NEW SPECIES OF LAND SNAIL, *MIRUS JEJUENSIS*, (GASTROPODA: ENIDAE) FROM JEJU ISLAND, KOREA

GAB MAN PARK

Department of Environmental Medical Biology, Kwandong University College of Medicine, Gangneung, Gangweon-do 210–701, Korea

Abstract *Several specimens of* Mirus jejuensis *n. sp. were collected alive for the first time from Jeju Island. Based on the new material, shell, radula, genital system and chromosome kartotype are here described. A terrestrial cave snail (Gastropoda: Enidae),* Mirus jejuensis *n. sp., occurs in Gungi cave on Jeju Island, South Korea and is proposed as a new species in the family Enidae. Diagnostic features of the new species include possession of a minute elongate-conical, sinistral shell, with apical microsculpture comprising low tubercles. The chromosome number and karyotype are 2n=56 and 8M+15SM+5ST, respectively.*

Key words Mirus jejuensis*, Korea, Cave snails, Jeju Island, Gastropoda, Enidae*

INTRODUCTION

The diversity of Enidae is highest in the temperate zone (especially in southwestern and central Asia), but some Asian groups extend into the tropics (Hausdorf, 2001a, 2001b). Some species of Enidae have sinistral shells (Annandale & Prashad, 1924; Thiele, 1931; Schileyko, 1998). Twenty-one species and subspecies have reported for the genus *Mirus* Albers 1850 (Yen, 1939). Asami *et al.* (1998) reported examples of sinistral and dextral forms occurring within one species. Also, Ueshima and Asami (2003) reported that the different mirror-image forms have evolved in favour of the genetically dominant handedness as a result of single-gene speciation. The Geonji cave was formed by lava-calcification and is located to the west of Hallim-eup on Jeju Island. The climate of the vicinity is temperate, with a mean annual temperature of 16°C. Annual rainfall is around 1500 mm. The new species is described in this study on the basis of the shell structure and the anatomical characteristics.

MATERIALS AND METHODS

All material (25 living snails) was collected by Mr. Y. G. Choi of the Korean Institute of Biospeleology. Snails were kept during three years of laboratory study to study the adult (Fig. 1). Relaxed, alcohol-preserved specimens were used for dissection. Adult specimens from Sindang-dong cave (5 exx.) were used for karyotypic analysis after being prepared by air-drying (Park, 2008). The centromeric position nomenclature for the chromosome classification, as proposed by Levan *et al*. (1964), has been followed in this study. The radula and the shell microsculpture were observed by SEM (Hitachi, S-4200). Specimens used in this study were deposited in the Department of Environmental Medical Biology, Kwandong University College of Medicine, Korea.

Contact author : gmpark@kd.ac.kr

SYSTEMATICS

Mirus jejuensis n. sp.
(Figs 1–6)

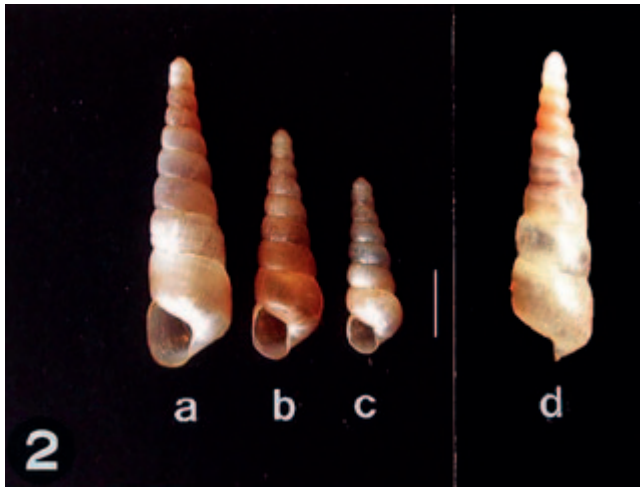
Material examined Holotype, SH 13 mm, SW 2.2 mm, WH 10, Geonji cave Hyubje-ri, Hallim-eup, Bukjeju-gun, Jeju Island.

Description Table 1 contains the shell morphometrics of the holotype and seven paratypes. Shells are illustrated in Figs 1–3. Shell colour was translucent-white with light yellowish shading. Head and foot of the animal was white. Head with two pairs of invaginable tentacles, with eyes at tips of upper tentacles (Figs 1, 2). Shell size ranged 7.2–13.1 mm high; height/width ratio 4.80–5.46. Whorls, 8–10, rounded. Spire outline convex. Aperture oblong-ovate, margin thin, occupying 19–21% of shell length. Shell lacking an umbilicus. Body whorl occupying 34–36% of shell length, with a rounded, convex periphery. Columella thin, outer lip rather thin, of which upper end slightly concaveforming a very shallow sinus. Lip of outer aperture not reflected.

Table 1 Shell parameters for eight specimens of *Mirus jejuensis*

Specimens	SH (mm)	SW (mm)	AL (mm)	AW (mm)	AS	WH
Holotype	13.0	2.2	0.32	0.23	1.39	10.0
Paratype 1	12.8	2.1	0.33	0.25	1.32	10.0
Paratype 2	12.9	2.2	0.31	0.22	1.41	9.5
Paratype 3	13.1	2.3	0.35	0.24	1.46	10.0
Paratype 4	12.8	2.1	0.31	0.24	1.29	10.0
Paratype 5	13.1	2.4	0.33	0.22	1.50	9.5
Paratype 6	8.9	1.7	0.28	0.19	1.47	8.0
Paratype 7	7.2	1.5	0.26	0.17	1.53	8.0

Abbreviations: SH=shell height; SW=shell width; AL=aperture length; AW=aperture width; AS=aperture length/aperture width; WH=number of whorls.



Figures 1–2 Photographs of *Mirus jejuensis*: 1 Dorsal view of an active *M. jejuensis*; 2 a, Holotype; b and c, paratype; d, side view of holotype (Bar=3 mm).

Inner surfaces of whorls smooth. Shell with relatively smooth surface sculptured by irregular growth lines (Fig. 3). No parietal callus and parietal wall. Protoconch rounded, protruding, with about 1.5 whorls. No operculum.

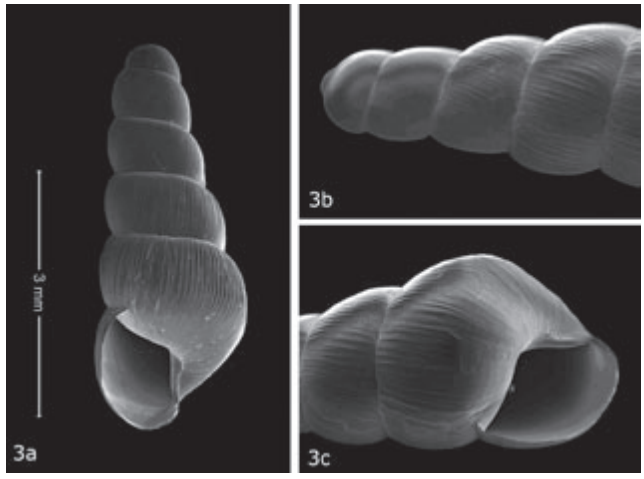


Figure 3 Scanning Electron Microscope photographs of *Mirus jejuensis*. Shell body: (a), apical whorls; (b) aperture; (c) lip.

Radular formula (Fig. 4): one central tooth +six lateral teeth +12 marginal teeth (from paratype). Central tooth (Fig. 4a) trapezoidal, somewhat short; basal process well excavated; basal cusps elongate (about as long as basal process). Central cusps of central and lateral teeth dagger-like, slightly enlarged. Marginal teeth with three cusps.

Genital system Characterized by style of receptaculum seminis (bursa copulatrix) being longer than the diverticulum (Fig. 5). Epiphallus almost uniformly thickened, about 6 mm long, with retractor muscle connected to middle. Vagina same length to siomewhat shorter than penis sheath, and narrowed somewhat toward atrium. Stalk of receptaculum seminis considerably thickened near vagina, strikingly thickened in middle, about 6 mm. Receptaculum

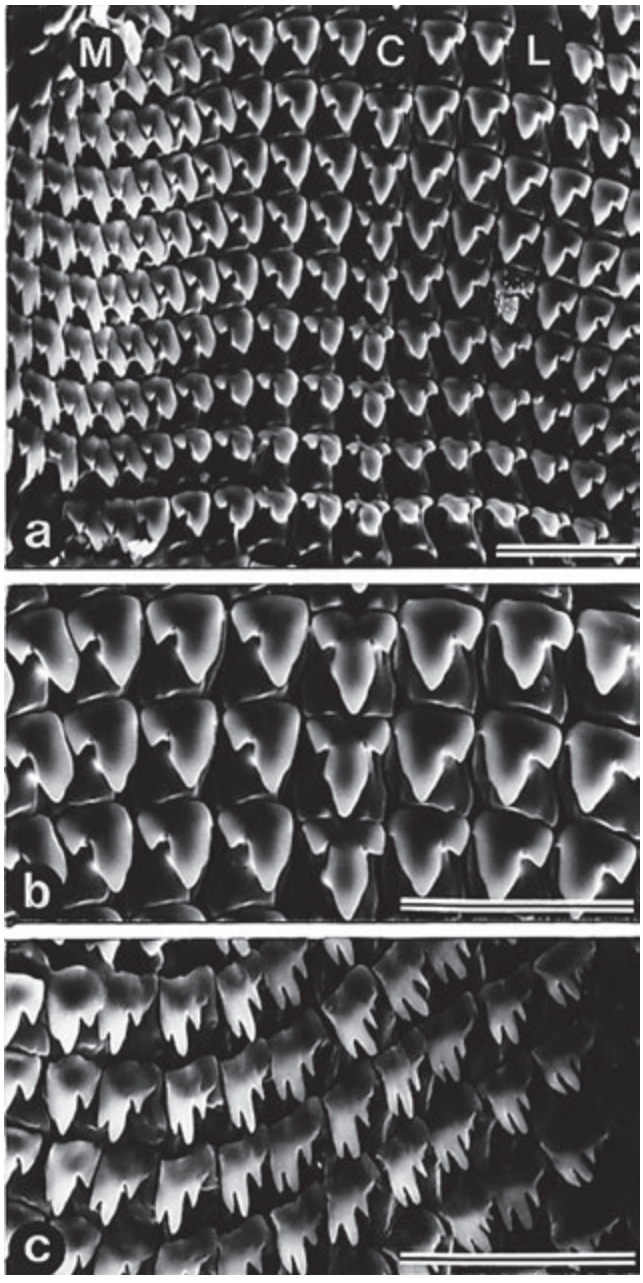


Figure 4 Scanning Electron Microscope photographs of radular teeth of *Mirus jejuensis* (all bar=30 µm): a radular teeth, C central tooth, L lateral tooth, M marginal tooth (X=500); b central and lateral tooth (X900); c marginal tooth (X900).

seminis oblong, connected at end of stalk, about 0.7 mm long. Penis without large glands. Ovary small, an unlobed mass filling about 0.5 whorls posterior to stomach. Pallial oviduct large. Oviduct with single thickened coil on albumen gland. Twenty-one mitotic cells were studied. Chromosome number and karyotype were 2n=56 and 8M+15SM+5ST, respectively (Fig. 6, Table 2).

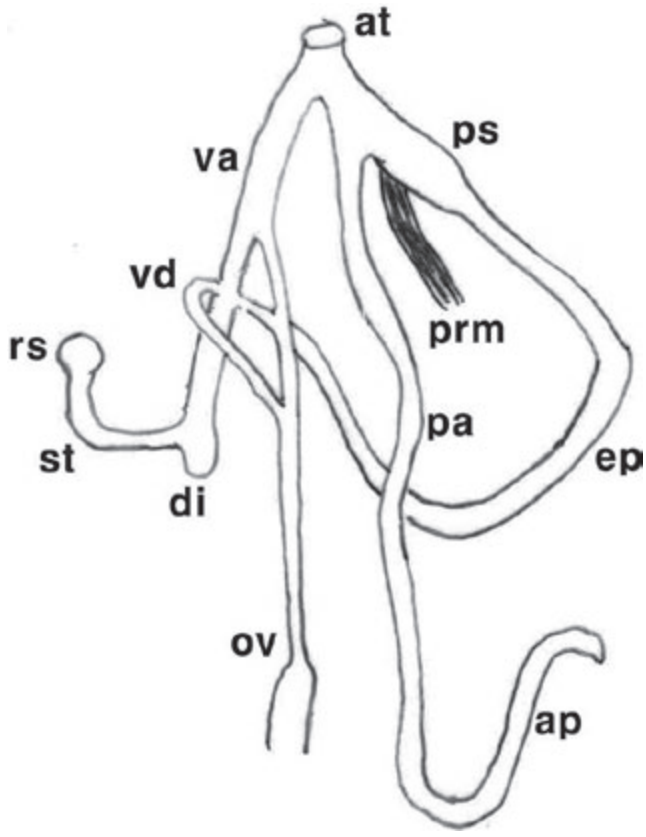


Figure 5 Genitalia of *Mirus jejuensis*: ap penial appendix; at atrium; di diverticulum; ep epiphallus; ov oviduct; pa stalk of penial appendix; pms penis retractor muscle; ps penis sheath; rs receptaculum seminis; st stalk of receptacum; va vagina; vd vas deferens.

Etymology Named after Jeju-Island, where the snail was discovered.

Habitat The snails inhabit areas of organic soil covered with rotten leaves and live under stones about 20 m inside a cave system. This species is always found in caves. No dextral forms were found within the caves.

Type locality Holotype and paratype from Geoji cave stream 3 km west of Hyubje-ri, Hallim-eup, Bukjeju-gun, Jeju Island, Korea (33°22'58" N, 126°14'47" E).

Distribution Other than the type locality, specimens were collected from caves at: Majungoreum-rock cavity, Jeoji-ri, Hangyeong-myeon, Bukjeju-gun (33°20'18'' N, 126°16'40'' E); Guenegi cave (33°32'44'' N, 126°41'17'' E); Sindang-dong cave (33°32'55'' N, 126°45'13'' E); and Gimnyeongbilremot cave (33°32'13'' N,

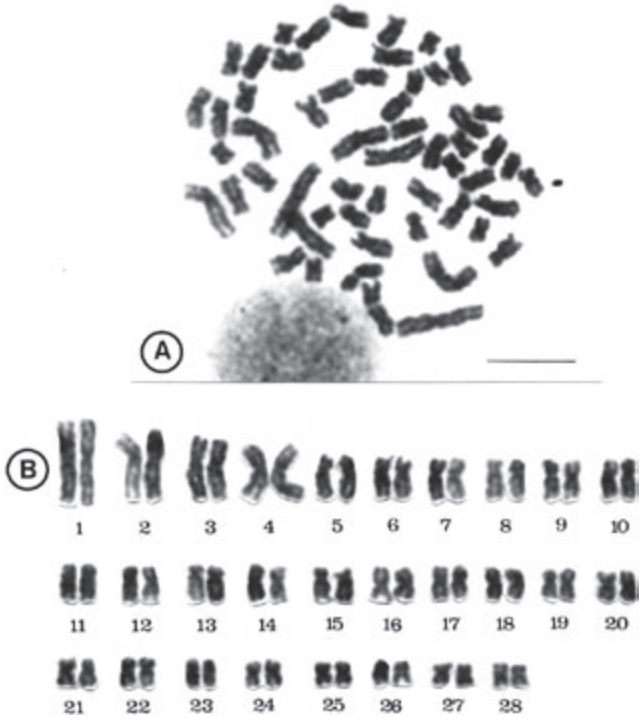


Figure 6 *Mirus jejuensis*: A metaphase chromosomes of a gonadal cell; B arrangement of the chromosomes in A into karyotypic sets. (Bar=10 μm).

126°45'25'' E), Donggimnyeong-ri, Gujwa-eup, Bukjeju-gun, Jeju Island.

Discussion

The classification of the family name Enidae has been discussed by several authors. Hausdorf (2001a, 2001b) reported that the family name Buliminidae Kobelt 1880 (type genus *Buliminus* Beck 1837) is a junior homonym of the name Buliminidae Jones 1875 (*Foraminifera*, type genus *Bulimina* d'Orbigny 1826) (ICZN, 2003). Woodward (1903) replaced the name Buliminidae Kobelt 1880 by Enidae Woodward 1903. Many of species in the Enidae are difficult to define satisfactorily, at least on shell characters alone. Until now, only three species, *Ena coreanica* Pilsbry & Hirase, 1908, *Mirus junensis* Kwon & Lee 1991, and *Mirus* sp. of Enidae are known in Korea (Kwon, 1990; Kwon & Lee, 1991). Species of the genus *Mirus* have an elongate spiral shell with smooth protoconch and often large size (Yen, 1939; Azuma, 1982; Kwon & Lee, 1991). The species are numerous and abundant in tropical areas. The new species differs considerably from other members of the genus *Mirus* not only in shell form but also in the reproductive system.

Table 2 Measurements of metaphase chromosomes in five spermatogonial cells from *Mirus jejuensis.*

Chromosome pair	Length(μm) Mean±SD	Arm ratio Mean±S.D.	Type*
1	9.8±0.29	1.10±0.15	M
2	8.4±0.36	1.89±0.13	SM
3	7.6±0.61	2.01±0.14	SM
4	7.5±0.77	2.04±0.15	SM
5	6.1±0.37	1.97±0.14	SM
6	5.4±0.66	2.99±0.13	ST
7	4.9±0.75	2.05±0.14	SM
8	4.9±0.86	2.87±0.12	ST
9	4.7±0.47	1.99±0.12	SM
10	4.6±0.55	1.81±0.15	SM
11	4.4±0.62	2.78±0.23	ST
12	4.3±0.68	2.11±0.21	SM
13	4.2±0.38	2.96±0.25	ST
14	4.0±0.55	2.03±0.19	SM
15	4.0±0.39	2.10±0.11	SM
16	4.0±0.35	1.20±0.14	M
17	3.9±0.79	1.16±0.16	M
18	3.9±0.49	1.18±0.12	M
19	3.9±0.85	1.97±0.18	SM
20	3.8±0.67	1.23±0.11	M
21	3.6±0.27	2.04±0.17	SM
22	3.5±0.70	1.86±0.17	SM
23	3.4±0.68	1.85±0.16	SM
24	3.3±0.66	2.01±0.20	SM
25	2.9±0.58	1.15±0.11	M
26	2.8±0.56	2.79±0.22	ST
27	2.6±0.52	1.21±0.13	M
28	2.5±0.50	1.23±0.12	M

*Abbreviations: M=medianly constricted chromosome; SM=submedianly constricted; ST=subterminally constricted.

It differs from *M. junensis* Kwon & Lee 1991 *and Mirus* sp. in the form of its spiral shell sculpture, as its peripheral cords are much more conspicuous and shell colouration is different. Hoso *et al.*, (2010) has reported that a single gene responsible for left-light reversal in many snails could be responsible for rapid speciation as dextral and sinistral snails have difficulty in mating. The evolution of the present species could therefore have been rapid.

It is worth noting that within the family Enidae, the number of haploid chromosomes reported lie in the range 21 to 25 (Barker, 2001). In the present species n=28.

Acknowledgements

I thank Mr. Y. G. Choi, for the supply of material.

References

Annandale TN & Prashad B 1924 Report on a small collection of mollusks from the Chekiang province of China. *Proceedings of the Malacological Society of London* **16**: 27–49.

Asami T, Cowie RH & Ohbayashi K 1998 Evolution of mirror images by sexually asymmetric mating behavior in hermaphroditic snails. *American Naturalist* **152**: 225–236.

Azuma M 1982 *Colored Illustrations of the Land Snails of Japan*. Hoikusha, Osaka, Japan: 110–114.

Barker GM 2001 Gastropods on Land: *P*hylogeny, Diversity and Adaptive Morphology. *In* Barker GM (ed.) *The biology of terrestrial molluscs*. CABI Publishing, Oxon, UK: 139–142.

Hausdorf B 2001a The genus *Ena* in Turkey, with remarks on its phylogenetic relationships (Gastropoda: Buliminidae). *Journal of Natural History* **35**: 1627–1638.

Hausdorf B 2001b Case 3192. Buliminidae Kobelt, 1880 (Mollusca, Gastropoda): proposed emendation of spelling to Buliminusidae, so removing the homonymy with Buliminidae Jones, 1875 (Rhizopoda, Foraminifera); and Enidae Woodward, 1903 (1880) (Gastropoda): proposed precedence over Buliminusidae Kobelt, 1880. *Bulletin of Zoological Nomenclature* **58**: 182–187.

Hoso M, Kameda Y, WU SP, Asami T, Kato M & Hori M 2010 A speciation gene for left-right reversal in snails results in anti-predator adaptation. *Nature Communications* **133**: 1–7.

Kwon OK 1990 *Illustrated Encyclopedia of Fauna and Flora of Korea*. Vol. 32. Mollusca(I). Ministry of Education, Seoul, Korea. 287 pp.

Kwon OK & LEE JS 1991 New land snails in Korea. *Korean Journal of Malacology* **7**: 1–11.

Levan A, Fredga K & Sandberg AA 1964 Nomenclature for centrometric position on chromosomes. *Heriditas* **52**: 201–220.

International Commission on Zoological Nomenclature 2003 Opinion 2018 (Case 3192). Buliminidae Kobelt, 1880 (Mollusca, Gastropoda): spelling emended to Buliminusidae, so removing the homonymy with Buliminidae Jones, 1875 (Rhizopoda, Foraminifera); and Enidae Woodward, 1903 (1880) (Gastropoda): given precedence over Buliminusidae Kobelt, 1880. *Bulletin of Zoological Nomenclature* **60**: 63–65.

Park GM 2008 Polyploidy in three sphaeriids (Bivalvia: Veneroida) from Korea. *Molluscan Research* **28**: 133–136.

Schileyko AA 1998 Treatise on recent terrestrial pulmonate mollusks 2. Gastrocoptidae, Hypselostomatidae, Vertiginidae, Truncatellinidae, Pachnodidae, Enidae, Sagdidae. *Ruthenica Supplement 2* : 129–261.

Thiele J 1931 *Handbuch der systematischen Weichtierkunde*. Band 1. Fischer, Jena. 778 pp.

Ueshima R & Asami T 2003 Single-gene speciation by left-right reversal. *Nature* **425**: 679.

Yen TC 1939 Die chinesischen Land-und Süßwasser-Gastropoden des Natur-Museums Senckenberg. *Abhandlungen Senckenbergianum Naturforschenden Gesellschaft* **444**: 77–80.

Woodward BB 1903 Note on the generic name *Buliminus*. *Proceedings of the Malacological Society of London* **5**: 309–310.