A SURVEY OF PARASITISM OF THE STARLING *STURNUS VULGARIS* L. IN NORTH AMERICA*

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Scant knowledge of the nature and extent of parasitism as it exists in the starling in North America is available, yet this bird is, unfortunately, extremely common and widespread throughout this continent. Information pertaining to this subject might prove of value in establishing the importance of the starling as a disseminator of parasites among wild and domesticated birds, and as source material for teaching in the field of parasitology. In addition, a comparison of parasitism of the starling in North America with its occurrence in this host in Europe would reveal the possible role that this bird may have played in introducing parasites into North America on its importation in 1890; and at the same time it would demonstrate whether this alien bird has acquired other parasites from native birds since its sojourn here.

An attempt is herewith made to assemble data from previously published work on parasitism of the starling in North America and by a further examination of 300 starlings to give as complete a picture as possible of the parasites of this bird and an indication as to their prevalence in North America. This study, however, has been confined to the ectoparasites and to the parasites of the respiratory-digestive tract of the host, which for brevity's sake will henceforth be referred to as endoparasites.

MATERIAL AND METHODS

The present investigation is based on an examination of 300 starlings. For convenience these have been placed into two divisions—the 'summer' and 'winter' groups. The 'summer' birds comprise 175 individuals of which 149 are immatures (identified by the persistence of bursa fabricii) and 26 adults. The 'summer' birds were shot in New York state, the first eight in July, '44 and the remaining 167 between August 17 and October 11, '45, apparently in the progress of migration. The 'winter' group of 125 birds, of which all but four were adults, was killed between December, '44 and March, '45 and between November 24, '45 and April 27, '46 and came from the following states—New York (9); Massachusetts (41); Connecticut (6); Maryland (3); Ohio (19); and Indiana (47) (Tables 2, 4). A study of the ectoparasites was omitted for the first 13 individuals collected (July 8, '44; Dec. 5, '44–March, '45, New York state).

The examination of all of the birds was done within 24 hours following death of the host with the aid of a binocular microscope and with a strong light projecting on the region under observation. The ectoparasites were found on careful scrutinization

Received for publication, June 29, 1950.

* This investigation was under the direction of Dr. Robert Matheson as partial fulfillment of the requirements for the degree of Doctor of Philosophy at Cornell University, while the author was holding the Allen Seymour Olmstead Scholarship. Sincere appreciation is due to Dr. Bequaert of Harvard University, Dr. Van Cleave of the University of Illinois, Dr. Baker of the U. S. National Museum and to Drs. McIntosh and Wehr of the Bureau of Animal Industry for aid in identification of the parasites.

of both feathers and skin of the bird and subsequently preserved in 70% alcohol. The alimentary-respiratory tract was next removed and the endoparasites obtained by dissecting out the component portions of the tract in warm water in separate dishes. Half of the intestinal contents was centrifuged (sugar flotation method) and examined for PROTOZOA and worm eggs; the remainder was set aside for three days in 2% potassium dichromate solution and subsequently checked for presence of coccidial spores. PLATYHELMINTHES and ACANTHOCEPHALA were fixed in Bouin's fluid following relaxation in the refrigerator; permanent preparations were made later. NEMATHELMINTHES were dropped into hot glycerine-alcohol and studied as temporary mounts in lactophenol. In a few instances sections were prepared of portions of the digestive tract with parasites *in situ* to obtain a microscopic picture of such infestations.

The incidence of parasitism ranks high in *Sturnus vulgaris* L. since in the present investigation all were infested by one or more parasites—95.1% by ectoparasites and 99.0% by endoparasites. Ninety per cent of the 300 hosts harbored helminthes. As there was no significant difference in the numbers of immature and adult birds harboring the ectoparasites these data were omitted in table 2.

TABLE 1.—*Ectoparasites recorded for the starling in North America*

Classification Name of parasite	*	x	In present survey % Infection	Location on host	Origin
INSECTA					
Mallophaga					
Myrsidea cucullaris			—		Old World
Degeeriella nebulosa			72.5	body feathers	Old World
D. illustris			—		America
Menacanthus spinosum			81.5	body feathers	Old World
Diptera					
Ornithomyia fringillina	*		0.3	skin	Old World
Siphonaptera					
Ceratophyllus gallinae		x	1.7	skin	Old World
Epitedia wenmanni			—		America
ARACHNIDA					
Acarina					
Haemaphysalis leporis-palustris		x	—		America
Ixodes brunneus		x	—		America
Atricholaelaps megaventralis			—		America
Liponyssus sylviarum		x		skin, body f.	Old World
Dermanyssus gallinae	*	x	3.8	skin, body f.	Old World
D. prognephilus	*			skin, body f.	America
Trouessartia rosterii	*		60.3	wing feathers	Old World
Rivoltasia sp.	*		0.7	body feathers	?
Cheyletiella sp.	*		5.2	skin, body f.	?

* first published record for the starling in North America.
x parasites also of gallinaceous birds.

ECTOPARASITES

A total of ten ectoparasites has been recorded in published data for the starling in North America. These comprise two ticks, two mites, four lice and two fleas. This total does not include the finding of larvae *Protocalliphora* sp. on nestling starlings (Mason, 1936). The present investigation adds six parasites, five mites and an hippoboscid fly, to the original list, thus bringing the count to sixteen (Table 1).

In addition to determining the incidence and variety of ectoparasites on the starling, some observations were made on the habits of certain of them. For example, it was found that only the blood-sucking ectoparasites tended to leave the host following its death, while the 'feather-mites' and one species of lice remained on the

host's plumage. Furthermore two observations suggest that the starling may use its bill to free its body from vermin. The single bird that was found with a deformed bill was heavily infested with MALLOPHAGA—a condition similar to that noted in a junco by Worth (1940). Secondly, in a few cases, lice were present in the stomach contents, a finding which parallels the report of Fox (1940) on the presence of fleas in the starling's stomach.

INSECTA

MALLOPHAGA: Lice exhibit relatively high host-specificity, and those that parasitize the starling in Europe are *Myrsidea cucullaris Nitzsch, Degeeriella nebulosa* Burmeister, *Menacanthus spinosum* Piaget, and *Philopterus sturni* Schrank (Harrison, 1916; Thompson, 1936). The first three species and also *D. illustris* Kell., a parasite of the purely American family of birds, the ICTERIDAE, have been recorded for the starling in North America (Peters, 1936). Thus the starling on its importation brought with it three of its four species of lice and has since acquired an American louse (Table 1). It has apparently been responsible for the spread of *D. nebulosa* to the Eastern robin, *Turdus m. migratorius* L. (Wilson, 1928).

In the present study, *D. nebulosa* and *M. spinosum* were the only two lice found on the starling and both were located on the body plumage. Both species occurred on hosts from all the states furnishing them, and in three states (Conn., Ind., Mass.) provide new state records. Undoubtedly they are to be found wherever the starling is present. The incidence of mallophagan infestation was high, 93.4%, even higher than that of 85.5% for 76 starlings examined by Geist (1935). New data on their frequency of occurrence proved to be of interest (Table 2). There was a marked reduction in number of infected birds and in number of lice per bird during the winter months (Fig. 1). The percentage of infestation was 68.3 and 71.9 for *D. nebulosa* and *M. spinosum*, respectively, in the 'summer' compared to 25.0 and 35.0 for the 'winter' group. Lice were entirely absent in January and few, predominantly nymphs, were present in February. Two types of eggs could be distinguished amongst the plumage, differing from each other in shape and location. Since eggs of different species of MALLOPHAGA have not as yet been described, it was first necessary to observe hatching in order to be certain of their identification. When this was done and the presence of eggs taken into account (with or without lice) the percentage of infestation changed to 76.6 and 79.0 in the 'summer' group and rose as high as 66.7 and 84.2 in the 'winter' group of individuals. It would seem, therefore, that the reproductive cycle has been slowed down with low temperatures and that these lice tend to 'winter-over' in the egg stage as suggested by Peters (1928) for bird lice in general.

Degeeriella nebulosa (ISCHNOCERA: PHILOPTERIDAE): This species remains alive long after the death of its host, and if the bird's skin is kept at room temperature it may be found biting at the plumage even as long as two or three weeks. The *Degeeriella* show some resistance to cold since most survive on bird skins kept in the refrigerator at 10° C. up to the fourth or fifth day. There was no indication of blood in their intestines. These observations support the findings of Wilson (1934) and others, namely, that the feathers alone supply the necessary food and water to the ISCHNOCERA lice. The egg is located on the under surface of the vane of the body feather, usually at a distance of 300–500 μ from the rachis and one to two mil-

TABLE 2.—*Incidence of starlings infected by ectoparasites in eastern North America*

	Date	Source	No. Birds examined	Insecta Mallophaga: *Degeeriella nebulosa* birds infected by adults		Insecta Mallophaga: *Degeeriella nebulosa* birds infected by eggs		Insecta Mallophaga: *Menacanthus spinosum* birds infected by adults		Insecta Mallophaga: *Menacanthus spinosum* birds infected by eggs		Diptera: *Ornithomyia fringillina*	Siphonaptera: *Ceratophyllus gallinae*	Parasitoidea	Arachnida Acarina: *Trouessartia fosterelli*	Arachnida Acarina: *Rhyncholaspis* sp.	Arachnida Acarina: *Chevletiella* sp.
				No.	%	No.	%	No.	%	No.	%	No.	No.	No.	No.	No.	No.
SUMMER	Aug. '45	N. Y.	71	49	69.0	55	77.5	39	54.9	46	64.8	—	—	10	67	—	1
	Sept. '45	N. Y.	64	49	76.6	51	79.7	56	87.5	58	90.6	1	4	1	61	—	1
	Oct. '45	N. Y.	32	16	50.0	22	68.8	25	78.1	29	90.6	—	—	—	32	—	—
	Nov. '45	Mass. Conn.	3 6	— 4	— 44.4	1 6	— 77.8	3 6	— 100.0	3 6	— 100.0	—	—	—	—	2	—
	Dec. '45	N. Y. Mass. Ohio	1 18 7	1 2 —	— 11.5 —	1 3 3	— 34.6 —	1 10 1	— 46.2 —	1 14 6	— 80.7 —	—	—	—	—	—	—
WINTER	Jan. '46	Mass. Ohio Ind.	11 7 24	— — —	— 0.0 —	— 4 23	— 64.3 —	— — —	— 0.0 —	5 — 23	— 83.3 —	—	—	—	—	—	1
	Feb. '46	Mass. Ohio Ind. Md.	3 16 3	— 7 1	— 33.3 —	1 4 2	— 85.2 —	— 2 —	— 28.6 —	3 3 16	— 81.5 —	—	—	—	—	—	1 10
	Mar. '46 Apr. '46	N. Y. Mass. Ind.	8 1 7	7 — 7	87.5 — —	7 — 7	87.5 — —	7 — 6	81.2 — —	8 — 6	87.5 — —	—	1 — —	—	6 — 7	— — —	1 2
	TOTAL		287	144	50.2	208	72.5	162	56.4	234	81.5	1	5	11	173	2	15
	'summer' group		167	114	68.3	128	76.6	120	71.9	133	79.0	1	4	11	160	—	—
	'winter' group		120	30	25.0	80	66.7	42	35.0	101	84.2	—	1	—	13	2	15

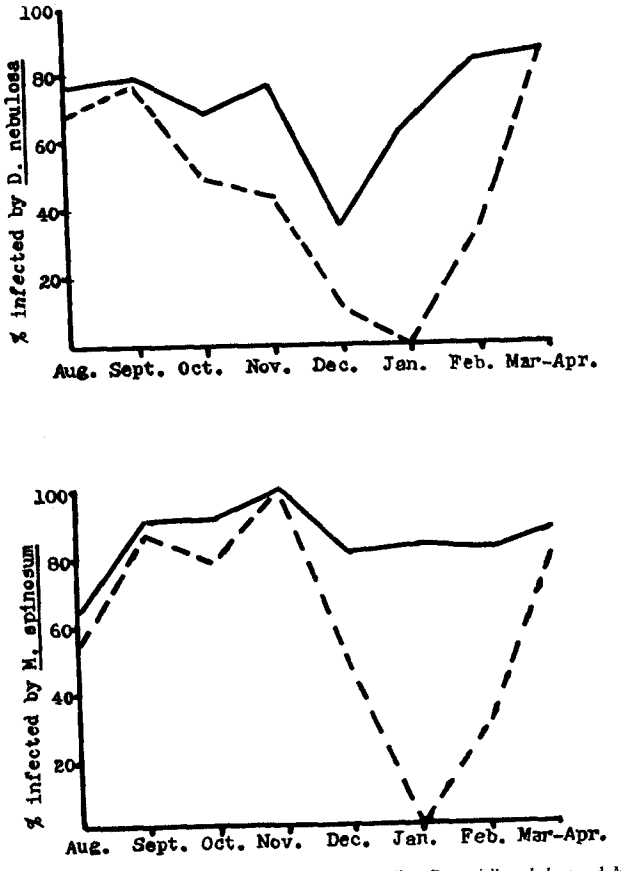

FIG. 1. Percentage incidence of starlings infected by lice, *Degeriella nebulosa* and *Menacanthus spinosum* between August, 1945 and March–April, 1946.
KEY: ——= presence of eggs with or without lice.
– – – = presence of lice.

limeters anterior to the end of the calamus, so that it is frequently overlapped by the aftershaft (Fig. 2). It is held in place by its base which is encircled and matted-over by the clumping together of barbules from adjacent barbs. In a heavy infestation several eggs may occur on the same feather, arranged one above the other and they may be found on either side of the shaft. The egg is cylindrical in shape, 550 μ in length with a cap 50–60 μ in height. Scattered irregularly over the cap are 22 micropyles and occasionally a slight thread is evident arising from its peak.

Menacanthus spinosum (AMBLYCERA: MENOPONIDAE): This species is short-lived once its host dies, and is dead by the second or third day even though the bird skin is kept at room temperature or in an incubator at 34° C. This and the fact that the intestines of the nymphs, in particular, were invariably red, substantiate the belief that blood is essential in the diet of the AMBLYCERA lice. The egg is attached by an apparently sticky secretion at its base to the under surface of a body feather at the level of the emergence of the aftershaft, and usually occurs singly or on rare occasions two or three per feather may be present (Fig. 3). It is oval to cylindrical in shape with a cap that terminates in a long tapering thread. The body portion of the egg measures 500–600 μ in length with its greatest width 255 μ. The cap proper is 123 μ high and the slender thread 600 μ long, so that the entire length of the egg is approximately 1.3 mm. The base of the cap is encircled by 14 micropyles, arranged relatively evenly in a single row. The cap on hatching separates from the rest of the egg case directly below the level of the micropyles.

DIPTERA: The fly, *Ornithomyia fringillina* Curtis (HIPPOBOSCIDAE), was taken on only one occasion, from a juvenile in September in New York state (Table 2). This marks the first published record of an hippoboscid fly attacking a starling in North America, though one was reported earlier from the same state in a private communication from Dr. Bequaert. Numerous birds may act as hosts to *O. fringillina*, including the starling in Europe (Thompson, 1937b). Probably the starling with the English sparrow may be responsible for its introduction into this country.

SIPHONAPTERA: The two fleas that have been previously collected from the starling in North America are *Epitedia wenmanni* Rothschild (a flea of the white-footed mouse) and *Ceratophyllus gallinae* Schrank (Fox, 1940). Only the latter was taken by the author (Table 2). Fleas exhibit relatively slight host-specificity compared to the MALLOPHAGA so that the record of *E. wenmanni* on the starling is not too surprising. It has evidently been acquired by the starling since its sojourn here. *Ceratophyllus gallinae* was encountered on four juveniles in September and on a female in April, all from New York state. Only one or two fleas were present per bird. It was observed that they were able to withstand the low temperatures of the refrigerator (10° C.) for at least six days. These constitute the first record in North America of *C. gallinae* taken from the skin of *Sturnus vulgaris* since the one reported by Fox had come from the animal's stomach. This is the commonest flea for the starling in Europe (Thompson, 1937a). According to Ewing and Fox (1943) *C. gallinae* was introduced into North America in the early part of the century, being first discovered in a 'henhouse' at Ottawa in 1909. Possibly the English sparrow or starling played a role in its introduction into this country.

ARACHNIDA

ACARINA: No ticks were found by the author. This is not strange since the majority of the birds came from New York state and those from more southerly states, Maryland, Ohio, and Indiana, numbered only 69 and were collected between December and April. The starling in North America, however, has been found to harbor two species of ticks—*Ixodes brunneus* Koch and *Haemaphysalis leporis-*

palustris Packard (Bishopp and Trembley, 1945). *Ixodes brunneus* is exclusively a bird tick with a large host list. Its original description was based on material from North America. According to Cooley and Kohls (1945, p. 208), "It is not

FIG. 2. Egg of *Degeeriella nebulosa* in situ on feather.
FIG. 3. Egg of *Menacanthus spinosum* in situ on feather.
FIG. 4. *Trouessartia rosterii:* A, a cluster in situ on feather; B, egg in situ on feather.
FIG. 5. Egg 'nest' of *Cheyletiella* sp., its protective covering of skin debris having been removed so as to reveal the eggs.

probable that *brunneus* has been carried on birds across the Atlantic Ocean, and it follows that records of this species in Europe and Africa are subject to scrutiny". The rabbit tick of America, *Haemaphysalis leporis-palustris,* is abundant especially in the south and is also widespread among birds. Bishopp and Trembley (1945)

listed 64 species of birds that act as its host, including the starling. Katz (1941) reported it from the starling in Ohio and Peters (1936) for the same bird in Ohio, Virginia and Delaware. It would thus seem that the starling has acquired both these ticks since its sojourn in North America.

Although no ticks were found in the present investigation, mites had infected 67.2% of the birds. For convenience, the mites are grouped into the blood-sucking forms in contrast to the 'feather-mites' that live on the skin and plumage debris and are rarely harmful (Banks, 1915). Two species of blood-sucking mites (PARASITOIDEA) have been reported for the starling in North America—*Atricholaelaps megaventralis* Strandtmann and *Liponyssus sylviarum* C. & F. (LAELAPTIDAE). The former was not observed by the author, but two additional mites, *Dermanyssus gallinae* Deeger and *D. prognephilus* Ewing (DERMANYSSIDAE) were collected. This brings the number of blood-sucking mites to four for the starling in North America (Table 1). Only a few of them were recovered and these were scattered on the plumage of 11 juveniles from New York state in August and September, 1945 (Table 2). The northern fowl mite, *L. sylviarum* is widely distributed throughout the world and has been reported from numerous birds on this continent, including the starling in Canada (Rayner, 1932; Cameron, 1938) and in the United States (Peters, 1936). It was first recorded on this continent in 1920 on poultry and possibly the starling and/or the English sparrow are responsible for its introduction into North America and the same may be true for the chicken mite, *D. gallinae.* The chicken mite is also common and occurs probably wherever poultry are raised (Ewing, 1923). However, the present study marks the first record for the starling in North America. The American species, *D. prognephilus* infests hole-nesting birds such as the eastern bluebird, purple martin, woodpeckers, as well as the cowbird and has been collected from the following states—Maryland, Alabama, Virginia, South Carolina, Michigan, and Ontario (Ewing, 1936). The author reports this species for the first time for the starling and also as a new record for New York state. It has evidently been acquired by this alien bird while usurping the nesting sites of native birds. A similar condition occurs for the mite, *A. megaventralis* which has been taken from hole-nesting animals—squirrels, numerous woodpeckers, from a cliff swallow's nest and in addition from the skins of both the English sparrow and the starling and from 10 states (Ohio and Pennsylvania to Florida and Texas) (Strandtmann, 1947).

Three species of 'feather-mites' were collected by the author, *Trouessartia rosterii* Berl. (EUSTATHIIDAE), *Rivoltasia* sp. (EPIDERMOPTIDAE) and *Cheyletiella* sp. (CHEYLETIDAE) (Table 2), though none has previously been reported for the starling in North America. Since *T. rosterii* is a common parasite of the starling in Europe along with two other species, *Analges passerinus* L. and *Pteronyssus truncatus* Hall var. *quadratus* Berl. (Bonnet and Timon-David, 1934), its presence in North America may be accounted for by its parasitizing those starlings that were imported.

Trouessartia rosterii is ordinarily located on the inner wing surface and lies between adjacent barbs with its head pointing toward the edge of the feather and its posterior end toward the rachis (Fig. 4A). As many as 60% of the starlings harbored this 'feather-mite,' but there was a striking difference in occurrence between the summer and winter months (Table 2). The 'summer' group showed a 96% in-

cidence and the mites were present in great numbers, in particular on the last primaries, the secondaries and on both surfaces of the greater inner coverts. On the other hand, in the 'winter' group only a few were to be found and these occurred on 11% of individuals, which represented the March–April set of birds. They were restricted to the innermost secondary or to the innermost greater covert of the wing. This reduction in prevalence of 'feather-mites' may be the outcome of reduced reproductive activity and development due to the low winter temperatures. The eggs are most frequently to be found on the under surface of the greater coverts within the proximal two thirds of the vane (Fig. 4B). Each egg is attached singly to the distal edge of the barb, thus overlapping the distal barbules of that region, with its long axis parallel to that of the barb. The egg is cylindrical in shape and measures 240 $\mu \times 70$ μ.

Rivoltasia sp. was found on only two birds taken in November, 1945 from Connecticut, and occurred deep down in the ventral body feathers.

Cheyletiella sp. was collected from 15 starlings, in three states—Indiana (13, Jan.–Apr.); Ohio (1, Feb.); New York (1, March), making an incidence of 5 per cent. The mites were found most frequently on the ventral body plumage. They are difficult to discern with their small yellow bodies and slow crawling movements. They, like the other 'feather-mites,' when few in number on the host, tend to escape detection, so that the percentage of occurrence may be greater than that stated. The eggs of this species of mite are laid singly on the body surface or occasionally in clusters or 'nests' covered over by a few layers of dead stratified squamous epithelium and feather debris. Each 'nest' (Fig. 5) consists of a small elevation of dried, paper-like skin containing within it several eggs and cast skins of mites. The egg is oval, measuring 152–180 μ by 76–83 micra.

ENDOPARASITES

A total of eight endoparasites has so far been recorded in previously published data for the starling in North America (Table 3). This comprises *Isospora* sp., two cestodes (if one discredits two questionable identifications); three nematodes and two acanthocephalans. This information has been obtained largely from scattered references in the literature. Two papers, however, deal solely with the starling. One is by Sommer (1936) who retrieved two tapeworms and an acanthocephalan in an examination of the trachea and intestines of 132 birds. The other is a report by Cannon (1939) who took two tapeworms and a nematode from the intestines of 11 individuals. The present investigation adds to the original list an unidentified flagellate, three trematodes, a third cestode, four nematodes and possibly a third acanthocephalan worm (Table 3). A seasonal variation in incidence of tapeworms has been observed and some original and revised descriptions of certain endoparasites have been included.

PROTOZOA

MASTIGOPHORA: As far as is known there have been no records for flagellates in starlings. However, an unidentified flagellate was found in enormous numbers amongst the fecal contents of a single adult (Table 4).

SPOROZOA: COCCIDIA of the family EIMERIIDAE have been recorded for the starling in Europe as *Isospora lacazii* Labbé (1896) and in America as *Isospora* sp.

(Boughton et al, 1938) and, as pointed out by these workers, the genus is cosmopolitan and widely distributed among the PASSERIFORMES. However, its frequency of occurrence in the starling has not been reported. The incidence in the present study is 75% and this high figure is consistent throughout the seasons studied (Table 4). Gross or microscopic lesions caused by the coccidia were not observed. The oöcyst is typically spherical to subspherical in shape with a three layered wall and measures 20.8–28.0 $\mu \times 20$–27 μ. Sporulation occurred in approximately 24 hours at room temperature. This agrees with observations of Henry (1932) though others (Labbé, 1896; Becker, 1934; Kudo, 1939) stated that it varied from three to, in some cases, 15 days. Each sporocyst is pear-shaped with a prominent knob at the narrow end and contains four sporozoites and a large centrally placed residual body. The average size is 16.6 $\mu \times 10.4$ μ ranging from 15–18 $\mu \times 9.5$–12.0 μ. These dimensions and those of the oöcyst fall within the range of measurements for *I. lacazii* (Boughton, 1930; Skidmore, 1934) found in the English sparrow.

TABLE 3.—*Endoparasites of respiratory-digestive tract for the starling in North America*

Classification Name of parasite	*	x	In present survey % infection	Location in host	Origin
PROTOZOA					
Mastigophora					
Unidentified flagellate	*		0.3	intestine	?
Sporozoa					
Isospora sp.	—		75.3	intestine	Old world
PLATYHELMINTHES					
Trematoda					
Leucochloridium certhiae	*		0.3	cloaca	America ?
Lutztrema sp.	*		0.3	gall bladder	America ?
Brachylaemus sp.	*		0.3	intestine	America ?
Cestoda					
Hymenolepis farciminosa	—		34.0	post. half small intestine	Old world
Choanotaenia musculosa	—		56.3	anterior half	Old world
Paricterotaenia parina	*		5.7	small intestine	Old world
ACANTHOCEPHALA					
Plagiorhynchus formosus		x	4.0	post. half	America ?
Mediorhynchus robustus (*M. grandis*?)		—	2.0	intestine	America
NEMATHELMINTHES					
Capillaria contorta	*	x	11.3	esophagus	Old world
C. oropunctatum				intestine	Old world
C. exilis	*		60.7	intestine	Old world
Dispharynx nasuta		x	4.3	proventriculus	Old world
Microtetrameres helix (?)	*		0.3	proventriculus	America
Acuaria gracilis v. *sturni*	*		3.3	gizzard	Old world
Porrocaecum ensicaudatum	—		5.7	intestine	Old world
ARTHROPODA-ARACHNIDA					
Acarina					
Speleognathus sturni	—		4.3	respiratory tract	Old world ?

* first published record for the starling in North America.
x parasites also of gallinaceous birds.

PLATYHELMINTHES

TREMATODA: There have been no records of flukes for the starling in North America, except for the experimental infection of a fledgling with *Leucochloridium actitis* following artificial feeding with snails carrying its sporocysts (McIntosh, 1939). In the present study three species of trematodes and an immature form have been found, but each was encountered in only a single bird (Table 4).

Lutztrema sp. (DICROCOELIIDAE). Ten liver flukes were collected from an adult female.

TABLE 4.—*Incidence of starlings infected by endoparasites of the respiratory-digestive tract in eastern North America. First figure signifies total number of birds; figure in parenthesis denotes numbers of juveniles*

			Protozoa			Platyhelminthes							
			Mastigophora	Sporozoa	Trematoda a. *Lutztrema* sp. b. *Brachylaemus* sp. c. *Leucochloridium certhiae* d. Immature					*Hymenolepis farciminosa*		Whole	
Date	Source	Birds No. examined	Unidentified	*Isospora* sp.									
			No.	No.	%	a. No.	b. No.	c. No.	d. No.	No.	%	No.	%
July '44	N. Y.	8(4)	..	6(2)	75	..	..	..	..	2	25	2	25
Dec. '44–Mar. '45	Mass.	5	..	3	60	..	1	..	..	2	40	1	20
Aug. '45	N. Y.	71(66)	..	53(48)	75	..	..	..	..	23(21)	32	23	32
Sept. '45	N. Y.	64(49)	..	48(38)	75	..	..	..	..	22(13)	34	22	34
Oct. '45	N. Y.	32(30)	..	25(24)	78	..	..	..	..	7(7)	22	6	19
Nov. '45	Mass.	3(1)	..	2	44	1	..	..	..	2	33	1	11
	Conn.	6(2)	..	2			..	..	..	1		..	
Dec. '45	N. Y.	1	1	..	81	..	..	..	..	..	54	..	38
	Mass.	18(1)	..	15(1)		..	..	..	..	11(1)		7	
	Ohio	7	..	5		..	..	..	..	3		3	
Jan. '46	Mass.	11	..	8	76	..	..	..	..	1	29	1	9
	Ohio	7	..	5		..	..	..	..	1		1	
	Ind.	24	..	10		..	..	..	..	10		2	
Feb. '46	Mass.	3	..	2	89	..	..	1	..	2	37	1	15
	Ohio	5	..	4		..	..	..	..	1		1	
	Ind.	16	..	15		..	..	..	..	5		2	
	Md.	3	..	3		..	..	..	..	2		..	
Mar.–Apr. '46	N. Y.	8	..	4	62	..	..	..	1	3	44	2	31
	Mass.	1	..	..		..	..	..	..	1		1	
	Ind.	7	..	6		..	..	..	..	3		2	
TOTAL		300(153)	1	226(115)	75	1	1	1	1	102(42)	34	78	26
'Summer' group		175	..	132	75	..	..	..	..	54	31	53	30
'Winter' group		125	1	94	73	1	1	1	1	48	38	25	20
PERCENTAGE			0.3		75	0.3	0.3	0.3	0.3		34		26

Description: (Fig. 7). Body semi-transparent, elongate 1.93–2.85 mm. long by 227–386 μ at acetabulum, the maximum width, tapering at the extremities, the anterior narrowing starting at the level of the genital aperture; cuticle smooth. Suckers weakly muscular; oral sucker 87.5–133 μ long by 98–125 μ wide, subterminal to a short lip-like projection of body wall; acetabulum 148–221 μ long by 153–228 μ wide situated within the anterior third of the body. Pharynx shorter than broad, 38–60 μ long by 44–70 μ wide, overlapping the posterior edge of the oral sucker. Esophagus narrow continued posteriorly by a single intestine that takes a zigzag course passing lateral to and between the two testes and between the posterior testis and ovary, keeping dorsal to the vitellaria and uterus and terminating blindly a short distance from the posterior end of the body. Excretory pore terminal. Genital aperture median approximately half-way between the oral and ventral suckers. Cirrus sac elongate, pyriform, 130–188 μ long by 55–86 μ wide, containing a folded seminal vesicle and an eversible cirrus. Testes spherical to transversely oval, never lobed, approximately equal in size, 86–141 μ long by 102–188 μ wide, located diagonally in front of each other in the posterior region of the anterior half of the body. The distances in the different specimens between acetabulum and anterior testis, anterior and posterior testes and posterior testis and ovary show marked variations, namely—94 to 241 μ; 17 to 93 μ, and 7 to 78 μ respectively. Ovary subspherical to transversely oval, 70–92 μ long by 95–123 μ wide, situated off centre about mid-way along the body length. Seminal receptacle small, post-ovarian and median. Vitellaria consist of large follicles that begin just posterior to the ovary and extend posteriorly for a distance of 0.2 to 0.5 mm. Uterus, greatly convoluted, fills practically all of the post-ovarian region and passes forward to the genital aperture keeping in the main to the wavy course of the intestine. Eggs 24–28 μ long by 16–17 μ wide.

TABLE 4.—*Continued.*

				Acanthocephala	Nemathelminthes						Arthropoda arachnid	
Cestoda		Whole										
Choanotaenia musculosa			*Paricterotaenia parina*	*Plagiorhynchus formosus Metorhynchus robustus*	*Capillaria contortia*	*Diapharynx nasuta Microtetrameres* sp.	*Acuaria gracilis V. sturni*	*Porrocaecum exiticaudatum*	*Capillaria exilis & C. oropuncticum*		*Speleognathus sturni*	
No.	%	No.	%	No.	No.	No.	No.	No.	No.	No.	%	No.
6(2)	75	5	62	..	2(2)	..	1(1)	1(1)	2(1)	7(3)	87	..
2	40	1	20	..	..	..	..	..	..	2	40	..
43(40)	61	37	52	2(2)	3(3)	7(6)	6(6)	3(3)	9(8)	46(44)	65	..
38(31)	59	34	53	..	3(2)	8(8)	2(2)	..	2(2)	32(27)	50	3(3)
19(17)	59	18	56	..	2(2)	5(5)	1(1)	..	..	15(14)	47	..
3(1)	78	2	22	..	..	..	1	..	..	..	44	..
4(2)		..		..	..	..	1	..	..	4		..
1				..	..	..	..	..	..	1		..
11(1)	58	2	8	..	..	4	..	..	1	4	42	..
3				..	2	..	1	..	..	6		..
7				..	..	2	..	..	..	7		..
1	40	..	0	..	2	2	1	..	..	4	64	1
9				5	..	..	..	2	..	16		1
1				..	..	1	..	..	..	1		..
..	26	..	0	1	1	..	..	..	..	4	18	1
6				8	..	..	..	1	..	14		1
..				1	2	..	..	..	..	3		..
8		7		..	..	5	..	2	3	8		..
1	94	1	69	..	..	..	..	..	..	1	100	..
6		3		..	1	..	..	1	..	7		..
169(94)	56	110	37	17(2)	18(9)	34(19)	14(10)	10(4)	17(11)	182(88)	61	13(3)
106	51	94	54	2	10	20	10	4	13	100	57	3
63	50	16	13	15	8	14	4	6	4	82	66	10
	56		37	6	6	11	5	3	6		61	4

The only description of a member of this genus so far published in North America is that of *L. monenteron* (Price and McIntosh, 1935) from *Turdus migratorius* and *Sialis sialis* and it differs from the above in certain respects. In the fluke from the starling the testis is entire, not lobed; the egg measures 24–28 μ, not 32 μ; the maximum width of the fluke is 227–386 μ, not 630–670 μ, and the acetabulum occurs within the anterior third instead of being within the anterior fifth of the body as in *L. monenteron*. However, it bears a close resemblance to the liver fluke from the bluejay, *Cyanocitta cristata*, studied by Nesslinger (1950), differing from the latter only in its body length which is 1.93–2.85 mm. in contrast to 4.1–4.7 mm. Possibly it is the same species as that from the bluejay but has not attained full maturity in the starling as host, for the body is foreshortened, and the posterior portion containing the uterine coils is full of eggs, but short in length. A description of the species from the bluejay has been made by Denton and is now in press.[1]

Brachylaemus sp. (BRACHYLAEMIDAE). A single specimen of this intestinal fluke was collected from an adult male.

Description: (Fig. 8). Body cylindrical 2.20 mm long by 0.6 mm wide; cuticle smooth. Oral sucker subterminal, almost spherical, 220 μ long by 195 μ wide. Acetabulum smaller than

[1] Private communication from Dr. McIntosh.

oral sucker, 183 μ long by 190 μ wide, located so as to divide the body 1 : 3. Pharynx subspherical, 108 μ long by 132 μ wide, overlapping the posterior edge of the oral sucker. Esophagus very short, intestinal ceca extend to within 70 μ of the posterior end. Genital aperture median, 55 μ anterior to anterior testis. Gonads median, tandem and overlapping each other in the posterior third of the body. Anterior testis 241 μ long by 250 μ wide; posterior testis 269 μ long by 228 μ wide. Ovary between the testes—spherical 188 μ diameter. Oviduct originates from the median posterior portion of ovary. Vitellaria extracaecal, starting at level of 160 μ posterior to the anterior edge of the anterior testis and extending forward to 35 μ beyond the acetabulum. Eggs 33–38 μ long by 14–20 μ wide. This is probably a young form as no eggs are in close proximity to the genital aperture.

The intestinal fluke, *B.* (*Harmostomum*) *fuscatus* that occurs in the starling in Europe (Baylis, 1928) differs from the above species in the following points: 1) the vitellaria terminate posterior to the acetabulum; 2) the anterior testis overlaps the genital aperture; 3) the gonads are well removed from each other; and 4) the egg measures 22.8 μ × 11.4 μ (Braun, 1902). The fluke here described bears closest resemblance to *B. mcintoshi* Harkema (1939) from the barred owl, but in the latter the body is narrower (0.29 mm.), the suckers and pharynx are smaller (210 μ × 163 μ; 130 μ × 121 μ; 77 μ × 95 μ, respectively), the pharynx does not overlap the oral sucker and the testes are contiguous. This last difference, however, may be accounted for by the fact that the intestinal fluke in the starling is probably a young specimen.

Leucochloridium certhiae McIntosh (BRACHYLAEMIDAE): The cloacal fluke was retrieved from an adult female. This fluke was first described in 1927 from the brown creeper and formed the first record of the genus in North America (McIntosh, 1927); later McIntosh (1932) pointed out that it is identical or closely related to one described as *Leucochloridium* sp. from the spotted flycatcher, *Musciapa striata* (Witenberg, 1925) in Europe. Species of *Leucochloridium* to date have not been encountered in the starling in Europe, although it infects a variety of PASSERIFORMES. Might it be the same species and might the starling have played a role in its introduction into North America?

Two immature flukes were found in the intestine of an adult female in April, 1946. Judging from the body shape, the strong large suckers, prominent pharynx, character of the intestinal crura and position of the gonad primordia, along with the fact that they were found in the intestinal tract, it is possible that they are immature forms belonging to the genus *Leucochloridium*.

CESTODA: The first of the two tapeworms taken from starlings in North America was *Hymenolepis farciminosa* Goeze by Chapin (1920) and later by Sommer (1936) and Cannon (1939). The latter worker at the same time collected the other cestode, *Choanotaenia musculosa* Fuhrmann. Sommer called the second tapeworm found in his study *Rhabdometra nullicollis*. Such identification should be questioned since this species is a parasite of grouse (GALLIFORMES). The same holds true for the report of *Monopylidium* sp. for the starling by Rayner (1932). Considering the fact that maceration of the scolex of *C. musculosa* readily occurs and its proglottids somewhat resemble those of *Rhabdometra*, the writer believes that the tapeworm found by Rayner and the one identified as *R. nullicollis* by Sommer is *C. musculosa*. In Europe *C. musculosa*, *H. farciminosa* and *Aploparaksis dujardinii* Krabbe constitute the tapeworms of *Sturnus vulgaris*. Occasionally four more, that typically parasitize other members of the PASSERIFORMES, may infect this host, of which one is *Paricterotaenia parina* Duj. of the English sparrow (Baylis, 1928, 1939; Joyeux and Baer, 1936; Sprehn, 1932).

In the present investigation, three species of tapeworms were collected,—*H. farciminosa* (HYMENOLEPIDAE) and two members of the family DILEPIDAE, *C. musculosa* and *P. parina* (Table 4). The finding of *P. parina* forms the first record of its occurrence in the starling in North America. Its failure to reach maturity in this host and its low incidence (6%) would indicate that the starling is probably not responsible for its presence in this country, but that the responsibility lies with its natural host, the English sparrow. Undoubtedly the introduction of *C. musculosa* and *H. farciminosa* is due to *Sturnus vulgaris*. The incidence of birds infected by tapeworms was high, 71%. Sommer (1936) obtained a much lower figure, 39% with 1.14 as the average number of specimens per bird, the maximum being 15 in any one bird. The general health of the starling seemed unimpaired by the presence of even a heavy infection by cestodes. The adult that harbored 101 *C. musculosa* and 15 *H. farciminosa* appeared in good condition and the juvenile with 125 *C. musculosa* and two *H. farciminosa* was extremely plump. Microscopically it is evident that the tapeworm can penetrate as far as the glands of Lieberkühn, destroying the mucosa in its path (Fig. 15).

Hymenolepis farciminosa: The size of its 10 hooks as given by Krabbe (1869) is 20–23 μ; the author found them to be 23–25 μ (Fig. 9A). The embryo has been said to measure 80 μ × 60 μ (Joyeux and Baer, 1936; Hughes, 1941). However, this figure was given for the egg in its original description (Volz, 1900) and has been confirmed by the writer, namely—egg, 76–88 μ × 69–70 μ; embryo, 48–54 μ × 40–45 μ; its hooks 18–20 μ. This long delicate worm lies coiled on itself in the posterior half of the small intestine. The maximum number of worms per bird was seven with an average of two, but when scolices only were present the number may be much higher—79 on one occasion. The percentage of infected birds was 31 and 38 for the 'summer' and 'winter' groups, respectively. However, when the presence of whole worms only was counted the figure was 30% and 20%, respectively (Fig. 6; Table 4). Thus a seasonal difference occurred though it was less striking than for *C. musculosa*.

Choanotaenia musculosa: There is disagreement as to the character of the hooks and egg of *C. musculosa* and neither has been illustrated. In the original account, Fuhrmann (1896) was unable to describe the nature of the hooks due to ready maceration of the scolex and gave 180 μ as the diameter of the egg (possibly this represented its uterine capsule). Joyeux and Baer (1936) stated that the hooks number 22, occur in two rows and measure 28 μ and 24 μ; and that the egg measures 50 μ, the embryo 30 μ and its hooks 18 μ in length. Cannon (1939) failed to obtain a complete crown of hooks, but noted that they were in two rows and measured 43 μ; he included no account of the egg. The writer was fortunate in securing ample fresh material and as a result is now able to redescribe and illustrate these portions. The hooks (Fig. 9C) number 18–20 and are arranged in two rows; those of the proximal row measure 36.6–43.5 μ and of the distal row, 43–48 μ. The egg (Fig. 10) has a diameter of 47–55 μ, the enclosed embryo 32–36 μ and its hooks are 13–14 μ in length. *Choanotenia* is localized in the anterior region of the small intestine. The percentage of infected birds was 56, but a seasonal difference was apparent both in the numbers of infected birds and in the presence of complete worms. The 'summer' group exhibited a 61% infection, and 54% possessed whole worms. In contrast to this, the 'winter' group showed a 50% incidence (43% omitting March–April) and only 13% (or

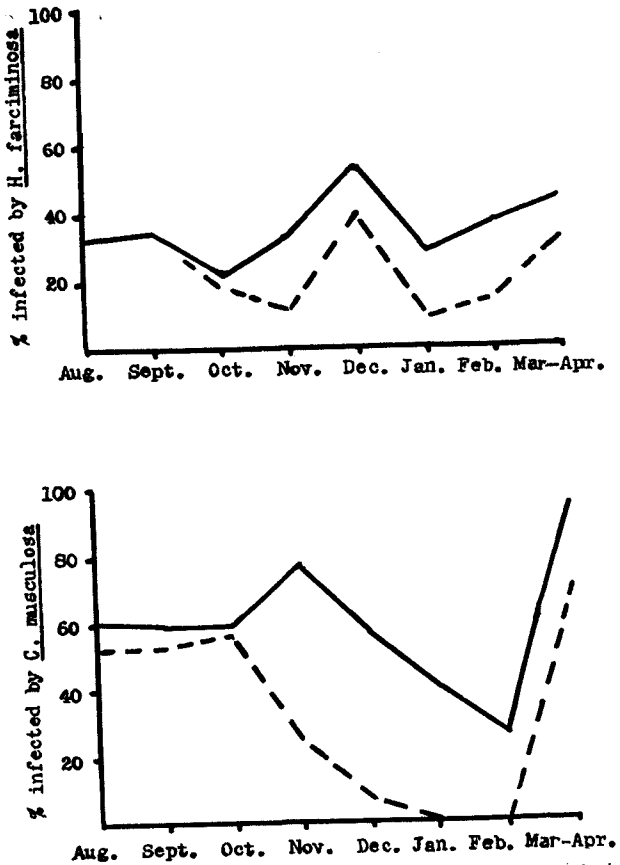

FIG. 6. Percentage incidence of starlings infected by tapeworms, *Hymenolepis farciminosa* and *Choanotaenia musculosa* between August, 1945 and March-April, 1946.
KEYS ——= presence of worms, both fragments and whole.
– – – = presence of whole worms only.

5% omitting March–April) harbored whole worms (Fig. 6; Table 4). The infestation in individual birds was heavy, 13 being the average per bird, though as many as 125 occurred in one instance.

Paricterotaenia parina: The identification of this species of tapeworm is based purely on the nature of the scolex and maturing proglottid, since none had reached sexual maturity. The shape and size (18–23 μ) of the hooks (Fig. 9B) agree with

those described by Krabbe (1869) who pointed out that the size varies with its host, being 15–17 μ in *Parus coeruleus* and 21 μ in *Sturnus vulgaris*. The tapeworms were located in the anterior region of the small intestine and often occurred merely as scolices, ranging from one to eleven, although in three cases the number reached 36, 39 and 164 per bird. They occurred in only 6% of individuals but these were widely distributed (N. Y., Ohio, Md., Ind.) (Table 4).

ACANTHOCEPHALA

Up to the time the present investigation was undertaken, two species of ACANTHOCEPHALA had been taken from *Sturnus vulgaris* in North America. Sommer (1936) collected three worms from 132 individuals examined from Illinois and identified them as *Mediorhynchus grandis* Van Cleave. Van Cleave (1942) found *Plagiorhynchus formosus* Van Cleave in a single bird from New Jersey. ACANTHOCEPHALA exhibit relatively slight host-specificity, so that a species may be found in a variety of different birds. In Europe *Prosthorhynchus transversus* Rud. (Baylis, 1928) and *Mediorhynchus micracanthus* Rud. (Sprehn, 1932) have been reported as parasites of the starling.

The writer obtained a 6% infection of starlings by ACANTHOCEPHALA and both genera were represented. None of the birds involved came from Massachusetts or Connecticut. Seven was the maximum number present at any one time and 2 the average number per bird. The starlings appeared to suffer from such infections for their bodies tended to be emaciated and the visceral contents black. The worms surpassed all others in their ability to penetrate the host's tissue for they were able to extend deep into the muscular coat and to lie in close proximity to the serosa (Fig. 16). Their point of attachment was at times visible on the external surface of the intestine.

Plagiorhynchus (*Prosthorhynchus*) *formosus* (RHADINORHYNCHIDAE): This acanthocephalan was found in 12 birds representing five each from New York and Ohio and two from Maryland. The Ohio findings constitute a new state record for this parasite. Van Cleave (1942) pointed out that with its restricted distribution and the fact that its intermediate host, *Armadillidium vulgare* is widely distributed throughout America, possibly *P. formosus* is not an American form, but has been introduced with its definitive host into this country. Could the definitive host be *Sturnus vulgaris*?

Mediorhynchus robustus: This worm was found on six occasions, five times in birds taken in New York and once in a bird from Indiana. These data, host and state records, with the addition of New Jersey, were published for the first time in a paper on *Mediorhynchus* by Van Cleave (1947). In the article (Van Cleave, 1947), the starling was omitted in the host list for *M. grandis* although Sommer (1936) reported its presence in this host in Illinois. Possibly Sommer's *M. grandis* should have been identified as *M. robustus* or the starling may serve as host to both these species of *Mediorhynchus*.

NEMATHELMINTHES

Three nematodes so far have been reported for *Sturnus vulgaris* in North America,—from the proventriculus, *Dispharynx nasuta* Rud. (Goble and Kutz, 1945a); and from the intestine, *Porrocaecum ensicaudatum* Zeder (Cram, 1933) and

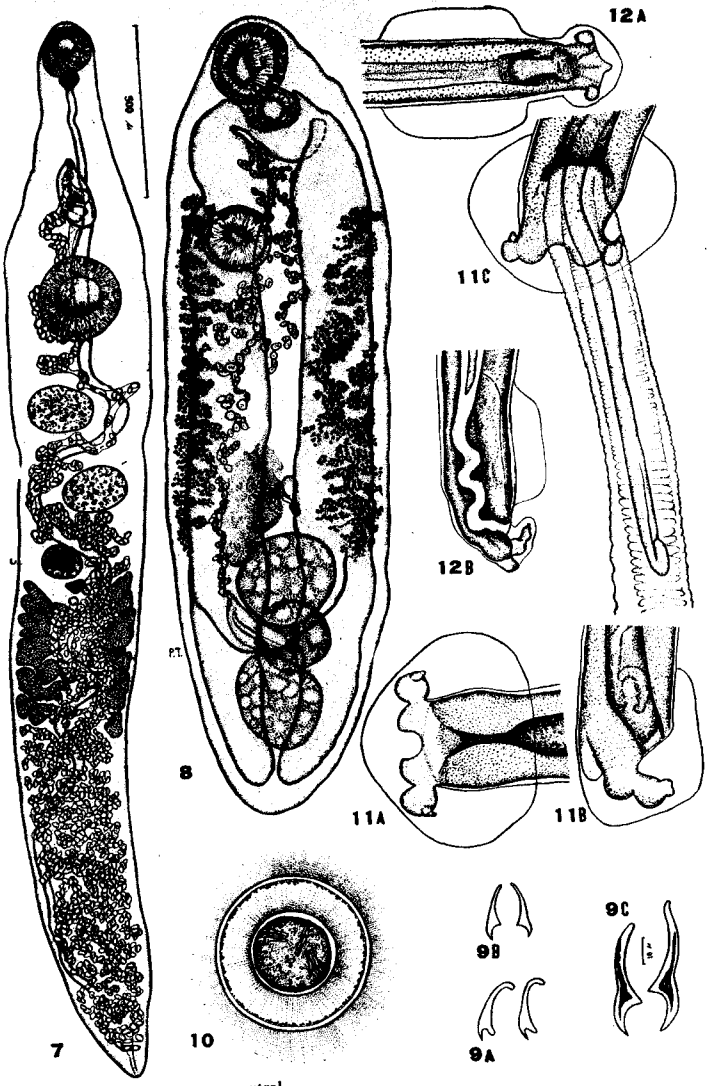

FIG. 7. *Lutztrema* sp., ventral.
FIG. 8. *Brachylaemus* sp., ventral.
FIG. 9. Hooks of tapeworms: A, *Hymenolepis farciminosa;* B, *Paricterotaenia parina;* C, *Choanotaenia musculosa.*
FIG. 10. Egg of *Choanotaenia musculosa,*—fresh preparation.
FIG. 11. *Capillaria ovopunctatum,* cauda of male: A, spicule sheath retracted, ventral; B, spicule sheath retracted, lateral; C, spicule sheath everted, ventral.
FIG. 12. *Capillaria exilis,* cauda of male; spicule sheath retracted: A, ventral; B, lateral.

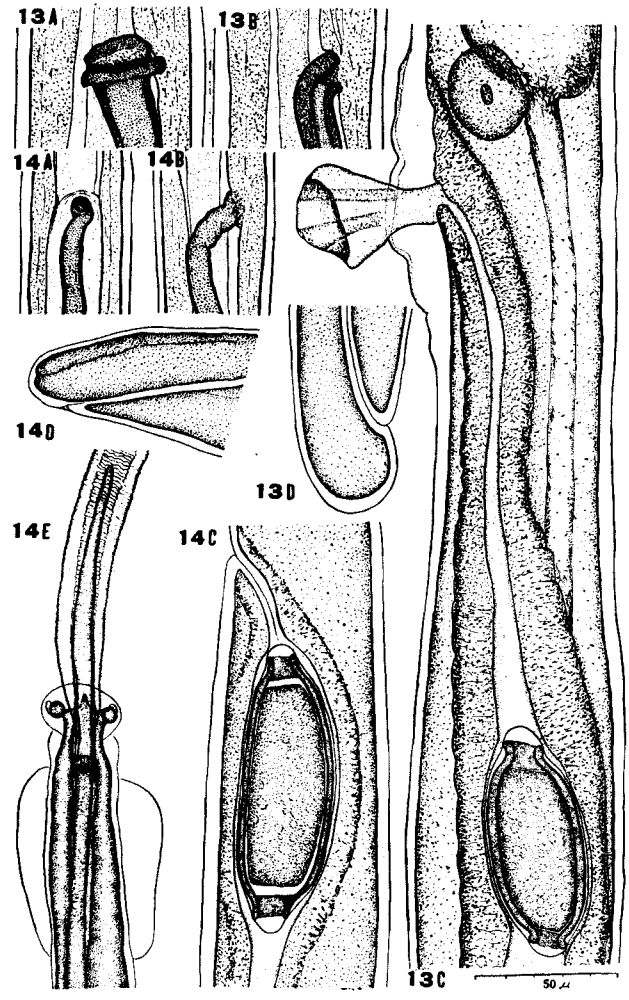

FIG. 13. *Capillaria ovopunctatum:* A, male, proximal end of spicule, ventral; B, male, proximal end of spicule, lateral; C, female, vulvar region, lateral; D, cauda of female.
FIG. 14. *Capillaria exilis:* A, male, proximal end of spicule, ventral; B, male proximal end of spicule, lateral; C, female, vulvar region; D, cauda of female; E, male, spicule sheath everted.

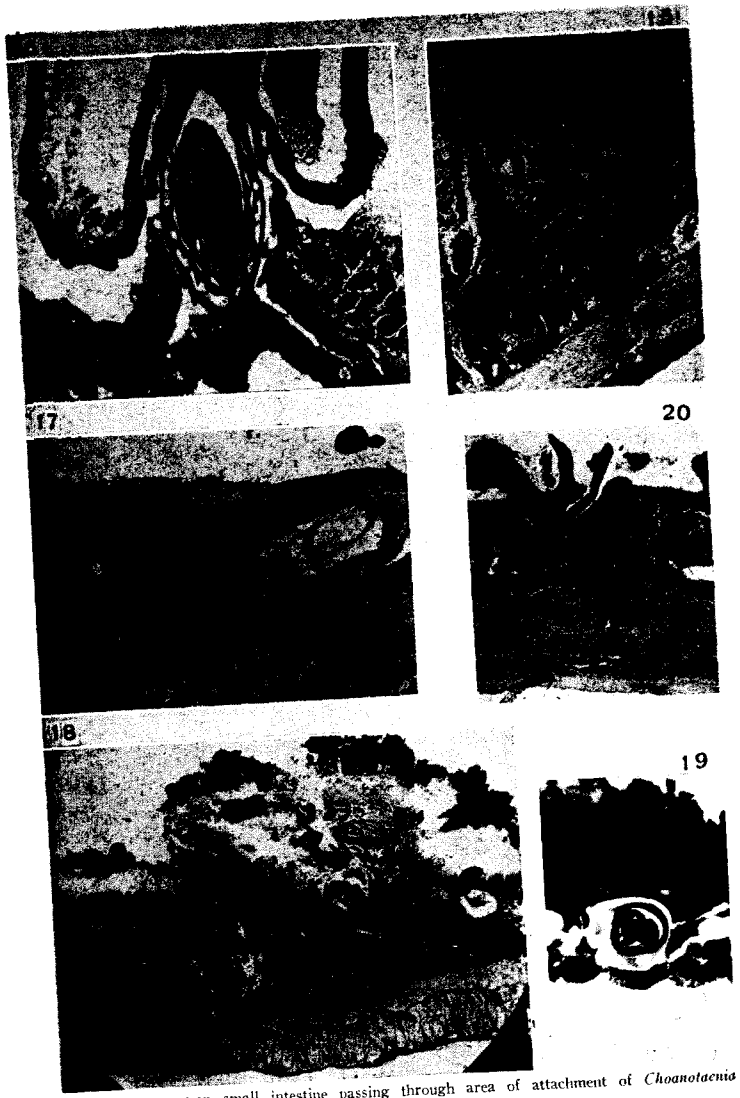

FIG. 15. Section small intestine passing through area of attachment of *Choanotaenia musculosa*.
FIG. 16. Section of small intestine at point of insertion of *Plagiorhynchus formosus*.
FIG. 17. Section of esophagus containing *Capillaria contorta*.
FIG. 18. Section of proventriculus showing marked pathological condition of the mucosa due to the presence of *Dispharynx nasuta*.
FIG. 19. Section of inner tunica of gizzard parasitized by *Acuaria gracilis* var. *sturni*.
FIG. 20. Section of small intestine through region of insertion of an intestinal *Capillaria*.

a species of *Capillaria* (Cannon, 1939; Read, 1949). The latter was tentatively named *C. columbae* var. *sturni* by Cannon and identified as *C. caudinflata* Molin by Read. These worms have been collected by the author but the *Capillaria* has been recognized as representing the two species *C. ovopunctatum* v. Linstow and *C. exilis* Duj., which, with the exception of *D. nasuta* and the addition of *Syngamus trachea* Montague, constitute the roundworms for the starling in Britain (Baylis, 1928). The author also found the esophageal *Capillaria* (*C. contorta* Creplin); the gizzard worm (*Acuaria gracilis* Gendre) and immature forms in the stomach and the intestine (Table 3). This makes a total of at least six roundworms for this host in North America. The nematode list for the starling in the rest of Europe is similar to that compiled by Baylis for Britain with the inclusion of *C. contorta*, *Viguiera turdi* Molin (Gizzard worm) and another *Porrocaecum*, *P. heteroura* Creplin (Sprehn, 1932). *Dispharynx nasuta* has been reported by Osersky (1927) from the starling in Asia along with two gizzard worms, *A. anthuris* Rud., and *A. sturni* Osersky.

In the present study as many as 68% of the hosts harbored nematodes, although the incidence of such infections recorded in the literature is meagre for this and other wild birds. This high figure may be accounted for by the fact that fresh material was always examined and all but one of the roundworms are slender and would be extremely hard to discern in the preserved condition. Except in two instances, tissue damage resulting from nematode infections appeared to be negligible. Gapeworms, *S. trachea*, were entirely lacking in the present study. Goble and Kutz (1945b) also found this to be true on dissecting 118 starlings. The absence of *Syngamus* in this host in America is surprising since in Britain Lewis (1925, 1926) obtained a 35% infection following an examination of 520 starlings, a much higher occurrence than in any other wild bird. The worms in the following account have been discussed in a definite sequence, namely those parasitizing the esophagus, proventriculus, gizzard and finally the intestines.

Capillaria contorta (TRICHURIDAE): This nematode was found in the esophagus of 11% of the starlings. No seasonal difference in occurrence was apparent but it was noted that they were absent in hosts from Indiana, Connecticut and Maryland (56 birds in all) whereas the incidence in birds from Ohio, New York and Massachusetts ranged from 10% to 17% (representing 244 individuals) (Table 4). Infections were light as the number of parasites present at any one time never exceeded seven, and averaged 1.7 per infected bird. The worm was located within the anterior half of the esophagus between adjacent longitudinal folds of the wall. The sinuous contour that each assumed would allow for the contraction and expansion of this region during food intake. Unlike the majority of helminthic infections, *C. contorta* typically was found imbedded in the mucosa throughout most of its body length. Microscopic preparations revealed that the worm failed to penetrate beyond the stratified squamous epithelium (Fig. 17). In some cases, the inner surface of the esophagus exhibited vascular patches and a catarrhal condition. Microscopically the infected area showed a thickening and often a sloughing of the mucosa accompanied by an infiltration of leucocytes. The above data constitute the first record for *C. contorta* for the starling in America. This worm is world-wide in distribution parasitizing numerous birds including gallinaceous and passerine forms. It was first found in North America in 1929 in the quail (Cram, 1936) and as none has

been found here in the English sparrow (Hopkins and Wheaton, 1935) the starling may have been responsible for its occurrence in America.

Dispharynx nasuta (ACUARIIDAE): This species of *Dispharynx* is widely distributed throughout the world and is known to parasitize the proventriculus of members of the GALLIFORMES, COLUMBIFORMES and PASSERIFORMES. Its first appearance in the United States was in 1913 and Goble and Kutz (1945a) included the starling in the list of 20 avian hosts for this worm in North America. They obtained a 5% infection in the starling as a result of an examination of 118 individuals collected between March and December 1944. In the present study 13 starlings were found to harbor *Dispharynx* but there appeared to be a slight seasonal variation in its occurrence. In the 'summer' group there was a 5% incidence (an average of 2 per infected bird) but a 3% for the 'winter' group and never more than one worm per bird. Two hosts revealed a marked pathological condition. The region of attachment of the worm had undergone proliferation so that it projected 1 mm into and partially obliterated the lumen (Fig. 18). Liquefaction and necrosis had set in with infiltration of leucocytes and excessive mucous secretion. A similar picture from such infections has been described in other hosts in particular in the grouse (Allen, 1924). The degree of proventriculitis is said to be correlated with the number of worms present (Goble and Kutz, 1945a). However, only a single worm was found in each of the two cases described above, although up to seven were present in other starlings without any apparent impairment. One of the 13 infected hosts collected in January from Ohio was parasitized by what is taken to be the third larval stage of *D. nasuta*, since it bears a close resemblance to the description as given by Cram (1931) for the infective stage of this species. Its round head lacks all evidence of cordons but possesses two small pointed lips with four papillae; its body measures 3.2 mm with a pharynx of 100 μ and an esophagus of 750 μ, and it is in the process of molting.

Microtetrameres helix (TETRAMERIDAE): An additional starling, a juvenile caught in August, was found to contain 10 larvae in its proventriculus differing markedly from *D. nasuta*. Their tails terminate in a characteristic ball-shaped knob and the body measurements are as follows: body length, 2.14–2.8 mm; tail, 250–285 μ; buccal cavity, 20–24 μ; muscular part of esophagus, 170–219 μ; glandular part of esophagus, 438–530 μ. They have been tentatively identified as larvae of the crow stomach worm, *M. helix* (?) as this description closely parallels that for the infective larva of this species (Cram, 1934b).

Acuaria gracilis var. *sturni* (ACUARIIDAE): Gizzard worms were encountered in 10 starlings though hitherto none has been reported for this bird in North America (Table 4). Their coiled bodies lay imbedded between the 'horny' layer and the mucous membrane of the inner tunica (Fig. 19), and on their removal would typically leave an undulating impression on this and occasionally also on the outer tunica. This coiling of their bodies is reminiscent of *Capillaria contorta* and undoubtedly aids in conforming to the muscular movements of the gizzard. Their presence appeared to cause little or no pathological condition. The worms were mature in eight of the hosts and have been identified as *Acuaria gracilis* var. *sturni*. They are identical with *A. gracilis* from the African birds, *Buchanga atra* and *Oriolis auratus* (Cram, 1927), except that the cordons in the male are 1.9–2.07 mm, that is 1/3 of the body length, and the tail 1/15–1/20 of the body length (220 μ and 1/40, respectively, in *A. gracilis*). Great variation, in cordon length however may occur within a single species (Shikhobalova, 1930). Unidentified larval forms occurred in two birds killed in July 1944 and April 1946. The larva in the July host possesses four cordons directed posteriorly for a distance of 66.6 μ; its esophagus is 333 μ in length and its body 2.32 mm long. The bodies of the two specimens from the April bird measure 4.5 and 4.9 mm, and the tails 153 and 156 μ respectively. The esophagi are 582 and 585 μ in length and the head of each possesses two lips and a cuticular collar. This latter feature is present in the third larval stage of *A. anthuris* (Cram, 1934a), but the spiny character of the tail present in this species is lacking in the specimens from the starling.

Porrocaecum ensicaudatum (ASCARIDAE): The intestinal roundworm, *P. ensicaudatum* has been reported for the starling in Canada (Cram, 1933) but not in the United States although it is prevalent in numerous birds here and in other parts of the world including the starling in Europe. In the present investigation it occurred in 17 hosts from Massachusetts and New York, 11 of which were juveniles (Table 4). Infection was light, the average number per bird being 2, and five the greatest number in any one bird. Immature forms, probably of this species, parasitized four birds killed in August 1945 and April 1946. They possess a body 3.76 mm in length; an anus, 220 μ anterior to tail extremity; a buccal cavity, 173 μ long and an esophagus, 85.3 μ in length.

Capillaria ovopunctatum and *C. exilis* (TRICHURIDAE): Two intestinal threadworms have been listed for the starling in Europe,—*C. ovopunctatum* described by von Linstow (1873) and *C. exilis* by Dujardin (1845). Although there exists no modern description, the meagre original descriptions are adequate to distinguish them from each other. The males differ in the size of the body and the spicule and in the presence or absence of caudal alae; whereas the females differ in the size of the egg and in the presence or absence of the vulvar appendage (Table 5). In this country intestinal *Capillaria* have been reported for this host by Cannon (1939) and Read (1949). Cannon collected several specimens from 11 starlings in Quebec and tentatively named them *C. columbae* var. *sturni* since they closely resembled *C. columbae* Rud. except in the presence of the vulvar appendage, which is absent in the threadworm of the pigeon. Read found two females in one of 25 starlings from Michigan and identified them as *C. caudinflata* Molin as they conformed to the description of this species. He also suggested that Cannon's specimens be referred tentatively to *C. caudinflata* due to the possession of the vulvar appendage.

In the present investigation, as many as 182 birds were infected by intestional *Capillaria*. It was obvious on microscopic observation that they represented two distinct species and are believed by the writer to be none other than the European forms, *C. ovopunctatum* and *C. exilis*. For comparative purposes a table has been compiled to demonstrate the salient features of the *Capillaria* under discussion (Table 5). The ratio of the length of the esophagus to the body length or to the intestinal length has been omitted as a specific character since this varies with the age of the individual (Morgan, 1932). It is evident (Table 5) that the two species collected by the author more closely resemble the European forms than either *C. caudinflata* or *C. columbae*, and they closely parallel the original descriptions of *C. ovopunctatum* and *C. exilis* as given respectively by von Linstow and Dujardin.

Cannon's and Read's specimens may prove to be *C. ovopunctatum* and it was thought wiser to omit them in Table 3. Read's identification was based solely on females, as males unfortunately were not available to him. A more detailed account with illustrations is now presented for these intestinal *Capillaria* of the starling.

Capillaria ovopunctatum von Linstow (Figs. 11A-C, 13A-D; Table 5).

Male: Caudal alae absent. Spicule 0.8–0.95 mm. in length, proximal end expanded laterally with a central groove, distal end terminated in a recurved point. Bursa expanded anterolaterally and supported by a pair of rays each of which carries a secondary outgrowth. Tail with a median terminal depression.

Female: Vulvar appendage present, varies in shape, but most frequently funnel-shaped with a width of 38–55 μ. Vulva usually 15–25 μ posterior to esophagus. Egg 59–65 μ long by 24–29 μ wide.

TABLE 5.—*Comparison of* Capillaria caudinflata, C. columbae *and intestinal* Capillaria *from the starling*

	Male body length in mm.	presence of caudal alae	spicule length in mm.	shape bursal rays	Female body length in mm.	presence of vulvar appendage	Egg	
							length in μ	breadth in μ
C. caudinflata	9.0–25.0	+	0.8–1.1	T-shape	14.0–40.0	+	53	23
C. columbae	8.4–13.8	–	1.0–1.7	L-shape	10.0–17.2	–	44–62	20–27
C. columbae var. *sturni* (Cannon)	7.0–17.25	–	approx. 1.0	secy. outgrowth	9.5–18.25	+	48–52	22–23
C. ovopunctatum (von Linstow)	6.24	–	0.9	2-lobed	9.5	+1mm.	59	29
C. ovopunctatum (Boyd)	7.0–10.0	–	0.8–0.95	secy. outgrowth	10.0–12.6	+	59–65	24–27
C. exilis (Dujardin)	9.5	+	1.0	?	9.6	–	72	34.5
C. exilis (Boyd)	9.9–12.0	+	1.2–1.3	lobed	11.4–11.9	–	71–78	33–35

Capillaria exilis Dujardin (Figs. 12A, B; 14A–E; Table 5).

Male: Caudal alae present, 37–39 μ long by 17–20 μ broad, emerging 8–15 μ anterior to bursa. Spicule 1.0–1.3 mm. long, not expanded proximally, ending in a straight point distally. Bursa relatively small, supported by a lobed ray on each side. Tail with a small median terminal outgrowth.

Female: Vulvar appendage absent. Vulva at level of junction of esophagus with intestine. Egg 71–78 μ by 33–35 μ.

Numbers of the two species collected in individual birds were not recorded but *C. ovopunctatum* appeared to be far more prevalent than *C. exilis*. There were fewer males present than females (349 : 403). Graybill (1924) also noted that females predominated in his work on *C. columbae* from the chicken and turkey. The percentage incidence was slightly higher in adult hosts than juveniles (64 : 57) and accounted for the lower percentage of infection, 57, of the 'summer' group of starlings and the higher percentage, 66, in the 'winter' individuals. Infestation was heavier in birds collected from certain states than from others: 79% of birds from Indiana were infected; 59% from New York but only 37% from Massachusetts. The average number per bird was 4 though on one occasion as many as 68 worms were encountered. The intestinal *Capillaria* is able to penetrate deep into the glands of Lieberkühn and by so doing causes a negligible degree of destruction (Fig. 20). The host's tissue responds by the development of a thin connective tissue layer encircling the implanted portion of the parasite and by a slight infiltration of leucocytes into the area.

Evidently *C. ovopunctatum* and *C. exilis* have been brought into North America along with the starling. Since both species have spread to members of the TURDIDAE in Europe and in the case of *C. exilis* to the pheasant also (Baylis, 1939), it will be interesting to note whether in time they will be observed in native birds in this country. Other nematodes that may have been introduced into America by this bird are *C. contorta, Dispharynx nasuta, Acuaria gracilis* and *Porrocaecum ensicaudatum*.

ARACHNIDA—*ACARINA*

Speleognathus sturni Boyd: A new species of mite was encountered in the trachea of 13 starlings. This mite has since been described as *S. sturni* (Boyd, 1948). Further dissection of the hosts revealed their presence in large numbers in the nasal cavities. Mites identical to this species were collected by C. D. Radford[2] in 1945 from the Mynah birds (*Manipur imphal* and others) in India while working with the scrub-fever commission. These birds belong to the same family as does the starling, namely the STURNIDAE, which has its major locale in the Indian and Ethiopian regions. Possibly the mite gained access to North America through the starling and has now spread to native birds such as the boat-tailed grackle, *Cassidix mexicanus* (Boyd, 1948).

DISCUSSION

The incidence of parasitism ranks high in *Sturnus vulgaris* particularly in the spring to fall months, and from this aspect it would be good source material for a course in parasitology. The prevalence of parasites is dependent on numerous factors, such as diet, habits, age and habitat of the respective host. The fact that the starling is omnivorous in its diet is in itself one of the main causes for its numerous parasites, both in quantity and diversity of species. The extremely low incidence of trematode infection in this host in America, possibly much lower than for the same bird in Europe, can probably be accounted for by the fact that less than one per cent of their animal food consumption consists of snails whereas in England the bird devours large quantities of molluscs (Kalmbach and Gabrielson, 1921). The habit of the starling of feeding and roosting with native birds possibly has been the cause of its acquiring the louse, *Degeeriella illustris* from grackles and the transference of its louse, *D. nebulosa*, to the Eastern robin. Similarly, its objectionable habit of usurping nesting sites of native animals may account for its acquisition of certain of their blood-sucking ectoparasites, namely, the flea, *Epitedia wenmanni*, the ticks, *Haemaphysalis leporis-palustris* and *Ixodes brunneus* and the mites, *Dermanyssus prognephilus* and *Atricholaelaps megaventralis* (Table 1). The age of the host is often important in the prevalence of a parasite for the host may acquire an immunity which would control the longevity of the parasite. Although 175 out of the 300 starlings were immature the endoparasitic picture was very similar to that in adults except in the case of the intestinal *Capillaria* and *Porrocaecum ensicaudatum*, where 57 and 7% juveniles were infected to 64 and 4% adults.

The habitat of the host, in particular the climate of its environment, may affect the presence of parasites, either directly by its influence on the ectoparasite and the

[2] Personal communication.

free-living stage of the endoparasite or indirectly by its control of their intermediate hosts. The relation of meteorological factors to parasitic incidence in starlings was demonstrated by Markov (1940). His study consisted of an examination of 215 birds including nestlings between April and October 1935 and 1936 at Leningrad where starlings are migratory, being absent in winter. He noted that the dry weather of June 1936 acted as a climatic barrier by destroying the spores and eggs of *Isospora* and *C. contorta* respectively. However, he stated that the ectoparasitic fauna fluctuated with the biology of the bird, the majority of the parasites being lost during the molting process of the host in the fall, and that ectoparasites are not affected by climatic conditions. The present findings disagree with the latter statement for a definite seasonal fluctuation was apparent for both species of MALLOPHAGA irrespective of molting (Fig. 1) and the same holds true for the 'feather-mite' *Trouessartia* (Table 2). The lice exhibited a steady decrease both in numbers on the host and in numbers of infected birds as winter approached and then rose again with the onset of spring. On the other hand, the mite, *Cheyletiella*, was collected in midwinter and this parasite, in contrast to the feather-loving forms, lays its eggs directly on the surface of the skin. Thus its close association with the warm body may account for its occurrence during the cold weather. The blood-sucking mites, like the fleas, are associated not only with the host but also with its home, the nest, and consequently are far more abundant during spring and summer, the nesting period of the bird. Markov also noted that the endoparasites, except for *Isospora* and *Hymenolepis farciminosa*, decreased both qualitatively and quantitatively towards the end of the summer so that by October only these two parasites and *P. ensicaudatum* and *Capillaria ovopunctatum* persisted. This was not found to be the case in the present investigation for the helminthes, with the exception of the cestodes, remained relatively constant for both the 'summer' and 'winter' groups of starlings. There was a marked seasonal fluctuation as regards the degree of the tapeworm incidence (*H. farciminosa* and *Choanotaenia musculosa*) in that the number became reduced as winter approached, especially so when presence of whole worms was considered. Markov also observed a reduction of the tapeworm *C. musculosa* as the summer waned but noted its complete absence in October.

The rôle of *Sturnus vulgaris* as an agent in importing its parasites into North America is evident from the results of this investigation. The starling has certainly been the means of introducing the three lice, *Degeeriella nebulosa, Menacanthus spinosum, Myrsidea cucullaris;* the mite, *T. rosterii;* the tapeworms, *H. farciminosa* and *C. musculosa;* and the nematodes, *Capillaria ovopunctatum* and *C. exilis.* It has possibly brought in other parasites such as the flea, *Ceratophyllus gallinae*, the mites *Liponyssus sylviarum* and *Dermanyssus gallinae* (all blood-suckers), and among the endoparasites—*Isospora* sp., and the nematodes, *C. contorta, Dispharynx nasuta, Acuaria gracilis* var. *sturni* and *Porrocaecum ensicaudatum.*

As an outcome of these importations, some of these parasites have now been recovered from native birds. The possibility that the starling may be a disseminator of disease among poultry and cattle has been discussed by several investigators. Bullough (1943) suggested that it might be responsible for the unexplained outbreaks of foot and mouth disease in Britain as the sudden isolated attacks could be correlated with the distribution of the bird. Lewis (1926) believed that this bird is sometimes responsible for the distribution of gapeworm among poultry in Britain.

In North America this could not be so since so far, gapeworms have not been found in starlings. However, gallinaceous birds are known to be hosts for eight parasites recorded for *Sturnus vulgaris* in this country (Tables 1, 3). The list comprises the blood-sucking parasites—*C. gallinae, Haemaphysalis leporis-palustris, Ixodes brunneus, L. sylviarum* and *D. gallinae;* also two nematodes, *C. contorta* and *D. nasuta* and the acanthocephalan, *Plagiorhynchus formosus.* That host-specificity in flukes is slight is apparent when one surveys the host list given for four species of trematodes that have been recorded for the starling in Europe (Baylis, 1928; Sprehn, 1932) for this includes representatives from widely separated orders of birds—ANSERIFORMES, GALLIFORMES, COLUMBIFORMES and PASSERIFORMES. Under these circumstances it is to be exected that starlings may act as hosts to certain flukes that parasitize birds in this country. The MALLOPHAGA and the CESTODA exhibit marked host-specificity so that it would be impossible to find the same species of these groups of parasites in both the starling and gallinaceous birds. The starling may be relatively unimportant as a disease distributor among members of the GALLIFORMES. However, Clapham (1940) obtained evidence that English sparrows can carry eggs of helminths of poultry mechanically, either via the dirt present on their bodies or within their intestines where the eggs are passed unchanged from the gut. If this proves true in the case of the starling, then it must certainly be a menace to the well-being of poultry, as it so frequently inhabits chicken yards.

SUMMARY

1. A total of 300 starlings (153 juveniles and 147 adults) were examined for parasites (287 for ectoparasites; 300 for endoparasites). These were collected from six different states— Connecticut (6); Indiana (47); Massachusetts (41); Maryland (3); Ohio (19); and New York (184). The majority from New York—175 individuals including 149 juveniles and 26 adults, were killed in July, 1944, and between August and October, 1945. The rest of the birds were caught between November and April, 1944–45 and 1945–46.

2. All of the starlings examined were parasitized by one or more parasites; 95 per cent by ectoparasites and 99 per cent by endoparasites. Mites were represented in 67 per cent of individuals, and the lice, *Menacanthus spinosum* and *Degeeriella nebulosa* in 81 per cent and 72 per cent of cases. A percentage of 75 of birds contained *Isospora* sp.; 90 per cent were infected by helminths; 71 per cent by cestodes (56% by *Choanotaenia musculosa* and 34% by *Hymenolepis farciminosa*); and 68 per cent by nematodes (61% by intestinal *Capillaria*).

3. Seasonal fluctuations occurred for the MALLOPHAGA, the mite, *Trouessartia rosterii* and the starling's two tapeworms. The number of hosts infected by these parasites decreased as winter approached but increased with the onset of spring.

4. A total of 28 parasites has been found in the starling by the author (10 ectoparasites and 18 endoparasites). This investigation, and reports previously published, provide a total list of 34 parasites for this bird in North America (16 ectoparasites and 18 endoparasites).

5. In the present survey 15 first records for the starling in this country have been collected (indicated by asterisks in Tables 1 and 3). Of these, 9, as far as is known, are new records for *Sturnus vulgaris:* the three mites, *Dermanyssus prognephilus, Rivoltasia* sp. and *Cheyletiella* sp.; the unidentified flagellate; the three flukes,

Lutztrema sp., *Brachylaemus* sp. and *Leucochloridium certhiae;* and two nematodes, *Microtetrameres helix* (?) and *Acuaria gracilis* var. *sturni.* New state records have been established—*Degeeriella nebulosa* and *Menacanthus spinosum* for Connecticut, Indiana and Massachusetts; *D. prognephilus* for New York and *Plagiorhynchus formosus* for Ohio.

6. Original descriptions have been given for the eggs of *D. nebulosa, M. spinosum* and *Trouessartia rosterii,* and previous descriptions of *Choanotaenia musculosa* (hooks and egg), *Capillaria ovopunctatum* and *C. exilis* have been revised. The degree of penetration of some of the helminths into the wall of the digestive tract has been illustrated.

7. A general discussion is included regarding the starling as a source of material for a course in parasitology, as an importer of parasites into North America and as a disseminator of disease among native birds and poultry.

LITERATURE CITED

ALLEN, A. A. 1924 The grouse disease. Am. Game **13:** 12–14.

BANKS, N. 1915 The Acarina or mites. U. S. Dept. Agric. Report, #108: 1–153.

BAYLIS, H. A. 1928 Records of some parasitic worms from British vertebrates. Ann. Mag. Nat. Hist. 10th Ser. **1:** 329–343.

———1939 Further records of parasitic worms from British vertebrates. Ann. Mag. Nat. Hist. 11th Ser. **4:** 473–498.

BECKER, E. R. 1934 Coccidia and coccidiosis of domesticated, game and laboratory animals. Collegiate Press, Inc., Ames, Iowa.

BISHOPP, F. C. AND TREMBLEY, H. L. 1945 Distribution and hosts of certain North American ticks. J. Parasit. **31:** 1–54.

BONNET, A. AND TIMON-DAVID, J. 1934 Recherches sur les acariens plumicoles. Ann. Parasit. **12:** 257–266.

BOUGHTON, D. C. 1930 The value of measurement in the study of a protozoan parasite *Isospora lacazii* (Labbé). Am. J. Hygiene **11:** 212–226.

BOUGHTON, D. C., BOUGHTON, R. B. AND VOLK, J. 1938 Avian hosts of the genus *Isospora.* Ohio J. Sci. **38:** 149–163.

BOYD, E. M. 1948 A new mite from the respiratory tract of the starling. Proc. Ent. Soc. Wash. **50:** 1; 9–14.

BRAUN, M. 1902 Fascioliden der Vögel. Zool. Jahr. Syst. **16:** 1–162.

BULLOUGH, W. S. 1943 The starling (*Sturnus vulgaris* L.) and foot-and-mouth disease. Proc. Roy. Soc. Series B, **131:** 1–12.

CAMERON, D. 1938 The Northern fowl mite. Canad. J. Research, D **16:** 230–254.

CANNON, D. G. 1939 On the parasites of the small intestine of the European starling (*Sturnus vulgaris*) in Quebec. Canad. Field Nat. **53:** 40–42.

CHAPIN, E. A. 1920 Report at the Helminthological Meeting of Sept. 17th, 1920. J. Parasit. **7:** p. 186.

CLAPHAM, P. A. 1940 On wild birds as transmitters of helminth parasites to domestic stock. J. Helminth. **18:** 39–44.

COOLEY, R. A. AND KOHLS, G. M. 1945 The genus *Ixodes* in North America. Nat. Inst. Health Bull. #184 U. S. Govt. Printing Office, Washington.

CRAM, E. B. 1927 Bird parasites of the nematode suborders Strongylata, Ascaridata and Spirurata. U. S. Nat. Mus. Bull. **#140:** 1–465.

———1931 Developmental stages of some nematodes of the Spiruroidea parasitic in poultry and game birds. U. S. Dept. Agric., Tech. Bull. **#227:** 1–27.

———1933 New records of nematodes of birds. J. Parasit **19:** 93.

———1934a Recent records of the gizzard worm, *Acuaria anthuris* (Rud., 1819) (Nematoda: Acuariidae) with observations on its life history. Helm. Soc. Wash. Proc. **1:** 48–49.

———1934b Orthopterans and pigeons as secondary and primary hosts respectively for the crow stomach-worm, *Microtetrameres helix* (Nematoda: Spiruroidea). Helm. Soc. Wash. Proc. **1:** 50.

———1936 Species of *Capillaria* parasitic in the upper digestive tract of birds. U. S. Dept. Agric., Tech. Bull. **#516:** 1–27.

DUJARDIN, F. 1845 Histoire naturelle des helminthes ou vers intestinaux. Paris.

EWING, H. E. 1923 The dermanyssid mites of North America. Proc. U. S. Nat. Mus. **62:** (13) 1–26.

———1936 A short synopsis of the North American species of the mite genus *Dermanyssus.* Proc. Ent. Soc., Wash. **38:** 47–54.

EWING, H. E. AND FOX, I. 1943 The fleas of North America. U. S. Dept. Agric. Misc. Pub. **#500:** 1–142.

FOX, I. 1940 Fleas of Eastern United States. The Iowa State College Press.

FUHRMANN, O. 1896 Beitrag zur Kenntnis der Vögeltaenien. Rev. Suisse Zool. **4:** 111–133.

GEIST, R. M. 1935 Notes on the infestation of wild birds. Ohio J. Sci. **35:** 93–100.

GOBLE, F. C. AND KUTZ, H. L. 1945a The genus *Dispharynx* (Nematoda: Acuariidae) in galliform and passeriform birds. J. Parasit. **31:** 323–331.

———1945b Notes on the gapeworms (Nematoda: Syngamidae) of galliform and passeriform birds in New York State. J. Parasit. **31:** 394–400.

GRAYBILL, H. W. 1924 *Capillaria columbae* (Rud.) from the chicken and turkey. J. Parasit. **10:** 205–207.

HARKEMA, R. 1939 A new species of *Brachylaemus* from the barred owl. J. Parasit. **25:** 277.

HARRISON, L. 1916 The genera and species of Mallophaga. Parasitol. **9:** 1–156.

HENRY, D. P. 1932 *Isospora buteonis sp. nov.* from the hawk and owl, and notes on *Isospora lacazii* (Labbé) in birds. Univ. Calif. Publ. Zool. **37:** 291–300.

HOPKINS, S. H. AND WHEATON, E. 1935 Intestinal parasites of English sparrows in Illinois. J. Parasit. **21:** 316–317.

HUGHES, R. C. 1941 A key to the species of tapeworms in *Hymenolepis.* Trans. Amer. Micros. Soc. **60:** 378–414.

JOYEUX, CH. AND BAER, J. G. 1936 Fauna de France. Cestodes. 30: 1–613. Paul Lechevalier et Fils, Paris.

KALMBACH, E. R. AND GABRIELSON, I. N. 1921 Economic value of the starling in the United States. U. S. Dept. Agric. Bull. **#868:** 1–66.

KATZ, J. S. 1941 A collection of Ohio ticks and their hosts. J. Parasit. **27:** 467–468.

KRABBE, H. 1869 Bidrag til Kundskab om Fuglenes Baendelorm. K. Dansk. Vidensk. Selsk. Kjøbenhaven Naturvid. og. math. Afd. **8:** 249–363.

KUDO, R. R. 1939 Protozoology. Charles C. Thomas, Springfield, Ill.

LABBÉ, A. 1896 Recherches zoologiques, cytologiques, et biologiques sur les coccidies. Arch. Zool. Exp. **4:** 517–654.

LEWIS, E. A. 1925 Starlings as distributors of "gapes". J. Helminth. **3:** 81–82.

———1926 Starlings as distributors of "gapes". J. Helminth. **4:** 43–48.

VON LINSTOW, O. F. B. 1873 Einige neue Nematoden nebst Bermerkungen über bekannte Arten. Arch. Naturg. **39:** 293–306.

MCINTOSH, A. 1927 Notes on the genus *Leucochloridium* Carus (Trematoda). Parasitol. **19:** 353–364.

———1932 Some new species of trematode worms of the genus *Leucochloridium* Carus, parasitic in birds from Northern Michigan, with a key and notes on other species of the genus. J. Parasit. **19:** 32–53.

———1939 Experimental infection of European starling with *Leucochloridium* Carus. J. Parasit. **25:** (Suppl.) 25–26.

MARKOV, G. C. 1940 Seasonal and annual variations in parasito-fauna of starlings in connection with changes in meteorological factors. Zool. Zhurn. **19:** 741–749.

MASON, E. 1936 Parasitism of birds' nests by *Protocalliphora* at Groton, Mass. Bird-Band. **7:** 112–121.

MORGAN, D. O. 1932 On three species of the genus *Capillaria* from the English domestic fowl. J. Helminth. **10:** 183–194.

NESSLINGER, C. L. 1950 A survey of ectoparasites and parasitic helminths of the blue jay (*Cyanocitta cristata cristata* L.) in South Hadley, Massachusetts. Master's Thesis, Mount Holyoke College.

OSERSKY, B. N. 1927 Zur Kenntnis der Nematodenfauna der Staren (Sturnidae) des Dongebiets, Armeniens und Turkestans. Sammlung Helminth. Arbeiten K. J. Skrjabin gewidmet, Moscow. 114–120.

PETERS, H. S. 1928 Mallophaga from Ohio birds. Ohio J. Sci. **28:** 215–228.

———1936 A list of external parasites from birds of the Eastern part of the United States. Bird-Band. **7:** 9–27.

PRICE, E. W. AND MCINTOSH, A. 1935 A new trematode, *Lyperosomum monenteron,* n. sp. (Dicrocoeliidae), from a robin. Proc. Helm. Soc. Wash. **2:** 63–64.

RAYNER, J. A. 1932 Parasites of wild birds of Quebec. Sci. Agric. 12: 307–309.

READ, C. P. 1949 Studies on North American Helminths of the genus *Capillaria* Zeder, 1800 (Nematoda): III. Capillarids from the lower digestive tract of North American Birds. J. Parasit. **35**: 240–249.
SHIKHOBALOVA, N. 1930 On a new genus of the Nematoda Family Acuariidae Seurat, 1913. J. Parasit. **16**: 220–223.
SKIDMORE, L. V. 1934 The incidence of coccidia in the common English sparrow (*Passer domesticus*). J. Parasit **20**: 331.
SOMMER, J. B. 1936 Notes on the European starling. Trans. Ill. State Acad. Sc. **29**: 267.
SPREHN, C. E. W. 1932 Lehrbuch der Helminthologie. Gebrüder Borntraeger Berlin.
STRANDTMANN, R. W. 1947 *Atricholaelaps megaventralis*, a new species of parasitic mite (Acarina, Laelaptidae) Proc. Ent. Soc. Wash. **49**: 112–114.
THOMPSON, G. B. 1936 The parasites of British birds and mammals. X. Records of Mallophaga from birds. Ent. Monthly Mag. **72**: 134–136.
———1937a The parasites of British birds and mammals. XV. Bird fleas and their hosts. Ent. Monthly Mag. **73**: 137–142.
———1937b The parasites of British birds and mammals. II. Records of *Ornithomyia* spp. from British birds. Ent. Monthly Mag. **73**: 47–51.
VAN CLEAVE, H. J. 1942 A reconsideration of *Plagiorhynchus formosus* and observations on Acanthocephala with atypical lemnisci. Trans. Amer. Micr. Soc. **61**: 206–210.
———1947 The acanthocephalan genus *Mediorhynchus*, its life history and a review of the species occurring in the United States. J. Parasit. **33**: 297–315.
VOLZ, W. 1900 Beitrag zur Kenntniss einiger Vogelcestoden. Arch. Natur. **66**: 115–174.
WILSON, F. N. 1928 Mallophaga, in a list of the insects of New York, Cornell Univ. Agric. Exp. Sta. Mem. #101: 63–66.
———1934 The life-cycle and bionomics of *Lipeurus heterographus* Nitzsch. J. Parasit. **20**: 304–311.
WITENBERG, G. 1925 Versuch einer Monographie der Trematodenunterfamilie Harmostominae Braun. Zool. Jahr. Syst. **51**: 167–254.
WORTH, C. B. 1940 A note on the dissemination of Mallophaga. Bird-Band. **11**: 23–24.

RELATIVE AND SEASONAL ABUNDANCE OF THE COMMON RAT ECTOPARASITES OF SAN JUAN, PUERTO RICO

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Murine typhus fever in Puerto Rico is seasonal favoring the months of May, June, July and August when the number of cases reported almost always exceeds that of the remainder of the year. The disease is also urban and the majority of the cases are said to occur in the city of San Juan. An ectoparasite survey of the rats of San Juan, therefore, should show a prevalence of the vectors which is in accord with the seasonal variation of the disease and such arthropods ought to be among the most common ectoparasites of the city's rats. Of the many species of arthropods parasitic upon or associated with the rats of San Juan, six are so abundant as to merit special consideration. They are *Xenopsylla cheopis* (Rothschild), *Echidnophaga gallinacea* (Westwood), *Polyplax spinulosa* (Burmeister), *Bdellonyssus bacoti* (Hirst), *Laelaps nuttalli* Hirst and *Ornithodoros puertoricensis* Fox, of which the first four have for some years been known to be experimental transmitters of rodent typhus. What has been found out about the relative and seasonal abundance of these species in San Juan is given in the following pages.

The municipality of San Juan is located on a peninsula with San Juan Bay to the south and the Atlantic Ocean to the north. On the point of the peninsula is the old city or San Juan proper which except for a coastal suburb known as La Perla and an ancient military post, El Morro, contains commercial buildings and apartment-house type residences. The streets are paved with no empty lots, lawns or vegetation to speak of, and there is considerable activity out-of-doors day and night among the people. A short distance inland lies the district called Puerta de Tierra made up of various types of buildings, including residences, commercial establishments, warehouses and wharfs, with empty lots and some unpaved streets. On the base of the peninsula is Santurce, separated from Puerta de Tierra by a well-bridged estuary, it is mainly residential, the houses being for the most part small with front and back yards; empty lots, unpaved streets and vegetation are common, and in the district are varying socio-economic conditions which influence greatly the types of construction present.

As regards the places from which the rats came there was little ecological difference between the Santurce and Puetra de Tierra localities. The traps used were of the wooden box type baited with fresh bread. They were set in the backyards or under the houses (sometimes in them) of the poorer sections. The houses were usually small, frame structures, far from rat-proof and rats were reported to run in and out of them from the unpaved ground around them. The residents being not well-off economically were not very successful as a rule in maintaining the environs of their homes on a plane in accord with modern sanitary standards. In San Juan proper very different ecological factors obtained. Here unbaited steel snap traps

Received for publication, June 8, 1950.