Karyological Studies of *Sinotaia quadrata* (Benson, 1842) (Gastropoda: Viviparidae) of Korea

Gab Man Park*

Department of Environmental Medical Biology, Catholic Kwandong University College of Medicine,
Gangneung 210–701, Korea

Received September 16, 2014; accepted November 5, 2014

Summary The karyotypes of *Sinotaia quadrata* using air-drying method collected from Hyogal-ri, Pungyang-myeon, Yecheon-gun, Gyeongbuk, Korea were investigated. The diploid number of chromosomes is $2n=16$. The eight chromosome pairs were identified and classified into three groups. The diploid cell has 1 pair of metacentric, 5 pairs of submetacentric and 2 pairs of subtelocentric chromosomes. Observed chromosomes ranged from 3.10 to $4.90\mu\text{m}$ and the total length was $34.12\mu\text{m}$. The karyotype of *S. quadrata* is described for the first time.

Key words Karyotype, Freshwater snail, Korea, *Sinotaia quadrata*, Viviparidae.

Freshwater snails are the first intermediate host for man and animals of helminthes parasites. *Sinotaia quadrata* has been recorded from eastern China, Taiwan, Japan and Korea (Pace 1973, Lee 2009). *S. quadrata* snail belongs to fresh water snails and has limited distribution in the southern Korean Peninsula. The subfamily Bellamyinae is difficult to taxonomy because of the morphological variety within and between populations. The shell of this species is more solid and narrow than either of the other viviparids, and the embryonic shell is similar to that of *Cipangopaludina chinensis* in shape. To date, only two species of *Cipangopaludina*, *C. chinensis malleata* and *C. japonica*, have been reported in Korea (Kwon *et al.* 1993). While Kira (1962) listed Korea as within the range of this species, it should be noted that Shiba (1935) said that only *C. chinensis* occurred in Korea. Recently, *Sinotaia quadrata* has been reported as an unrecorded species in Korea (Lee 2009). The adult shell of *S. quadrata* can easily be distinguished from other Korean species by the shell with acute spire and usually with spiral angulations or low carinae on the whorls.

The few species belonging to the Viviparidae have been reported to serve in their native habitat as an intermediate host and a vector to numerous parasites (Pace 1973, Malek and Cheng 1974, Johnson 1992, Chung and Jung 1999, Devkota *et al.* 2011). While Ito (1964) listed *Cercaria shanghaiensis* and *C. echinolophocauda* from *S. quadrata*, no record was found to indicate that they are important vectors of human parasites.

In recent years, through a considerable number of works, a large amount of information has been accumulated on the chromosomes of the mollusks. Chromosome counts were obtained for 997 molluscan species within 124 terminal taxa and included members of five major extant classes (Polyplacophora, Bivalvia, Cephalopoda, Scaphopoda, and Gastropoda) (Hallinan and Lindberg 2011). Cytogenetic studies of mollusks have been important in aspects of phylogenetics and cytogenetic relationships among the species. Detailed studies of chromosome morphology and population cytology of the Viviparidae are well known (Baršienė *et al.* 2000, Thiriot-Quiévreux

* Corresponding author, e-mail: gmpark@cku.ac.kr

DOI: 10.1508/cytologia.80.89

Table 1. Chromosome numbers and karyotypes of subfamily Bellamyinae.

Species	Diploid no.	Karyotype	Source	References
<i>Bellamya aeruginosa</i>	16	2M+4SM+2ST	China	Zhou <i>et al.</i> 1988
<i>B. angularisa</i>	16	2M+4SM+2ST	China	Zhou <i>et al.</i> 1988
<i>B. bengalensis</i>	22	7M+4SM	India	Choudhury and Pandit 1997
<i>B. quadrata</i>	16	2M+4SM+2ST	China	Zhou <i>et al.</i> 1988
<i>B. unicolor</i>	18	5S+2SM+2ST	Egypt	Yaseen <i>et al.</i> 1991
<i>Cipangopaludina cathayensis</i>	18	5M+3SM+1ST	China	Zhou <i>et al.</i> 1988
<i>C. chinensis</i>	18	5M+3SM+1ST	China	Zhou <i>et al.</i> 1988
<i>C. chinensis malleata</i>	18	2M+7SM	Korea	Park <i>et al.</i> 1997
<i>C. japonica</i>	18	2M+7SM	Korea	Park <i>et al.</i> 1997
<i>Sinotaia quadrata</i>	16	1M+5SM+2ST	Korea	This study

*M, metacentric; SM, submetacentric; ST, subtelocentric chromosomes.

Fig. 1. Shell of *Sinotaia quadrata*.

2003). The chromosome numbers of nine species in Bellamyinae until now studied by some workers and including the present study were $n=8$, $n=9$ and $n=11$ (Table 1). The aim of this study was to determine the chromosome numbers and to identify the karyotype of *S. quadrata*.

Materials and methods

The 29 specimens used in this study were collected in Hyogal-bridge, Hyogal-ri, Pungyang-myeon, (128°16'55"E, 36°29'41"N), Yecheon-gun, Gyeongbuk, Korea, May 2014, and examined shortly after collection (Fig. 1). The chromosome preparations were made on gonad of the specimens by the usual air-drying method following the techniques described by Park and Yong (2014). The prepared slides were observed under an Olympus (BX51) microscope. Voucher specimens of the samples studied have been deposited at the Department of Environmental Medical Biology, Catholic Kwandong University College of Medicine, Korea.

Results

A microphotograph of somatic metaphase chromosomes and the karyogram are shown in Fig. 2, and measurements of the chromosomes in Table 2. The present cytological preparations showed 15 well-spread mitotic cells on a slide. This species showed a diploid chromosome number of $2n=16$, with 1 metacentric, 5 submetacentric and 2 subtelocentric chromosome pairs. Observed chromosomes ranged from 3.10 to 4.90 μm in length. This species had no inter-specimen variability in chromosome counts. Also, sexual dimorphism of chromosomes was not found in this study.

Table 2. Relative lengths and total lengths (μm) of chromosomes of *Sinotaia quadrata*.

Chromosome	RL $\pm$ SE	TL $\pm$ SE	Type
1	14.36 $\pm$ 0.20	4.90 $\pm$ 0.31	M
2	14.21 $\pm$ 0.12	4.85 $\pm$ 0.25	SM
3	14.06 $\pm$ 0.24	4.80 $\pm$ 0.13	SM
4	13.92 $\pm$ 0.09	4.75 $\pm$ 0.16	SM
5	13.24 $\pm$ 0.34	4.52 $\pm$ 0.15	SM
6	10.96 $\pm$ 0.17	3.74 $\pm$ 0.20	SM
7	10.14 $\pm$ 0.34	3.46 $\pm$ 0.32	ST
8	9.08 $\pm$ 0.14	3.10 $\pm$ 0.21	ST

*Based on measurements from four sets from *Sinotaia quadrata* of karyotyped cells. M, metacentric; RL, relative length; SE, standard error; SM, submetacentric; ST, subtelocentric; TL, total length.

Fig. 2. Metaphase chromosomes of *Sinotaia quadrata* (A, B) and karyotype constructed from A (C).

Discussion

Viviparidae is one of the most cytologically attentive families of Mesogastropoda with three sub-families Bellamyinae, Vivipparinae and Lioplacinae (Choudhury and Pandit 1997). *Sinotaia quadrata* of the present study belongs to the subfamily Bellamyinae of Viviparidae. The family Viviparidae is conservative in regard to chromosome numbers in that 34 species range from $n=7$ to $n=32$ (Choudhury and Pandit 1997, Thiriott-Quievreux 2003), but the detailed morphology of chromosomes are available for 16 species only. The published data on chromosome number and metaphase karyotypes for the Bellamyinae, including the new records from this study, are shown in Table 1. The Bellamyinae shows haploid chromosome numbers ranging from 8 to 11. The haploid number of chromosomes in what Inaba (1965) called *Sinotaia histicus* was found to be eight, one less than that reported for *C. chinensis*. In this study, *S. quadrata* has eight chromosome numbers. The highest chromosome number, $n=11$, is reported from *B. bengalensis* within the Bellamyinae (Choudhury and Pandit 1997). Techniques of karyological analysis have greatly improved recently for phylogeny and evolution on gastropods (Thiriott-Quievreux 2003, Pascoe *et al.* 2004, Hallinan and Lindberg 2011). Many authors reported that low chromosome number is often related to more

evolved species in mollusk families (Ahmed 1976, Vitturi *et al.* 1982). Pascoe *et al.* (2004) have suggested a general evolutionary trend towards an increase in genome size and a decrease in chromosome number and haploid length within the group. Most of the Viviparidae chromosomes in the karyotype were metacentric or submetacentric. Vitturi and Catalano (1984) have reported that within the mesogastropoda an increase in the amount of chromosomal DNA is not always necessarily accompanied by an increase in the chromosome number. Also, few workers postulated the existence of a chromosomal sex-determining mechanism in Viviparidae and different diploid chromosome numbers in males and females. Patterson (1969) and Stern (1975) have reported XX and XY types in *Viviparus purpureus* and *Tulotoma angulata*, respectively. Also, Baršienė *et al.* (2000) have described a sex-determining mechanism of ZW female/ZZ male from *V. ater*, *V. acerosus* and *V. mamillatus*. In this study, I could not identify the sex chromosome from *S. quadrata*.

The importance of snails as intermediate and paratenic host for certain species of nematodes, although well recognized, has been overshadowed by the role of snails in the life cycle of medically and economically important trematodes (Chung and Jung 1999, Farahnak *et al.* 2006). Although some viviparid snails such as *Cipangopaludina chinensis malleata* act as the second intermediate host of echinostome trematodes in Korea, the parasitological role of *S. quadrata* has not been reported yet. In this study, I did not find trematode cercarial infection from *S. quadrata*. Shimazu (1974) described the free (unencysted) brachylaimid metacercaria of *Amblosoma suwaense* from the viviparid snail *Sinotaia quadrata* in Japan. More studies will need various analyses for the investigation of the karyo-systematic evolution, and accumulation of karyological information is very much required in the subfamily Bellamyinae.

References

- Ahmed, M. 1976. Chromosome cytology of marine pelecypod mollusk. *J. Sci. (Karachi)* **4**: 77–94.
- Baršienė, J., Ribi, G. and Baršyte, D. 2000. Comparative karyological analysis of five species of *Viviparus* (Gastropoda: Prosobranchia). *J. Molluscan Stud.* **66**: 259–271.
- Choudhury, R. and Pandit, R. K. 1997. Chromosomes of three prosobranch gastropods (Viviparidae, Pilidae and Cyclophoridae) (Order Mesogastropoda). *Caryologia* **50**: 341–353.
- Chung, P. R. and Jung, Y. 1999. *Cipangopaludina chinensis malleata* (Gastropoda: Viviparidae): a new second molluscan intermediate host of a human intestinal fluke *Echinostoma cinetorchis* (Trematoda: Echinostomatidae) in Korea. *J. Parasitol.* **85**: 963–964.
- Devkota, R., Budha, P. B. and Gupta, R. 2011. Trematode cercariae infections in freshwater snails of Chitwan district, central Nepal. *Himalayan J. Sci.* **7**: 9–14.
- Farahnak, A., Mobedi, I. and Ghobadi, H. 2006. Nematode association with *Bellamya bengalensis* snail and its medical and veterinary importance in Khuzestan province (south west of Iran). *Arch. Razi Inst.* **61**: 49–52.
- Hallinan, N. M. and Lindberg, D. R. 2011. Comparative analysis of chromosome counts infers three paleopolyploidies in the mollusca. *Genome Biol. Evol.* **3**: 1150–1163.
- Inaba, A. 1965. Cytotaxonomic studies of freshwater gastropods (I). *Venus* **23**: 223–228.
- Ito, J. 1964. A monograph of cercariae in Japan and adjacent territories. In: Morishita, K., Komiya, Y. and H. Matsubayashi, H. (eds.). *Progress of Medical Parasitology in Japan*, Vol. I. Meguro Parasitological Museum, Tokyo. p. 753.
- Johnson, S. G. 1992. Parasite-induced parthenogenesis in a freshwater snail: Stable, persistent patterns of parasitism. *Oecologia* **89**: 533–541.
- Kira, T. 1962. *Shell of the Western Pacific in Color I*. Hoikusha Pub. Co., Ltd., Osaka. p. 224.
- Kwon, O. K., Park, G. M. and Lee, J. S. 1993. *Coloured Shells of Korea*. Academy Publishing Company, Seoul. p. 445.
- Lee, J. S. 2009. Rediscovery of *Sinotaia quadrata* (Architaenioglossa: Viviparidae) of Kumpung Reservoir in the Jellabuk-do, Korea. *Korean J. Malacol.* **25**: 243–245.
- Malek, E. A. and Cheng, T. C. 1974. *Medical and Economic Malacology*. Academic Press, New York. pp. 68–69.
- Pace, G. L. 1973. The freshwater snails of Taiwan (Formosa). *Malacol. Rev. Suppl.* **1**: 1–118.
- Park, G. M., Jung, Y. and Chung, P. R. 1997. Cytological studies of two species of genus *Cipangopaludina* (Mesogastropoda: Viviparidae) in Korea. *Korean J. Malacol.* **13**: 21–27.

- Park, G. M. and Yong, T. S. 2014. Karyological studies of *Biomphalaria tenagophila* (d'Orbigny, 1835) (Gastropoda: Planorbidae) from Rio de Janeiro, Brazil. *Korean J. Parasitol.* **52**: 449–452.
- Pascoe, P. L., Jha, A. N. and Dixon, D. R. 2004. Variation of karyotype composition and genome size in some muricid gastropods from the northern hemisphere. *J. Molluscan Stud.* **70**: 389–398.
- Patterson, C. M. 1969. Chromosomes of mollusks. In: *The 2nd Symposium on Mollusca*, Ernakulam. pp. 635–686.
- Shiba, N. 1935. The distribution of *Viviparus (Cipangopaludina) chinensis malleatus* (Reeve) in Chosen. *Venus* **5**: 17–22.
- Shimazu, T. 1974. A new digenetic trematode, *Amblosoma suwaense* sp. nov., the morphology of its adult and metacercaria (Trematoda, Branchylaimidae). *Jpn. J. Parasitol.* **23**: 100–105.
- Stern, E. M. 1975. The chromosomes of *Viviparus subpurpureus* (Say) (Streptoneura: Viviparidae). *Malacol. Rev.* **8**: 107–108.
- Thiriot-Quievreux, C. 2003. Advances in chromosomal studies of gastropod mollusks. *J. Molluscan Stud.* **69**: 187–201.
- Vitturi, R. and Catalano, E. 1984. Spermatocyte chromosomes in 7 species of the sub-class Prosobranchia Mollusca, Gastropoda. *Biol. Zent. Bl.* **1031**: 69–76.
- Vitturi, R., Rasotto, M. B. and Farinella-Ferruza, N. 1982. The chromosomes of 16 molluscan species. *Boll. Zool.* **49**: 61–71.
- Yaseen, A. E., Braid, A. M. and Kawashti, I. S. 1991. Studies on the chromosomal analysis and shell measurements of two species *Bellamya unicolor* and *Lanistes bolteni* (Prosobranchia: Gastropoda). *Cytologia* **56**: 503–509.
- Zhou, D., Zhou, M. and Wu, Z. 1988. The karyotype of five species of freshwater snails of the family Viviparidae. *Acta Zoologica Sinica* **34**: 364–370.
-