A SURVEY OF THE HELMINTHS OF THE SNAPPING TURTLE, *CHELYDRA SERPENTINA*, FROM OKLAHOMA

By

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INTRODUCTION

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The writer undertook an investigation involving pure science and chose to determine what helminths occurred in the common snapping turtle, Chelydra serpentina. Such a problem was chosen because (1) no report of a similar survey was found in the literature; (2) snapping turtles are abundant and reasonably easy to obtain; (3) the habitat and habits of snapping turtles are favorable for parasitism; (4) snapping turtles are of no major economic importance; (5) information could possibly be gained concerning the unknown life histories of several of their parasites; and (6) much could be learned about parasitological techniques. It is the hope of the writer that the material compiled in this thesis will be of value to future workers who are interested in a study of the helminths which parasitize snapping turtles.

Collection of snapping turtles was begun in April, 1951, and was continued through the Summer until August, 1951. This was the period of the year when these turtles were most easily obtained, and many were migrating from water impoundments in preparation for laying their eggs.

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Chelydra as type species. This turtle is commonly called the "snapping turtle" because of its characteristic aggressiveness when disturbed. Snapping turtles are widely distributed in North America and parts of Central America. The parasite data for this paper are based on thirty of these hosts.

The review of the literature for each species is included in the body of the thesis, following the respective parasite description.

The descriptions given in this thesis are based largely on those taken from the literature, unless otherwise stated at the conclusion of each. In certain instances, however, the writer organized or condensed the descriptions, for uniformity, when this was possible without basic alteration.

CHAPTER II

METHODS AND MATERIALS

Snapping turtles for this survey were collected from two principal localities. Eight turtles were obtained from the region around Stillwater, Oklahoma and twenty-two from the vicinity of the Oklahoma A. & M. College Wildlife Conservation Station at Braggs, Oklahoma. Most of the turtles were obtained by the writer, but other interested individuals were responsible for the collection of several.

Various methods were employed in capturing these turtles. Cylindrical, wire-mesh fish traps were placed in both a creek and a lake and six turtles were captured. Four specimens were taken in seines and five were captured on land by persons other than the writer. The remaining turtles were collected manually from creeks or other water impoundments by the writer or by students while on field trips.

Whenever possible, specimens were examined soon after capture. Dead turtles which could not be examined immediately, were stored temporarily in a refrigerator. Whenever live turtles were collected in too great a number to examine soon after capture, they were held in an improvised pond.

Since it is generally accepted that animals may sometimes lose their parasites after being in captivity, the writer attempted to hold the turtles under semicaptive conditions in an area where food could be provided. A portion of an unused, concrete, water-filter pit of the Camp Gruber swimming pool was partitioned for this purpose. The pit was normally filled with water to a level of about ten inches. Rotted wood and debris had accumulated in the impoundment making conditions similar

to the native habitat of the snapping turtle. Abundant in the pit were crayfishes and minnows, which are natural foods of the snapping turtle.

The turtles were decapitated for examination, since this method proved to be the easiest and the fastest. The usual procedure consisted in grasping the turtle's lower jaw with a pair of pliers and pulling its head out until the neck was fully extended. A sharp hunting knife was then used to sever the head from the body. Extensive post-mortem movement ceased within a short time after decapitation. Minor reflex movement, however, persisted for several minutes.

Before the turtle was dissected, it was weighed, its carapace was measured, its sex determined, and these data recorded. The turtle was then orientated for dissection by placing it on its back, ventral side up.

A cut, through the skin, was made around the entire edge of the plastron. The latter was removed by lifting it with a pair of forceps and cutting away the adhering muscle. The internal organs and body cavity were exposed by cutting through the peritoneum. Both fore and hind legs were pulled outward and pinned down to provide maximum working space in the body cavity.

Individual organs were removed and placed in separate containers. Petri dishes were used to hold the smaller organs while 500 ml. beakers were used for the larger ones. The parts of the alimentary tract were always removed to saline solution until actual examination was possible. Since the stomach and intestine usually contained many nematodes, the saline solution prevented them from rupturing. All other organs were transferred to tap water.

Following the removal of all visceral organs, the body fluid and clotted blood left in the shell was collected in a container to be examined microscopically for possible helminths. On several occasions heart flukes were recovered. It was interesting to note that these flukes could be seen actively contracting and expanding in an attempt to escape from the fluid.

The deviscerated turtle was examined with a dissecting microscope for any cysts or parasites attached to the linings of the body cavity or to the muscles.

The pelvic fasciae and mesenteries of the internal organs were carefully examined. Dracunculus globocephalus was often found beneath the fasciae in the dorsal pelvic region, particularly in males at the base of the penis. The surrounding fasciae was torn away from the worms until they were freed and could be picked up with bent teasing needles.

The lining of the mouth and pharyngeal regions was examined under the dissecting microscope for the presence of helminths. The oviducts of females were examined on several occasions for possible parasites. Major blood vessels were usually opened and examined for blood flukes.

The visceral organs in their respective containers were examined separately with the aid of the dissecting microscope. The liver and spleen were shredded with the aid of teasing needles. The urinary bladder was examined by manipulating it with fine-pointed needles. The heart was carefully opened with the aid of fine-pointed probes while under the dissecting microscope. Flukes were difficult to remove from the heart. They were intimately associated with the muscles of the ventricle at their mid-body region, much like the belt around the waist

of a man. As a result, they were easily broken or torn in teasing procedures to remove them, and many specimens were damaged in this process. With practice, patience and extreme care, the writer acquired a fair degree of proficiency in removing them with a minimum of damage.

Organs of the digestive tract were taken separately and slit with an enterotome. Sections of each were cut to a size which could be placed lengthwise in a petri dish of tap water. These sections could be carefully examined under the dissecting microscope by manipulation with a pair of teasing needles. The smaller nematodes, the acanthocephalans, and the trematodes were usually removed with the aid of a pipette. The large nematodes which were found loose in the stomach and intestine, or in the surrounding water in the container were removed with a bent teasing-needle.

Camallanus microcephalus, found in the esophagus, stomach and anterior small intestine, was usually firmly attached to the mucosa. The release of these specimens could not always be effected by gently probing them with a teasing needle. In such cases, a pair of fine-pointed tweezers was used to grasp them, pulling slightly and applying traction until they were released from the mucosa. Spiroxys contortus in the stomach was also difficult to remove. These nematodes, while mostly free in the lumen, were always attached beneath the mucosa, usually in groups of three to seven. To remove them, it was necessary to tease the host tissue until their anterior ends were exposed. They could then be extracted by gently applying tension with a pair of forceps.

Following the removal of all visible parasites from the sections of the digestive organs, the mucosa was scraped off and examined for small

worms. The outside of both the stomach and intestinal tract was examined for possible cysts. After the entire alimentary tract had been examined closely, the residual fluid was decanted several times. A close inspection of the residue with aid of the dissecting microscope, concluded the examination of these organs.

Parasites were collected in Syracuse watch glasses or petri dishes. They were relaxed as soon as possible by putting them in cold tap water. The length of time required for relaxation depended upon the specific parasite involved, and the condition of the host carcass at the time of examination.

Heart flukes and lung flukes were relaxed almost immediately after being put in water. Another fluke, Telorchis corti, required from thirty to forty-five minutes for proper relaxation. The flukes, Allassostoma parvum and Polystomoidella oblongum, required a much longer period of time, ranging from three to eight hours, and whenever possible, the latter species was allowed to relax overnight.

Nematodes were much more difficult to relax. To prevent overrelaxation with subsequent bursting and destruction of the specimens, they were fixed immediately after relaxation occurred. Spironoura chelydrae and S. wardi could be relaxed in cold water in a refrigerator in forty-five minutes to an hour. Camallanus microcephalus was relaxed in tap water in thirty to forty-five minutes. Specimens of Spiroxys contortus were difficult to relax because of their tendency to coil in a corkscrew fashion. A fair degree of relaxation was secured by placing the worms in tap water in the refrigerator for about thirty minutes. Dracunculus globocephalus relaxed almost immediately in tap water.

A variety of fixatives was used in an attempt to determine which one offered the best fixation for a particular species. A mixture, consisting of 4% glycerine and 70% isopropyl alcohol, was used to fix the nematodes from the majority of hosts, since it was determined to be the best fixative. Some were fixed in 10% formalin, and a few were fixed in an alcohol-formalin-acetic acid solution. The latter fixative is commonly called A. F. A. and consists of 5 parts glacial acetic acid, 10 parts of 10% formalin, and 85 parts of 85% isopropyl alcohol.

Following relaxation, parasites were always fixed by flooding them with hot fixative. Two species of nematodes required special techniques in their fixation. Spiroxys contortus was placed upon a petri dish with a small amount of water. With the aid of two camel's hair brushes, the specimens had to be straightened while the hot fixative was poured over them. Similar procedures were used in fixing specimens of Dracunculus globocephalus.

In the fixation of gravid females of Camallanus microcephalus, it was observed that larvae inside the uteri remained active from three to four minutes after they were flooded with hot fixative. This seems to demonstrate that the cuticula has insulation properties or the larvae are exceedingly resistant to heat.

The majority of the flukes were fixed in A. F. A., some were fixed in 10% formalin, and a few either in 70% alcohol or corrosive-acetic. The corrosive-acetic method, while providing very good fixation and good staining reaction, presented the disadvantage of being very dangerous to the handler because it is a drastic poison. The flukes fixed in this way also required subsequent treatment with an alcohol-iodine

solution before they could be permanently stored. The first step involved in this post-fixation procedure necessitated that the flukes be washed with water to remove the excess corrosive-acetic. Then they had to be treated with 70% alcohol, to which enough iodine-stock reagent had been added to give the solution a port wine color, to remove the corrosive sublimate. The flukes were allowed to remain in this solution for fifteen minutes to one hour. The iodine was then removed by washing the trematodes several times in 70% alcohol until there was no more color. The specimens were then ready for storage in 70% alcohol.

Acanthocephalans, which were found in only three hosts, were fixed with A. F. A. in one instance and in 70% glycerine-alcohol in the others.

All nematodes were stored in small vials in 4% glycerine-70% alcohol solution. The vials were plugged, each with a small piece of cotton, and placed in one-pint Mason jars containing a similar solution. Flukes and acanthocephalans were stored in 70% alcohol in vials which were plugged with cotton and put in similar large containers of 70% alcohol. Cotton was placed in the bottoms of all large jars to cushion the vials, and thus reduce the possibilities of breakage.

Small labels were placed in the vials to identify the specimens by hosts. The initial of the writer's last name, the year, the host number, and the vial number were written on the labels in india ink.

Host records were kept on 6 by 4 inch cards. A sample host record card is shown in figure 1.

Random samples from the parasites of each host were mounted for identification purposes. Permanent stained mounts were made of trematodes and acanthocephalans. These parasites were stained either in Semichon's Acid

Carmine, Harris' Hematoxylin, or Dr. Robert Rubin's modification of Delafield's Hematoxylin. The specimens were destained in acid-alcohol or acid-water, dehydrated in alcohol, cleared in methyl salicylate, and mounted in Canada balsam. The number of specimens of each species selected for staining from each host, varied from two to eight. Temporary mounts of nematodes were made in phenol-alcohol or lacto-phenol. Permanent mounts were made in polyvinyl alcohol, according to the method of Rubin (1951). Two specimens from each habitat in each host were selected for mounting. Slides were labeled as to the number of the host, the name and habitat of the parasite, and the date of preparation. Two specimens of each species were selected at random for measurements and comparison with the descriptions as given in the literature.

Host Sex No. Carapace size
Locality Date
Collector Preparator
Fixative Preservative Weight
Parasites Found:

Classification	No.	Habitat	Remarks	Vial. No.

Fig. 1

Sample of Host Record Card

CHAPTER III

DATA CONCERNING PARASITES

The snapping turtles examined in this survey were very heavily infected with helminth parasites and no host was found to be negative. The abundance of mature parasites in a host varied from twenty-eight to five-hundred ten individuals while the immature forms were calculated to range from one to several hundred. An accurate count of the immature specimens was not made. The data concerning infections are presented in Table I.

The table shows that thirty snapping turtles were examined, of which nineteen were males and eleven were females. The data presented give the dates of collection, the weight, size, and sex of each host, and the habitat of the parasites obtained from them. The weight of the individual hosts ranged from 0.3 to 8.2 pounds, and the carapace size from 3 1/4 in. by 3 in. to 10 1/4 in. by 9 in. The data show that trematodes, nematodes and acanthocephalans were found to be parasitic in Chelydra serpentina in this region. The incidence of infection is shown by the percentages for the various helminths. On the basis of these figures, it is revealed that the incidence ranges from 3.3% for the mouth trematode to 97% for an intestinal nematode.

Nematodes were encountered in greater numbers in each host as well as from a greater percentage of hosts as compared with trematodes and acanthocephalans. No cestodes were found in this survey, and none have been reported from the snapping turtle.

The writer attempted to correlate the degree of infection of helminths with the size and age of the host in an effort to determine if any age

HOSTS					TREMATODES					NEMATODES			ACANTHO-CEPHALANS
No.	Sex	Weight in lbs.	Carapace size in inches	Date Collected	Mouth	Urinary bladder	Heart	Lungs	Intest-ine	Stomach	Pelvic fasciae	Intest-ine	Intest-ine
1	M.	1.6	7 x 6 1/4	4-13-51			x	x	x	x	x	x	
2	M.	7.5	10 1/4 x 9	5-24-51					x			x	
3	F.	1.3	5 1/2 x 5	5-29-51			x			x	x	x	
4	M.	2.1	6 1/2 x 5 1/2	5-31-51			x		x	x			
5	M.	3.6	8 1/2 x 7 1/2	6- 6-51			x		x		x	x	
6	M.	0.9	5 1/2 x 4 1/2	6-11-51				x	x	x	x	x	
7	M.	2.5	7 1/2 x 6 1/2	6-12-51		x	x			x	x	x	
8	F.	2.7	7 1/2 x 6	6-14-51				x	x	x		x	
9	M.	0.7	4 1/2 x 4	6-15-51			x		x			x	
10	F.	0.8	4 3/4 x 4	6-16-51		x	x	x	x	x	x	x	
11	M.	0.75	4 1/2 x 3 3/8	6-26-51					x			x	
12	F.	0.3	3 1/4 x 3	6-19-51					x	x		x	
13	F.	3.5	7 1/2 x 6 1/4	6-23-51			x	x	x	x	x	x	
14	M.	8.2	9 1/2 x 8 1/2	6-24-51					x	x	x	x	
15	F.	4.5	8 1/4 x 6 3/4	7- 3-51		x	x		x	x	x	x	x
16	F.	3.8	8 x 6 3/4	7- 6-51				x	x	x	x	x	
17	F.	2.8	7 1/4 x 5 3/4	7- 6-51					x	x	x	x	x
18	F.	1.4	5 3/4 x 4 3/4	7-13-51			x	x	x	x		x	
19	F.	3.5	7 1/2 x 6 1/4	7-14-51			x	x	x	x	x	x	
20	M.	2.6	6 1/4 x 6	7-15-51		x	x			x	x	x	x
21	M.	1.2	5 1/2 x 4 1/2	7-16-51			x		x	x		x	
22	M.	1.4	5 1/2 x 4 1/2	7-18-51			x		x	x	x	x	
23	M.	7.1	9 x 8	7-17-51					x		x	x	
24	M.	1.5	6 1/4 x 5	7-26-51			x	x	x	x	x	x	
25	F.	5.2	8 1/4 x 7	7-27-51		x	x	x	x	x	x	x	
26	M.	1.3	5 1/2 x 4 1/2	7-28-51		x	x	x	x	x	x	x	
27	M.	2.4	6 3/4 x 5 3/4	8- 2-51			x		x	x	x	x	
28	M.	3.8	8 3/4 x 6 3/4	8- 3-51	x	x	x	x		x	x	x	
29	M.	2.0	7 1/2 x 6 1/4	8- 4-51		x	x	x		x	x	x	
30	M.	1.6	5 3/4 x 5	8- 5-51			x			x		x	
Percentage of hosts infected					3.3%	27%	70%	43%	80%	83%	70%	97%	10%

TABLE I

DATA CONCERNING HOSTS AND THEIR PARASITES

immunity existed. It was found that on the average the larger and, presumably, older turtles possessed fewer numbers of most species of parasites than did the smaller and younger ones. Therefore, it seems likely that some degree of age immunity is developed by the host, but this can be substantiated only by the accumulation of further data from a greater number of hosts. There was no apparent difference in the degree of infection between males and females.

In addition to the mature helminths, many immature specimens were found, but no attempt was made to identify them. Many immature nematodes were observed in the stomach and intestine, and a few were encysted on the outside of the stomach wall. Immature flukes were obtained from the intestine and the major blood vessels. Immature blood flukes were recovered on several occasions in blood vessels and in clotted blood that remained in the peritoneal cavity after the removal of internal organs. These specimens showed only slight development of sex organs, which is characteristic of immature helminths. They were similar in appearance to the adult Spirorchis haematobium that is found in the heart, and they were thought to be young specimens of this species. Strigeid metacercaria of the Neascus type were obtained in large numbers from the intestine of one host. Since strigeids are more prevalent in birds and mammals, it is interesting that these were found in a snapping turtle. This can be explained, perhaps, on the basis of the food habits of Chelydra serpentina. They are carnivorous in part, and possibly in this instance, ate the infected organism that normally transfers the parasite to the usual definitive host. It appears that the larvae are able to persist in this abnormal host for considerable periods after ingestion. The writer could not find

any instance where strigeids have been reported specifically from turtles. Apparently, this represents a new host record for these immature flukes. All acanthocephalans that were found were immature and were obtained from beneath the mucosa of the intestine. These immature acanthocephalans are discussed in more detail later in this chapter.

In connection with the lung fluke, Heronimus chelydrae, an attempt was made to determine its first intermediate host. During the Summer of 1951, Dr. Philip E. Smith and the writer exposed about two hundred snails of the genera Physa and Helisoma to the miracidia of this lung fluke, hoping to establish an infection in them. Only negative results, however, were obtained from this experiment. This evidence does not exclude these snails as being potential intermediate hosts for H. chelydrae since, by a proper combination of environmental factors, it may be possible to establish an infection in them.

As part of this survey, general observations were made on the stomach contents of the snapping turtle. A variety of material was found in the stomach of the snappers, including the remains of crayfishes, clams, fishes, snails and insects. Crayfish remains were encountered in about ninety percent of hosts examined and, thus, seems to be a constant food item of Chelydra serpentina. The fact that snapping turtles are extremely varied in their food habits may account for the numerous species of helminths in them.

From a study of the literature, twenty-eight valid species are recognized from the snapping turtle. These species have a variety of habitats in the host and represent a wide geographical distribution. Fifteen

species of helminths are reported from Chelydra serpentina in this survey and are described in detail.

Trematode species:

Spirorchis haematobium (Stunkard, 1922) Price, 1934:

Spirorchiidae MacCallum, 1921.

Synonyms: Henotosoma haematobium Stunkard, 1922; Spirorchis chelydrae MacCallum, 1926.

Synonyms according to Price (1934).

Description: Elongate, flattened monostomate blood fluke with almost parallel sides, pointed anterior and rounded posterior ends. Relaxed individuals widest at level of testes with narrowest zone in midbody region. Fixed and mounted specimens, 5 to 9 mm. in length and 0.48 to 0.7 mm. in width. Cuticula thin, smooth, spineless. Oral sucker at tip of body, 0.077 to 0.1 mm. in length and 0.071 to 0.084 mm. in width, capable of considerable extension and retraction. Mouth opening subterminal. Esophagus 0.39 to 0.77 mm. in length, increasing in diameter posteriorly. Pharynx absent. Posterior end of esophagus forming sac or pouch which extends caudad and ventrad from origin of ceca. Intestinal crura arising immediately before posterior end of esophagus, passing laterad about one-half of distance to body wall, then turning sharply posteriad, extending nearly to posterior end of body; their course notably sinuous, passing lateral to testes and ovary. Excretory pore at posterior end of body, bladder dividing almost immediately, forming paired collecting ducts which extend anteriorly. Genital pore ventral, near level of caudal margin of ovary, beneath cecum of left side.

Opening of eversible cirrus anterior to that of uterus. Ten testes, except during decline of sexual activity when certain ones may disintegrate, in posterior half of body, tandem, in intercecal area. Testes, each 0.12 to 0.27 mm. in length and 0.27 to 0.43 mm. in width, irregularly lobed, contiguous structures, flattened antero-posteriorly, occupying practically all space between ceca. Posterior testis opening directly into large ovoid or pyriform seminal vesicle. Cirrus sac small, 0.154 to 0.22 mm. in length and 0.05 to 0.077 mm. in width, muscular wall slightly developed. Ovary lobed, oval, 0.22 to 0.28 mm. in length and 0.154 to 0.23 mm. in width, situated on right side of body between seminal vesicle and genital pore. Oviduct arising at median posterior margin, passing dextrad and posteriad. Laurer's canal, ootype, vitelline receptacle, and metraterm present. Vitellaria extensively developed, masses of follicles extending from origin of ceca to near posterior end of body. Eggs in tissue of host dark in color, 0.155 mm. in length and 0.081 mm. in width. The description is based on Stunkard (1922, 1923).

Host: Chelydra serpentina.

Habitat: Heart and major arteries.

Distribution: United States (North Carolina, Oklahoma, Texas, New York, New Jersey, Ohio, and Indiana).

Discussion: MacCallum ~~in~~ (1921a) named and briefly described the species Spirorchis chelydrae, which he had found in the heart of Chelydra serpentina. The original description of Spirorchis haematobium was made by Stunkard in 1922. In this work he created the genus Henotosoma to include Spirorchis

chelydrae MacCallum, 1921 and his new species which he described and named, Henotosoma haematobium. In 1923 Stunkard reaffirmed his original work with a supplementary description of H. haematobium. MacCallum in 1926 gave a more complete description of S. chelydrae and observed that his species was identical with the species described by Stunkard as Henotosoma haematobium. If both names applied to the same species, then the name given by MacCallum would be valid since in 1921 he published a description of the parasite. However, most subsequent workers have recognized as valid the name given by Stunkard, and it is not the purpose of this paper to consider the validity of the two names.

Harwood (1932) recognized Stunkard's genus Henotosoma in reporting H. chelydrae (MacCallum) which he had taken from the heart of a snapping turtle in Texas. Price (1934) did not regard Henotosoma Stunkard sufficiently different from the genus Spirorchis to be considered distinct, and placed Henotosoma as a synonym of Spirorchis. Mehra (1934) also regarded the genus Henotosoma as a synonym of Spirorchis, because of the "close similarity of their structural relationships". Byrd (1939) and Wall (1939, 1941) accepted this change as proposed by Price and by Mehra. In addition, Byrd recommended that Spirorchis chelydrae MacCallum be suppressed as a synonym of S. haematobium (Stunkard, 1922). Hughes et al (1942) in agreement with Byrd's recommendation, recognized S. haematobium (Stunkard) as the valid species. Dawes (1946) cited a key to the genera of the family Spirorchiidae which was given by Price (1934), and thus recognized the latter worker's designation of the former genus Henotosoma.

The writer accepts the work of Price in establishing Spirorchis as the valid genus. Most workers, since this genus was created by MacCallum

in (1918a), have noted the numerous variations which it exhibits. The genus Henotosoma as created by Stunkard differs from Spirorchis only in length of esophagus and position of testes in the posterior half of the body. These characters are not considered to be of sufficient magnitude to justify separating the genera.

The specimens of Spirorchis haematobium found in this survey agree closely with the description of the species given by Stunkard in 1922, 1923. Minor variations exist in a few measurements, in the relative shape, and location of certain internal structures. However, since the species in the genus are variable, and since there was probably some distortion and shrinkage of specimens during fixation, these differences are not sufficient to exclude my specimens from this species.

It should be mentioned that one blood fluke was found which differed from S. haematobium. In some respects it resembled Hapalorhynchus gracilis Stunkard, 1922, but since the specimen was broken and could not be studied thoroughly, it is considered as a "species inquirendo."

Heronimus chelydrae MacCallum, 1902:

Heronimidae Ward, 1917.

Synonyms: Aorchis extensus Barker and Parsons, 1914; Heronimus geomydae MacCallum, 1921; Heronimus maternum MacCallum, 1921.

Synonyms according to Stunkard (1924) and Caballero (1940).

Description: Monostomate lung fluke. Body thick, 4.9 to 15 mm. in length and 1.57 to 2.65 mm. in width, somewhat club-shaped, tapering toward anterior end, bluntly rounded at posterior end, greatest width

at level of second anterior fifth of body length. Cuticula thin, unarmed, sometimes thrown up into small folds or rugae independent of musculature. Oral sucker, 0.204 to 0.314 mm. in length and 0.314 to 0.455 mm. in width, sub-terminal, sub-globular, with weak musculature. Pharynx, 0.219 to 0.345 mm. in length and 0.219 to 0.314 mm. in width, immediately posterior to oral sucker, muscular, globular. Esophagus very short, 0.047 mm. in length by 0.143 mm. in width. Intestinal ceca wide, passing posteriorly as straight unbranched tubes to near posterior end of body. Excretory pore median, dorsal, immediately posterior to level of pharynx; large medium dorsal bladder extending from pharyngeal region to posterior end of body. Genital pore ventral, slightly lateral to median line at margin of oral sucker. Testis U or V-shaped, irregularly lobed with closed portion cephalad, situated one-fourth to one-fifth of body length from anterior end; testicular crura extending caudad to a level one-eighth of body length from posterior end. Testis tending to atrophy in older worms. Seminal vesicle extending short distance caudad from median part of testis, turning anteriad in ventral part of body and passing without demarcation into thin-walled cirrus sac just anterior to ovary. Cirrus eversible, non-muscular. Vas deferens short, arising from anterior part of testis. Prostate gland absent. Ovary, 0.392 to 0.518 mm. in length and 0.314 to 0.455 mm. in width, rounded or ovoid, lying dorsally and slightly posterior to bifurcation of intestine and to right or left of median line. Seminal receptacle about one-fourth size of ovary, on postero-median side of ovary. Oviduct continues caudad from posterior margin of ovary and joins vitelline duct. Ootype and Mehlis' gland present; Laurer's canal absent. Uterus voluminous, extensive, heavily pigmented in part,

occupying most of available space from bifurcation of ceca to posterior end of body. Metraterm muscular, extending from genital pore posteriorly to point slightly behind level of pharynx. Vitellaria consisting of two glandular structures, meeting anteriorly, forming vitelline receptacle, and extending almost to terminal end of body, median and ventral to ceca. Eggs very thin-shelled, 0.045 to 0.065 mm. in length and 0.022 to 0.030 mm. in width. Embryos develop eye-spots, and fully-developed ciliated miracidia may be free in uterus.

The description is based on MacCallum (1902), Barker and Parsons (1917), and Stunkard (1919).

Hosts: Chelydra serpentina, Chrysems picta, C. marginata, Emys blandingi, Geoemyda punctularia, Graptemys geographica, Kinosternon hirtipes, K. subrubrum, Pseudemys scripta, and Sternotherus odoratus.

Habitat: Lungs and larger bronchial tubes.

Distribution: North America and Trinidad Island.

Discussion: This monostomate lung fluke, Heronimus chelydrae, was described originally by MacCallum in 1902 from the lungs of the American snapping turtle, Chelydra serpentina, taken in Canada. MacCallum created the genus Heronimus to include this fluke, which, in his opinion, stood out from other monostomes in several respects, but especially in the position and nature of the genital pore, in the complexity of the uterus, the unusual formation of the vitellaria, in the presence of but one testis and in the position of the excretory pore. Barker and Parsons in

1914 briefly described a monostome, parasitic in the lungs of Chrysemys marginata, which they named Aorchis extensus. In a later paper, Barker and Parsons (1917) gave a more extensive description of the species. Ward in 1917 created a new family Heronimidae to include the genera Heronimus and Aorchis. Stunkard in 1919 made an extended study of the two species and after comparing them, regarded Aorchis extensus Barker and Parsons as identical with Heronimus chelydrae MacCallum. He pointed out noticeable errors which Barker and Parsons had made. Stunkard confirmed the work of MacCallum and included many additions to the description of the species which subsequent workers have accepted. MacCallum ~~in~~ (1921b) described two monostome lung flukes from turtles and named them Heronimus geomydae and H. maternum. Caballero (1940) considered these species to be Heronimus chelydrae in which retrogressive changes had taken place and recommended that they be placed in synonomy. Hughes et al (1942) accepted this proposal. The writer concurs in Caballero's recommendation.

The specimens of Heronimus chelydrae collected in this survey agree closely with the descriptions of the species as given originally by MacCallum and supplemented by Stunkard. Although the internal anatomy of this worm is extremely difficult to study in whole mounts, the writer was able to mount three specimens in toto which showed most of the diagnostic characters of the species. Sections would be needed to successfully demonstrate the more detailed characters, especially of the reproductive system.

This species is interesting from the standpoint of its complicated and unusual anatomy and from the fact that, although many workers have

attempted to determine the life cycle, none have succeeded. The life cycle of this species is certainly worthy of consideration.

Telorchis corti Stunkard, 1915:

Reniferidae Baer, 1924.

Synonyms: Telorchis linstowi Goldberger, 1911 (nec Stossich, 1890); T. lobosus Stunkard, 1915; T. insculpti MacCallum, 1918; T. guttati MacCallum, 1918; T. chelopi MacCallum, 1918; T. pallidus MacCallum, 1918; T. angustus MacCallum, 1921 (nec Stafford, 1900); Cercorchis corti (Stunkard, 1915) Perkins, 1928; Telorchis stenoura Ingles, 1930; Cercorchis texanus Harwood, 1932; Cercorchis medius McMullen, 1934 (nec Stunkard, 1915).

Synonyms according to Wharton (1940).

Description: Body elongate with near parallel sides, 4 to 7.15 mm. in length and 0.35 to 0.5 mm. in width, uniformly rounded at ends, and greatest width at acetabulum. Oral sucker 0.14 mm. in diameter, surrounded by cuticular spines, 0.003 to 0.004 mm. in length. Pharynx, 0.070 to 0.080 mm. in diameter. Esophagus, 0.050 mm. in length, 0.025 mm. in diameter. Ceca extending beyond testes. Acetabulum equal to or slightly smaller than oral sucker, one-sixth to one-seventh of body length from anterior end. Excretory pore at posterior tip of body; large median bladder extending anteriorly, bifurcating at level of ovary to form pair of collecting tubules. Genital pore immediately anterior to acetabulum. Testes spherical to oval, 0.2 to 0.29 mm. in length and 0.16 to 0.24 mm. in width, usually somewhat to left of median line, separated by 0.05 to 0.1 mm. Cirrus sac, 1.12 to

1.18 mm. in length and 0.088 mm. in width, extending caudad from genital pore for three-fourths distance to ovary. Vas deferens much coiled. Ovary spherical to slightly oval, 0.117 mm. by 0.147 mm. in smallest specimens and 0.147 mm. by 0.176 mm. in largest, long axis parallel to that of body, in median line or slightly to its left, about three-eighths of body length from anterior end. Seminal receptacle present; Laurer's canal opening caudad of ovary. Uterus extending posteriad on left side, rarely descending and ascending limbs cross about one-third of distance to cephalic testis, and passing anteriad on right side of metraterm. Metraterm almost straight, extending from genital pore one-fourth to one-third distance to ovary. Vitellaria arranged in lobes, beginning one-third distance from ovary to acetabulum, cephalad of posterior end of cirrus sac, and extending five-sixths of distance from ovary to cephalic testis. Eggs, 0.031 mm. by 0.015 mm.

The description is based on Stunkard (1915).

Hosts: Chelydra serpentina, Chrysemys marginata, C. picta, Clemmys guttata, C. insculpta, C. marmorata, Deirorchelys reticularia, Graptemys geographica, Malaclemys macrospilota, M. pileata, Pseudemys elegans, and P. scripta.

Habitat: Intestine.

Distribution: North America.

Discussion: Before attempting a discussion of the species, it will be necessary to consider the status of the genus Telorchis and recount some of the confusing points that have existed concerning this genus since it

was first proposed.

On December 29, 1899, Lühe proposed a new genus of trematode, Telorchis, with T. clava as type. A paper by Looss appeared on the following day in which he proposed the genus Telorchis, with T. Linstowi as type. December 28, 1899 was the publication date for both papers. In 1900 Braun recognized Lühe's genus and stated that it had priority over Telorchis Looss, 1899. The two genera were considered to be identical.

Lühe in 1900, after Braun had accepted his genus, compared the two genera. He divided the genus Telorchis into two sub-genera, Telorchis with T. clava as type and Cercorchis with T. Linstowi as type. A third sub-genus Protenes was created by Barker and Covey in 1911. Stunkard in 1915 rejected the sub-genus Cercorchis and raised the sub-genus Protenes to generic rank. Ward in 1918 listed Telorchis Lühe, 1899 as the valid genus, stated that Cercorchis Lühe graded into Telorchis and could not be accepted as a valid sub-genus, and accepted the genus Protenes. Perkins in 1928 revived Cercorchis as a genus, redefined both Telorchis and Cercorchis, and accepted Protenes as a valid genus. Dollfus in 1929, failing to recognize Perkins' work, accepted the interpretation of the genus by Stunkard. Ingles (1930) accepted Telorchis Lühe as valid in describing T. stenoura. Mehra and Bokhari (1932) created a new genus Paracercorchis, with P. pellucidus as type species, as intermediate between Telorchis and Cercorchis. Harwood in 1932 accepted Perkins' work and transferred all North American species of Telorchis to the genus Cercorchis. Krull (1935) accepted the genus Telorchis in reporting work done with T. robustus. McMullen (1935), Bennett and Tobie (1936), and Byrd (1936) all accepted Cercorchis as redefined by Perkins. Wharton

(1940) redefined the genera Telorchis and Protenes. He stated that the genera Cercorchis and Paracercorchis were not valid and should be included in Telorchis. Caballero (1940) and Parker (1941) accepted the genus Cercorchis but Hughes et al (1942) recognized Telorchis as redefined by Wharton. Dawes (1946) accepted the definition of Cercorchis given by Perkins. Currently, Dr. Paul D. Harwood and Leroy H. Fisk are working on a redefinition of the genus Telorchis with descriptions of new species, and will probably reduce some genera to synonymy.

It is apparent that the taxonomy of this group has long been in a state of confusion and it is not the purpose of this writer to attempt to settle the issue. The writer does accept, however, the genus Telorchis as proposed by Wharton. The writer agrees with Wharton that Perkins' work is not valid since the distinguishing characters listed for Cercorchis are not of generic rank, and fail to differentiate it from Telorchis.

Wharton undertook to redefine the genus Protenes since, as he stated, the diagnosis given by Bennett (1935) was too detailed to be practical. The writer does not recognize the diagnosis given by Wharton as being valid since it differs from his diagnosis of the genus Telorchis only in the length of the metraterm. It does not seem wise to establish generic distinctions on the basis of such a character. Therefore, the writer accepts as valid Bennett's diagnosis of the genus Protenes, which seems distinctive enough to separate Protenes from Telorchis.

Wharton committed a noticeable error which did not lessen the confusion already existing. In a summarizing sentence following the historical background of the genera studied, Wharton stated: "The genera Telorchis, Cercorchis, Protenes, and Paracercorchis all fall into the genus

Telorchis Lühe, 1899". Yet, in succeeding sections he gave a diagnosis of Protenes as a separate genus and also gave a revision of the species of Protenes. Such a gross error is rather inexcusable in a scientific paper, especially in instances where the writer is attempting to clarify the existing taxonomic confusion.

The species, Telorchis corti, was described originally by Stunkard in 1915 from a collection of some fifty specimens that were found in the intestine of Malacoclemmys lesueuri from Texas. T. corti has remained a valid species since that time. Several workers have described, as a new species, flukes which are regarded now as synonyms of T. corti. Wharton (1940) recorded as synonyms of T. corti the species which the writer has cited previously. Differences which had been used to separate them were not sufficient, in his opinion, for the creation of distinct species. He assumed this in the light of the wide variation which was shown to be present within a single species of the genus.

The specimens of Telorchis corti taken in this survey agree closely with the original description by Stunkard. However, there are certain characters shown in my specimens that are not covered in his description and which seem worthy of mentioning. The anterior portion of the pharynx of many of my specimens appears to be scalloped, and the length of the esophagus is quite variable. It would seem better to describe the length of the esophagus as being one and one-half to two times the length of the pharynx instead of giving measurements. The length of the cirrus sac is quite variable also, being longer in my specimens than Stunkard described, and, in addition, it is convoluted, presenting usually three or four coils. This seems to be a constant character and would appear to

be of good diagnostic value. These variations are not considered to be sufficient to designate these specimens as other than Telorchis corti.

Auridistomum chelydrae (Stafford, 1900) Stafford, 1905:

Plagiorchiidae Ward, 1917.

Synonyms: Distomum chelydrae Stafford, 1900; Pterygotomaschalos attenuatus Stunkard, 1924; P. chelydrae (MacCallum, 1921) non Stafford, 1901; Tetrapapillatrema concavocorpa (Sizemore, 1936) Ralph, 1938.

Synonyms according to Wharton (1940).

Description: Body elongate, 2.46 mm. (2.06 to 2.73) in length and 0.472 mm. (0.456 to 0.493) in width, slightly constricted at center, widest at level of testes. Cuticula covered with fine spines. Oral sucker, 0.243 mm. (0.243 to 0.243) in length and 0.271 mm. (0.271 to 0.271) in width, with pair of ear-like lateral projections. Prepharynx absent. Pharynx spherical or oval, 0.135 mm. (0.128 to 0.143) in length and 0.147 mm. (0.143 to 0.150) in width. Esophagus absent. Ceca long, extending to posterior end of body. Acetabulum, 0.177 mm. (0.171 to 0.185) in length and 0.184 (0.178 to 0.192) in width, smaller than oral sucker and in center of anterior half of body. Excretory pore terminal, bladder very long, extending nearly to acetabulum, dividing into short lateral branches directed anteriad. Genital pore located to right or left of median line immediately posterior to bifurcation of intestine. Testes, 0.167 mm. (0.157 to 0.178) in length and 0.179 mm. (0.171 to 0.187) in width, spherical or slightly oval, tandem, median, slightly posterior to

body constriction. Cirrus sac large, extending from posterior margin of acetabulum to genital pore. Large coiled seminal vesicle in posterior portion of cirrus sac. Ovary spherical, 0.132 mm. (0.129 to 0.136) in diameter, immediately posterior and to right of acetabulum. Oviduct arising from dorsal median surface of ovary and passing caudad and dorsad. Laurer's canal thick-walled, in fork of excretory ducts. Uterus both extracecal and intracecal, extending from anterior margin of anterior testis to genital pore. Vitellaria extensive, continuous from side to side both above and below crura and excretory duct, extending from posterior margin of acetabulum to posterior end of body. Eggs elliptical, 0.032 mm. (0.031 to 0.033) by 0.0145 mm. (0.013 to 0.016).

The description is based on Stafford (1900, 1905), with supplementary description by the writer.

Host: Chelydra serpentina.

Habitat: Intestine.

Distribution: North America.

Discussion: Auridistomum chelydrae was described originally by Stafford in 1900 as Distomum chelydrae. In 1905 he created the genus Auridistomum to include this species. Ward in 1918 accepted Stafford's work as valid, listing Auridistomum with one species, A. chelydrae. In 1924 Stunkard obtained from the intestine of the snapping turtle, flukes that he noted were similar to Auridistomum chelydrae, but which, in his opinion, differed sufficiently from this species to justify the establishment of a new genus.

Consequently, he created the genus Pterygotomaschalos and named the species P. attenuatus. Pterygotomaschalos was differentiated from Auridistomum on the basis of body shape, and the location of the acetabulum, ovary, and testes. Perkins in 1928 recognized as valid the genera Pterygotomaschalos with two species, P. chelydrae (MacCallum, 1921) non Stafford, 1901 and P. attenuatus Stunkard, 1924, and Auridistomum with one species, A. chelydrae (Stafford, 1900). Ralph in 1938 described a new genus, Tetrapapillatrema, and a new species, T. concavocorpa. He established the genus on the basis of four muscular papillae on the oral sucker. Wharton (1940) considered Tetrapapillatrema and Pterygotomaschalos as synonyms of Auridistomum. He suggested that the differences in body shape and location of internal organs, on which Stunkard had based Pterygotomaschalos, were normal characteristics of immature specimens of Auridistomum chelydrae. He stated that as A. chelydrae matured, the posterior end became relatively larger and the numerous eggs which crowded between the ovary and testes changed the relative positions of the organs and the shape of the body. Hughes et al (1942) recognized Wharton's work. The writer also accepts Wharton's work as valid.

The writer compared the specimens of A. chelydrae collected in this survey with the original description of the species by Stafford and with that given later by Ward. Since both descriptions were lacking in measurements and additional details of diagnostic value, a complete comparison could not be made. However, all of the principal diagnostic features listed by these workers are exemplified in my specimens. The writer has given a more detailed description by including complete measurements of external characters and major internal structures and by listing

additional diagnostic characters not included by Stafford. The writer's description is based on a study of four stained specimens mounted in toto.

Allassostoma parvum Stunkard, 1916:

Paramphistomidae Goto and Matsudaira, 1918.

Synonyms : Paramphistomum chelydrae MacCallum, 1918; probably Cercaria inhabilis Cort, 1914; and C. convoluta Faust, 1919.

Synonyms according to Hughes (1942).

Description : Body thick with near parallel sides, tapering slightly anteriorly, rounded posteriorly, 3 to 5.5 mm. in length and 0.8 to 1.6 mm. in width. A lateral prominence or evagination, one on either side, at level of anterior border of acetabulum. Oral sucker terminal, oval in shape, 0.32 to 0.64 mm. in length and 0.27 to 0.46 mm. in width. Pair of oral evaginations arising from dorsal, postero-lateral margin of sucker, each 0.06 to 0.08 mm. in length. Pharynx absent. Esophagus straight in protracted state, 0.3 to 0.6 mm. in length and 0.035 to 0.07 mm. in width; oval-shaped esophageal muscular bulb, 0.16 to 0.3 mm. in length and 0.14 to 0.21 mm. in width, enclosing posterior end of esophagus. Ceca sac-like, almost one-fourth of body width in diameter, extending posteriad and terminating immediately anterior to acetabulum. Acetabulum posteriorly terminal, circular, 0.67 to 1.2 mm. in diameter. Excretory pore median, dorsal, at level of cephalic margin of acetabulum. Short bladder passing ventrad and anteriad, dividing into two collecting tubes. Genital pore in mid-ventral line, immediately posterior to bifurcation of ceca. Testes spherical to oval, 0.28 to 0.32 mm. in length and 0.24 to 0.32 mm. in width, contiguous,

tandem in anterior half of worm. Vas efferentia arising at dorsal margins of testes, uniting anterior to cephalic testis; vas deferens expanding immediately into long, much-coiled seminal vesicle, which passes anteriad into cirrus sac and opens through genital pore. Ovary spherical to oval, 0.16 to 0.2 mm. in diameter, slightly posterior to middle of body in median plane. Oviduct arising at posterior margin of ovary, passing posteriad. Ootype, Mehlis' gland, Laurer's canal present. Uterus in adult specimens much coiled, containing many eggs. Vitellaria extend from level of anterior testis almost to ends of ceca, lateral to ceca anteriorly, enter intercecal area posterior to testes, but not extending to median plane; becoming confluent posterior to ovary. Vitelline follicles large and spherical, 0.1 to 0.2 mm. in diameter. Eggs oval, 0.145 mm. in length and 0.1 mm. in width.

The description is based on Stunkard (1917, 1924).

Hosts: Chelydra serpentina, Chrysemys picta, and Pseudemys floridana.

Habitat: Urinary bladder and cloaca.

Distribution: North America.

Discussion: The original description of Allassostoma parvum was given by Stunkard in 1916, based on specimens taken from the urinary bladder of Chelydra serpentina. He created the genus Allassostoma to include A. parvum and A. magnum, the type species. Since these specimens of A. parvum were not mature, Stunkard in 1917 gave a more complete description based on mature flukes. MacCallum ~~in~~ (1918a) described a new species, Paramphistomum chelydrae, based on three amphistomes collected from the rectum of Chelydra

serpentina. In 1924, after a careful examination of MacCallum's specimens, Stunkard stated that the species was identical with Allassostoma parvum and recommended that it be considered a synonym of A. parvum. In this same paper Stunkard proposed the subgenus name Allassostomoides to include Allassostoma parvum, which, in his opinion, differed sufficiently from A. magnum to necessitate such a separation. Krull (1933) recognized as valid the name Allassostoma parvum as given originally by Stunkard. Travassos (1934) recommended that Allassostomoides Stunkard be raised to generic rank with A. parvum as type. Hughes et al (1942) accepted this proposal by Travassos. In addition, they listed as synonyms of A. parvum, the following: Paramphistomum chelydrae MacCallum, as previously recommended by Stunkard, and Cercaria inhabilis Cort, 1914 and C. convoluta Faust, 1919, as probable. Dawes (1946) recognized Allassostoma and Allassostomoides as valid genera.

The writer prefers to recognize Allassostoma parvum as the valid name for the species. In my opinion, sufficient evidence has not yet been presented to justify the separation of A. parvum from the type species A. magnum. However, the discovery of additional species similar to A. parvum may warrant the creation of a distinct genus to include them. The writer also agrees with Stunkard in considering as synonymous with Allassostoma parvum, the specimens described by MacCallum as Paramphistomum chelydrae. Apparently, MacCallum either failed to consider or simply disregarded the diagnostic characters of the genus Allassostoma in naming his specimens.

The specimens of A. parvum in the writer's collection agree with the description as given by Stunkard.

Polystomoidella oblongum (Wright, 1879) Price, 1939:

Polystomatidae Gamble, 1896.

Synonyms: Polystoma oblongum Wright, 1879; Polystoma (Polystomoides) oblongum (Wright, 1879) Ward, 1918; P. hassalli Goto, 1899; P. (P.) hassalli (Goto, 1899) Ward, 1918.

Synonyms according to Price (1939)

Description: Body more or less oval, 1.3 to 2.3 mm. in length and 0.510 to 0.616 mm. in width at level of vaginal apertures. Oral sucker, 0.095 to 0.190 mm. in length and 0.210 to 0.360 mm. in width, opening subterminal. Pharynx oval, 0.114 to 0.190 mm. in length by 0.095 to 0.190 mm. in width; esophagus very short; intestinal ceca simple, terminating somewhat in front of anterior margin of haptor. Haptor, 0.460 to 0.715 mm. in width, more or less cordate, bearing the usual three pairs of suckers, each 0.133 to 0.190 mm. in diameter, and with one pair of large hooks 0.121 to 0.152 mm. in length, with deeply incised roots, between posterior pair of suckers; sixteen larval hooklets present, arranged as follows: Six between anterior pair of suckers, four between posterior pair of suckers and one in each sucker. Genital aperture median, slightly posterior to intestinal bifurcation; genital coronet with sixteen hooks, alternating large and small, the longer 0.020 mm. and the shorter 0.015 mm. in length. Testis, 0.250 mm. in length by 0.340 mm. in width. Ovary comma-shaped, 0.076 mm. in width. Vitellaria, consisting of relatively few follicles, extending from level of base of pharynx to level of anterior margin of haptor. Vaginal apertures lateral, equatorial. Genito-intestinal canal somewhat convoluted, opening into intestine near ovary. Eggs oval, 0.235 mm. in length by 0.195 mm. in width.

The description is based on Price (1939).

Hosts: Chelydra serpentina, Sternotherus odoratus, S. carinatus, Kinosternon pennsylvanicum (= K. subrubrum subrubrum), and (?) Chrysemys picta.

Habitat: Urinary bladder.

Distribution: Canada and United States (Maryland, North Carolina, Texas, Iowa, Virginia, and Oklahoma).

Discussion: Polystomoidella oblongum was described originally as Polystoma oblongum by Wright in 1879 from specimens taken from the urinary bladder of Aromochelys odoratus (= Sternotherus odoratus) in Canada. It was first reported from Chelydra serpentina by Stafford (1900). The same worker in 1905 reported it from Chrysemys picta, but this report is questionable since the specimens were taken from the mouth instead of the urinary bladder.

Ward (1918) created the sub-genus Polystomoides and considered Polystoma oblongum Wright, 1879 and P. hassalli Goto, 1899 as species in this sub-genus. Subsequent workers reported Polystoma oblongum as P. (P.) oblongum (Wright, 1879) Ward, 1918 until Price (1939) created the new genus Polystomoidella and included P. (P.) oblongum as type. His work was based on a revision of the family Polystomatidae with a combination of more recent diagnostic characters which were found to better clarify the taxonomy of Polystomes. Price regarded Polystoma hassalli Goto, 1899 and Stunkard's (1917) P. hassalli as synonyms of Polystomoidella oblongum since the large haptoral hooks in all three forms had incised roots and were identical in every other respect. Price also did not regard as valid the subgeneric name, Polystomoides, which Ward created for the two species in 1918.

Subsequent workers, notably Caballero (1940), Hughes et al (1942), and Dawes (1946) accepted the validity of Price's work in recognizing his genus Polystomoidella with its designated species.

The writer accepts the work of Price (1939) in creating the genus Polystomoidella and in placing P. oblongum as type species of the genus. The specimens of P. oblongum found in this survey agree with the description of the species as given by Price. It should be mentioned however, that the larval hooklets on the haptor are very difficult to distinguish on mounted specimens, but they are constant for the members of the family and can be distinguished readily on living specimens.

Polystomoides coronatum (Leidy, 1888) Ozaki, 1935:

Polystomatidae Gamble, 1896.

Synonyms: Polystoma coronatum Leidy, 1888; P. (Polystomoides) coronatum (Leidy, 1888) Ward, 1917; P. opacum Stunkard, 1916; P. (Polystomoides) opacum (Stunkard, 1916) Ward, 1918; P. megacotyle Stunkard, 1916; P. (Polystomoides) megacotyle (Stunkard, 1916) Ward, 1918; P. microcotyle Stunkard, 1916; P. (Polystomoides) microcotyle (Stunkard, 1916) Ward, 1918; P. albicollis MacCallum, 1919; P. digitatum MacCallum, 1919.

Synonyms according to Price (1939).

Description: Body elongate oval, 3 to 6.4 mm. in length and 0.765 to 1.6 mm. in width at level of vaginal apertures. Oral sucker, 0.133 to 0.306 mm. in length and 0.323 to 0.765 mm. in width. Pharynx sub-globular, 0.274 to 0.460 mm. in length and 0.304 to 0.595 mm. in width; esophagus very short;

intestinal ceca extending to near posterior end of body proper. Haptor more or less cordate, 0.970 to 1.8 mm. in width, bearing three pairs of suckers, each 0.340 to 0.510 mm. in diameter and armed with two pairs of large hooks between the posterior pair of suckers, and with sixteen larval hooklets distributed as follows: Six between anterior pair of suckers, four between posterior pair of suckers and one in each sucker. Outer pair of large hooks 0.095 to 0.197 mm. in length, inner pair 0.045 to 0.095 mm. in length, and larval hooklets 0.020 to 0.025 mm. in length. Genital aperture median, immediately posterior to intestinal bifurcation; cirrus 0.133 to 0.220 mm. in width; genital coronet of fourteen to forty hooks, blades 0.020 to 0.026 mm. in length. Testis circular or bluntly oval, 0.285 to 0.680 mm. in length and 0.190 to 0.525 mm. in width, median, preequatorial. Ovary comma-shaped, 0.133 to 0.435 mm. in length and 0.064 to 0.114 mm. in width, pretesticular, to right or left of median line. Vitellaria extending from level of base of pharynx to posterior end of body proper, follicles forming band across body at intestinal bifurcation and completely filling posttesticular portion of body. Vaginal apertures ventral, near margins of body, slightly posterior to level of distal pole of ovary. Genito-intestinal canal opening into intestine on ovarial side. Eggs oval, 0.228 to 0.250 mm. in length.

The description is based on Price (1939).

Hosts: Chelydra serpentina, Trionyx ferox, T. spinifers, Pseudemys elegans, P. scripta, Graptemys geographica, "spotted turtle", and "terrapin".

Habitat: Mouth and nostrils, and urinary bladder.

Distribution: Canada and United States (New York, Massachusetts, North Carolina, Texas, and Oklahoma).

Discussion: The original description of Polystomoides coronatum was given by Leidy under the name, in 1888, Polystoma coronatum, and was based on one specimen obtained from the common food terrapin, Emys palustris. Leidy included no figures and the description was decidedly meager. Stunkard in 1917 redescribed in greater detail the species from the type specimen. Ward in 1918 created the sub-genus Polystomoides in which he included Polystoma coronatum. This classification remained until 1935 when Ozaki raised Polystomoides to generic rank and designed Polystomoides coronatum (Leidy, 1888) as type species. Price (1939) accepted this designation by Ozaki and in addition included as synonyms of P. coronatum, the species listed at the beginning of this section. According to Price, these species, for the most part, were based on the number of hooks in the genital coronet. After comparing specimens and descriptions of these species, Price concluded that this character was extremely variable and of questionable value in determining species, especially in the absence of correlated characters. He gave a complete and detailed redescription of P. coronatum and included explanatory figures. His work is substantiated by the fact that he made a revision of the family Polystomatidae, using a combination of more recent diagnostic characters to clarify the taxonomy of Polystomes.

Hughes (1942) and Dawes (1946) accepted the validity of the genus Polystomoides as established by Ozaki and of the designated species as proposed by Price.

The writer accepts the redescription of P. coronatum (Leidy, 1888) Ozaki, 1935 as given by Price (1939) and the designated synonyms of this species. It is the opinion of the writer that Price has simplified the taxonomy of this group by redefining the most outstanding and constant specific diagnostic characters and allowing for the wide variations of certain characters that have been shown to exist among the species now listed as synonyms of P. coronatum.

The specimens of Polystomoides coronatum found in this survey agree with the description of the species as given by Price.

Neopolystoma orbiculare (Stunkard, 1916) Price, 1939:

Polystomatidae Gamble, 1896.

Synonyms: Polystoma orbiculare Stunkard, 1916; P. (Polystomoides) orbiculare (Stunkard, 1916) Ward, 1918; P. oblongum Wright, of Leidy, 1888; P. troosti MacCallum, 1919; P. inerme MacCallum, 1919; P. elegans MacCallum, 1919; P. spinulosum MacCallum, 1919; P. aspidonectis MacCallum, 1919; P. floridanum Stunkard, 1924; Polystomoides orbiculare (Stunkard, 1916) Ozaki, 1935.

Synonyms according to Price (1939).

Description: Body elongate oval, 2.4 to 5.8 mm. in length by 0.318 to 1.6 mm. in width. Oral sucker, 0.170 to 0.340 mm. in length by 0.272 to 0.588 mm. in width, opening subterminal. Pharynx, 0.187 to 0.30 mm. in length and 0.204 to 0.390 mm. in width; esophagus very short; intestinal ceca simple, extending to near posterior end of body proper. Haptor circular, 0.700 to 1.6 mm. in diameter, bearing six suckers and sixteen larval hooklets;

suckers 0.170 to 0.425 mm. in diameter, usually equidistant; larval hooklets 0.020 mm. in length, distributed as follows: Six between anterior pair of suckers, four between posterior pair of suckers, and one in each sucker. Genital aperture median, near intestinal bifurcation. Genital coronet with sixteen hooks, blades 0.020 mm. in length; cirrus pouch 0.076 to 0.148 mm. in diameter. Testis oval, 0.425 to 1.0 mm. in length and 0.340 to 0.680 mm. in width, equatorial or slightly pre-equatorial. Ovary more or less comma-shaped, 0.120 to 0.375 mm. in length and 0.065 to 0.170 mm. in width, to right or left of median line. Vitellaria extend from level of posterior margin of pharynx to posterior end of body proper, follicles forming band across median field at intestinal bifurcation and filling posttesticular area. Vaginal apertures ventro-lateral, at level of posterior pole of ovary. Genito-intestinal canal opening into intestine on ovarial side. Eggs oval, 0.228 to 0.272 mm. in length by 0.153 to 0.170 mm. in width. The description is based on Price (1939).

Hosts: Pseudemys scripta, P. alabamensis, P. troosti, P. elegans, Chrysemys belli marginata, C. picta, Trionyx ferox, Malaclemys centrata concentrica, Chelydra serpentina (new host), and "terrapin".

Habitat: Urinary bladder.

Distribution: United States (North Carolina, Illinois, Iowa, New York, Minnesota, Florida, Oklahoma, and Texas.)

Discussion: This species was originally described as Polystoma orbiculare by Stunkard in 1916 from the urinary bladder of Pseudemys scripta and Chrysemys marginata. In 1917 he gave a detailed account of the morphology

of the genus Polystoma and a description of North American species known at the time. He supplemented his previous description of P. orbiculare and included a key to the species of the genus Polystoma. Ward in 1918 created the sub-genus Polystomoides, in which he included Polystoma orbiculare. Stunkard (1924) in describing a new species, Polystoma floridanum, noted distinct similarities between it and P. orbiculare but considered them distinct. He further suggested that Polystoma troosti, P. inerme, P. elegans, and P. spinulosum, described by MacCallum in 1918, were possibly synonyms of P. orbiculare. Harwood (1932) recognized the sub-genus Polystomoides Ward, 1918 in reporting Polystoma (Polystomoides) orbiculare from specimens of Pseudemys elegans taken in Texas. Ozaki (1935) gave the sub-genus Polystomoides generic rank and listed Polystoma orbiculare Stunkard, 1916 as Polystomoides orbiculare (Stunkard, 1916). In a revision of the family Polystomatidae in 1939, Price created the genus Neopolystoma and established N. orbiculare (Stunkard, 1916) as the type species. He classed as synonyms of N. orbiculare the species listed at the beginning of this section. Hughes et al (1942) and Dawes (1946) accepted the validity of the genus Neopolystoma and its designated species as proposed by Price.

The writer accepts Neopolystoma and the redescription of N. orbiculare (Stunkard, 1916) as given by Price. He has adequately redefined under one species, certain diagnostic characters which had been used previously to separate several species.

The one specimen of N. orbiculare collected in this survey agrees very closely with the description as given by Price. The one exception in which this specimen differs from his description is in the number of hooks

in the genital coronet. There are seventeen hooks surrounding the genital aperture of this specimen while sixteen were listed in Price's description. While no variations in this character have been reported for this species, other Polystomes are known to exhibit such variations. In 1924 Stunkard, after a study of MacCallum's specimens of Polystoma species, reported that "frequently slight variations have been observed in the number of genital hooks." Since the specimen agrees closely with the description in other respects, it is the writer's opinion that this variation is not sufficient to exclude the fluke from the species Neopolystoma orbiculare.

This report, apparently, constitutes a new host record for this species. A study of the literature reveals no instance in which this species has been reported from the snapping turtle.

Another specimen was found which very closely resembles the description of N. orbiculare. It possesses the usual number of sixteen hooks in the genital coronet, but differs from N. orbiculare in having much more dense-appearing vitellaria, arranged in clumps of follicles which completely fill the inter-cecal region. Since the specimen is broken and can not be studied thoroughly, it is considered as a "species inquirendo."

Nematode species:

Camallanus microcephalus (Dujardin, 1845) Railliet and Henry, 1915: Camallanidae Railliet and Henry, 1915.

Synonyms: Camallanus cyathocephalus MacCallum, 1918; C. scabrae MacCallum, 1918; C. troosti MacCallum, 1918; C. chelydrae MacCallum, 1918; C. floridianae MacCallum, 1918; C. elegans

MacCallum, 1918; C. testudinis MacCallum, 1918; C. seurati Magath, 1919; C. americanus Magath, 1919; C. trispinosus (Leidy, 1851).

Synonyms according to Chitwood (1932).

Description: Body slightly reddish-brown in color, slender, cylindrical, and finely striated. Mouth consisting of large corneous capsule, reddish in color, in form of two valves, united at posterior ends. Both valves having five to eight radiating lines or ridges on each side of unstriated median band. Two sets of three posteriorly directed spikes lying dorsally and ventrally at posterior end of buccal capsule. Single pair of minute cervical papillae situated dorso-laterally at level of thickest region of posterior end of second esophagus. Nerve ring and excretory pore, 0.20 and 0.35 mm. respectively, from anterior end. Esophagus of two portions; anterior one, cone-shaped or elongated pyriform, expanding gradually posteriorly and posterior one, cylindrical and slightly dilated at terminal end. Three esophageal valves present at junction of esophagus and intestine.

Male: Body 4.9 to 11.3 mm. in length and 0.15 to 0.27 mm. in width. Caudal alae arising anteriorly as a ventral cuticular swelling, extending to tip of tail, 0.439 to 0.793 mm. in length and 0.031 mm. in width, containing seven pairs of supporting rays. Tail curved ventrally, 0.084 mm. in length from anus. Anal and genital apertures indicated by a prominent lip and separated by a small conical papilla. Spicules unequal. Right one, having an acute angular anterior end, is slightly curved, acuminate, 0.840 to 0.920 mm. in length, and 0.075 mm. from distal end a small process 0.005 mm. in length, projects dorsad and curves slightly anteriad. Left spicule is slender, acuminate, slightly curved, with no embellishments, 0.310 mm. in length.

Female: Body 7.4 to 19.4 mm. in length and 0.16 to 0.46 mm. in width. Tail straight, drawn out into long conical point with three minute terminal papillae, 0.14 to 0.31 mm. in length. Anterior ovary pyriform in shape, measuring 1.9 to 3.5 mm. in length; posterior ovary absent. Uterus consists of large sac, which may contain developing eggs and embryos. Vulva slightly posterior to middle of body, provided with a prominent anterior lip, 0.3 mm. in length and jutting out 0.12 mm. ventrally from body. Vagina extending slightly dorsal and turning posteriorly to join uterus. Larvae in uterus, 0.20 to 0.36 mm. in length.

The description is based on Leidy (1851) and Magath (1919).

Hosts: Chelydra serpentina, Chrysemys marginata, C. picta, Pseudemys scripta, P. troosti, P. elegans, Sternotherus odoratus.

Habitat: Stomach and small intestine.

Distribution: North America.

Discussion: Camallanus microcephalus was described originally by Dujardin in 1845 under the genus Cucullanus Müller, 1777. Unfortunately, Dujardin's description was very meager and caused many subsequent workers to question the validity of the species. Leidy in 1851 described and named a nematode, Cucullanus trispinosus, from the stomach of the snapping turtle, Chelydra serpentina. Seurat (1915) discussed a species in his collection under the name of Cucullanus microcephalus Dujardin. Railliet and Henry (1915) created the genus Camallanus and included in it Camallanus microcephalus (Dujardin) and Camallanus trispinosus (Leidy). Subsequent workers accepted this classification. Ward (1918) recognized Camallanus trispinosus (Leidy) but failed

to list C. microcephalus (Dujardin). Magath (1919) after comparing both Dujardin's and Seurat's specimens of C. microcephalus, considered Seurat's material a new species, Camallanus seurati, and considered C. microcephalus of Dujardin valid. In the same publication, Magath described a new species, Camallanus americanus, from Chelydra serpentina. In addition, he considered Camallanus trispinosus as a "species inquirendo" because of the meager description which Leidy gave. Yorke and Maplestone (1926) recognized both Camallanus microcephalus (Duj.) and C. trispinosus (Leidy) as valid species. Walton (1927) after a revision of the nematodes in the Leidy collection, regarded C. americanus Magath as a synonym of C. trispinosus. A Swedish worker, Tornquist (1931) recognized the species, Camallanus scabrae MacCallum, 1918, as valid and reduced to synonymy all other North American species parasitic in turtles. Harwood (1932) reported Camallanus trispinosus from snapping turtles in Texas. He agreed with Walton and regarded C. americanus as a synonym of this species. According to Chitwood (1932), all North American turtle species of the genus Camallanus should be considered as synonyms of C. microcephalus (Dujardin, 1845). Caballero (1943) agreed with Tornquist as to his designation of Camallanus scabrae. Rausch (1947) recognized Camallanus microcephalus as valid for all species, as recommended by Chitwood.

It is apparent that confusion has existed as to the proper designation for the species of this genus which parasitize North American turtles. The writer accepts the proposal by Chitwood in considering C. microcephalus (Dujardin, 1845) as the only valid species for the parasites described in this genus from North American turtles. Chitwood is recognized as being the outstanding nematologist of the present time, and in the writer's opinion is

well qualified to make such a recommendation. His work, apparently, included a comparison of the original worm described by Dujardin in 1845 with representatives of existing species.

Representative specimens of C. microcephalus in the writer's collection were compared with the original description of C. trispinosus by Leidy and with the description of C. americanus by Magath. Measurements of my specimens fall within range of those listed by these workers, and other diagnostic characters agree closely. Some difficulty was experienced in locating the structural parts of the spicules in fixed specimens. These structures would probably be seen more clearly in living specimens.

Spiroxys contortus (Rudolphi, 1819) Schneider, 1866:
Spiruridae Oerley, 1885.

Synonyms: Spiroptera contorta Rudolphi, 1819;
Spiroxys contorta (Rud., 1819) Schneider, 1866.

Description: Body long, slender, semi-transparent, transversely striated, 2 to 4 cm. in length. Oral opening surrounded by two tri-lobed lips, each bearing two submedian and one lateral papillae. Vestibule having distinct cuticular prominences and indentations. A definite cuticular collar bounding posterior margin of head. Tri-lobed cuticular support for each of two lips arising from each arch of collar. Two prominent cervical spines and one small inconspicuous lateral spine on each side of collar. Small single, dorsal and ventral, cervical papilla, 0.8 to 0.9 mm. from anterior end of worm. Nerve ring and excretory pore, 0.47 to 0.67 mm. and 0.525 to 0.75 mm. respectively, from anterior end. Esophagus consisting of anterior muscular and posterior glandular parts. Posterior end of muscular part of esophagus

and posterior end of esophagus, 0.375 to 0.435 mm. and 1.5 to 5.7 mm. respectively, from anterior end. Three small valves guarding entrance of esophagus into tessellated intestine, which is distinctly brown in some specimens. Rectum of female and cloaca of male, each having two large ventral and one large dorsal unicellular glands. Tail in both sexes rather short, ending in abrupt, sharp, conical tip.

Male: Alae well-developed, meeting ventrally anterior to anus and forming vesicular swelling. Four pre-anal and seven post-anal papillae present. Single median genital papilla, 0.108 to 0.196 mm. anterior to anus. Spicules long, 1.85 to 3.5 mm. in length, slender, cylindrical, without keel, transversely striated, and ending in sharp points. Colorless gubernaculum measuring laterally, 0.140 to 0.164 mm. in length and 0.049 to 0.063 mm. in width. Testis long, tortuous, joining seminal vesicle 10 to 15.2 mm. anterior to anus. Seminal vesicle, a straight, thin-walled sac, 4.6 to 6.2 mm. in length, emptying into thick-walled ejaculatory apparatus, 2.3 to 3.4 mm. in length. Slender ejaculatory tube 3.4 to 5.4 mm. in length emptying into cloaca.

Female: Uterus, divided into four pouches and two intra-uterine tubes, measuring as follows: First pouch anterior, 1.36 to 1.51 mm. in length, 0.20 to 0.21 mm. in width; intra-uterine tube, anterior, 0.75 mm. in length, 0.075 mm. in width; second pouch anterior, 5.2 to 6.1 mm. in length, 0.272 mm. in width; first pouch posterior, 1.29 to 1.51 mm. in length, 0.15 mm. in width; intra-uterine tube posterior, 0.76 mm. in length; second pouch posterior, 5.53 to 6.3 mm. in length, 0.30 mm. in width. Two cuticular prominences guarding opening of vulva, just posterior to mid-body region. Vagina, directed anteriorly, thick-walled, muscular, annulated, 0.72 to 1.66 mm. in length. Caudal papillae

consisting of two dorso-lateral ones on caudal part of tail, about mid-way between anus and caudal tip. Distance from caudal papillae to posterior tip of tail, 0.225 to 0.27 mm. Eggs, 0.055 to 0.073 mm. in length and 0.039 to 0.05 mm. in width.

The description is based on Hedrick (1935).

Hosts: Chrysemys belli marginata, Terrapene ornata, Chelydra serpentina, Emys blandingi, E. orbicularis, Graptemys geographica, Sternotherus odoratus, Kinosternum subrubrum, Pseudemys texana, P. elegans, P. hieroglyphica.

Habitat: Stomach.

Distribution: Europe and North America (United States---Ohio, Texas, Oklahoma, Michigan, Louisiana, Wisconsin, Washington).

Discussion: Rudolphi in 1819 was the first to describe a nematode, Spiroptera contorta, belonging to the present genus Spiroxys, from the stomach of Emys orbicularis. Schneider in 1866 established the genus Spiroxys for the one species, contorta Rudolphi, which he separated from the genus Spiroptera Rudolphi. Subsequent workers accepted this classification. Seurat (1918) described a nematode from the stomach of an Algerian turtle and identified it as Spiroxys contortus (Rudolphi), using a masculine ending for the trivial name. Baylis and Lane (1920) described a nematode from the stomach of Emys orbicularis under the name Spiroxys contorta Rudolphi. These workers pointed out that their material differed in several important particulars from Seurat's description. Yorke and Maplestone (1926) and Harwood (1931) recognized Spiroxys contorta as the valid name for the species and listed Spiroptera contorta Rudolphi, 1819 as a synonym. Hedrick (1935a) agreed with Baylis

and Lane that Seurat's material was different from the nematode they described as Spiroxys contorta Rud. He proposed a new name, Spiroxys algericus, for Seurat's specimens, with a notation that if further study of these specimens should prove that they are really S. contortus, then S. algericus could be reduced to synonomy. Hedrick preferred to use the masculine ending for the trivial name as originally initiated by Seurat. Caballero (1939) recognized as valid the name Spiroxys contortus, in reporting a new host and a new locality for this species. Rausch (1947) also recognized as valid the name, Spiroxys contortus (Rudolphi) Schneider, in reporting this species from a snapping turtle in Ohio.

The writer recognizes as valid the name, S. contortus (Rudolphi, 1819) Schneider, 1866, using the masculine ending as recommended originally by Seurat and later by Hedrick. This writer also accepts the redescription of the species given by Hedrick (1935b). There had been some confusion about the diagnostic characters of S. contortus, which Hedrick cleared up with a detailed morphological and life history study of this species. His work is very complete, and adequately describes and differentiates the species.

The specimens of Spiroxys contortus in the writer's collection agree closely with the description given by Hedrick. Some of the more detailed portions of his description, however, can not be followed through completely in my preserved specimens.

Spironoura chelydrae (Harwood, 1932) Mackin, 1936:
Kathlaniidae (Travassos, 1918) Yorke and Maplestone, 1926.

Synonym: Falcaustra chelydrae Harwood, 1932.

Description: Slender white nematode with finely striated cuticula. Mouth surrounded by three large lips, each bearing two forked papillae. Esophagus consisting of three parts; pharynx, cylindrical midportion, and terminal hourglass-shaped bulb. Female distinctly narrower posterior to vulva. Tail in both sexes sharply pointed, nearly straight in female, usually curved ventrally in male.

Male: Body 6.65 to 16.3 mm. in length and 0.32 to 0.66 mm. in width. Pharynx 0.07 to 0.10 mm. in length and 0.06 to 0.10 mm. in width. Esophagus consisting of anterior cylindrical portion, 1.60 to 1.79 mm. in length and 0.08 to 0.13 mm. in width, and posterior hourglass-shaped bulb, 0.27 to 0.51 mm. in length and 0.24 to 0.44 mm. in width. Nerve ring and excretory pore about 0.37 and 1.34 mm. respectively, from anterior end. Tail 0.40 to 1.00 mm. in length. Spicules equal, plainly striated, 3.2 mm. to 4.0 mm. in length; their anterior ends, in retracted state, lying in region of pseudosucker. Gubernaculum, 0.14 to 0.20 mm. in length, oblong flat plate, flaring somewhat at anterior end. Ten pairs of caudal papillae arranged as follows: Two ventral pairs immediately beyond middle of tail, a subdorsal pair at same level; three ventral pairs close together just caudad to cloacal opening, and a subdorsal pair at same level; three preanal pairs not evenly placed, anterior two pairs in the rows of three, farther apart than posterior two pairs. Precloacal oblique muscles beginning immediately anterior to anus and extending forward about one-fourth of body length. Pseudosucker immediately anterior to oblique muscle system, containing fewer muscles.

Female: Body 9.5 to 22.55 mm. in length and 0.47 to 0.89 mm. in width. Pharynx, 0.08 to 0.10 mm. in length and 0.08 to 0.12 mm. in width. Anterior cylindrical portion of esophagus, 1.24 to 1.84 mm. in length and 0.10 to 0.15

mm. in width; posterior hourglass-shaped bulb, 0.35 to 0.59 mm. in length and 0.28 to 0.47 mm. in width. Nerve ring and excretory pore, 0.40 and 1.60 mm. respectively, from anterior end. Tail, 0.66 to 1.64 mm. in length. Vulva, 6.23 to 13.68 mm. from anterior end, close to cephalic end of caudal third of body. Vagina very long, 2.44 to 4.8 mm., somewhat less than one-third total body length. Length of each ovary and uterus roughly twice entire body length; extremity of anterior ovary a short distance posterior to posterior bulb of esophagus, 0.059 to 0.072 mm. in width.

The description is based on Harwood (1932) and Mackin (1936).

Hosts: Chelydra serpentina and Trionyx ferox.

Habitat: Rectum.

Distribution: United States (New York, Texas, Oklahoma).

Discussion: Before beginning a discussion of the species, it seems advisable to briefly review the genus Spironoura Leidy, 1856 and its relation to the genus Falcaustra Lane, 1915.

The genus Spironoura as erected by Leidy contained two species, S. gracile as type and S. affine. Lane created the genus Falcaustra in 1915 and designated F. falcata as the type species. Of Leidy's species, only Spironoura affine has subsequently been found and redescribed. Boulenger in 1923 redescribed it under the name Falcaustra chapini. Yorke and Maplestone (1926) and Chapin (1926) recommended that Falcaustra Lane be considered a synonym of Spironoura Leidy. Walton (1927) however, after a study of the nematodes in Leidy's collection, regarded Falcaustra and Spironoura as being distinct. On the basis of Walton's work, Harwood (1932) recognized

Falcaustra as valid. Mackin (1936) considered Spironoura to be the valid genus and Falcaustra as a synonym. The writer concurs in this, since Mackin gave ample evidence to support the fact that this genus is quite variable and includes the characters which were used to establish the genus Falcaustra.

Spironoura chelydrae was described originally under the genus Falcaustra by Harwood in 1932 from the rectum of Chelydra serpentina. His description was rather brief and his single drawing decidedly sketchy. Mackin (1936) gave a detailed redescription of Spironoura chelydrae and chose it for an extended morphological study. It was his opinion that the species was a representative of one of those groups which has become parasitic only recently, relatively speaking, as evidenced by the position within the host. The medium within which these nematodes live in the rectum is not much different from the habitat of some free-living species which live in fresh or decaying dung. Species of Spironoura live for the most part in the feces of the host and feed upon this material. It is the opinion of the writer that this was an interesting observation by Mackin and one which is worthy of further consideration, from the standpoint of habitat, by future workers.

The specimens of Spironoura chelydrae in the writer's collection agree with the descriptions as given by both Harwood and by Mackin.

Spironoura wardi Mackin, 1936:

Kathlaniidae (Travassos, 1918) Yorke and Maplestone, 1926.

Description: Slender white nematode with finely striated cuticula. Mouth surrounded by three large lips, each bearing two forked papillae. Angle nodes

of lip support ring having horn-like points directed obliquely outward. Esophagus consisting of three parts; pharynx, cylindrical midportion, and terminal hourglass-shaped bulb. Female distinctly narrower posterior to vulva. Tail in both sexes sharply pointed, nearly straight in female, usually curved ventrally in male.

Male: Body 6.61 to 8.41 mm. in length and 0.25 to 0.33 mm. in width. Pharynx, 0.06 mm. in length and 0.05 mm. in width. Esophagus consisting of anterior cylindrical portion, 0.93 to 1.32 mm. in length by 0.07 to 0.08 mm. in width, and posterior hourglass-shaped bulb with portions almost spherical, total length equaling total width of 0.25 mm. Nerve ring and excretory pore, 0.29 and 0.97 mm. respectively, from anterior end. Tail, 0.28 to 0.41 mm. in length. Spicules equal, short, 0.33 to 0.37 mm. in length. Gubernaculum, 0.08 mm. in length. Eleven pairs of caudal papillae arranged as follows: Two pairs of postanal subventrals close together about two-thirds of length of tail from anus, lateral pair at level between these two, another lateral pair just posterior to level of anus; third pair of subventral postanals about one-third of tail length posterior to anus; two pairs of circumanals close together at level of anus, third pair slightly posterior to anus; first pair preanals at anterior end of cloaca, second pair slightly anterior to level of anterior end of spicules, and third pair slightly more anterior to second pair than second pair is anterior to first pair. Pseudo-sucker containing more muscles, 40 to 48 pairs, than precloacal oblique system, 35 to 40 pairs.

Female: Body 7.98 to 13.72 mm. in length and 0.29 to 0.47 mm. in width, greatest width usually immediately anterior to vulva. Pharynx, 0.06 mm. in length and 0.07 mm. in width. Anterior cylindrical portion of esophagus,

1.18 to 1.47 mm. in length and 0.08 to 0.10 mm. in width; posterior hourglass-shaped bulb with total length equaling total width of 0.30 mm. Nerve ring and excretory pore, 0.32 and 1.19 mm. respectively, from anterior end. Tail, 0.53 to 0.79 mm. in length. Vulva, 5.13 to 8.12 mm. from anterior end of worm. Vagina extraordinarily long as compared with spicule length in male. Anterior tip of ovary far back of posterior bulb of esophagus, tip of posterior ovary rarely reaching rectum. Eggs 0.079 to 0.099 mm. in length and 0.059 mm. in width.

The description is based on Mackin (1936).

Host: Chelydra serpentina.

Habitat: Rectum.

Distribution: United States (Oklahoma).

Discussion: The species Spironoura wardi was described by Mackin in 1936 from the rectum of Chelydra serpentina taken in Southeastern Oklahoma. S. wardi corresponds closely to the other species in the genus but is very distinctive in several ways. According to Mackin, this is the only North American species in which the pseudosucker contains more muscles than the precloacal oblique system. These muscle areas are very outstanding in appearance even in some uncleared specimens. S. wardi in comparison with S. chelydrae, has much shorter spicules and has the caudal papillae differing in number and in arrangement.

The writer was not able to find any reference to Spironoura wardi, since its description by Mackin, and this species, apparently, has not been reported from any locality other than Oklahoma.

The specimens of S. wardi obtained in this survey agree very closely with the description given by Mackin. My specimens show slight variations in a few measurements, but since other species in genus are quite variable, and since the specific diagnostic characters agree with those listed by Mackin, the writer regards these specimens as identical with Spironoura wardi Mackin, 1936.

Capillaria serpentina Harwood, 1932:
Trichinellidae Stiles and Crane, 1910.

Description: Slender, white, hair-like nematode with an unstriated cuticula. Body narrowest at anterior end, tapering gradually until reaching maximum width about mid-body region, and continuing posteriorly in a near uniform diameter. Mouth simple, opening directly into long esophagus, which extends to near mid-body region, accompanied by row of encircling cells, except for the anterior one-eighth of its length. Intestine, widest at junction with esophagus, tapering rather suddenly at beginning of rectum. Anus terminal, opening between two liplike cuticular protuberances.

Male: Body smaller than female, 4.67 mm. (4.43 to 4.87) in length and 0.064 mm. (0.057 to 0.071) in width. Esophagus 2.74 mm. (2.71 to 2.77) in length, accompanied by row of circular cells except for anterior one-eighth of its length. Spicule sheath, 0.066 mm. (0.055 to 0.078) in total length and 0.018 mm. (0.017 to 0.019) in width, bulbous and finely spined. Spines covering spicule sheath arranged in seven to ten irregular rows and each spine, 0.003 mm. in length. Sheath usually extruded, distance variable, 0.042 mm. (0.026 to 0.055) from posterior end of worm. When spicule is extruded, the sheath turns back upon itself, revealing rows of spines. Spicule, 0.178 mm. (0.162 to 0.195) in length and 0.007 mm. (0.006 to 0.008)

in width, slender and bluntly pointed at tip.

Female: Body 12 to 14 mm. in length and 0.08 to 0.103 mm. in width. Esophagus 5 to 6 mm. in length; anterior one-eighth of length not encircled by cells. Vulva, a short distance posterior to termination of esophagus. Eggs lemon-shaped, with opercular plug at each pole. Shell consisting of two parts, the outer, membranous and somewhat wrinkled, and inner, much heavier and slightly constricted at the middle. Eggs, 0.067 to 0.072 mm. in length by 0.025 to 0.034 mm. in width.

The description of the female is based on Harwood (1932), and that of the male is new.

Host: Chelydra serpentina.

Habitat: Large intestine and rectum.

Distribution: Texas and Oklahoma (new locality).

Discussion: Capillaria serpentina was described originally by Harwood in 1932 from the rectum of the snapping turtle, Chelydra serpentina, from Texas. His description was based on a study of two females. He found no males of the species.

The writer found forty-five females and four males in this survey. The males are described in this paper for the first time and supplementary notes are added to the description of the female as given by Harwood. The females in my collection agree closely with Harwood's description, except that the range in body length is 8 to 14 mm. instead of 12 to 14 mm. as stated by Harwood.

The description of the male is based on a study of three specimens mounted in lacto-phenol. Since the internal anatomy of these worms is exceedingly difficult to study in preserved specimens, the description included only the more obvious anatomical characters. A full length drawing of a male is shown in the photograph in figure 2. The posterior extremity of the same male under greater magnification is shown in figure 3.

Dracunculus globocephalus Mackin, 1927:

Dracunculidae Leiper, 1912.

Description: Body long, threadlike, with uniform diameter throughout length. Slight constriction near head giving appearance of a neck. Anterior end rounded, without lips, but with eight symmetrically arranged cephalic papillae; a dorso-ventral pair, a lateral pair, and four submedians. Pair of cervical papillae situated laterally about 0.9 mm. front anterior end. Excretory pore, 1 to 1.5 mm. from anterior extremity, varying with size of nematode. Large excretory gland in anterior region of body, attached to left lateral line. Buccal cavity and pharynx absent. Triangular-shaped mouth opening directly into esophagus, which consists of anterior muscular and posterior glandular portions. Large sac-like glands attached to outside of muscular esophagus on one side. Larger gland opposite these glands extends from without 0.5 mm. of anterior extremity posteriorly for one-third of body length, ending at junction of esophagus and intestine. Simple intestine, apparently ending blindly in mature females.

Male: Body 16 to 20 mm. in length by 0.170 to 0.220 mm. in width. Caudal papillae consisting of a single minute preanal and one pair of dome-shaped postanals, situated ventro-laterally and not exactly at same level.

EXPLANATION OF PLATE

Fig. 2. Male, camera lucida drawing, in lacto-phenol, showing the most important anatomical features.

Fig. 3. Posterior end of male, camera lucida drawing, magnified to show details of spicule and spicule sheath, both partly extruded.

PLATE

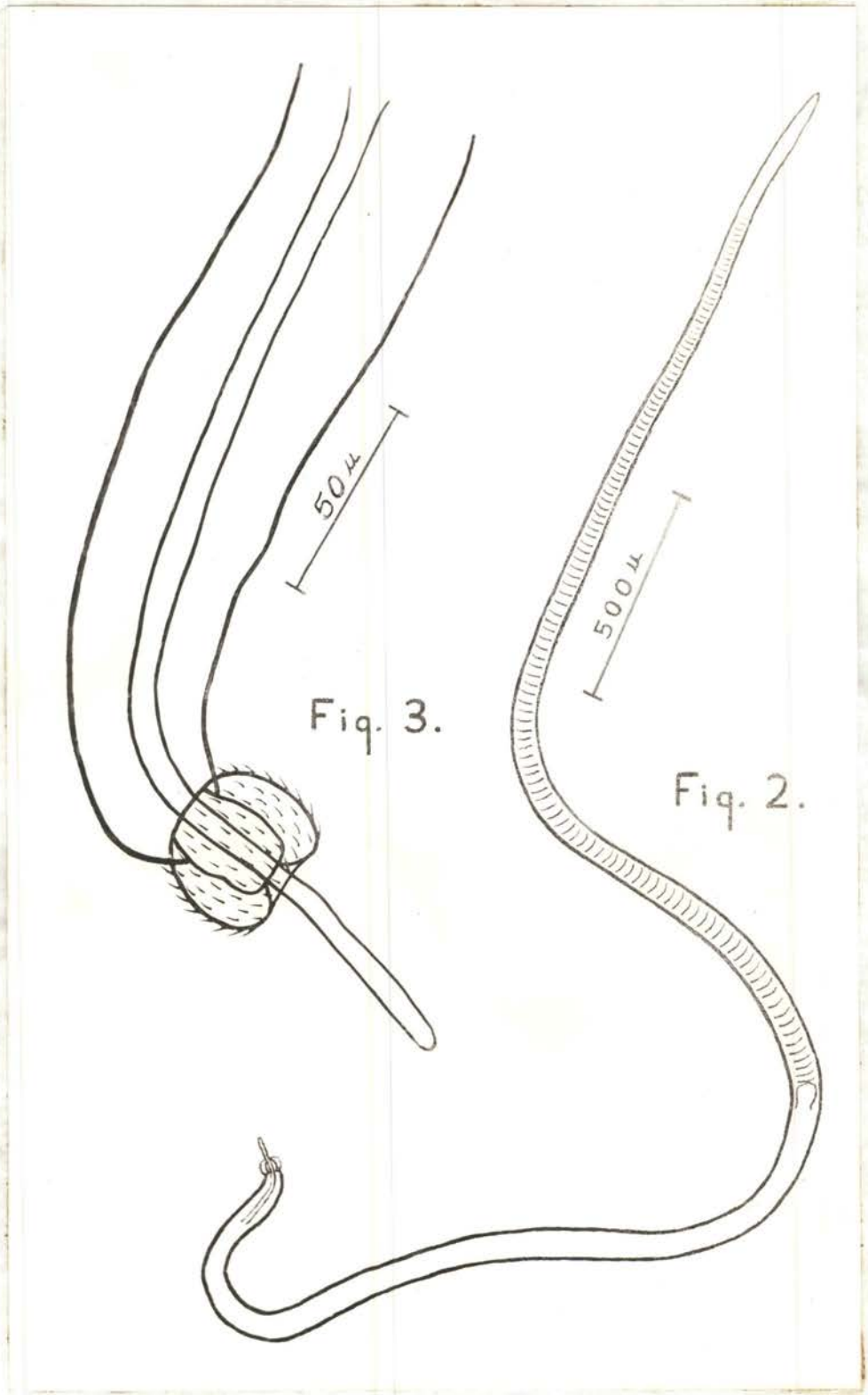

Fig. 3.

Fig. 2.

CAPILLARIA SERPENTINA

Tail coiled in spiral, one to four loops in fixed specimens. Spicules unequal; right one longer, having form of long, narrow needle without wings, 0.8 mm. in length and 0.005 mm. in width; left one, flaring at end, distal two-thirds in form of two tubes joined laterally, 0.2 mm. in length and 0.010 mm. in width. Spicules merging distally into fine point. Genital system of single straight tube, beginning with testis one-fourth of body length from anterior end extending posteriad to cloaca.

Female: Body 30 to 133 mm. in length and 0.28 to 0.68 mm. in width. Anterior ovary, wound around glandular portion of esophagus, extending to within 2 mm. of anterior end of body; posterior ovary, wound around posterior end of intestine, reaching to anal region. Uteri fill body cavity completely, forming one long continuous tube, each joining an ovary. Vulva short distance posterior to midportion of body, communicating with bulbous structure connected with vaginal lumen. Vagina extending dorsally to region of left lateral line, turning anteriorly to join uteri. Gravid female filled with larvae.

The description is based on Mackin (1927).

Host: Chelydra serpentina.

Habitat: Pelvic fasciae and peritoneal cavity.

Distribution: United States (Illinois, Oklahoma).

Discussion: Dracunculus globocephalus was described originally by Mackin in 1927 from snapping turtles which he had taken at Ada, Oklahoma and in Illinois. In this work Mackin gave the first description of any male Dracunculus. Only two males had been found previously, and these were recovered by Leiper

in 1907 from a monkey which had been experimentally infected. He gave no description, but recorded their length as 22 mm. Mackin compared D. globocephalus with the long known, Dracunculus medinensis (Linnaeus, 1758) and stated that, with the exception of a few minor details of anatomy, size, and primary host, these species were almost identical. Hsü (1933) recognized Dracunculus globocephalus Mackin as valid, and compared it with a new species which he described as Dracunculus houdemeri. Moorthy (1937) gave a redescription of the female and a description of the male of D. medinensis. He stated that D. globocephalus differed from D. medinensis in having markedly unequal spicules. Moorthy further stated that D. houdemeri Hsü appeared to be a dubious species. Brackett (1938) redefined the genus Dracunculus and described a new species D. ophidensis from the garter snake. He separated this species from D. globocephalus Mackin mainly on the basis of spicule differences.

The specimens of Dracunculus globocephalus in the writer's collection agree very closely with the description given by Mackin. The spicules of my specimens are distinctly unequal, which is a diagnostic character used in separating this species from others in the genus.

As far as the writer has been able to determine, the snapping turtle, Chelydra serpentina, is the only definitive host for D. globocephalus, and Illinois and Oklahoma are the only localities from which it has been reported. This parasite is, apparently, host specific and does not occur in any other aquatic turtles.

Acanthocephalan species:

Neoechinorhynchus emydis (Leidy, 1851) Hamann, in Stiles and Hassall, 1905: Neoechinorhynchidae Hamann, 1892.

Synonyms: Echinorhynchus emydis Leidy, 1851; E. hamulatus Leidy, 1856; Neorhynchus emydis (Leidy, 1851) Van Cleave, 1913; Eorhynchus emydis (Leidy, 1851) Van Cleave, 1914.

Synonyms according to Van Cleave (1924).

Description: Body slender and nearly cylindrical. Females 10 to 32 mm. in length and 0.7 mm. in width. Males 8 to 11 mm. in length and 0.7 mm. in width. Proboscis globular, breadth usually equaling length, which averages 0.18 mm.; bearing three circles of six hooks each. Terminal hooks, 0.095 to 0.103 mm. in length, points usually reaching beyond bases of hooks of middle circle. Hooks of middle circle, 0.049 to 0.059 mm. and those of basal circle, 0.035 to 0.054 mm. in length. Eggs within body cavity of gravid female, oval and 0.016 mm. by 0.011 mm. Adults parasitic in alimentary canal of turtles.

The description is based on Van Cleave (1924).

Hosts: Graptemys geographica, G. pseudogeographica, Clemmys insculpta, C. guttata, "Emys serrata", Pseudemys elegans, P. troosti, P. scripta, P. concinna, Chrysemys emydis, Chelydra serpentina.

Habitat: Intestine.

Distribution: North America.

Discussion: Under the name, Echinorhynchus emydis, Leidy in 1851 described an acanthocephalan from the intestine of Emys geographica. This was the first valid record of the occurrence of an acanthocephalan from a turtle. Five years later, in 1856, without offering any explanation for so doing, Leidy renamed the species as Echinorhynchus hamulatus. Van Cleave (1913) called attention to this obvious renaming when he assigned the species to the genus Neorhynchus, and emphasized the necessity of accepting the prior name emydis as the valid name of the species. Van Cleave (1924) transferred the species to the genus Neoechinorhynchus, where it has the unique distinction of being the only representative of the genus in hosts other than fishes.

As far as the writer has been able to determine, Neoechinorhynchus emydis is the only species of an acanthocephalan to be reported from turtles of North America. Many species of turtles, representing a very broad geographical range, have been reported to harbor this parasite. The writer could not discover any previous instance where this parasite was reported specifically from Chelydra serpentina. Van Cleave (1947) gave an alphabetical index of the generic names of hosts of acanthocephala of the world included in Anton Meyer's Monograph (1932-1933). This index did not include Chelydra serpentina as a host. This report therefore, appears to be a new host record for Neoechinorhynchus emydis.

Leidy's original description of N. emydis was very meager and did not include the specific diagnostic characters by which species of acanthocephala have come to be recognized. Consequently, Van Cleave's description (1924) was intended to supplement Leidy's work. Van Cleave's work is noticeably lacking, however, in detail and completeness with regard to internal anatomy.

The specimens of N. emydis in the writer's collection are immature and do not fall within range of the body measurements given by Van Cleave. Nevertheless, they are included in this species because of their agreement with Van Cleave's description of proboscis size and comparative length of hooks, which seem to be constant characters whether the specimens are mature or immature. Of additional value in identifying my specimens is the arrangement of the seven nuclei, which agrees with Van Cleave's drawing of an immature specimen, and the fact that N. emydis is the only acanthocephalan that has been reported from turtles.

It should be pointed out that the proboscis hooks of my specimens appear to be arranged alternately in irregular rows instead of the arrangement in three "circles" as described by Van Cleave, but this is not of sufficient value to regard the specimens as other than N. emydis.

Other helminths reported in the literature from Chelydra serpentina:

In addition to discussing the helminths found in this survey, it was thought desirable to record all other valid species which have been recorded in the literature from Chelydra serpentina. Besides the helminths reported by the writer, there are ten trematodes species and three immature nematode species that parasitize snapping turtles. These species with their synonyms, hosts, and geographical distribution are listed as follows:

Trematodes:

1. Spirorchis magnitestis Byrd, 1939:

   Spirorchiidae MacCallum, 1921.

   Host: Chelydra serpentina.

   Distribution: United States (Tennessee).

2. Spirorchis minutum Byrd, 1939:

   Spirorchiidae MacCallum, 1921.

   Host: Chelydra serpentina.

   Distribution: United States (Tennessee).

3. Hapalorhynchus gracilis Stunkard, 1922:

   Spirorchiidae MacCallum, 1921.

   Host: Chelydra serpentina.

   Distribution: North America.

4. Telorchis singularis (Bennett, 1935) Wharton, 1940:

   Reniferidae Baer, 1924.

   Hosts: Chelydra serpentina, Pseudemys elegans, P. scripta, P. troosti.

   Distribution: North America.

5. Telorchis attenuatus Goldberger, 1911:

   Reniferidae Baer, 1924.

   Hosts: Chelydra serpentina, Chrysemys marginata,
   C. picta.

6. Eustomos chelydrae MacCallum, 1921:

   Plagiorchiidae Ward, 1917.

   Hosts: Chelydra serpentina, Chrysemys picta.

   Distribution: United States.

7. Dictyangium chelydrae Stunkard, 1943:

   Microscaphidiidae Travassos, 1922.

   Hosts: Chelydra serpentina, Chrysemys ornata, Graptemys geographica.

   Distribution: United States (Louisiana), Mexico.

8. Cotylaspis stunkardi Rumbold, 1928:

   Aspidogastridae Poche, 1907.

   Host: Chelydra serpentina.

   Distribution: United States (North Carolina).

9. Microphallus opacus (Ward, 1894) Rausch, 1947:

   Microphallidae Viana, 1924.

   Synonym: Microphallus ovatus Osborn, 1919.

   Hosts: Chelydra serpentina, Chrysemys belli marginata, Graptemys geographica.

   Distribution: United States.

10. Herpetodiplostomum delillei Zerecero y D., M. C., 1947:

    Diplostomatidae Poirier, 1886.

    Host: Chelydra serpentina.

    Distribution: Mexico.

Nematodes:

1. Eustrongylides sp. (immature forms, reported by Rausch, 1947):

   Dioctophymidae Railliet, 1915.

   Host: Chelydra serpentina.

   Distribution: United States (Ohio).

2. Aplectana sp. (immature forms, reported by Rausch, 1947):

   Oxyuridae Cobbold, 1864.

   Host: Chelydra serpentina.

   Distribution: United States (Ohio).

3. Foleyella sp. (immature forms, reported by Rausch, 1947):

Filariidae (Cobbold, 1864) Claus, 1885.

Host: Chelydra serpentina.

Distribution: United States (Ohio).

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary:

1. Thirty specimens of the snapping turtle, Chelydra serpentina, from the vicinities of Stillwater and Braggs, Oklahoma were examined for helminths.
2. No species new to science were discovered, but all species found are described and discussed.
3. The following species of helminths are reported from Chelydra serpentina in this survey: Trematodes, Spirorchis haematobium (Stunkard, 1922); Heronimus chelydrae MacCallum, 1902; Auridistomum chelydrae (Stafford, 1900); Allassostoma parvum Stunkard, 1916; Telorchis corti Stunkard, 1915; Polystomoidella oblongum (Wright, 1879); Polystomoides coronatum (Leidy, 1888); Neopolystoma orbiculare (Stunkard, 1916): Nematodes, Camallanus microcephalus (Dujardin, 1845); Spiroxys contortus (Rudolphi, 1819); Dracunculus globocephalus Mackin, 1927; Spironoura chelydrae (Harwood, 1932); Spironoura wardi Mackin, 1936; Capillaria serpentina Harwood, 1932: Acanthocephalan, Neoechinorhynchus emydis (Leidy, 1851).
4. This thesis presents the first report and description of the male of Capillaria serpentina. Four specimens of the male were collected.
5. A supplementary description of Auridistomum chelydrae is given, which includes complete measurements of external characters and major internal structures, and additional diagnostic characters not included in previous descriptions.

6. Chelydra serpentina is reported as a new host for Neopolystoma orbiculare, Neoechinorhynchus emydis, and juvenile strigeids.
7. Twenty-eight valid species of parasites are reported as occurring in Chelydra serpentina and all but the following were found in this survey: Trematodes, Spirorchis magnitestis Byrd, 1939; Spirorchis minutum Byrd, 1939; Hapalorhynchus gracilis Stunkard, 1922; Telorchis singularis (Bennett, 1935); Telorchis attenuatus Goldberger, 1911; Eustomus chelydrae MacCallum, 1921; Dictyangium chelydrae Stunkard, 1943; Cotylaspis stunkardi Rumbold, 1928; Microphallus opacus (Ward, 1894); Herpetodiplostomum delillei Zerecero y D., M. C., 1947: Nematodes, Eustrongylides sp., Aplectana sp., Foleyella sp. Nematodes were all immature specimens reported by Rausch (1947).
8. Many immature nematodes were encountered, but no attempt was made to identify them.
9. No cestodes were observed in this survey and none have been reported from Chelydra serpentina.

Conclusions:

This survey shows that snapping turtles are very heavily parasitized both in numbers of species and in numbers in each species. The incidence of parasitism is shown to vary considerably with the different species, from 3.3 percent for the mouth trematode to 97 percent for an intestinal nematode.

The helminths which were found in this study are of interest from the standpoints of anatomy, life history, relation to their hosts and geographical distribution. Parasitic helminths constitute one of Nature's most unusual, and yet, most common and interesting phenomenon, and certainly will continue to hold the interests of both scientists and laymen.

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