Proceedings of the Iowa Academy of Science

Volume 66 | Annual Issue Article 61

1959

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Patricia Jena Schroeder
Iowa State University

Martin J. Ulmer
Iowa State University

Host-Parasite Relationships of *Spirorchis elegans* Stunkard (Trematoda: Spirorchiidae)[1]

By Patricia Jean Schroeder and Martin J. Ulmer

Abstract. Twenty-eight turtles collected in northwest Iowa were examined for helminth infections. *Spirorchis* spp. were encountered in 16 *Chrysemys picta belli* and 1 *Emys blandingi.* At least 4 species were found, namely, *S. elegans, S. scripta, S. artericola,* and *S. pseudemyae. Spirorchis elegans* was found in 7 of the 24 painted turtles and was always recovered from the lymphatics and from the sub-mucosa of the esophagus of the host. These specimens were all sexually mature. It appears that the family diagnosis for Spirorchiidae should be extended to include these habitats. *Spirorchis pseudemyae* was recovered from intestinal washings of *C. picta belli* and *E. blandingi.* These represent new host records for this species.

Although nearly a century has elapsed since the first discovery of blood flukes in turtles by Leared (1862), relatively few life cycles have been elucidated and little is known concerning host-parasite relationships.

During the summer of 1958, twenty-eight turtles collected in the vicinity of the Iowa Lakeside Laboratory at Lake Okoboji were examined for helminth infections. These turtles represented four species. Particular efforts were made to check carefully for infections with flukes of the family Spirorchiidae. The history of this family was thoroughly reviewed and a taxonomic revision presented by Byrd (1939). Until recently, these flukes have always been reported as parasites of the circulatory systems of turtles, the most frequently chosen areas being the heart and associated arteries, vessels of the mesenteric circulation, and arterioles of the gut wall. However, Ulmer (1959) found *Spirorchis haematobium* (Stunkard, 1922) embedded in the sub-mucosa of the esophagus of *Chrysemys picta belli* Gray. He stated in his paper reporting these findings, ". . . it would appear that spirorchid trematodes should be considered as occasional tissue invaders as well as inhabitants of lymphatics and blood vessels." Because of this statement of a new location of the parasite within the host, part of the purpose of this investigation was to study related species of spirorchids *in situ.*

Life cycles for four members of the genus *Spirorchis* have been reported—*Spirorchis artericola* (Ward, 1921) by Peiper (1953), *S.*

[1]This study was supported in part by a grant from the National Science Foundation.

parvus (Stunkard, 1923) by Wall (1940, 1941b), *S. elephantis* (Cort, 1917) by Wall (1941a) and *S. elegans* Stunkard, 1923, by Goodchild and Kirk (1957). Of the above mentioned species, *S. artericola* and *S. elegans* have been found in turtles from the Okoboji region. Other members of the genus (*S. haematobium, S. pseudemyae, S. scripta*) have also been recovered.

Materials and Methods

Most of the turtles were provided by the Iowa State Conservation Commission in conjunction with their rough fish removal operations. Additional specimens were collected by various co-workers at the Iowa Lakeside Laboratory.

Examination of the turtles involved the removal of various internal organs which were isolated in individual containers of saline. The blood lost in the process of killing the host and the body washings from dissected animals were carefully inspected. Following preliminary examination of the external surfaces of the viscera, using a binocular dissecting microscope, the organs were dissected and the parasites recovered were transferred to saline. Heart and lung tissues, as well as major blood vessels, were carefully examined for the presence of blood-inhabiting helminths. When this was completed, a final check was made of all washings in order to recover worms previously overlooked.

Spirorchids recovered were fixed in AFA for the preparation of whole mounts and sections. Those specimens used for whole mounts were slightly flattened under coverslip pressure. The stain employed for whole mounts was Mayer's paracarmine with a fast green counterstain. Sections of worms including those *in situ* were stained in Delafield's haematoxylin with eosin counterstain.

Turtle Hosts and Incidence of Infection

The turtle hosts examined included 24 painted turtles (*Chrysemys picta belli* Gray), two snapping turtles (*Chelydra serpentina* Linnaeus), one Blanding's turtle (*Emys blandingi* Holbrook) and one elegant slider (*Pseudemys scripta elegans* Wied). The first two species are common in northwest Iowa. More painted turtles were examined because they predominate and are more easily collected. The latter two species, Blanding's turtle and the elegant slider, are found only rarely in northwest Iowa. Turtles were collected from the following areas: Ingham Lake (Emmet County), Virgin Lake (Palo Alto County), Spirit Lake, East and West Okoboji, and Gar Lake (all in Dickinson County).

About two-thirds of these turtles were found to harbor flukes of the genus *Spirorchis*. Also commonly encountered were trematodes of the genera *Heronimus, Telorchis* and *Polystomoides*, and nema-

todes of the genera *Camallanus* and *Spiroxys*. In one instance, acanthocephalans of the genus *Leptorhynchoides* were recovered. These findings are summarized in Table 1. The number of infected turtles listed in the table includes only instances in which adult parasites were recovered. In a few cases the presence of spirorchid eggs in the tissue gave evidence of past or present infection, but no worms could be found.

Table 1
Summary of Turtle Hosts Examined and Helminths Recovered

Turtle host	Number examined	Number infected with *Spirorchis*	Other helminths	
			Genus	Number of hosts infected
Chrysemys picta belli	24	16	*Polystomoides*	5
			Heronimus	8
			Telorchis	3
			Spiroxys	9
			Camallanus	10
Chelydra serpentina	2	0	*Telorchis*	1
			Spiroxys	1
			Camallanus	2
Pseudemys scripta elegans	1	0	*Polystomoides*	1
			Telorchis	1
			Spiroxys	1
			Camallanus	1
			Leptorhynchoides	1
Emys blandingi	1	1	*Polystomoides*	1
			Telorchis	1
			Spiroxys	1
	—	—	*Camallanus*	1
TOTALS	28	17		

Blood Flukes (Family Spirorchiidae)

Heretofore, no detailed studies on the blood flukes of turtles from the Okoboji region have been made. Ulmer (1959) has found two species, *Spirorchis haematobium* (Stunkard, 1922), and *Spirorchis elegans* Stunkard, 1923. In this study, *S. elegans* and at least three additional species were recovered, namely, *S. scripta* Stunkard, 1923, *S. pseudemyae* Byrd, 1939, and *S. artericola* (Ward, 1921). These are all monostomate, apharyngeal species possessing a bifurcate digestive tract with prominent esophageal glands. A median caecal pouch is located at the bifurcation of the gut. The testes are anterior to the ovary and are arranged in linear fashion between the intestinal caeca. These species are distinguished from one another on the basis of the position of the genital pore, the extent of the vitellaria, and the size and distribution of the testes. In many members of this genus a prominent reserve vesicle has been described. This vesicle, situated between the two branches of the V-shaped excretory bladder, extends anteriad between the intestinal crura. Stunkard (1923) speculated that it might be a lymph receptacle. Wall (1941a)

suggested that it might be part of a reserve excretory system. Ulmer (1959) reported that in *Spirorchis haematobium* there appeared to be a definite connection between this vesicle and the excretory bladder.

Table 2 summarizes the spirorchid infections encountered in this study. Under *Spirorchis* spp. are included those instances in which specimens could not be identified with certainty. This was sometimes due to immaturity of the worms.

Table 2
Summary of Spirorchid Infections

Turtle host	Number of hosts infected	Species of *Spirorchis* recovered	Location in host
Chrysemys picta belli	5	*S. elegans*	Sub-mucosa of the esophagus
	3	*S. scripta*	Atria of the heart, tracheal washings, heart washings
	1	*S. artericola*	Intestinal washings
	1	*S. elegans*	Sub-mucosa of the esophagus
		S. scripta	Intestinal washings
	1	*S. elegans*	Sub-mucosa of the esophagus
		S. artericola	Ventricle of the heart
		S. pseudemyae	Intestinal washings
	5	*S. spp.*	Atria of the heart, esophageal, tracheal, heart and intestinal washings
Emys blandingi	1	*S. pseudemyae*	Intestinal washings
TOTAL	17		

Spirorchis elegans Stunkard, 1923.

Adults. The most commonly encountered of the spirorchid species in this study was *S. elegans* (Figure 3), found in *Chrysemys picta belli*. Byrd considered *S. picta* Stunkard, 1923, as a synonym of *S. elegans*. Specimens in our collection range from 1.67 to 2.18 mm. in length. The genital pore is located one-fourth the body length from the posterior end. Vitellaria extend from the bifurcation of the digestive tract almost to the caudal end of the body. The prominent reserve vesicle characteristic of many members of this genus is not visible in any whole mounts of *S. elegans*, nor is it present in cross-sections of the worm. Stunkard (1923) did not mention its presence in his original description of *S. elegans;* he did show it, however, in a figure of *S. picta*.

Although these worms are of delicate structure, they are capable of the intense movements characteristic of some other members of this genus. When a living worm is teased out of the host tissue into the dissection fluid, it flexes and extends its body with extreme rapidity. This bending alternates with a distinct fluttering movement. When the fluke comes in contact with the surfaces of the container or dissecting instruments, these rapid movements cease but are sometimes replaced by waves of constrictions passing over the length of the body. Such contractions begin at either end of the body or in the middle. Movement of this nature may enable the organism to move through narrow lymph vessels, tissue spaces, or blood vessels.

A preliminary report on the life cycle of *S. elegans* by Goodchild and Kirk (1957) listed *Menetes dilatatus* and young *Helisoma* sp. as intermediate molluscan hosts of this trematode.

Location in the definitive host. Members of the family Spirorchiidae have been characterized as parasites in the blood stream of turtles. Wall (1941b) stated, "In all reports on the Spirorchiidae in which their habitat has been definitely determined and in my investigation dealing with blood flukes from seven genera (nine species) of hosts, the specimens have always been found in the arteries and heart." In 1952, Martin and Bamberger reported finding two species of a new genus (*Haemoxenicon*) in the mesenteric veins of the marine turtle, *Chelonia mydas* (L.) and, more recently, Ulmer (1959) found *S. haematobium* in the lymphatics and sub-mucosal tissue of the esophagus of *Chrysemys picta belli.*

All specimens in our collection which were definitely identified as *Spirorchis elegans* were taken from the sub-mucosa of the esophagus. The intestinal caeca of the worm, when filled with partially digested blood, appear as strikingly black, sinuous stripes, making the worms easily visible. Sometimes the flukes may be seen moving quite rapidly through the tissue. In order to determine the exact position of the trematodes in the sub-mucosa, cross-sections of the esophagus were prepared. These indicate that the parasite is definitely not within blood vessels. In some sections, the worm appears to be within lymphatics (Fig. 7). These thin-walled vessels become greatly distended due to the size of the fluke, and often appear to have ruptured. In some cases, the connective tissue of the sub-mucosa may be seen in direct contact with the cuticle of the worm, apparently with no intervening lymphatic wall between two areas. In all sections, the sub-mucosal tissue of the host is damaged and the lymphatics distended, especially in those areas immediately adjacent to the parasite. The worm itself, as well as host tissues other than the sub-mucosa, does not show any distortion. Figures 6 and 7 are photomicrographs of cross-sections of the esophagus showing the parasite *in situ.*

The specimens from esophageal tissue which were used for whole mounts are all sexually mature. Thus, in view of the frequency of the worms in this region, and their consistent maturity, it appears that this is the normal location within the host for this species.

The report by Ulmer (1959) on *Spirorchis haematobium* and this study on *S. elegans* indicate that the diagnosis for the family Spirorchiidae should be extended to include the lymphatics and connective tissues of the sub-mucosa of the esophagus as normal habitats within the definitive host.

Spirorchis scripta Stunkard, 1923 (Figure 1).

This is the smallest of the species encountered, its body length ranging from 0.78 to 1.36 mm. in our specimens. The genital pore is located about one-fourth of the body length from the posterior end. The vitellaria extend from the nerve ring almost to the posterior end of the body. Previous descriptions of adult worms of this species indicate that the vitellaria extend anteriorly only to the bifurcation of the digestive tract. The reserve vesicle is prominent. Using a key to the species of *Spirorchis* presented by Byrd (1939), *S. scripta* was easily identified on the basis of the anterior limits of the testes. In this species, they begin immediately posterior to the median caecal pouch. In other species of the genus *Spirorchis,* testes commence at varying distances posterior to the caecal pouch. Examination of the four whole mounts of *S. scripta* in our collection indicates that there is considerable variation in the relative size of the testes. In the specimen illustrated in Figure 1, the testes are much larger than the ovary, the width of each testis being greater than one-third the body width. In the other whole mounts they are proportionally much smaller, corresponding more closely to those of *S. elegans* as indicated previously. This size variation may be associated with the maturity of the worm.

S. scripta was recovered from the atria of the heart, from pericardial washings, and from washings of the intestinal and esophageal regions of *Chrysemys picta belli.* Figures 9 and 10 are photomicrographs of sections of the atrium of the heart showing trematodes, probably *S. scripta, in situ.* In Figure 9, the parasite appears to be within the cavity of the heart. In Figure 10, it appears to be embedded in the muscular atrial wall.

Spirorchis pseudemyae Byrd, 1939 (Figure 2).

Only two flukes of this species were collected. Whole mounts of these specimens measure 1.23 and 1.3 mm. These worms agree in all respects with those described originally by Byrd (1939). The genital pore is one-fifth the body length from the posterior end, the vitellaria extend as far forward as the nerve ring, and the testes are very small in relation to the ovary. The reserve excretory vesicle is prominent.

Byrd (1939) reported this species as a parasite of the mesenteric circulation of *Pseudemys troostii* (Holbrook). Both of our specimens were recovered from intestinal washings, one from *Chrysemys picta belli* and the other from *Emys blandingi*. These turtles represent new host records for the species.

Spirorchis artericola (Ward, 1921) (Figure 4).

Two specimens, one recovered from the ventricle of the heart and the other from intestinal washings of *Chrysemys picta belli,* correspond closely to the descriptions of *S. artericola* as presented by Ward (1921) and by Stunkard (1923). The body length of these specimens is 1.6 and 1.8 mm., respectively. The genital pore is situated at a point between one-fifth and one-sixth the body length from the posterior end. Vitellaria extend from the bifurcation of the digestive tract to the posterior end of the body. In one of the specimens the vitellaria partially obscure the reserve vesicle. In the other specimen, however, the vesicle is clearly apparent.

Some difficulty was encountered in identifying these two specimens when Byrd's (1939) key was used. According to his key, our specimens would be *S. pseudemyae* rather than *S. artericola* because the ovary in each specimen exceeds the testes in size. However, Ward (1921) and Stunkard (1923) in their descriptions of *S. artericola* made no definite statement that the ovary exceeded the testes in size. Furthermore, in the figure presented by Ward and in one of two figures by Stunkard, the testes were shown to be smaller than the ovary. In this respect, Byrd's key is inadequate in differentiating *S. pseudemyae* from *S. artericola.* In the extent of the vitellaria, and in body size, our specimens correspond more closely to *S. artericola.*

Whether these differences between *artericola* and *pseudemyae* could be the result of individual variations within a single species depends upon elucidation of the life cycle of *S. pseudemyae* and the examination of a large number of experimentally-reared adults.

That wide variation exists within an individual species was suggested by Byrd (1939) when he considered two species of *Spirorchis* (*elegans* and *picta*) as synonymous. These two species had previously been considered by Stunkard (1923) as separate and distinct. If they are indeed synonymous, wide variation in the relative size of reproductive organs within a species is common. As previously indicated, our specimens of *Spirorchis scripta* exhibit this same variation in size of gonads. This is a factor which might vary with maturity. It is also possible that some difference may result from methods of handling the specimens. Differences in the size and form of testes, ovary, and intestinal caeca induced by the use of various fixatives and different degrees of pressure are illustrated by Ulmer (1952) in studies on *Postharmostomum helicis* (Leidy, 1847) Robinson, 1949.

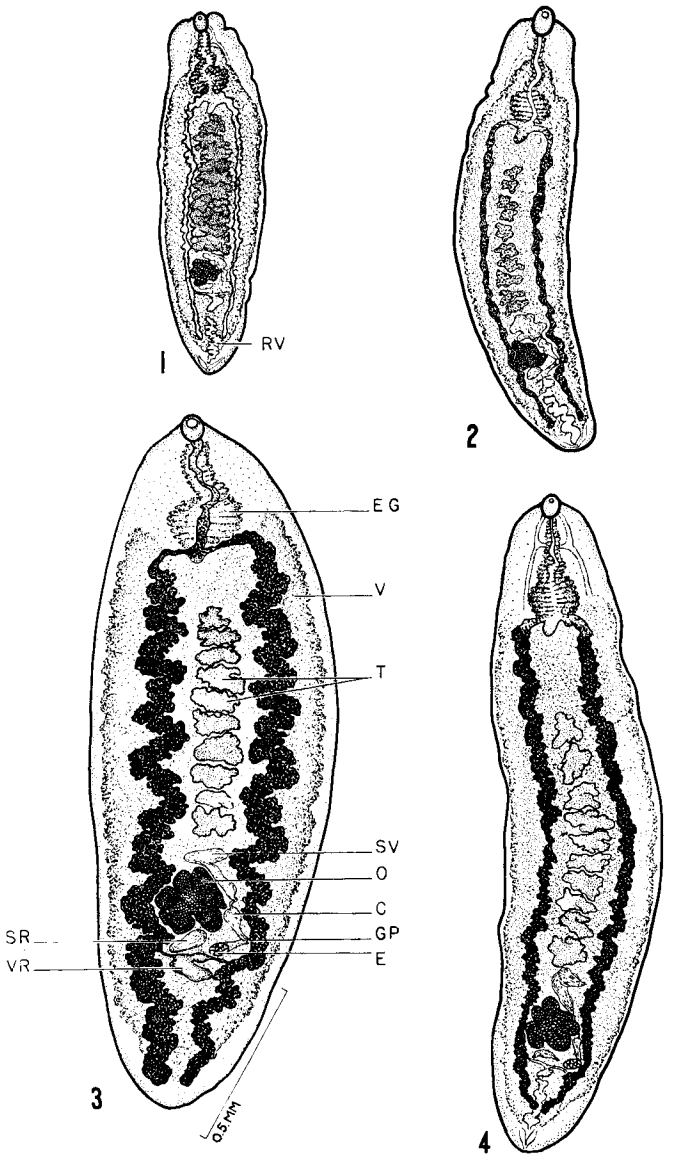


PLATE I

Figure 1. *Spirorchis scripta* Stunkard, 1923. Whole mount, ventral view.

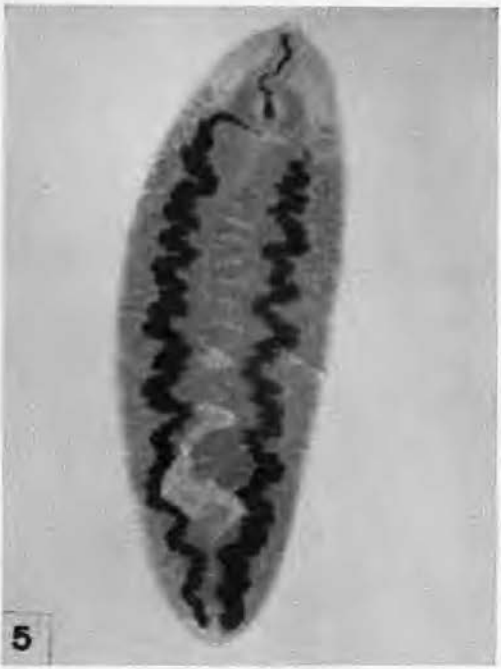
Figure 2. *Spirorchis pseudemyae* Byrd, 1939. Whole mount, ventral view.

Figure 3. *Spirorchis elegans* Stunkard, 1923. Whole mount, ventral view.

Figure 4. *Spirorchis artericola* (Ward, 1921). Whole mount, ventral view.

(All drawings were prepared with the aid of a microprojector and are drawn to the same scale as that shown in Figure 3.)

Abbreviations: C, cirrus; E, egg; EG, esophageal glands; GP, genital pore; O, ovary; RV, reserve vesicle; SR, seminal receptacle; SV, seminal vesicle; T, testes; V, vitellaria; VR, vitelline reservoir.



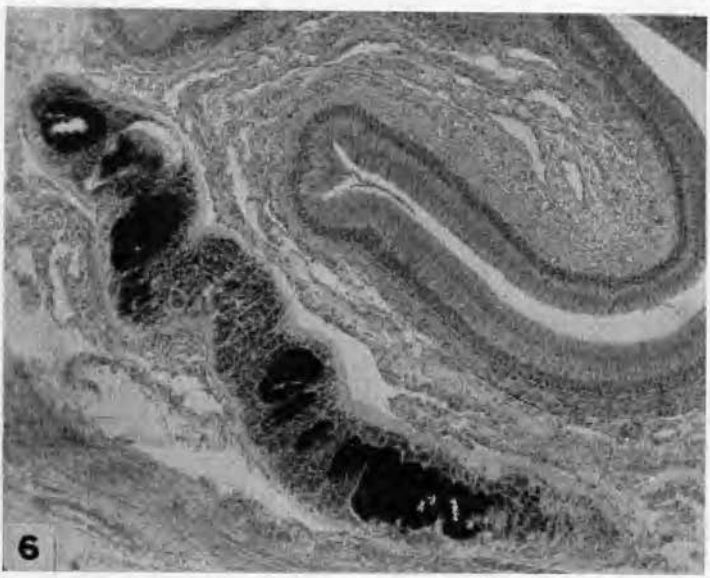
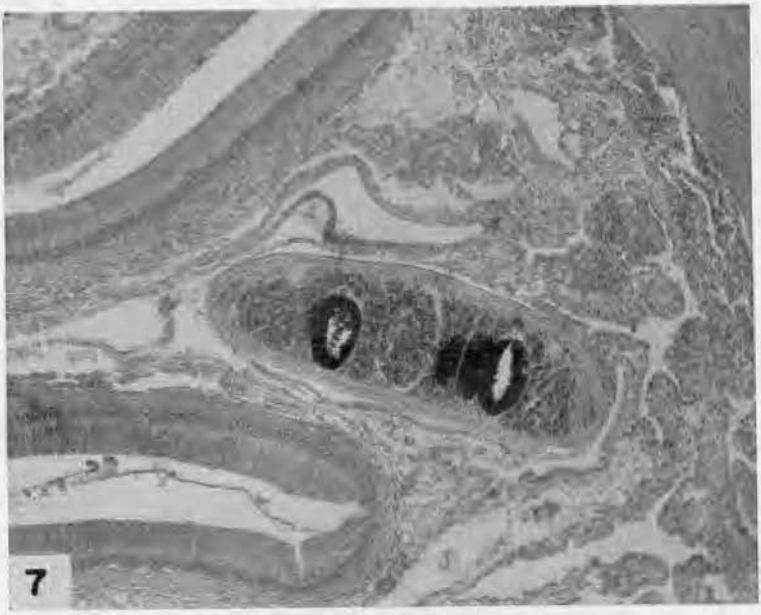


PLATE II

Figure 5. *Spirorchis elegans* Stunkard, 1923. Photomicrograph of whole mount, dorsal view.

Figure 6. Photomicrograph of cross-section of the esophagus of *Chrysemys picta belli* showing *S. elegans* in the sub-mucosa.



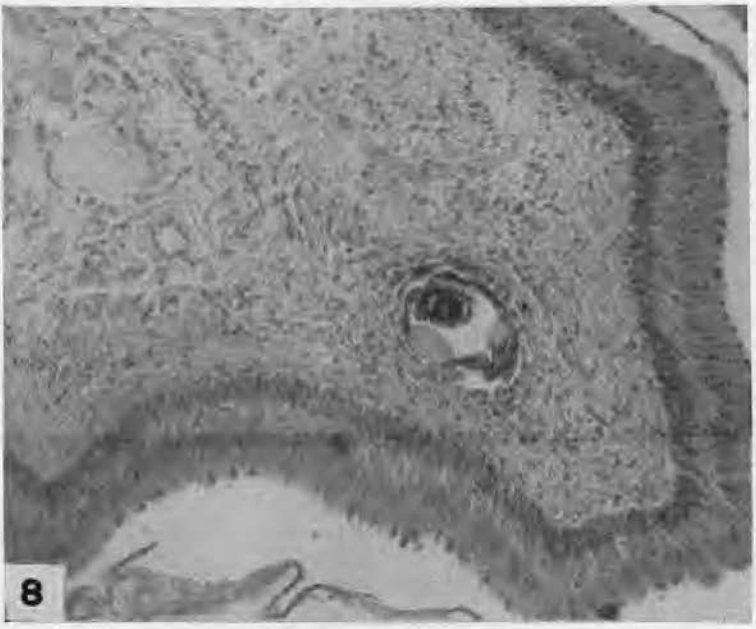
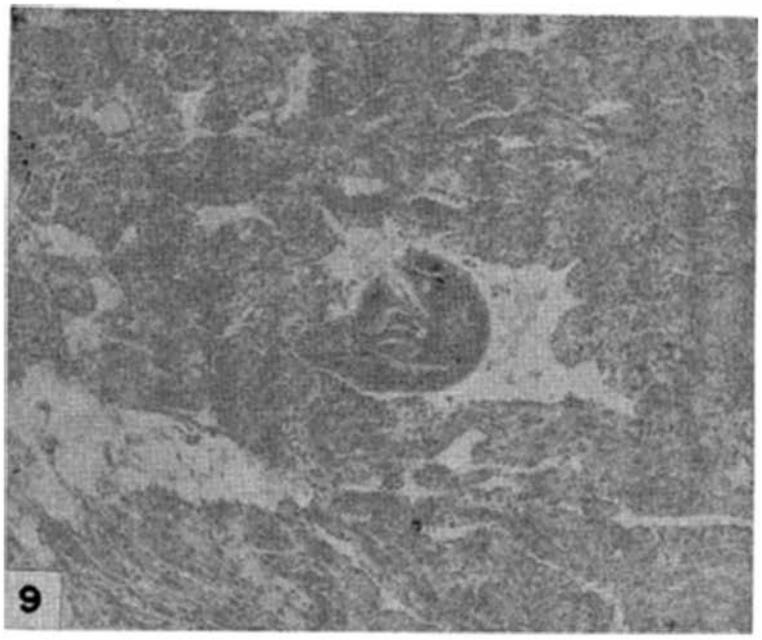


PLATE III

Figure 7. Photomicrograph of cross-section of the esophagus of *Chrysemys picta belli* showing *S. elegans* in the sub-mucosa.

Figure 8. Photomicrograph showing spirochid egg in esophageal sub-mucosa of *Chrysemys picta belli*.



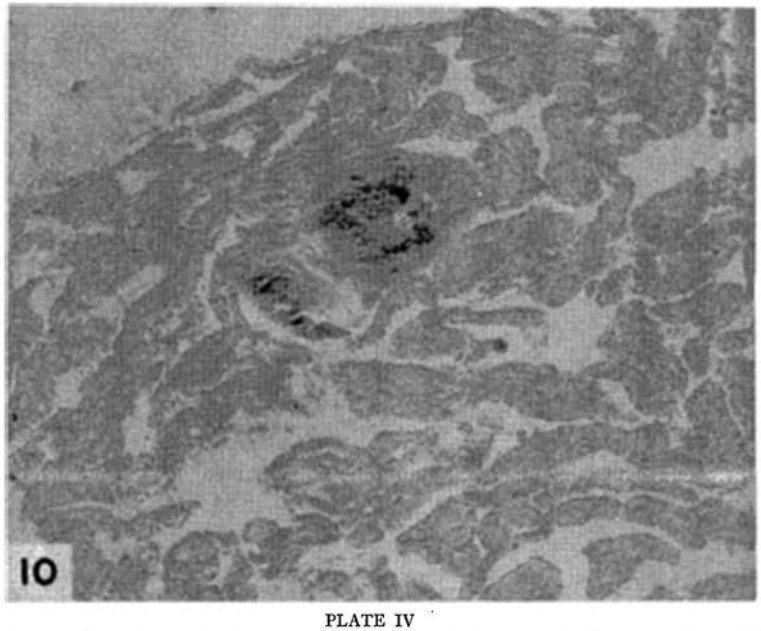


PLATE IV

Figure 9. Photomicrograph of section through atrium of the heart of *Chrysemys picta belli* showing *Spirorchis* sp. in atrial chamber.

Figure 10. Photomicrograph of section through atrium of the heart of *Chrysemys picta belli* showing *Spirorchis* sp. in the muscular atrial wall.

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Department of Zoology and Entomology
Iowa State University
Ames, Iowa

Iowa Lakeside Laboratory
Milford, Iowa