THE VISCERAL ANATOMY OF THE GARTER SNAKE

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INTRODUCTION

Our information on the visceral anatomy of the Ophida is very limited. Hopkinson and Pancoast ('37) described the visceral anatomy of the Python, and Jaquart ('55) described its circulatory system. Schlemm ('27) studied the circulation of *Tropidonotus natrix* and *Trigonocephalus mutus.* Bronn's Thier Reich ('90) contains a resumé of the work up to the time it was published. Beddard has contributed much to our knowledge of serpent anatomy in his papers published between 1903 and 1909. O'Donoghue ('12) gave an excellent account of the circulation of *Tropidonotus natrix.* Thompson ('13, '14) contributed some valuable notes on a number of species. In 1916 the author described the visceral anatomy of *Zamenis Constrictor.*

The entire blood system of snakes may be injected through the ventricle of the heart. The valves do not prevent the fluid from passing, under pressure, into the atria and hence into the veins. The vena cava should be injected at the anterior end of the liver; the portal vein may be injected at the posterior end of the liver when it is desirable to have two colors in the veins. The injection fluid used in this work was gelatine colored with lead chromate or india ink.

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DESCRIPTIONS OF SPECIMENS

Because of the great variability of garter-snakes and the complexity of their classification descriptions have been inserted of the specimens used in this investigation, so that the reader may satisfy himself as to the affinities of the types dissected.

The principal characters which are of value in classification are given in Table I. The two specimens from Granite City, Illinois, were of a dark olive-brown color. No. 1 showed much red on the sides between the black spots. No. 2 showed no red at all; otherwise they were alike. I judge these specimens to be *Thamnophis sirtalis.* The red on the sides of No. 1 indicates that it belonged to the subspecies of *T. sirtalis parietalis.*

Specimen No. 3 from Holland, Michigan, was of a chestnut brown color with a small amount of red on the sides (*T. sirtalis parietalis*); the dorsal stripe was obscure and the belly color was continuous with, and the same as, the color of the lateral stripe covering the first scale row. (*T. sirtalis pallidula*). Although *T. sirtalis parietalis* is not reported east of the Mississippi River the writer has frequently seen specimens having the characteristic red color near Granite City, Illinois, and at Holland, Michigan.

The specimens from Madison, Wisconsin, are difficult to classify. They all look alike excepting No. 9 but on close investigation they seem to fall into different groups.

TABLE I — *Showing general points about the garter-snakes studied.*

Number	Locality	Dorsals	Supra-labials	Infra-labials	Ventrals	Caudals	Body length	Tail length	Lateral stripe	Sex
1	Granite, Ill.	19–17	7	11	152	66	25.50	7.50	2, 3	F
2	" "	19–17	7	11	150	....	33.	..	2, 3	F
3	Holland, Mich.	19–17	7	9	146	63	16.	4.50	1, 2, 3	F
4	Madison, Wis.	19–19	7	10	149	74	16.	5.	3 (4)	M
5	" "	19–17	7	10	155	79	14.50	4.75	2, 3	M
6	" "	19–21	7	11	154	71	15.50	4.50	2, 3	F
7	" "	21–19–17	7	10	151	63	16.50	4.	3, 4	F
8	" "	17–19	7	10	162	67	21.	5.75	2, 3	F
9	" "	17–19–21	7–8	10	157	70	13.65	3.75	(1) 3 (4)	F
10	" "	19–17	7	10	155	63	18.75	4.75	1, 2. 3	F
11	Marion Co.	19–17–15	7	9	150	....	22.50	......	2, 3	F
12	" "	21–19–17	7	10	145	69	28.	7.50	2, 3	F
13	" Fla.	19–17	7	10	144	70	23.	6.75	2, 3	F
14	" "	19–17	7	10	143	68	20.50	6.	2, 3	F
15	" "	19–17	7	10	135	71	22.50	6.50	2, 3	F
16	" "	19–17	7	10	145	....	22.50	......	2, 3	F
17	" "	19–17	6–7	10	142	67	27.	7.50	2, 3	F
18	" "	19–17–15	7–8	10–11	158	...	22.50	......	3 (4)	F

I believe that the forms with the lateral line on the second and third scale rows and those with the lateral line on the third and fourth scale rows (*T. radix* and *T. sirtalis*) are interbreeding in this locality. No. 4 and No. 7 have the lateral stripe in the third and fourth scale rows (*T. radix*). No. 9 has the lateral stripe on the third row and some color on the second and fourth rows. This suggests *T. butleri,* but the scutellation has not been reduced enough to fit that species. The sides of this specimen were marked with two rows of black spots divided by yellow. The yellow also appeared on the scales slightly. I therefore judge this specimen to represent the yellow phase of *T. sirtalis parietalis* although it differs from the type specimen and its known range does not include this locality. Nos. 6 and 8 were very much alike *(T. sirtalis).* In No. 10 *(T. sirtalis)* the stripes were all very broad, those on the sides covering the first scale row. The specimens from Marion County, Florida, (Nos. 11, 12, 13, 14, 15, 16, 17,—*T. sirtalis*) were alike in color, having prominent black spots on a light blue background. Specimen No. 18 from Marion County Florida, was a typical *T. sauritus sackeni.*

Circulatory System.

The Arteries of the Neck.

Three arteries leave the right aortic arch to supply the body anterior to the heart. The left *carotid* artery lies dorsal to the left jugular vein and ventral to the esophagus; supplies the left thymus gland, the thyroid gland, the fat body, the esophagus, the trachea and the head. Its branches are all very small and variable in the neck region.

The right carotid artery has been reduced to the small *thyroid artery* of O'Donoghue ('12) (*ramus glandularis* of Brown, '90). It supplies the thyroid gland and in some specimens sends a large branch to the esophagus. This esophagaegal branch passed dorsal to the heart and ran caudalward along the ventral wall of the esophagus, (Fig. 1). It was found by the writer ('16) in *Zamenis constrictor* and its root was figured but its course could not be fully traced, hence it was not described. I do not know that it has been mentioned before or that it exists in all specimens of the species herein considered. Twigs from the thyroid artery to the right thymus gland were made out in only three specimens and were exceedingly small.

The glands of this region become very small during starvation. In some specimens the thyroid became colorless and transparent. The fact that the fat body of the neck had been entirely absorbed and that the neck glands had been so much reduced may account for the smallness of the blood vessels in this region. It is noted elsewhere in this paper that the veins of the oviducts are larger while the oviducts are filled with eggs. It seems that the size of the blood vessels varies somewhat with their activity.

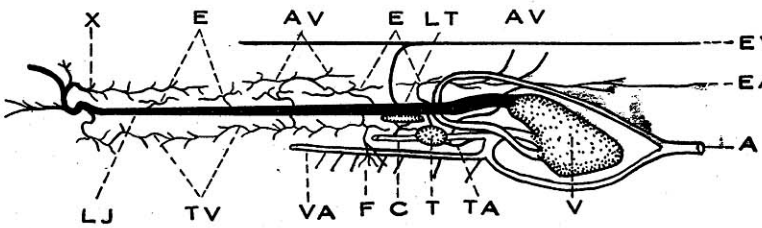

FIG. 1.

The left jugular vein. A, aorta; AV, X, remains of the left azygous vein; C, carotid artery; E, esophageal veins; EA, esophageal artery from thyroid artery; EV, epigastric vein; F, vein from fat body; LT, left thymus gland; RJ, right jugular vein; T, thyroid gland; TA, thyroid artery; TV, tracheal vein; V, ventricle; VA, vertebral artery.

The *vertebral artery* leaves the right aortic arch and runs forward about half way to the head before passing into the mid-line of the dorsal parietes. In two specimens it sent eight branches to the mid-line of the dorsal parietes; in one specimen seven; in eight specimens six; in five specimens five; and in one specimen only three. These variations were apparently not correlated with variations in the external anatomy. The twigs from the vertebral artery to the esophagus were very small. Six were counted in one specimen. In some specimens they could not be made out at all.

The Dorsal Aorta and Its Branches

As in other snakes the aorta originates just posterior to the heart from the junction of the two aortic arches, (Fig. 1). In the eighteen specimens examined the right arch gave off one or two intercostals to the mid-line of the dorsal parietes before uniting with the left arch. The left arch is larger than the right and gives off no branches to the parietes.

The branches from the aorta to the dorsal parietes in fourteen specimens examined varied from forty-three to eighty. Table II shows the total number of rib-bearing vertebra in the first column, the total number of inter-costals from the junction of the two aortic arches to the anus in the second column and the number of vertebrae between the first aortic branch and the anus in the third column. It will be seen that in specimen No. eighteen (*T. sauritus sackeni*) the aortic branches begin farther back than in any other specimen. This individual has a longer neck and the heart is placed farther back than in the specimens of *T. sirtalis*.

TABLE II—*Showing the Relation of the Intercostal Arteries to the Rib-bearing Vertebrae.*

Specimen	Rib-bearing vertebrae	Intercostals	Intercostal spaces covered
1	151	55	120
2	146	80	122
6	146	46	119
7	149	54	118
8	155	74	124
9	149	71	122
10	142	51	114
11	151	54	123
12	142	50	113
14	139	54	115
15	142	55	114
16	142	61	112
17	141	44	110
18	145	43	102

All of the intercostal arteries enter the mid-line of the dorsal parietes and are not paired.* In the *Boidae* these intercostal arteries are paired and enter to the left and right of the mid-line of the dorsal parietes. (Beddard, '04, '06, '08). In the *Colubridae* these conditions vary and may prove to be of great importance in classification.

The branches of the aorta to the liver and esophagus are small, numerous, and variable. *The lieno-gastric artery* runs to the region of the pyloric end of the stomach to supply the stomach.

*One abnormal pair was found but both its branches entered the mid-line of the dorsal parietes.

O'Donoghue ('12) describes this artery in *Tropidonotus natrix* as supplying the spleen and gall bladder also. In *Zamenis constrictor* this artery was figured and described by the writer ('16). It supplies the stomach, gall bladder, spleen, pancreas and fat body.

The *superior mesenteric artery* leaves the aorta a short distance posterior to the pancreas and sends a large anterior branch to the region of this organ. The branch supplies the stomach, duodenum, spleen, pancreas and fat body. It probably supplies the gall bladder also, but I could not be certain in any case. The posterior branch of the superior mesenteric artery follows the intestine and forms a junction with the first inferior mesenteric artery.

The aorta gives off one branch to each of the adrenal bodies. These arteries send variable branches to the ovaries or testes, the oviducts or sperm ducts, and to the fat bodies.

Between the adrenal bodies and the kidneys of each side arteries pass from the aorta, down to the oviducts or fat bodies or both. They could not always be found and did not exceed three in number in any case. The most posterior one may be connected with the anterior renal artery which often supplies the fat body or oviduct.

The *renal arteries* vary from three to six. Any one of them may be connected with the oviduct or fat body.

The Right Jugular Vein.

The right jugular vein receives blood from the following organs: trachea, esophagus, right thymus gland, thyroid gland, fat body, epigastric vein, tongue muscles, and head, (Fig. 2). It does not receive any blood from the right dorsal parietes except through the azygous veins. The anterior branch of the *azygous vein* extends forward to the head, receiving branches from the right dorsal parietes and the esophagus. The branches from the esophagus form a reticulation on the esophagus and send branches off to the left which enter the right jugular vein; so the anterior azygous and right jugular veins are connected by this reticulation. The *posterior azygous* vein differs greatly. It may consist of three large trunks from the right parietes in its maximum condition or may be reduced to a medium sized trunk entering the anterior azygous vein just before it enters the rigth jugular vein.

The azygous veins of different species of serpents differ greatly and in the writer's estimation might well be used in classification.

The branches from the *epigastric vein* to the right jugular vein varied from three to seven in eighteen specimens examined. They averaged four. The epigastric vein in *Thamnophis* is more continuous in the neck region than in *Zamenis constrictor* (Atwood, '16), and has fewer connections with the right jugular vein.

The *esophageal vein* of O'Donoghue ('12) could not be found in *Thamnophis.*

The Left Jugular Vein.

The *left jugular vein* originates in the head and courses along the left ventral surface of the esophagus to the heart. It passes ventral and to the left of the left atrium and traverses the dorsal surface of the heart, from left to right, between the left atrium and the ventricle to enter the right atrium through the sinus venosus together with the vena cava and the right jugular vein. It is nearly as large as the right jugular vein.

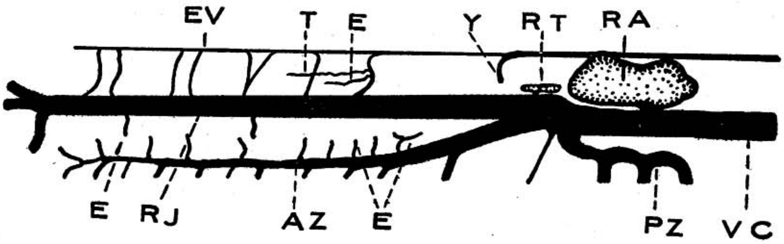

FIG. 2.

The right jugular vein. AZ, right azygous vein; E, esophageal veins; EV, epigastric vein; PZ, posterior azygous vein; RA, right atrium; RJ, right jugular vein; RT, right thymus gland; T, vein from tongue muscles; VC, vena cava; Y, branch from the epigastric vein to the left jugular.

The first branch of the left jugular vein is received just before it enters the pericardium of the heart near the anterior end of the left atrium. It carries blood from the esophagus and is the first of a series of veins, which differ in number, from the esophagus to the left jugular vein. This series begins in the region of the heart and extends throughout the length of the vein. On the left surface of the esophagus the veins of this series are broken up into small tracts which reassemble and form trunks from the left dorsal parietes. Only one large vein leads directly from the left dorsal parietes to the left jugular vein, (Fig. 1-x). It is quite uniform and runs along the body wall, as does the right anterior azygous vein (Fig. 2), but carries blood forward and empties into the left jugular at the angle of the jaw. This vein does not seem to have been mentioned before and does not exist in *Zamenis constrictor* (Atwood, '16).

There is a tendency for the parietal veins to form a small azygous trunk (Fig. 1, AV) posterior to the termination of the vein mentioned above, but such a condition is not uniform. This suggests the remains of the left anterior azygous vein.

In the region of the heart three, or less, veins leave the left, dorsal parietes and join the reticulation of veins on the left surface of the esophagus then assemble to form the first trunk which enters the left jugular vein (Fig. 1). These parietal veins are variable and are the remains of the left posterior azygeous vein. *Zamenis* differs from *Thamnophis* in that the veins from the left and right parietes do not form a finely divided reticulum on the esophagus but enter the jugular veins more directly (Atwood, '16).

On the ventral surface of the trachea, between the two jugular veins a longitudinal trunk occurs (Fig. 1). It receives blood from the trachea and is connected with the jugular veins and the fat body. The blood leaving the trachea has probably been more or less aerated in its walls.

The connections between the left jugular vein and the epigastric are described along with the epigastric vein.

The left jugular vein receives blood from the following sources: head, esophagus, left dorsal parietes, trachea, fat body, left thymus gland, thyroid gland and epigastric vein.

The Afferent Renal Veins.

The *caudal vein* runs parallel to, and in close contact with, the caudal artery—both lying in the haemal canal of the tail. Above the anus the caudal vein divides to form two trunks, the right and left *afferent renal veins; (illiac veins,* Cope, '00; *venae renalis advehens,* Schlemm, '27; renal portal veins, O'Donoghue, '12). From a position dorsal to the anus these veins course forward along the sides of the cloaca and pass along the ventral edges of the kidneys to their anterior end, but do not pass beyond this point as they do in the *Boidae* (Beddard, '04, '06, '08). As in other snakes these veins receive blood from the region of the anus and vagina, sperm ducts or oviducts, epigastric vein and from the dorsal parietes. The connections between the afferent renal veins and the vein of the fat body are not prominent and could not be made out. The *iliac veins* are very prominent in Thamnophis. They carry blood from the body wall on either side of the anus to the afferent renal veins. They have no connection with the abdominal or epigastric veins. They were described in *Tropidonotus natrix* by O'Donoghue ('12) as the *pelvic veins*, and in *Zamenis constrictor* by the writer ('16).

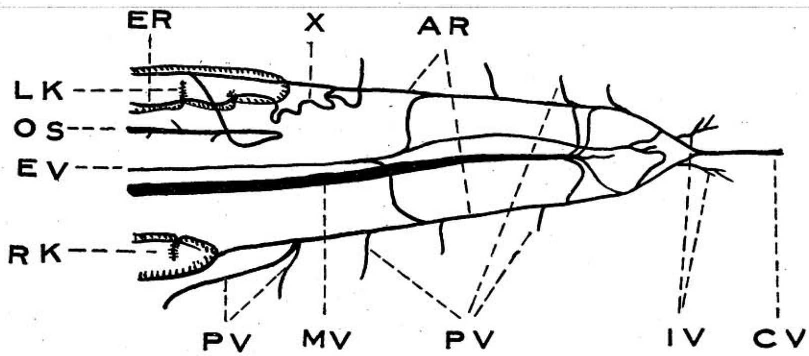

FIG. 3.

The afferent renal veins. AR, afferent renal veins; CV, caudal vein; ER, efferent renal vein; EV, epigastric vein; IV, illiac veins; LK, left kidney; MV, mesenteric vein; OS, oviducal sinus; PV, parietal veins; RK, right kidney; X, abnormal connection between the efferent and afferent renal veins.

In the specimens observed from three to five veins leave the dorsal parietes of each side and enter the afferent renal veins before they reach the kidneys. In specimen No. 1 a vein from the parietes of the left side entered the afferent renal vein of that side just posterior to the kidney. Just before this parietal vein entered the afferent renal vein it gave off a large branch which entered the efferent renal vein. Thus permitting the blood to pass from the afferent renal vein to the efferent renal vein directly, without first passing through the kidney, (Figs. 3, 4). A similar condition was observed on the right side in two other specimens. The above conditions probably represent persisting connections between the subcardinals and the post cardinals which were not broken down when the blood from the caudal vein ceased flowing through the kidneys by way of the subcardinals and began to flow by way of the post cardinals before they broke down anterior to the kidneys.

In specimen No. 2 a parietal vein entered the efferent renal vein in the mid-kidney region. This is undoubtedly an abnormal case as veins in this position have not been described in the Ophidia and were not found in any other specimen. It is probably a persisting connection between the subcardinal veins and the parietes.

One large branch leaves the afferent renal vein and becomes the *oviducal sinus*. Blood may flow through this from the caudal vein to the heart by way of the vena cava without passing through any portal capillaries (Fig. 4).

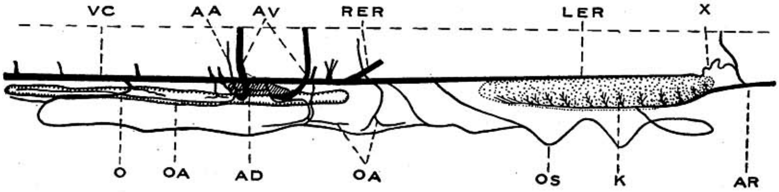

FIG. 4.

The left oviducal sinus, from the left side. AA, adrenal artery; AD, left adrenal body; AR, afferent renal vein; AV, adrenal portal veins; K, kidney; LER, left efferent renal vein; O, ovary; OA, ovarian arteries; OS, oviducal sinus; RER, right efferent renal; VC, vena cava; X, abnormal connection between the efferent and the afferent renal veins.

The origin of the *inferior mesenteric vein* from the afferent renal veins is described in connection with the portal vein.

The Vena Cava

The *vena cava* originates from the junction of the two efferent renal veins near the anterior end of the right kidney and runs forward to the heart. It may receive blood from the caudal vein by any one of the following routes: (1) through the kidneys, (2) by way of the oviducal sinus, (3) by an occasional direct connection between the afferent and efferent renal veins, (Figs. 3, 4).

The vena cava receives blood from the parietes by way of the adrenal bodies. From one to three veins leave the dorsal parietes of either side, take their way in the mesentery of the ovary for a short distance, and then enter the adrenal bodies; or they may enter the adrenal bodies direct. They often receive branches from the longitudinal vein of the oviduct before entering the adrenal body. This adrenal portal system has been mentioned as existing in several snakes and is probably present in all members of the order. (Ecker, '46; Gratiolet, '53; Beddard, '04; Atwood, '16).

From eight to twelve veins enter the vena cava from the ovaries and oviducts between the kidneys and the liver, some entering posterior to the adrenal bodies. These veins all connect the vena cava with a long sinus in each oviduct, which originates from the afferent renal vein of the same side and runs along the oviduct to the anterior end where it enters the vena cava, (Fig. 4). This *oviducal sinus* was first described by O'Donoghue ('12) in *Tropidonotus natrix.* It is not prominent except when the oviducts are filled with developing eggs. This probably accounts for the fact that it has been overlooked until recently.

The region between the adrenal bodies and the liver is drained by the portal vein. The vena cava receives no branches in this region except from the structures connected with reproduction. It passes along the ventral surface of the liver on its way to the sinus venosus, receiving blood through the capillaries of the liver from the portal vein, the dorsal parietes, the epigastric vein, the stomach and esophagus. All of the blood from the posterior part of the body enters the heart through the vena cava except that from the lungs.

The Portal Vein

The *portal vein* originates as the *inferior mesenteric* vein from the rectum and from branches from the right and left afferent renal veins. This vein runs along the intestine, but does not follow its folds very closely. After its origin the mesenteric vein receives no branches other than those from the intestine until it is joined by the *abdominal vein* of the fat body. These two veins are of about equal size and unite about one inch caudal to the pancreas.

In the specimens examined no veins from the parietes entered the portal vein posterior to the pancreas as is the case in *Zamenis* *constrictor,* (Atwood, '16). Between the pancreas and the anterior termination of the portal vein branches from the parietes are received both before the vein reaches the liver and along its course in the dorsal surface of the liver. These veins vary from five to ten in number; four of the specimens examined having only five, three having ten, and others varying between these limits.

The veins of this series which enter the portal vein near the anterior end of the liver come from the left dorsal parietes while those which enter the portal vein more posteriorly have a tendency to come from the right. This is also true for *Zamenis constrictor,* (Atwood, '16), and of *Tropidonotus natrix,* (O'Donoghue, '12).

Numerous veins enter the portal from the esophagus. They lie in the mesentery which connects the liver and the alimentary tract. The most anterior of these runs far forward as the continuation of the portal. It carries blood from the esophagus but does not reach the heart. This vein has been variously described in other snakes, (Beddard, '04; Cope, '00; Atwood, '16). It is absent in *Tropidonotus natrix* (O'Donoghue, '12).

The Epigastric Vein

The epigastric vein originates just anterior to the anus and extends forward in the muscles of the ventral body wall to near the head. Above the center of each gastrostege it receives a branch from the lateral body wall of each side. It is single throughout its entire length excepting where it is divided in some specimens by the scar of the umbilicus, where it is double. This indicates that it was double originally.

Normally the epigastric vein receives one or two branches from each afferent renel vein in the vicinity of the cloaca. These may be connected with the oviducts or vagina.

Between the posterior kidney region and the pancreas the epigastric vein is connected with the vein of the fat body by from eight to fourteen veins in the specimens examined. The most anterior of these originated far forward of its connection with the epigastric vein. This indicates that in this genus the pancreas now lies farther forward than formerly.

In the short space between the pancreas and the liver from one to three veins enter the portal from the epigastric vein. They are usually connected with the fat body and the intestine.

Along the liver branches from the epigastric vein enter the tissue of the liver to the left of the vena cava but do not enter this vein. These varied in number from four in No. 3 and No. 4 to thirteen in No. 7.

At the anterior end of the liver the portal vein is continued forward and receives blood from the intestine and also from the epigastric vein by a large branch which may be absent.

Anterior to the heart a large vein enters the left jugular from the epigastric. It was present in all specimens excepting No. 4. In Nos. 6, 9 and 18, it occurred as two veins, and No. 11 had three separate veins about a half inch apart (Fig. 1). The fact that this vein varies greatly in the garter-snake agrees with conditions found to exist in *Zamenis constrictor*, (Atwood, '16).

The connections of the epigastric vein in the neck region have been described in the discussion of the right jugular vein.

The Respiratory System

The right lung originates dorsal to the heart and lies in the right, dorsal part of the body-cavity. It extends beyond the caudal end of the liver nearly to the anterior adrenal body in the specimens from Illinois, Michigan, and Wisconsin. In the specimens from Florida it is longer, reaching beyond the anterior adrenal in all cases and to the mid-kidney region in some. In all of the females from Illinois, Michigan and Wisconsin the lung was less than half the length of the body without the tail. In the specimens from Florida the lung was more than half the length of the body. In one male from Wisconsin the lung-length was slightly more than half the body-length.

Although this difference in the length of the lung seems to be quite pronounced and constant I do not consider it of specific significance. It is probably correlated with a more rapid metabolism due to higher temperature.

The left lung is small and rounded but functional, and is connected with the trachea by a pore one sixteenth of an inch anterior to the termination of the tracheal tube in the tissue of the right lung. It is situated to the left of the pulmonary vein.

The alveolar tissue of the trachea begins gradually near the head and becomes more and more prominent until the lung is reached where it becomes confluent with the lung tissue on the right side of the trachea.

To the right of the junction of the trachea and the lung an anterior projection of the lung receives along its ventral surface the *pulmonary artery.* Thompson ('14) describes this projection in *Thamnophis ordionoides* as entering the lung through a constriction but no such constriction was found in the specimens examined by me.

The *pulmonary vein* enters the lung to the left of the pulmonary artery and is embedded in the tissue of the lining of the lung on the ventral side while the artery runs along the external, ventral surface of the lung. This is a general condition in the snakes with one lung.

The vascular lining of the lung decreases gradually toward the caudal end so that all but the first two or three inches is little more than an air reservoir.

Opposite the pancreas blood vessels were found on the surface of the lung-sack in the specimens of *T. sirtalis* from Florida. In specimen No. 11 they were especially prominent and of large size. They seemed to be connected in a reticulation and entered the portal vein through at least three trunks, and the vena cava through one. I consider this condition to be very unique and therefore was very careful to make sure that my observations were correct.

The Visceral Organs.

The Alimentary Canal.

The alimentary canal of *Thamnophis* differs but little from that of other serpents. The esophagus and stomach are continuous and are not differentiated. The stomach folds begin in the esophagus and become more and more complex and extensive as the stomach region is reached. The stomach folds are thrown into more complex transverse convolutions than are those of *Zamenis* as judged by preserved specimens. The stomach proper is also shorter than in *Zamenis* (Atwood, '16).

The pyloric end of the stomach is reduced to a small tube lined with comparatively simple, longitudinal folds. It is very short and joins the bluntly rounded stomach proper so that the transition is distinct. The pyloric valve is simply a constriction of the food tube lined with small longitudinal folds which project into the duodenum.

The folds of the lining of the small intestine are very complex in the duodenum and decrease gradually toward the rectum. They do not differ materially from those of the lining of the intestine in other snakes.

The diameter of the tube is greatest in the duodenum and decreases gradually toward the anterior kidney region where it reaches its smallest diameter, again increasing toward the rectum. The intestine becomes very large just anterior to its connection with the rectum. There is a constriction at the junction which gives the intestine the appearance of ending in a caecum.

The lining of the rectum is soft, whereas the outer wall of the rectum is more rigid and comparatively harder. The lining of the rectum is a membrane with great surface exposed and is extensively folded in order to accommodate itself to the inside of the rectal tube.

The Liver.

The left lobe of the liver usually extends beyond the right, along the vena cava, both anteriorly and posteriorly, but the posterior ends of the two lobes are sometimes equal. In large specimens of *T. sirtalis* the liver originates about a half inch posterior to the heart. In the specimen of *T. sauritus sackeni* the liver began farther back and was very slender.

The vena cava is embedded in the ventral surface of the liver in all snakes and not in the "superior" surface as stated by Cope ('00). The portal vein is embedded in the dorsal surface. The two veins thus divide the liver into two lobes.

A large scar occurs on the ventral surface of the left lobe to the left of the vena cava and near the anterior end. It is the same scar which occurs in *Zamenis constrictor* and *Z. flagelliformis* and has been described (Atwood, '16) as the remains of the umbilical vein. Beddard ('06) has described the persistent umbilical vein in *Boa* and *Python regius* as connected with the vena cava direct.

The liver receives arterial blood from the aorta through many hepatic arteries which are also connected with the esophagus. It receives venous blood from the portal vein, the epigastric vein, the dorsal parietes and the alimentary canal opposite the liver.

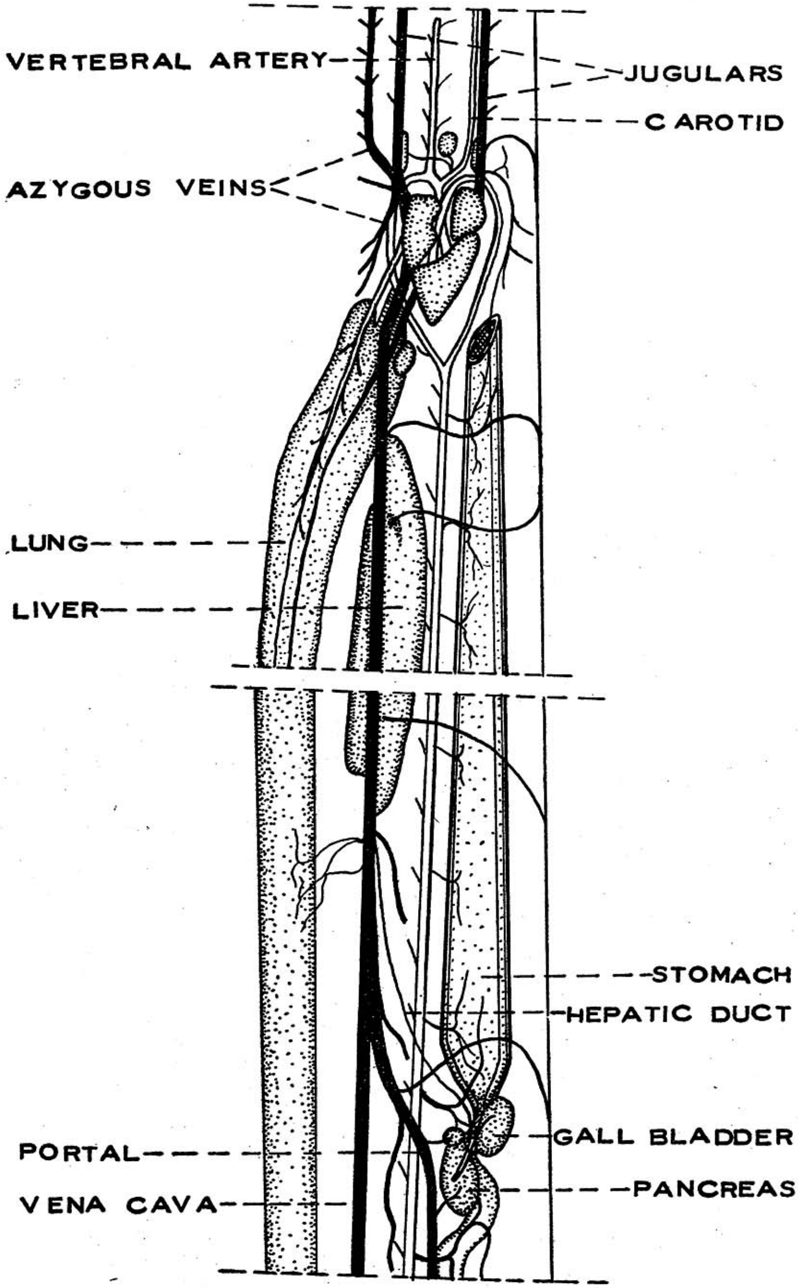

FIG. 5. Ventral view of the viscera.

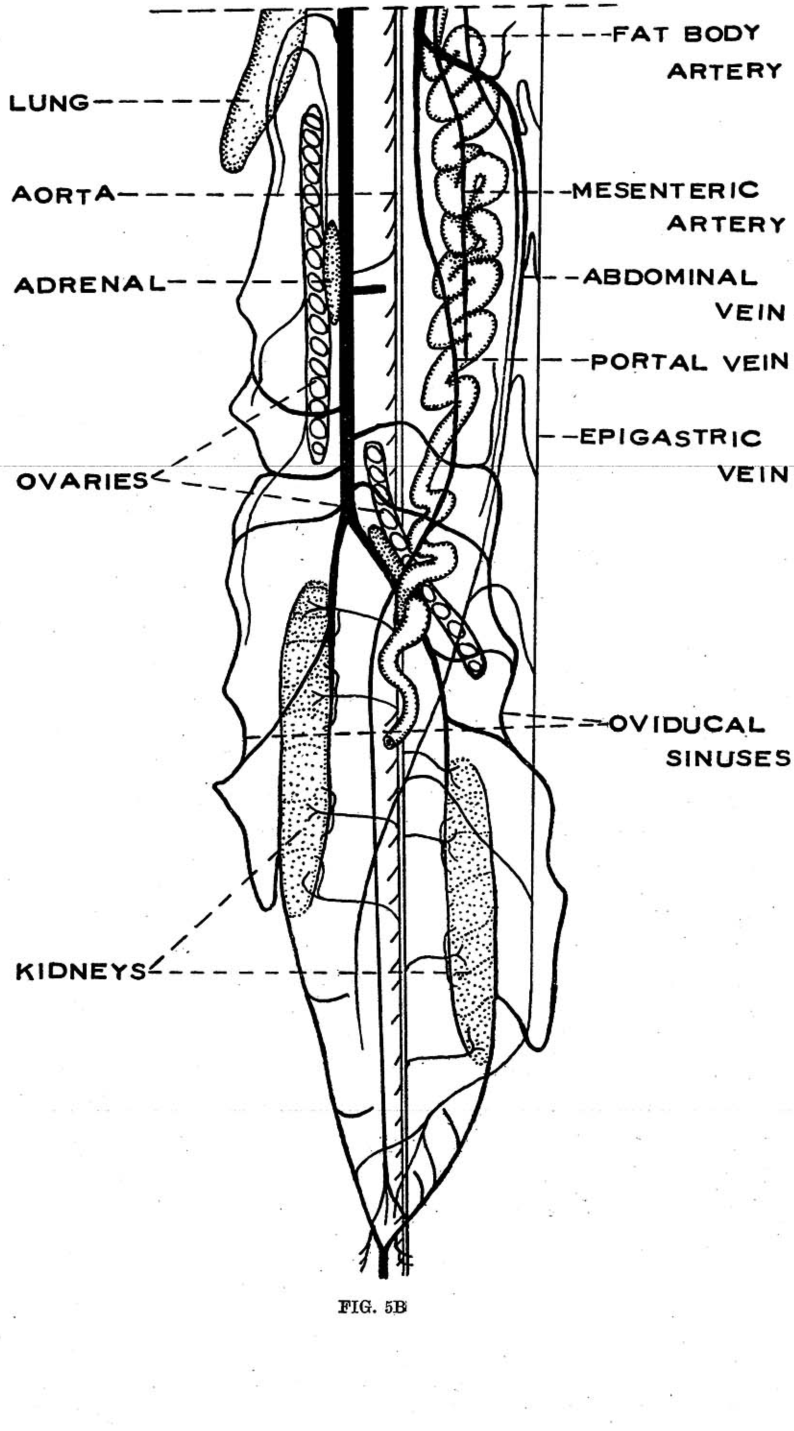
FAT BODY ARTERY
LUNG
AORTA
MESENTERIC ARTERY
ADRENAL
ABDOMINAL VEIN
PORTAL VEIN
EPIGASTRIC VEIN
OVARIES
OVIDUCAL SINUSES
KIDNEYS

FIG. 5B

These veins from the alimentary canal are numerous and difficult to count. All blood leaves the liver through the vena cava. These conditions are general for serpents.

The Pancreas.

The pancreas is large and creamy white in color. It is about a half inch long in large specimens and is a little longer than wide. It lies at the anterior end of the duodenum but is not attached to it except where the ducts pass from the pancreas to the intestine. In specimens that are well filled with eggs the pancreas is crowded up close to the liver but in males and females without eggs it lies farther back.

The fact that the veins from the parietes which enter the portal vein anterior to the pancreas run far forward from their origin in the body-wall in order to reach the portal vein anterior to the pancreas suggests that the pancreas once occupied a more posterior position.

The Spleen.

The spleen is of a dark red-brown or chocolate color. It is nearly spherical and attached to the anterior end of the pancreas. It is not fastened to the intestine.

The Fat Bodies.

The two fat bodies of the abdomen extend caudally to a point about opposite the posterior ends of the kidneys. The right one extends caphalad to just beyond the gall bladder while the left reaches about one inch anterior to the caudal end of the liver in large specimens.

Each body consists of a long, much folded strip of white, adipose tissue well supplied with blood vessels.

The fat body of the neck is single and extends from the heart forward about half the distance to the head. It is a thick, solid mass of white adipose tissue. The posterior end is large and blunt, while the anterior end tapers to a point toward the head.

During starvation the fat bodies may entirely disappear leaving only the blood vessels and connective tissues.

The Ovaries and Adrenal Bodies.

The ovaries vary in position with the adrenal bodies. The right adrenal body lies along the vena cava but the left usually lies along the left efferent renal vein. In three specimens it was situated at the anterior end of this vein and came in contact with the vena cava. In specimen No. 1 the left adrenal body lay wholly along the vena cava a half inch anterior to the junction of the efferent renal veins.

As in other snakes the ovaries are attached by the mesentery to the adrenal bodies and are very closely associated with them. The oviducts extend anterior to the ovaries and when filled with eggs are very large. The left oviduct is short and contains a smaller number of eggs than the right. The right oviduct when filled with eggs extends forward to the pancreas and crowds this organ up close to the liver. The total number of eggs in the right oviducts of seven large specimens was 101, in the left oviducts there were 51. This would indicate that the capacity of the right oviduct is twice that of the left, and gives an average of 21.7 eggs per snake. The largest of these specimens measured 34.5 inches in total length and contained 33 eggs.

The Kidneys.

The kidneys of *Thamnophis* are like those of other snakes in most particulars. They are very deeply lobed. The right kidney often extends beyond the junction of the efferent renal veins. When it does it sends blood into the vena cava through one or more small twigs. In nine specimens which varied in body length from 22 inches to 28 inches, averaging 23.8 inches, the kidneys averaged three inches in length. In the specimen of *T. sauritus sackeni,* which measured 22.5 inches in body length, the right kidney measured 1.4 inches, the left 1.25 inches. If the kidneys in this specimen were normal there is considerable difference in the size of the kidneys in the two species.

Discussion.

The blood system of *Thamnophis* is very similar to that of *Tropidonotus natrix* as described by O'Donoghue ('12). This tends to confirm the belief that the two genera are very closely related.

The genus *Thamnophis* differs from *Zamenis* in that the intercostal arteries plunge into the mid-line of the dorsal parietes and are not paired, while in *Zamenis* they enter to the left or right and are frequently paired (Atwood, '16). In the Boidae (Beddard, '04, '06, '08, '09), the condition of the intercostals varies but they do not enter the mid-line of the dorsal parietes and are usually paired. In their primitive condition it is probable that a pair entered each intercostal space and in the specialized forms reduction has taken place. If this assumption is true *Thamnophis* is rather highly specialized in this respect.

In regard to the right anterior azygous vein *Thamnophis* and *Tropidonotus* (O'Donoghue, '12) stand rather low in the scale of specialization.

The writer ('16) has mentioned finding many trematodes and nematodes in the viscera of *Zamenis constrictor*. Very few of these were found in *Thamnophis*. This comparative immunity may be a factor in the relative abundance of the garter-snakes.

The writer ('16) has previously commented upon the great individual variability of snakes and the advisability of examining many specimens before making statements. Much of the work on the anatomy of the Serpentes is based on the examination of only one or two specimens.

Thompson ('14) gives some notes on the visceral anatomy of one specimen of *T. ordinoides*. His description does not indicate that it differs specifically from the specimens of *T. sirtalis* described in this paper. He states that the maximum number of dorsal scale rows in this species varies from twenty-one to seventeen. This fact alone indicates that it is extremely variable. Ruthven ('08) records cases where certain species of *Thamnophis* gave birth to young bearing the characteristic marks of other species. Many specimens of *Thamnophis* have been differently classified by different authorities. The facts set forth in this paper show that there is great variation in different individuals. In consideration of the above facts it seems likely that the *individual variability* of *Thamnophis* has been too largely taken to represent *specific variability*. The writer desires to express his admiration for the excellent efforts of Ruthven ('08) to synthesize this genus.

BIBLIOGRAPHY.

Atwood, Wm. H.—1916. The Visceral Anatomy of the Black Snake, *Zamenis constrictor*. Washington Univer. Stud. (4) 4; 1–38.

Beddard, F. E.—1903. On the Trachea, Lungs and Other Points in the Anatomy of the Homodryad Snake, *Ophiophagus bungarus*. Proc. Zool. Soc. London, II; 319–328.

Beddard, F. E.—1904. Notes upon the Anatomy of Certain Snakes of the Family Boïdae. *Ibid.*, II; 107–121.

Beddard, F. E.—1904. Contribution to the Knowledge of the Visceral Anatomy of the Pelagic Serpents, *Hydrus platyurus* and *Platyurus colubrinus*. *Ibid.*, II; 147–154.

Beddard, F. E.—1906. Contributions to the Anatomy of the Ophidia. *Ibid.*, I; 12–44.

Beddard, F. E.—1906. Contributions to the Vascular and Respiratory System of Ophidia, and Anatomy of *Boa* and *Corallus*. *Ibid.*, II; 499–532.

Beddard, F. E.—1908. A Comparison of the Neotropical Species of *Corallus* with *Corallus madagascariensis*, and on some points in the Anatomy of *Corallus caninus*. *Ibid.*, I; 135–158.

Beddard, F. E.—1909. Some Notes upon *Boa occidentalis* and *Boa madagascariensis*. *Ibid.*, II; 918–927.

Bronn, H. G.—1890. Klassen und Ordungen des Thierreichs.

Cope, E. D.—1900. The Crocodilians, Lizards, and Snakes of North America. Ann. Rep. Smiths. Inst., 688–705.

Ecker, A.—1846. Der feinere Bau der Nebennieren beim Menchen und den vier Wirbelthierklassen. Braunschweig.

Gratiolet, P.—1853. Note sur le Systèmie Vineux des Reptiles. Journ. de l'Inst. XXI; 60–62.

Hopkinson, J. P. and Pancoast, S. T.—1837. On the Visceral Anatomy of the Python (Couvier) Described by Daudin as the *Boa reticulata*. Trans. Amer. Phil. Soc. U. S., V; 121–134.

Jacquart, H.—1855. Memoire sur les Organes de la Circulation chez le serpent Python. Ann. des Sci. Nat. IV.

O'Donoghue, C. H.—1912. The Circulatory System of the Common Grass-snake, *Tropidonotus natrix*. Proc. Zool. Soc. London, II; 612–647.

Ruthven, A. G.—1908. Variations and Genetic Relationships of the Garter-snakes. Bull. 61, Smith. Inst. U. S. Nat. Mus.

Schlemm, F.—1827. Anatomischer Beschreibung des Blutgefasssysteme des Schlangen. Trev. Zeitscher. Physiol., III.

Thompson, J. C.—1913. Contributions to the Anatomy of the Ophidia. Proc. Zool. Soc. London; 414–425.

Thompson, J. C.—1914. Contributions to the Anatomy of the Ophidia. *Ibid.*, I; 379–402.