HELMINTH PARASITES OF THE COMMON (NORTH AMERICAN) CROW (CORVUS BRACHYRHYNCHOS BREHM, 1822) IN INSULAR NEWFOUNDLAND

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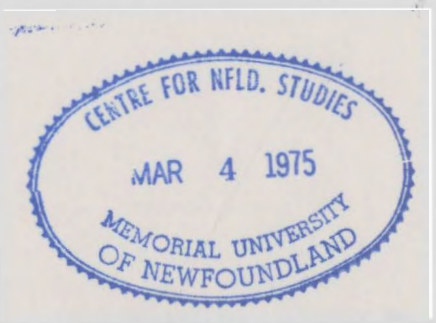
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HELMINTH PARASITES OF THE COMMON (NORTH AMERICAN) CROW (*CORVUS BRACHYRHYNCHOS* BREHM, 1822) IN INSULAR NEWFOUNDLAND

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ABSTRACT

Ninety-nine crows (*Corvus brachyrhynchos* Brehm, 1822) including 37 adult males, 18 adult females, 4 adults of unknown sex, and 40 immatures were examined from twelve localities in Newfoundland. Ninety-eight percent of the crows were infected. Eighteen species of parasites were recovered; seven being new host records for North America.

Four adult female ravens (*Corvus corax* Linnaeus, 1758) were also examined. Eight species of parasites were recovered; five being new host records for North America.

The percentage infection, range of numbers, and the mean number of parasites per host is given for adult birds of each sex, and for immatures. Parasite species are discussed individually with regard to infection, host records, authorities used in specific determinations, and minor variations, if any, from the original descriptions.

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INTRODUCTION

The Common (North American) Crow, *Corvus brachyrhynchos* Brehm, 1822, is a familiar bird throughout Canada and the United States. It is a member of the family Corvidae which has a cosmopolitan distribution and contains approximately 100 species (Peters, 1962). The genus *Corvus*, established by Linnaeus in 1758, includes all the crows and ravens of the world. Listed below are members of the genus occurring in North America and a range summary for each species (A.O.U. Checklist, 1957).

Corvus corax Linnaeus, 1758. Raven. Range--Europe, Northern and Central Asia, North Africa, North America and Mexico.

Corvus cryptoleucus Couch, 1854. White-necked Raven. Range--Southwestern U.S. and Mexico.

Corvus brachyrhynchos Brehm, 1822. Common (North American) Crow. Range--Temperate North America.

Corvus caurinus Baird, 1858. Northwestern Crow. Range--Northwest coast of North America from Southern Alaska south to Oregon.

Corvus ossifragus Wilson, 1812. Fish Crow. Range--Southeastern U.S.

Corvus cornix Linnaeus, 1758. Hooded Crow. Range--Great Britain, Continental Europe, and Northern Asia.

Four geographic races (subspecies) of *Corvus brachyrhynchos* are recognized in the A.O.U. Checklist of North American Birds (1957) namely:

a. *Corvus brachyrhynchos brachyrhynchos* Brehm, 1822. Eastern Crow. Range--This Eastern population ranges from Southwestern Mackenzie, Northern Manitoba, Southern Quebec, and Newfoundland South to Maryland, the Northern part of the Gulf States and Northern Texas.

b. *Corvus brachyrhynchos paulus* Howell, 1913. Southern Crow. Range--From lower Potomac and Ohio Valleys (Ohio River) Southward to Georgia and Gulf of Mexico and the Northern Border of Florida and Western to Eastern Texas and Arkansas.

c. *Corvus brachyrhynchos pascuus* Coues, 1899. Florida Crow. Range--Peninsula of Florida.

d. *Corvus brachyrhynchos hesperis* Ridgway, 1887. Western Crow. Range--Western North America, occupying Southwestern Canada (East Central British Columbia, Central Alberta and Saskatchewan) and the Western United States (Montana South to Southern California) Southward to Central New Mexico, along its Eastern Border it integrates with *Corvus brachyrhynchos paulus* and *Corvus brachyrhynchos brachyrhynchos*.

Many aspects of the biology of the common crow have been studied (Black, 1941) but few of the papers have been concerned with its parasites. In the United States some of the more recent works are those of Ward (1935), Beaver (1936, 1937), Morgan and Waller (1940, 1941), Good (1952), Daly (1957), Jones (1968), Hendricks *et al.* (1969) and Hendricks (1971). In Canada limited

work has been done on crows; Rayner (1932), Mawson (1956a, 1956b, 1956c, 1956d, 1957) and Hodasi (1963) noted helminths from this host during the course of general surveys of bird parasites; while Andrews and Threlfall (1973) organized much of the formidable literature concerning the helminths of corvids.

This study was undertaken to determine the nature and burden of parasites of the Common Crow in Newfoundland, and to correlate any differences with the work of previous authors in North America.

MATERIALS AND METHODS

The host specimens were obtained by using various firearms, the most reliable being the 12-gauge shotgun, using high velocity shells with shot ranging in size from No. 2 to No. 7½. The majority of specimens were collected just after sunrise on a sanitary fill at Robin Hood Bay, approximately five miles north-east of the city of St. John's. Ninety-nine crows*(37 adult male, 18 adult female, 4 adult birds of unknown sex and 40 immature birds) were examined from twelve localities in Newfoundland. Eighty-five specimens were obtained at Robin Hood Bay (47°37'N, 52°40'W). A single bird was taken at each of Tors Cove (47°13'N, 52°51'W), Mt. Scio (47°34'N, 52°43'W), Foxtrap (47°32'N, 52°57'W), Lawrence Pond (47°27'N, 53°05'W), Pouch Cove (47°47'N, 52°45'W), Logy Bay (47°38'N, 52°41'W), Mt. Pearl (47°31'N, 52°47'W), and Topsail (47°33'N, 52°55'W). Two specimens were taken at each of Rocky Harbour (49°29'N, 57°52'W),Glovertown (48°42'N, 54°10'W) and Bay Roberts (47°36'N, 53°17'W).

Four adult female ravens were also examined during the course of the study. One specimen was taken at each of Robin Hood Bay, Rocky Harbour, Marystown (47°09'N, 55°09'W) and Paddy's Pond (47°26'N, 52°51'W).

The birds were shot on the wing as they flew over the areas in search of food. It was noted during the course

*"Crows were collected from April 1971 to May 1973."

of collection that at various times of the year the birds would fly into the fill at Robin Hood Bay from particular points of the compass so that it could be predicted where the birds would enter. Frequent sampling tended to increase the birds' wariness so that a discharged gun would disperse the flock beyond shooting range. This was not the case for young birds whose experience with hunters was minimal.

More crows could be shot when foliage or other available material was used as a blind. Best results were obtained when using a crow call, which attracted birds within range. The number of times a particular bird or flock responded to the crow call varied according to the skill of the user. Young birds responded to the call more readily than adults and all birds responded well just prior to the mating season. Specimens were more difficult to obtain during the breeding season as the birds tended not to flock. The best periods for collection were during the fall, winter and early spring.

Other methods of capture were attempted without success. Bait traps were not used on the sanitary fill because of the already high availability of food and the anticipated interference by rats.

In an attempt to increase sample size, two narcotics, alpha-chloralose and tribromomethanol, were used without success in the manner outlined by Caithness

(1968) and Borg (1955).

As soon as a bird was shot it was placed in a plastic bag (10 lb. size) along with a data card and a cotton wad soaked in petroleum ether. The latter was introduced to limit the movement of ectoparasites before examination.

Weights and standard measurements (wing, tail, tarsus and culmen) were taken as part of a wider survey. The intensity and location of moult, if any, was noted.

External regions of the host were examined to locate ectoparasites, if present, and to determine their frequency of occurrence. Regions examined included head and neck, dorsal and ventral regions, tail, wings, nictitating membranes, inner surface of the eyelids, nasal cavities, uropygial gland, and toes. Ectoparasites recovered were placed in labelled, 4 dram vials containing 70% ethyl alcohol, and set aside for future identification. The knees were broken at the joints and the skin incised to locate any parasites that might be present.

The host specimen was then skinned after a median longitudinal incision had been made along the ventral surface. The skin was separated from the muscles and underlying fascia and removed intact from the body. The wings were broken along the humerus and removed with the accompanying skin. The entire inner surface of the skin was then examined and scraped for parasites.

Underlying muscles were inspected externally for encysted parasites. The leg and breast muscles were examined under the dissecting microscope.

The eyes were removed from their sockets after the optic nerve had been severed, to make extraction easier. Each eye was placed in a petri dish of physiological saline and examined both internally and externally. The brain was removed and examined.

The nasal cavities were inspected after an incision had been made in the roof of the mouth. The contents were flushed with fresh water into a 250 micron mesh sieve. Any detritus was washed into a dish of saline and examined under the dissecting microscope.

The body cavity was exposed by means of a median longitudinal incision in the muscles. The ribs of one side and a coracoid were severed with bone cutters so that the keel and its muscles could be lifted to expose the air sacs within the body cavity. Once the air sacs had been examined, they were severed to expose the internal organs. A blood smear was taken from the heart whenever possible. Each organ was removed separately and placed in saline for examination under the dissecting microscope. Organs such as the liver, spleen, kidneys, lungs, heart, testes and ovaries were teased apart. The trachea was cut longitudinally into two halves to present the internal surface for examination. The oesophagus and proventriculus were

slit longitudinally and stretched open so that the various folds became visible. The gall bladder was carefully removed from the liver using surgical clamps and scissors to prevent the contents from escaping into the exposed body cavity. The gall bladder was then placed in saline and examined under the dissecting microscope. The bile ducts in the liver were opened and examined.

The gizzard was removed and its contents sieved and flushed into a finger bowl for examination. The inner lining of the gizzard was removed and both surfaces were examined.

The remainder of the gut was removed intact. The duodenum was separated from the rest of the small intestine and placed in saline. The remaining small intestine was cut into three equal sections, (S_1, S_2, S_3), each of which was placed in saline. The rectum, cloaca, and bursa of fabricius were placed in individual dishes for examination. The oviducts received similar treatment.

After removal of all tissues and organs, the contents of the body cavity were flushed with water into a sieve and examined. The body wall was then inspected.

Where the gut was severely damaged by shot, the entire intestine was examined in one segment. Stomach contents, when present, were preserved and later identified.

Parasites recovered were prepared for examination using the various techniques, fixatives, and stains outlined in Appendices 3 and 4.

RESULTS AND DISCUSSION

Twelve species of helminth parasites were recovered from *Corvus brachyrhynchos* during the study (3 trematodes, 3 cestodes, 5 nematodes, and 1 acanthocephalan). Of these, seven are new host records for North America and twelve are new host records for Canada (Table 1). Three species of Mallophaga and three species of blood protozoans are reported.

Ninety-four crows (95%) were infected with helminth parasites (range 1 - 190; mean 63 per infected bird). Eighty-two crows (83%) were infested with ectoparasites (range 1 - 357; mean 51 per infected bird).

Six species of helminth parasites (1 trematode, 2 cestodes and 3 nematodes) and two species of Mallophaga were recovered from *Corvus corax*. Of these, five of the helminths are new host records for North America, and six are new for Canada. All four ravens were infected with helminth parasites (range 1 - 56; mean 23 per infected bird) and infested with ectoparasites (range 1 - 99; mean 63 per infested bird).

All measurements in the following text are given in microns, unless otherwise stated.

In several instances, parasites were recovered from the body cavity of the host, probably having migrated to this location after the death of the host and as a result of shot damage to the viscera.

TABLE 1

DETAILS OF THE INFECTION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH PARASITES

Host	Parasite	*Conspicuum macrorchis**	*Brachylecithum stunkardi***	*Prosthogonimus macrorchis**	*Dilepis undula***	*Hymenolepis farciminosa***	*Schistocephalus solidus***	*Capillaria resecta***	*Capillaria contorta**	*Cyathostoma lari***	*Prosthorhynchus formosum**
Male birds	No.(%)birds infected	26(70%)	2 (5%)	-	16(43%)	4(11%)	2 (5%)	22(59%)	22(59%)	10(27%)	18(49%)
	Total No. parasites recovered	293	160	-	148	12	4	1047	165	37	746
	Range of No. recovered	(1-97)	(35-125)	-	(1-100)	(1-6)	(1-3)	(1-153)	(1-27)	(1-15)	(1-190)
	Av. No. / infected bird	11	80	-	9	3	2	48	8	4	41
Female birds	No. (%) birds infected	14(78%)	-	-	11(61%)	2(11%)	-	14(78%)	8(44%)	2(11%)	9(50%)
	Total No. parasites recovered	87	-	-	44	8	-	543	30	2	187
	Range of No. recovered	(1-18)	-	-	(1-21)	(1-7)	-	(1-137)	(1-7)	1	(1-82)
	Av. No. / infected bird	6	-	-	4	4	-	39	4	1	21

TABLE 1 (CONTINUED)

Host	Parasite	*Conspicuum macrorchis**	*Brachylecithum stunkardi***	*Prosthogonimus macrorchis**	*Dilepis undula***	*Hymenolepis farciminosa***	*Schistocephalus solidus***	*Capillaria resecta***	*Capillaria contorta**	*Cyathostoma lari***	*Prosthorhynchus formosum**
Immature birds	No. (%) birds infected	35(88%)	-	17(43%)	28(70%)	6(15%)	2(5%)	30(75%)	27(68%)	22(55%)	30(75%)
	Total No. parasites recovered	501	-	41	471	36	23	542	189	107	314
	Range of No. recovered	(1-59)	-	(1-6)	(1-111)	(1-22)	(2-21)	(1-82)	(1-32)	(1-13)	(1-28)
	Av. No. / infected bird	14	-	2	17	6	12	18	7	5	10
Birds of unknown sex	No. (%) birds infected	4(25%)	-	-	1(25%)	1(25%)	-	3(75%)	2(50%)	3(75%)	3(75%)
	Total No. parasites recovered	10	-	-	103	1	-	45	16	7	21
	Range of No. recovered	(1-4)	-	-	(1-73)	1	-	(1-34)	(1-11)	(1-4)	(1-8)
	Av. No. / infected bird	3	-	-	103	1	-	15	8	2	7
Total	No. (%) birds infected	79(80%)	2(2%)	17(17%)	56(57%)	13(13%)	4(4%)	69(70%)	59(60%)	37(37%)	60(61%)
	Total No. parasites recovered	891	160	41	766	57	27	2177	400	153	1268
	Range of No. recovered	(1-97)	(1-125)	(1-6)	(1-111)	(1-22)	(1-21)	(1-153)	(1-32)	(1-15)	(1-190)
	Av. No. / infected bird	11	80	2	14	4	7	32	7	4	21

*New host record for Canada; **New host record for North America.

Trematoda

Three species of trematodes belonging to three genera were recovered from 79 (80%) of the crows examined (range 1 - 125; mean 14 per infected bird).

Conspicuum macrorchis Denton and Byrd, 1951.

This species was recovered from 79 (80%) of the crows examined (range 1 - 97; mean 11 per infected bird) (Table 1). Immature crows were the most frequently infected age class (88% infected) while adult females were 78% infected and adult males 70% infected. (Table 1). The four birds of unknown sex were all infected.

Adult male and immature crows had the highest intensity of infection, 33% of the parsites being recovered from the former and 56% from the latter. Adult female birds yielded only 10% of the parasites (Table 2).

The gall bladder was the preferred site of infection, 58% of the parasites being recovered from this region. Bile ducts contained an additional 35% while the remaining 7% were distributed between the duodenum, gizzard, intestine and body cavity (Table 2).

Immature specimens of *C. macrorchis* were recovered from one adult male crow (one specimen from the bile duct), one adult female crow (three from the gall bladder) and one immature crow (six from the gall bladder).

TABLE 2

DETAILS OF INFECTION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH ADULT TREMATODES

Site of Infection	*Conspicuum macrorchis*										*Brachy-lecithum stunkardi*		*Prostho-gonimus macrorchis*	
	Male birds		Female birds		Immature birds		Birds of unknown sex		Total		Male birds		Immature birds	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total
(Parasites recovered)	293	33	87	10	501	56	10	1	891	-	160	-	41	-
Bursa of fabricus	-	-	-	-	-	-	-	-	-	-	-	-	34	83
Gall bladder	134	45.7	35	40	341	68	4	40	514	58	10	6	-	-
Bile duct	133	45	44	51	127	25	3	30	307	35	146	91	-	-
Gizzard	3	1	-	-	-	-	1	10	4	.4	-	-	1	2
Duodenum	5	2	4	5	4	.8	-	-	13	1	-	-	-	-
Intestine	9	3	2	2	8	2	1	10	20	2	-	-	-	-
Rectum	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Body cavity	8	3	2	2	16	3.2	1	10	27	3	4	3	5	13
Other regions	1	.3	-	-	5	1	-	-	6	.6	-	-	-	-

Conspicuum macrorchis was first recorded and described by Denton and Byrd (1951) from *Corvus brachyrhynchos* in Texas. Jones (1968) recorded this parasite from the same host in Ohio.

One of the ravens examined harbored twenty-three parasites of this species in the gall bladder and one in the duodenum. This parasite has not previously been recorded from ravens in North America or Europe (*vide* Andrews and Threlfall, 1973).

Measurements and morphological characters of specimens obtained during the present study agree with those of Denton and Byrd (1951) (Table 3). However, in two specimens the cirrus sac was extremely large measuring 961 X 175 μ in one and 692 X 429 μ in the other. This large size may be due to differences in the various techniques of preservation and staining (Ulmer, 1952).

Conspicuum macrorchis is closely related to *C. icteridorum* Denton and Byrd, 1951, but is easily distinguished from it by its larger, more muscular body, extensively developed vitellaria and uterus, and much larger testes (Denton and Byrd, 1951).

Brachylecithum stunkardi (Pande, 1939).

Brachylecithum stunkardi was recovered from two male crows (35 specimens in one; 125 in the other). Sites of infection were the bile ducts (91% of specimens recovered),

TABLE 3

MEASUREMENTS OF *CONSPICUUM MACRORCHIS* DENTON AND BYRD, 1951 OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) AND THE RAVEN (*CORVUS CORAX*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF DENTON AND BYRD (1951)

	Corvus brachyrhynchos Present Study		*Corvus corax* Present Study		Denton and Byrd, 1951	
	Mean	Range	Mean	Range	Mean	Range
Body, length (mm.)	5.5	1.9 -7.6	3.8	3.6 -404	-	4.2-5.4
width (mm.)	1.2	.58-2.2	.84	.69- .94	-	1.4-2.04
Oral sucker, length	340	185-497	262	224-283	-	
width	348	190-507	266	229-292	-	
diameter					-	300-500
Acetabulum, diameter	610	317-766	542	463-603	-	550-840
Pharynx, length	139	78-224	104	97-117	-	
width	160	102-248	140	126-151	-	
diameter					-	140-240
Esophagus, length	222	126-356	-	-	-	150-200
width	48	-	-	-	-	
Cirrus sac, length	564	263-961	361	263-351	-	330-660
width	175	87-429	110	87-136	-	120-190
Left testes, diameter	345	204-507	329	312-361	-	250-770
Right testes, diameter	341	195-507	324	263-390	-	250-770
Ovary, diameter	263	146-390	229	195-253	-	300-370
Eggs, length	36	23-42	38	37-40	-	27-31
width	24	16-23	23	17-28	-	19-21
Vitellaria, length (mm.)	1.6	.80-2.7	1.1	1.0 -1.3	-	1.7-2.2

TABLE 4

MEASUREMENTS OF *PROSTHOGONIMUS MACRORCHIS* MACY, 1934 OBTAINED FROM THE COMMON CROW *CORVUS BRACHYRHYNCHOS* DURING THE PRESENT STUDY COMPARED WITH THOSE OF MACY (1934b)

	Prosthogonimus macrorchis Present Study		*Prosthogonimus macrorchis* Macy, 1934	
	Mean	Range	Mean	Range
Body, length (mm.)	4.6	2.6 -6.6	-	3.9-4.0
width (mm.)	2.0	.19-3.6	-	1.9-2.3
Oral sucker, length	343	185-546	-	306-396
width	336	175-614	-	326-396
Acetabulum, length	687	439-897	-	594-612
width	711	439-1278	-	594-612
Pharynx, length	186	131-188	-	126-180
width	206	136-419	-	162-190
Cirrus sac, length	472	263-780	-	468-720
width	121	97-185	-	-
Left testes, length	867	629-1100	-	522-720
width	642	370-761	-	216-396
Right testes, length	777	575-976	-	522-720
width	651	375-741	-	216-396
Ovary, length	-	-	-	234-288
width	-	-	-	378-588
Eggs, length	22	19-28	28	-
width	14	11-16	16	-

the gall bladder (6%) and the body cavity (3%) (Table 2).

It is interesting to note that the two host specimens were those taken on the west coast of Newfoundland approximately 600 miles from the main sampling areas. This would suggest either that this parasite is at the extreme edge of the range of its intermediate host, or that there are differences in the diets of the different host populations.

B. stunkardi has not previously been recorded from *Corvus brachyrhynchos* in North America.*

The measurements of material recovered during this survey agree with those of Denton and Byrd (1951), with the exception of the egg measurements (Table 5). However, these authors consider that the method of preservation may affect egg size.

Prosthogonimus macrorchis Macy, 1934.

This parasite was recovered from 17 (17%) of the crows examined (range 1 - 6; mean 2 per infected bird) (Table 1). The main site of infection was the Bursa of Fabricius, a lympho-epithelial organ of immature birds. The organ completely disappears in the adult bird. Of the 20 immature birds with a bursa, 17 (85%) were infected. The bursa harbored 83% of the parasites recovered, the body cavity 13%, the gizzard 2% and the rectum 2% (Table 2). It is suspected that specimens taken from areas other than

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*normally found in the Blue Jay (Cyanocitta cristata (L)). Presence in this host in Newfoundland not yet determined."

TABLE 5

MEASUREMENTS OF *BRACHYLECITHUM STUNKARDI* (PANDE, 1935) OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF DENTON AND BYRD (1951)

	Brachylecithum stunkardi Present Study		*Brachylecithum stunkardi* Denton and Byrd, 1951	
	Mean	Range	Mean	Range
Body, length (mm.)	6.4	4.7 -8.0	-	2.8 -3.9
width (mm.)	.26	.19- .34	-	.22- .30
Oral sucker, length	238	185-283	-	-
width	228	180-302	-	-
Acetabulum, length	341	224-439	-	190-280
width	390	-	-	220-350
Pharynx, length	90	58-165	-	-
width	79	53-102	-	-
diameter	-	-	-	50-70
Oesophagus, length	-	-	-	200-320
Cirrus sac, length	185	126-253	-	140-190
width	97	58-136	-	70-90
Anterior testes, length	295	190-527	-	-
width	276	151-551	-	-
diameter	-	-	-	100-360
Posterior testes, length	340	156-579	-	-
width	276	122-507	-	-
diameter	-	-	-	100-360
Ovary, length	158	97-244	-	70-190
width	158	106-263	-	150-250
Vitellaria, length (mm)	1.05	.91-1.23	-	-
Eggs (*in situ*) length	-	-	-	38-45
width	-	-	-	28-33
Eggs (preserved), length	44	38-49	-	30-41
width	28	26-33	-	21-27

the bursa reached there by migrating after the death of the host or as a result of shot damage to the gut.

Prosthogonimus macrorchis, mainly found in domestic fowl, has previously been recorded from *Corvus brachyrhynchos* by Macy (1934a, 1934b). However, his infections were experimentally induced and this is the first record of the species from a wild population of crows.

Measurements of the present specimens agree closely with those of Macy (1934b), with the exception of the acetabulum (Table 4). However, Macy (1934b) has indicated that in experimentally infected crows the suckers are slightly larger than those found in hens and the placement of the ovary is nearer the ventral sucker. In general, Macy (1934b) indicates that specific characters hold for specimens reared in different hosts, although host influence was present in each case, and that *P. macrorchis* shows a tendency for considerable variation.

The width of the testis in one specimen fell outside the ranges given by Macy (1934b). This is probably due to the fact that *P. macrorchis* is a relatively thick parasite and there is a considerable amount of dorsoventral flattening when it is mounted (Ulmer, 1952).

Cestoda

Three species of cestodes belonging to three genera were recovered from 60 (61%) of the crows examined (range 1 - 111; mean 14 per infected bird).

Dilepis undula (Schrank, 1788).

Dilepis undula was noted in 56 (57%) of the crows examined (range 1 - 111; mean 14 per infected bird) (Table 1).

Sites of infection were the small intestine (duodenum, S_1, S_2, S_3), the rectum and the body cavity. The greatest intensity of infection was found in the second section of the small intestine (Table 6). Adult male and immature crows harbored the greatest number of parasites (Table 6).

This species has not previously been recorded from *Corvus brachyrhynchos* in North America. However, it has been recorded from other *Corvus* species (*vide* Andrews and Threlfall, 1973 and this study).

Of the four ravens examined only one was infected with *D. undula*. Fifty-six adult specimens were recovered (1 from the duodenum, 20 from S_1, 28 from S_2, 4 from S_3 and 3 from the body cavity).

D. undula has previously been recorded from the raven by many researchers (*vide* Andrews and Threlfall, 1973).

TABLE 6

DETAILS OF INFECTION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH ADULT AND IMMATURE FORMS OF THE CESTODE *DILEPIS UNDULA* (SCHRANK, 1788)

Site of infection	*Dilepis undula*																			
	Adult										Immature									
	Male birds		Female birds		Immature birds		Birds of unknown sex		Total		Male birds		Female birds		Immature birds		Birds of unknown sex		Total	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total
(parasites recovered)	144	25	38	7	320	56	73	12	575	-	4	2	6	3	151	79	30	16	191	-
Duodenum	1	.7	-	-	1	.3	-	-	2	.3	-	-	-	-	-	-	-	-	-	-
S_1	16	11.1	24	63	17	5.3	1	1	58	10.1	1	25	2	67	9	6	-	-	12	6
S_2	115	79.9	6	16	170	53.1	70	96	361	63	1	25	-	-	88	58.3	29	97	118	62
S_3	11	7.6	7	18	98	30.6	2	3	118	20.5	-	-	4	33	53	35	1	3	58	30
Rectum	1	.7	-	-	7	2.2	-	-	8	1.3	-	-	-	-	-	-	-	-	-	-
Body cavity	-	-	1	3	27	8.5	-	-	28	4.8	2	50	-	-	1	.7	-	-	3	2

Measurements of specimens from both the crow and the raven agree with the descriptions and measurements given by Davies (1935) and Mettrick (1958b) (Table 7).

Hymenolepis farciminosa (Goeze, 1782).

This species was recovered from 13 (13%) of the crows examined (range 1 - 22; mean 4 per infected bird) (Table 1).

Sites of infection were the small intestine (duodenum, S_1, S_2, S_3) with S_2 containing the greatest number of parasites (Table 8). Immature birds were found to harbor the majority of parasites of this species (Table 8). A single specimen was taken from S_3 of the small intestine of one raven.

Hymenolepis farciminosa has not previously been recorded from *Corvus brachyrhynchos* or *Corvus corax* in North America.

Measurements obtained during the present study agree with those of Mettrick (1958b) and Saxena (1972), with the exception of rostellar hook length, and scolex and cirrus sac widths (Table 9). Two scoleces were recovered and only one of these bore hooks; thus quantitative results could not be obtained.

The width of the cirrus sac was extremely large compared with the data of Mettrick (1958b) and Saxena (1972). This might be attributed to distinct morphological

TABLE 7

MEASUREMENTS OF *DILEPIS UNDULA* (SCHRANK, 1788) OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF DAVIES (1935) AND METTRICK (1958b)

	Dilepis undula Present Study		*Dilepis undula* Davies, 1935		*Dilepis undula* Mettrick, 1958	
	Mean	Range	Mean	Range	Mean	Range
Body, length (mm.)	9.1	5.3 -12.8	50 (max.)	-	70 (max.)	-
width (mm.)	1.7	.63- 4.40	2.5 (max.)	-	3.5 (max.)	-
Scolex, length	416	205 - 678	-	-	-	-
diameter	720	556 -1018	725	-	-	450-930
Neck, length	-	-	-	550-596	-	550-750
diameter	-	-	-	459-642	-	-
Outer Rostellar sac,	-	-	-	-	-	-
length	482	341 - 595	-	-	-	-
diameter	236	156 - 297	-	275-367	-	-
Inner Rostellar sac,	-	-	-	-	-	-
length	392	283 - 497	-	-	-	-
diameter	185	92 - 244	-	138-229	-	-
No. Hooks	-	-	-	45-60	-	48-64
Hooks, length	83	57-107	-	-	-	-
1st row	-	-	84	-	-	91-116
2nd row	-	-	72	-	-	70-88
Suckers, diameter (1)	215	136-283	-	-	-	-
(2)	234	165-234	-	-	-	-
(3)	221	156-273	-	-	-	-
(4)	230	170-546	-	-	-	-

TABLE 7 (CONTINUED)

	Dilepis undula Present Study		*Dilepis undula* Davies, 1935		*Dilepis undula* Mettrick, 1958	
	Mean	Range	Mean	Range	Mean	Range
Excretory canal						
Dorsal, diameter	6.6	2.3-15.4	-	-	-	8-14
Left dorsal, diameter	-	-	-	11-15	-	-
Right dorsal, diameter	-	-	-	8-11	-	-
Ventral, diameter	22	13-26.1	-	-	-	28-42
Left Ventral, diameter	-	-	-	47-68	-	-
Right Ventral, diameter	-	-	-	42-53	-	-
Transverse, diameter	5.8	3.5-10.7	-	17-32	-	10-20
Cirrus sac, length	265	149-357	-	321-431	-	280-420
diameter	42	33-54	-	34-54	-	32-44
No. Testes	30	21-42	-	28-35	-	28-36
Testes, length	58	38-92	-	-	-	48-63
width	63	40-99	-	-	-	60-70
diameter	-	-	-	62-66	-	-
Vitellarium, length	69	35-140	-	42-80	-	40-70
width	188	66-257	-	83-188	-	97-170
Receptaculum seminis, length	69	26-114	-	-	-	-
width	124	78-238	-	-	-	-
diameter	-	-	-	-	-	-
Eggs, diameter	30	-	-	-	-	36-40
Embryonic envelope, length	49	40-54	-	-	-	48-56
width	45	-	-	-	-	4-48
Embryonic hooks, length	11	9-14	-	-	-	18-20

TABLE 8

DETAILS OF INFECTION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH THE CESTODES *HYMENOLEPIS FARCIMINOSA* (GOEZE, 1782) AND *SCHISTOCEPHALUS SOLIDUS* (MÜLLER, 1776)

Site of infection	*Hymenolepis farciminosa*										*Schistocephalus solidus*									
	Male birds		Female birds		Immature birds		Birds of unknown sex		Total		Male birds		Female birds		Immature birds		Birds of unknown sex		Total	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total
(parasites recovered)	12	21	8	14	36	63	1	2	57	100	4	15	-	-	23	85	-	-	27	100
Duodenum	-	-	-	-	2	6	-	-	2	3	-	-	-	-	-	-	-	-	-	-
S_1	-	-	8	100	14	39	-	-	22	39	1	25	-	-	1	4	-	-	2	7
S_2	7	58	-	-	17	47	1	100	25	44	-	-	-	-	18	78	-	-	18	67
S_3	5	42	-	-	3	8	-	-	8	14	3	75	-	-	4	18	-	-	7	26

TABLE 9

MEASUREMENTS OF *HYMENOLEPIS FARCIMINOSA* (GOEZE, 1782) OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF METTRICK (1958b) AND SAXENA (1972)

	Hymenolepis farciminosa Present Study		*Hymenolepis farciminosa* Mettrick, 1958		*Hymenolepis farciminosa* Saxena, 1972	
	Mean	Range	Mean	Range	Mean	Range
Body, length (mm.)	-	-	82 (max.)	-	150 (max.)	-
width (mm.)	1.05	.55-1.7	1.2(max.)	-	1.8(max.)	-
Scolex, length	259	138-380	-	180-250	-	120-210
width	449	138-761	-	-	-	170-240
Rostellum, length	199	57-341	-	200-240	-	70-87
diameter	132	40-224	-	-	-	-
Rostellal hooks, length	19	19-21	-	-	-	13-15
Suckers, diameter				85-90	-	84-101
(1)	115	61-204	-	-	-	-
(2)	131	58-204	-	-	-	-
(3)	126	66-244	-	-	-	-
(4)	71	66-76	-	-	-	-
No. testes	3	-	-	-	3	-
Testes, diameter		-	-	90-100	-	75-195
(1)	139	85-185	-	-	-	-
(2)	139	80-204	-	-	-	-
(3)	138	83-185	-	-	-	-

TABLE 9 (CONTINUED)

	Hymenolepis farciminosa Present Study		*Hymenolepis farciminosa* Mettrick, 1958		*Hymenolepis farciminosa* Saxena, 1972	
	Mean	Range	Mean	Range	Mean	Range
Cirrus sac, length	260	59-419	200	-	-	128-220
diameter	204	66-204	45	-	-	32-48
Genital pore, length	136	76-168	-	-	-	-
diameter	49	35-64	-	-	-	-
Eggs, length	-	-	48	-	-	70-77
diameter	-	-	30	-	-	52-56
Embryo hooks, length	18	14-26	-	-	-	8-10

differences resulting from host influence, or techniques used in preparation for examination.

Body lengths of specimens were not taken since the worms were in fragments when extracted.

Schistocephalus solidus (Müller, 1776).

Schistocephalus solidus was recovered from 4 (4%) of the crows examined (range 1 - 21); mean 7 per infected bird) (Table 1).

Site of infection was the small intestine (S_1, S_2, S_3) with S_2 containing the greatest number of parasites (Table 8). Numbers of parasites were greater for immature birds than adult males; no parasites of this species were recovered from adult females (Table 8).

Schistocephalus solidus has not previously been recorded from *Corvus brachyrhynchos* in North America. However, it has been recorded from *Corvus corax* L. and *Corvus corone cornix* in Europe (*vide* Andrews and Threlfall, 1973).

Only posterior segments, containing eggs, were recovered from the host. The eggs were ellipsoid, with a mean size of 60 X 34 μ (range 49 - 60 μ X 29 - 40 μ). These measurements agree with those of Hopkins and Smyth (1951) and Dubinina (1957, 1966). The former author report the egg measurements as 58 - 77 μ X 35 - 46 μ, and indicate that egg size will show a great range of variation.

The adult of this cestode normally occurs in the intestine of fish-eating birds (Hopkins and Smyth, 1951). Cooper (1918) lists forty different bird species as hosts. In spite of a wide range of hosts, the adult worm is comparatively rare. The apparent scarcity results from the rapid (36 hours) maturation of the plerocercoid larva in the definitive host, and the short time (3 - 4 days) that the adult remains there (Hopkins and Smyth, 1951). From this, it follows that the chances of recovering this parasite from any particular bird will vary with the frequency that it eats infected fish.

Specimens recovered during the present study were probably accidentals since the crow does not consume large amounts of fish. The time of collection coincided with a mass die-off of the intermediate host the three-spined stickleback, *Gasterosteus aculeatus* L. (Threlfall, 1968c). It is possible that the crows, being scavengers, fed on dead sticklebacks washed up on the shore, and thus became hosts for the adult worms.

Nematoda

Four species of adult nematodes and one larval form were recovered from 73 (74%) of the crows examined (range 1 - 153; mean 37 per infected bird).

Capillaria resecta (Dujardin, 1843).

Capillaria resecta was recovered from 69 (70%) of the crows examined (range 1 - 153; mean 32 per infected bird) (Table 1).

Adult male and immature birds harbored the greatest numbers of parasites (Table 1). Sites of infection were the small intestine (duodenum, S_1, S_2, S_3), rectum, and body cavity. Most parasites were recovered from S_3, of the small intestine. The lightest infection was found in the duodenum, S_1, the body cavity, and the rectum (Table 10).

Male and female nematodes showed no differential infection preference for the sex of the host. Immature forms of the parasite were recovered from adult males, immatures, and birds of unknown sex. However, insufficient numbers of immature nematodes were recovered to indicate that this is true for the total population of birds.

One female specimen of *C. resecta* was noted in the body cavity of a raven.

This parasite has not previously been recorded from *Corvus brachyrhynchos* or *Corvus corax* in North America.

TABLE 10

DETAILS OF INFECTION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH THE NEMATODES *CAPILLARIA RESECTA* (DUJARDIN, 1843) AND *CAPILLARIA CONTORTA* (CREPLIN, 1839)

Site of infection	*Capillaria resecta*								*Capillaria contorta*							
	Male		Female		Immature		Total		Male		Female		Immature		Total	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total
(Parasites recovered)	977	44.8	1189	54.6	11	.6	2177	100	68	17	323	81	9	2	400	100
Sinus	-	-	-	-	-	-	-	-	7	10	28	8	2	22	37	9
Oesophagus	-	-	-	-	-	-	-	-	54	80	257	80	6	67	317	79
Duodenum	32	3	32	3	2	18	66	3	-	-	-	-	-	-	-	-
S_1	68	7	37	3	2	18	107	5	-	-	-	-	-	-	-	-
S_2	150	16	157	13	-	-	307	14	-	-	-	-	-	-	-	-
S_3	638	65	868	73	7	64	1513	70	-	-	-	-	-	-	-	-
Rectum	68	7	70	6	-	-	138	6	-	-	-	-	-	-	-	-
Body cavity	21	2	25	2	-	-	46	2	7	10	38	12	1	11	46	12

However, Andrews and Threlfall (1973) report that it has a wide distribution among members of the genus *Corvus* in other parts of the world.

Capillaria contorta (Creplin, 1839).

Capillaria contorta was noted in 59 (60%) of the crows examined (range 1 - 32; mean 7 per infected bird) (Table 1). The major infection site was the oesophagus, although specimens were recovered from the sinus and body cavity (Table 10). These worms were probably in abnormal locations due to post-mortem movement or shot damage. The oesophagus contained the greatest number of parasites. The majority of parasites recovered were females (Table 10). As in *C. resecta;* male, female, and immature nematodes showed no differential infection preference for the sex of the host infected.

This parasite has previously been recorded from *Corvus brachyrhynchos* in the United States by Canavan (1931), Morgan and Waller (1941), Fendinger (1952), Jones (1968), and Hendricks *et al.*, (1969). There are no previous records of this parasite from *C. brachyrhynchos* in Canada. However, Threlfall (1968a, 1968b) recorded it from the Herring Gull (*Larus argentatus* Pont.) in Newfoundland.

One male and one female were recovered from the oesophagus of a raven. This parasite has not previously been reported from the raven in North America. However,

TABLE 11

MEASUREMENTS OF *CAPILLARIA RESECTA* (DUJARDIN, 1843) OBTAINED FROM THE COMMON CROW, *CORVUS BRACHYRHYNCHOS* DURING THE PRESENT STUDY COMPARED WITH THOSE OF METTRICK (1959)

	Capillaria resecta Present Study				*Capillaria resecta* Mettrick, 1959			
	Males		Females		Males		Females	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Body, length (mm.)	8.2	5.8 -12.4	9.8	5.8-14.1	-	9.8-12.7	-	10.1-13.6
diameter	43	27-64	55	30-107	60 (max. dia.)	-	72 (max. dia.)	-
Spicule, length (mm)	1.0	.79- 1.2	-	-	-	1.2- 2.4	-	-
width	7	3-13	-	-	-	7-9	-	-
Spicule sheath, dia.	11	7-16	-	-	-	15-20	-	-
Eggs, length	-	-	50	45-54	-	-	-	51-59
diameter	-	-	26	21-35	-	-	-	25-27

records of this parasite have been reported from the raven in Europe (*vide* Andrews and Threlfall, 1973).

Measurements of specimens obtained during the present study agree with those of Mettrick (1959) (Table 12).

Cyathostoma lari Blanchard, 1849.

Representatives of this species were recovered from 37 (37%) of the crows examined (range 1 - 15; mean 4 per infected bird) (Table 1).

Site of infection was the nasal cavities. Most parasites were recovered from immature birds (Table 13). Male and female parasites of this species showed no differential infection preference for the sex of the host infected.

A frequent and usually highly infected host of *C. lari* is the Herring Gull (Threlfall, 1968a). It is possible that infection in the crow is facilitated by species interaction at the sanitary fill, which is a feeding area for both crows and Herring Gulls. Since the life cycle of *C. lari* is direct; transfer from one host to another might be expected in this situation.

Cyathostoma lari has not previously been recorded from *Corvus brachyrhynchos* in North America. Records of this parasite for *Corvus frugilegus* L. and *Corvus corone* L. in Europe are reported (Burt and Eadie, 1958). The life

TABLE 12

MEASUREMENTS OF *CAPILLARIA CONTORTA* (CREPLIN, 1839) OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF METTRICK (1959)

	Capillaria contorta Present Study				*Capillaria contorta* Mettrick, 1959			
	Males		Females		Males		Females	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Body, length (mm.)	10.6	6.0 -13.3	16.1	5.3-20.2	-	10-45.5	-	15.4-46
diameter	78	52 -111	107	45-173	-	-	143 (max. dia.)	-
Spicule, length	.67	.47- .95	-	-	-	-	-	-
diameter	-	-	-	-	-	3-4	-	-
Spicule sheath, length(mm.)	-	-	-	-	-	.8-4.03	-	-
diameter	12	8 -16	-	-	-	-	-	-
Eggs, length	-	-	55	47-64*	-	-	-	46-62
diameter	-	-	28	22-35	-	-	-	23-25

*Measurement of egg length includes yolk plug.

TABLE 13

DETAILS OF INFECTION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH THE NEMATODE *CYATHOSTOMA LARI* BLANCHARD, 1849 AND THE ACANTHOCEPHALAN *PROSTHORHYNCHUS FORMOSUM* (VAN CLEAVE, 1918)

Site of Infection	*Cyathostoma lari*										*Prosthorhynchus formosum*									
	Male birds		Female birds		Immature birds		Birds of unknown sex		Total		Male birds		Female birds		Immature birds		Birds of unknown sex		Total	
	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total	No.	% of total
(Parasites recovered)	37	-	2	-	107	-	7	-	153	-	746	59	187	15	314	25	21	1	1268	-
Sinus	37	24	2	1	107	70	7	5	153	100	-	-	-	-	-	-	-	-	-	-
Duodenum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S_1	-	-	-	-	-	-	-	-	-	-	23	3.1	-	-	1	.4	1	5	25	2
S_2	-	-	-	-	-	-	-	-	-	-	330	44.2	115	61.5	189	60.2	6	29	640	50.4
S_3	-	-	-	-	-	-	-	-	-	-	381	51.1	70	37.5	120	38.2	14	66	585	46.2
Rectum	-	-	-	-	-	-	-	-	-	-	2	.3	1	.5	2	.6	-	-	5	.4
Body cavity	-	-	-	-	-	-	-	-	-	-	10	1.3	1	.5	2	.6	-	-	13	1

cycle has been worked out by Threlfall(1965).

Measurements taken during the present study agree with those of Burt and Eadie (1958) (Table 14).

Syngamus trachea Montagu, 1811.

Ten specimens of *S. trachea* were recovered from the trachea of one raven. Measurements of these specimens agreed with those of Chapin (1925). This parasite has not previously been recorded from ravens in North America or Europe (*vide* Andrews and Threlfall, 1973).

No specimens of this parasite were recovered from the crows examined.

Larval ascarids.

Two immature crows were infected with these nematodes. One specimen was recovered from S_2 of the small intestine of one crow, and another was recovered from S_3 of a second crow. Identification was based on the morphology of the oesophagus.

No representatives of the family Ascarididae have previously been recorded from crows in North America.

TABLE 14

MEASUREMENTS OF *CYATHOSTOMA LARI* BLANCHARD, 1849 OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF BURT AND EADIE (1958)

	Cyathostoma lari Present Study				*Cyathostoma lari* Burt and Eadie (1958)			
	Males		Females		Males		Females	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Body, length (mm.)	5.4	4.3 -8.7	15.9	10.7-21.1	-	6.6 -9.1	-	14-22
width	.22	.11- .47	.89	.29-1.40	-	.26- .38	-	.7-1.5
width as % of length	4.7	-	5.5	-	-	-	-	-
Buccal capsule, diameter	96	64-127	185	138-253	98	-	-	192-275
depth	76	54-97	183	107-234	83	-	-	163-256
depth as % of diameter	79	-	98	-	81	-	-	-
Esophagus, length	453	331-614	661	107-936	-	500-610	-	-
length as % of body length	8.3	-	4.1	-	-	6.7 -7.8	-	4.7-6.2
Left spicule, length	475	333-476	-	-	443	384-550	-	-
Right spicule, length	450	309-452	-	-	440	350-499	-	-
Eggs, length	-	-	77	52-90	-	-	81	72-86
width	-	-	48	42-78	-	-	44	39-48

Acanthocephala

Prosthorhynchus formosum (Van Cleave, 1918).

Representatives of this species were recovered from 60 (61%) of the crows examined (range 1 - 190; mean 21 per infected bird) (Table 1).

Sites of infection were the small intestine (S_1, S_2, S_3), rectum and the body cavity. Adult male and immature birds harbored the greatest number of parasites. Most parasites were recovered from S_2 and S_3 of the small intestine (Table 13). The rectum, body cavity and S_1 of the small intestine had a very light infection.

Prosthorhynchus formosum has previously been recorded by Hendricks *et al.*, (1969) from *Corvus brachyrhynchos* in North Carolina. Yamaguti (1963), and Schmidt and Neiland (1966) report a wide range of hosts for this species in North America.

Measurements obtained during the present study agree with those of Van Cleave (1918) (Table 15).

TABLE 15

MEASUREMENTS OF *PROSTHORHYNCHUS FORMOSUM* (VAN CLEAVE, 1918) OBTAINED FROM THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) DURING THE PRESENT STUDY COMPARED WITH THOSE OF VAN CLEAVE (1918)

	Prosthorhynchus formosum Present Study				*Prosthorhynchus formosum* Van Cleave, 1918	
	Males		Females		Males	Females
	Mean	Range	Mean	Range	Approx.	Approx.
Body, length (mm.)	6.8	3.7 -8.9	9.0	4.8 -12.6	8.5	9.5
width (mm.)	1.2	.89-1.7	1.6	.76- 2.4	2	2
Proboscis, length	820	551-1370	839	517-976	1060	-
diameter	237	126-331	238	171-287	330	-
No. rows of proboscis hooks	16	-	15	13-16	16	-
No. proboscis hooks per row	12	11-13	12	8-16	13-14	-
Proboscis hooks, length	68	57-80	71	59-83	65-83	-
Left lemnisci, length (mm.)	1.1	.88-1.46	-	-	1.92	-
width	75	59-92	-	-	58	-
Right lemnisci, length (mm.)	1.4	-	-	-	1.92	-
width	97	-	-	-	58	-

TABLE 15 (CONTINUED)

	Prosthorhynchus formosum Present Study				*Prosthorhynchus formosum* Van Cleave, 1918	
	Males		Females		Males	Females
	Mean	Range	Mean	Range	Approx.	Approx.
Proboscis receptacle, length(mm)	1.5	1.07-1.90	1.6	.63-1.9	1.73	-
diameter	319	204-439	424	263-507	420	-
Anterior testes, length	657	332-1490	-	-	1150	-
diameter	469	290-900	-	-	600	-
Posterior testes, length	620	292-1510	-	-	1150	-
diameter	398	300-970	-	-	600	-
Embryos, length	-	-	59	42-73	-	40-60
diameter	-	-	30	19-45	-	12-20

Blood Parasites

A light infection of blood parasites was noted in 13 (14%) of the crows examined. The parasites recovered belong to four genera, namely: *Leucocytozoon* (6 birds infected [7%]), *Haemoproteus* (6 birds infected [7%]), *Plasmodium* (2 birds infected [2%]), and *Microfilaria* (1 bird infected [1%]).

To date, one species of *Plasmodium*, namely, *P. relictum* has been recorded from *Corvus brachyrhynchos* by Morgan and Waller (1941), Coatney and West (1938), and Wetmore (1941). Hendricks (1971) noted two species of *Leucocytozoon* (*L. berestneffi*, *L. sakharoffi*, *Leucocytozoon* sp.) and three species of *Haemoproteus* (*H. columbae**, *H. danilewski*, *Haemoproteus* sp.) from this host. Microfilaria have been reported from *Corvus brachyrhynchos* by Elliot (1903), Beaudette and Hudson (1936), Morgan and Waller (1941) and Wetmore (1941) in North America. The occurence of Microfilaria represents a new host record for Canada.

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*Record doubtful due to host specificity of the parasite.

Ectoparasites

Mallophaga

Three species of mallophaga representing three genera were recovered from 82 (83%) of the crows examined (range 1 - 357; mean 51 per infected bird).

Philopterus ocellatus (Scopoli, 1763).

This species was noted on 70 (70%) of the crows examined (range 1 - 357; mean 19 per infected bird) (Table 16). Sites of infestation were the head and neck, and the dorsal and ventral regions. The greatest percentage of ectoparasites were recovered from the head and neck regions (Table 17). Female and immature birds had the highest intensity of infestation (Table 16). Immature specimens of *Philopterus ocellatus* were found to occur more frequently than either adult male or female forms (Table 16).

Philopterus ocellatus has been previously recorded from *Corvus brachyrhynchos* by Peters (1936), Morgan and Waller (1941), Edwards (1952), Fendinger (1952), Good (1952), Jones (1968), Hendricks and Axtell (1968), and Hendricks (1971).

No specimens of this parasite were recovered from the ravens.

TABLE 16

DETAILS OF THE INFESTATION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*) WITH ECTOPARASITES

Host	Parasite	*Philopterus ocellatus*				*Myrsidea interrupta*				*Brueelia rotundata*			
		Male	Female	Im-mature	Total	Male	Female	Im-mature	Total	Male	Female	Im-mature	Total
Males	% ectoparasites infesting birds	25	27	48	100	35	31	34	100	19	21	60	100
	Total No. recovered	75	82	143	300	162	144	160	466	72	78	229	379
	Range of No. recovered	(1-15)	(1-15)	(1-27)	(1-57)	(1-65)	(1-56)	(1-81)	(1-202)	(1-23)	(1-34)	(1-153)	(1-205)
	No. infested birds (% infest.)	14	19	18	21(57%)	16	18	11	19(51%)	7	8	7	9(24%)
	Av. No./ infested bird	5	4	8	14	10	8	15	25	10	10	33	42
Females	% ectoparasites infesting birds	20	28	52	100	37	33	30	100	11	13	76	100
	Total No. recovered	98	141	256	495	79	69	65	213	20	25	146	191
	Range of No. recovered	(1-58)	(1-105)	(1-194)	(1-357)	(1-24)	(1-23)	(1-35)	(1-53)	(1-17)	(1-19)	(1-135)	(1-171)
	No. infested birds (% infest.)	11	11	11	13(72%)	9	8	8	11(61%)	4	4	6	7(39%)
	Av. no./ infested bird	9	13	23	38	9	9	8	19	5	6	24	27

TABLE 16 (CONTINUED)

Host	Parasite	*Philopterus ocellatus*				*Myrsidea interrupta*				*Brueelia rotundata*			
		Male	Female	Im-mature	Total	Male	Female	Im-mature	Total	Male	Female	Im-mature	Total
Immatures	% ectoparasites infesting birds	25	30	45	100	40	40	20	100	18	23	59	100
	Total No. recovered	107	129	191	427	202	197	100	499	191	237	618	1046
	Range of No. recovered	(1-14)	(1-16)	(1-41)	(1-60)	(1-40)	(1-27)	(1-14)	(1-74)	(1-49)	(1-67)	(1-146)	(1-262)
	No. infested birds (% infested)	27	23	27	33(83%)	30	30	28	35(88%)	18	21	22	26(65%)
	Av. No. / infested birds	4	6	7	13	7	7	4	14	11	11	28	40

TABLE 16 (CONTINUED)

Host	Parasite	*Philopterus ocellatus*				*Myrsidea interrupta*				*Brueelia rotundata*			
		Male	Female	Im-mature	Total	Male	Female	Im-mature	Total	Male	Female	Im-mature	Total
Birds of unknown sex	% ectoparasites infesting birds	35	29	36	100	25	25	50	100	12	36	52	100
	Total No. recovered	27	23	28	78	10	10	20	40	9	27	40	76
	Range of No. recovered	(1-21)	(7-16)	(3-35)	(4-72)	(2-8)	(4-6)	(1-19)	(1-31)	(9)	(8-19)	(3-37)	(31-51)
	No. infested birds(% infested)	3	2	2	3(75%)	2	2	2	2(50%)	2	2	2	2(50%)
	Av. No. / infested bird	9	12	14	26	5	5	10	20	5	14	20	38
Total	% ectoparasites infesting birds	24	29	47	100	37	34	29	100	17	22	61	100
	Total No. recovered	307	375	618	1300	453	420	345	1218	292	367	1033	1692
	Range of No. recovered	(1-58)	(1-105)	(1-194)	(1-357)	(1-65)	(1-56)	(1-81)	(1-202)	(1-49)	(1-67)	(1-153)	(1-262)
	No. infested birds(% infested)	55	55	58	70(70%)	57	58	49	67(68%)	31	35	37	44(44%)
	Av. No. / infested bird	6	7	11	19	8	7	7	18	9	10	28	38

Myrsidea interrupta (Osborn, 1896).

This ectoparasite was recovered from 67 (68%) of the crows examined (range 1 - 202; mean 18 per infected bird) (Table 16). Sites of infestation were the head and neck, and the dorsal and ventral regions. The greatest percentage of ectoparasites were recovered from the ventral region (Table 17). Male and immature birds had the highest intensity of infestation (Table 16). Adult males of *Myrsidea interrupta* were found to occur more frequently than either adult female or immature forms (Table 16).

Myrsidea interrupta has previously been recorded from *Corvus brachyrhynchos* by Ward (1935), Morgan and Waller (1941), Good (1952), Carriker (1958), Hendricks and Axtell (1968), and Hendricks (1971).

Three of the ravens examined were infested with *Myrsidea interrupta* (Table 18).

Brueelia rotundata (Osborn, 1896).

Brueelia rotundata was recovered from 44 (44%) of the crows examined (range 1 - 262; mean 38 per infected bird) (Table 16). Sites of infestation were the head and neck, and the dorsal and ventral regions. The greatest percentage of ectoparasites were recovered from the ventral region (Table 17). Immature birds had the highest intensity of infestation. Immature specimens of this ectoparasite were most numerous (Table 16).

TABLE 17

DETAILS CONCERNING THE SITES OF ECTOPARASITE INFESTATION OF THE COMMON CROW (*CORVUS BRACHYRHYNCHOS*)

Site of Infestation	*Philopterus ocellatus*		*Myrsidea interrupta*		*Brueelia rotundata*	
	No.	% of total	No.	% of total	No.	% of total
Head and neck region	1102	85	285	23	499	29
Dorsal region	108	8	351	29	468	28
Ventral region	90	7	582	48	725	43
Total	1300	100	1218	100	1692	100

TABLE 18

DETAILS OF ECTOPARASITE INFESTATION OF ADULT FEMALE RAVENS (*CORVUS CORAX*)

Parasite	*Philopterus corvi*				*Myrsidea interrupta*			
	Male	Female	Immature	Total	Male	Female	Immature	Total
No. (%) birds infested	3 (75%)	3 (75%)	3 (75%)	4(100%)	2 (50%)	2 (50%)	- -	3 (75%)
No. (%) parasites recovered	56 (23%)	85 (34%)	106 (43%)	247(100%)	4 (67%)	2 (33%)	- -	6 (100%)
Range of No. recovered	(1-50)	(3-75)	(3-99)	(1-99)	2	1	- -	(1-2)
Av. No./infested bird	19	28	35	62	2	1	- -	2

Brueelia rotundata has been previously recorded from *Corvus brachyrhynchos* by Ward (1935), Peters (1936), Morgan and Waller (1941), Good (1952), Carriker (1958), Jones (1968), and Hendricks (1971).

No specimens were recovered from the ravens examined.

Philopterus corvi Linnaeus, 1758.

Philopterus corvi was recovered from all of the ravens examined (range 1 - 99; mean 62 per infected bird) (Table 18). Sites of infestation were the head and neck (213 recovered), the dorsal region (8 recovered), and the ventral region (26 recovered). Immature specimens of this ectoparasite were more common than adult male or female forms.

No specimens were recovered from the crows examined.

GENERAL DISCUSSION

Trematodes were most frequently found in the gall bladder (*Conspicuum macrorchis*), the bile ducts (*Brachylecithum stunkardi*, *Conspicuum macrorchis*), and the Bursa of Fabricius (*Prosthogonimus macrorchis*) of the crows examined, while cestodes were found most frequently located in second (S_2) portion of the small intestine (*Hymenolepis farciminosa*, *Dilepis undula*, *Schistocephalus solidus*). Nematodes were found in the nasal cavities (*Cyathostoma lari*), the oesophagus (*Capillaria contorta*), the third portion (S_3) of the small intestine (*Capillaria resecta*) and the blood (*Microfilaria* sp.). Acanthocephala (*Prosthorhynchus formosum*) were noted in the second and third portions of the small intestine.

Trematodes (*Conspicuum macrorchis*) were noted in the gall bladder; while cestodes were found in the second (*Dilepis undula*) and third portions (*Hymenolepis farciminosa*) of the small intestine of the raven. Nematodes were located in the trachea (*Syngamus trachea*), the oesophagus (*Capillaria contorta*), and the body cavity (*Capillaria resecta*).

Mallophaga from the crow (*Philopterus ocellatus*, *Myrsidea interrupta*, and *Brueelia rotundata*) and the raven (*Philopterus corvi*, *Myrsidea interrupta*) were found to infest the head, neck and dorsal and ventral regions of the birds.

Nematodes were found in higher numbers in infected birds than species of any other helminth group. These were followed in order by acanthocephala, trematodes and cestodes. Generally, immature birds were found to harbor the greater numbers of each species of parasite. However, *Brachylecithum stunkardi*, *Capillaria resecta* and *Prosthorhynchus formosum* were recovered in larger numbers from adult birds.

Brachylecithum stunkardi was recovered during the avian breeding season from crows taken on the west coast of Newfoundland, but was not found in crows taken from the other sampling areas.

Prosthogonimus macrorchis was found in immature crows from September to November. This parasite may have been lost in the late fall as the bursa regressed.

Adult and immature crows showed similar infection patterns for all parasite species throughout the year. However, only a small number of birds of either age group were obtained during the period of April to August.

It was not possible to examine similar numbers of birds each month, due to difficulties of hunting, weather conditions, and the irregular presence of crows at the sampling sites during the breeding season. However, enough data was obtained to indicate a trend towards seasonal variations, though the data so far obtained is not fully conclusive. Helminth parasites were recovered in greatest

numbers in early and late fall, with a decline during the winter. Seasonal variations, probably modified by other factors such as host age, would imply that the inspection of bulk data without regard to season or host age cannot be relied upon to provide an accurate picture of overall parasitization.

During the fall and winter large flocks of Herring Gulls and starlings (*Sturnus vulgaris* L.) also occupy the sampling areas. It is suspected that infection by three of the parasites recovered from crows is facilitated by the interaction of the crows with these other two bird species.

Cyathostoma lari, normally a parasite of gulls, was found to occur in greatest numbers in crows during fall and winter when gulls tend to flock and move inland. It is not unreasonable to assume that gulls might play an important role in maintaining infection of the crows with this species, particularly as the life cycle of the parasite is direct (Threlfall, 1965).

The other two parasites suspected of being acquired in a similar way are *Hymenolepis farciminosa* and *Capillaria contorta*, both common parasites of starlings (Owen and Pemberton, 1962).

Two of the ectoparasites recovered (*Myrsidea interrupta*, *Brueelia rotundata*) were found to occur in greater numbers in the late fall. This might be explained

by the fact that crows tend to flock in the fall such that an increase in ectoparasites at the time of flocking would be beneficial for the distribution of these ectoparasites. However, *Philopterus ocellatus* was greater in numbers during the winter. Foster (1969) indicates that the peak of breeding of *Philopterus* spp. falls just prior to the avian breeding period to aid dispersal during the breeding of the host and to ensure the infection of immature birds.

It is to be expected that, in general, the number of available intermediate hosts would decrease in winter and increase in the summer and fall. Other seasonal variations could be linked to a change in the feeding habits of the bird, since in winter and early spring, the diet of the crows examined consisted mostly of vegetable matter, while during the remainder of the year it was generally animal matter.

Data from this study indicates that the crow may serve as an unnatural and not a natural host for several of the parasites recovered. This is supported by Macy (1934b) who suggested that birds harboring mature specimens of *Prosthogonimus macrorchis* probably serve in nature as reservoir hosts for this fluke. Dunn (1969) mentions that rooks and crows are important reservoirs of infection for this parasite.

Cyathostoma lari is normally found in the nasal cavities of the Herring Gull. Since, as previously

mentioned, the crow and the Herring Gull were in close association in all areas where crows were taken, one might expect to find the crows as an unnatural rather than a new natural host for this parasite.

Syngamus trachea, obtained from the ravens in this study, is frequently recorded from wild birds whose significance as reservoirs of this nematode is well known (Keymer *et al.*, 1962). Rooks and starlings are particularly important in this respect and may act as dangerous reservoirs of infection for wild as well as domestic birds (Clapham and Middleton, 1948), although it is necessary for this parasite to pass through a transport host before domestic birds can become infected (Clapham 1934, 1938). The importance of wild birds in the transmission of parasites, however, is dependant upon adequate contact between wild and domestic birds. Where an intermediate host is involved in the life cycle of the parasite it is also necessary for this to be available to both host types (Keymer *et al.*, 1962).

Hopkins and Smyth (1951) indicate that as the plerocercoids of members of the genus *Schistocephalus* occurs normally in various stickleback species (family Gasterosteidae), its occurence in hosts other than water birds is probably accidental.

A number of different helminth species have been recorded as pathogenic to wild birds (Keymer *et al.*, 1962).

Prosthogonimus macrorchis has been shown to be a pathogen, and even small numbers is sufficient to cause disease (Macy 1934b). This parasite matures in the Bursa of Fabricius then passes into the oviduct where it indicates pathological importance. Death, in domestic birds, can occur in two to three days.

Syngamus trachea has been found to occur in numerous species of wild birds. Clapham (1939) has studied the relationship between this worm and game birds, and has experimentally demonstrated that it is pathogenic. Elton and Buckland (1928) found syngamiasis to be common in young rooks. The pathogenicity of *S. trachea* was shown in a survey by Keymer *et al.*, (1962) to be responsible for 50 of 64 deaths attributed to helminths.

In some cases authors (Keymer *et al.*, 1962) indicate (based on pathological evidence) that parasites have been the actual cause of death while, in other instances, in the absence of other causes, parasites have been wrongly incriminated in the deaths of large numbers of birds.

Three of the parasites recovered are capable of causing considerable tissue damage. *Conspicuum macrorchis* was observed in this study to cause a mushroom-like projection into the gall bladder at the site of attachment. Bassett (1958) in a study of *C. icteridorum*, a very closely related species, found the same mushroom-like projections with a subsequent loss of supporting tissue and the lining of the gall bladder

wall, and considerable proliferation of connective tissue.

Cyathostoma lari attaches to the host by drawing a plug of mucosal lining into the buccal capsule. A sucking action (Colam, 1971) brings the host tissue into contact with the buccal teeth which rupture the mucosa and underlying blood vessels. Then blood is either sucked from the exposed vessels by the highly muscular esophagus or host blood pressure may force it into the body of the parasite (Threlfall, 1966).

Prosthorhynchus formosum can cause damage at the site of attachment, since the hooks and probosis usually penetrate the mucosa of the small intestine. Schmidt (1963) reports the histopathology of a robin infected with this parasite. He notes that the armed probosis penetrates the mucosa and muscle layer of the small intestine. At the point of attachment the intestinal villi and crypts of Lieberkuhn were completely destroyed.

SUMMARY

A survey was conducted to determine the parasite burden of the Common (North American) Crow, *Corvus brachyrhynchos* Brehm, 1822 in insular Newfoundland. Collection localities, methods of host collection, measurements, and dissection techniques were discussed. Techniques used in the location, preservation, staining, measurement and identification of parasites are dealt with.

Ninety-nine crows from twelve localities in Newfoundland were examined. Eighteen species of parasites were recovered, including three trematodes, three cestodes, five nematodes, one acanthocephala, three blood protozoans, and three Mallophaga. Seven of these are new host records for North America, and twelve are new host records for Canada.

Ninety-five percent of the crows examined were infected with helminth parasites (range 1 - 190; mean 63 per infected bird). Eighty-three percent of crows examined were infested with ectoparasites (range 1 - 357; mean 51 per infested bird) and fourteen per cent were infected with blood parasites.

A total of four ravens from two localities were examined. Eight species of parasites were recovered, including one trematode, two cestodes, three nematodes, and two Mallophaga. Five of these are new host records for North America. All four of the ravens examined were

infected with helminth parasites (range 1 - 56; mean 23 per infected bird), and infested with ectoparasites (range 1 - 99; mean 63 per infested bird).

For each of the major groups of parasites the percentage infection, range of numbers and mean number per infected bird for each sex and age group are given. Also discussed for each species of parasite is the location of the parasite within the host, previous host records, authorities used in species determinations, and an explanation of variation, if any, from the original descriptions. Measurements from original descriptions and from the present study are compared in tabular form, for some species.

Nematodes were found in higher numbers in infected birds than species of any other helminth group. Immature birds were found to harbor the greater numbers of each species of parasite.

Differences in infection with parasites and seasonal variations are discussed.

Crows may act as reservoir hosts for several of the parasites recovered.

The pathogenicity to the host caused by parasites is indicated for several species recovered.

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APPENDIX 1

Food Analysis

The gizzard contents of the crows examined revealed a varied and extensive diet. The majority of the contents recovered consisted of barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), wild raisin (*Viburnum* sp.), and quack grass seeds (*Agropyron* sp.).

Fragments of insects were abundant and represented the following orders and families: Order Diptera (family Tabanidae), Order Coleoptera (familes Carabidae, Staphylinidae and Elateridae), Order Hemiptera, Order Lepidoptera and the Order Trichoptera.

A more complete study of the food habits of the crow may be found in the works of Barrows and Schwarz (1895), McAtee (1912), Kalmbach (1918), Hering (1932), Black (1941) and Good (1952).

APPENDIX 2

Birds were weighed on a Fisher direct reading counter style scale with a capacity of 4500 grams (10 lbs.). Data of measurements taken from the crows examined are given in Table 19.

Measurements taken from the ravens examined were as follows: [mean (range)]; weight 1174 gms. (1074 - 1342); wing length 415 (407 - 435); tarsus 68 (64 - 71); tail 234 (216 - 254); exposed culmen length 68 (66 - 70); tip of culmen to skull length 75 (73 - 78); culmen depth 25 (24 - 26).

TABLE 19

MEASUREMENTS OF COMMON CROW (*CORVUS BRACHYRHYNCHOS*) IMMATURES AND ADULTS

	No. meas.	Weight (gm.)			No. meas.	Wing length (mm.)			No. meas.	Tarsus (mm.)			No. meas.	Tail (mm.)		
		Mean	Range	±s.d.		Mean	Range	± s.d.		Mean	Range	± s.d.		Mean	Range	± s.d.
Adult Males	37	534	327-621	±11.4	37	315	250-345	± 2.8	37	58	50-64	± .58	37	186	157-204	± 1.7
Adult Females	19	516	460-613	± 8.8	19	307	287-325	± 2.3	19	56	49-61	± .77	19	182	173-196	± 1.6
Immatures	40	522	438-665	± 8.6	40	301	195-337	± 3.2	40	56	50-63	± .49	40	178	164-201	± 1.1
Birds of unknown sex	4	511	437-594	±32.9	4	307	286-331	± 9.2	4	54	52-58	±1.2	4	187	178-195	± 3.9

TABLE 19 (CONTINUED)

MEASUREMENTS OF COMMON CROW (*CORVUS BRACHYRHYNCHOS*) IMMATURES AND ADULTS

	No. meas.	Exposed culmen length (mm.)			No. meas.	Tip of culmen to skull length (mm.)			No. meas.	Culmen depth (mm.)		
		Mean	Range	± s.d.		Mean	Range	± s.d.		Mean	Range	± s.d.
Adult Males	36	46	40-58	± .61	34	51	45-57	± .44	36	17	14-20	± .22
Adult Females	19	45	41-52	± .59	19	50	47-59	± .70	19	16	15-17	± .13
Immatures	39	42	37-48	± .48	39	47	40-51	± .40	40	16	15-18	± .14
Birds of unknown sex	4	43	42-45	± .70	4	49	48-52	± .85	4	16	16-17	± .28

APPENDIX 3

TECHNIQUES USED IN THE FIXATION, STAINING AND MOUNTING OF PARASITES

In all cases, trematodes were first treated with the Catechol technique to bring out the vitellaria and uterus. Staining was performed using Trichrome, Mayer's, and Semichon's. In some cases the trematodes were mounted directly into Rubin's fluid to clear all structures, including vitellaria and eggs.

Trichrome and Mayer's were found to be the best stains, the former yielding tissue differentiation by color; the latter yielding clarity of structure.

The general procedure for trematodes is outlined as follows:

Physiological saline Urethane (10°C for 30-60 mins. or until relaxed)	30-60 min.
Water, distilled	10 min.
Catechol technique	4 hrs.
35% ethyl alcohol	15 min.
50% ethyl alcohol	15 min.
70% ethyl alcohol	15 min.
EITHER: Method No. 1	
70% ethyl alcohol	15 min.
90% ethyl alcohol	15 min.

95% ethyl alcohol (twice) . . . . . 15 min.
100% ethyl alcohol (twice) . . . . . 15 min.
Xylene (3 parts 100% ethyl alcohol:1 part xylene) 15 min.
Xylene (1 part 100% ethyl alcohol:1 part xylene) 15 min.
Xylene (1 part 100% ethyl alcohol:3 parts xylene) 15 min.
Xylene . . . . . until clear
Mount in balsam.

OR: Method No. 2

Stain using Semichon's acid carmine, Mayer's HCL carmine, or Trichrome stain, and dehydrate as outlined in Method No. 1.

OR: Method No. 3

Mount trematodes directly into rubin's fluid from 70% alcohol, to clear all structures.

Semichon's Acid Carmine Stain

Physiological saline
Urethane (10°C or until relaxed) . . . . . .30-60 min.
Water, distilled . . . . . 10 min.
35% ethyl alcohol . . . . . 15 min.
50% ethyl alcohol . . . . . 15 min.
70% ethyl alcohol . . . . . 15 min.
Semichon's Acid Carmine (dilute) . . . . . 10 min.
(or until pink)
70% ethyl alcohol . . . . . 15 min.

90% ethyl alcohol . . . . . 15 min.
95% ethyl alcohol (twice) . . . . . 15 min.
100% ethyl alcohol (twice). . . . . 15 min.
Xylene (3 parts 100% ethyl alcohol:1 part xylene) 15 min.
Xylene (1 part 100% ethyl alcohol:1 part xylene) 15 min.
Xylene (1 part 100% ethyl alcohol:3 parts xylene) 15 min.
Xylene . . . . . until clear
Mount in balsam.

This is the same method used for Mayer's HCL carmine except that after staining 12 hours, and into 70% ethyl alcohol, acid alcohol is then used until specimen becomes sufficiently destained. Then specimens are dehydrated as outlined in Method No. 1.

Trichrome Stain (Gomori)

Physiological saline
Urethane (10 C or until relaxed) . . . . . 30-60 min.
Water, distilled . . . . . 10 min.
35% ethyl alcohol . . . . . 15 min.
50% ethyl alcohol . . . . . 15 min.
70% ethyl alcohol . . . . . 15 min.
Trichrome stain (stock) . . . . . 2-5 min.
70% ethyl alcohol . . . . . 15 min.
Acid alcohol (stock) . . . . . until slightly green
70% ethyl alcohol . . . . . 15 min.
90% ethyl alcohol . . . . . 15 min.

95% ethyl alcohol (twice) . . . . . 15 min.

100% ethyl alcohol (twice) . . . . . 15 min.

Xylene (3 parts 100% ethyl alcohol:1 part xylene) 15 min.

Xylene (1 part 100% ethyl alcohol:1 part xylene) 15 min.

Xylene (1 part 100% ethyl alcohol:3 parts xylene) 15 min.

Xylene . . . . . until clear

Mount in Balsam.

Catechol Technique (Johri and Smyth, 1956)

Fix in 70% ethyl alcohol . . . . . 1-3 days.

Water, distilled . . . . . 30 min.

Catechol, 0.1% (freshly prepared) for 60-90 min. at 40°C. or 4½ hrs. at room temperature (25°C.).

Water, distilled . . . . . 15 min.

For vitellaria and uterus only--dehydrate, clear and mount in balsam. For complete morphology, stain using a nuclear stain for 3-12 hours. Dehydrate, clear and mount in balsam.

2. CESTODES:

The technique follows that used for trematodes with two exceptions: (1) the catechol technique and rubin's fluid were not used, and (2) cestodes were fixed and preserved in Demke's solution and stained using Semichon's, Trichrome, Mayer's, or Celestian Blue Stain. Mayer's stain obtained best results.

The general procedure is as follows:

Physiological saline	
Urethane (10°C or until relaxed)	30-60 min.
Water, distilled	10 min.
Demke's solution	(fixative)
70% ethyl alcohol	15 min.

Stain, dehydrate, clear and mount in balsam.

Celestian Blue Stain

Physiological saline	
Urethane, (10°C or until relaxed)	30-60 min.
Water, distilled	10 min.
Celestian blue stain (stock)	15-30 min.
Water, distilled (twice)	20 min.
35% ethyl alcohol	15 min.
50% ethyl alcohol	15 min.
70% ethyl alcohol	15 min.
Destaining solution (until internal organs clearly seen)	
70% ethyl alcohol (4 changes)	1 hr.
70% ethyl alcohol	1 day.
Methyl salicylate	until clear

Mount in balsam.

3. NEMATODES:

Physiological saline	
Acetic acid, glacial	until straight

70% glycerine alcohol . . . . . fixative

Mount directly into rubin's fluid.

4. ACANTHOCEPHALA:

Physiological saline

Fresh water . . . . . until proboscis extrudes

Demke's solution . . . . . fixative

Mount directly into rubin's fluid.

5. ARTHROPODS:

70% ethyl alcohol . . . . . fixative

Mount directly into rubin's fluid.

APPENDIX 4

FIXATIVES AND STAINS

1. FIXATIVES.

Acid Alcohol (2%)

Alcohol (70%)	98 ml.
Hydrochloric Acid, commercial	2 ml.

Demke's Solution (Ble's Fixative)

Alcohol, (70%)	90 ml.
Formalin, commercial	1 ml.
Acetic Acid, glacial	3 ml.

Alcohol-glycerine Mixture

Alcohol (70%)	95 ml.
Glycerine	5 ml.

Formalin (5%)

Water, distilled	95 ml.
Formalin, commercial (40% U.S.P.)	5 ml.

Commercial formalin is a saturated aqueous solution of formaldehyde gas and contains approximately 40% formaldehyde by weight. This solution is known as 100% formalin and is diluted accordingly when concentrations of formalin, rather than formaldehyde, are specified.

Giemsa's Stain

Giemsa stock solution (Azure type B)	1 ml.
Phosphate buffer (ph. 7.2)	9 ml.

Buffer (ph. 7.2)

Buffer salt solution (ph. 7.2)	10 gm.
Water, distilled	1000 ml.

Rubin's Fluid

Polyvinyl alcohol, stock	56 ml.
Lactic acid	22 ml.
Phenol	22 ml.

Dissolve 15 gms. of polyvinyl alcohol in 100 ml. of distilled water in an 80°C water bath. This comprises the stock solution.

Physiological Saline

For parasites of warm blooded vertebrates

Sodium chloride	8.5 gm.
Distilled water	1000 ml.

2. STAINS

Semichon's Acetic-Carmine

Acetic acid, glacial	100 ml.
Water, distilled	100 ml.
Carmine "in excess"	1.5 gm.

Mix water and acetic acid in Erlenmeyer flask, and

add carmine. Heat in a boiling water bath for 15 minutes, then cool the flask in cold water and filter the contents. Best results are obtained when stock solution is filtered approximately five times using a Whatman No. 2 qualitative filter. This stock stain may then be diluted to approximately two parts of 70% alcohol before use.

Mayer's HCL Carmine, Modified

Water, distilled	15 ml.
Hydrochloric acid, (sp. gr. 1.19)	15 drops
Carmine, alum lake	4 gm.
Alcohol, 85%	95 ml.

Boil carmine in acid and water until dissolved. Cool, add alcohol, filter and neutralize to point of precipitation with ammonium hydroxide. One drop of concentrated ammonium hydroxide is required to neutralize 20 ml. of stock solution. This should be added very slowly and with constant stirring. Before using, one part of stock solution is added to four parts of 70% alcohol.

Celestian Blue Stain

Ferric Ammonium sulphate (violet crystals) . .	2 gm.
Distilled water	100 cc.
Sulfuric acid, concentrated	2 cc.
Celestian blue	1 cc.
Alcohol, absolute methyl	10 cc.
Glycerine	10 cc.

Dissolve the ferric ammonium sulfate in cold distilled water and add the concentrated sulfuric acid. Bring to a boil, add the celestian blue, and boil for five minutes. Cool, and add the absolute methyl alcohol and glycerine.

Detaining Solution (for Celestian blue). Destaining is accomplished with a 0.5% lactic acid--0.5% hydrochloric acid in 70% alcohol solution. Add two to three drops per 5 cc. of 70% alcohol in which specimens have been placed.

Gomori Trichrome Stain

Chromotrope 2R	0.6 gm.
Fast green FCF	0.3 gm.
Phosphotungstic acid	0.8 gm.
Acetic acid	1 ml.
Water, distilled	100 ml.

This is a modified trichrome stain capable of demonstrating the various structures of helminths. Differentiation occurs between hooklets, suckers, digestive systems and the integuement by means of an indicative color. Suckers usually stain purple, hooklets pink, integument green, and the reproductive organs and digestive systems lavender to shades of purple. For thick specimens the stock solution must be diluted in the proportion of one drop of stock solution to 3 ml. of distilled water. The specimens in dilute stain should remain for approximately 12 hours at room temperature (25°C).

Small, thin specimens may be stained in the undiluted stock solution and usually require 2-7 minutes at room temperature (±25°C), depending on the size of the specimen. There is a great tendency to overstain the integuement and so reduce the clearing process for identification. This is usually overcome by the use of dilute stock stain and a longer time interval. This permits the stain to reach internal tissues without overstaining the integuement. Destaining is accomplished by the use of a stock solution of acid alcohol. Specimens must be observed at all times in acid alcohol as it may reduce the intensity of stain if the specimen remains in the solution for any great length of time.

The stock solution is stable and may be kept for approximately a year at room temperature.

Catechol Solution

Catechol crystals	1 gm.
Water, distilled	1000 ml.

This yields a 0.1% solution of catechol. For best results the specimen should be fixed in 70% alcohol.

In successful tanning only vitellaria and eggs are shown. These appear as a brown to reddish brown depending on the nature of the material to be stained. Generally, no other structure is stained, permitting the use of further staining techniques to demonstrate remaining structures.