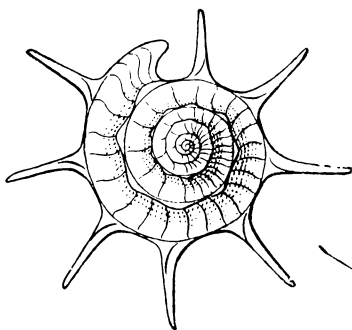


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マメタニシの解剖

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Anatomy of Parafossarulus manchouricus Bourguignat
(Bithyniidae)

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(図版, Plates 17—19)

Parafossarulus manchouricus is a fresh-water snail widely distributed in Japan except in Hokkaido and was studied by Muto (1918, 1919) to be the appropriate first intermediate host of the Chinese liver fluke, *Clonorchis sinensis*. As to the species of the Japanese specimens opinion has differed by the workers. Sugihara (1954) reached the conclusion on the morphological studies on the shell and radula that the Japanese specimens were the same as those from the continent, namely, *Parafossarulus manchouricus* Bourguignat, but his studies were not performed on anatomical base. No study has been made on the anatomy of the snail and the anatomical information would contribute to its classification.

Material and method

The material used was collected at Okayama City by the late Mr. Waichi Hatakeda in December 1959. Dissection was made under the stereoscopic binocular dissecting microscope of from 24 to 48 magnifications with a living snail removed from the shell and pinned down in a small Petri dish.

Results

1. External morphology. The shell is whitish yellow or occasionally greenish in color according to the presence of algae attached on the surface, with

several raised spiral lines or lirae; the outer lip slightly thickened; the apex frequently eroded in the full grown shells; the operculum broad oval in outline, calcareous, concentric with the nucleus near the center. The shell scarcely shows sexual dimorphism, but generally speaking, the male shells somewhat more slender than those of the female (Pl. 17, figs. 1, 2).

The animal has an elongate proboscis and a pair of slender, filiform tentacles near the outer base of the proboscis. The eye lies at the outer base of the tentacle, where the tentacle is somewhat swollen externally. The mantle siphon projects over the rim of the aperture, posterior to the right tentacle in an extended animal. The sole is of medium size and ovoidal, truncated at the front margin. The operculum is attached to the postero-dorsal part of the foot and broad ovate in outline. The animals are yellowish brown and the sole is lighter in color than the body (Pl. 17, fig. 3).

2. Internal morphology. When the mantle is cut longitudinally along the rectum and pinned aside, the arrangement of the frontal visceral organs will be ready for observation. The male specimen has the conspicuous penis, which is attached to the dorsal surface of the body, somewhat posterior to the level of the base of the tentacle and is posteriorly succeeded by a whitish "ridge-like projection" on the floor of the mantle cavity. This projection reaches the apical end of the mantle cavity, and there the pericardium borders on and the renal orifice opens into the cavity. The ctenidium extends over the inner surface of the mantle on the left side from the part near the anterior mantle edge to the apical-most part of the mantle cavity; on the right side lies the rectum along the elongate prostate gland of a light yellowish color to terminate near the right anterior edge of the mantle. Adjacent to the pericardium is the yellowish brown kidney. The midgut gland is spiral in shape and occupies a few apical whorls, and the stomach borders on it anteriorly.

In the female specimens the organs are generally equal to those of the male in arrangement, except for the genitals. That is to say, the oviduct opens slightly posterior to the anus. The "ridge-like projection" on the floor of the mantle cavity is also observed in the female.

Alimentary system: (Pl. 17, figs. 4, 5; Pl. 18, figs. 8, 9, 10, 11, 12)

The small buccal mass is oval when viewed dorsally and elongate ovate when viewed laterally, and is light brown in color except for the dorsal part which is more whitish. The radular sac is relatively short and attached to the ventral side of the buccal mass. Dorsal to the sac a set of retractor muscles occurs. The salivary glands are dorso-ventrally flattened, shorter than the buccal mass, orange yellow in color and are joined to the buccal mass near the posterior end.

The esophagus is a slender canal and swollen slightly in the middle portion. It passes posteriorly through the lymph space or haemocoel in the ridge-like projection and is joined to the stomach at its posterior end after running along the left side of the stomach.

The stomach receives the midgut gland ducts at the ventral side, near the esophageal opening into the stomach and is divided into two portions. The anterior portion of the stomach has a relatively large gastric shield near the center, but is hardly provided with the inner folds; while the posterior portion consists of the canal and crystalline style sac.

The midgut gland is dark brown in color and contains numerous dark granules. The right lobe of the gland is remarkably greater than the left, though the border between these lobes is indistinct. The left lobe is situated ventral to the stomach. The ducts of these lobes are united into a thick tube to pour into the stomach near the esophageal opening to it.

The radula has 1 central, 2 lateral, 2 inner marginal, 2 outer marginal teeth in a transverse tooth row. The central tooth is symmetrical and provided with 1 great, pointed central and 2 smaller lateral apical cusps and with 6 basal cusps; the lateral tooth with 1 large central cusp and 3 on each side at the anterior end; the inner marginal tooth with about 14 small cusps of almost equal size; and the outer marginal tooth with about 12 minute cusps almost equal in size. The cusps of these teeth vary in number according to individual.

Reproductive system: (Pl. 18, figs. 13, 14, 15, 16, 17,; Pl. 19, figs. 24, 25)

The male system consists of the testis, vesicula seminalis, vas deferens, prostate gland, and penis. The testis is orange yellow in color and large, elongate in shape, extending over a few apical whorls of the midgut gland,

and is of a granular structure, but smooth at the surface. The vas deferens, arising from about the middle of the columellar side of the testis, is dilated and twisted about a half of the way from the testis to the prostate gland. This dilated portion is also called the "vesicula seminalis", because of the presence of the white, mucous sperm. The sperm in this portion contains numerous typical spermatozoa together with round and pyriform cells. The typical spermatozoon is composed of the very short "head", 5.4μ , and long "tail", 60μ in length.

The prostate gland is a large, elongate, light yellow organ and lies internally along the rectum. It receives the vas deferens at the posterior or upper end and gives rise to the deferent duct of a light yellow color from the anterior or lower end to the penis. This duct passes through the subjacent tissues of the epithelium and opens at the tip of the penis.

The penis is located on the floor of the mantle cavity, slightly posterior to the tentacles and is elongate sub-triangular in shape when retracted. Moreover, it bears a project or the flagellum at the anterior third on the left side, which is about 12 mm in length, namely about five and a half times as long as the penis. The flagellum is frequently observed to be extended in the living specimens. In the proximal part of the penis, a kind of white, elastic, convolved tube or the cul-de-sac of the flagellum is seen through the thin skin. The open end of the tube is at the tip of the flagellum and the other end is closed. The white mucous fluid in the cul-de-sac contains round and pyriform cells, the round cells measuring about 11μ in diameter and having a small nucleus near the center. The round cells are almost equal in size and shape to those found in the sperm in the vesicula seminalis. The typical spermatozoa were not found in the cul-de-sac.

The female reproductive system is composed of the ovary, oviduct, spermatheca, gonopericardial diverticulum, and mass-membrane gland. The ovary is composed of divergent diverticula and is dark yellow, extending along the columellar side of the spiral midgut gland in about one and a half apical whorls. The oviduct originates at about the midst of the ovary on the inner side and runs along the inner surface of the spiral midgut gland to be convolved near the posterior end of the mass-membrane gland where a small

pouch, the gonopericardial diverticulum, occurs. The looped oviduct then bifurcates into the spermathecal duct and the duct passing through the mass-membrane gland. Moreover, the repeated dissections revealed the presence of the vaginal orifice near the junction of the spermatheca and its duct. The mass-membrane gland, the conspicuous elongate organ, is welded to the inner surface of the right side mantle and terminates near the edge of the mantle, close to the anus. A narrow lumen is present throughout almost its whole length, being elongate elliptical about the middle of the length and of a slit-like shape about the level of the posterior third when sectioned transversally.

The spermatheca and oviduct are dark orange yellow owing to the presence of mucous contents.

Nervous system: (Pl. 19, figs. 18, 19, 20, 24)

The visceral nervous system is composed of 9 ganglia (the paired cerebral, pleural, and buccal, and the unpaired supra-esophageal, sub-esophageal, and visceral ganglia) and the nerves from these ganglia.

The cerebral ganglia are somewhat elongate in shape. They are joined to each other by a short commissure and are also joined to the pleural and pedal ganglia by a very short and a fairly long connectives respectively. The nerves to the snout and the cerebro-buccal connective arise from the anterior lobes of the cerebral ganglia; namely, the outer proboscis nerves arise from the outermost sides, the inner snout nerves from the middle portions, and the labial nerves and cerebro-buccal connectives from the innermost sides of the ganglia. In addition to these nerves the tentacular nerves are sent out of the ganglia at the antero-lateral sides and the optical nerves arise from the postero-lateral sides.

The paired pleural ganglia are oval in shape and are almost equal in size to each other. The left ganglion gives off a nerve to the left side mantle, while the right one does a nerve to the penis and another nerve to the lateral body wall.

The supra-esophageal ganglion is joined to the right pleural and visceral ganglia by an exceedingly short connective and a very long one respectively. This ganglion also sends a thin nerve to the osphradium.

The sub-esophageal ganglion is oval in shape and smaller than the supra-esophageal one. That ganglion gives rise to a nervous trunk to the mantle edge on the right side and is joined to the left pleural and the visceral ganglia by a very short connective and a very long one respectively.

The supra-esophago-visceral connective is very stout and passes along the ventral side of the esophagus and then through the haemocoel in the right body wall to reach the visceral ganglion. On the other hand, the sub-esophago-visceral connective is also stout and runs longitudinally on the dorsal side of the columellar muscle along the right side of the ridge-like projection on the back of the body.

The visceral ganglion is situated on the thin membrane near the junction of the oviduct and mass-membrane gland in the female or near that of the vas deferens and prostate gland in the male. This ganglion sends off the delicate visceral nerves posteriorly

The pedal nervous system consists of the pedal ganglia and their nerves. The pedal ganglia are joined to the cerebral and pleural ganglia by relatively long connectives, namely, the cerebro-pedal connectives arise from the outer antero-lateral portions of the cerebral ganglia and are joined to the pedal ganglia at the outer antero-lateral corners; and the pleuro-pedal connectives arise from near the posterior ends of the pleural ganglia and are joined to the pedal ganglia posterior to the junction of the cerebro-pedal connectives. The pedal ganglia are almost spherical in shape; and they send out two pairs of the anterior pedal nerves from the midst of the ventral sides, the lateral pedal nerves from the lateral sides near the posterior ends, and the posterior pedal nerves from the posterior ends. The posterior pedal nerves consist of principally the thicker inferior and the thinner superficial nerves.

Sensory system: (Pl 19, fig 19)

The statocysts are spherical in shape, each containing a great, round statolith and situated by the external sides of the pedal ganglia, slightly anterior to the lateral pedal nerves.

The tentacle is slender and supplied by the cerebral ganglion with a stout nerve ramifying into a few branches, while the eye is innervated by that ganglion with a delicate thread.

The snout appears to be very sensible when the animal is in locomotion. The osphradium is yellowish brown in color and welded to the left side mantle along the ctenidium.

Circulatory system: (Pl. 19, fig. 21)

The heart is located at the most anterior portion of the visceral hump, bordering on the mantle cavity near the posterior terminal point of the ridge-like projection. The aorta arising from the ventricle is narrowly recognized to divide into two short arteries, which open posteriorly into the haemocoels near the "duodenum" and crystalline style sac and farther into the irregular lacunae between the stomach and midgut gland. The peri-esophageal lymph space is present throughout the ridge-like projection and is connected to the cephalic haemocoel. Consequently, the vessels are feebly developed, while the haemocoel is well differentiated.

Respiratory system: (Pl. 17, figs. 6, 7)

The ctenidium extends longitudinally over the inside of the left mantle from the posterior terminal point of the ridge-like projection to the anterior edge of the mantle. The ctenidium consists of many gill leaflets of a subtriangular shape.

Excretory system: (Pl. 17, figs. 6, 7)

The kidney lies between the rectum and pericardium, bordering anteriorly on the apical part of the mantle cavity, and its lobular structure could not be defined by dissection. The renal aperture opens directly into the mantle cavity beside the posterior terminal point of the ridge-like projection and the renal duct is unrecognized.

The excreta of the kidney are carried by the exhalant ciliary current observed along the right side of the ridge-like projection and along the inside of the mantle siphon. Moreover, a ciliary current is found to proceed externally near the female genital orifice and anus, and these currents may be useful for carrying away faeces and further for depositing eggs.

Eggs: (Pl. 19, fig. 25)

The eggs are contained in a transparent gelatinous band-like egg-mass in which they are regularly arranged in two rows, and laid on the leaves of water weeds or on the wall of the container, several centimeters below the

surface. The greatest egg-mass measured is 18 in length and 2 mm in breadth and the egg is about 1.4 in number by 1.0 mm in both diameters. The embryos develop into the veliger larvae in the egg-capsule and the juvenile snail immediately before hatching bears two spiral black color bands on the shell composed of 1.5 whorls.

Discussion

The radular teeth show the numerical variation in the cusps, for example, in a male specimen the central tooth bore 7 pointed cusps at the anterior end and 6 near the base, this formula of the cusp being most common; but in another female specimen the central tooth had 10 cusps at the anterior end and 7 near the base and in another male 5 cusps at the tip. In the other teeth similar variations have been observed by some investigators. The radular teeth do not appear to differ according to sex, but to individual. Sugihara (1954) investigated the specimens collected from Fukuoka, Hiroshima, Okayama, Hyōgo, Shiga, Gunma, Miyagi, and Akita Prefectures in Japan to conclude that the numerical variation of cusps had no correlation with the differences in the size and shape of the shell and the existence of the spiral shell sculpture. He added that the central tooth usually had 7 cusps at the tip and 6 near the base, the lateral teeth each had 1 central cusp and 3 or 4 lateral ones on each side, and the inner and outer marginal teeth bore minute cusps varying in number from 12 to 23 and from 8 to 18 respectively.

The presence of the flagellum of the penis is a characteristic of *Parafossarulus* and its allied genera, but its function has not been elucidated. But this organ is considered to play an important role in copulation from the following observation and anatomical structures of the genitals: the vaginal orifice opens near the spermatheca at a fairly long distance from the mantle edge and the penis itself was not observed to extend at the tip, while the flagellum was observed to be stretched in living specimens under dissection, so the flagellum might play a role in carrying the sperm to the vaginal opening: a long elastic tube convolved in the basal part of the penis opens at the tip of the flagellum and the round and pyriform cells in this tube are the same as those in the "vesicula seminalis".

The function and nature of the round and pyriform cells are obscure. Dimorphism is known in the spermatozoa of prosobranch molluscs and Ankel (1924) described the atypical spermatozoa of *Bythinia tentaculata*. The genus *Bythinia* is akin to the genus *Parafossarulus*, so these two forms of cells might be related to the dimorphism.

Summary

The shell of *Parafossarulus manchouricus* scarcely shows sexual dimorphism, but the male shells appear to be somewhat more slender than those of the female. A transverse row of the radular tooth consists of 1 central, 2 lateral, 2 inner and 2 outer marginal teeth, and the cusps of these teeth show numerical variation in different individuals.

The stomach is composed of two parts; the anterior part is broader and provided with the gastric shield near the center, while the posterior part contains the crystalline style and its sac.

The penis has a characteristic flagellum at the anterior third on the left side, but its function is obscure. A convoluted tube containing a mucous fluid is situated at the base of the penis and its opened end is at the tip of the flagellum.

The vaginal opening is located at a fairly long distance from that of the oviduct; the former is near the spermatheca at the apical-most part of the mantle cavity and the latter slightly posterior to the anus.

The central nervous system is composed of 9 ganglia and the pedal system 2 ganglia.

The vessels are feebly developed, while the haemocoel is well differentiated.

The renal aperture opens directly into the mantle cavity at the apical part and no renal duct is recognized.

マメタニシの殻形は雌雄によって差はないが雄のものがやや細長である。歯舌の1列は中歯(1コ), 側歯(2コ), 内縁歯(2コ), 外縁歯(2コ)からなり, それぞれの歯の小鉤には個体差がある。胃は2部からなり, 前部の方が広くて中央に胃楯があり, 後部には晶体と晶体嚢がある。陰茎には鞭状体があるが,

その作用は不明である。陰茎基部の皮下には長い盲管があり、その開口は鞭状体の先端にある。この盲管内に白色粘液を含み、その中に円形と洋なし状の細胞がある。陰門は産卵門とは遠く離れ、陰門は外套腔の奥に、産卵門は肛門の少し後方に開く。中枢神経系は 9 神経節、足神経系は 2 神経節からなる。血管は発達が悪いが、血とうはよく発達している。排出孔は直接に外套腔の奥に開き、尿管はない。

Abbreviations used in Figures

an: anus	k: kidney
ao: supra-esophageal ganglion	ln: lateral pedal nerve
au: auricle	ls: lateral proboscis nerve
b: buccal mass	m: mouth
be: sub-esophageal ganglion	md: midgut gland
bg: buccal ganglion	mg: mass-membrane gland
bv: subesophago-visceral connective	mn: mantle nerve
c: cerebral ganglion	np: anterior proboscis nerve
cbc: cerebro-buccal connective	nr: nerve to osphradium
cm: columellar muscle	esophagus
cn: columellar nerve	oan: outer anterior pedal nerve
cpc: cerebro-pedal connective	od: oviduct
cs: crystalline style sac	omg: opening of midgut gland duct
ct: ctenidium	on: optic nerve
du: duodenum	opening of oviduct into mantle
e: eye	cavity
en: pleural nerve	op: operculum
ev: supraesophago-visceral connective	opn: outer posterior pedal nerve
f: foot	os: osphradium
fc: faeces	osn: osphradium nerve
fl: flagellum	ov: ovary
gn: genital nerve	pb: proboscis
gs: gastric shield	pc: pericardium
h: heart	pe: penis
intestine	pg: pedal ganglion
ian: inner anterior pedal nerve	pl: left pleural ganglion
ipn: inner posterior pedal nerve	plr: right pleural ganglion

ppc: pleuro-pedal connective	sg: salivary gland
prg: prostate gland	sh: siphon
ps: penis sheath	sinus
pv: ventral nerve of proboscis	sp: spermatheca
rb: retractor muscle of buccal mass	t: tentacle
rectum	tn: tentacular nerve
rn: ridge-like projection	ts: testis
rp: renal pore	ty: typhlosole
rs: radular sac	v: visceral ganglion
s: stomach	vd: vas deferens
sc: statocyst	vt: ventricle

Literature cited

1. Ishizaki, T. & K. Kato, 1958. The fine structure of atypical spermatozoa of the pond snail, *Viviparus malleatus*. The Dobutsugaku Zasshi, (Zool. Mag.) 67 (9): 286—294. (Japanese with Eng. summ.)
2. Sugihara, H., 1954. Taxonomical studies on *Parafossarulus manchouricus* Bourguignat in Japan. (日本産マメタニシの分類学的研究) J. Kyoto Pref. Med. Univ. (京府医大誌) 56 (3): 512—560. (Japanese with Eng. summ.)

Explanation of Plates 17~19 第 17~19 図版説明

Plate 17.

1. Shell; left in ventral view, right in dorsal view. 殻.
2. Operculum. 蓋.
3. Right side view of animal in locomotion. 運動中の動物体.
4. Radular teeth; C: central, L: lateral, IM: inner marginal, OM: outer marginal. 歯.
5. Radular ribbon; left, in dorsal view, right in left side view. 歯舌; 左, 背面, 右, 側面.
6. Male animal, with mantle cut open; dorsal view. 雄貝, 外套膜を切り開く.
7. Female animal, with mantle cut open; dorsal view. 雌貝, 外套膜を切り開く.

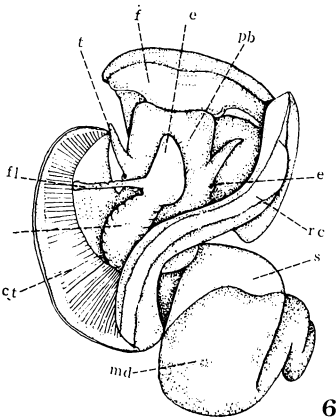
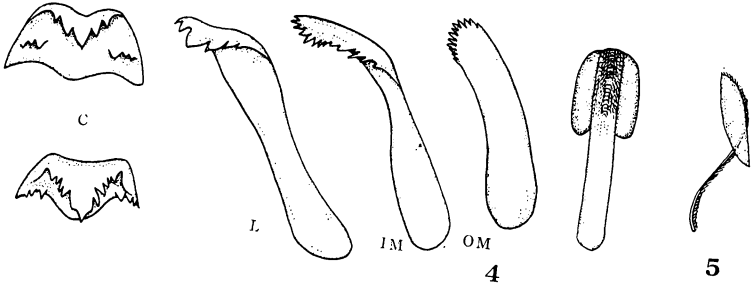
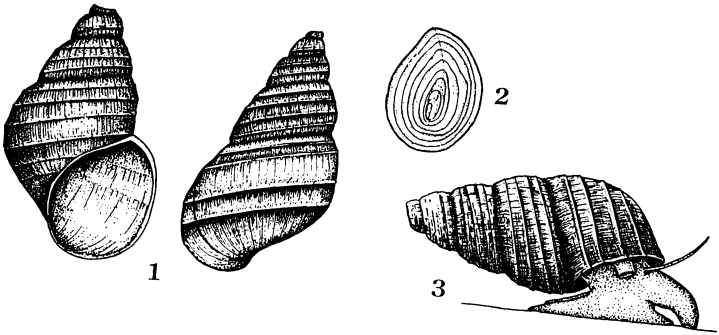
Plate 18.

8. Alimentary system. 消化系.
9. Stomach and midgut gland; left, left side view; middle, dorsal view; right, ventral view. 胃と中腸腺; 左, 左側面, 中, 背面, 右, 腹面.
10. Buccal mass in left side view. 口球, 左側面.

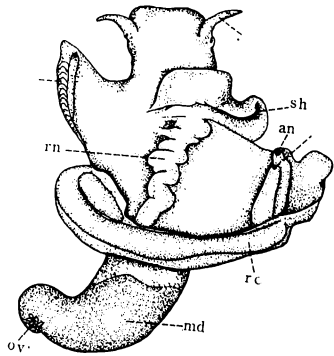
11. **Figure showing the internal structure of stomach.** 胃内部構造.
12. **Showing the course of alimentary canal near stomach.** 胃付近の消化管の走路を示す.
13. **Typical spermatozoon (left), pyriform cell (middle), and round cell (right) found in vesicula seminalis.** 貯精囊内の正形精子 (左), 円形細胞 (中), 洋なし状細胞 (右).
14. **Penis and flagellum, with cul-de-sac cut open.** 陰茎と鞭状体, 盲嚢は切り出してある.
15. **Penis and flagellum, with cul-de-sac convolved in the basal part of penis.** 陰茎と鞭状体.
16. **Male reproductive system.** 雄生殖系全図.
17. **Female reproductive system. Arrows show the transverse sections of mass-membrane gland.** 雌生殖系全図. 矢印は卵塊膜腺の横断部を示す

Plate 19.

18. **Nervous system excluding pedal one. (Male specimen)** 中枢神経系.
19. **Pedal nervous system.** 足神経系.
20. **Ganglia and their nerves.** 神経節とその神経.
21. **Circulatory system.** 循環系.
22. **Figure shows renal opening.** 排出孔 (腎) を示す
23. **Showing the structure of the apical-most part of mantle cavity.** 外套腔の最奥部の構造.
24. **Figure showing the arrangement of kidney, heart, visceral ganglion, spermatheca, etc.** 腎, 心臓, 内臓神経節, 受精嚢の配置を示す
25. **Egg-mass and juvenie snails immediately before hatching.** 卵塊と孵化直後の幼貝.
26. **Copulation.** 交尾.

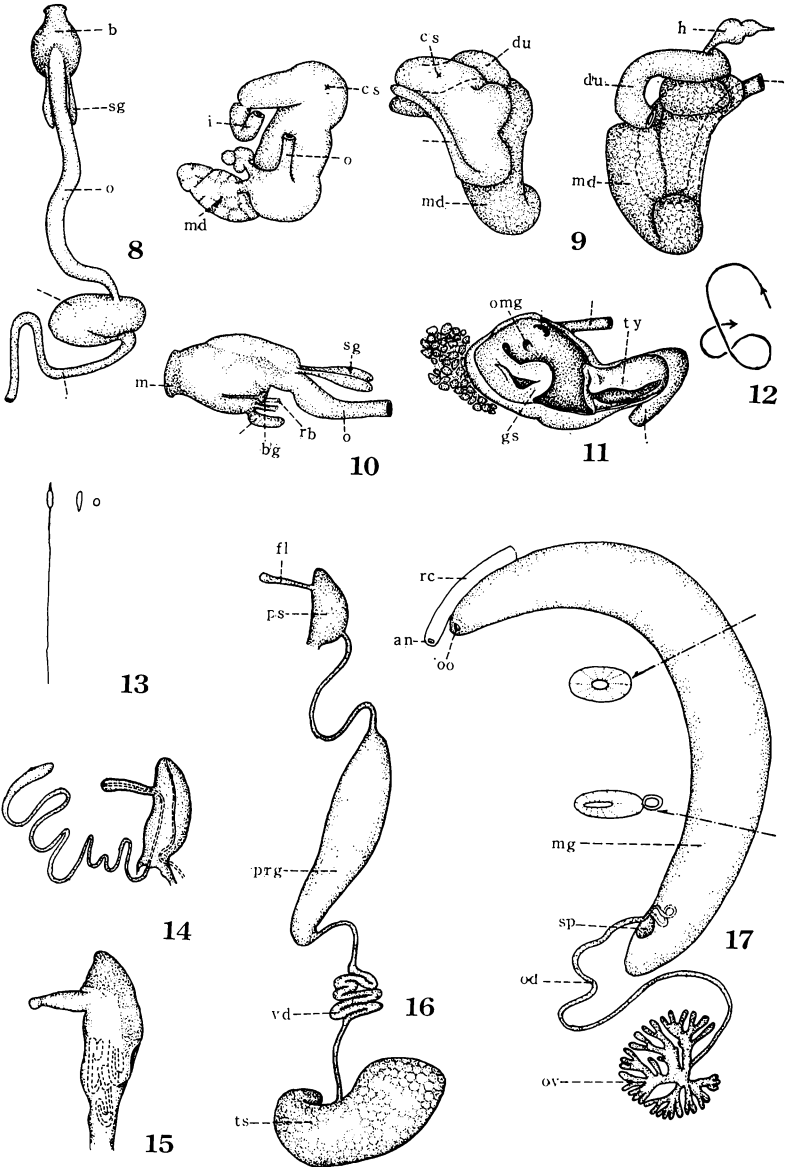


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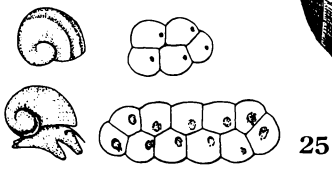
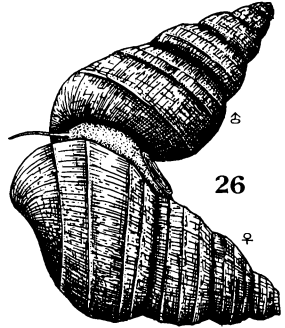
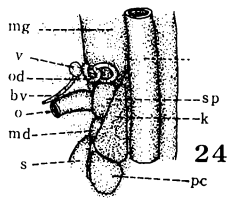
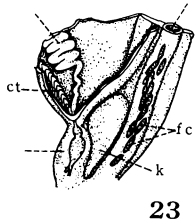
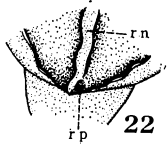
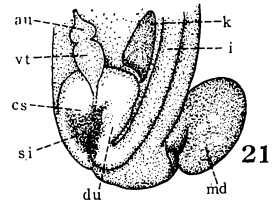
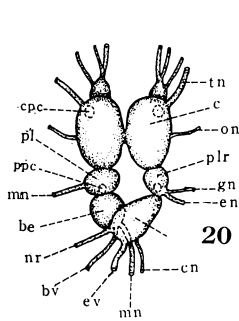
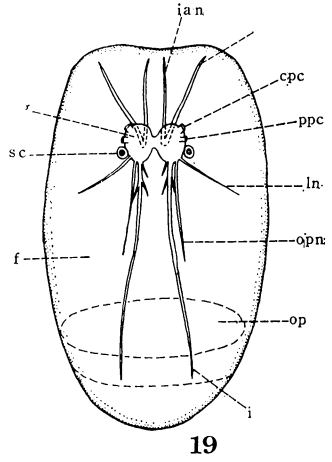
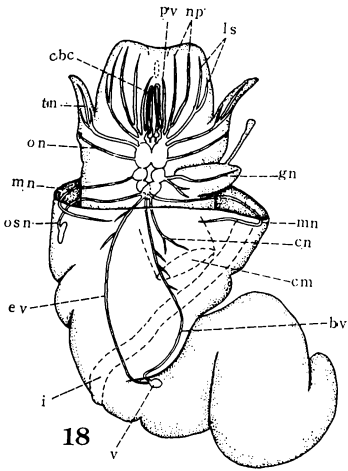


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ITAGAKI: Anatomy of *Parafossarulus manchouricus*



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