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A taxonomic study of fleas of the genus Foxella (Wagner) in Utah (Siphonaptera: Dolichopsyllidae)

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A TAXONOMIC STUDY OF FLEAS OF THE GENUS FOXELLA (WAGNER) IN UTAH (SIPHONAPTERA: DOLICHOPSYLLIDAE)

A Thesis

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by

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This thesis by Robert L. Amoureux is accepted in its present form by the Department of Zoology and Entomology as satisfying the thesis requirement for the degree of Master of Science.

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INTRODUCTION

Fleas of the genus Foxella Wagner, commonly known as "gopher fleas," have various species of the mammal genus Thomomys Weid Neuweid in the Western United States as their hosts. Some workers maintain there are at least two species of fleas while others consider that all gopher fleas are of one species.

The most recent significant publication on fleas related to the present problem was by Stark (1958). He contends there is only one species, Foxella ignota which Baker named in 1895. According to Stark this species is cosmopolitan, with a distribution extending throughout the western part of the United States and parts of western Canada. The principal exponent of the two species concept is Hubbard (1947). In 1947 he recognized the validity of F. ignota but described a new species, utahensis.

In order to assist in the classification of the one species-two species status the present study was undertaken. The general approach in an attempt to resolve the problem was as follows:

1. To comparatively analyze each specimen by use of

original descriptions and illustrations.

2. To check all specimens against the keys devised by Hubbard in establishing the two species concept.

3. To comparatively analyze each specimen in light of present day concepts on flea taxonomy and morphology.

It was felt that the zoogeographic expanse of gopher distribution in Utah, plus systematically scheduled seasonal collections of these hosts would provide a good series of gopher fleas by which a comparative examination could be made. With these data, comparative estimates could be extended to other parts of the western United States in determining the specific status of gopher fleas. At least it would provide clues to the taxonomic resolution of the Utah problem.

A total of 777 specimens were available for this study. Three hundred and eight of these were collected by the writer. Other specimens were provided by several institutions and from private collections.

REVIEW OF LITERATURE

The species Foxella ignota was first described by Baker (1895), as ignotus and was included in the genus Pulex. In 1904, while studying Nearctic species of fleas, Baker removed ignotus from the genus Pulex and placed it in the genus Ceratophyllus. Wagner (1929), studying specimens of gopher fleas from the United States, raised a new genus to include the species ignotus. He named the genus Foxella in honor of Irving Fox, one of the early workers in Siphonaptera in the United States. In 1895 Baker also established another genus and species of gopher flea, Typhlopsylla americana. These fleas were later placed in synonymy by Jordan (1929), who considered Typhlopsylla equivalent to Foxella and recognized americana as a subspecies of ignota.

In 1943 Ewing and Fox placed ignota in the genus Dactylopsylla. In 1943 Hubbard published a paper on the subspecies of ignota but this time listed them under Dactylopsylla. Still later in 1943, Jellison and Kohls listed ignota but retained it with the genus Foxella. In 1936 Wagner examined a number of fleas taken from rodents in the western United States. In the collection of fleas taken from gophers

in Utah, he named a subspecies of ignota. These fleas were collected in Wellsville, in northern Utah, and were described as Foxella ignota utahensis. In 1945 Gates listed Foxella as a subgenus of Dactylopsylla. Hubbard (1947) returned to the use of Foxella as the genus, but gave specific status to the subspecies of F. i. utahensis, naming it F. utahensis. Stark (1958) listed Foxella as a subgenus of Dactylopsylla with only one species, ignota.

Other workers, who have listed fleas from Utah, recognize Foxella. Among these workers are Stanford (1931), Allred (1952), and Beck (1955). However, Augustson and Durham (1961) listed ignota in the genus Dactylopsylla, and noted one subspecies collected on gophers from northern Arizona, near the Utah border.

METHODS AND PROCEDURES

Field methods.--A systematic schedule of trapping gophers was planned, in order to provide specimens which would represent any seasonal, morphological and anatomical variations in flea populations.

Gophers were trapped from three separate geographic areas. The areas chosen were: (1) the sand dunes area at the Arizona-Utah border four miles southeast of the town of Kanab, Kane County, Utah; (2) Hobble Creek Canyon, six miles east of Springville, Utah County, Utah; and (3) the foothills area east of Hyrum, Cache County, Utah. The Kanab area was collected the first weekend, the Springville area the second weekend, and the Hyrum area the third weekend of each month, from October 1960 through May 1961.

Gopher runs were opened where fresh deposits of earth were found, and a trap was installed. The traps used were the wire ring trap and the California box trap, the latter being the better. The traps were checked every two hours for a period of eight hours from time of setting, after which time they were removed and placed in a new location if no gophers were obtained.

Trapped gophers were removed from the traps and placed in paper bags. The soil beneath the trapped gophers was examined for fleas that might have left the host following capture. The bags were labeled with date, place and collector. Specimens in the bags were returned to the laboratory and placed under cold storage, although not at freezing temperatures.

Laboratory methods.--The gophers were left in storage for 24 hours after which they were removed, placed in a white enamel pan, and examined under 150 watt illumination placed 10 inches directly above the specimens. The heat from the light warmed the body, causing the fleas to move about. Captured fleas were preserved in 70% alcohol. After being thoroughly checked for fleas, the gophers were placed under refrigeration to await specific identification of the host.

Agents used in preparing the fleas for mounting on microslides were 10% sodium hydroxide, 1% sodium hydroxide, distilled water, a series of 30%, 50%, 70%, 85%, 95%, and 100% ethyl alcohol, and methyl salicylate (Oil of Wintergreen).

The fleas were first placed in the 10% solution of NaOH until they started to clear, transferred next to a 1% solution of NaOH until they were almost clear, and then placed in a distilled water. When the internal chitinous structures could be seen under magnification, the flea was

considered as properly cleared. Once cleared, they were placed in 30% ethyl alcohol and transferred through the alcohol series of 50%, 70%, 85%, 95% to absolute alcohol, and finally placed in methyl salicylate. The transfer was made at 24 hours intervals. Piccolyte was used as the mounting medium. A male and female flea were mounted on each slide whenever possible, as collections from the same host. The slides were then placed flat in a drying cabinet for several days to harden the mounting medium. All mounted specimens were examined with a compound binocular microscope at magnifications of 100x and 450x.

Illustrations were made by using a microprojector, projecting the structures to art board paper, then tracing the outlines in pencil. Detail in anatomical structures was observed under compound microscope magnification, with the final illustration completed in India ink medium.

Synonymy

Foxella ignotus (Baker) 1895

1895 Pulex ignotus Baker, Can. Ent., 27:110.
1895 Typhlopsylla americana Baker, Can. Ent., 27:189.
1904 Ceratophyllus ignotus: Baker, Proc. U. S. Nat. Mus., 27:416.
1915 Ceratophyllus ignotus: Jordan and Rothschild, Ectoparasites, 1:54.
1929 Foxella ignotus: Wagner, Konowia, 8:314.
1933 Foxella ignotus: Jordan, Nov. Zool., 39:75.
1938 Foxella ignotus ignotus: Jordan, Nov. Zool., 41:123.

1943 Dactylopsylla (Foxella) ignota ignota: Ewing and Fox, The Fleas of North America, p. 41.
1943 Dactylopsylla (Foxella) ignota ignota: Hubbard, Pac. Univ. Bull. 20(2):6.
1943 Foxella ignota: Jellison, Kohls, and Mills, Species and host list of Montana fleas, Misc. Publ. No. 2, Montana State Bull. of Ent., p. 1-22.
1945 Dactylopsylla (Foxella) ignota ignota: Gates, Ent. News, 56:11.
1947 Foxella ignota ignota: Hubbard, Fleas of Western North America, p. 179.
1958 Dactylopsylla (Foxella) ignota: Stark, Siphonaptera of Utah, p. 157.

Original Descriptions of Species

Foxella ignota

The only description given for ignota by Baker (1895) was that contained in a key couplet. The key was designed for the separation of several species of fleas in various genera. The couplet is reproduced below:

> Bristles on second antennal joint longer than joint 3: eye very small, almost obsolete: maxillary palpi in female with joint 2 as long as 4: head in female evenly rounded from occiput to mouth; pronotal comb of 20 spines; first two or three abdominal segments with several short minute teeth on discus above; bristles on abdomen as follows: first row on dorsum of each segment with 12 to 14 on either side, second row with 11 to 12 on either side, each ventral row with about 6 on either side; in posterior tarsi joint 5 is shorter than 3 and 5 together: uniform light brown length; female, 2.5 mm . . . . ignotus, n. sp.

Redescription of Foxella ignota by Hubbard (1947) is given below.

> Frontal tubercle sharp if exposed: Rostrum does not reach trochanter. Eye is rudimentary. Ocular bristle

is well above the eye. Three or 4 stout bristles in lower genal row, 4 to 6 bristles in upper genal row. Pronotal comb of from 16 to 24 teeth. Hind-femur with complete row of bristles on both sides. Segment 5 of hind-tarsus shorter than 3 with all plantar bristles lateral.
Male: Bristles of segment 2 of antennae short. One or two long and one very short antepygidial bristle. VIII st. is small without apical membranous lobe; close to apex a long bristle. Process of clasper narrow, conical; finger very long and narrow. Apical area behind pygidial plate setiferous at apex. Apices of anal tergite and sternite on a level, tergite conical, sternite not pointed, with many apical bristles.
Female: Bristles of segment 2 of antennae long. Three or 4 antepygidial bristles. Basal abdominal sternite with lateral bristles. Stylet with 2 or 3 lateral bristles. Anal sternite not distinctly angulate beneath, with bristles from near the base. Spermatheca with globular body and tail more or less bent, a distinct medium appendage at its apex.

Foxella utahensis (Hubbard) 1947

1936 Foxella ignota utahensis Wagner, Ztsch, f. Parasitenk., 8:655.
1943 Dactylopsylla (Foxella) ignota utahensis: Ewing and Fox, The Fleas of North America, p. 42.
1945 Foxella ignota utahensis: Prince, Can. Ent., 77:20.
1947 Foxella utahensis: Hubbard, Fleas of Western North America, p. 179.
1949 Foxella utahensis: Link, Am. Jour. Trop. Med., 29:498.
1958 Dactylopsylla (Foxella) ignota utahensis: Stark, Siphonaptera of Utah, p. 159.
1961 Dactylopsylla (Foxella) ignota utahensis: Augustson and Durham, Bull. So. Calif. Acad. Sci., 60(2):102.

Foxella utahensis was first described as a subspecies by Wagner (1936); the description was later used by Hubbard with some changes, to establish the species. The original description by Hubbard (1947) is as follows:

The 7th tergite of the male has almost always 3 - seldom 4 - of its big varying antepygidial bristles (on each

side) of which two of the lower ones are always well developed. There are four antepygidial bristles in the female. The 8th tergite is very thickly covered with the bristles, whose total number is never less than 35, generally, however, about 40. The 8 sternite of the male and the endopodite are as Foxella ignota apachinus.

RESULTS

Distributional records in Utah for the two species of Foxella recognized by Hubbard show: (1) F. ignota collected throughout the state, and (2) F. utahensis collected in two widely separated areas, one at Wellsville, Utah, the type locality, and the other at Kanab, Utah. The 777 specimens used in this study were collected throughout the state with the exception that collections were not made in the northwestern, southwestern, or southeastern corners.

The comparison of all specimens with the original description given by Baker for F. ignota revealed that all specimens conformed fully with Baker's concept of the species.

Hubbard's concept of "two species" shows some interesting complications when his descriptions were applied to specimens used in this study. He considers F. ignota to have one weak and one strong antepygidial bristle in the male and three bristles in the female. He defines F. utahensis as having 3 well-developed antepygidial bristles in the male and 4 in the female. It is on the basis of these differences that the two species were separated by him. Of the total 777 specimens, 724 agreed with Hubbard's species designation

for utahensis. Only fifty-three specimens, all females, agree with his designation for F. ignota.

Contemporary anatomical and morphological characteristics used were the eye spot, ocular bristles, antennal bristles, pronotal comb, antepygidial bristles, spermatheca, 7th sternite of the female, 8th sternite of the male, process and finger of the clasper, including the number of bristles on the finger. The results of analyses are described below.

Eye spot (Fig. 1 & 2, Plate I).--The eye spots of the 777 specimens were identical in size, shape, position and coloration.

Ocular bristles (Fig. 1 & 2, Plate I).--The ocular bristles are located ventral to the cibarial pump and anterior to the eye spot in two rows, an upper and lower series. Variations in the total number of bristles ranged from 4 to 7, with the lower genal row varying from 3 to 5.

Antennal bristles (Figs. 1 - 7, Plate II).--The antennae are located posterior to the eye spot and are attached to the dorso-lateral portions of the head, lying ventro-laterally in the antennal grooves. The bristles on the second and third segments of the antennae are used for identification in this genus. The bristles differ markedly in length and number between the sexes.

Males: The bristles on the second and third segments of the antennae are the same length but vary in the total number per segment. In all the specimens examined, the length and number of these bristles on each segment of the antennae were observed to be the same.

Females: Bristles on the third segment are longer than those on the second. Comparisons of the bristles on the second and third segment were the same for all specimens.

Pronotal comb (Figs. 1 & 2, Plate I).--The pronotal comb consists of large, heavy, spiniform, comb-like teeth located on the posterior margin of the pronotum. In comparing the pronotal combs of all specimens, it was observed that the number of teeth varied from 20 to 24, with the average number being 22.

Antepygidial bristles (Figs. 1 - 6, Plate III).--Antepygidial bristles are the stout spines located anterior to the pygidium.

Of 354 females, the antepygidial bristles comprised two groups. One group of 301 specimens possessed a total of four bristles, usually 3 long and one short (Figures 3 & 4, Plate III). The other group of 53 possessed 2 long and 1 short bristle for a total of 3 (Figure 2, Plate III).

Of the 423 male specimens, all possessed one short

Plate 1

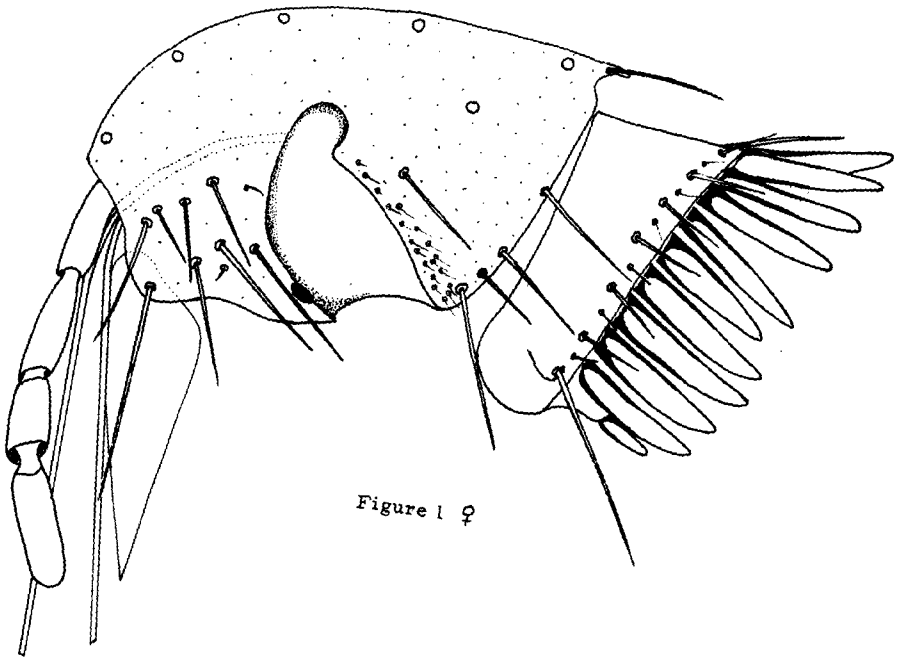


Figure 1 ♀

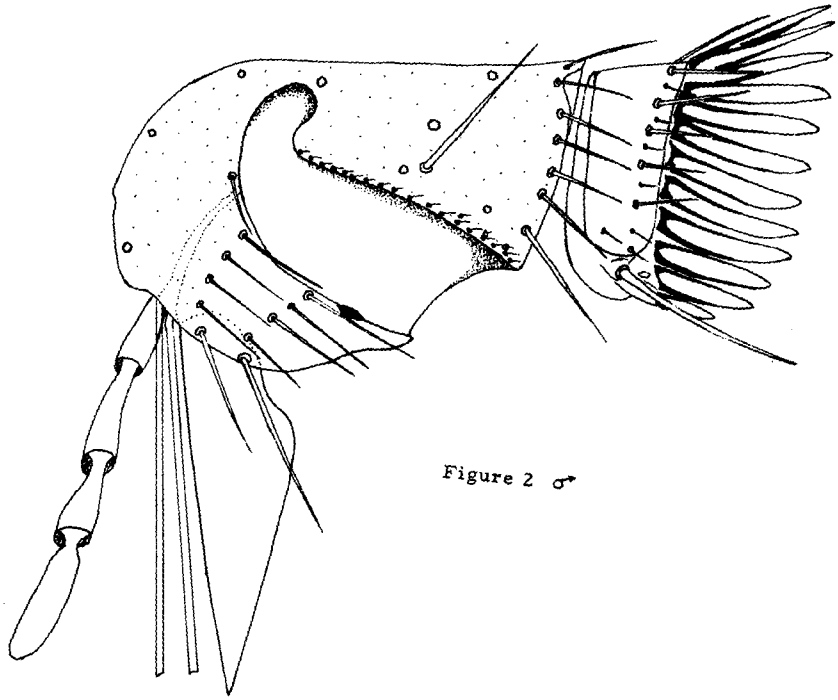


Figure 2 ♂

Plate 11

Figure 1

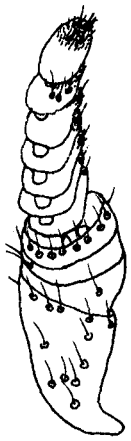


Figure 2

Figure 3

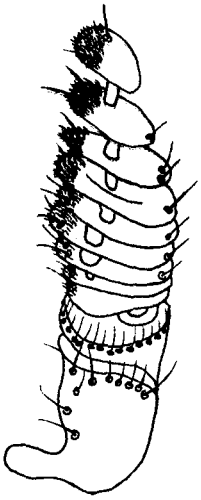


Figure 4

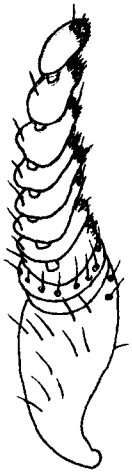


Figure 5

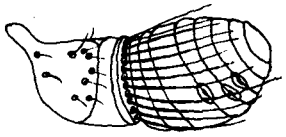


Figure 6

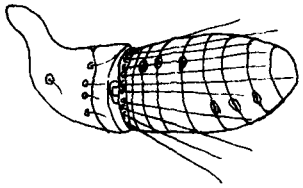


Figure 7

Plate III

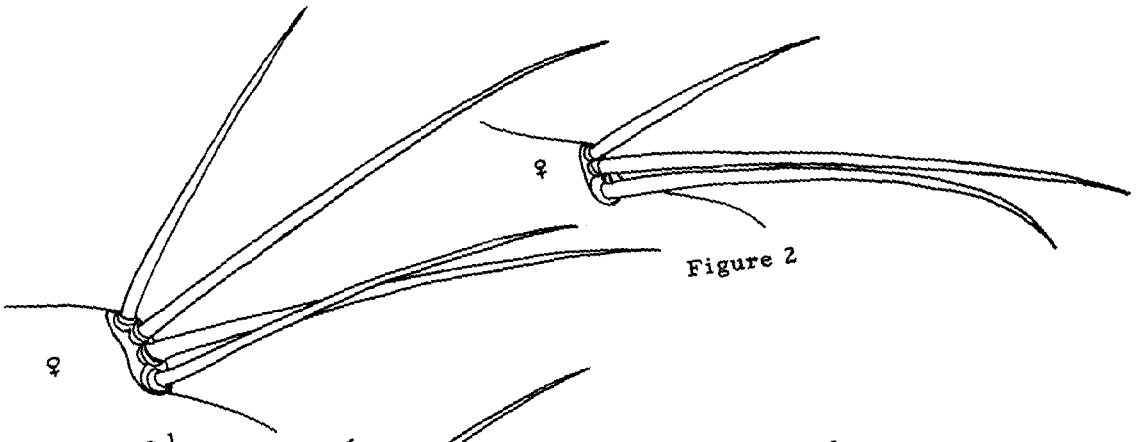
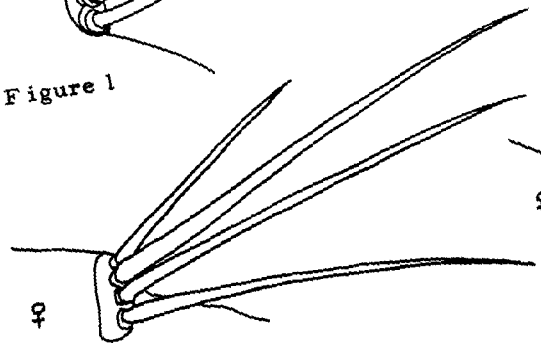


Figure 1

Figure 2



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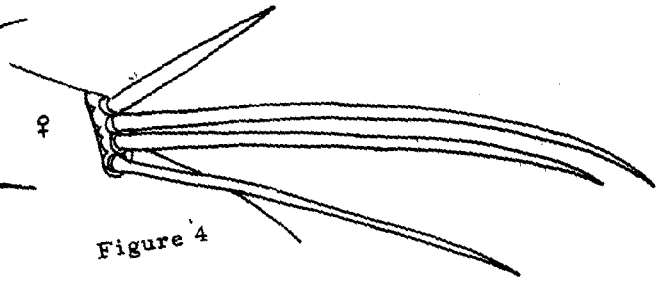

Figure 4

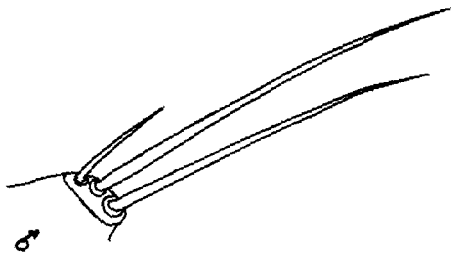

Figure 5

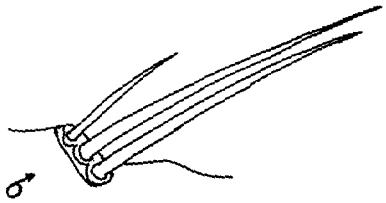

Figure 6

and two long bristles with the exception of three specimens (Figures 5 & 6, Plate III). These three were observed to have one short and one long bristle.

Spermatheca (Fig. 1, Plate IV).--The spermatheca is a sclerotized reproductive organ in female fleas. It receives the sperm during coitus. It is located in the posterior-medium area of the abdomen. There were no observable differences in length, width, or shape in all of the specimens examined.

VIIth sternite of females (Fig. 2, Plate IV).--The VIIth sternite is located at the ventro-lateral region of the abdomen. The shape of the VIIth sternite was found to be variable. There were at least five different groups of fleas differentiated on the shape (outline) of the posterior margin of this sternite. The variations in the posterior margin of this sternite were not related to geographic distribution.

VIIIth sternite of males (Figs. 1 - 7, Plate V).--The VIIIth sternite of the male also is located at the ventro-lateral region of the abdomen. The characteristic features of this structure which were found important to this study were the shape of the distal part of the sternite and the number, size and position of bristles. Considering these features it was found that all specimens could be referred to one of two groups. The largest group of 380 specimens

Plate IV

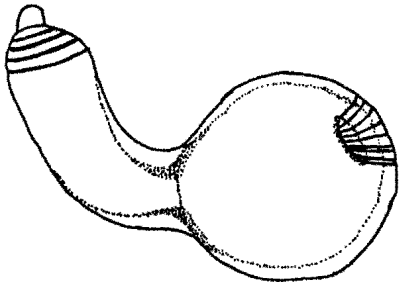

Figure 1

Figure 2

Plate V

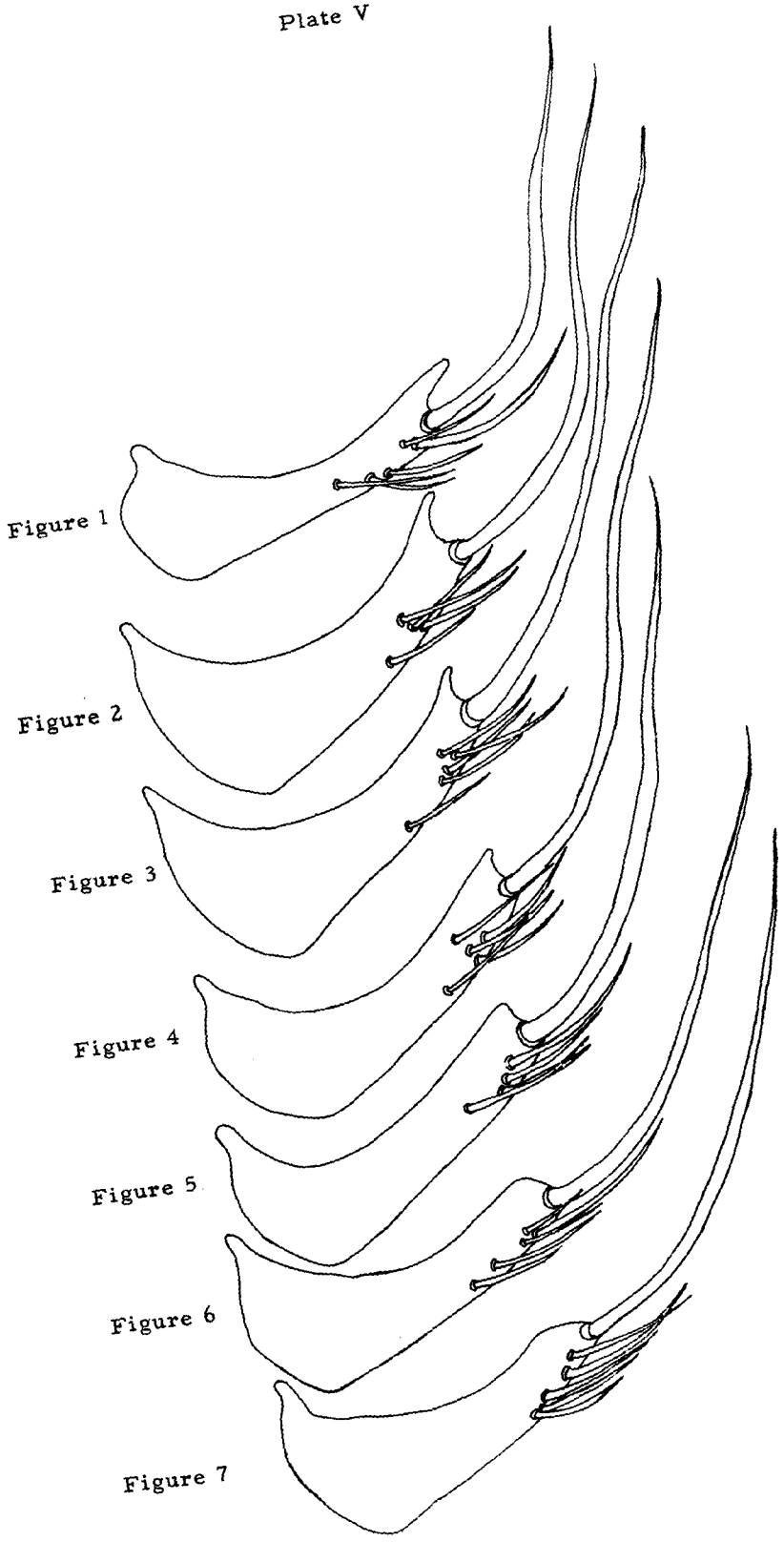

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

possessed a posterior-dorsal projection (Fig. 1 - 3, Plate V). The smaller group of 28 specimens lacked a posterior-dorsal projection, and in addition there was a secondary long bristle present, lateral to the main bristle (Fig. 6, Plate V). A total of 15 specimens were found to be intermediate between the two groups (Figs. 1, 4, 5 & 7, Plate V).

Finger and process of clasper (Figs. 1 - 4, Plate VI). --The finger and process are structures of the male reproductive system, located posterior-dorsally to the aedeagus at the posterior end of the abdomen. The shape of the process was observed to be identical in all specimens. However, in comparing the shape of the finger, two groups were observed. In one group of 30 specimens the width of the finger was wider by almost 1/3 as compared to the second group of 397 specimens.

The number of bristles present on the posterior border of the finger in the first group of 30 specimens varied from 4 to 5 long well-developed bristles, and 2 to 3 short medium bristles, averaging 6 in number with 3 or 4 minute bristles at the apex of the finger. The second group of 397 specimens possessed from 3 to 4 long well-developed bristles, and 1 or 2 short medium bristles averaging 5, with 2 to 5 minute bristles at the apex (Figs. 1 - 4, Plate VI).

Plate Vl

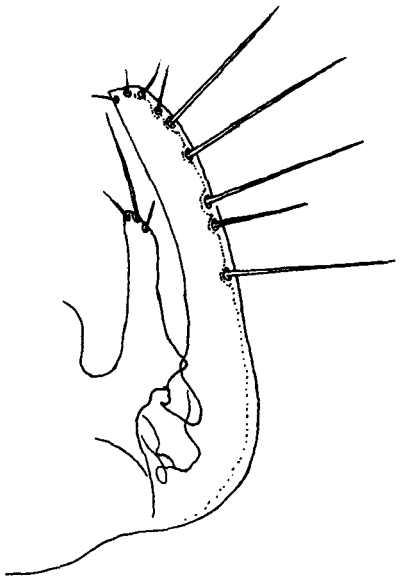

Figure 1

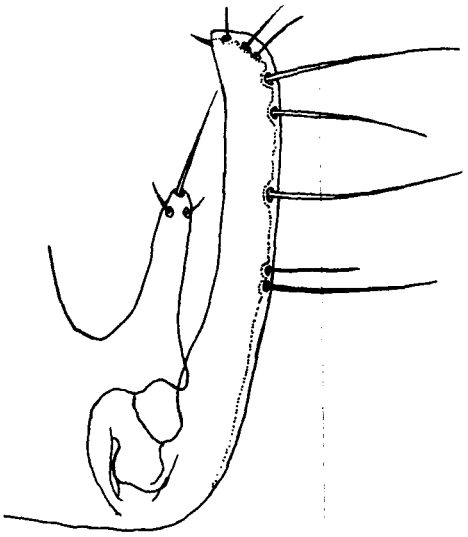

Figure 2

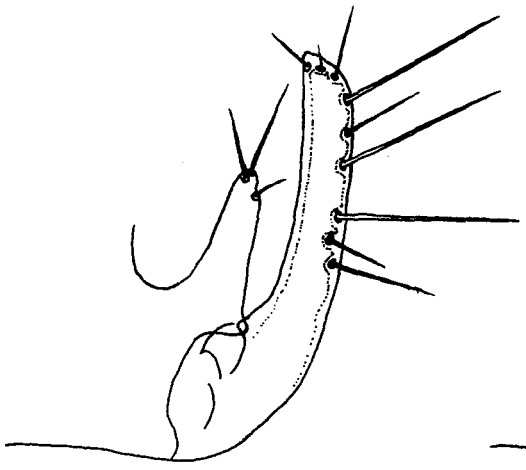

Figure 3

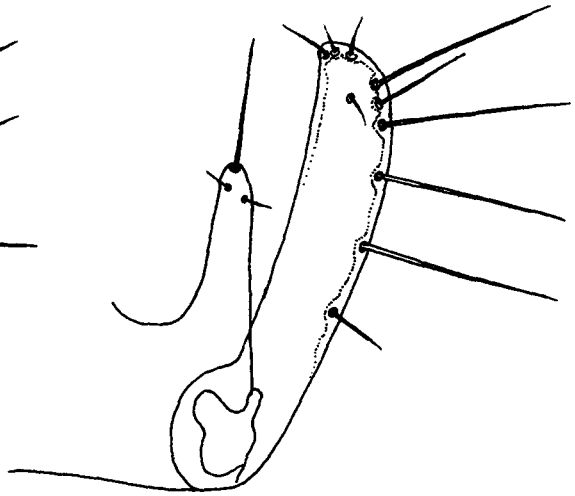

Figure 4

DISCUSSION AND CONCLUSIONS

There is no question that variations of various kinds occur among animals. Fleas are no exception. Baker was aware that there was a wide range of variations in the anatomical structures of fleas. In his original description for the species from the gopher he allowed for such. When the several anatomical and morphological features normally used in present-day flea taxonomy were applied to the 777 specimens used in this study, similarities and differences were also observed among the specimens from the same individual host, or from closely associated or geographically widely separated locations.

Those features in which similarities were found to be more or less the rule were the eye spot, antennal bristles of both sexes, pronotal comb, antepygidial bristles of the male, spermatheca, seventh sternite of the female, and the process of the clasper in the male. Variations were found in the shape of the eighth sternite of the male, the number of bristles on the posterior surface of the finger, the width of the finger, number of antepygidial bristles on the female, and the difference in the number of ocular bristles in the

upper genal row in both sexes.

When Baker (1895) wrote the original description for Foxella ignota, he made it broad enough to include a wide spectrum of variations. All specimens used in this study validated his concept, for none had difficulty in fitting this description. The same was true for Hubbard's (1947) concept in his redescription for Foxella ignota.

When Wagner (1936) described the subspecies Foxella ignota utahensis from specimens taken at Wellsville, Utah, he planted the seeds of taxonomic confusion regarding the status of Foxella in Utah. The principal characteristic used by him for subspecific identity of utahensis referred to the number of antepygidial bristles. Hubbard (1947) took Wagner's subspecies and gave it specific standing. The main characteristic for identification of Foxella utahensis was 3 antepygidial bristles (one long and two short) in the male flea, and four in the female (three long and one short). He designated Foxella ignota as having 2 antepygidial bristles (one long and one short) in the male, with three antepygidial bristles in the female (two long and one short).

Using the above characteristics listed by Hubbard and applying them to the 777 specimens in this study it was found that 724 of the specimens agreed with his concept of Foxella utahensis, and 53 did not. The latter fleas were all females

and were collected in the extreme southern part of the state at Kanab. Examined on the basis of sex, 354 females were of two different groups. One group of 301 specimens possessed 3 long and 1 short bristles and another group of 53 possessed 2 long and 1 short bristles. Of a total of 423 male specimens, all possessed two long and one short bristles. On these bases it is obvious that there is a varietal difference among the specimens in either sex. Certainly they do not conform strictly to Hubbard's concept of F. utahensis, or for that matter, Wagner's subspecific designation.

It seems presumptuous for Hubbard to redesign the interpretation of what constituted the species Foxella ignota, so that it would comprise a new species, Foxella utahensis. Actually that is what happened whether he intended it to be so or not. When Hubbard's interpretation of F. utahensis was applied to the 777 specimens used in this study, Foxella ignota was completely eliminated as a species which would be present in Utah.

When the concept of Foxella ignota by Baker and the redescription by Hubbard for this species is applied to the 777 specimens, all specimens were in agreement with the original Foxella ignota. It is the author's opinion, therefore, that the original description by Baker should stand; and that there is only one species of Foxella fleas in Utah, Foxella

ignota.

Whether one uses Baker's species concept or Hubbard's, it is found that variations occur both in general and with reference to sex. Nevertheless, Baker's species concept for Foxella ignota is broad enough to include the breadth of variation. This is not the case with Hubbard's concept for Foxella utahensis. There is no question that variation does occur among the gopher fleas of the genus Foxella and the species ignota for Utah. No doubt there are geographic races. These variations and their relationship to geographic distribution have not been sufficiently measured to establish what might be of subspecific identity.

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A TAXONOMIC STUDY OF FLEAS OF THE GENUS FOXELLA (WAGNER) IN UTAH (SIPHONAPTERA: DOLICHOPSYLLIDAE)

An Abstract of a Thesis

Submitted to the Faculty of the

Department of Zoology and Entomology

Brigham Young University

In Partial Fulfillment

of the Requirements for the

Degree Master of Science

by

Robert L. Amoureux

April 15, 1964

ABSTRACT OF THESIS

The purpose of this study is to determine the taxonomic status in Utah of Foxella ignota and Foxella utahensis, known as gopher fleas. A total of 777 specimens was assembled for examination. The specimens were either collected personally by trapping pocket gophers and removing the fleas, or specimens which had been collected in Utah by other investigators were made available for the study.

Analyses of all the specimens were accomplished by (1) comparing them to the original taxonomic descriptions by Baker (1895), (2) checking specimens against keys and descriptions used by Hubbard in establishing the two species concept, and (3) making comparisons with the use of standard anatomical characteristics in flea anatomy and morphology.

Analyses of the anatomical characters of the fleas, comparisons with original descriptions, and redescriptions of the species designed by Hubbard, reveal no significant differences. These comparative studies lead to the conclusion that there is only one species of Foxella fleas in Utah. This species is Foxella ignota.

This abstract is accepted in its present form by the Department of Zoology and Entomology as satisfying the thesis abstract requirement for the degree of Master of Science.

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