and trachea-like tube from the supracoxal gland. Right side only.

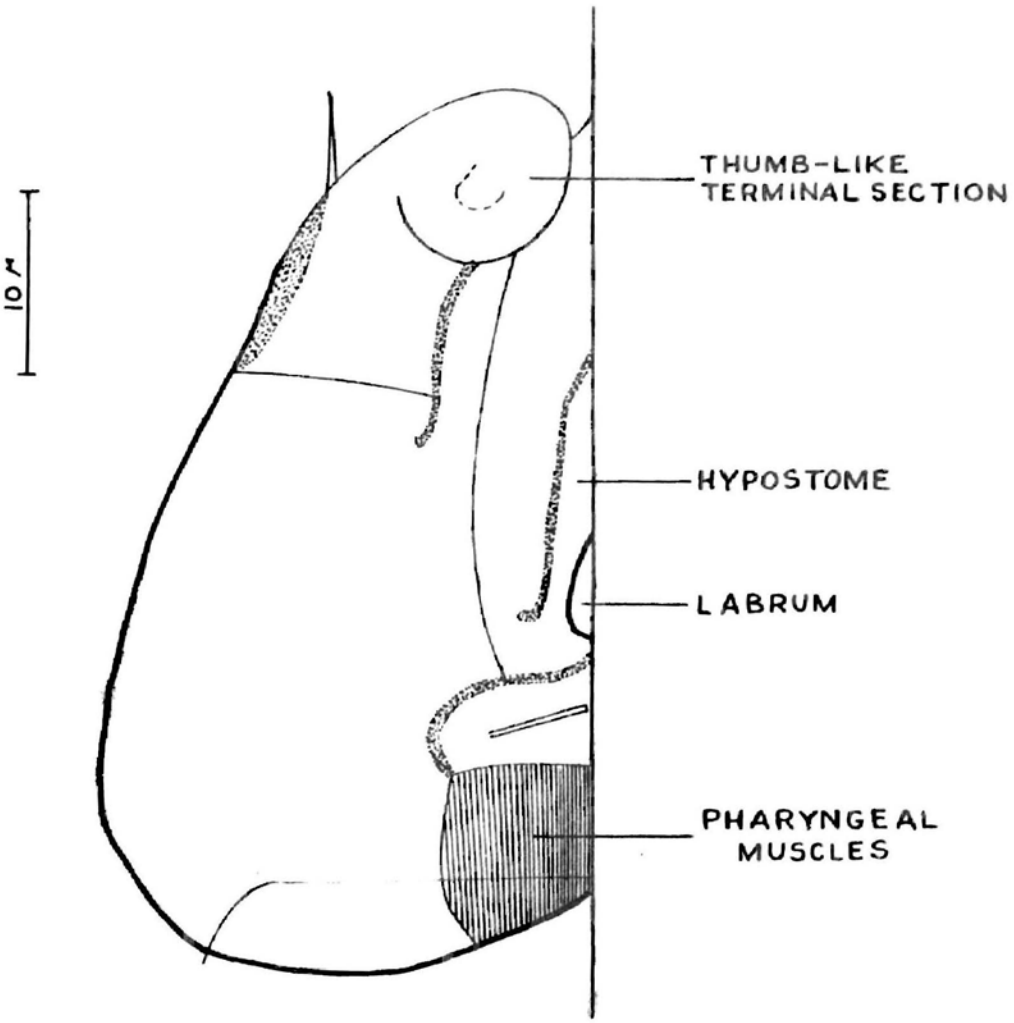
PLATE 6


10 μ
APODEME
TUBE FROM THE SUPRACOXAL GLAND
SUBCHELICERAL PLATE

EXPLANATION OF PLATE 6A

Ventral view of gnathosoma of female, showing pharyngeal muscles, labrum, and hypostoma. Right side only.

PLATE 6A


10 μ
THUMB-LIKE TERMINAL SECTION
HYPOSTOME
LABRUM
PHARYNGEAL MUSCLES

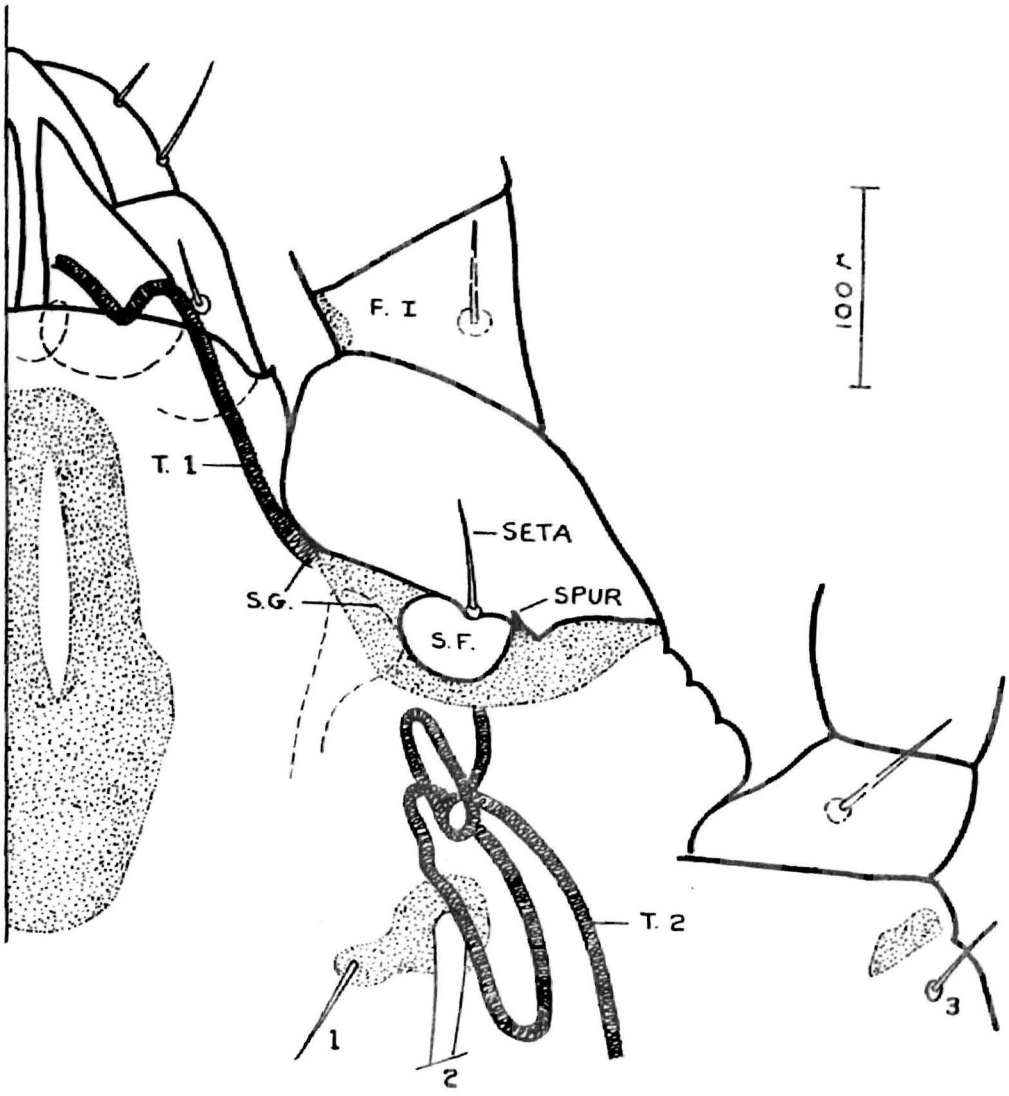
EXPLANATION OF PLATE 7

Dorsal view of proterosomal region of *Otodectes cynotis* showing supracoxal gland.

Abbreviations are as follows:

F.I.	Femur I.
S.F.	Supracoxal fossa.
S.G.	Supracoxal gland.
T. 1	Tube leading from supracoxal gland to gnathosoma.
T. 2	Tube leading from supracoxal gland to near the anus.
1	Seta 1.
2	Seta 2.
3	Seta 3.

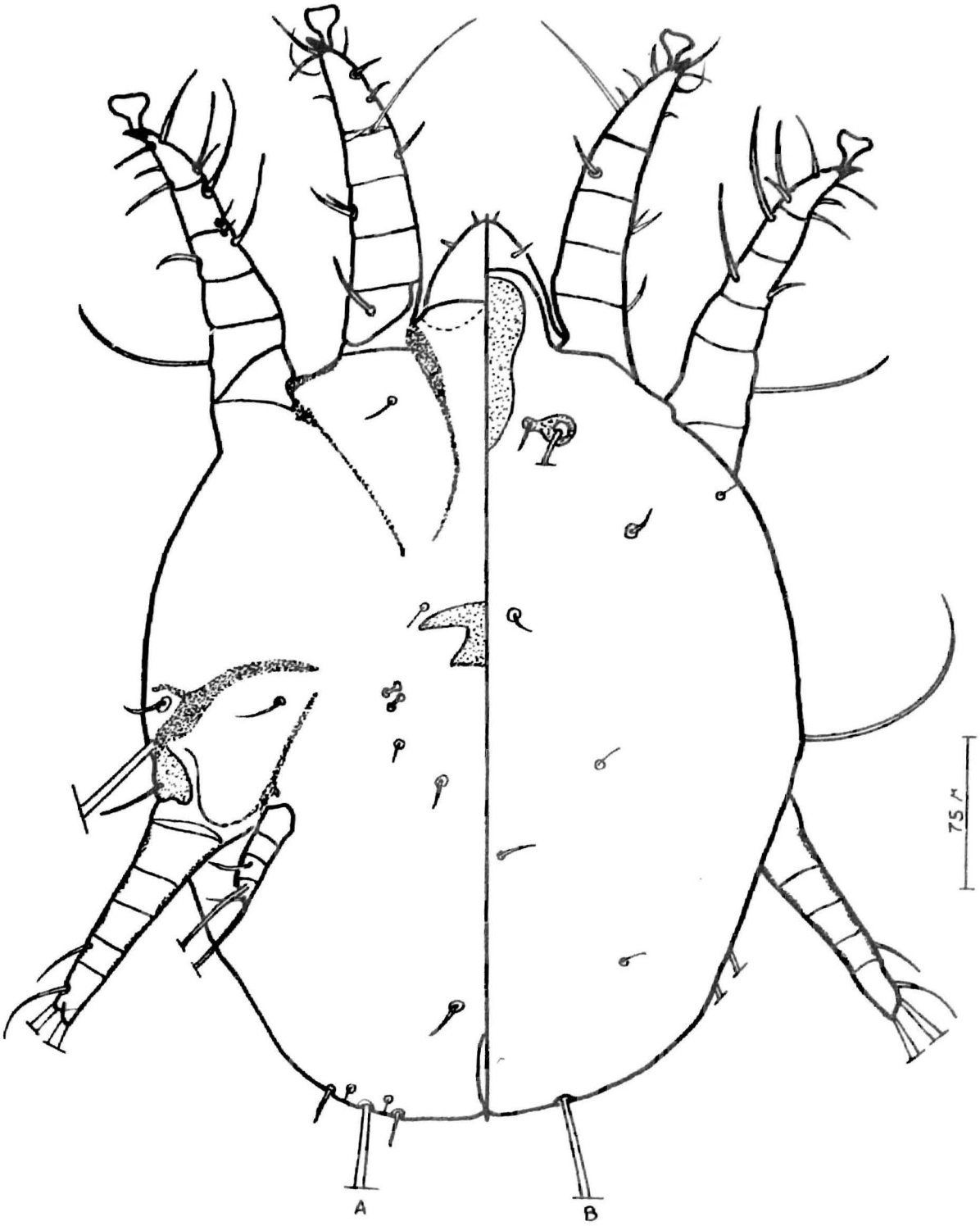
PLATE 7



EXPLANATION OF PLATE 8

Female of Otodectes cynotis: A. venter of female showing setae and plates; B. dorsum of male showing setae and plates.

PLATE 8



EXPLANATION OF PLATE 9

Tarsi of the female of *Otodectes cynotis* showing size and position of setae and terminal structures.

Figure A. Tarsus I

Figure B. Tarsus II

PLATE 9

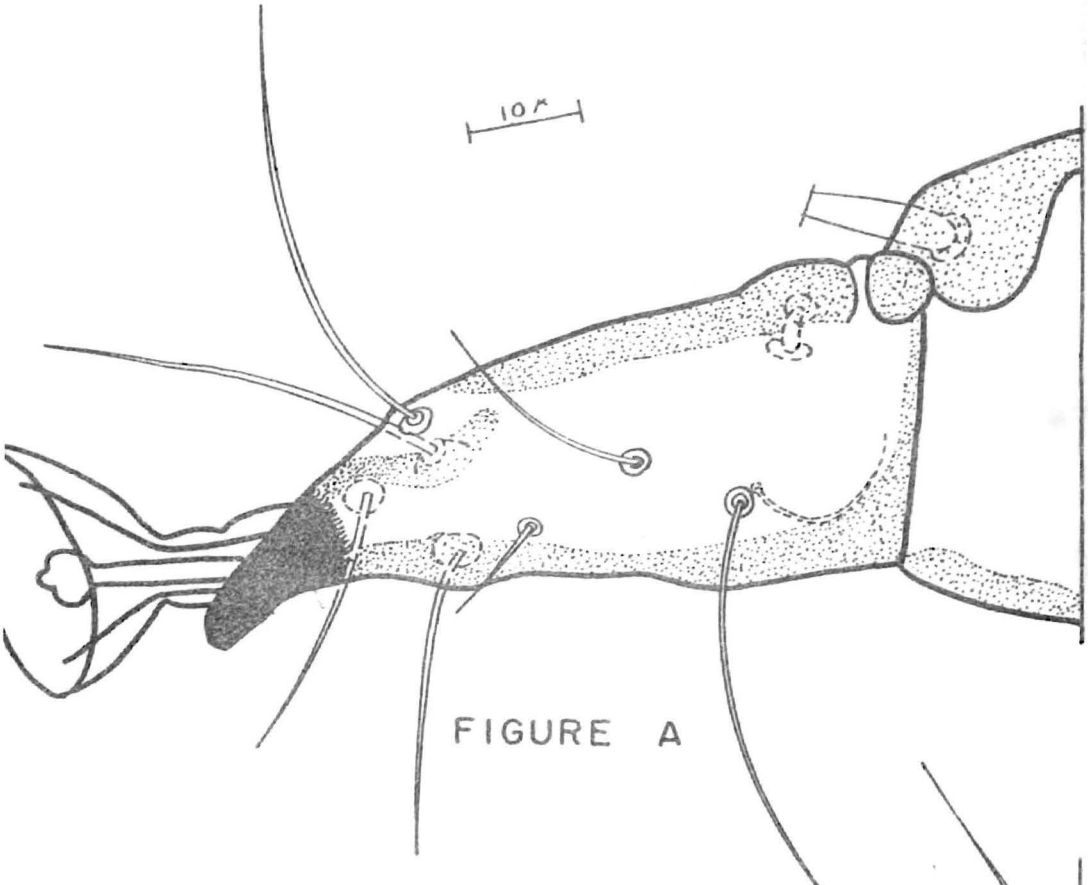


FIGURE A

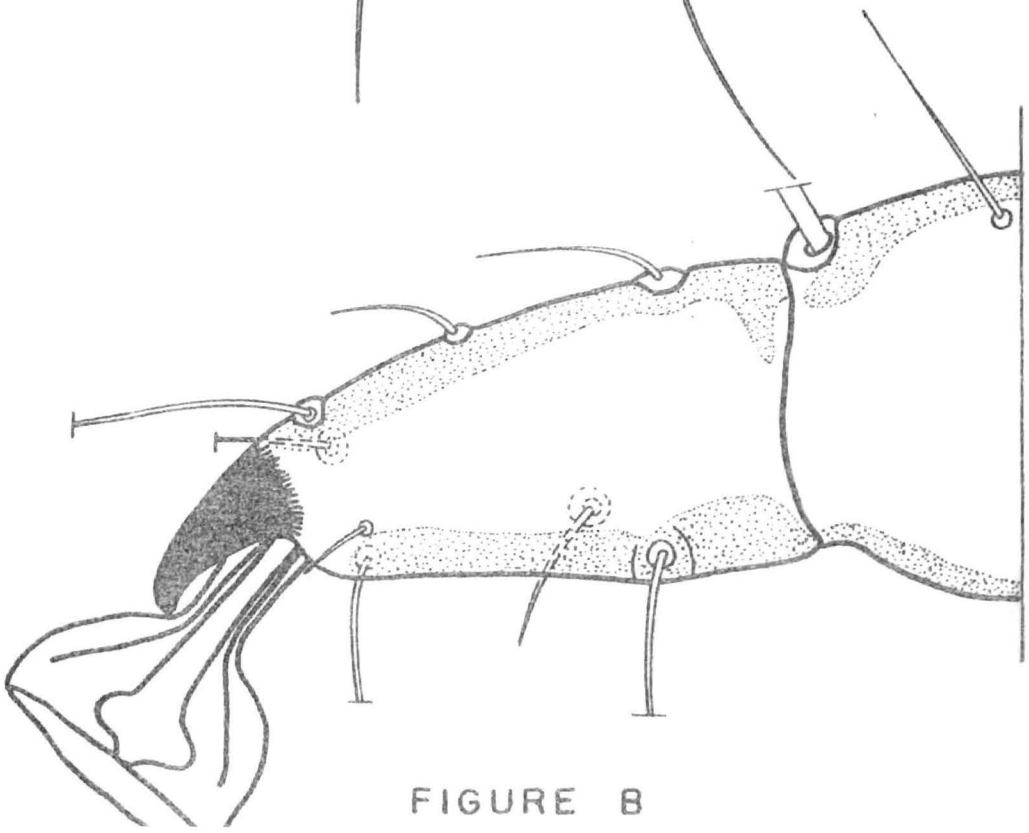


FIGURE B

EXPLANATION OF PLATE 10

Tarsi of the female of Otodectes cynotis showing size and position of setae and terminal structures.

Figure A. Tarsus III

Figure B. Tarsus IV

PLATE 10

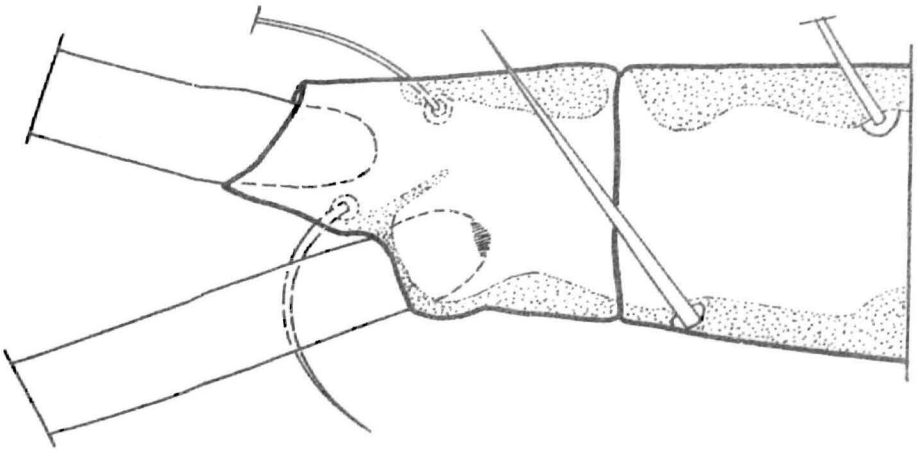


FIGURE A

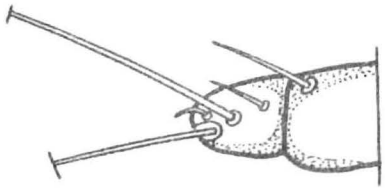
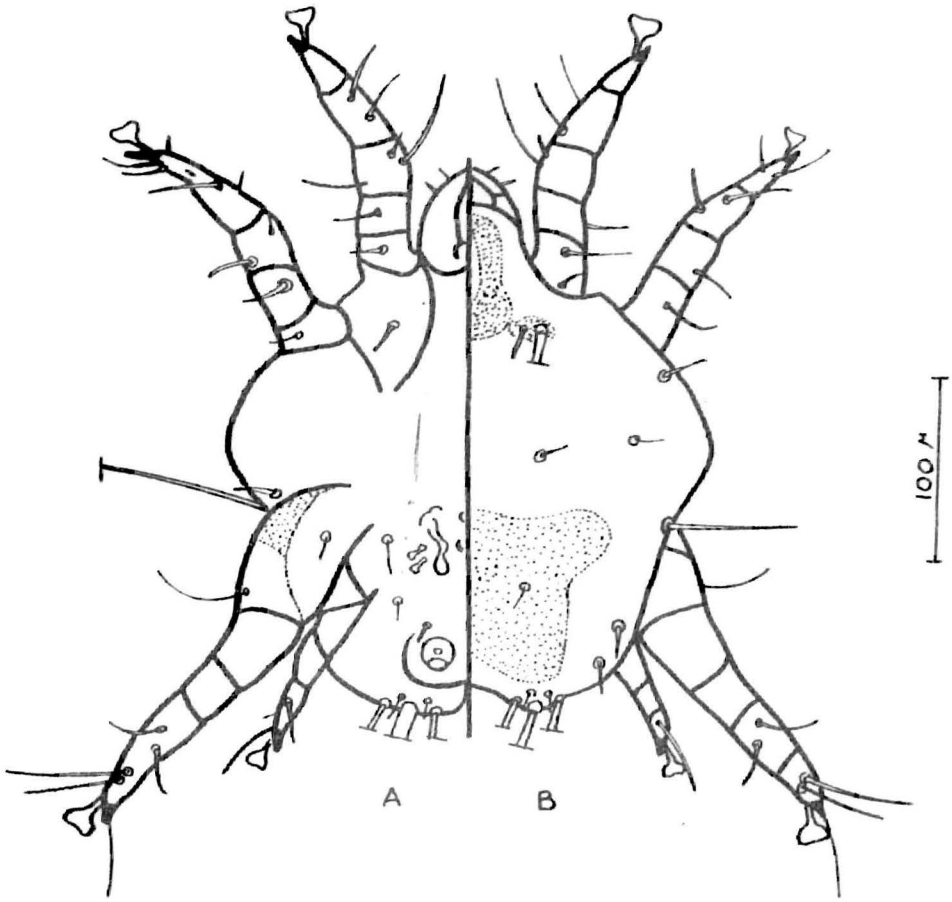


FIGURE B

EXPLANATION OF PLATE 11

Male of *Otodectes cynotis*: A. venter of male showing setae and plates; B. dorsum of male showing setae and plates.

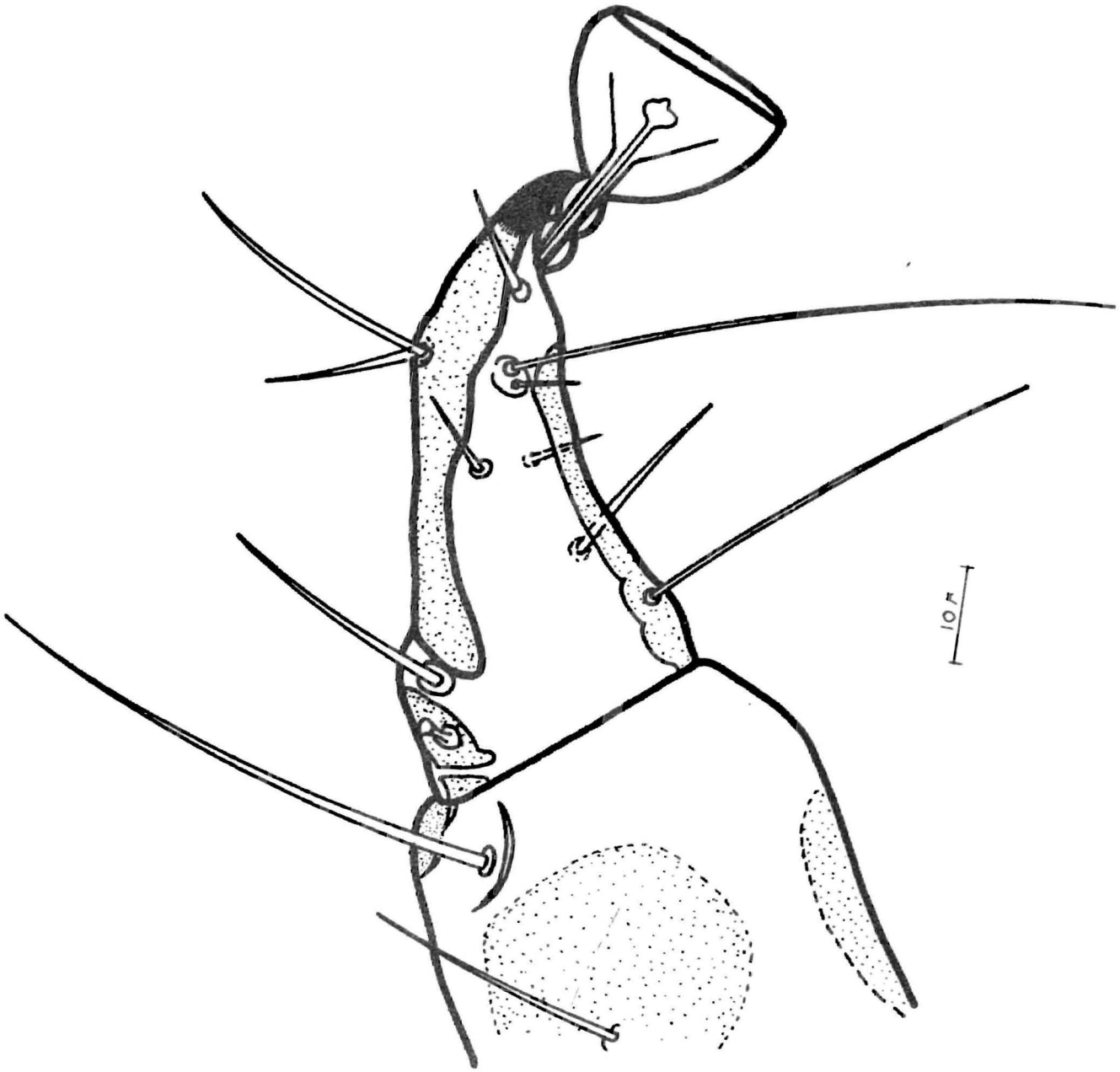
PLATE II



EXPLANATION OF PLATE 12

Tarsus I of the male of Otodectes cynotis showing size and position of the setae and terminal structures.

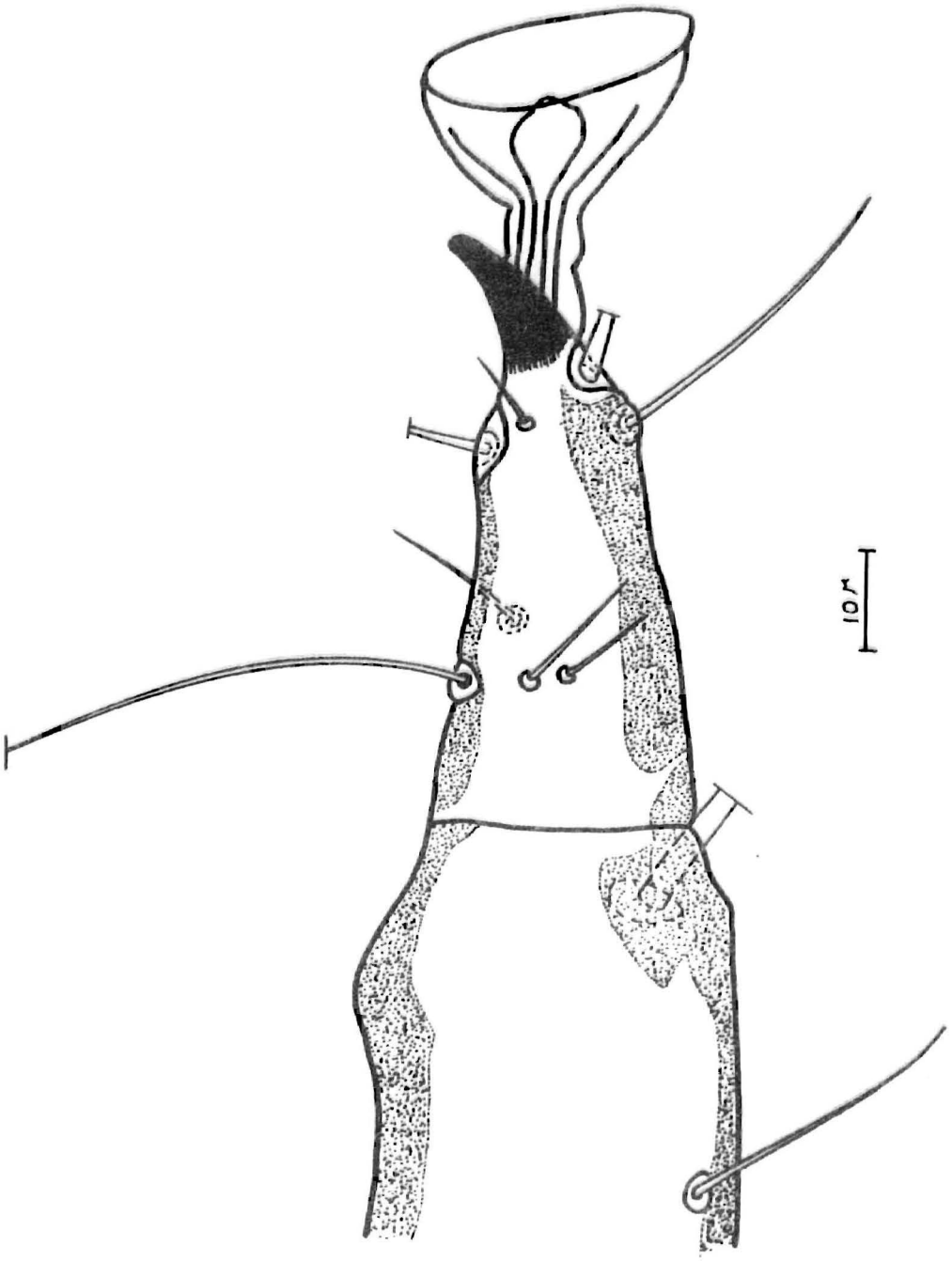
PLATE 12



EXPLANATION OF PLATE 13

Tarsus II of the male of *Otodectes cynotis* showing size and position of the setae and terminal structures.

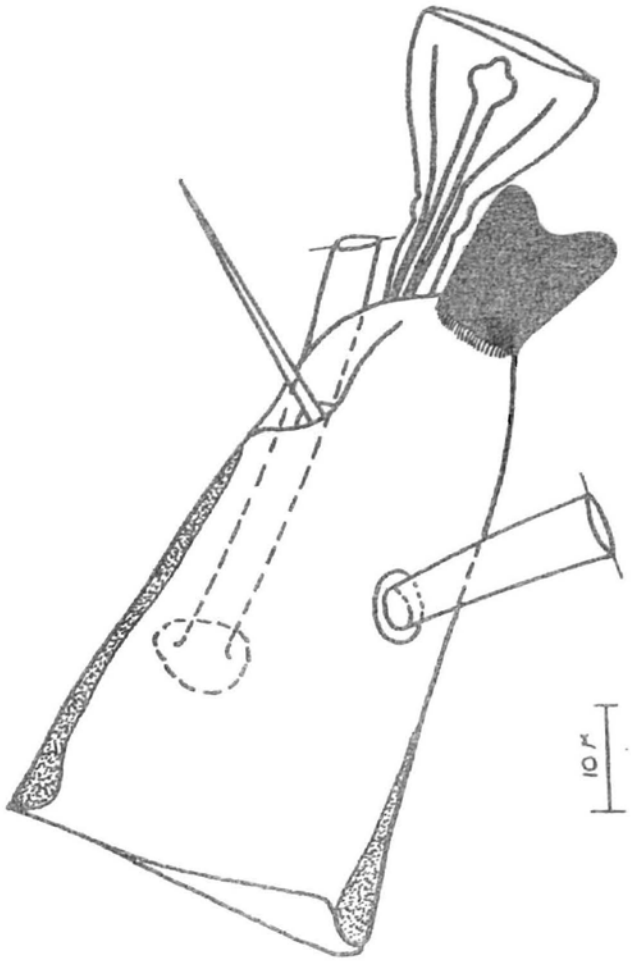
PLATE 13



EXPLANATION OF PLATE 14

Tarsus III of the male of *Otodectes cynotis* showing size and position of the setae and terminal structures. Note the shape of the claw.

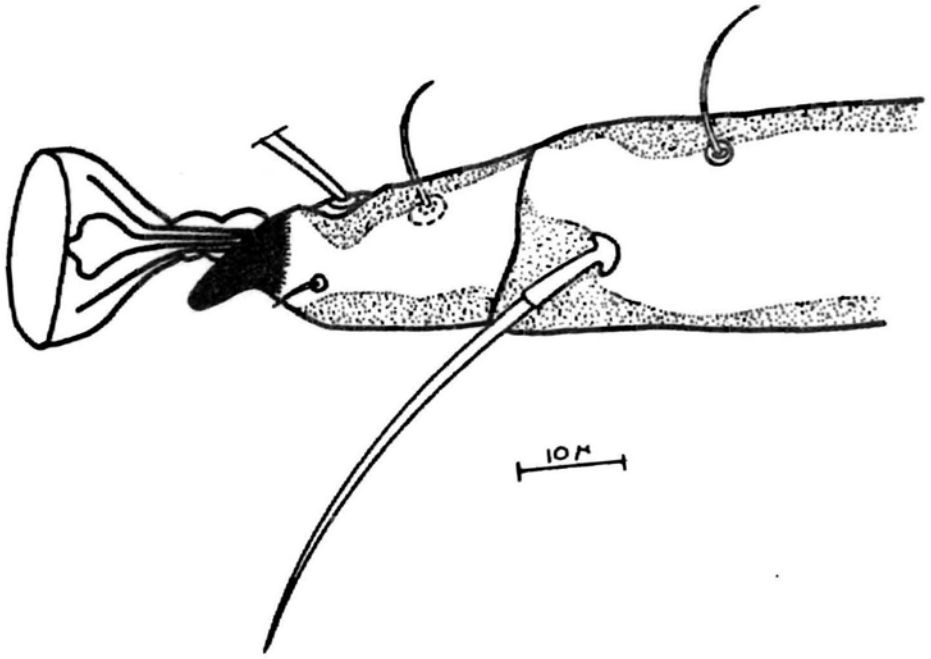
PLATE 14



EXPLANATION OF PLATE 15

Tarsus IV of the male of *Otodectes cynotis* showing size and position of setae and terminal structures.

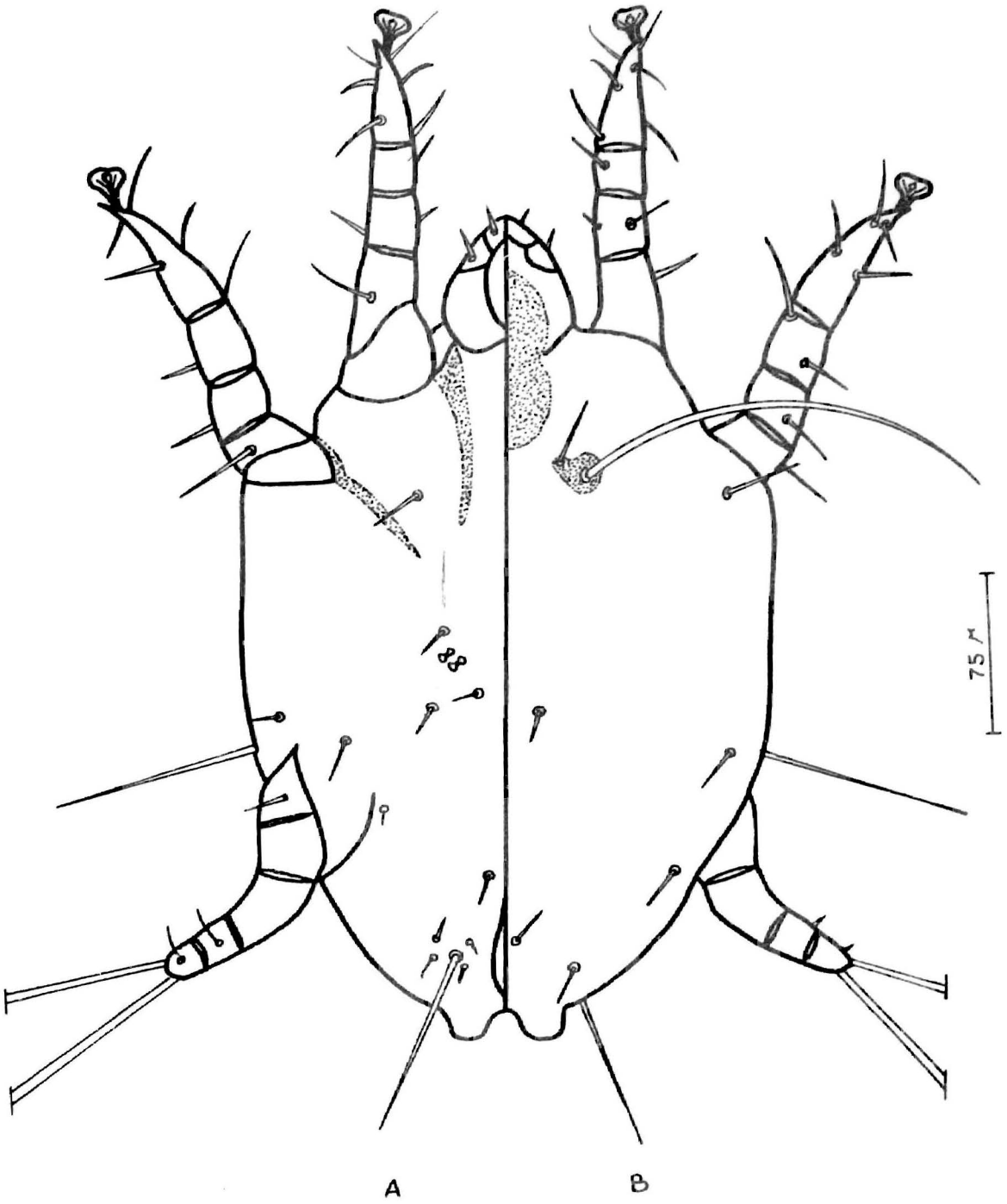
PLATE 15



EXPLANATION OF PLATE 16

Deutonymph of *Otodectes cynotis*: A. venter of deutonymph showing setae and plates; B. dorsum of deutonymph showing setae and plates.

PLATE 16



EXPLANATION OF PLATE 17

Tarsi of the deutonymph of *Otodectes cynotis* showing size and position of setae and terminal structures.

Figure A. Tarsus I

Figure B. Tarsus II

Figure C. Tarsus III

PLATE 17

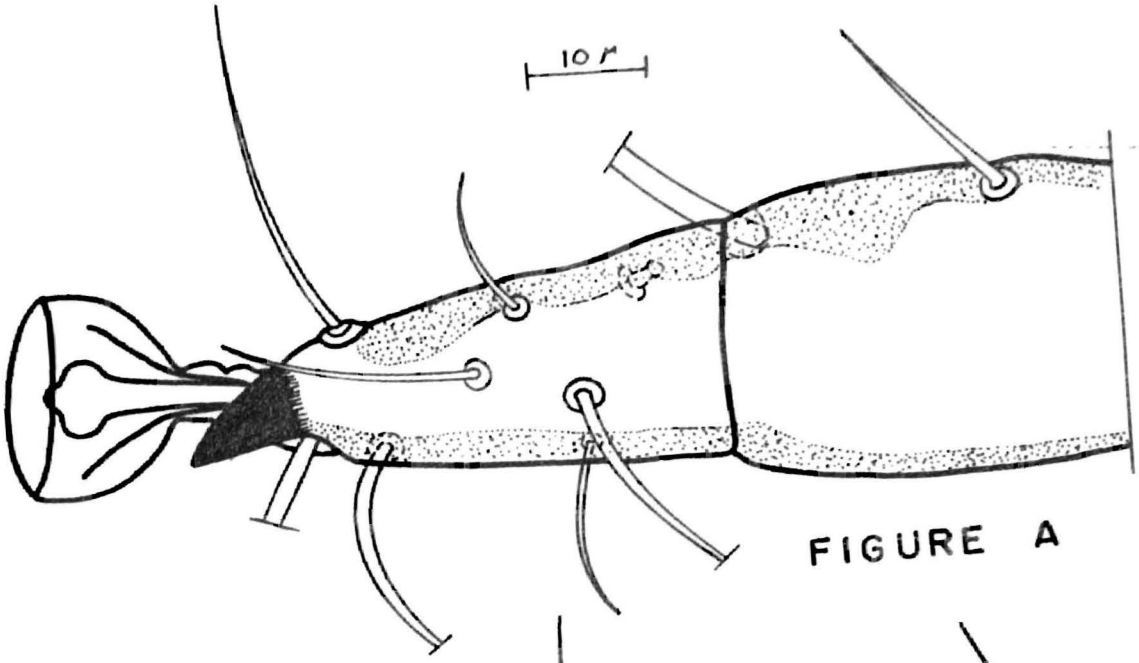


FIGURE A

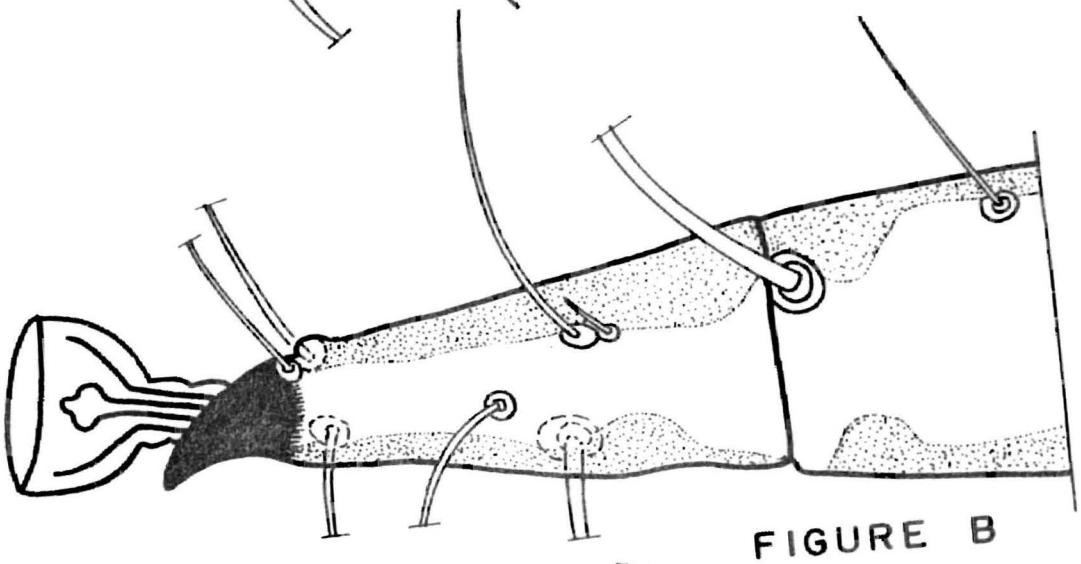


FIGURE B

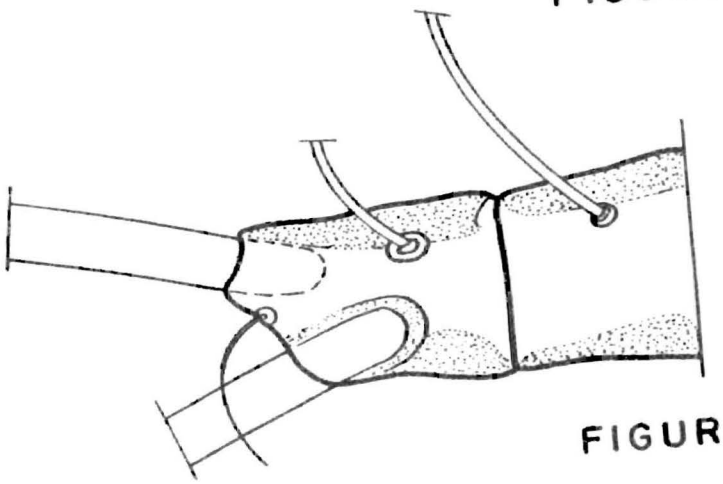
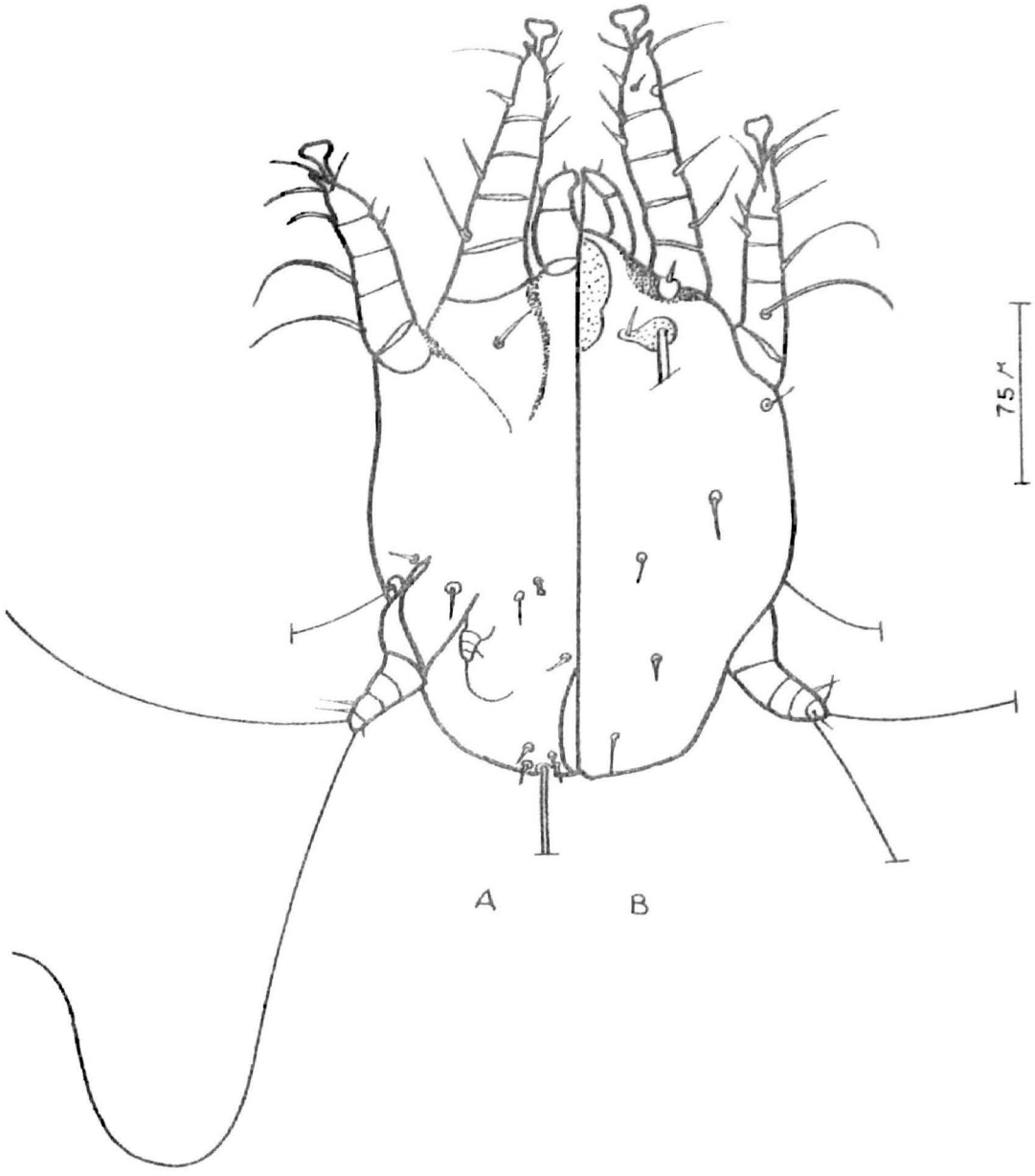


FIGURE C

EXPLANATION OF PLATE 18

Protonymph of *Otodectes cynotis*: A. venter of protonymph showing setae and plates; B. dorsum of protonymph showing setae and plates.

PLATE 18



EXPLANATION OF PLATE 19

Tarsi of the protonymph of *Otodectes cynotis* showing size and position of setae and terminal structures.

Figure A. Tarsus I

Figure B. Tarsus II

Figure C. Tarsus III

Figure D. Tarsus IV

PLATE 19

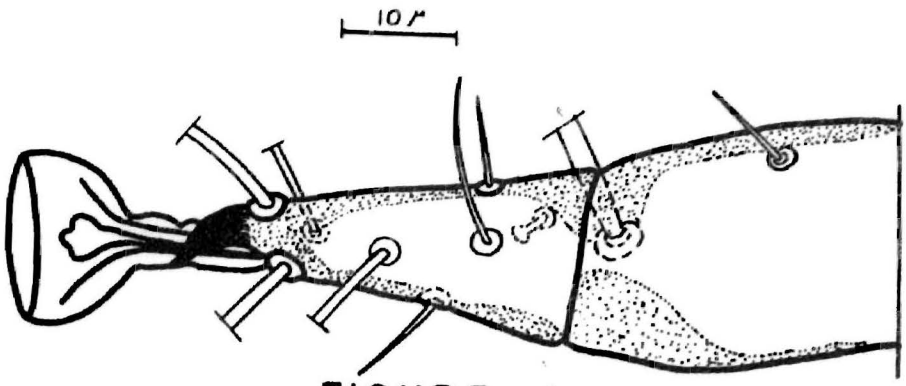


FIGURE A

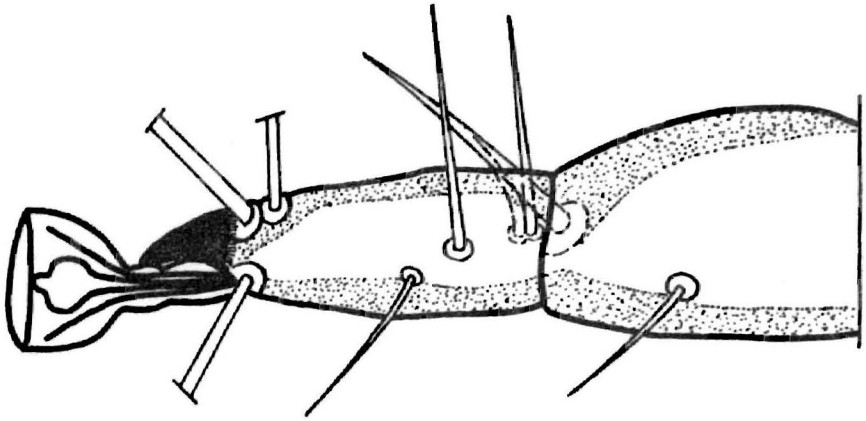


FIGURE B

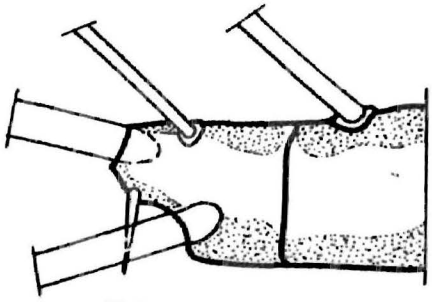


FIGURE C

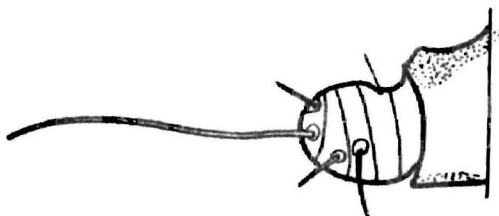
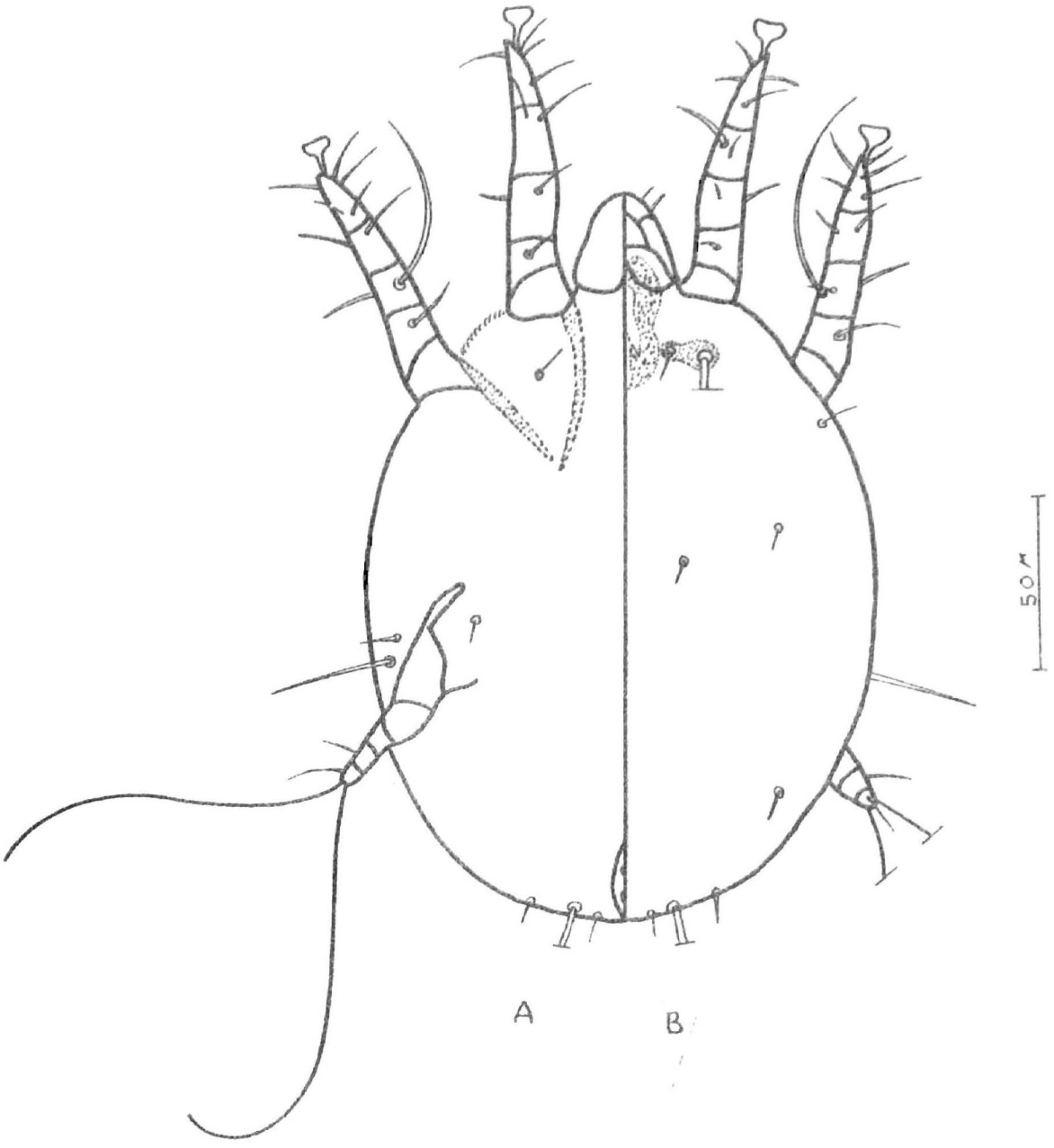


FIGURE D

EXPLANATION OF PLATE 20

Larva of *Otodectes cynotis*: A. venter of larva showing setae and plates; B. dorsum of larva showing setae and plates.

PLATE 20



EXPLANATION OF PLATE 21

Tarsi of the larva of *Otodectes cynotis* showing size and position of setae and terminal structures.

Figure A. Tarsus I

Figure B. Tarsus II

Figure C. Tarsus III

PLATE 21

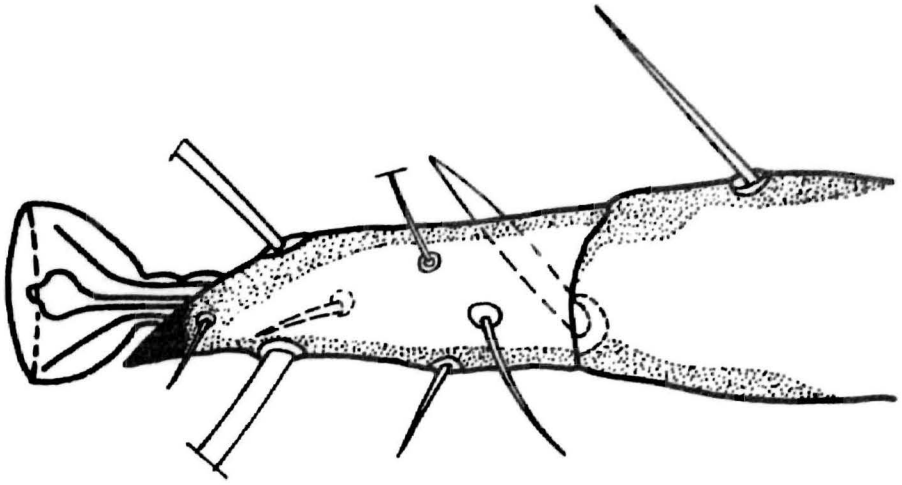


FIGURE A

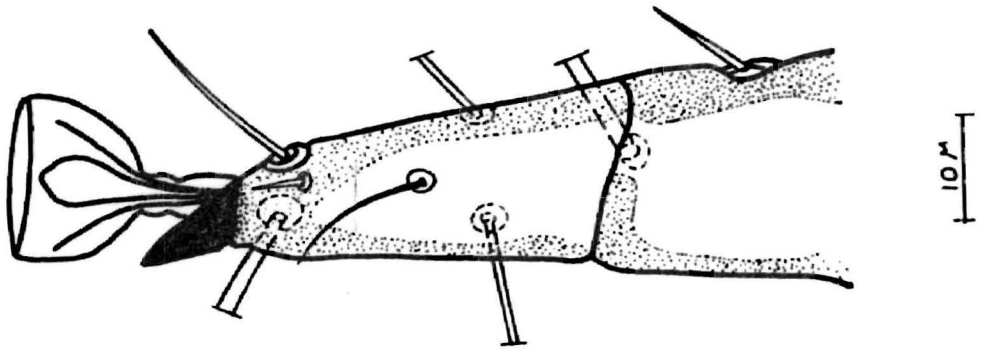


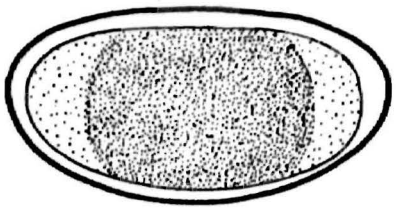
FIGURE B

FIGURE C

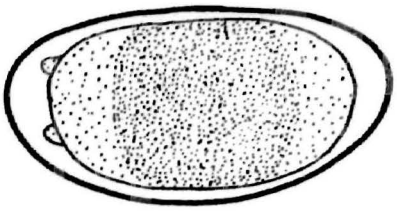
EXPLANATION OF PLATE 22

The embryonic development of Otodectes cynotis showing the general pattern of development of the major gross anatomical structures.

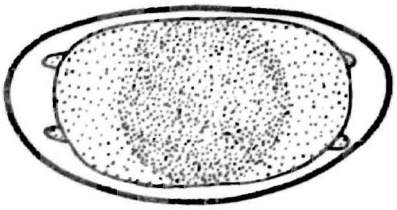
PLATE 22



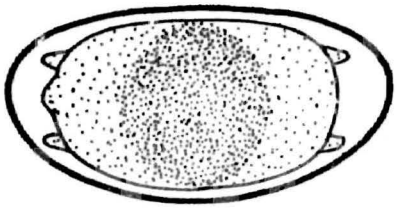
16 HOURS



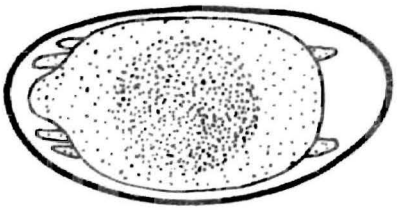
18 HOURS



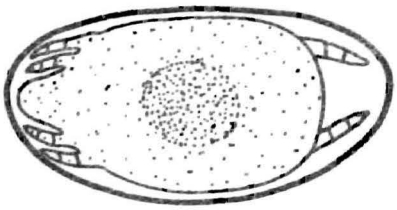
22 HOURS



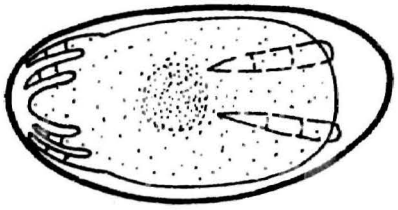
28 HOURS



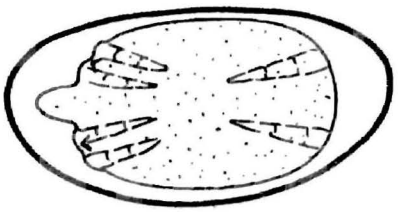
34 HOURS



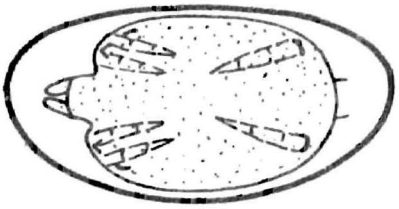
38 HOURS



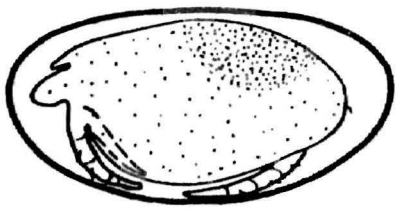
42 HOURS



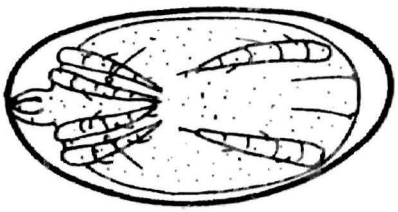
48 HOURS



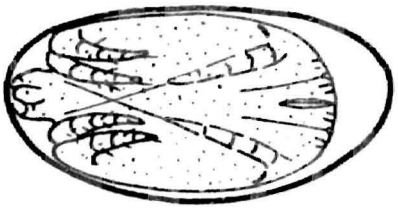
54 HOURS



60 HOURS
(SIDE VIEW)



64 HOURS

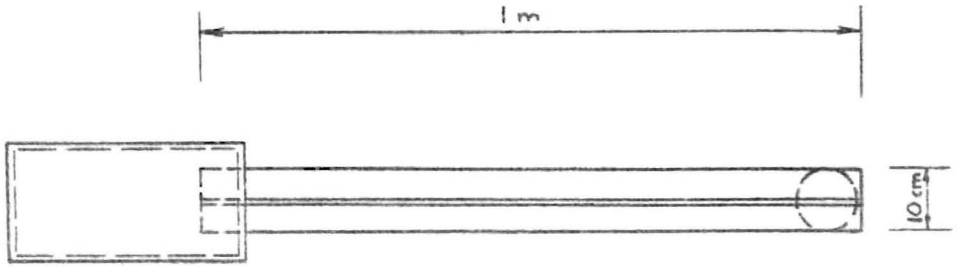


70-76 HOURS

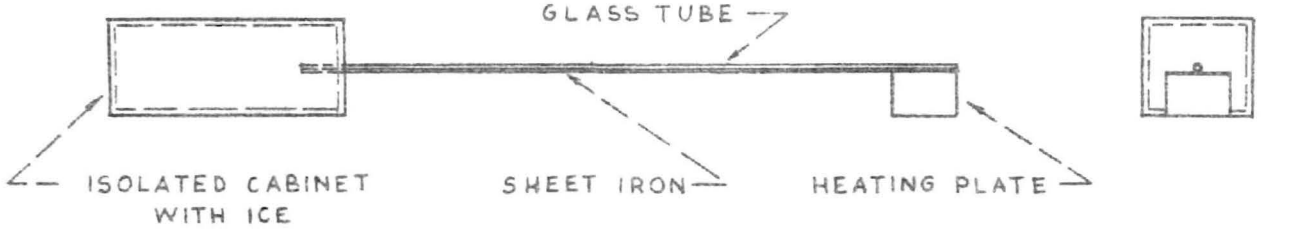
EXPLANATION OF PLATE 23

Temperature Gradient Apparatus

PLATE 23



TOP VIEW



SIDE VIEW

END VIEW

VITA

Robert James Tonn

Candidate for the Degree of

Doctor of Philosophy

Thesis: MORPHOLOGICAL AND EXPERIMENTAL STUDIES ON Otodectes cynotis (Hering, 1838)

Major Fields: Veterinary Parasitology and Entomology

Biographical Sketch:

Personal data: Born in Watertown, Wisconsin, June 23, 1927, the son of Harry J. and Elisa F. Tonn

Education: Graduated from Hillsboro High School, Hillsboro, North Dakota in 1945; attended North Dakota State College, Fargo, North Dakota from 1945 to 1946; received the Bachelor of Science Degree from Colorado State University, Fort Collins, Colorado with a major in Zoology, in 1949; received the Master of Science degree from Colorado State University, Fort Collins, Colorado with a major in Zoology, in 1950; completed the requirements for the Doctor of Philosophy degree in May, 1959.

Professional experience: Laboratory assistant in the Department of Zoology at Colorado State University from 1948 to 1950; Laboratory assistant in the Department of Biology at the University of Georgia in 1950; Instructor in the Department of Biology, St. Olaf College, Northfield, Minnesota from 1953 to 1954; Instructor in the Department of Biology, Fresno State College, Fresno, California from 1954 to 1955; Laboratory assistant in the Department of Entomology at Oklahoma State University, Stillwater, Oklahoma from 1955 to 1956; Assistant Professor of Biology, Texas Lutheran College, Seguin, Texas from 1956 to 1958; Graduate Assistant in the Department of Preventive Medicine and Public Health, Oklahoma School of Medicine, Oklahoma City, Oklahoma from 1958 to present.

Honorary and Professional Societies: Tri Beta; Phi Sigma; Sigma Xi; American Society of Parasitologists; Entomological Society of America and Iowa Academy of Science.