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河南华溪蟹消化系统的形态结构观察和组织学研究

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摘要: 为研究河南华溪蟹消化系统的形态结构及组织学特征,采用石蜡切片、H. E. 染色和光镜等技术,对河南华溪蟹成蟹消化系统各组织器官的结构进行了观察。结果显示,河南华溪蟹的消化系统主要由消化道和消化腺组成。消化道主要包括食道、胃、中肠和后肠,消化腺为肝胰腺。胃包括贲门胃和幽门胃:贲门胃内有钙化的几丁质齿、隆嵴、短刺及刚毛等组成的胃磨,可磨碎食物;幽门胃内侧可见特殊形态的梳状结构,可过滤食物。在光学显微镜下,食道、中肠和后肠均由黏膜层、肌层和结缔组织层构成,其各段内表面均有由上皮细胞与基膜内凸形成的多级皱褶和嵴,有由环形、纵形和辐射状排列的肌层。仅中肠表面有典型微绒毛结构,无角质膜。食道与后肠上皮表面均有较发达的纤毛层。肝胰腺主要由基膜和 4 种上皮细胞构成,即吸收细胞(R 细胞)、泡状细胞(B 细胞)、纤维细胞(F 细胞)和胚细胞(E 细胞)。

关键词: 河南华溪蟹; 胃磨; 消化系统; 组织形态学

中图分类号: S 917. 4　　**文献标志码**:A

河南华溪蟹(*Sinopotamon henanense*),隶属节肢动物门(Arthropoda)、甲壳纲(Crustacea)、十足目(Decapoda)、溪蟹科(Potamidae)、华溪蟹属(*Sinopotamon*),广泛分布于中国河南、山西、河北等地,是生活于河、溪的石下或泥洞中的一类底栖水生动物,易采集、养殖,是理想的实验材料。近年来,就环境污染物对河南华溪蟹主要组织器官的毒性作用已进行了大量研究,如对其心肌细胞、卵巢形态结构的影响[1-3]、对鳃组织和精子的氧化损伤[4-5]以及精细胞和肝胰腺细胞凋亡的检测[6-7]等等,但对河南华溪蟹消化系统的研究非常有限。消化系统的基本生理功能是摄取、转运、消化食物和吸收营养、排泄废物,这些功能的完成有赖于整个胃肠道协调的生理活动,消化系统的损伤可直接影响动物的营养健康甚至生长发育。国内外对其他十足目动物的消化系统组织结构的研究已有诸多报道[8-12],但多局限于简单的组织切片观察,鲜有完整、清晰的形态学图像,而有关河南华溪蟹消化系统形态结构的研究尚属空白。鉴于此,本研究对河南华溪蟹消化系统各部位组织器官进行了系统的观察,以便深入了解河南华溪蟹消化系统的形态学特征,并初步探讨结构与功能的关系,其结果为研究河南华溪蟹的消化生理学提供基础资料,也为进一步研究环境改变对河南华溪蟹消化能力的影响奠定基础。

1　材料与方法

1.1　实验材料

河南华溪蟹(以下简称“溪蟹”)购自太原市五龙口东安水产批发市场。于实验室条件下暂养两周,取大小均一雌蟹 5 只,除去背壳后置于体视显微镜(Olympus SZX16,日本)下,并取出完整消化系统作解剖观察并拍照。

1.2　胃的解剖及贲门胃形态结构的观察

取出溪蟹完整胃部,用生理盐水将其表面冲洗干净,于腹面食道与胃连接处将胃剖开,再用生

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理盐水冲洗胃内容物,于体视显微镜(Olympus SZX16,日本)下观察,照相。

1.3　消化系统各部位组织学切片与观察

同时取出食道、幽门胃、中肠、后肠和肝胰腺5个部位的组织,迅速放入Bouin氏固定液固定24 h,经梯度乙醇脱水,二甲苯透明,石蜡包埋、全自动切片机(Leica RM2255,德国)切片、H. E染色、中性树胶封片,于显微镜(Olympus BX51,日本)下观察并照相。切片厚6 μm。

2　结果

2.1　河南华溪蟹消化系统的解剖镜观察

溪蟹的消化系统包括消化道和消化腺两部分(图版Ⅰ-1):消化道主要由食道、胃、中肠和后肠构成;消化腺主要为肝胰腺(图版Ⅰ-2)。

食道为一垂直短管,上与口腔连接,下通至贲门胃。胃分为前部的贲门胃和后部的幽门胃,贲门胃前端与食道相接,为薄膜囊状结构;幽门胃前大后小,呈漏斗状。中肠前接幽门胃,后接后肠,为一段细长直管。中肠末端有一环绕肠壁形成的肌样结构,为后肠的起始部,后肠末端直达肛门。肝胰腺位于生殖系统下方心脏两侧,左右各一大叶,由大量肝小管构成,通过一对导管与中肠相连(图版Ⅰ-2)。

2.2　河南华溪蟹消化道的形态学观察

胃　　溪蟹胃的部分腹壁上凸形成一较厚的近三角形瓣膜,称贲门-幽门瓣(图版Ⅱ-1),将胃分隔成前后两部分,即前部的贲门胃和后部的幽门胃。贲门胃的胃腔大(图版Ⅱ-1),壁薄,胃壁的几丁质层在胃的不同部位特化形成齿、隆嵴、短刺及刚毛等结构,构成胃磨。其中位于贲门胃后部的背壁和侧壁的背齿及侧齿是最典型的胃磨结构,其基部包埋于胃壁,齿端突入胃腔(图版Ⅱ-2)。贲门胃末端与幽门胃连结处的胃腔变窄,密布大量长短不一的几丁质刚毛。刚毛向胃腔中央汇聚,并朝固定的方向倾斜,形成滤器结构(图版Ⅱ-3,4)。

幽门胃较贲门胃小,其腹壁每一侧加厚呈两个半球形,称幽门垂(图版Ⅲ-1),幽门胃腹面中间的黏膜内凸形成中央突或称间壶腹脊,将幽门胃分成两个侧室,室内有梳状结构(图版Ⅲ-2)。幽门胃组织内表面被覆单层柱状上皮细胞(图版Ⅲ-3);肌层发达,肌束呈环形、纵形或辐射状排列,其中中央突基部纵形肌束最为发达(图版Ⅲ-3);外膜厚,由疏松结缔组织(图版Ⅲ-3)和单层立方细胞构成(图版Ⅲ-4)。

食道　　食道组织内壁向腔面凸起形成多个皱褶,表面被覆薄层结缔组织,构成外膜(图版Ⅳ-1_1)。食道黏膜为单层柱状上皮细胞,可见大量黏液细胞,有发达的纤毛(图版Ⅳ-1_2)。肌纤维横纹明显,内环外纵的横纹肌排列疏松,薄厚不均,常进入黏膜下层扩伸至上皮细胞基膜下(图版Ⅳ-1_3)。

中肠　　中肠内壁形成褶皱凸入腔内,皱褶较矮小、不明显,外膜由疏松结缔组织构成(图版Ⅳ-2_1)。中肠上皮为典型的单层柱状上皮细胞,排列紧密(图版Ⅳ-2_2);细胞核呈卵圆形或椭圆形,位于细胞基部,细胞表面有微绒毛,基膜明显(图版Ⅳ-2_3)。

后肠　　后肠上皮为单层柱状细胞,形状多样,以高柱状为主,管壁向内凸起形成发达的皱褶,肌层发达,横纹肌延伸至肠褶上皮下(图版Ⅳ-3_1)。后肠前中段,褶皱少而大,外层由疏松结缔组织包围(图版Ⅳ-3_2);而后肠后段褶皱小而多,纤毛发达(图版Ⅳ-3_3)。

2.3　河南华溪蟹消化腺的组织学光镜观察

溪蟹的肝胰腺为其主要的消化腺,有无数分枝的肝小管,呈“菊花”状,横切面呈圆形或椭圆形(图版Ⅴ-1)。肝小管由基膜和单层柱状上皮细胞围成(图版Ⅴ-1~3),内表面可见纹状缘(图版Ⅴ-4)。根据形态差异,上皮细胞可分为4类[13]:R细胞(resorptive cells,吸收细胞)、B细胞(blister-like cells,泡状细胞)、F细胞(fibrillar cells,纤维细胞)和E细胞(embryonic cells,胚细胞)。

R细胞:数目最多,位于管腔近中部和近端,呈高柱状,胞质色浅,含大量液泡,细胞核位于近基部;

F细胞:数目较多,位于管腔近中部和远端,形态与R细胞类似,胞质蓝色,几乎不含液泡,细胞核位于近基部;

B细胞:数目较多,位于分泌管近端,呈柱状,胞质色深,顶端具大液泡,可见絮状分泌物,细胞核多数位于基部或近基部,有的移至液泡基部;

E细胞:数目最少,位于管腔最远端,呈多边形,胞质深蓝色,无液泡,细胞核位于基部,且核质

比最大。

3 讨论

消化系统是动物消化食物、吸收营养的主要场所。实验结果显示,溪蟹消化系统的形态结构与其他十足目动物的相类似,但也有各自特征。

溪蟹的食道是一条肌性管道,前段黏膜层纤毛丰富,同时内环外纵排列的横纹肌发达,牵引其口咽开合自如,可以很好地伸缩,从而将食物从口处推送至贲门胃[14]。食管上皮层向腔内弯折形成 4 个纵褶突,使其内腔呈“X”形,与三疣梭子蟹(*Portunus trituberculatus*)[15]和波纹龙虾(*Panulirus homarus*)[16]的结构相似,可使内壁的扩张度与摄入食物的大小及数量相适应。与其他甲壳动物的食道形态结构类似,溪蟹食道上皮细胞密布几丁质纤毛,食物随纤毛的摆动向胃输送,还可以在胃研磨食物时防止食物倒流[17]。

Patwardhan[18]研究了十足目短尾部动物的胃磨结构和机理,Allardyce 等[19]报道,草食性、杂食性和肉食性的蟹类胃磨结构类似[19]。溪蟹的贲门胃常储满食物,其内特殊的胃磨结构可将食物磨碎,使食物易于与肝胰腺或中肠分泌的消化液完全混合,从而达到初步消化的目的。布满刚毛的滤器可将食物过滤,使未被磨碎的食物颗粒再由胃磨重新加工,而细化的食物可以经过贲门-幽门瓣进入幽门胃,这样可以有效防止食物逆流。幽门胃较贲门胃体积小,其特殊的栅状、梳状结构等,使之具有过滤食物和防止食物残渣进入中肠的作用。

在胚胎发育过程,蟹类的前肠已明显分化为食道和胃两部分[20],因此肠道只有中肠和后肠。中肠由内胚层分化而来[21],是消化道中惟一不具几丁质内衬的组织,也是消化周期发生的最后部位,其主要功能是消化从幽门胃过滤来的食物小颗粒,并吸收其中的营养物质,最后将剩余的食物残渣送入后肠形成粪便[22]。实验结果表明,溪蟹中肠具有大小不等的皱褶和微绒毛结构,增加了消化吸收的面积,并且,中肠起始端有与肝胰腺管相通的导管,肝胰腺合成分泌的各类消化酶可经此注入中肠,用以将食物进行分解、消化。因此,中肠是溪蟹消化吸收的主要场所之一。

溪蟹的后肠结构与其他十足目动物类似[2,23],柱状上皮细胞具有较厚的分泌层与纤毛,肌肉层发达,直接延伸至上皮下方,可以控制肠褶的收缩。后肠前中段皱褶少而大,后肠后段的褶皱却小而多。由于后肠主要是接收由中肠消化后的食物残渣和直接来自胃中没有被消化吸收的粗大颗粒,进而形成粪便,并促使这些残渣从肛门处排出,因此后肠具有发达的纤毛和肌群等结构特点,与其功能相适应。

Reddy[24]将 *Paratelphusa*(*Oziotelphusa*)*hydrodromus* 的肝胰腺细胞分为酶细胞和吸收细胞两种;Stanier 等[25]通过透射电镜,对 *Carcinus maenas* 的肝胰腺细胞进行了观察,将上皮细胞重新归类为 E、F、B、R 4 种细胞,并认为 E 细胞可分化为 F 细胞,F 细胞又可衍生为 B 细胞,而 F 细胞与 R 细胞可相互转化。此后,学者们大多沿用 Stanier 等[25]对甲壳动物肝胰腺细胞的分类方法进行学术研究[26-29]。本实验的观察结果同于 Stanier 等[25],认为肝胰腺由 4 种细胞构成。本研究认为,R 细胞中的小液泡可储存脂质、糖原等物质,且具营养吸收功能;F 细胞主要合成并分泌消化酶;B 细胞的功能目前争议较多,较多研究者认为 B 细胞可吸收营养物质,进行消化,并可由大液泡将无法消化的废物排入管腔;E 细胞则为其他细胞母体,具分裂能力[30-31]。因此,肝胰腺是溪蟹消化系统中重要的消化和吸收器官。

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Morphological observation and histological studies on the digestive system of *Sinopotamon henanense*

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Abstract: The freshwater crab *Sinopotamon henanense* is a species commonly found in freshwaters of China. However, the relevant studies on digestive system of *S. henanense* have not been reported yet. In the present study, morphological and histological observation of digestive system of the freshwater crab *S. henanense* was performed based on paraffin section technique, H. E. staining method and light microscope technique. The results showed that the digestive system comprises digestive tract and digestive glands. The digestive tract is composed of esophagus, stomach, midgut and hindgut. The digestive gland is hepatopancreas. The stomach of the crab is divided into cardiac stomach and pyloric stomach. There is a gastric mill with calcified teeth, ridges, spines and setae in the cardiac stomach, which is used to grind food. There are several special structures such as combs in the pyloric stomach, which are for food filtration. The results of light microscopy showed that the wall of esophagus, midgut and hindgut is surrounded by mucosal, muscular and connective tissue layers. The ridges in the surface of epithelium mucosa of each segment of the digestive tract wall take the shape of multigrade wrinkles. The muscular layers consist of longitudinal muscle, striated muscle and radiant muscle. Only in the midgut there are typical microvilli. The epithelium of the digestive tract is covered by cuticle except the midgut. There are more developed cilia on the surface of epithelial mucosa of esophagus and hindgut. The hepatopancreas is composed of several ramose hepatic ducts. Each hepatic duct consists of four types of cells: resorptive cells (R cell), blister-like cells (B cell), fibrillar cells (F cell) and embryonic cells (E cell). The relationship between the tissues and functions of the digestive system were discussed. These results will provide the basic data for the study of digestion physiology of freshwater crabs.

Key words: *Sinopotamon henanense*; gastric mill; digestive system; histomorphology

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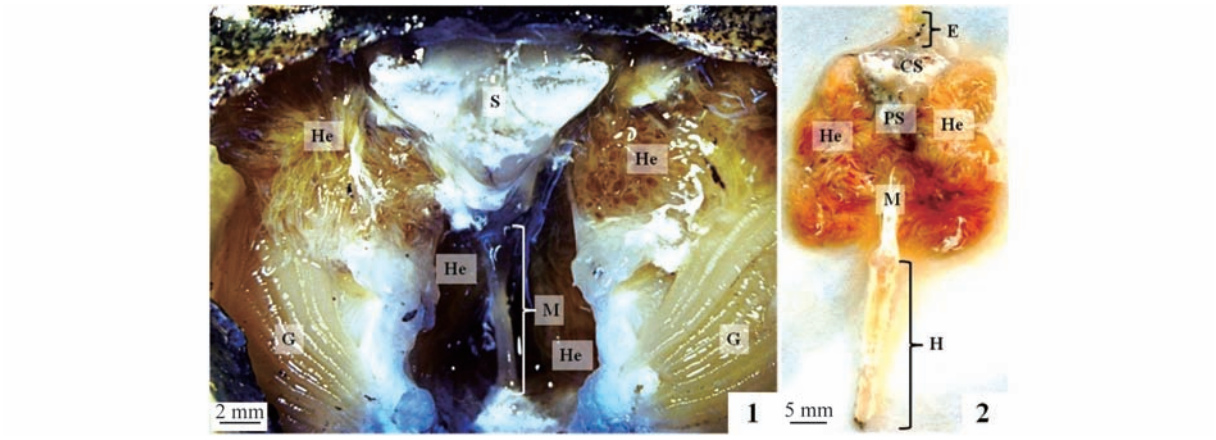


图版 I 河南华溪消化系统解剖学形态

1. 河南华溪蟹背面解剖形态；2. 河南华溪蟹消化系统解剖结构

E：食道；S：胃；CS：贲门胃；PS：幽门胃；M：中肠；H：后肠；He：肝胰腺；G：鳃

Plate I Anatomical morphology of digestive system of *S. henanense*

1. dorsal view of anatomical morphology of *S. henanense*; 2. anatomical structure of digestive system of *S. henanense*

E: esophagus; S: stomach; CS: cardiac stomach; PS: pyloric stomach; M: midgut; H: hindgut; He: hepatopancreas; G: gill

图版说明 Explanation of Plate

图版 II

1. 贲门胃胃磨整体结构，可见一个背齿，一对侧齿及侧附齿，贲门－幽门瓣，滤器等结构；2. 侧齿；3. 背齿下方密集的刚毛簇；4. 密布在侧附齿上的刚毛簇

UO：尾贲门骨；MT：背齿；LT：侧齿；AT：侧附齿；SC：刚毛；CV：贲门－幽门瓣；F：滤器

Plate II

1. ventral view of gastric mill in cardiac stomach, the gastric mill is made up of one medial tooth, a pair of lateral tooth and accessory tooth, cardiopyloric valve, filter, etc; 2. view of lateral tooth and tidy; 3. view of medial tooth and a cluster of setae; 4. view of accessory tooth covered densely with setae

UO: urocardiac ossicle; MT: medial tooth; LT: lateral tooth; AT: accessory tooth; SC: setae clusters; CV: cardiopyloric valve; F: filter

图版 III

1. 幽门胃横切面，可见中央突将幽门胃分隔为两个侧室，×100；2. 幽门垂及梳状结构，×100；3. 中央突基部的纵肌束，×200；4. 黏膜上皮细胞，×400

PC：幽门垂；Pec：梳状结构；LB：纵肌束；CP：中央突；MEp：黏膜上皮细胞

Plate III

1. the transverse sections of pyloric stomach, the pyloric stomach is divided into two ventricles by central projection, ×100; 2. view of pyloric caecum and pectination, ×100; 3. view of longitudinal bundle, ×200; 4. view of mucosal epithelial cells, ×400

PC: pyloric caecum; Pec: pectination; LB: longitudinal bundle; CP: central projection; MEp: mucosal epithelial cells

图版 IV

1_1. 食道横切面，可见管腔呈“X”形，×100；1_2. 食道上皮细胞及纤毛层，×400；1_3. 食道的肌层，×400；2_1. 中肠横切面，肠腔由单层柱状上皮细胞围成；×100；2_2. 中肠上皮细胞及外层结缔组织，×400；2_3. 微绒毛结构，×400；3_1. 后肠横切面，可见不规则的管腔，×200；3_2. 后肠发达的纵肌束和疏松结缔组织，×400；3_3. 后肠上皮细胞及纤毛层，×1 000

Lu：肠腔；CT：结缔组织；Lc：纤毛层；Ep：上皮细胞；MF：肌肉层；Mv：微绒毛；Bl：基膜；LB：纵肌束

Plate IV

1_1. the transverse sections of esophagus, the lumen was “X” shape, ×100; 1_2. view of ciliated columnar epithelium, ×400; 1_3. view of muscle fiber, ×400; 2_1. the transverse sections of midgut, the enteric cavity is surrounded by a single layer of columnar epithelial cells, ×100; 2_2. view of epithelial cells and connective tissue, ×400; 2_3. view of microvilli, ×400; 3_1. the transverse sections of hindgut, lumen is irregular, ×200; 3_2. view of developed longitudinal bundle and loose connective tissue, ×400; 3_3. view of ciliated columnar epithelium, ×1 000

Lu: lumen; CT: connective tissue; Lc: layer of cilium; Ep: epithelial cells; MF: muscle fiber; Mv: microvilli; Bl: basal lamina; LB: longitudinal bundle

图版 V

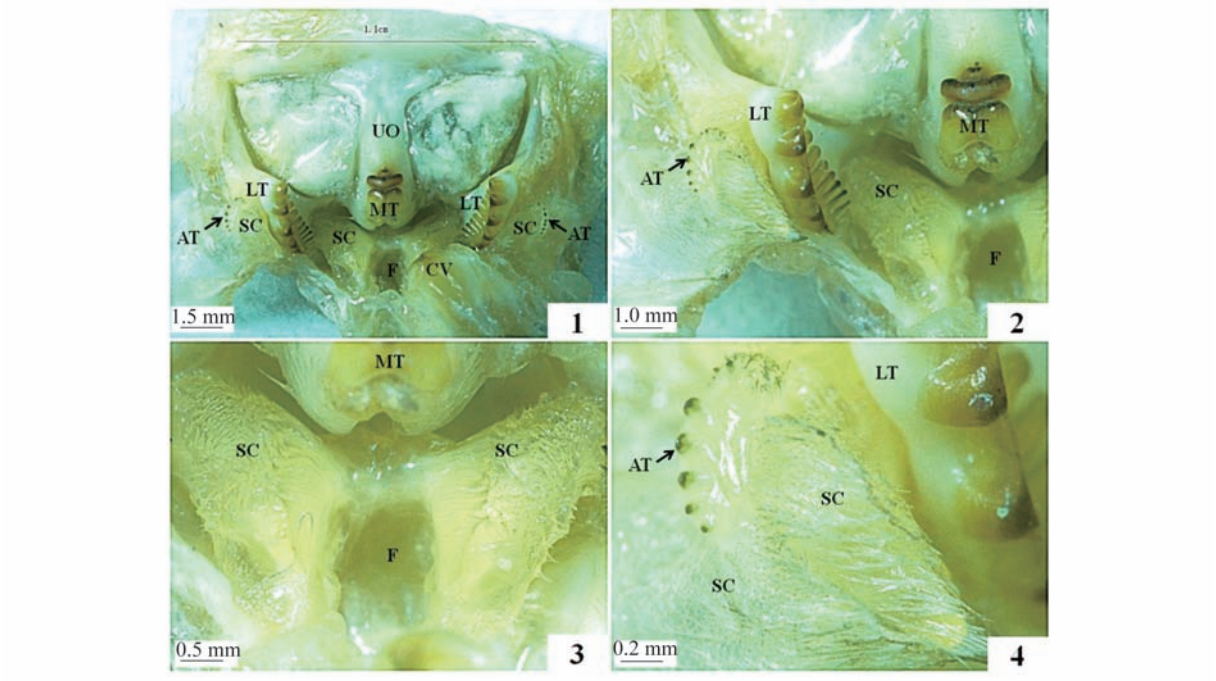
1. 肝小管横切面，管腔不规则，管壁由单层细胞构成，×100；2. R 细胞和 F 细胞，×200；3. B 细胞和 E 细胞，×200；4. 各类型细胞和纹状缘形态，×400

Lu：肝小管管腔；E：胚细胞；R：吸收细胞；B：泡状细胞；F：纤维细胞；SB：纹状缘

Plate V

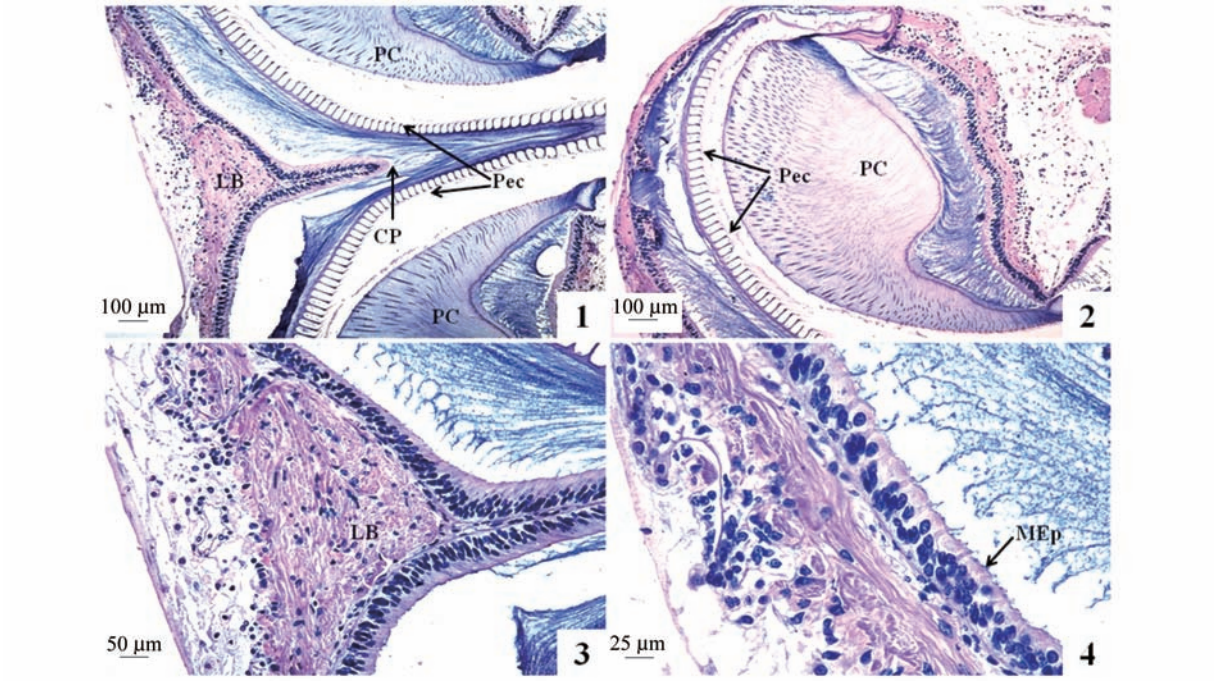
1. the transverse sections of hepatopancreas, lumen is irregular and the wall is consisted of a single layer of cells, ×100; 2. view of R-cells and F-cells, ×200; 3. view of B-cells and E-cells, ×200; 4. view of epithelial cells and structure of striated border, ×400

Lu: lumen of tubules; E: embryonic cells; R: resorptive cells; B: blister-like cells; F: fibrillar cells; SB: striated border



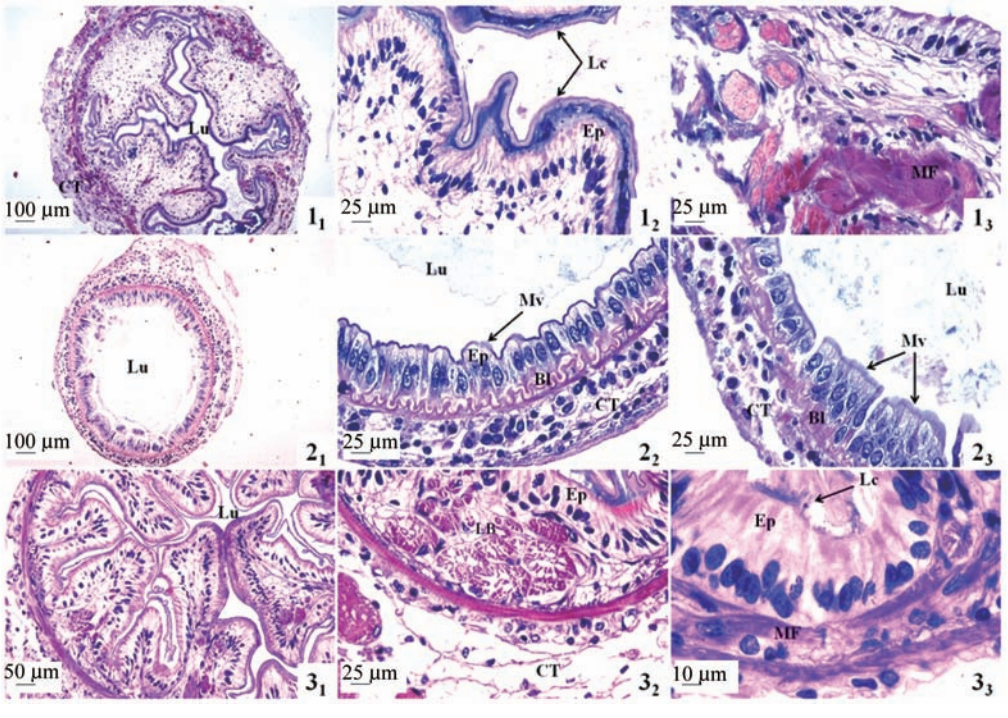
图版Ⅱ　河南华溪蟹贲门胃胃磨形态结构

Plate Ⅱ　The structure of gastric mill in cardiac stomach of *S. henanense*



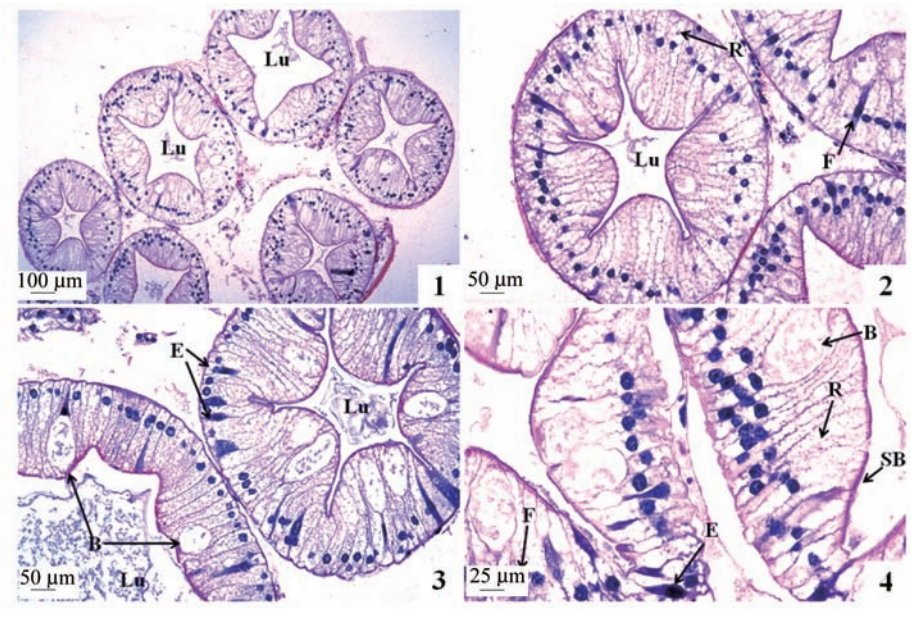
图版Ⅲ　河南华溪蟹幽门胃形态结构

Plate Ⅲ　Light micrographs of pyloric stomach of *S. henanense*



图版Ⅳ 河南华溪蟹消化道主要组织形态结构

Plate Ⅳ Light micrographs of digestive tract of *S. henanense*



图版Ⅴ 河南华溪蟹肝胰腺形态结构

Plate Ⅴ Light micrographs of hepatopancreas of *S. henanense*