Anatomy of the Digestive System of *Radix* sp. (Bassomatophora: Lymnaeidae) from Lake Taal, Batangas

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ABSTRACT

The digestive anatomy of *Radix sp.* from Taal Lake, Batangas, Philippines, was studied. The major differences with the other known lymnaeids previously described from the Philippines are found in the radular formula, presence of intestinal caecum, the orientation of the pylorus and the intestine, and the number of loops made by the intestine around the stomach and the digestive gland.

INTRODUCTION

In the Philippines, three species of lymnaeid snails have previously been reported. *Bullastra cuminguiana*, *Austropeplea philippinensis*, and *Radix quadrasi*. In 1995, Pagulayan and Mamaril reported the presence of another lymnaeid snail from Lake Taal. They noted the peculiar characteristic of the shell of this snail. The snail was classified under the genus *Radix* because, like that of *Radix quadrasi*, its shell has a collumenar twist. However, unlike *R. quadrasi*, the snail has a very low spire and a considerably large aperture.

Although the snail belongs to the genus *Radix*, its exact species has yet to be confirmed. It has thus been temporarily identified as *Radix auricularia* sp. This study reports on the anatomy of the digestive system of *Radix* sp. from Lake Taal, in the hope of clarifying its taxonomy.

MATERIALS AND METHODS

Collection of the Specimen

Samples of *Radix* sp. (Fig. 1) clinging on *Vallisneria* leaves were collected from August to October 1996 from Lake Taal. They were later placed in plastic containers and brought to the laboratory. Before dissection, the snails were first relaxed for 24 hrs with the use of menthol crystals, fixed in formalin for 24 hrs, and then stored in 70 % ethyl alcohol.

Dissection

Twenty snails, having shell length of 8.0 - 11.0 mm, were dissected under a stereozoom microscope. The dimensions of each of the parts were approximated by means of a Vernier caliper. The whole system was then drawn to scale.

The shells were cracked and the soft tissues were carefully removed. An incision close to the middorsal line of the head was made. Muscles and connective tissues were removed to expose the buccal mass, salivary glands, and esophagus. The mantle was then cut at the region of the collar, where it is attached to the columellar muscle. This was folded back, along with obscuring fibers and tissues, to reveal the visceral hemocoelus containing the digestive organs. In studying the radula, the buccal mass of a relaxed snail was separated from the rest of the digestive system. This was left for several hours in 10% NaOH solution in order

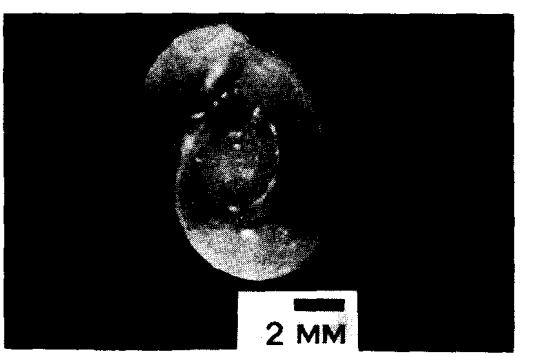

Fig. 1. The shell of *Radix* sp.

Key words: digestive system, anatomy, *Radix* sp., Lake Taal, Batangas, Philippines

to remove the tissues surrounding the radula. The radula was then washed in distilled water and stored in 75% EtOH. The radula was air-dried, mounted in copper blocks, gold-coated, and then viewed through a JEOL scanning electron microscope.The radular formula and the form of the different teeth were noted.

RESULTS

The digestive system of *Radix* sp. consists of a mouth, a buccal mass, a pair of salivary glands, an esophagus, a stomach, a caecum, an intestine, an anus, and a digestive gland, the liver (Fig. 2). Descriptions of each digestive organ are presented in Table 1.

External morphology of the digestive tract

The mouth (MO) is located at the middle anteroventral portion of the head. It opens into the buccal mass (BM), which occupies the anterior third of the body cavity.

The esophagus (ES) protrudes from the dorsoposterior end of the buccal mass. It continues posterioventrad , bending slightly to the left to occupy the middle third of the body cavity. It then passes left of the uterus, moves up slightly, and turns to the right before finally joining the stomach (ST).

The salivary glands (SG) are a pair of yellowish lobe structures situated oblique to the sides of the esophagus. The ducts (SD) of these glands connect the anterior portion to the dorsoposterior surface of the buscal mass.

The stomach (ST) is located in the posterior portion of the body cavity, together with the intestine, caecum, and the digestive gland. It is partly hidden by the curvature of the digestive gland, such that the latter must first be deflected before the entire stomach region can be revealed. The stomach consists of a crop (CR), a gizzard (GI), and a pylorus (PY).

The crop (CR) connects the esophagus to the gizzard. Although there is no definite boundary dividing the posterior portion of the esophagus and the crop, the latter can be distinguished by its longer diameter.

The gizzard (GI) is made up of two very muscular gizzard lobes connected to each other by the gizzard tendons, the tough fibers having a silvery texture. The right lobe of the gizzard is directed dorsally while the left lobe is directed ventrally.

The pylorus (PY) is a tapering tube at the immediate posterior of the gizzard. Its walls narrow slightly in the area where it unites with the gizzard to accommodate the rear opening of the latter. From the gizzard, the pylorus curves to the left, then moves anteriad, passing the left lobe of the gizzard before joining the intestine (IN). The two digestive gland ducts (DGD) connecting the digestive gland to the digestive tract are found at the junction of the pylorus and the intestine.

Attached to the proximal segment of the intestine (IN) is the small caecum (IC), just a short distance from the stomach. The intestine follows a path anteriad along the left lobe of the gizzard, bends sharply to the right at the

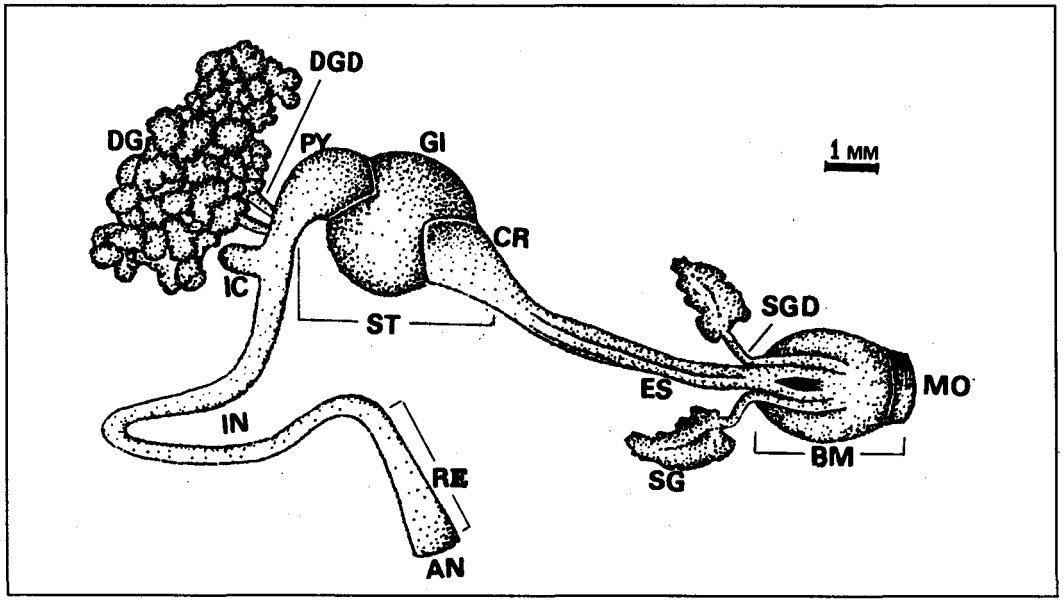

Fig. 2. Scale drawing of the alimentary system of *Radix* sp.

Table 1. Summary of the features of the different organs of the alimentary system of *Radix* sp. from Lake Taal.

Organ	Location/Position	Color	Shape	Others
mouth	middle anteroventral portion of head		triangular	
buccal mass	occupies anterior third of the body	cream to pale peach	pear-shaped	may or may not be pigmented; contains the jaw and the radula
salivary duct	arises from dorsoposterior surface of the buccal mass	cream	elongated	smooth-walled; branches out to each gland
salivary glands	found on each side of the anterior segment of the esophagus	grayish	elongated but irregular	granulated or spongy in texture
esophagus	arises from dorsoposterior end off the buccal mass; occupies middle third of the body cavity	light cream	elongated	thin-walled, smooth exterior is covered by a thin layer of connective tissue
crop	posterior portion of the body; connects the esophagus to the gizzard	beige	elliptical (dorsally)	soft and fleshy; bulb-like (laterally); thin-walled
gizzard lobes	between the crop and the pylorus	pale peach	elliptical	tough and muscular; connected by tough fibers
pylorus	immediate posterior of the gizzard	translucent and beige	tapering	soft and fleshy
caecum	junction of pylorus and the intestine	cream	oval-shaped; slightly tapering	
liver	surrounds the stomach at the posterior end of the body cavity	cream to light yellow (young snails) light brown (in old snails)	irregular	covered by a thin layer of muscle; atrophies in older snails
Intestine	arises from the pyloric end of the stomach	cream	elongated	long and thin-walled
rectum	right middle section of the body	cream		greater in diameter than the intestine
anus	right midventral portion of the body			

region of the crop and passes over it toward the level of the right lobe of the gizzard. At this point, the intestine becomes evidently thinner in diameter.

The distal half of the intestine follows a course along the right half of the stomach and descends over the right contour of the liver. It passes the tissues of the liver superficially, then bends back on itself as it moves anteriad, thereby forming a U curve. It finally moves further anteroventrad into the right middle section of the body cavity, where it gradually increases in diameter to form the rectum (RE).

The digestive tube terminates in the anus (AN), located at the right midventral portion of the body.

The Radula

The radula is a very thin structure consisting of numerous transverse rows of teeth. When mounted whole and spread out, the radula is more or less quadrangular in form. It is broad at the base and gradually tapers posteriorly.

Examination of a single radula shows the presence of around 75 rows of teeth, each row consisting of a central tooth, seven lateral teeth, nine intermediate teeth, and three or four marginal teeth (Fig. 3). Each transverse row of teeth follows a radular formula of 19/20-1-19/20 (3/4-9-7-1-7-9-3/4). A single longitudinal row of median or central teeth (Fig. 4a) is found at the middle of the radula. The central teeth

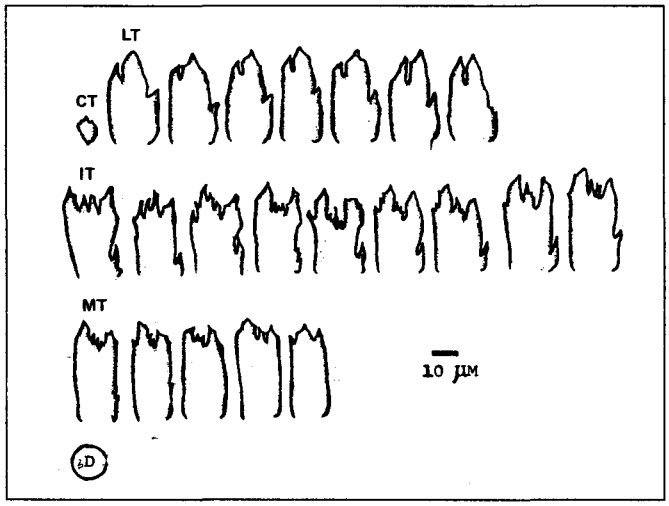

Fig. 3. Schematic diagram of the right side of a row of teeth (central tooth included).

are generally unicuspid, although cusps may vary in form and symmetry . Some are more pointed than the rest. Other primary cusps may also bear a number of small secondary denticles. These are also much smaller in size compared to all other tooth types.

The lateral teeth (Fig. 4a/4b) are found on either side of the median tooth. These are distinctly tricuspid. The inner cusp or endocone is small but relatively long and narrow. It is slightly directed toward the large middle cusp or mesocone. The dorsal tip of the middle cusp is pointed, but is less sharp compared to cusp on its side. In some cases, the mesocone has additional swellings along its lateral margins. The outer cusp or ectocone is also small and found near the base of the tooth. The side of the mesocone leading to the endocone is shorter compared to the side leading to the ectocone.

The intermediate teeth (Fig. 4b) are located next to the laterals on either side. They are multicuspid, although for the most part, it is the endocone which breaks off into smaller, and narrower, thorn-like cusplets. The number of cusplets formed from the division of the endocone varies from two to six. The mesocone has small swellings on either side of the main cusp. The ectocone can break off into two or three cusps, but only one of these usually becomes most prominent.

The marginal teeth (Fig. 4c), the last of the morphological tooth types, are the outermost groups of teeth on each side of a transverse row. The endocones possess secondary cusplets on the side bordering the mesocones. The ectocones appear to degenerate or be absent from the base of the teeth.

The teeth found at the posterior and lateral borders of the radula are incompletely formed. All teeth at the posterior portion of the radula have more or less the same blunt shape when viewed dorsally. At this region, formation of cusps is not yet apparent. Marginal teeth occupying the extreme lateral borders of the radula have small and poorly defined cusps. Differences among the four morphological tooth types become evident anteriorly as cusps assume more developed forms.

DISCUSSION

A comparison of the various lymnaeids studied thus far shows that their alimentary tracts are more or less similar in general structure and form, varying mostly in terms of size and color. Table 2 shows the differences in color of the digestive organs of various lymnaeids.

The radula of *Radix* sp. from Lake Taal is similar to that of *L. emarginata* and *R. quadrasi*. The radula of these species are more or less quadrangular in form and are made up of numerous transverse rows of teeth. The four morphological tooth types are present in all three species, although the presence of marginals in *L. emarginata* was

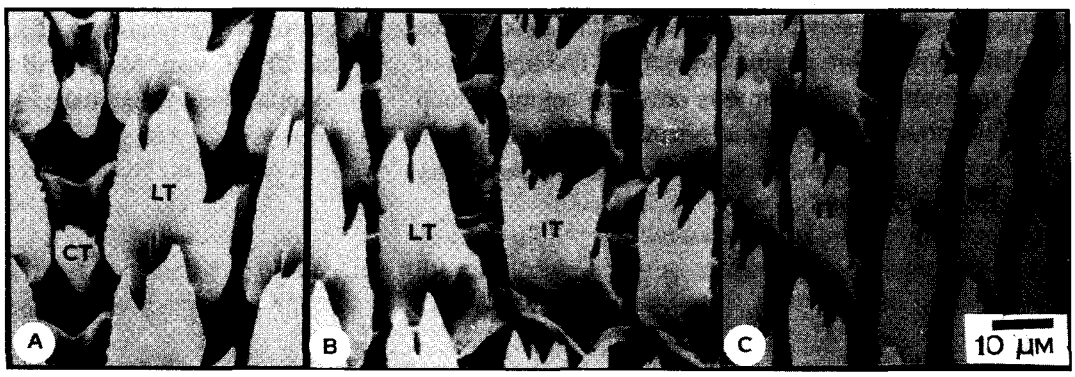

Fig. 4. Scanning electron micrograph of the radula; 4a. Central tooth and lateral teeth; 4b. Lateral and intermediate teeth; 4c. Intermediate and marginal teeth.

Table 2. A comparison of the colors of the digestive organs of various lymnaeids.

Organ	*Radix* sp.	*L. emarginata*[1]	*L. s. appressa*[2]	*L. humilis*[3]	*M. cumingiana*[4]	*R. quadrasi*[5]
buccal mass	pale peach	bluish	bright chestnut red	light red orange	red	red
salivary glands	yellow	yellow	yellow	yellow	yellow	yellow
crop	beige	yellow	yellow to gray	?	red	red
gizzard	beige	almost black	chestnut red	bright red orange	red	red

[1]Baker 1900; [2]Carriker 1946; [3]McCraw 1957; [4]Pagulayan et al. 1986; [5]Pagulayan et al. 1996

not explicitly stated (Baker 1900). The number of cusps forming each tooth type and the radular formula followed by each transverse row of teeth are the main features which vary among these snails. For instance, the gross radular formula of *Radix* sp. is 19-1-19 or 20-1-20. In *L. emarginata*, the formula is 35-1-35 (Baker 1900), whereas in *R.quadrasi*, it is 37-1-37 (Remigio 1983).

The presence of a caecum along the junction of the pylorus and the intestine of a lymnaeid has been shown only in *L. stagnalis appressa* by Carriker (1946). Baker (1900) mentioned a similar inconspicuous organ in his work, but he identified the organ as the pancreas. Other researchers consider it absent among lymnaeids (cf. Carriker 1946). It has not been described in the previously studied lymnaeid snails from the Philippines.

The size, shape, and color of the liver are similar for most lymnaeids. However, the shape of the liver of *Radix* sp. more or less resembles that of *M. cumingiana*. This may be explained by the fact that both snails have shells that exhibit a very short spire.

In 1951, Hubendick reported that aside from the radula, the remaining parts of the digestive system have variations of no comparative morphological value. Comparative studies of the digestive anatomy that are based solely on color and size will yield the same results. It is interesting to note, however, that unlike most lymnaeids, the pylorus and the intestine in *Radix sp.* from Lake Taal do not turn right and move anteriad to pass the right lobe of the gizzard. Furthermore, in most lymnaeids, the intestine makes three complete loops before joining the rectum. The intestine of *Radix* sp. from Lake Taal makes only one complete loop around the stomach. This type of orientation of the digestive tract has been so far described only in *Myxas cumingiana* (Pagulayan et al. 1986).

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