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# A survey of parasitism in a population of pigeons

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# A SURVEY OF PARASITISM IN A POPULATION OF PIGEONS (*COLUMBA LIVIA* GMELIN) IN HENRICO COUNTY, VIRGINIA

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## INTRODUCTION

Numerous papers relative to parasites in pigeons can be found in the literature, but information concerning parasitic infections in pigeons of Virginia is scant, and no survey of parasitism has been made. Furthermore, no one survey of parasitism in pigeons of North America has included the incidence of both ectoparasites and endoparasites. Information relative to the incidence of individual parasites or groups of parasites, however, is available in recent literature, as well as information concerning isolated cases of parasitism.

The present study was undertaken to (1) determine the nature and extent of parasitism in a population of pigeons in Henrico County, Virginia, and (2) to determine the usefulness of the pigeon as a source of material for studies on individual parasites.

## HISTORICAL

Intracorpuscular parasites in the blood cells of birds were first observed by Danilewsky in 1885. In 1906, Sergent showed that the fly, Pseudolynchia canariensis, was the vector of Haemoproteus columbae. Information relative to the incidence of Haemoproteus in birds other than pigeons can be found in surveys made by Herman (1938), Huff (1939), Wood (1943), and Manwell (1951). In a survey of birds caught for

banding purposes, Huff (1939) reported that the highest incidence of Haemoproteus infection (80%) was in mourning doves. Giovannoni (1946) reported the incidence of Haemoproteus in pigeons of Parana, Brazil, and Kartman (1949) reported the incidence in Honolulu, Hawaii.

The nature of Haemoproteus infections in pigeons was studied by Coatney (1933), and seasonal variation in the incidence of Haemoproteus infections was noted in blue jays and brown thrashers by Jordan (1943), and in black-billed magpies by Stabler (1961). Neither investigator gives an explanation for seasonal variation.

Trichomonas gallinae, a flagellate of the upper digestive tract of pigeons, was first described by Rivolta in 1878. Its morphology, pathogenicity, and incidence in pigeons was studied by Stabler (1941a, 1941b, & 1947). Recently, Locke and Herman (1961) reported on the incidence of Trichomonas gallinae in mourning doves of Maryland.

The nematode parasites of birds were reviewed by Cram (1927, 1928). Miller (1937) and Levi (1941) have described the species of helminths found in pigeons up to the time of publication of their respective papers.

A feather mite of pigeons, Falculifer rostratus, was described by Buchholz in 1869. A recent review of acarids of pigeons was published by Hollander (1956). The life history and habits of the slender louse Columbicola columbae, were studied by Martin (1934), and Wilson (1941) reviewed the

slender lice of pigeons. Seasonal variation in the incidence of the lice of starlings has been noted by Boyd (1951).

The biology of Pseudolynchia canariensis was studied by Coatney (1931), and since its appearance in the United States about 1896, it has become an important parasite of pigeons (Bishopp, 1929).

## MATERIALS AND METHODS

During July, 1961 through March, 1962 sixty pigeons [*Columba livia* Gmelin, according to the American Ornithologist's Union (1957)] were examined for ectoparasites and endoparasites. A population of pigeons nesting in the outbuildings of Cheswick Farm in Henrico County, Virginia provided the material for this survey. The birds at Cheswick Farm live in a semi-wild state, are of unknown origin, and are not being raised commercially. All of the birds except four were captured alive, and kept in the laboratory for a period not longer than three days before post mortem examination. The four birds which were dead were examined within twenty-four hours.

Examination began with the removal of blood from a wing vein of each specimen. Blood smears were prepared, stained with Wright's stain, and observed under the oil immersion objective. Pigeons were placed in plastic bags and killed with chloroform. Internal examination proceeded as follows: the bird was placed on its back and the feathers wet with water to facilitate manipulation. The skin from the abdomen, thorax, and thighs was stripped by tearing with the fingers. A small transverse incision was made in the ventral abdominal wall. Starting at the lateral end of this incision the thoracic wall was cut, including breast

muscles and the ribs on either side of the body to the axilla. The abdominal and thoracic viscera were exposed by bending the keel bone forward. All of the internal organs, including the serous surfaces and air sacs, were examined for lesions. The proventriculus was exposed and the esophagus anterior to it was excised. The entire digestive tract posterior to the esophagus was removed by applying traction and cutting adherent tissues. A longitudinal cut was made through the proventriculus, gizzard, small intestine, large intestine, and rectum. The mucosa of these organs was examined with the aid of a binocular microscope. Fresh smears from the mouth cavity, esophagus, proventriculus, small intestine, large intestine, and rectum were prepared for immediate examination.

Feces were removed for examination by the sucrose flotation method. The flotation solution (sp gr 1.25) consisted of the following:

Sucrose.....454 g
Tap water.....355 ml
40 per cent formaldehyde solution.....6 ml

The flotation technique consisted of the following steps:

1. A fine suspension of feces was made in a vial (6 cm long, 15 mm in diameter).
2. The suspension was centrifuged at 1500 rev/min

for two minutes and the supernatent fluid decanted.

3. The vial was filled half way with water and the sediment broken up by shaking.

4. This suspension was centrifuged and decanted as in step 2.

5. The vial was filled with sugar solution and the sediment broken up by shaking. The suspension was centrifuged at 1500 rev/min for two minutes.

6. The meniscus was raised a short distance above the top of the vial by adding flotation solution drop by drop.

7. A clean slide was placed on top of the vial and removed for microscopic examination after fifteen minutes.

Next, the mandibular articulation at the angle of the mouth was cut on both sides, and an incision was made down into the pharynx, through the esophagus and into the crop. The mouth cavity, pharynx, esophagus, and crop were examined with a binocular microscope for parasites. Fresh scrapings were made from various parts of the upper digestive tract and examined with a compound microscope. The nasal chambers and sinuses were incised and examined. Material from the reproductive ducts was obtained with a wire loop, mixed with physiological saline solution on a slide, and examined.

The intestinal contents were centrifuged (sugar flotation method) and examined for protozoa and helminth eggs. Helminths

were either fixed in Bouin's fluid or a saturated bichloride of mercury solution and stained with Grenacher's borax carmine (Jones, 1950). Permanent preparations were made using balsam as the mounting medium.

Ectoparasites were preserved in seventy per cent ethyl alcohol, and permanent preparations were made later using Hoyer's mounting medium (Baker and Wharton, 1952).

Cultures of Trichomonas gallinae were prepared in order to have an ample supply of trichomonads on hand for identification. Material from the mouth cavities of seven birds was inoculated into tubes containing nutrient agar and modified Ringer's solution, according to the method outlined by Bland (1932) for Trichomonas vaginalis. The tubes were incubated at 37 C and subcultures were made every three or four days. Trichomonads were examined with the oil immersion objective following treatment with methylene blue (1:10,000 prepared in absolute alcohol). A drop of the dye solution was placed on a clean slide and allowed to evaporate before trichomonads were added. Unstained trichomonads were observed with a phase contrast microscope.

If blood smears were positive for Haemoproteus columbae, five hundred erythrocytes were counted, and the percentage of those containing gametocytes was calculated. A special reticule was devised to serve as a guide in determining the number of infected blood cells. This simply involved fastening

four fine human hairs in the eyepiece of the microscope in the form of a square.

Where possible, photomicrographs of the parasites were taken using a Bausch and Lomb vertical camera loaded with Kodak Royal Pan film (3¼ by 4¼ inches). Kodak DK 50 developer and Kodak Dektol were used to develop the film and prints.

## OBSERVATIONS

The incidence of parasitism has been high among the pigeons examined in this survey, as can be seen from Table I. The commonest parasites encountered were ectoparasites and protozoans of the families Haemoproteidae and Trichomonadidae. Descriptions of each parasite can be found in the appendix, and those authorities consulted in the identification of parasites are listed among the literature citations.

## PROTOZOA

Four protozoan species, representing four families were found. Seasonal variation in the severity of Haemoproteus infections was observed, as well as variation in the incidence of trichomonads and coccidia in immature pigeons and adults.

### Haemoproteus columbae Kruse, 1890 (HAEMOSPORIDIA: HAEMOPROTEIDAE):

Gametocytes of Haemoproteus columbae, easily identified in dried blood smears stained with Wright's stain, were found in the erythrocytes of 58.3 per cent of the pigeons. Female gametocytes appeared deep blue with a pale pink nucleus that measured 2.3 microns at its widest dimension. Male gametocytes stained light blue, but their nuclei were not clearly outlined. Female gametocytes contained an average of 26.8 pigment granules and measured

TABLE I

RESULTS OF A SURVEY OF PARASITISM IN PIGEONS

| CLASSIFICATION | LOCATION ON OR IN HOST | PER CENT INFECTION |
|---|---|---|
| PROTOZOA | | |
| *Haemoproteus columbae* | blood | 58.3 |
| *Trichomonas gallinae* | upper digestive tract | 50.0 |
| *Hexamita sp.* | ileum | 1.6 |
| *Eimeria labbeana* | small intestine | 35.0 |
| HELMINTHS | | |
| *Aporina delafondi* | small intestine | 1.6 |
| *Raillietina sp.* | small intestine | 1.6 |
| *Ascaridia columbae* | small intestine | 1.6 |

| CLASSIFICATION | LOCATION ON OR IN HOST | PER CENT INFECTION |
|---|---|---|
| *Capillaria columbae* | small intestine | 10.0 |
| *Ornithostrongylus quadriradiatus* | small intestine | 1.6 |
| *Heterakis gallinae* | feces (eggs) | 1.6 |
| ARTHROPODA | | |
| *Falculifer rostratus* | on wing and tail feathers between adjacent barbs | 71.6 |
| *Columbicola columbae* | feathers | 93.3 |
| *Goniocotes bidentatus* | base of rump feathers | 46.6 |
| *Menacanthus latus* | base of rump feathers | 6.6 |
| *Pseudolynchia canariensis* | feathers | 8.3 |

2.6 by 12 microns. Male gametocytes contained fewer pigment granules (an average of 14.7) and measured 3 by 11.6 microns.

In most of the infected pigeons there were no symptoms other than the presence of gametocytes in the red blood cells. Necrotic areas on the liver were observed in three specimens having large numbers of gametocytes in their blood. The greatest incidence of the parasite occurred between November and December (Table II). The severity of infection in each bird is indicated in Table III. The most severe infections were found between July and December; whereas during the colder months of January through March, the severity of the infections declined. A statistically significant difference was demonstrated between the mean number of infected erythrocytes found in the July through December group and the January through March group. No significant difference was demonstrated between birds of different age and sex.

Trichomonas gallinae Rivolta, 1878 (TRICHOMONADIDA: TRICHOMONADIDAE

The incidence of Trichomonas gallinae was 50 per cent. Trichomonads were found in the mouth cavity, esophagus, and crop in 36.6 per cent of the cases. In 63.3 per cent of the cases they were found only in the mouth cavity.

TABLE II

BIMONTHLY INCIDENCE OF PARASITES

| MONTHS | JULY-AUG. | | SEPT.-OCT. | | NOV.-DEC. | | JAN.-FEB. | | MARCH | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER OF SPECIMENS | 6 | | 12 | | 8 | | 21 | | 13 | | 60 |
| SPECIES | # | % | # | % | # | % | # | % | # | % | |
| PROTOZOA | | | | | | | | | | | |
| Haemoproteus columbae | 3 | (50.0) | 5 | (41.6) | 7 | (87.5) | 12 | (57.1) | 8 | (61.4) | |
| Trichomonas gallinae | 0 | 0 | 7 | (58.3) | 5 | (62.5) | 13 | (61.9) | 5 | (38.4) | |
| Hexamita sp. | 0 | 0 | 0 | 0 | 1 | (12.5) | 0 | 0 | 0 | 0 | |
| Eimeria labbeana | 4 | (66.6) | 7 | (58.3) | 3 | (37.7) | 6 | (28.6) | 1 | (7.7) | |
| HELMINTHS | | | | | | | | | | | |
| Aporina delafondi | 0 | 0 | 0 | 0 | 0 | 0 | 1 | (4.8) | 0 | 0 | |
| Raillietina sp. | 0 | 0 | 1 | (8.3) | 0 | 0 | 0 | 0 | 0 | 0 | |
| Ascaridia columbae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | (7.7) | |
| Capillaria columbae | 1 | (16.6) | 1 | (8.3) | 0 | 0 | 3 | (14.7) | 1 | (7.7) | |

| MONTHS | JULY-AUG. | | SEPT.-OCT. | | NOV.-DEC. | | JAN.-FEB. | | MARCH | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER OF SPECIMENS | 6 | | 12 | | 8 | | 21 | | 13 | | 60 |
| SPECIES | # | % | # | % | # | % | # | % | # | % | |
| Ornithostrongylus quadriradiatus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | (7.7) | |
| Heterakis gallinae | 0 | 0 | 1 | (8.3) | 0 | 0 | 0 | 0 | 0 | 0 | |
| ARTHROPODA | | | | | | | | | | | |
| Falculifer rostratus | 4 | (66.6) | 11 | (91.6) | 6 | (75.0) | 14 | (66.6) | 9 | (69.2) | |
| Columbicola columbae | 6 | (100) | 12 | (100) | 7 | (87.5) | 17 | (81.5) | 13 | (100) | |
| Goniocotes bidentatus | 4 | (66.6) | 7 | (58.3) | 2 | (25.0) | 7 | (33.3) | 8 | (61.6) | |
| Menacanthus latus | 1 | (16.6) | 2 | (16.6) | 0 | 0 | 1 | (4.8) | 0 | 0 | |
| Pseudolynchia canariensis | 2 | (33.3) | 3 | (25.0) | 1 | (12.5) | 0 | 0 | 0 | 0 | |

TABLE III

PER CENT OF ERYTHROCYTES CONTAINING GAMETOCYTES

| MONTHS | SPECIMEN NUMBER | PERCENT OF CELLS INFECTED |
|---|---|---|
| July-August | 3 | 2.80 |
| | 5 | 0.20 |
| | 6 | 2.20 |
| September-October | 7 | 3.40 |
| | 12 | 0.80 |
| | 13 | 6.20 |
| | 14 | 0.60 |
| | 17 | 4.00 |
| November-December | 19 | 0.20 |
| | 21 | 6.00 |
| | 22 | 0.40 |
| | 23 | 0.40 |
| | 24 | 0.20 |
| | 25 | 12.40 |
| January-February | 26 | 4.60 |
| | 27 | 0.00* |
| | 28 | 0.00* |
| | 29 | 2.80 |
| | 30 | 3.60 |
| | 31 | 0.00* |
| | 32 | 8.60 |
| | 33 | 0.80 |
| | 34 | 0.00* |
| | 41 | 0.60 |
| | 43 | 0.40 |
| | 45 | 0.40 |
| March | 47 | 0.20 |
| | 48 | 0.40 |
| | 49 | 0.60 |
| | 51 | 0.20 |
| | 52 | 0.00* |
| | 53 | 0.00* |
| | 54 | 0.00* |
| | 55 | 0.00* |
| | 57 | 0.00* |

* Gametocytes were found in small numbers, but none were observed in the particular 500 erythrocytes counted.

Trichomonas gallinae was found in seven of the twelve immature birds examined, and in twenty-three of the forty-eight adults examined. One heavily infected bird was greatly emaciated, but caseous lesions, characteristic of trichomonad infections, were not found in any of the birds. Several birds, however, had large amounts of mucus in their mouth cavities which contained hundreds of trichomonads

Trichomonas gallinae was readily cultivated in the laboratory using the method outlined by Bland (1932) for Trichomonas vaginalis. Organisms were maintained in culture for periods up to twenty days, at which time they were discontinued. Trichomonads remained active in two cultures which were not transferred to fresh culture media until a week after initial inoculation, but bacterial contamination was heavy as would be expected in cultures which were not pure.

Hexamita sp. Dujardin, 1841 (POLYMASTIGINA: HEXAMITIDAE):

A number of pyriform flagellates measuring 6 by 10 microns were found in the ileum of one pigeon. The organisms, when stained with methylene blue reagent, were seen to possess six anterior flagella and two longer posterior flagella. There were many refractile granules in the endoplasm, but further details were not observed. The organisms were identified as belonging to the genus Hexamita, but the species could not be determined. An attempt to culture the organisms in sterile

tubes of nutrient agar and modified Ringer's solution was not successful. No lesions were observed in the large intestine or rectum.

Eimeria labbeana Rivolta, 1896(COCCIDIA: EIMERIIDAE):

Oocysts of the coccidian, Eimeria labbeana, were found in thirty-five per cent of the pigeons examined. Oocysts were present in the feces of 57.1 per cent of the infected birds, and in fresh smears from the small intestine in 42.9 per cent of the infected birds. The incidence of infection was 58.3 per cent in immature birds; 29.2 per cent in adults. Hemorrhagic areas were noted in the small intestines of two pigeons having large numbers of oocysts, but definite lesions were not observed. The oocysts were round or elliptical, light yellow in color, and measured 17.4 by 19.9 microns. These dimensions fall within the range of measurements listed by Morgan and Hawkins (1952) for Eimeria labbeana.

HELMINTHS

Six species of helminths representing only the classes Cestoidea and Nematoda were found in this survey. The incidence of helminths was low in comparison to those parasites already reported.

Aporina delafondi Railliet, 1892 (CYCLOPHYLLIDEA: ANOPLOCEPHALIDAE):

A single specimen 85 mm in length was removed from the small intestine of one pigeon. No eggs were recovered from the fecal material or intestinal contents, and no lesions were observed in the small intestine.

Raillietina sp. Railliet, 1892 (CYCLOPHYLLIDEA: DAVAINEIDAE):

A tapeworm, Raillietina sp., was found in the small intestine of one pigeon. The specimen measured 91 mm in length and about 1.2 mm in width, and contained numerous proglottids. The scolex was 91 microns in diameter with a double circle of hooks, each of which contained about 72 hooks 15 microns long. The suckers were armed with small hooks each 8 microns long, and there were about 40 oval testes per segment. The genital apertures were unilateral, but detailed observations of the male and female genitalia were not possible because the mature proglottids did not stain well. The gravid proglottids toward the end of the body were much longer than the mature proglottids, and were barrel-shaped. Gravid proglottids contained forty to

fifty egg pouches each with four onchospheres in surface view. The oval egg pouches measured 17 by 28 microns, and the eggs were 8.3 microns in diameter. The species could not be determined.

Ascaridia columbae Gmelin, 1790 (ASCARIDATA: ASCARIDIDAE):

A single male ascarid was collected from one pigeon. The worm, 34 mm long, was found in the small intestine just posterior to the jejunum. No eggs were found in the intestinal contents or in the feces, and no lesions were observed.

Capillaria columbae Rudolphi, 1819 (TRICHURATA: TRICHURIDAE):

This species was found in the small intestine of six pigeons. Although this was the most frequently encountered helminth, no more than four worms were found in any of the infected pigeons. In all cases eggs were found in smears from the small intestine or in the feces. Eggs measured 27.8 by 48 microns. No lesions were observed in the small intestines of infected birds.

Ornithostrongylus quadriradiatus Stevenson, 1904 (STRONGYLATA: TRICHOSTRONGYLIDAE):

A male and the posterior part of a female were found in the small intestine of one pigeon. The male measured 10 mm in length and was examined while alive. The living

worm had a distinct pink color. The vesicular enlargement, characteristic of this species, was clearly observable at the anterior end. No eggs were found in the intestinal contants or fecal material, and no lesions were observed in the small intestine.

Heterakis gallinae Gmelin, 1790 (ASCARIDATA: HETERAKIDAE):

Eggs of the cecal worm, found in a fecal specimen from one pigeon, were ellipsoidal, thick-shelled, and in the single cell stage. The eggs measured 42 by 72 microns. These measurements correspond to those reported by Cram (1927) for this species.

ARTHROPODA

One or more species of ectoparasites were found on 96.6 per cent of the sixty pigeons examined. The bimonthly incidence of ectoparasites between July, 1961 and March, 1962 is shown in Table III. The percentage of pigeons harboring ectoparasites, and the number of ectoparasites per bird declined between November and February. A larger number of mallophagan eggs was found during these months, but it was not possible to identify them because of lack of information.

Falculifer rostratus Buchholz, 1869 (ACARINA: DERMOGLYPHIDAE):

Feather mites occurred on 71.6 per cent of the birds examined. The mites were usually found between adjacent barbs on the wing and tail feathers.

Columbicola columbae Linné, 1758 (MALLOPHAGA: PHILOPTERIDAE):

The slender louse was found on 93.3 per cent of the pigeons. It was encountered most frequently on the wing and tail feathers between adjacent barbs, although, occasionally it was found on other feathers. In most cases the head of the louse was facing toward the shaft of the feather. On several occasions feathers were placed in the refrigerator to be examined later, and it was observed that lice were alive after exposure to a temperature of 5 C for one week.

Lice that were kept at room temperature (24 C) for one week were also alive.

Goniocotes bidentatus Scopuli, 1763 (MALLOPHAGA: PHILOPTERIDAE):

The golden feather louse, found on 46.6 per cent of the pigeons, was most frequently encountered at the base of the rump feathers. The number of lice per bird was considerably less than the number of slender lice per bird.

Menacanthus latus Piaget, 1880 (MALLOPHAGA: MENOPONIDAE):

This louse, collected from 6.6 per cent of the birds, occurred at the base of the rump feathers. It was readily distinguished from the other Menoponidae by its larger size and poorly developed pleural apodemes.

Pseudolynchia canariensis Macquart, 1840 (DIPTERA: HIPPOBOSCIDAE):

The pigeon fly, the vector of Haemoproteus columbae, was found on 8.3 per cent of the pigeons. It was most frequently encountered on the wing feathers or among the contour feathers on the back. All of the flies were collected between July and December.

## DISCUSSION

The incidence of parasitism in the pigeons of this survey was high, especially in regard to ectoparasites. The results are compared with data of other workers in Table IV. In the four cases where incidences of parasites found by other authors are compared with those here, large variations in the data make a meaningful interpretation difficult.

The severity of Haemoproteus infections declined significantly in the January-March group of pigeons. The following information from studies of individual cases of Haemoproteus infection by Coatney (1933), is necessary to interpret the data in this survey. He found that there was generally a rise in the number of gametocytes during the acute phase of the infection followed later by a decline. The severity of infection varied from one bird to another, and was thought to be associated with individual resistance. There was a 28-30 day incubation period before the appearance of gametocytes in the blood. In the beginning of the acute phase the number of gametocytes increased rapidly, however, a significant decrease in the number of gametocytes occurred by the 20th day after their appearance. Large numbers of gametocytes in the blood after the 20th day indicated either a reinfection or a relapse. Apparently no antibodies were produced in response to the Haemoproteus

TABLE IV

RESULTS OF A SURVEY OF PARASITISM IN PIGEONS

COMPARED WITH THOSE OF OTHER INVESTIGATORS

| SPECIES | PER CENT INFECTION (Henrico County, Va.) | PER CENT INFECTION | LOCALITY | AUTHORITY |
|---|---|---|---|---|
| Haemoproteus columbae | 58.2 | 82.2 | Honolulu, Hawaii | Kartman (1949) |
| | | 57.7 | Parana, Brazil | Giovannoni (1946) |
| Trichomonas gallinae | 50.0 | 64.5 | Pa., Md., and S. Ca. | Stabler (1941) |
| | | 75.0 | Colorado Springs, Colorado | Stabler (1951) |
| Hexamita sp. | 1.6 | 4 cases reported | Calif. | Hinshaw and McNeil (1941) |
| Eimeria labbeana | 35.0 | * | | |
| Aporina delafondi | 1.6 | * | | |
| Raillietina sp. | 1.6 | * | | |

| SPECIES | PER CENT INFECTION (Henrico County, Va.) | PER CENT INFECTION | LOCALITY | AUTHORITY |
|---|---|---|---|---|
| Ascaridia columbae | 1.6 | 16.1 | Quebec, Canada | Miller (1937) |
| Capillaria columbae | 10.0 | 9.6 | Quebec, Canada | Miller (1937) |
| Ornithostrongylus quadriradiatus | 1.6 | cases reported | Maine, Md., D. C. | Cram (1933)** |
| Heterakis gallinae | 1.6 | * | | |
| Falculifer rostratus | 71.6 | * | | |
| Columbicola columbae | 93.3 | * | | |
| Goniocotes bidentatus | 46.6 | * | | |
| Menacanthus latus | 6.6 | * | | |
| Pseudolynchia canariensis | 8.3 | reported | Va., D. C. | Bishopp (1929) |

* no figures available on incidence

** in Levi (1941)

organism. No periodicity of gametocyte production or periodicity of relapse was demonstrated, but small numbers of gametocytes persisted in the blood up to 68 days after their initial appearance.

The above facts indicate that most of the Haemoproteus infections encountered between January and March were probably infections which began seven to fourteen weeks prior to examination, and before the onset of cold weather. There was a seasonal variation in the severity of Haemoproteus infections, and the data indicate that seasonal variation may be related to temperature changes which influence the vector, Pseudolynchia canariensis. No members of this species were found on pigeons of the January-March group. According to Bishopp (1929) the pupal stage of the pigeon fly ranges from 29-31 days when the mean daily temperature is about 73 F. Lower temperatures lengthen the pupal period. It is quite likely that lower temperatures between January and March account for the absence of pigeon flies, and the resulting decline in the severity of Haemoproteus infections.

Jordan (1943) noted seasonal influence on Haemoproteus infections and Stabler (1961) accumulated data relative to seasonal variations in the Haemoproteus of magpies (Pica pica hudsonia). Neither investigator relates seasonal variation in severity of infection to temperature changes that influence the vector.

Trichomonas gallinae was more commonly encountered in immature birds than in adults. Cauthen (1936) found that

trichomonad lesions occurred frequently in juvenile pigeons, and Stabler (1947) points out that it is impossible for young birds to escape exposure to whatever is in the parent's mouth and crop, as the squab is dependent on the parent for its food supply.

Evidence of trichomonad infection was, for the most part, no more than the presence of trichomonads in scrapings from the upper digestive tract. One bird with hundreds of trichomonads in the mouth, esophagus, and crop had a serious infection, however, pigeons at Cheswick Farm were infected with what appeared to be a non-virulent strain of T. gallinae. Stabler (1948a) presented evidence which indicated that there is variation in the virulence of strains of trichomonads. A total of five strains were used in his experiments. Stabler (1948b) has also shown that an attack from one of the less virulent strains of the organism results in a high degree of immunity to virulent strains. Juvenile pigeons are more susceptable to trichomonad infections than adults, as they have not had an opportunity to develop immunity.

The relatively high incidence of T. gallinae suggests the possibility that the pigeon could be a disseminator of trichomonads among other birds. Stabler (1951) has shown that trichomonads from mourning doves (Zenaidura macroura) are pathogenic to trichomonad-free domestic pigeons, and that the pigeon is the source of infection in outbreaks among turkeys, chickens, mourning doves,

and other pigeons.

The small number of helminths encountered were not sufficient to draw condlusions concerning seasonal variation. It is possible that pigeons are disseminators of Capillaria columbae among chickens. Capillarid eggs similar to those of C. columbae were found in two of ten fecal specimens from chickens at Cheswick Farm. Todd (1946) found C. columbae in seven of 390 chickens examined in East Tennessee.

The cecal worm, Heterakis gallinae, has not been reported from pigeons. The recovery of eggs of this species from a fecal specimen of one pigeon should probably not be interpreted as an actual case of cecal worms. Pigeons at Cheswick Farm could easily ingest cecal worm eggs accidently from contaminated food or water, as eggs were abundant in fecal specimens from chickens.

Temperature undoubtedly has an effect on the number of birds harboring ectoparasites and on the severity of ectoparasitism. Two mallophagan species, Goniocotes bidentatus and Menacanthus latus appear to be more severely affected by the onset of cold weather than the slender louse, Columbicola columbae, and the feather mite Falculifer rostratus. Columbicola shows some resistance to cold as it is able to survive in the refrigerator at 5 C for one

week. This fact might explain its continued abundance during the winter months. The larger number of mallophagan eggs found during the winter probably results from the fact that embryonic development has slowed down, and the lice tend to "winter over" in the egg stage as suggested by Peters (1928), and demonstrated by Boyd (1951) in the lice of the starling (Sturnus vulgaris).

## SUMMARY

1. Post mortems were performed on sixty pigeons from Cheswick Farm in Henrico County, Virginia, and each was examined for animal parasites.

2. All of the pigeons except two were parasitized by one or more species: 58.3 per cent by Haemoproteus columbae; 50 per cent by Trichomonas gallinae; 1.6 per cent by Hexamita sp.; 35 per cent by Eimeria labbeana; 1.6 per cent by Aporina delafondi; 1.6 per cent by Raillietina sp.; 1.6 per cent by Ascaridia columbae; 10 per cent by Capillaria columbae; 1.6 per cent by Ornithostrongylus quadriradiatus; 1.6 per cent by Heterakis gallinae; 71.6 per cent by Falculifer rostratus; 93.3 per cent by Columbicola columbae; 46.6 per cent by Goniocotes bidentatus; 6.6 per cent by Menacanthus latus; and 8.3 per cent by Pseudolynchia canariensis.

3. The effect of temperature on the incidence of ectoparasites was noted, as well as seasonal variation in the severity of Haemoproteus infection.

4. Variation in the incidence of trichomonads and coccidia in immature birds and in adults was observed.

5. The role of the pigeon as a disseminator of trichomonads and capillarid worms was discussed.

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# APPENDIX

## PROTOZOA

### Haemoproteus columbae

Gametocytes of Haemoproteus columbae are halter-shaped, elongated bodies that may surround the nucleus of the red blood cells. The male gametocyte measures 3 microns wide by 11.6 microns long, and its nucleus is not clearly outlined (Plate I). The female gametocyte, measuring 2.6 microns wide by 12 microns long, has a conspicuous pink nucleus (Plate II). Pigment granules in the female gametocyte are scattered throughout the cytoplasm, whereas in the male gametocyte they are aggregated in several groups.

### Trichomonas gallinae

In natural infections, Trichomonas gallinae, is found in the upper digestive tract of pigeons. The pear-shaped organisms measure 2.3 to 8.5 microns in width and 6.2 to 18.9 microns in length. There are four free anterior flagella. The undulating membrane extends three quarters the body length, and a fifth flagellum runs along its margin. An axostyle, extending through the long axis of the body, can be seen protruding at the posterior end. A costa is present at the base of the undulating membrane. The nucleus

PLATE I

Female gametocyte of *Haemoproteus columbae* (slightly right of center). 3100 X.

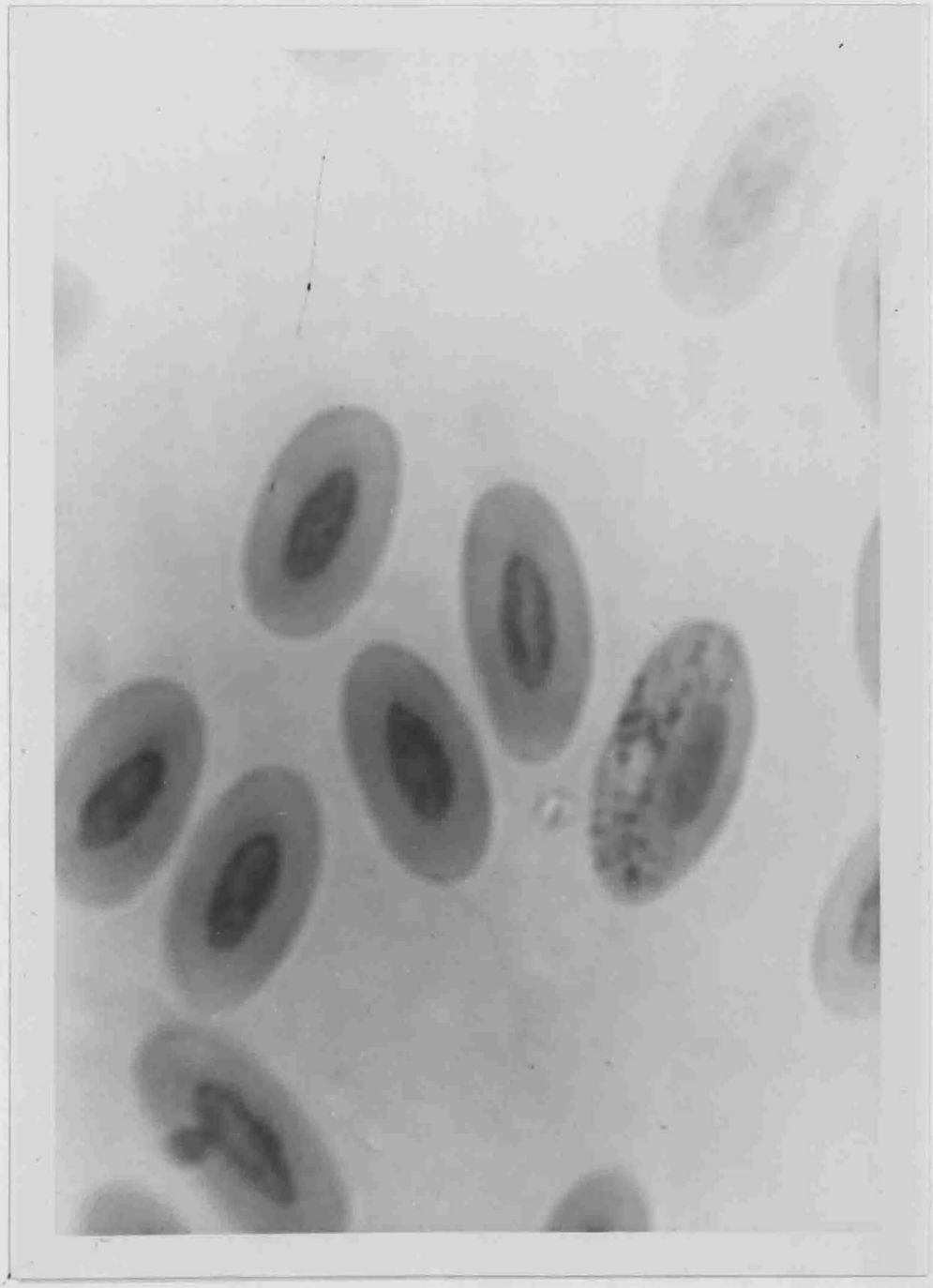
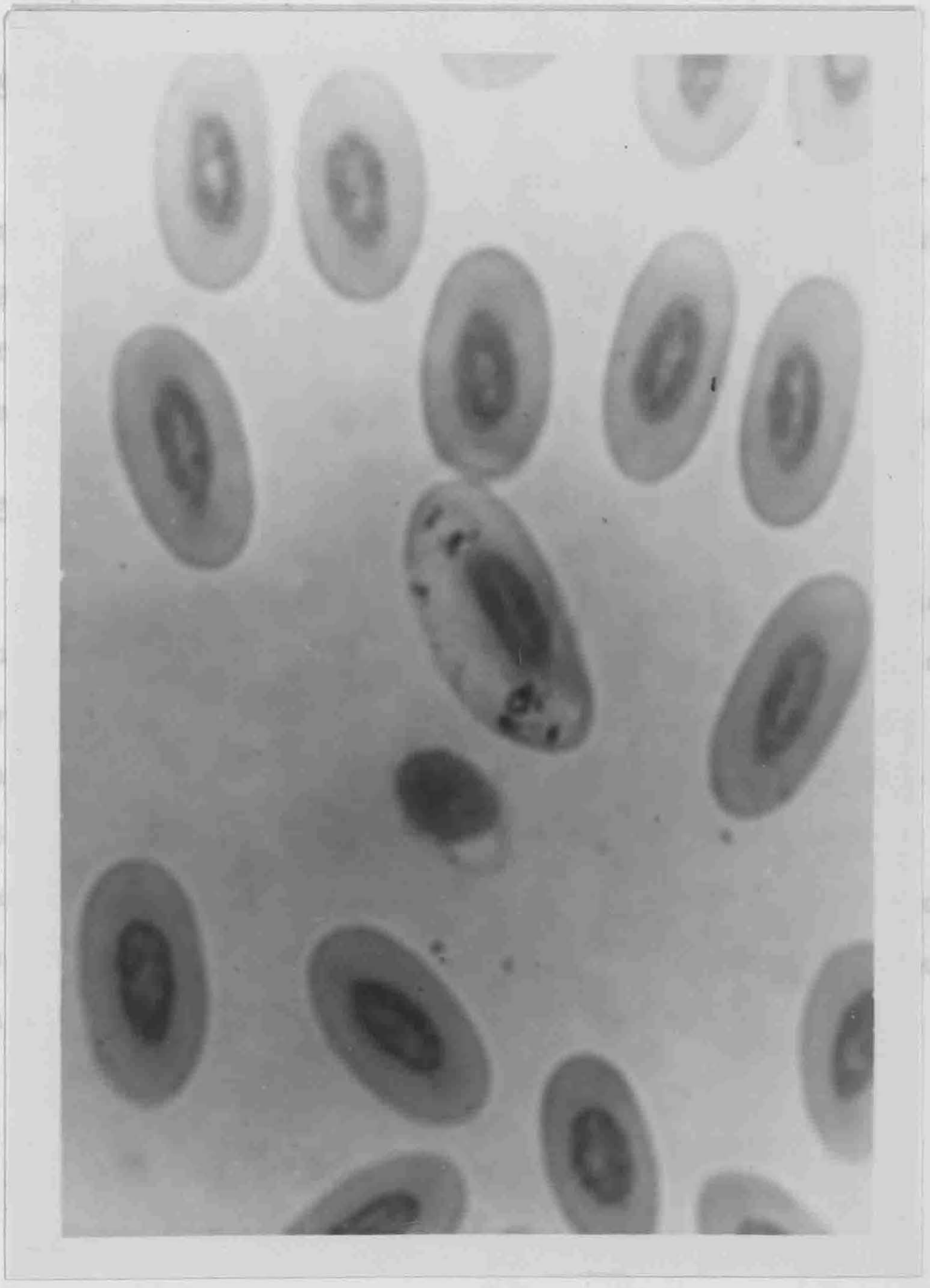


PLATE II

Male gametocyte of *Haemoproteus columbae* (center). 3100 X.



and blepharoplast are situated at the anterior end of the body.

Hexamita sp.

Organisms belonging to the genus Hexamita are pyriform, with two nuclei at the anterior end, six anterior flagella, two posterior flagella, and two axostyles. Refractile granules are present in the endoplasm. The organisms, found in one pigeon, measured 6 by 10 microns.

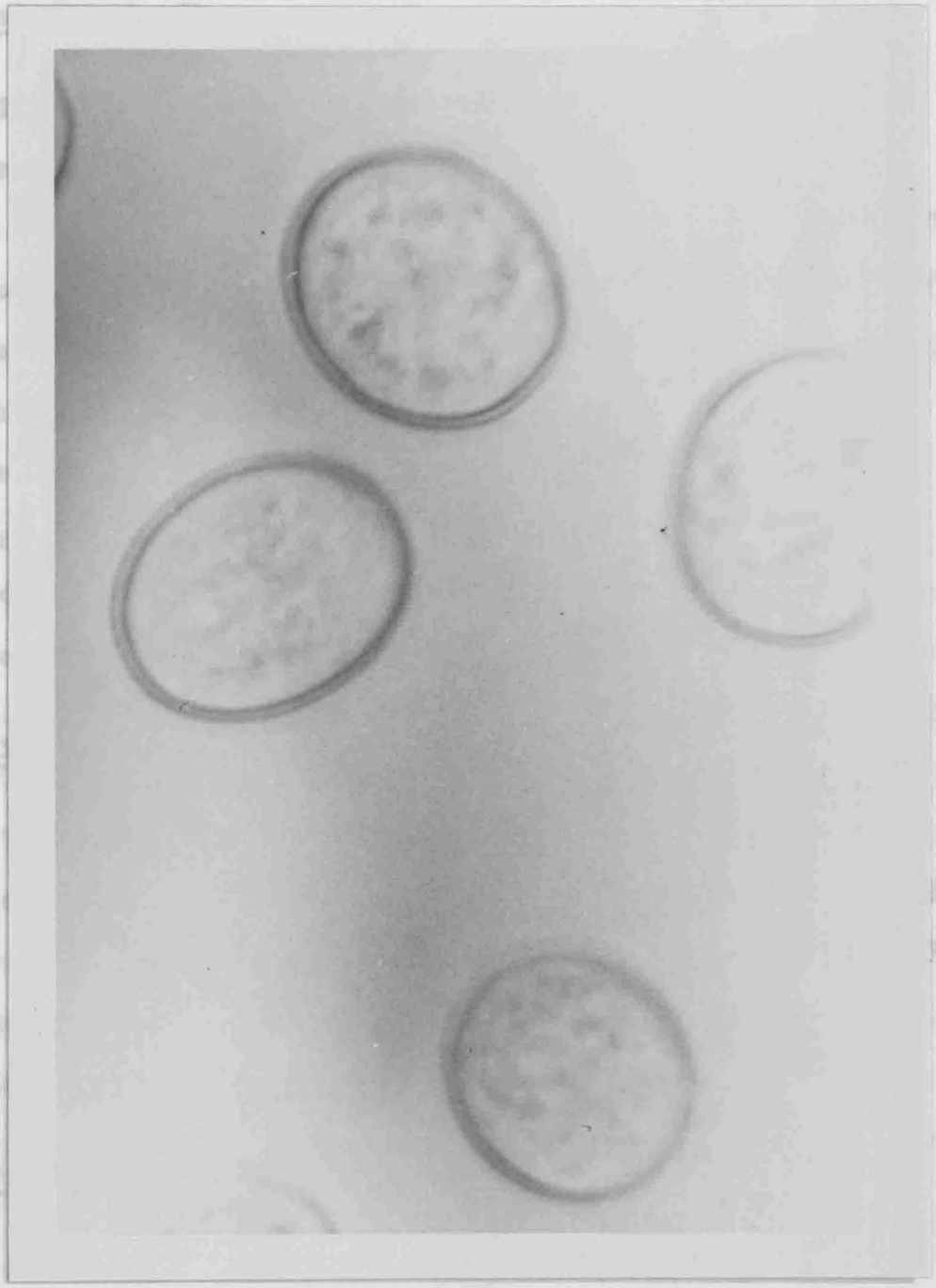
Eimeria labbeana

Eimeria labbeana, parasitic in the epithelial cells of the small intestine of pigeons, has round or elliptical oocysts measuring 15 to 26 microns by 14 to 24 microns (Plate III). The average oocyst size is 18.7 microns by 20.5 microns (Morgan and Hawkins, 1952). Oocysts are light yellowish brown in color without any visible micropyle. In the genus Eimeria each oocyst produces four spores, each with two sporozoites.

PLATE III

Oocysts of *Eimeria labbeana*.

2000 X.



## HELMINTHS

### Aporina delafondi

The pigeon tapeworm measures 70 to 160 mm in length. The small, globular, scolex, with four unarmed suckers, lacks a rostellum. Mature segments are wider than they are long and possess a dorsal and ventral pair of osmoregulatory canals. The ovary, a deeply lobed structure, is joined to a short muscular oviduct that connects to the vagina. The vagina and cirrus pouch open into a common genital passage. A genital aperture is lacking from mature and gravid segments. Eggs lack a pyriform apparatus and are not contained in capsules.

### Raillietina sp.

Tapeworms of this genus have a scolex with a double circle of hammer-shaped hooks, and suckers with small degenerate hooks. Genital apertures alternate irregularly or are unilateral. Testes are numerous, and one or several eggs are contained in parenchymatous pouches.

### Ascaridia columbae

Males of this species of nematodes measure 35 to 42 mm long; females are 43 to 54 mm long. The mouth has one median and two lateral lobes. Each median lobe has two small papillae.

The tail of the male is provided with a pre-anal sucker measuring 150 to 200 microns long by 150 to 160 microns wide. Males have 14 pairs of caudal papillae, and small caudal alae are present on each side of the tail. The vulva of the female is near the middle of the body, and the anus is 1.2 mm from the end of the tail. A longitudinal depression is present posterior to the anus. Eggs, deposited in the single cell stage, are 74 to 84 microns long and 49 microns wide.

## Capillaria columbae

Capillaria columbae, a slender, thread-like nematode, is found in the small intestine of pigeons. The males measure 8.4 to 13.8 mm in length and 50 to 70 microns in width; females are 10 to 18 mm long and 80 to 110 microns wide. A small bursal lobe, connected by a delicate membrane, is present on either side of the cloacal opening. The male's spicule is 1.2 to 1.7 mm long, and its spicule sheath possesses transverse folds. The vulva of the female, posterior to the junction of the esophagus and intestine, is located on a slight prominence. The eggs are operculated and measure 44 to 60 microns long and 23 to 27 microns wide (Plate IV).

PLATE IV

Egg of *Capillaria columbae*.

2500 X.

Ornithostrongylus quadriradiatus

This species of delicate, slender nematodes is characterized by a vesicular enlargement about the head. The simple mouth is unarmed and without papillae. The cuticle is longitudinally striated, and when freshly collected, the worms have a distinct red color. Males measure 9 to 12 mm long; females are 18 to 24 mm long. The bursa of the male is bilobed with no distinct dorsal lobe and its ventro-ventral and ventro-lateral rays are parallel and lie close together. The dorsal ray is short and possesses a stumpy process on each side near its base. Spicules are 150 to 160 microns long, and each terminates in three sharp points. The vulva of the female is 5 mm from the end of the tail, and the anus is 140 microns from the end of the tail. Eggs are 70 to 75 microns long and 38 to 40 microns wide.

Heterakis gallinae

The cecal worm is a small, white nematode with its head bent dorsally from the region of the esophageal bulb. The mouth has three small lips without teeth. Males are 7 to 13 mm long, and have straight tails terminating in points. Two large bursal lobes are present just anterior to the tip of the tail. A preanal sucker, 60 to 75 microns in diameter, and 12 pairs of papillae are located on the ventral side of the body. The female is 10 to 15 mm long and possesses a long, pointed tail. The vulva, just posterior to the middle of the body, is about 4.5 mm from the bifrication of the uterus.

Eggs are thick-shelled, ellipsoidal, and measure 63 to 71 microns long and 38 to 48 microns wide (Plate V).

ECTOPARASITES

Falculifer rostratus

Feather mites of this genus have a propodorsomal shield fitted with a pair of dorsal setae. Legs III and IV are often stouter than the others. Heteromorphic males with deviations from the normal in legs I and II and in chelicerae are occasionally seen. Falculifer rostratus occurs most frequently between adjacent barbs on the flight feathers of pigeons (Plate VI).

Columbicola columbae

The genus Columbicola includes the most slender of the biting lice. Columbicola have an elongated head in front of the five-segmented antennae, and a clypeus with two pairs of dorsal spines. The first segment of the antennae is much enlarged. Columbicola columbae is found on the long flight feathers of pigeons (Plates VII & VIII).

Goniocotes bidentatus

This louse has the following characteristics: a broad, rounded, abdomen, a metathorax fused with the mesothorax, and angulate temples. No prongs are present on the antennae of the male, and spines in front of the insertion of the antennae in both sexes are lacking.

PLATE V

Egg of *Heterakis gallinae*.

1500 X.

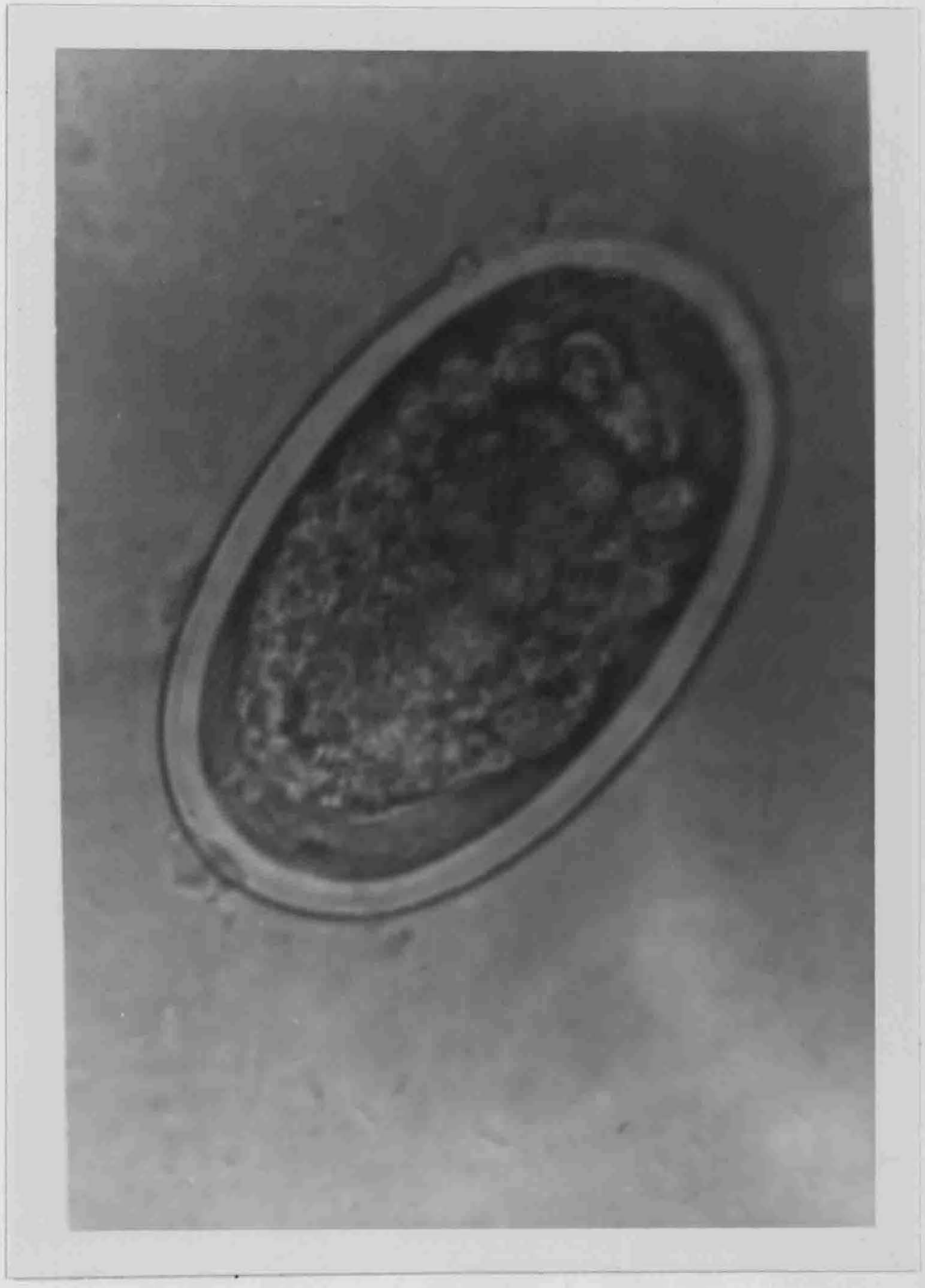


PLATE VI

Falculifer rostratus.

100 X.

PLATE VI

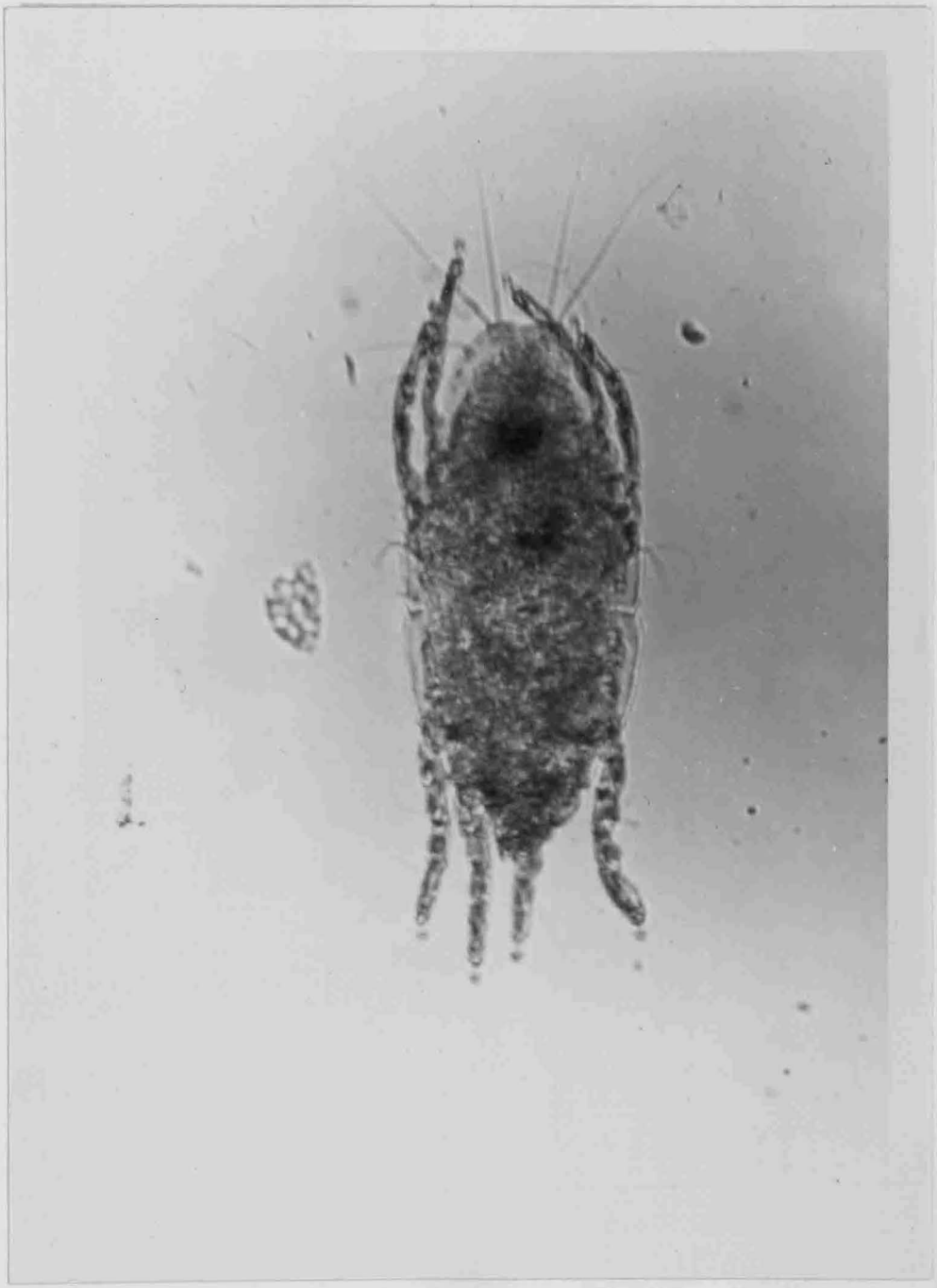


PLATE VII

Columbicola columbae (male).

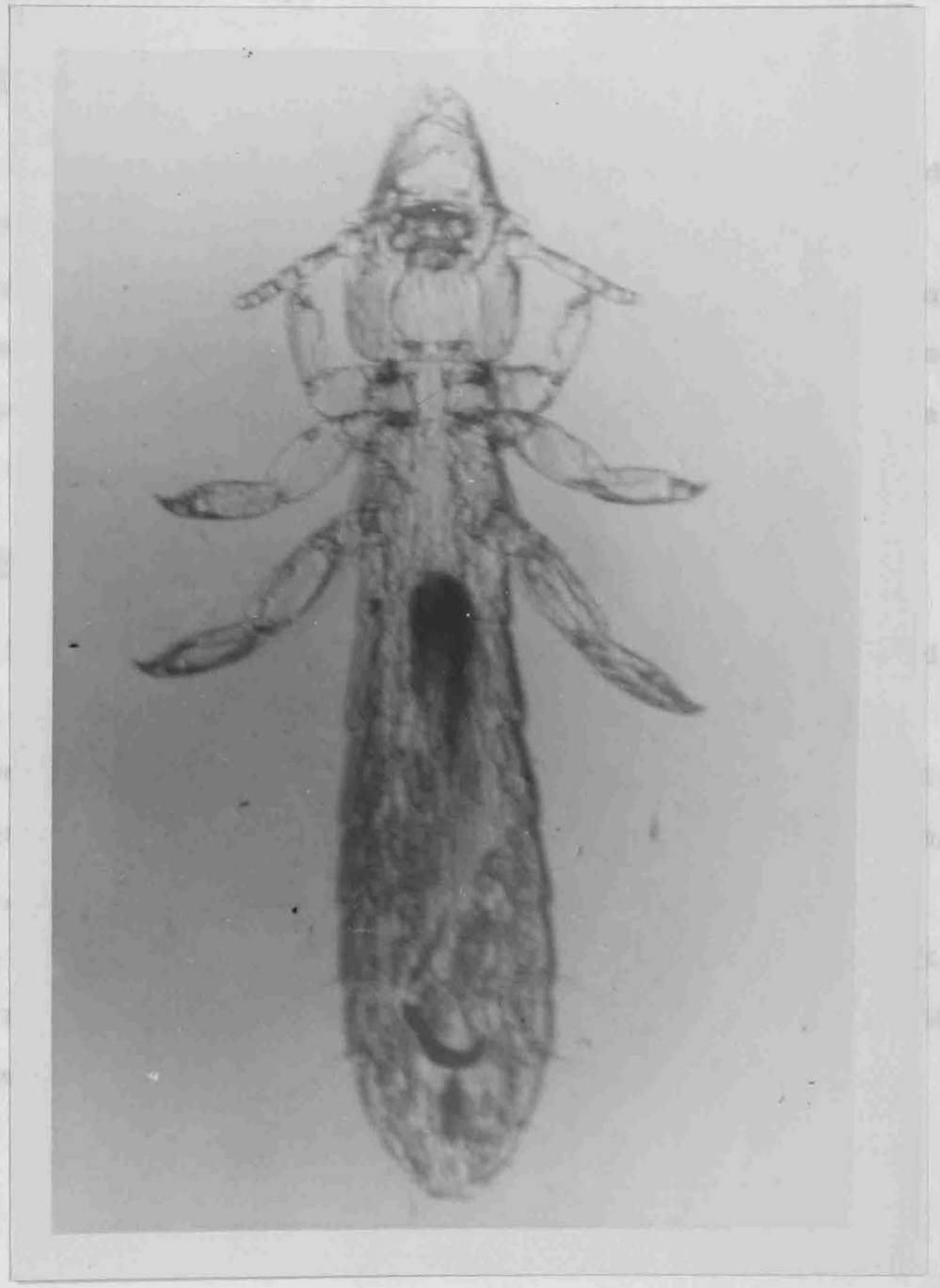
100 X.

PLATE VII

PLATE VIII

*Columbicola columbae* (female).

100 X.



Goniocotes bidentatus is found on the fluff feathers of pigeons (Plate IX).

Menacanthus latus

Spine-like processes, directed backward and downward, are present on the forehead of lice of this genus. The antennal fossae are covered dorsally by lateral expansions of the broadly triangular head. Two strong claws are present on the tarsi. Menacanthus latus (Plate X) is found at the base of the contour feathers of pigeons.

Pseudolynchia canariensis

The pigeon fly is a small, flat fly with a flattened head, short face, and palpi which form a sheath for the proboscis. The eyes are round or oval and ocelli are entirely absent. The sac-like abdomen, with chitinized basal segments, lacks distinct sutures. The short legs have short tarsi with strong claws. The wings, characterized by weak posterior veins, have five distinct veins behind the costa (Plates XI & XII).

PLATE IX

Goniocotes bidentatus.

125 X.

PLATE IX

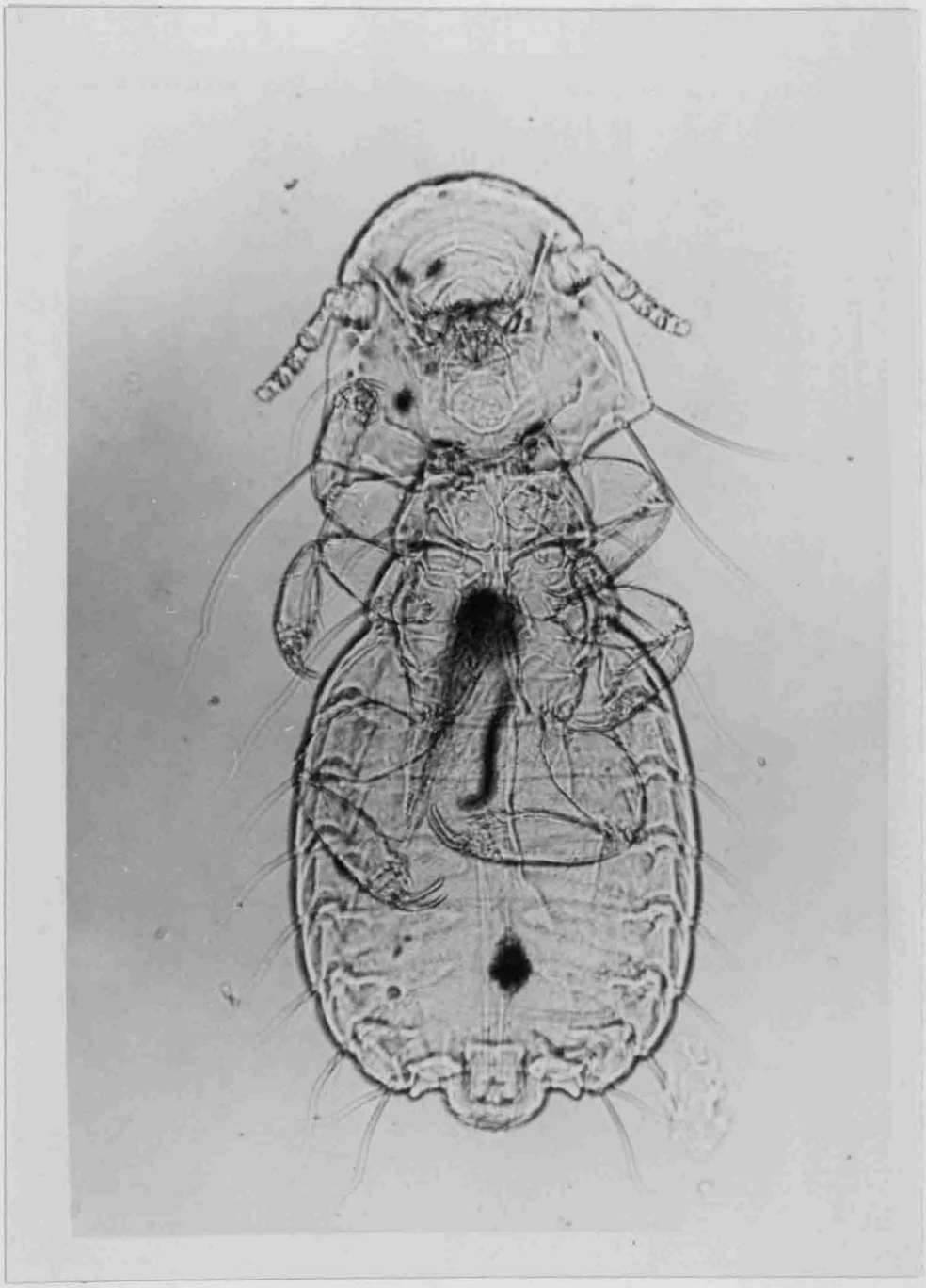


PLATE X

*Menacanthus latus*.

80 X.

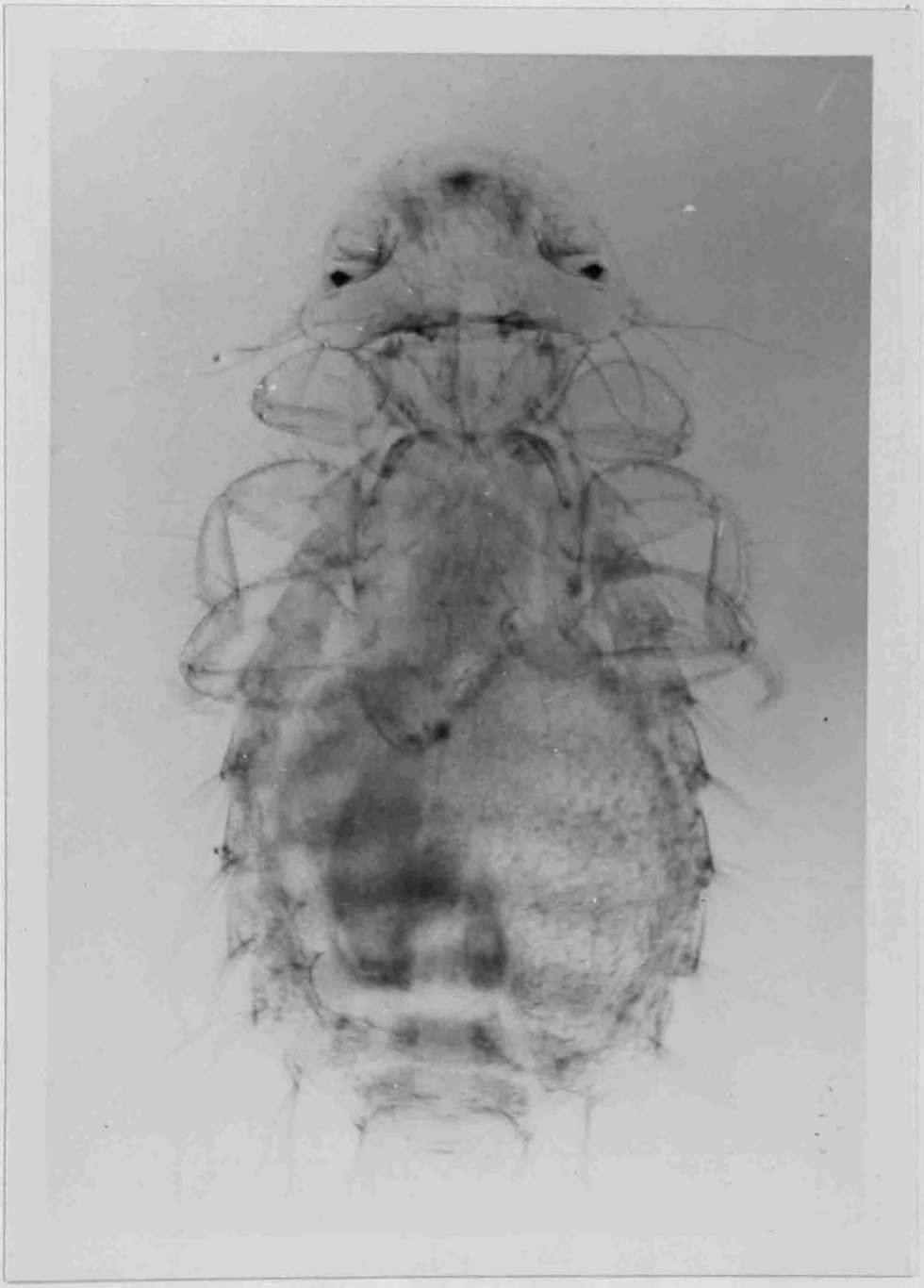


PLATE XI

*Pseudolynchia canariensis*.

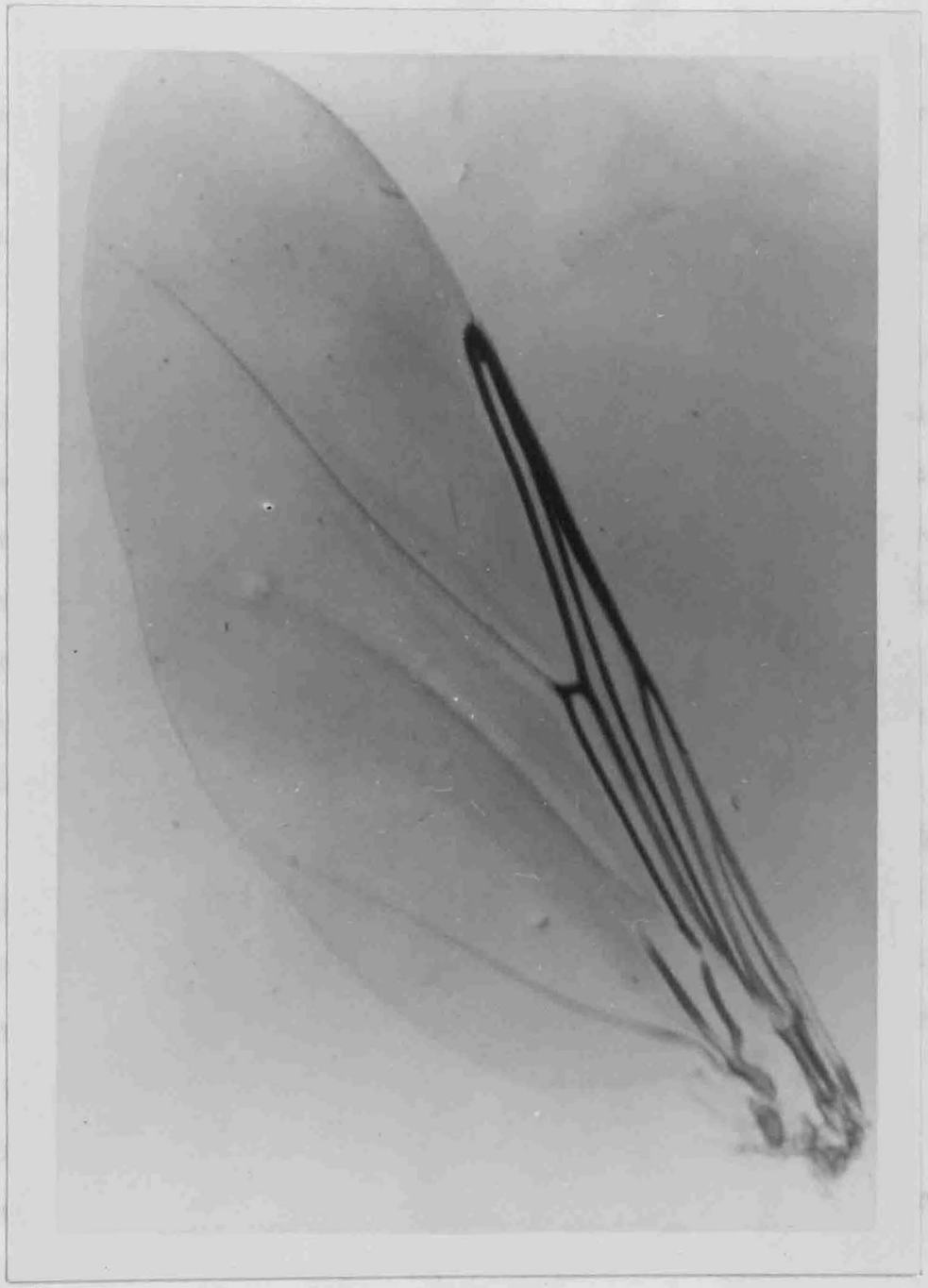
15 X.

PLATE XII

Wing of *Pseudolynchia canariensis*

(note weak posterior veins). 20 X.

PLATE XII



# VITA

Robert Flynn Jochen was born in Rahway, New Jersey on March 27, 1938. He attended elementary and secondary schools in Metuchen, New Jersey and was graduated from Metuchen High School in June, 1956 receiving the California Oil Company award for citizenship. In September of that year he began studies at the University of Virginia where he majored in biology. He was active in Phi Sigma, national, honorary biological society, and served as its vice-president. In his senior year he received an undergraduate teaching assistantship in biology. He was business manager of Mountain Lake Biological Station during the summers of 1959 and 1960. In June, 1960 he received the Bachelor of Arts degree.

Jochen began his graduate studies at the University of Richmond in September, 1960. He held a graduate assistantship for the 1960-61 session, and was awarded a Williams Fellowship for the 1961-62 session. He is a member of the Virginia Academy of Science and Beta Beta Beta, national biological society. During the summer of 1961 he was employed by the Virginia State Department of Agriculture as a veterinary bacteriologist.

Jochen plans to continue studies at the University of Pennsylvania in September, 1962.