Vol. 2 No. 1 page 56-62
DOI: 10.14456/randk.2016.7

RESEARCH & KNOWLEDGE

Research Article

New species of *Cipangopaludina* (Caenogastropoda: Viviparidae) from Zhejiang, China

Lu Hong–Fa[1], Fang Mei–Juan[1] and Du Li–Na[2,*]

[1]Zhejiang Normal University, Hangzhou 311231, China
[2]Kunming Natural History Museum of Zoology, Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming 650223, China

(Received 22 June 2015; accepted 29 February 2016)

Abstract - A new species of Viviparidae, *Cipangopaludina hehuensis* sp. nov. is described from irrigation ditches on terraces in Hehu Town of Qingyuan County, Zhejiang Province, China. The new species was placed into *Cipangopaludina chinensis* group due to spiral depth longer than aperture height. New species could be distinguished from other congeners of *chinensis* group by shell without color bands vs. with color band in *C. ussuriensis*; vas deferens opens in last 1/4 of testis vs. 1/3 of tesitis in *C. chinensis* and *C. c. fluminalis*; vas deferens with 5–6 branches vs. 8–9 in *C. haasi*. Additionally, the character of osphradium long, about two times the length from the anterior of osphradium to mantle edge could be distinguished from other species of *Ciapangopaludina*.

Keywords: *Cipangopaludina hehuensis*, gastropoda, Viviparidae, new species

1. Introduction

Hannibal (1912) described *Cipangopaludina* as a subgenus of *Idiopoma*, based on invasive specimens bought in a market in California. Although some researchers have treated *Cipangopaludina* as an invalid taxon or as a subgenus of *Bellamya* (Annandale, 1920; Smith, 2000). Lu and others (2014) considered that *Bellamya* had previously been treated as a junior synonym of *Cipangopaludina*. *Cipangopaludina* is a complicated genus with 35 taxa having been recorded in this genus. *Cipangopaludina* distributes in China, Japan, Korean, Thailand, Vietnam, Laos, India, Burma and Malaya (Brandt, 1974; Liu *et al*., 1993; Lu *et al*., 2014). Due to intraspecific variations in shell shape, the identification of *Cipangopaludina* species is difficult. Lu and others (2014) reviewed the genus *Cipangopaludina* based on shell and anatomical characters, and recognized 11 species and two subspecies in China, which were divided into two groups, viz. the *chinensis* group (spiral height longer than aperture height) and the *cathayensis* group (spiral height shorter than aperture height), according to the spiralspire height being longer than the aperture height.

Specimens of *Cipangopaludina* were collected in Hehu Town, Qingyuan County, Lishui City, Zhejiang Province, China (Fig. 1). Comparison with other species of *Cipangopaludina* revealed that the samples were of an undescribed species.

2. Material and methods

This study was based on material collected by the authors on the rice terraces (Fig. 2) in the Hehu Town, Qingyuan County, Lishui City, Zhejiang in June 2012. All type samples were preserved in 75% ethanol and have been deposited in the Kunming Institute of Zoology (KIZ), Chinese Academy of Sciences (CAS) (see material examined for details).

Dimensions of the shells were measured with calipers accurate to 0.1 mm. The shell height (H) was the maximum dimension parallel to the axis of the coiling, and shell breadth (B) was the maximum dimension perpendicular to H. The length of the aperture (LA) was the maximum dimension from the junction of the outer lip with the penultimate whorl to the anterior edge of the aperture, and it was oblique with the coiling axis; the width of the aperture (WA) was the maximum dimension perpendicular to LA. The height of the body whorl (BW) was the dimension from the lower margin of the aperture to the upper suture delimiting the first whorl. N was the number of whorls. Embryonic shells were measured to 0.1 mm using an ocular micrometer. Anatomy was studied using a microscope with camera lucida. Radulae and embryonic shells were studied by scanning electron microscopy (SEM). The radulae were cleaned enzymatically with proteinase K, as described by Holznagel (1998), sonicated and then mounted on aluminum specimen stubs with adhesive pads. Embryonic shells were cleaned mechanically, sonicated and mounted on adhesive carbon-coated pads. Both radulae and embryonic shells were coated with gold-palladium and studied with an AMRAY 1000B SEM at 30 kV. The description of shell features and visceral hump followed the general terminology suggested by Annandale and Sewell (1921).

* Author for correspondence: duln04@mail.kiz.ac.cn

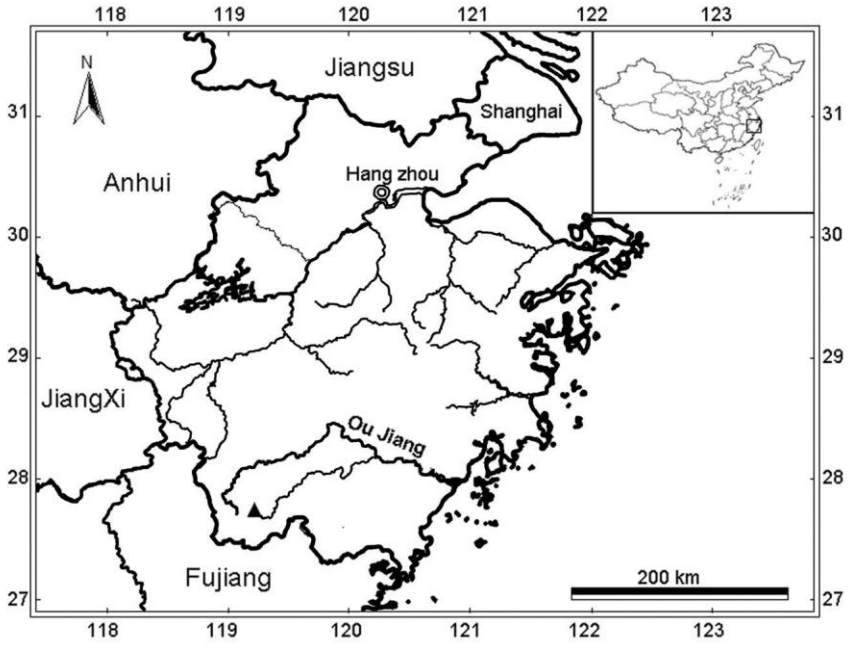

Figure 1. Map showing the known type locality of *Cipangopaludina hehuensis* sp. nov. in Zhejiang (black triangular indicates type locality).

Figure 2. Habitat of *Cipangopaludina hehuensis* sp. nov. in the type locality in the "rice terraces".

3. Result

SYSTEMATICS

Family Viviparidae Gray, 1847

Genus *Cipangopaludina* Hannibal, 1912

***Cipangopaludina hehuensis* sp. nov.**

urn:lsid:zoobank.org:act:EF653941-3D26-4FB0-B1F1-DC7CC0871259

3.1 Material examination

Holotype. KIZ 003992 (ethanol preserved specimen; Fig. 3E–F). Paratypes. KIZ 003993–003994, 003997 and 003999–004003 (eight preserved specimens).

Type locality. Hehu Town, Qingyuan County, Lishui City, Zhejiang Province, China (Fig. 1). The specimens were collected in June 2012 from rice terraces (Fig. 2). The water in the terraces was from mountains, and the water depth (of the rice terraces) was about 10 cm, pH 6.0.

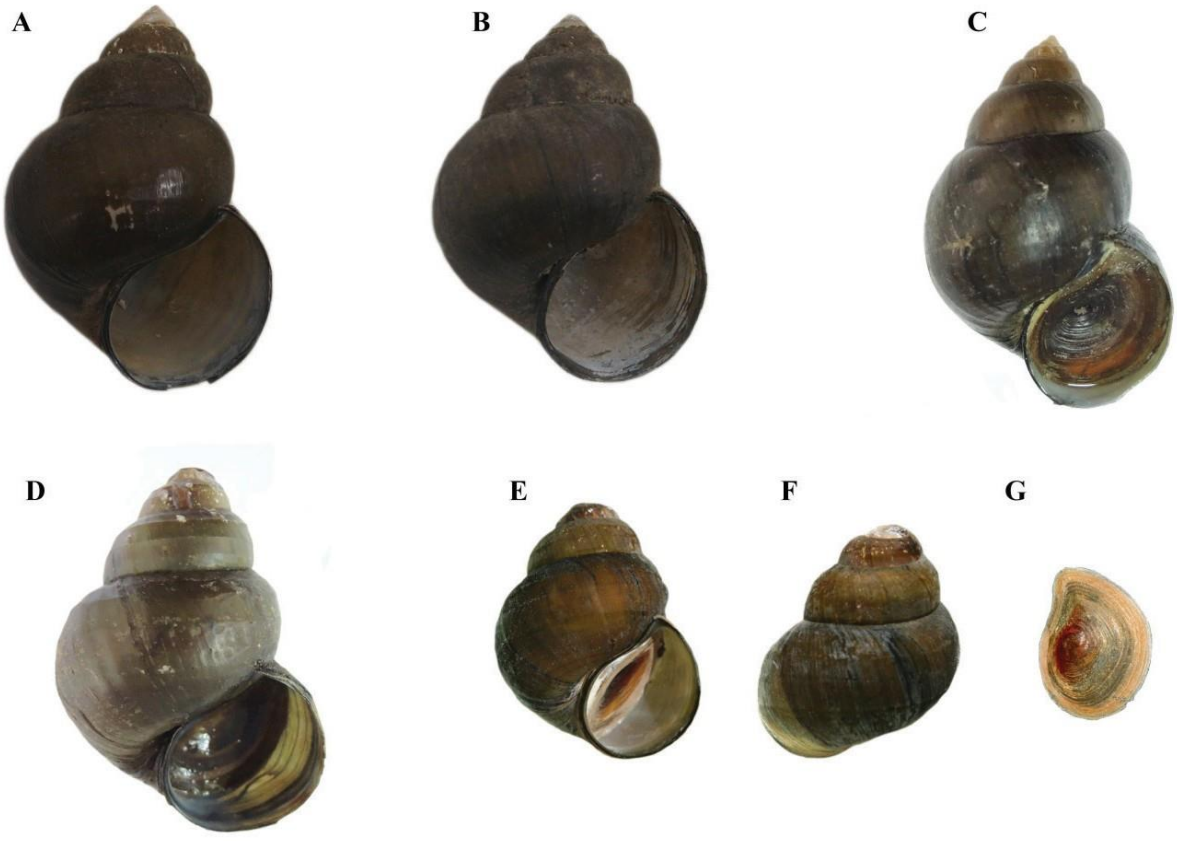

Figure 3. Species of *Cipangopaludina chinensis* group: A, *C. chinensis*, IOZ-FG497042, 59 mm, Sichuan Province; B, *C. chinensis fluminalis*, IOZ-FG497043, 52.6 mm, Sichuan; C. *C. haasi*, KIZ 000491, 58.8 mm, Zhejiang province; D, *C. ussuriensis*, KIZ006769, 51.8 mm, Heilongjiang Province; E-G, *C. hehuensis* sp. nov., holotype KIZ003992, 39.9 mm.

3.2 Description

Anatomy was based on three specimens: two females and one male.

Shell (Fig 3. E–F): Large, large, ampulliform, shell height 33.3–41.3 mm (Holotype 39.9 mm), shell width 27.4–31.7 mm (Holotype 31.7 mm) (Table 1), oval, thin, brown in color. Apex eroded, normally four or five whorls remains. Body whorl inflated, with three weak keels, and other whorls have two weak keels, suture narrow. Aperture subcircular, columella and inner lip whitish blue, outer lip has a black color and easily broken. Umbilicus narrow or closed. Spiral height longer than aperture height.

Operculum (Fig. 3G): Ovate, corneous, nucleus near the inner lip, surrounded with growth lines, he centre was brown, and outer greenish in color.

External morphology (Fig. 4A. Preserved in 75% alcohol): Head and foot black. Snout cylindrical, anterior margin flat. The length of tentacles was equal to snout, base at side of snout base. Ommatophore short, located between basal and middle third of outer surface of each tentacle. Foot large, sole simple.

Radula (Fig. 5A): Taenioglossa, with 110–112 rows, 62 mm long, on average 1.8 teeth per mm (n=2). Central tooth with wide rounded major cusp and four smaller triangular cusps on each side. Lateral tooth with tongue-shaped major cusp and three minor cusps on each side. Inner marginal tooth with tongue-shape major cusp and three minor cusps and outer marginal teeth with eight 8 small equal–sized cusps.

Mantle organs (Fig. 4A–B): Mantle border simple and thick. Osphradium long, about two times the length from the anterior of osphradium to mantle edge, ridge like, very close to gill. Ctenidial gill long and narrow, about same length as mantle cavity. Hypobranchial gland lies on

left of gill margin. Right margin of mantle cavity filled by oviduct in females. Ureter runs along mantle cavity right margin in males or edging oviduct in females. Rectum on dorsal and left sides of ureter. At right end of mantle border, in females, presenting three openings, most posterior and smaller than ureter pore, anus most anterior. Female pore larger, located between anus and ureter pore.

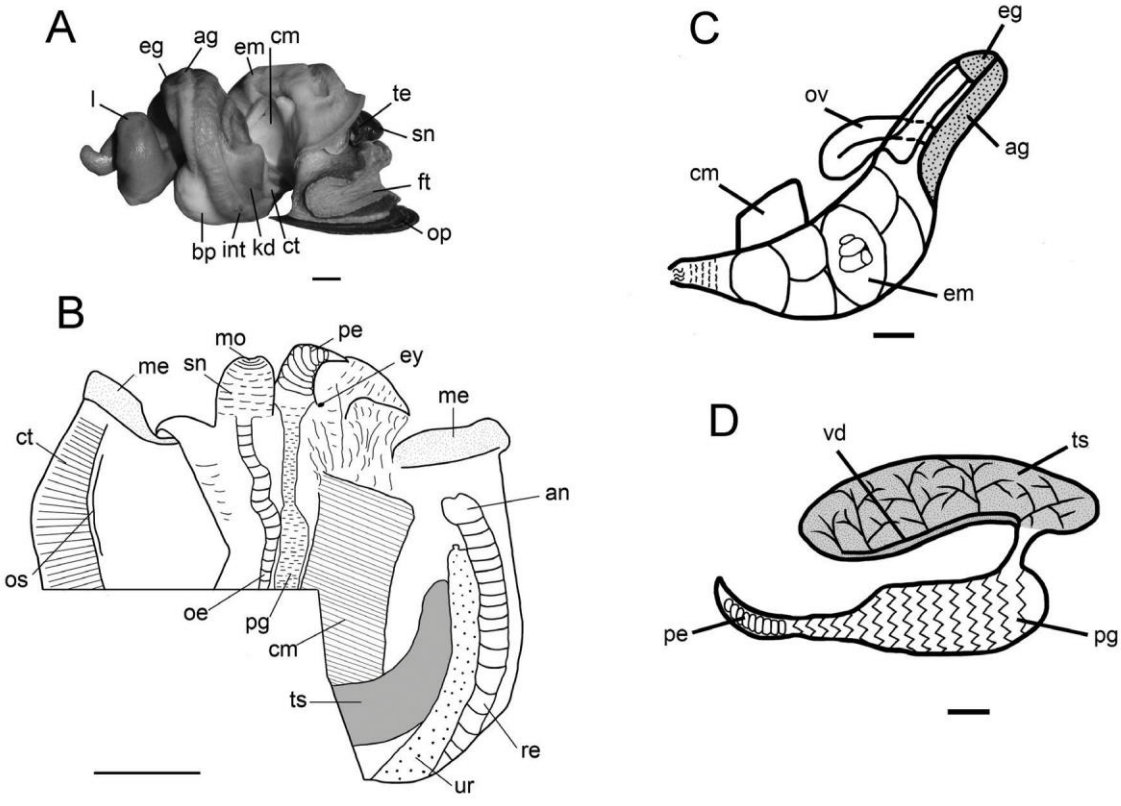

Figure 4. Anatomy and genital system of *Cipangopaludina hehuensis* sp. nov. A, KIZ 004004 with shell removed showing external features of animal. B, KIZ 003990, male with mantle cavity opened mid-dorsally. C, KIZ 003991, female genital system. D, KIZ 003990, male genital system. Scale bars = 0.5 cm. Abbreviations: ag – albumen gland; an – anal papilla; bc – branchial chamber; bp – brood pouch; cm – columellar muscle; ct – ctenidium; eg – egg-shell gland; em – embryo; ey – eye; ft – foot; hy – hypobranchial gland; int – intestine; kd – kidney; l – liver; me – mantle edge; mf – mantle fold; mo – mouth; oe – oesophagus; op – operculum; os – osphradium; ov – oviduct; pe – penis; pg – prostate gland; re – rectum; sn – snout; te – tentacle; ts – testis; ur – ureter; vd – vas denferens.

Alimentary canal: Mouth oval, bounded by fleshy lips, ventral at anterior end of snout. Oesophagus thin–walled and usually blackish due to contents. Posterior end of mantle cavity oesophagus passes upwards in floor of pericardial chamber to reach digestive gland in upper part of visceral hump where it curves round to open into stomach. Intestine forms loop overlying pericardial cavity and when it reaches digestive gland turns sharply forwards to continue as rectum. Rectum passes forwards on right of mantle cavity to open at anus lying just behind mantle edge.

Kidney: Triangular, pyramidal, in roof of mantle cavity at extreme apex. Along right margin runs rectum and blood sinus, below which lie commencement of ureter. At left (i.e., inner margin) afferent gill vein commences and base of gill. Posterior border of kidney connected with loop of intestine.

Table 1. Shell measurements of type specimens. Minimum-maximum (standard deviation).
H= shell height; B= shell breadth; LA= length of the aperture; BA= width of the aperture; BW= height of the body whorl; N= number of whorls

Type	Code number	H	B	LA	BA	BW	N
Holotype	KIZ003992	39.9	31.7	22.5	14.6	30.1	4
Paratypes	KIZ003993-4003	33.3-41.3 (2.13)	27.4-31.4 (1.05)	19.0-22.2 (1.11)	13.2-15.9 (0.76)	27.0-30.2 (0.97)	4-5 (0.5)

Genital system Male (♂): Testis compact, semi-lunar, on right of mantle cavity. Extends to upper end of branchial cavity, where apex close to pericardial cavity also connected by thin fold of membrane with lower surface of digestive gland. Testis flattened laterally, right surface abuts columellar mussel while left surface abuts right wall of ureter. Vas deferens very narrow, running on columellar and inferior-ventral margin of testis, with five or six main branches, and the five branches have many very narrow branches from different portions of testis. The vas deferens opens in the last 1/4 of testis and to prostate gland in mantle cavity, running along mantle cavity floor for about 3/4 of its length, the left 1/4 length of vas deferens abruptly narrows and surrounded by very thick, muscular walls. Vas deferens opens in right tentacle tip (Fig. 4D). Female (♀): Ovary grey, located in same position as testis. Oviduct and ovary in close contact with posterior wall of cardiac region of stomach and along course of hepatic artery. Oviduct very narrow, from albumen gland runs to posterior of columella, and then oviduct running to left and making a loop. The oviduct increases in size and runs to egg shell gland along brood pouch. Brood pouch located in dorsal of oviduct. Albumen gland tongue-shaped, slightly curved, egg–shell gland on dorsal and posterior surface. Egg shell gland opens to brood pouch. Walls of brood pouch thin, semi–transparent, smooth (Fig. 4C). Pouch filled with about 22–42 embryos in various stages of development.

Embryonic shells (Fig. 5B): 6.6 mm (length of largest juvenile in brood pouch), of four whorls (N=6 individuals). Three primary rows of chaetae on last whorl.

Etymology: The specific epithet "*hehuensis*" is derived from the name of the type locality, Hehu Town.

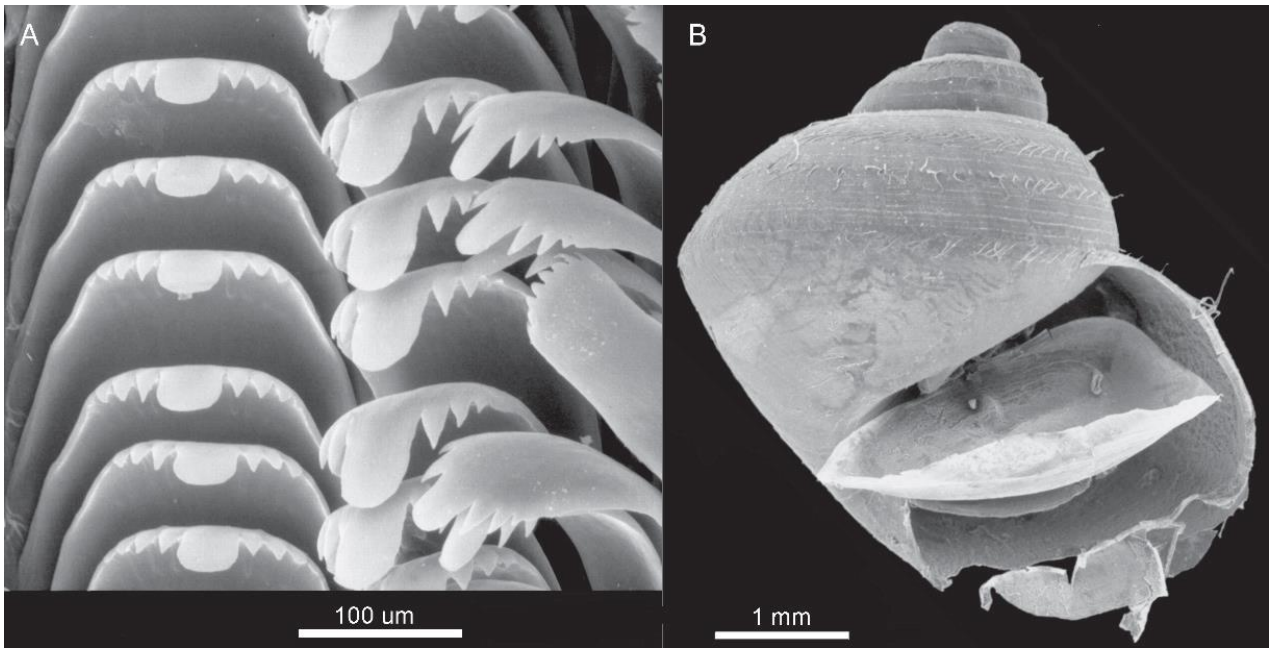

Figure 5. Radula and embryo of *Cipangopaludina hehuensis* sp. nov, KIZ 003991, A, radula, scale is 100μm. **B**, embryonic shell, scale bars = 1 mm.

3.3 Diagnosis

Cipangopaludian hehuensis was placed into *Cipangopaludian chinensis* group as the spiral depth longer than aperture height. *C. hehuensis* can be distinguished from other speices of *chinensis* group by the following characters: lack of color bands on the shell vs. four or five color bands in C. *ussuriensis*, and vas deferens opening in last 1/4 vs. 1/3 in *C. fluminalis* and *C. chinensis*, with five or six branches vs. 8 branches in *C. haasi* (Fig. 3; Table 2).

3.4 Remark

The distribution of *Cipangopaludina hehuensis* is restricted to Hehu County where it is an important economic species. There are four square kilometers of rice terraces on which 4.5 tons of snails were collected per square kilometer. The loss of habitat and overharvesting has resulted in the decrease of the snail population.

Table 2. Characters comparisons of *Cipangopaludina* species.

Species	Group	Shell	Color band	Apex	Umbilicus	Flat shoulder in body whorl	Vas deferens opens	Number of vas deferens branches	The length of osphradium/ length of tip of osphardium to mantle border	Shape of kidney
C. chinensis	*chinensis*	thin	without	point	narrow or closed	without	1/3 of testis	5-6	equal	triple
C. chinensis fluminalis	*chinensis*	thick	without	point	big and deep	without	1/3 of testis	5-6	equal	triple
C. haasi	*chinensis*	thin	without	point	narrow	without	1/4 of tesits	8-9	longer	triple
C. ussuriensis	*chinensis*	thin	with	obtused	deep	without	-	-	-	-
C.hehuensis sp. nov.	*chinensis*	thin	without	eroded	narrow	without	1/4 of tesits	5-6	2 times	triple
C. cathayensis	*cathayensis*	thin	without	point	narrow	with	1/3 of testis	3-4	equal	triple
C. aubryana	*cathayensis*	thick	without	point	narrow	without	1/3 of testis	4	longer	triple
C. lecythis	*cathayensis*	thin	without	point	narrow	with	1/3 of testis	3	shorter	triple
C. lecythis ampullacea	*cathayensis*	thick	without	obtused	deep	with	1/4 of tesits	4	equal or shorter	arch
C. leucostoma	*cathayensis*	thin	without	obtused	closed	without	1/3 of testis	4	longer	arch
C. ventricosa	*cathayensis*	thin	without	point	big and deep	without	1/4 of tesits	4	longer	triple
C. hainanensis	*cathayensis*	thick	without	obtused	big and deep	without	-	-	-	-
C. lecythoides	*cathayensis*	thin	without	point	narrow	without	1/3 of testis	3	-	-
C. latissima	*cathayensis*	thin	without	obtused	big and deep	with	-	-	-	-

4. Discussion and conclusion

Cipangopaludina hehuensis exhibits key morphological characteristics, which readily place it within the genus *Cipangopaludina*. Its shell shows features typical of *Cipangopaludina*, such as being thin, subglobose or ovoidal, without color bands (Brandt, 1974; Liu *et al*., 1993; Lu *et al.*, 2014).

Lu and others (2011) mentioned the specimens from Hehu County were *C. lecythoides* and *C. chinensis fluminalis*. However, *C. hehuensis* could be distinguished with *C. lecythoides* and *C. chinensis fluminalis* by the following characters: spiral depth longer than aperture height vs. shorter in *C. lecythoides*, vas deferens opens in last 1/4 of testis vs. 1/3 in *C. lecythoides* and *C. c. fluminalis*.

Four species of *Cipangopaludina* have been recorded in Zhejiang Province, viz. *C. chinensis* (Gray, 1834), *C. cathayensis* (Heude, 1890), *C. lecythoides* (Benson, 1842) and *C. haasi* (Prashad, 1928) (Cai and Huang, 1991). *C. hehuensis* sp. nov. could be distinguished from these four species by the relative length of the osphradium, which is about twice as long as the distance between the anterior end of the osphradium and the mantle edge. In other congeners, the osphradium length is equal to the distance between the osphradium and the mantle edge. *C. hehuensis* sp. nov. can be distinguished from *C. chinensis* by the following characters: apex obtuse vs. pointed; vas deferens opens in last 1/4 of testis vs. 1/3; and 22–42 embryos in female pouch vs. 84 embryos. *C. hehuensis* can be distinguished from *C. haasi* by the following characters: 22–42 embryos in female pouch vs. 128–188 embryos; vas deferens having five or six branches vs. eight or nine branches; and shell having four or five whorls vs. seven whorls. *C. hehuensis* can be distinguished from *C. cathayensis* and *C. lecythoides* by the spiral depth being longer than aperture height vs. shorter and vas deferens opens in last 1/4 of testis with five or six branches vs. 1/3 with three branches (Table 2).

The species of *Cipangopaludina* were divided into two groups according to the spiral depth being longer than the aperture depth or not by Lu and others (2014). *C. hehuensis* sp. nov. is placed into the *chinensis* group as the spiral depth is longer than the aperture height. Three species and one subspecies were placed into the *chinensis* group, including *C. chinensis*, *C. haasi*, *C. ussuriensis* (Gerstfeld, 1859) and *C. chinensis fluminalis* (Heude, 1890). *C. hehuensis* sp. nov. can be distinguished from *C. ussuriensis* by a lack of color bands on the shell vs. four or five color bands. *C. hehuensis* can be distinguished from the other three species by the vas deferens opening in last 1/4 with five or six branches and 22–42 embryos in female pouch.

There are more than 30 lakes and eight main rivers in Zhejiang Province, such as West Lake, Qiantang River, Oujiang River and Yongjiang River (Ma *et al*., 1994). Abundant water resources bear and diverse of freshwater habitats bear high gastropod diversity, but due to few people studying freshwater gastropods in China, thus this component of freshwater ecosystem is still poorly known. We hope that our report will inspire future studies to look more closely into the diversity of the freshwater gastropod fauna of China, given the obvious potential of new discoveries.

Acknowledgments
This research was funded by the National Natural Science Foundation of China (31301865) and the Natural Science Foundation of Zhejiang Province of China (LY12C19006). We greatly thank Meng Kaibayier for generous helping when we checked the specimens at National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences (IZCAS). We thank two anonymous reviewers for their helpful comments on the manuscript.

References

Annandale, N. 1920. The Indian general of Viviparidae. Records of the Indian Museum 19, 114–115.

Annandale, N. and Sewell, R. B. S. 1921. The banded pond–snail of India (Vivipara bengalensis). Records of the Indian Museum 22, 215–292.

Brandt, R. A. M. 1974. The non–marine aquatic mollusca of Thailand. Archiv für Molluskenkunde 105, 1–423.

Cai, R. X. and Huang, W. H. 1991. Fauna of Zhejiang (Molusks). Zhejiang Science and Technology Publishing House, Zhejiang, China, 4–7. (in Chinese)

Hannibal, H. 1912. A synopsis of the Recent and Tertiary freshwater Molluscs of the Californian province, based upon an ontogenetic classification. Proceedings of the Malacological Society of London 10, 112–165.

Holznagel, W.E. 1998. A nondestructive method for cleaning gastropod radulae from frozen, alcohol–fixed, or dried material. American Malacological Bulletin 14, 181–183.

Liu, Y. Y., Zhang, W. Z. and Wang, Y. X. 1993. Medical Malacology. China Ocean Press, Beijing, pp. 157.

Lu, H. F., Du, L. N., Li, Z. Q., Chen, X. Y. and Yang, J. X. 2014. Morphological analysis of the Chinese *Cipangopaludina* species (Gastropoda: Caenogastropoda: Viviparidae). Zoological Research 35(6), 510–527.

Lu, H. F., Fang, M. J. and Zhang, X. F. 2011. Introduction test of alpine thin shell field snails. Journal of Zhejiang Ocean University (Natural Science) 30(5), 458–461.

Ma, Z. X., Lao, G. F., Zhou, Q. S. and Dong, Z. D. 1994. The evaluation of water resource in Zhejiang Province. Journal of China Hydrology 1, 7–10.

Smith, D. G. 2000. Notes on the taxonomy of introduced *Bellamya* (Gastropoda: Viviparidae) species in northeastern North America. The Nautilus 114(2), 31–37.

Editor's note: This article was amended at the request of the author on the 09 January 2017 to include "urn:lsid: zoobank.org:act:EF653941-3D26- 4FB0-B1F1-DC7CC08 71259" on page 58 (page 3 of the manuscript).