SOME ANATOMICAL FEATURES OF THE TIGER SNAIL, *ANGUISPIRA ALTERNATA* (SAY)

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The present study is an attempt to understand the organization of the viscera of the very common Indiana land snail, *Anguispira alternata*, a widespread complex, which up to this time has been generally left in one species. The study has been made at Indiana University, Zoology Department, in connection with a study on secretion of shell, particularly of this same snail. All specimens were collected at Bloomington, Indiana.

The anatomical drawings have been taken from several dissections, perhaps twenty or twenty-five in number. After killing the snail, the soft parts were extracted from the shell by immersing shell and snail in nearly boiling water for from fifty to sixty seconds. Some of the dissections were made from fresh material, other from material hardened several days in 70% and later 50% alcohol. The histological sections were made from four animals. Fixation was in Carnoy-Le Brun fluid or in a special fixative of equal parts of 1% chromic acid, 3% potassium dichromate, saturated solution of corrosive sublimate, 95% alcohol, and 10% formalin which I was trying experimentally. Tissues were fixed from one to three minutes. After passing through the usual gradation of alcohols, xylol, xylol-paraffin, and embedding, the paraffin sections were cut at either five or ten micra. Ehrlich's acid haematoxylin and eosin, or Heidenhain's iron haematoxylin were the two staining methods used.

The pioneer work on anatomy of land snails in this country was done by Dr. Joseph Leidy for Dr. Amos Binney from 1844-1851, and was published in the first volue of Amos Binney's "Terrestrial mollusks and shells of the United States" in 1851. Three figures were given on the anatomy of *Anguispira* (then *Helix*) *alternata*, which though accurate from the standpoint of representing the structures, were inaccurately labelled. Pilsbry in his "Guide to the study of Helices" (Vol. IX, Series II, Tryon's Manual of Conchology 1894) gives a figure of the genitalia of *Anguispira* (then *Pyramidula*) *alternata*. I have not had access to this article, but I have had copies of the figures during the present study. Valuable comparative material on other species is given in Simpson's "Anatomy and physiology of *Polygyra albolabris* and *Limax maximus* and embryology of *Limax maximus*" (Bull. N. Y. State Mus. No. 40, Vol. 8, Oct. 1901) and in Simroth's and Hoffmann's work in Bronn's "Klassen und Ordnungen des Tier-Reichs" (Bd. 3, Abt. 2, 1908-1928).

While lack of space makes it imperative that the figures tell their own story, the following observations are given as supplementary:

"Proc. Ind. Acad. Sci., vol. 42, 1932 (1933)."

The digestive system (Fig. 3) is remarkably adapted to the extension of the animal. The buccal mass, containing the jaw and radula (not shown) are pulled well down into the body when the snail emerges from its shell. How much of the oesophagus is involved in this stretching is problematic, though its slender size seems to allow it to extend into the expanded body. Kinked salivary ducts perhaps allow for movement of the head region in crawling, feeling, and feeding. The apical (right) lobe of the liver and lower (left) lobe open by wide hepatic ducts near the origin of the intestine as shown in figures 3 and 7. Simpson explains that the liver of snails is more like a pancreas in function since bilary liquids are absent. He suggests the name "digestive gland" rather than "liver." Other authors however state that the hepatic cells store digested nutritive material absorbed from the intestine, which is a function of the liver. Golden secretion granules (Fig. 9) are very apparent in the cells of the lobules. Of 105 snails "pulled" on April 20, 1932, 5 had black livers, though all had been collected on the same stone wall on I. U. campus. The ordinary color of the liver is a rich brown, almost tan. The stomach shows no differentiation of a crop. If that organ be present, it is probably represented by a slight swelling of the oesophagus shown by some specimens. The path of food and of wastes is as follows: mouth, buccal cavity (with calcareous jaw and radular ribbon), oesophagus, stomach, intestine, rectum, and anus. The sigmoid loops of the intestine, where most of the absorption takes place, are pressed into the liver. Microscopic examination of the oesophagus and stomach of *Anguispira alternata* shows that the food of the specimens examined consists mostly of bits of superficial angiosperm tissue, as disclosed by the radular filings of cutin, epidermal cells, occasionally epidermal cells with palisade layer, tracheae, and plant hairs. There are also many spores and filaments of fungi, possibly Phycomycetes or Ascomycetes, and occasionally bacteria and diatoms. Food particles, except for insoluble material, are rarely identifiable beyond the stomach.

The circulatory system (Figs. 2 and 6) has been worked out only in its grosser aspects. The course of the blood is said to be: auricle, ventricle, aorta, arteries, sinuses where blood bathes the organs, pulmonary sinus, network of veins on roof of pulmonary cavity where blood is aerated, pulmonary vein, auricle. Some authors report in certain parts of the body that arteries lead to capillaries, from which veins lead to pulmonary sinus, then through fine veins of the renal organ or of the pulmonary roof to the pulmonary vein. The circulatory system is said to play an important part in emergence from the shell. "The snail emerges from its shell by forcing the blood into great spaces in its foot and front region, but withdraws by muscular action." (Ellis, British Snails, p. 19.) The anterior part of the body when retracted is turned outside in. Likewise the tentacles are pulled in by retractor muscles "like turning the fingerstall of a glove outside in," but are forced out by blood turgor. Ellis states that when blood pressure of the snail is used during copulation for penial erection, the tentacles droop due to withdrawal of blood from the tentacles. Thus snail emergent and retractile movement is largely accomplished by blood turgor working against retractor muscles, instead of extensor muscles vs. retractor muscles. The blood is practically clear or faintly bluish in those snails having the copper compound, haemocyanin. The Planorbidae have red blood, which Fulton says is due to haemoglobin (Quart. Jour. Mic. Sci. N. S., Vol. 66, p. 364, 1922). The number of heart beats varies greatly in *Anguispira alternata* due to activity, temperature, and possibly other factors. In retracted tiger snails of various ages at room temperature, the heart beat varied from 37 upward beyond 60. During activity the larger number increased, the highest count being 92 beats per minute. In spite of the variation, the pulsation is very regular in this species, in marked contrast to the irregular flare-up in rhythm observed in *Polygyra tridentata* (Say).

Anguispira alternata shows no muscular waves on the sole of the foot in locomotion. In *Polygyra elevata* (Say) 52 pedal waves per minute are to be observed confined to a broad median part of the sole when the animal is progressing. *In Anguispira alternata* longitudinal wrinkles appear in the sole during locomotion, and under the binocular ciliary action is evident on the sides of the foot between the sole and lateral groove of the foot.

The nervous system consists chiefly of a supraoesophageal ganglionic mass and an infraoesophageal ganglionic mass, connected to the former by two connectives on either side. These have divisions as shown (Fig. 5).

In connection with the reproductive system, I have the following notes. *Anguispira alternata* is hermaphroditic but not viviparous. I have no data as to when copulation occurs. The ovotestis of a specimen taken on April 16, 1932, shows in section (Fig. 8) large almost mature eggs and immature male germ cells, the latter being separated from the former in the organ. Mature male germ cells are present in this same section in the spermatheca, the duct of the same, and in the seminal groove (Fig. 7). Egg laying in 1932 started about June 1st and continued well through June in specimens kept in containers. All eggs laid in these containers (8 in all) were solitary. F. C. Baker (Mollusca of Chicago Area, Part 2, p. 208, 1902) found eggs of *alternata* in agglutinated clusters of from 20 to 80 eggs, and placed the hatching time at 30 days. In my containers 2 eggs laid around June 1st, hatched in about two weeks. The young snails had whorls of 1¼ and 1½ whorls respectively when first found. The eggs are ovoid, with a very elastic shell which is frosty white. This shell is enclosed with an almost-liquid gelatinous layer. Inside the shell is a great amount of semi-fluid material in which the embryo is suspended as a mere speck. The diameter of the eggs vary. One measured 3 x 2½ x 2½ mm., though the diameter may be as low as 1.7 mm.

The eggs and sperm are each formed in different parts of the ovotestis and mature at different times. Each descend through the hermaphroditic duct at different seasons. Shortly after its convoluted portion this duct separates into a seminal grove and an oviduct. Near the junction of the hermaphroditic duct with these partially separated tubes is a small pocket, by some conceived to be a seminal vesicle, by others, an accessory gland of the duct called a talon (ac. g. of Fig. 4).

In the same region a large banana-shaped albumen gland opens into the reproductive tract. It is suposed to supply the albuminous coats for the eggs. In the region of the partially separated tubes, the sperm duct or seminal groove is surrounded by glands, while the oviduct wall is much folded to form uterine lobes, which are so extensive that they form uterine pouches opening into the oviduct (ut. of Figs. 4 and 7). Peculiar cells (x. of Fig. 10) are perched on or are lodged quite regularly between the wall cells of these uterine lobes. They were found in snails killed on April 16 and May 2, 1932. As quite mature live germ cells were found in the ovotestis of several individuals examined on June 28, 1932, I can not conceive of these as being a stage of the developing sperm. They may be developing egg cells though if such be the case, they are much smaller than the eggs in the ovotestis, which might be interpreted that they are eggs which have undergone a pycnotic change. Another likely explanation is that they are parasites, as Leidy's spermathecal parasites figured by Simpson (reference as above, p. 261, Pl. 13, Fig. 6). The naming of uterine lobes and adjacent structures is yet in confusion. Robson (Quart. Jour. Mic. Sci., N. S., Vol. 66, Fig. 9, p. 176) shows evidently the same organ in a water snail under the name of "oviducal gland." The cells of the wall are the same but no cells corresponding to these (x) cells are present.

Nearer the front of the animal the oviduct and sperm duct separate, the one going into the vestibule, the other as the vas deferens entering the base of the penis sac, within which it terminates in the penis. The duct of the spermatheca, which is especially long in this species, also opens into the vestibule (or vagina). It is independent of the other organs throughout its course. Though data on copulation are lacking, it is supposed that cross-fertilization occurs (parthenogenesis and occasional self-fertilization, however, are known in some aquatic snails). In the tiger snail, it is probable that the ripe sperm cells are mutually transferred from the reproductive system of one snail to that of another snail before the eggs mature. The sperms are stored in the spermatheca until the eggs mature. *Anguispira alternata* has no dart, dart sac, large accessory glands, or flagellum as does the European *Helix pomatia*.

This article is written not only with the research aim in view, but also to point out the chief anatomical features of this snail so that high school and college biology teachers may use the material here given, along with that on *Helix pomatia* in Hegner's textbook, to compile their own laboratory sheets. *Anguispira alternata* is usually abundant near old stone walls, limestone outcroppings, or under logs in moist places, anywhere in the northern states from Iowa to the Atlantic seaboard. It is often as plentiful in town as in the woods. Its flame-red markings sometimes separated into red spots, or at other times jaggedly united show very conspicuously on its yellowish brown groundwork (Fig. 11). Its gregarious habits are also favorable for collecting. Tiger snails come out of their hiding places in great numbers before or after a thunderstorm, when they can be gathered literally by the hundreds.

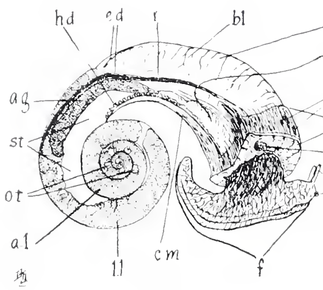
FIGURE TITLES AND EXPLANATION. *Anguispira alternata* (Say).

1. Apical view of animal, X 4, as it was pulled from shell after immersing in warm water to loosen the hold of the columellar muscle.
2. Basal view of animal, X 4.
3. Digestive system, apical view.
4. Reproductive system, circumferential view.
5. Nervous system, dorsal view.
6. Heart, renal organ, and adjacent structures, viewed basally.
7. Vertical section, near midline, through whorls of spire and upper part of body whorl. Drawn to scale. Special fixative (see text). Stain-Iron hematoxylin.
8. A small lobule of the ovotestis in section. Special fixative. Outline by camera lucida. Iron hematoxylin.

9A. Section through a lobule of the liver. Special fixative. Outline by camera lucida. Ehrlich's acid hematoxylin and eosin.

9B. Enlargement of region between a and b of Fig. 9A. Outline by camera lucida.

10. Section of wall of uterine lobe. Special fixative. Outline by camera lucida. Iron hematoxylin.
11. Side view and basal view of shell of *Auguispira alternata.*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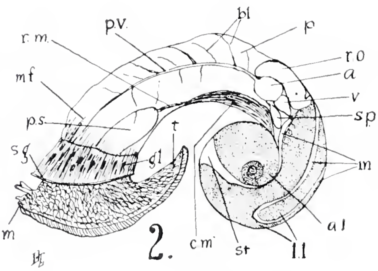
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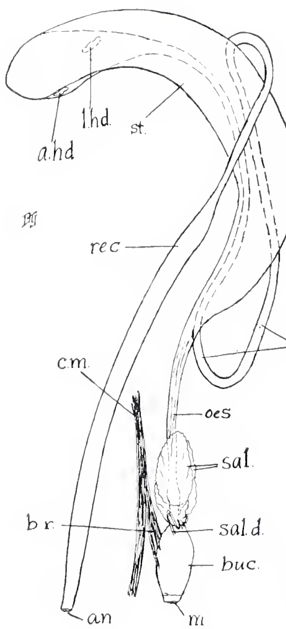
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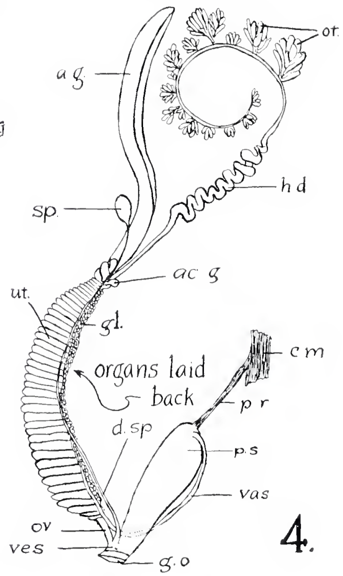
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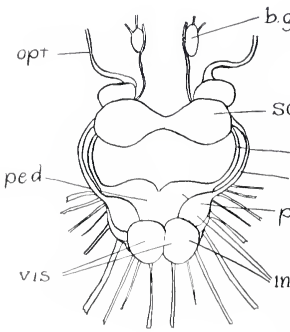
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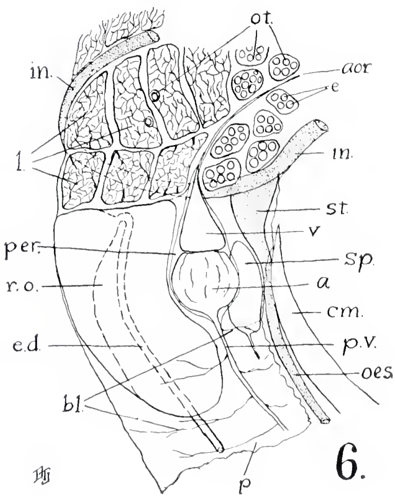
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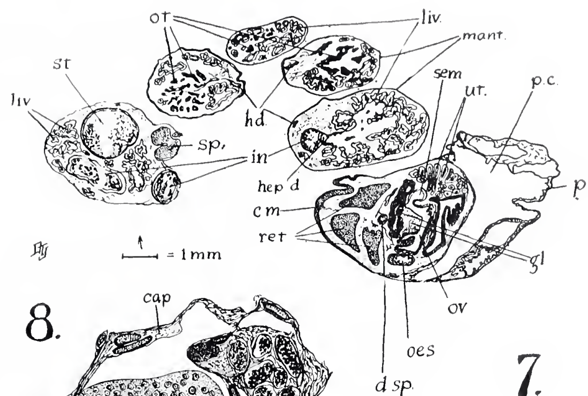

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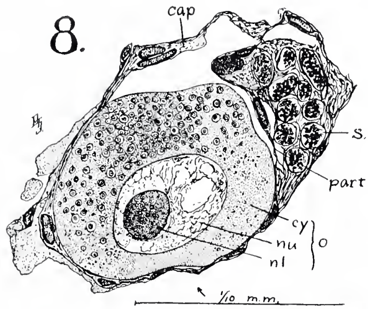

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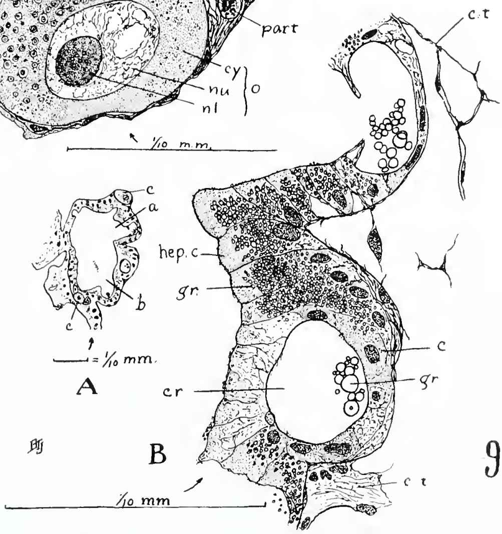

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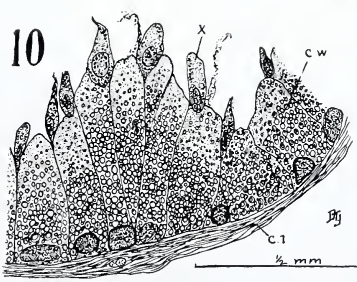

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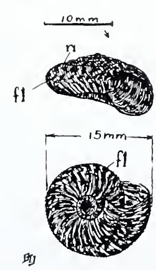

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11.

KEY LETTERS FOR ALL FIGURES

a auricle
a-b lines between which enlargement represented in Fig. 9 was made
ac.g accessory gland or talon
a.g. albumen gland
a.h.d. apical hepatic duct
a.l. apical lobe of liver
an. anus
ant. anterior connective
aor. aorta
b. see a-b, above
b.g. buccal ganglion
bl. blood vessel
b.r. buccal retractors
buc. buccal mass
c. non-granular cell
cap. capsule
c.m. columellar muscle
cr. crypt
c.t. connective tissue
c.w. cells of wall of uterine lobe
cy. cytoplasm
d.sp. duct of spermatheca
e. eggs
e.d. excretory duct
f. foot
fl. flame bands of color
gl. glands
g.o. genital opening
gr. granules
h.d. hermaphroditic duct
hep.c. hepatic cell
hep.d. hepatic duct
in. intestine
inf. infraoesophageal ganglionic mass
l. lobules of lower lobe of liver
l.h.d. lower hepatic duct
liv. liver
l.l. lower lobe of liver
m. mouth
mant. mantle of the spire
m.c. mantle collar
m.f. muscle fibers
nl. nucleolus
nu. nucleus
o. ovum or egg
oes. oesophagus
opt. optic nerve
ot. ovotestis or hermaphroditic gland
ov. oviduct
p. pulmonary cavity, roof of
part. partition
p.c. pulmonary cavity
ped. pedal portion of ganglionic mass
per. pericardial cavity
pl. possibly the pleural portion of ganglionic mass
post. posterior connective
p.r. penis retractor
p.s. penis sac or verge sac
p.v. pulmonary vein
r. rectum
r.a. respiratory aperture
rec. rectum
rep. reproductive organs (accessory)
ret. retractor muscles
ri. rib on shell
r.m. retractor muscle of penis
r.o. renal organ
s. immature male germ cells
sal. salivary glands
sal.d. salivary ducts
sem. seminal groove
s.g. supramarginal groove of mantle collar
s.o. supraoesophageal ganglia
sp. spermatheca
st. stomach
t. tail
ten. tentacles
ut. uterine lobes
v. ventricle
vas. vas deferens
ves. vestibule
vis. visceral portion
x. problematic cell in uterine lobe.