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# Genetic Relationships among Korean Brown Frog Species (Anura, Ranidae), with Special Reference to Evolutionary Divergences between Two Allied Species Rana dybowskii and R. huanrenensis

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**ABSTRACT**—Allozyme analysis for 41 populations of brown frog species, *Rana dybowskii*, *R. huanrenensis*, and *R. amurensis* from Korea and three reference species (Chinese *R. chensinensis* and Japanese *R. dybowskii* and *R. tsushimensis*), were performed to clarify taxonomic status of Korean brown frogs. The level of average genetic differentiation (Nei's D) among local populations of each species in Korea was very low (D<0.012) and Korean and Japanese *R. dybowskii* also showed conspecific level of differentiation (D=0.070). Whereas, much larger, discrete genetic differences were detected in the interspecific comparisons (D>0.370). In the genetic relationships among five species examined, the 24 chromosome brown frogs (*R. dybowskii*, *R. huanrenensis*, and *R. chensinensis*) did not form a monophyletic group. *Rana dybowskii* with the chromosome number of 2n=24 was grouped together with *R. amurensis* with the chromosome number of 2n=26. The hypothesis of reversal change from 24 to 26 in Korean *R. amurensis* seems to better explain the phylogenetic relationships of east Asian brown frogs than the assumption of parallel reduction in chromosome number from 2n=26 to 24 in *R. dybowskii* and in the common ancestor of *R. huanrenensis* and *R. chensinensis*. The genetic, morphological, and reproductive divergences between Korean *R. dybowskii* and *R. huanrenensis* were compared.

**Key words:** allozyme, brown frog, chromosome number, genetic differentiation, phylogenetic relationship

# INTRODUCTION

The Eurasian brown frogs are a morphologically conservative assemblage consisting of the Eurasian *Rana temporaria* and a large number of similar species considered to be related (Frost, 1985; Borkin and Kuzmin, 1988; Green and Borkin, 1993; Nishioka *et al.*, 1992; Maeda and Matsui, 1999). The chromosome number of great majority of *Rana* species is 26 and most of brown frog species have the same number. Some of brown frogs, however, are unique in having diploid chromosomes of 2n=24 (Matsui, 1991; Green and Borkin, 1993; Xie *et al.*, 1995). These 24 chromosome brown frogs include the European *R. arvalis* and several

east Asian species allied to R. chensinensis, such as R. dybowskii, R. ornativentris, R. pirica, and R. huanrenensis (Kobayashi, 1962; Seto, 1965; Wu, 1982; Green, 1983; Luo and Li, 1985; Lee and Park, 1986; Ma, 1987; Wei et al, 1990; Liu et al., 1993; Green and Borkin, 1993; Xie et al., 1995; Lee and Lee, 1998). These east Asian brown frogs are quite similar in morphology, and are very difficult to identify (Nakamura and Ueno, 1963; Matsui et al., 1993, 1998; Xie et al., 1995; Yang et al., 2000). Indeed, most of them were originally described on the basis of slight morphological differences. Recently, taxonomic status of each species was made clearer by lines of additional information, such as considerable genetic divergences among them (Matsui, 1991; Green and Borkin, 1993; Tanaka-Ueno et al., 1998; Matsui et al., 1998; Kim et al., 1999; Yang et al., 2000). Although extensively studied in the laboratory (Kawamura et al., 1981), the direct evidence of reproductive isolation in the field among these allied species have never been reported

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because of their geographic isolation due to allopatric distribution

Until recently, it has been reported that *R. dybowskii* (a 24 chromosome member) and *R. amurensis coreana* (a 26 chromosome member) are distributed in South Korea (Yang and Yu, 1978; Sengoku, 1979; Green and Borkin, 1993; Matsui *et al*, 1998). Most recently, we (Yang *et al.*, 2000) reported a new Korean brown frog member (*R. huanrenensis* Fei, Ye and Huang, 1990) which was morphologically and karyologically (2n=24) very similar to *R. dybowskii*.

In this study, we investigate the degree of inter- and intraspecific genetic variation and to clarify the genetic relationships among three species of Korean brown frogs. For comparisons, Japanese *R. dybowskii* and *R. tsushimensis* and Chinese *R. chensinensis* are also incorporated to the analysis. In addition, we surveyed the levels of morphological, genetic, and reproductive divergence between sympatricsamples of *R. dybowskii* and *R. huanrenensis* from South Korea

#### **MATERIALS AND METHODS**

#### Collection and field notes

Five brown frogs were collected from 41 localities in Korea, Japan, and China (Table 1). During most collecting trips in Korea and Japan, the notes and photographs on color pattern of each specimen and records of each breeding site were taken.

# **Protein Electrophoresis**

For an electrophoretic examination, a total of 849 specimens belonging to 41 populations of five species were employed. These include 10 populations of *Rana huanrenensis* from South Korea, 17 populations of *R. dybowskii* from South Korea and Japan, 2 populations of *R. chensinensis* from China, 11 populations of *R. amurensis* from South Korea, and 1 population of *R. tsushimensis* from Japan (Table 1).

Live samples were transported to the laboratory and were stored at -70°C until use. In the laboratory, the tissues of liver, heart and skeletal muscle were removed from each specimens and homogenized by glass homogenizer in an equal volume of distilled water and were centrifugated at 18,000 rpm for 30 min at 4°C to obtain the supernatant for electrophoresis. Voucher specimens were fixed in 10% formalin, preserved in 70% ethanol, and deposited in Yang's collection at Inha University. The supernatant was subjected to horizontal starch-gel (12%) electrophoresis and histochemical staining procedures (Yang *et al.*, 1997: Appendix I). Multiple loci were numbered sequentially, and alleles were designated alphabetically with "a" being the fastest migrant.

Individual genotypes were used to calculate allele frequencies for each population, these in turn were used to calculate matrices of genetic similarity (Rogers, 1972) and genetic distance (Nei, 1978). Three different methods were employed to infer relationships among populations. First, Nei's (1978) distance was clustered according to the UPGMA algorithm (Sneath and Sokal, 1973). Then, modified Rogers' distance (Wright, 1978) was analyzed by the Neighbor-joining (NJ) method (Saitou and Nei, 1987), and finally, we employed Felsenstein's (1993) DNAML procedure with allele frequencies for the maximum-likelihood (ML) analysis. These analyses were performed by use of BIOSYS-1 (Swofford and Selander, 1981) and PHYLIP vers. 3.5 C computer packages (Felsenstein, 1993).

#### Morphology

In order to detect morphological differences between Korean *Rana dybowskii* and *R. huanrenensis*, conditions of vocal sacs and the pattern of coloration on the body were examined for these two species.

#### **RESULTS**

# Genetic variation and relationships among brown frogs

Genetic variation—By-products of 18 loci were scored from 13 enzymes and general proteins. Observed allelic frequencies are given in Appendix II.

Based on allelic frequencies listed in Appendix II, the degree of genetic variation of each population was estimated (Table 2). The genetic variability of R. dybowskii was P=26.0% (22.2-33.3%), Ho=0.118 (0.070-0.183), and He=0.122 (0.078-0.153). The genetic variabilities of R. huanrenensis and R. amurensis were P=22.2% (16.7–27.8%), Ho=0.063 (0.046-0.073), He=0.067 (0.058-0.081) and P=22.2% (5.6-33.3%), Ho=0.080 (0.029-0.120), He=0.086 (0.035-0.124), respectively. In Korean brown frogs, Kanseong population of R. dybowskii had the highest genetic variability (P=36.4%, Ho=0.165, He=0.165) while Koseong population of R. amurensis showed the lowest variability (P=9.1%, Ho=0.048, He=0.042). On the other hand, Chinese R. chensinensis, a reference species, showed P=22.3%, Ho=0.078, He=0.075. Another reference species Japanese R. tsushimensis, was more variable, with P=27.8%, Ho=0.094, He=0.097, than in Korean brown frog species.

Genetic relationships—Based on allelic frequencies listed in Appendix II, average genetic similarities (Rogers' S) and distances (Nei's D) among populations of five brown frog species were calculated (Appendix III). In the Korean brown frogs, *R. huanrenensis*, *R. dybowskii* and *R. amurensis*, the degree of genetic differentiation within a species was small (D=0.034: Appendix III), but differentiations among these Korean brown frogs were very distinct (D=0.584 between *R. huanrenensis* and *R. amurensis*, and D=0.788 between *R. huanrenensis* and *R. amurensis*, and D=0.500 between *R. dybowskii* and *R. amurensis*) due mainly to *Gp-4*, *aGpd*, *Mdh*, and *Ldh-1* loci that were ascertained as diagnostic among these Korean species.

When populations of 24 chromosome species from outside of Korea were included, genetic dissimilarities between *R. huanrenensis* (populations 1–10; Appendix III) and *R. dybowskii* (pops. 11–30) included fixed allelic differences at *Gp-4*, *Mdh*, and *Iddh* loci and diagnostic differences at the 95% confidence level (Ayala and Powell, 1972) at *Ldh-1* locus. *Rana huanrenensis* and *R. chensinensis* (pops. 28 and 29) included fixed allelic difference at *Ldh-1* locus and diagnostic differences at *Iddh*, *Aat-1*, and *Acoh*. Fixed allelic differences at *Gp-4*, *Ldh-1*, *Mdh*, and *Iddh* and diagnostic differences at *Aat-1* were found between *R. dybowskii* and *R. chensinensis* (Appendix II). Among populations of three brown frog species with 24 chromosomes (Appendix III),

**Table 1.** Collection localities, collection dates, and sample sizes (N) for electrophoretic and morphological analyses of *Rana huanrenensis*, *R. dybowskii*, *R. chensinensis*, *R. amurensis*, and *R. tsushimensis* from Korea, Japan, and China.

	Collection localities	Date	N
	Rana huanrenensis (2n=24)		
1.	Jangseong: Bukha-myon, Jangseong-gun, Chollanam-do	Mar. 29, 1995	2
2.	Pohang: Bokyung-sa, Pohang-shi, Kyongsangbuk-do	Apr. 25, 1997	2
3.	Cheongsong: Daejeon-sa, Cheongsong-gun, Kyongsangbuk-do	Mar. 28, 1997	3
4.	Yeongdeog: Namjung-myon, Yeongdeog-gun, Kyongsangbuk-do	Apr. 25, 1997	2
5.	Pyeongchang: Chinbu-myon, Pyeongchang-gun, Kangwon-do	May 19, 1994	
6.	Hanso-ri: Hanso-ri, Bekjeon-myon, Jeongseon-gun, Kangwon-do	Apr. 27, 1995	2
7.	Oban-ri: Oban-ri, Dong-myon, Jeongseon-gun, Kangwon-do	Mar. 27, 1997	2
8.	Inje: Baekdam-sa, Buk-myon, Inje-gun, Kangwon-do	Apr. 14, 1995	
9.	Kapyeong: Hwaak-ri, Buk-myon, Kapyeong-gun, Kyonggi-do	Apr. 4, 1998	1
10.	Donghae: Bicheon-dong, Donghae-shi, Kangwon-do <i>R. dybowskii</i> (2n=24)	Feb. 26, 1998	3
11.	Yangpyeong: Yongmun-myon, Yangpyeong-gun, Kangwon-do	Apr. 3, 1997	1
12.	Cheongyang: Taechi-myon, Cheongyang-gun, Chungchongnam-do	Mar. 30, 1997	2
13.	Muju: Ansung-myon, Muju-gun, Chollabuk-do	Mar. 12, 1997	2
14.	Jangseong: Bukha-myon, Jangseong-gun, Chollanam-do	Mar. 29, 1995	3
15.	Kurye: Hwaom-sa, Kurye-gun, Chollanam-do	Mar. 6, 1994	1
16.	Haenam: Masan-myon, Haenam-gun, chollanam-do	Mar. 16, 1997	1
17.	Jeju: Sogwipo-shi, Jeju-do	Mar. 23, 1996	3
18.	Keoje: Shinhyun-up, Keoje-shi, Kyongsangnam-do	Mar. 15, 1997	2
19.	Hadong: Ssangkye-sa, Hadong-gun, Kyongsangnam-do	Mar. 15, 1997	2
20.	Yangsan: Naewon-sa, Yangsan-gun, Kyongsangnam-do	Mar. 10, 1995	2
21.	Donghae: Bicheon-dong, Donghae-shi, Kangwon-do	Mar. 21, 1997	2
22.	Inje: Baekdam-sa, Buk-myon, Inje-gun, Kangwon-do	Apr. 14, 1995	1
23.	Kanseong: Kanseong-up, Koseong-gun, Kangwon-do	Apr. 15, 1995	
24.	Keojin: Keojin-up, Koseong-gun, Kangwon-do	Mar. 2, 1997	2
25.	Kapyeong: Hwaak-ri, Buk-myon, Kapyeong-gun, Kyonggi-do	Apr. 4, 1998	1
26.	Wonju: Chiak-Mt., Wonju-shi, Kangwon-do	May 23, 1997	1
27.	Tsushima Isl.: Tokoya, Tsushima-Isl., Nagasaki-pref., Japan <i>R. chensinensis</i> (2n=24)	Mar. 9, 1998	
28*.	Ningxia Hui: Yinnan-pref., Ningxia Hui-prov., China	_	
29*.	Qinghai: Haidong-pref., Qinghai-prov., China <i>R. amurensis</i> (2n=26)	_	
30.	Haenam : Masan-myon, Haenam-gun, Chollanam-do	Mar. 16, 1997	2
31.	Kangwha: Naega-myon, Kangwha-gun, Incheon	Apr. 4, 1997	3
32.	Sorae : Sorae, Shihung-shi, Kyonggi-do	May 22, 1995	
33.	Yangpyeong : Yongmoon-myon, Yangpyeong-gun, Kyonggi-do	Sep. 26, 1997	2
34.	Cheongju : Sangdang-dong, Cheongju-shi, Chungchongbuk-do	Mar. 12, 1997	3
35.	Yeongdong : Chupungryong-myon, Yeongdong-gun, Chungchongbuk-do	Sep. 28, 1997	3
36.	Cheongyang : Chongsan-myon, Cheongyang-gun, Chungchongnam-do	Mar. 29, 1997	3
37.	Yangsan : Changan-up, Yangsan-gun, Kyongsangnam-do	Mar. 10, 1995	
38.	Kyeongju: Kangdong-myon, Kyeongju-shi, Kyongsangbuk-do	Jun. 20, 1997	3
39.	Kangnung : Yuchon-dong, kangnung-shi, Kangwon-do	Sep. 27, 1997	3
40.	Koseong : Keojin-up, Koseong-gun, Kangwon-do  R. tsushimensis (2n=26)	Mar. 21, 1997	2
41.	Tsushima Isl.: Tokoya, Tsushima-Isl., Nagasaki-pref., Japan	Mar. 9, 1998	1

<sup>\*</sup> Part of frozen tissues (RM 5176, 5178, 5180, 5308, 5309, 5431, 5432, and 5435, and TP 19669 and 19670) deposited in the MVZ (Museum of Vertebrate Zoology, University of California, Berkely).

average genetic distances among local populations of a single species were low (D=0.008 in *R. huanrenensis*, D=0.005 in Korean *R. dybowskii*, D=0.070 in Korean and Japanese

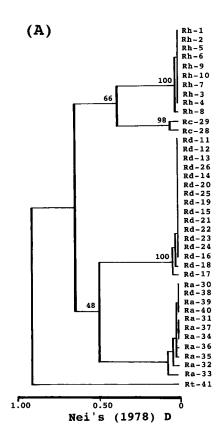
R.~dybowskii, D=0.053 in R.~chensinensis), whereas the average genetic distances among three species were distinctly high (D=0.584 between R.~huanrenensis and R.~

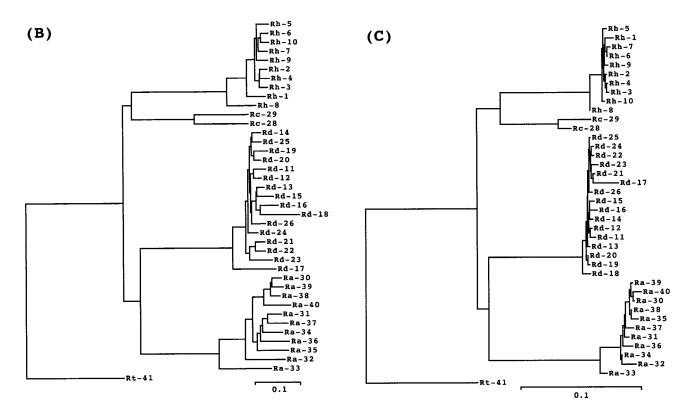
**Table 2.** Genetic variation of 41 populations in *Rana huanrenensis*, *R. dybowskii*, *R. chensinensis*, *R. amurensis* and *R. tsushimensis* from Korea, Japan, and China.

			Mean N	% Polymorphism	Mean Heterozygosity			
	Population	N	of Alleles (N)	(P)	Observed (Ho)	Expected (He)		
Rana hu	anrenensis							
1.	Jangseong	27	1.3	27.8	0.064	0.080		
2.	Pohang	28	1.6	22.2	0.046	0.060		
3.	Cheongsong	30	1.5	22.2	0.065	0.065		
4.	Yeongdeog	26	1.4	22.2	0.073	0.060		
5.	Pyeongchang	8	1.4	27.8	0.069	0.072		
6.	Hanso-ri	29	1.6	16.7	0.050	0.058		
7.	Oban-ri	29	1.6	16.7	0.073	0.066		
8.	Inje	7	1.3	22.2	0.063	0.081		
9.	Kapyeong	16	1.4	27.8	0.066	0.066		
10.	Donghae	30	1.6	16.7	0.063	0.058		
R. dybov	vskii							
11.	Yangpyeong	16	1.7	22.2	0.108	0.113		
12.	Cheongyang	21	1.9	22.2	0.138	0.120		
13.	Muju	21	1.8	22.2	0.116	0.131		
14.	Jangseong	33	2.0	22.2	0.121	0.131		
15.	Kurye	14	1.6	27.8	0.095	0.117		
16.	Haenam	14	1.4	27.8	0.087	0.118		
17.	Jeju	30	1.4	22.2	0.070	0.078		
18.	Keoje	27	1.6	27.8	0.130	0.122		
19.	Hadong	25	1.7	27.8	0.109	0.124		
20.	Yangsan	29	1.8	27.8	0.111	0.125		
21.	Donghae	29	1.9	22.2	0.113	0.109		
22.	Inje	14	1.6	22.2	0.119	0.120		
23.	Kanseong	7	1.5	27.8	0.183	0.153		
24.	Keojin	28	1.9	33.3	0.129	0.135		
25.	Kapyeong	13	1.7	27.8	0.120	0.123		
26.	Wonju	10	1.6	33.3	0.133	0.126		
27.	Tsushima Isl.	1	_	_	_	_		
R. chens		•						
28.	Ningxia	5	1.2	16.7	0.078	0.067		
29.	-	5	1.3	27.8	0.078	0.083		
R. amure		Ü	1.0	27.0	0.070	0.000		
	Haenam	26	1.4	16.7	0.068	0.070		
31.	Kangwha	30	2.1	33.3	0.107	0.115		
32.	Sorae	5	1.2	16.7	0.067	0.057		
33.	Yangpyeong	20	1.6	33.3	0.007	0.100		
34.	Cheongju	30	1.6	27.8	0.100	0.103		
35.			1.6					
36.	Yeongdong Cheongyang	30 30	1.7	22.2 27.8	0.083 0.089	0.082 0.108		
36. 37.	•• •	6						
	Yangsan		1.5	33.3	0.120	0.124		
38.	Kyeongju	35 30	1.7	22.2	0.076	0.084		
39.	Kangnung	30	1.3	16.7	0.044	0.058		
40.	Koseong	25	1.2	5.6	0.029	0.035		
		40	4.0	07.0	0.004	0.007		
R. tsushi 41.	imensis Tsushima Isl.	10	1.3	27.8	0.094	0.09		

dybowskii, D=0.386 between R. huanrenensis and R. chensinensis, and D=0.485 between R. dybowskii and R. chensinensis).

Between Korean *R. amurensis* (pops. 30–40) and Japanese *R. tsushimensis* (pop. 41), both with 26 chromosomes, genetic dissimilarities included fixed allelic differ-





**Fig. 1.** A UPGMA tree (A), a neighbor-joining tree (B), and a maximum-likelihood tree (C) among a total of 41 populations of *Rana huanrenensis* (Rh), *R. dybowskii* (Rd), *R. chensinensis* (Rc), *R. amurensis* (Ra), and *R. tsushimensis* (Rt). For population number, refer to Table 1. Nodal values on the UPGMA tree (A) indicate percent support for branches in 100 bootstrap replicates.

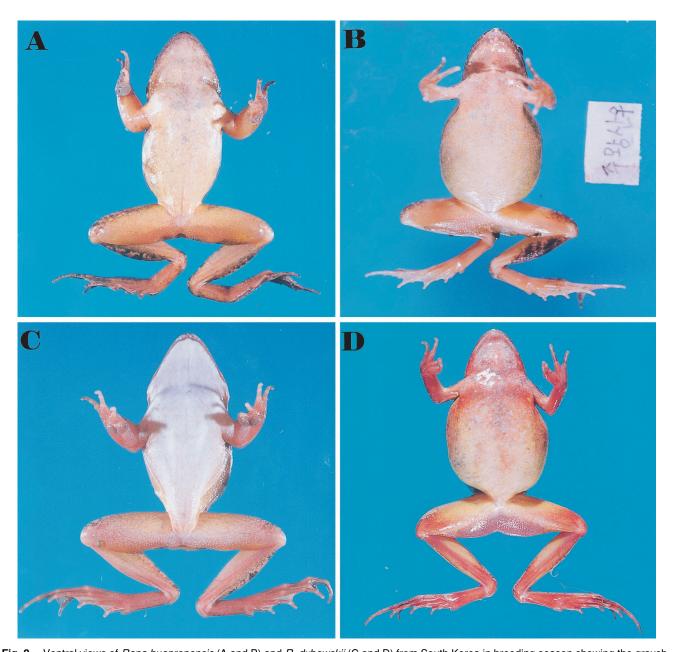
ences at *Got-1*, *Gp-4*, *Idh*, *Sod*, *Ldh-1*, and *Ldh-2* loci and diagnostic differences (at the 95% confidence level) at *Mdh*, *Pgm-1*, and *Pgm-2* loci (Appendix II). The average genetic differentiation among these two 26 chromosome species were distinctly high (mean D=0.935).

Fig. 1A shows the UPGMA tree based on Nei's unbiased genetic distance. Although the bootstrap support for most of the nodes, except for monophyly of each species (not shown in the figure), was weak, *Rana tsushimensis* exhibited the earliest divergence among all populations examined. The remaining populations were divided into two distinct groups; One group included *R. huanrenensis* and *R.* 

chensinensis, and the other included *R. dybowskii* and *R. amurensis*. Topologies of NJ (Fig. 1B) and ML (Fig. 1C) trees based on modified Rogers' distance and allele frequenicies, respectively, were similar to that of UPGMA tree in that *R. tsushimensis* first diverged and *R. amurensis* and *R. dybowskii*, and *R. chensinensis* and *R. huanrenensis*, respectively, formed a separate subcluster.

# Comparisons between R. dybowskii and R. huanrenensis

Morphology — Intraspecific morphological variation was much less notable than interspecific one. Rana huanrenen-



**Fig. 2.** Ventral views of *Rana huanrenensis* (A and B) and *R. dybowskii* (C and D) from South Korea in breeding season showing the grayshyellow throat and chest of male *R. huanrenensis* (A) compared to the milky-white throat and chest of male *R. dybowskii* (C) and the greenishyellow throat and chest of female *R. huanrenensis* (B) compared to the reddish-yellow throat and chest of female *R. dybowskii* (D).

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Characters	Rana huanrenensis	Rana dybowskii						
Female ventral color	minute black dots densely distrib- uted over throat and yellowish green chest	red color patched over throat and chest						
Egg mass nature	relatively small and tightly clustered	relatively large and loose						
Egg deposition	egg mass attached on the sub- merged rock in montane streams	egg mass floating on still water mainly in rice field						

**Table 3.** Morphological and ecological diagnostic characters between *Rana huanrenensis* and *R. dybowskii* in breeding season

sis was morphologically very similar to *R. dybowskii*, but differs from the latter in the ventral color pattern (Fig. 2). In males, *R. dybowskii* had a milky white ground (Fig. 2C), whereas the ground color of male *R. huanrenensis* was yellowish gray with minute black dots densely distributed over the throat and chest (Fig. 2A). In the breeding season, females of *R. huanrenensis* had throat and chest covered with yellowish green (Fig. 2B), whereas in females of *R. dybowskii*, the red color patched over the throat and chest, which color turned to black patches in alcohol (Fig. 2D). In addition to these differences in coloration, male *R. dybowskii* had paired internal vocal sacs, while male *R. huanrenensis* lacked vocal sacs.

Protein electrophoresis—R. huanrenensis and R. dybowskii showed a discrete genetic difference (Nei's D=0.585: Appendix III) and no evidence of gene flow between these two species was found in the sympatric areas surveyed (Jangseong, Inje, Kapyeong, and Donghae; see Table 1, Appendix II).

Ecological notes—R. huanrenensis is sympatric with R. dybowskii in some parts of South Korea such as Tonghae, Inje, Jangseong, and Kapyeong (see Table 1), and therefore, ecological comparison of the two species is pertinent. R. dybowskii altitudinary ranges very wide, from plains to montane regions, where they breed in still waters in rice fields and small pools in early spring. On the other hand, R. huanrenensis occurs only at valley in relatively high montane regions, where the species spawn on the rocks in streams. Eggs of the species laid in relatively small and tightly clustered egg mass, and each egg mass is attached on the submerged rock in small streams in early spring (Table 3).

### **DISCUSSION**

The Eurasian brown frogs are very difficult to classify (Matsui, 1991; Green and Borkin, 1993; Tanaka-Ueno *et al.*, 1998). Especially, members with 24 chromosomes are morphologically quite similar to each other and have a complicate taxonomic history, but now, taxonomic status of each member is made more clear than before by the presence of distinct genetic divergences among them (Matsui, 1991; Green and Borkin, 1993; Tanaka-Ueno *et al.*, 1998; Matsui *et al.*, 1998; Kim *et al.*, 1999). It has long been known that the frogs with 24 chromosomes include several east Asian

species allied to *R. chensinensis*, such as *R. ornativentris*, *R. dybowskii*, *R. pirica*. However, it has been known recently that *R. huanrenensis*, originally described from China (Fei *et al.*, 1990), is also a member of this group (Xie *et al.*, 1995) and co-occurs with *R. dybowskii* in South Korea (Yang *et al.*, 2000). Before this finding, *R. huanrenensis* has been known only from the type locality, Huanren County, Liaoning Province, China for nearly 10 years. The significant range extention to Korea was recorded from localities that were well-known for the presence of *R. dybowskii* (Yang *et al.*, 2000).

In South Korea, *R. huanrenensis* has been misidentified as *R. dybowskii* because of difficulties in identification. However, as shown in the present study, *R. huanrenensis* is actually well differentiated morphologically from *R. dybowskii* chiefly by the ventral color pattern. Moreover, males of these two species clearly different in the presence or absence of vocal sacs.

Since the separation of gene pools is the essence of species formation, a study of speciation must involve the examination of the level of reproductive isolation between the taxa compared. Allozymic analysis has been used extensively for such an examination at the zones of sympatry, and the contact zones of amphibian species that are problematic in taxonomic status (Wake et al, 1980; Yang and Park, 1988; Yang et al, 1988, 1997; Good, 1989). In our result, genetic divergence between R. huanrenensis and R. dybowskii included fixed allelic differences at Gp-4, Mdh, and Iddh loci, and these three loci are diagnostic genetic markers to identify them. No evidence of gene flow between these two species was found at the zone of sympatry. R. huanrenensis and R. dybowskii are completely isolated reproductively by their microhabitats, especially of the spawning site, and breeding habits. Particularly, the different condition of vocal sacs in males of the two species means the presence of clear differences of mating signals between them.

The east Asian brown frogs include two chromosomal groups (Kuramoto, 1979; Nishioka *et al.*, 1986; Matsui, 1991; Green and Borkin, 1993). *R. dybowskii*, *R. huanrenensis*, and *R. chensinensis* have 2n=24 chromosomes, while *R. amurensis* and *R. tsushimensis* have 2n=26 (Lee and Park, 1986; Nishioka *et al.*, 1986; Xie *et al.*, 1995; Yang *et al.*, 2000). It is generally believed that the fundamental chromosome number in *Rana* is 2n=26 (Morescalchi, 1973;

Wilson et al., 1974; Kuramoto, 1979, 1989; Schmid, 1980; Green, 1983; Park, 1990). From the study of R. dybowskii, Green (1983) proposed that the karyotypes with 24-chromosomes could have arisen in east Asia, based on the location of secondary constrictions and chromosome bands. Meanwhile, from the banding patterns of Eurasian and North American brown frogs, Nishioka et al. (1986, 1987) similarly suggested the chromosome number reduction from 2n=26 to 2n=24. Chromosome evolution through reduction in number resulted from inversion/fusion has also been reported in other anuran species (King, 1990; Bogart and Tandy, 1981; Blommers-Schlosser, 1978). Considering this pattern of chromosome evolution as a single event, it could be presumed that the species with putative derived chromosome number (2n=24) form a monophyletic group. However, our results indicate that R. dybowskii with 2n=24 is genetically closer to R. amurensis with 2n=26 (D=0.500) than to R. huanrenensis (D=0.584) or to R. chensinensis (D=0.584) both with 24 chromosomes. Reflecting this situation, R. amurensis did not form a cluster, but was included in a cluster containing other brown frogs with 24 chromosomes in all the three trees we obtained.

These results imply that the interspecies relationships incidental to the chromosomal evolution are not in accordance with relationship inferred from genetic analyses. In view of our results, two assumptions of chromosomal evolution in brown frogs around Korea would emerge. One possibility is that the chromosome number reduction has evolved independently at least two times (parallel reduction in chromosome number from 2n=26 to 24). Namely, R. tsushimensis first differentiated from the common stock of brown frogs around Korea with 2n=26 chromosomes. Subsequently, through a reduction of primary chromosome number, divergence of an ancestor of the R. huanrenensis and R. chensinensis lineage (2n=24) occured from an ancestral species (2n=26) common to the Korean R. amurensis and R. dybowdkii lineage. Finally, speciation of R. dybowskii (2n=24) and Korean R. amurensis (2n=26) occurred while also accompanying a secondary chromosome number reduction in the R. dybowskii lineage.

Another possibility is that the common ancestor of all these four species, after diverged from *R. tsushimensis*, reduced the chromosome number from 26 to 24 before the separation of the *R. huanrenensis* and *R. chensinensis* lineage and the Korean *R. amurensis* and *R. dybowskii* lineage. Subsequent speciation of the latter lineage would have included the reversal change in chromosome number from 24 to 26 in Korean *R. amurensis*.

It is yet to be surveyed which of these two assumptions is more probable, but the first assumption parallels with the idea proposed by Green and Borkin (1993) or Nishioka *et al.* (1992) that *R. arvalis* with 2n=24 chromosomes is paraphyletic with east Asian brown frogs having the same 2n=24 chromosomes. However, there are strong disagreements between Green and Borkin (1993) and Nishioka *et al.* (1992). Green and Borkin (1993) suggested parallel reduc-

tion to 2n=24 in European *R. arvalis* and all east Asian species including *R. dybowskii*, but according to Nishioka *et al.* (1992), all east Asian brown frogs with 26 chromosomes, excepting *R. tsushimensis* but including *R. amurensis* and even European *R. temporaria*, have that number as a result of reversal change in chromosome number from 24 to 26.

The second assumption more conforms to Green and Borkin (1993) or Tanaka-Ueno *et al.* (1998). These authors considered Japanese *R. ornativentris*, with 24 chromosomes, represents the sister group of other east Asian species having 24 chromosomes. Including *R. ornativentris*, "the parallel chromosome number reduction" hypothesis needs three steps (reductions in *R. ornativentris*, *R. dybowskii*, and the *R. huanrenensis* and *R. chensinensis* lineage), but "reversal change in Korean *R. amurensis*" requires only two steps (one reduction in the common ancestor of all species with 24 chromosomes and one reversal in Korean *R. amurensis*).

Moreover, later divergence of *R. amurensis* among east Asian brown frogs, suggested by our result and Nishioka et al. (1992), strongly contradicts to the idea proposed by Green and Borkin (1993) from allozyme analyses and by Tanaka-Ueno et al. (1998) from the analyses of mitochondrial DNA. Both of these reports suggested the earliest divergence of Russian R. amurensis among east Asian brown frogs. Interestingly, Korean and Russian R. amurensis exhibit different degree of genetic differentiation between R. dybowskii; The genetic differentiation between Korean R. dybowskii and R. amurensis we obtained in the present study (D=0.500) was intermediate between those reported between Korean R. dybowskii and Russian R. amurensis (D=0.874) by Green and Borkin (1993) and between R. dybowskii from Tsushima and R. amurensis from Mongolia, China, and Russia (D=0.304-0.311) reported by Nishioka et al. (1992).

These genetic inconsistencies of Korean and Russian *R. amurensis* suggest a distinct taxonomic status of each population. In order to clarify the problem of chromosome number change, as well as the relationships of local populations of *R. amurensis*, more extensive studies including many more taxa from regions surrounding Korea are strongly required.

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Appendix I. Buffer systems and enzymes for the analysis of horizontal starch gel electrophoresis

Buffer System	E. C. No.*	Enzyme	Condition			
Continuous tris citrate II (pH 8.0)	2.7.3.2	Creatine kinase ( <i>Ck-1,2</i> )	100V/3 hrs			
	1.1.1.42	Isocitrate dehydrogenase (Idh)				
	5.4.2.2	Phosphoglucomutase (Pgm-1,2)				
	1.1.1.14	Iditol dehydrogenase (Iddh)				
	3.4.11.1	Leucine amino-peptidase (Lap)				
LiOH (pH 8.1)	N. S.**	S.** General protein ( <i>Gp-3,4</i> )				
	1.1.1.37	Malate dehydrogenase (Mdh)				
Discontinuous tris citrate (pH 8.2)	2.6.1.1	Aspartate aminotransferase (Aat-1)	200V/3 hrs			
	4.2.1.3	Superoxide dismutase (Sod)				
	1.15.1.1	Aconitate hydratase (Acoh)				
	1.1.1.27	Lactate dehydrogenase (Ldh-1,2)				
	5.3.1.8	Mannose-6-phosphate isomerase ( <i>Mpi</i> )				
Tris maleic EDTA (pH 7.4)	1.1.1.8	Glycerol-3-phosphate dehydrogenase (G3pdh)	100V/4 hrs			
	2.6.1.1	Aspartate aminotransferase (Aat-2)				

<sup>\*</sup> E. C. No. : Enzyme commisson number

<sup>\*\*</sup> N. S.: Non specific

**Appendix II.** Allele frequencies of 41 populations in *Rana huanrenensis*, *R. dybowskii*, *R. chensinensis*, *R. amurensis* and *R. tsushimensis* from Korea, Japan, and China.

Losi					Rana hua	anrenensi	3				Ra	na dybow	skii
Loci	1	2	3	4	5	6	7	8	9	10	11	12	13
Acoh	b	a(0.02) b(0.98)	b	a(0.02) b(0.98)	b	b	b(0.96) c(0.02) d(0.02)	b	b	b	а	а	а
Ck-1	а	а	а	а	а	а	а	а	а	а	а	а	а
Ck-2	a(0.93) c(0.07)	а	а	а	а	а	а	а	а	а	а	а	а
Aat-1	h(0.91) j(0.09)	g(0.04) h(0.90) j(0.02) K(0.04)	h	h	h(0.81) j(0.06) K(0.13)	h	c(0.03) h(0.95) K(0.02)	h	h(0.94) j(0.06)	h(0.93) k(0.97)	b(0.03) c(0.03) h(0.59) i(0.03) j(0.06) k(0.26)	b(0.02) c(0.12) g(0.02) h(0.59) j(0.02) k(0.21) l(0.02)	c(0.12) h(0.57) j(0.02) k(0.29)
Aat-2	b	b	b	b	a(0.06) b(0.94)	a(0.03) b(0.97)	b	a(0.07) b(0.93)	b	b	b	b	b
Gp-3	С	С	С	С	С	С	b(0.02) c(0.98)	С	С	С	c(0.97) d(0.03)	c(0.98) d(0.02)	a(0.05) c(0.95)
Gp-4	d(0.07) e(0.93)	d(0.05) e(0.95)	d(0.03) e(0.95) f(0.02)	d(0.04) e(0.96)	е	d(0.02) e(0.96) f(0.02)	е	е	е	е	а	a(0.91) c(0.09)	a(0.95) c(0.05)
G3pdh	b	b	b	b	b	a(0.02) b(0.98)	a(0.03) b(0.97)	b	b	a(0.05) b(0.92) d(0.03)	b(0.47) d(0.53)	b(0.43) d(0.57)	b(0.55) d(0.45)
Idh	b	b	b(0.93) c(0.07)	b	b	b	b	b	b	b	b	b	b
Sod	С	С	С	С	С	С	С	С	c(0.97) d(0.03)	С	С	c(0.95) e(0.05)	c(0.95) e(0.05)
Lap	а	а	а	а	а	а	а	а	а	а	а	а	а
Ldh-1	е	d(0.02) e(0.98)	е	d(0.02) e(0.98)	е	d(0.03) e(0.95) f(0.02)	d(0.02) e(0.98)	е	d(0.06) e(0.94)	d(0.03) e(0.97)	b	b	b(0.98) c(0.02)
Ldh-2	d	d	a(0.03) d(0.97)	a(0.08) d(0.92)	d	d	d	d	a(0.03) d(0.97)	a(0.02) d(0.98)	d	d	d
Mdh	d(0.46) f(0.48) g(0.06)	d(0.32) f(0.59) g(0.09)	d(0.32) f(0.56) g(0.12)	d(0.44) f(0.50) g(0.06)	d(0.19) f(0.62) g(0.19)	d(0.22) f(0.62) g(0.16)	d(0.12) f(0.60) g(0.28)	d(0.36) f(0.50) g(0.14)	d(0.25) f(0.69) g(0.06)	a(0.02) d(0.22) f(0.56) g(0.20)	a(0.06) c(0.94)	С	С
Мрі	d(0.70) e(0.30)	b(0.04) d(0.94) g(0.02)	b(0.02) d(0.98)	b(0.06) d(0.94)	b(0.06) d(0.94)	d(0.97) e(0.03)	d(0.97) e(0.03)	d	b(0.09) d(0.91)	d	b(0.06) d(0.19) e(0.53) f(0.06) g(0.16)	b(0.12) d(0.07) e(0.58) g(0.21) h(0.02)	b(0.05) d(0.09) e(0.50) g(0.31) h(0.05)
Pgm-1	b	b(0.96) c(0.04)	b(0.87) c(0.13)	b(0.94) c(0.06)	a(0.06) b(0.94)	b	b	b(0.93) c(0.07)	b	a(0.02) b(0.98)	С	С	b(0.09) c(0.91)
Pgm-2	b	b	b	b	b	b	b	b(0.43) c(0.57)	b	b(0.98) c(0.02)	С	С	b(0.02) c(0.98)
lddh	е	е	d(0.02) e(0.98)	е	е	d(0.09) e(0.91)	d(0.15) e(0.85)	е	d(0.09) e(0.91)	е	b	b(0.98) c(0.02)	a(0.02) b(0.98)

# Appendix II. (Continued)

Loci							Rana d	ybowskii						
LUCI	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Acoh	a(0.92) b(0.08)	а	a(0.89) b(0.11)	а	а	a(0.94) b(0.06)	a(0.98) b(0.02)	a(0.98) b(0.02)	а	а	a(0.98) b(0.02)	а	а	a(0.50) b(0.50)
Ck-1	а	а	а	а	а	а	а	а	а	а	а	а	а	а
Ck-2	a(0.97) b(0.03)	а	а	а	а	а	а	а	a	а	а	а	а	а
Aat-1	c(0.11) h(0.41) j(0.08) k(0.38) l(0.02)	c(0.14) h(0.61) j(0.07) k(0.18)	h(0.54) j(0.07) k(0.39)	b(0.08) d(0.25) h(0.57) k(0.10)	h(0.46) k(0.46) l(0.08)	c(0.26) h(0.48) k(0.26)	b(0.02) c(0.21) h(0.45) k(0.32)	c(0.02) f(0.02) g(0.02) h(0.31) i(0.02) k(0.60) I(0.01)	c(0.04) f(0.04) h(0.28) j(0.14) k(0.50)	f(0.21) h(0.36) k(0.43)	c(0.09) f(0.05) h(0.48) j(0.07) k(0.27) l(0.04)	c(0.08) f(0.04) h(0.39) j(0.08) k(0.41)	c(0.10) h(0.55) k(0.35)	c(0.50) h(0.50)
Aat-2	b	a(0.04) b(0.96)	b	b	b	b	b	a(0.02) b(0.98)	b	b	b	b	b	b
Gp-3	С	С	С	c(0.98) d(0.02)	С	С	С	С	С	С	С	С	С	С
Gp-4	a(0.97) c(0.03)	а	а	a(0.85) c(0.15)	а	а	а	a(0.88) c(0.12)	a(0.79) c(0.21)	a(0.71) c(0.29)	a(0.84) c(0.14)	a(0.96) c(0.04)	a(0.95) c(0.05)	а
G3pdh	b(0.42) d(0.58)	b(0.64) d(0.36)	b(0.54) d(0.46)	b(0.02) d(0.93) e(0.05)	b(0.83) d(0.17)	b(0.40) d(0.60)	b(0.43) d(0.57)	b(0.41) d(0.55) e(0.04)	b(0.46) d(0.54)	b(0.57) d(0.43)	b(0.39) d(0.59) e(0.02)	b(0.42) d(0.58)	b(0.40) d(0.60)	b(0.50) d(0.50)
ldh	b	a(0.07) b(0.93)	b	b	a(0.02) b(0.98)	b	b	b	b	b	b	b	b	b
Sod	c(0.97) e(0.03)	С	b(0.14) c(0.86)	С	a(0.02) c(0.98)	c(0.98) e(0.02)	a(0.02) c(0.96) e(0.02)	c(0.97) e(0.03)	С	С	c(0.98) e(0.02)	c(0.96) e(0.04)	c(0.95) e(0.05)	С
Lap	a(0.99) b(0.01)	а	а	а	а	а	а	а	а	а	а	а	а	а
Ldh-1	b(0.99) e(0.01)	b	b	b	a(0.02) b(0.98)	b(0.98) e(0.02)	b(0.98) e(0.02)	b	b	b	b	b	b	b
Ldh-2	d	d	d	d	d	d	d	d	d	d	d	d	d	d
Mdh	С	С	С	С	С	С	С	С	С	С	c(0.98) e(0.02)	С	С	С
Мрі	a(0.02) b(0.06) d(0.11) e(0.55) g(0.20) h(0.06)	b(0.14) d(0.07) e(0.50) g(0.25) h(0.04)	b(0.04) d(0.04) e(0.39) g(0.54)	е	d(0.02) e(0.46) g(0.45) h(0.07)	b(0.06) d(0.10) e(0.66) g(0.12) h(0.06)	b(0.03) d(0.07) e(0.54) g(0.29) h(0.07)	b(0.02) d(0.10) e(0.66) g(0.17) h(0.05)	b(0.04) d(0.18) e(0.64) g(0.14)	b(0.07) d(0.14) e(0.51) g(0.21) h(0.07)	b(0.11) d(0.09) e(0.61) g(0.19)	d(0.08) e(0.62) g(0.27) h(0.04)	a(0.05) d(0.10) e(0.45) g(0.35) h(0.05)	d
Pgm-1	С	С	С	С	b(0.39) c(0.61)	b(0.16) c(0.84)	b(0.10) c(0.90)	С	b(0.04) c(0.96)	С	b(0.07) c(0.93)	b(0.08) c(0.92)	С	С
Pgm-2	a(0.03) c(0.97)	С	С	С	С	С	С	С	С	С	С	С	С	С
lddh	a(0.04) b(0.96)	a(0.07) b(0.93)	b	a(0.25) b(0.75)	b(0.93) c(0.07)	a(0.02) b(0.96) c(0.02)	a(0.03) b(0.94) c(0.03)	b	b	b(0.79) c(0.21)	b(0.93) c(0.07)	b(0.92) c(0.08)	b(0.85) c(0.15)	b

Appendix II. (Continued)

Loci	R. chen	sinensis					Rana ar	murensis		36 37			F	?. t
LOCI	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Acoh	а	a	a(0.83) b(0.17)	a(0.63) b(0.37)	а	a(0.40) b(0.60)	a(0.53) b(0.47)	a(0.40) b(0.58) c(0.02)	a(0.17) b(0.45) c(0.38)	a(0.58) b(0.42)	a(0.78) b(0.19) c(0.02) d(0.01)	a(0.93) b(0.07)	a	a(0.65) b(0.35)
Ck-1	а	а	а	а	а	а	а	а	а	а	а	а	а	а
Ck-2	а	а	а	а	а	а	а	а	а	а	а	а	а	а
Aat-1	g	b(0.10) g(0.90)	h(0.08) j(0.92)	g(0.04) h(0.04) j(0.90) l(0.02)	h(0.30) j(0.70)	h(0.15) j(0.85)	g(0.02) h(0.25) j(0.73)	j(0.92) I(0.08)	h(0.10) j(0.88) l(0.02)	g(0.08) j(0.84) l(0.02)	h(0.01) j(0.89) l(0.10)	j	j	a(0.35) e(0.65)
Aat-2	b	b	b	b(0.93) c(0.07)	b	b	a(0.05) b(0.95)	b	b	a(0.25) b(0.75)	b	b	b	a(0.15) b(0.85)
Gp-3	С	С	С	С	С	С	С	С	С	С	c(0.97) d(0.03)	С	С	С
Gp-4	е	е	d(0.98) e(0.02)	d	d	d	d	d	d	d	d	d	d	b
G3pdh	b	a(0.80) b(0.20)	С	c(0.97) d(0.33)	a(0.10) c(0.90)	b(0.05) c(0.88) d(0.07)	a(0.05) c(0.93) d(0.02)	С	a(0.05) c(0.95)	С	С	С	С	c(0.05) d(0.95)
ldh	b	b	b	b	b	b	b	b	b	a(0.08) b(0.92)	b	b	b	С
Sod	С	a(0.10) c(0.90)	d	d(0.96) f(0.02) g(0.02)	d	b(0.05) c(0.88) d(0.07)	d	d	d	d	d	d	d	е
Lap	а	а	а	а	а	а	а	а	а	а	а	а	а	а
Ldh-1	f	f	С	С	С	С	С	С	С	С	С	С	С	е
Ldh-2	a(0.10) d(0.50) e(0.40)	d(0.90) e(0.10)	d	d(0.97) e(0.33)	d	d(0.95) e(0.05)	d(0.97) e(0.03)	b(0.02) d(0.96) e(0.02)	d	d	d	d	d	С
Mdh	f	f	е	b(0.02) e(0.95) g(0.02) h(0.01)	е	e(0.90) h(0.10)	b(0.02) e(0.98)	е	b(0.02) e(0.98)	e(0.92) g(0.08)	b(0.03) e(0.94) g(0.03)	e(0.90) g(0.10)	е	b
Мрі	d(0.80) e(0.20)	b(0.20) d(0.80)	e(0.13) g(0.37) h(0.06) i(0.13) j(0.21) k(0.10)	e(0.18) g(0.07) i(0.30) j(0.42) k(0.03)	i(0.80) j(0.20)	e(0.05) g(0.07) i(0.68) j(0.15) l(0.05)	e(0.13) g(0.07) i(0.55) j(0.25)	e(0.40) g(0.48) i(0.05) j(0.07)	e(0.13) g(0.15) i(0.32) j(0.38) k(0.02)	e(0.08) g(0.08) i(0.25) j(0.59)	d(0.01) e(0.27) g(0.37) i(0.20) j(0.15)	e(0.22) g(0.38) i(0.15) j(0.25)	g(0.20) i(0.06) j(0.56) k(0.18)	a(0.20) c(0.75) g(0.05)
Pgm-1	b(0.90) c(0.10)	b	С	b(0.08) c(0.88) d(0.04)	С	С	С	С	b(0.02) c(0.98)	С	С	С	С	b
Pgm-2	С	С	С	c(0.98) d(0.02)	С	С	С	c(0.95) d(0.05)	С	С	С	С	С	d
lddh	d	d	d	b(0.02) d(0.98)	d	d	d	d(0.98) e(0.02)	d(0.88) e(0.12)	d	d(0.99) e(0.01)	d	d	d

**Appendix III.** Nei's (1978) genetic distance coefficients (above diagonal) and Rogers' (1972) genetic similarity coefficients (below diagonal) among 41 populations of *Rana huanrenensis*, *R. dybowskii*, *R. chensinensis*, *R. amurensis* and *R. tsushimensis* from Korea, Japan and China

China																					
population	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
R. huanrenesis 1 Jangseong		.005	.007	.004	.007	.007	.011	.024	.006	.008	.573	.588	.556	.584	.566	.582	.640	.514	.558	.577	
2 Pohang	.965	_	.000	.000	.000	.000	.003	.017	.000	.000	.581	.599	.565	.594	.575	.589	.670	.525	.574	.588	
3 Cheongsong 4 Yeongdeog	.952 .963	.978 .982	.977	.000	.001 .002	.001 .002	.004	.017 .017	.002 .002	.001 .002	.576 .582	.594 .600	.563 .568	.591 .598	.570 .576	.585 .592	.664 .671	.531 .531	.573 .577	.587 .591	
5 Pyeongchang	.950	.975	.963	.963	_	.000	.001	.018	.000	.000	.592	.610	.575	.601	.586	.598	.683	.532	.582	.596	
6 Hanso-ri 7 Oban-ri	.952 .942	.975 .967	.971 .957	.968 .956	.971 .964	_ .979	.000	.018 .021	.000 .002	.000	.586 .583	.605 .601	.570 .567	.601 .597	.581 .578	.596 .594	.672 .669	.530 .527	.578 .573	.594 .589	
8 Inje	.925	.946	.948	.947	.943	.943	.930	-	.019	.017	.510	.528	.499	.526	.504	.519	.595	.463	.505	.519	
9 Kapyeong 10 Donghae	.952 .950	.972 .977	.963 .968	.966 .967	.966 .974	.978 .976	.968 .973	.930 .945	.969	.001	.590 .587	.607 .606	.574 .573	.604 .600	.583 .585	.598 .597	.679 .672	.532 .534	.581 .578	.597 .594	
R. dybowskii																					
11 Yangpyeong 12 Cheongyang	.547 .538	.541 .532	.538 .529	.538 .528	.539 .530	.535 .527	.541 .532	.563 .555	.538 .531	.541 .532	.973	.000	.000	.001	.000 .001	.005 .005	.026 .022	.022 .024	.002 .001	.002 .000	
13 Muju	.550	.545	.539	.538	.543	.540	.545	.567	.541	.544	.961	.969	_	.001	.000	.002	.033	.011	.002	.000	
14 Jangseong 15 Kurye	.539 .550	.531 .545	.525 .543	.524 .538	.530 .547	.526 .543	.530 .544	.553 .571	.527 .539	.530 .543	.960 .961	.968 .961	.961 .961	.952	.003	.004 .004	.026 .037	.022 .015	.001 .005	.000	
16 Haenam	.534	.532	.526	.525	.530	.526	.530	.554	.528	.530	.952	.948	.955	.954	.947	_	.045	.015	.011	.004	
17 Jeju 18 Keoje	.515 .571	.508 .568	.503 .564	.502 .561	.504 .566	.504 .563	.509 .567	.531 .591	.502 .563	.506 .566	.915 .919	.926 .917	.904 .937	.911 .921	.906 .933	.888 .931	.864	.075	.022 .022	.027 .016	
19 Hadong	.546	.540	.535	.534	.538	.535	.540	.563	.535	.538	.955	.962	.958	.967	.947	.939	.913	.925	_	.000	
20 Yangsan 21 Donghae	.540 .525	.535 .519	.530 .513	.529 .512	.533 .519	.530 .515	.535 .518	.558 .543	.531 .514	.534 .518	.960 .955	.968 .966	.972 .950	.973 .965	.957 .940	.951 .944	.910 .918	.939 .917	.978 .954	_ .958	
22 Inje	.538	.531	.525	.524	.529	.525	.529	.553	.525	.529	.958	.959	.949	.958	.938	.938	.917	.916	.950	.954	
23 Kanseong 24 Keojin	.550 .546	.545 .540	.540 .534	.539 .533	.543 .538	.540 .534	.544 .538	.567 .562	.539 .535	.543 .538	.940 .959	.945 .974	.943 .960	.943 .964	.942 .949	.931 .939	.906 .927	.916 .922	.927 .966	.940 .970	
25 Kapyeong	.534	.528	.522	.521	.527	.523	.527	.551	.524	.527	.959	.969	.967	.974	.949	.949	.916	.938	.966	.979	
26 Wonju 27 Tsushima Isl.	.538 —	.534	.528 —	.527 —	.532	.528 _	.533	.556 –	.530 —	.532	.959 .903	.971 .895	.967 .891	.966 .898	.952 .895	.955 .897	.918 .845	.930 .852	.955 .899	.970 .896	
R. chensinensis	050	004	050	000	005	000	074	007	074	000	F00	500	500	500	500	F70	F00	004	500	507	
28 Ninxia 29 Quing	.653 .611	.664 .629	.659 .616	.660 .624	.665 .631	.666 .634	.671 .641	.687 .647	.674 .648	.660 .634	.599 .589	.592 .588	.599 .589	.586 .581	.599 .580	.578 .572	.566 .572	.631 .600	.596 .590	.597 .592	
R. amurensis																					
30 Haenam 31 Kangwha	.439 .452	.435 .448	.430 .444	.429 .443	.431 .447	.432 .446	.437 .449	.457 .473	.436 .450	.430 .444	.600 .580	.603 .581	.600 .584	.608 .586	.600 .578	.617 .586	.587 .569	.582 .563	.594 .584	.602 .586	
32 Sorae	.433	.432	.427	.425	.427	.428	.433	.454	.433	.427	.606	.608	.601	.602	.604	.602	.597	.579	.593	.601	
33 Yangpyeong 34 Cheongju	.509 .459	.507 .455	.504 .452	.504 .451	.503 .456	.503 .456	.509 .457	.529 .483	.510 .458	.503 .452	.619 .585	.620 .587	.613 .579	.623 .589	.615 .585	.624 .592	.608 .574	.592 .557	.611 .577	.615 .581	
35 Yeongdong	.460	.453	.450	.449	.449	.449	.455	.474	.455	.449	.579	.584	.581	.589	.578	.600	.566	.565	.572	.582	
36 Cheongyang 37 Yangsan	.467 .431	.463 .429	.458 .428	.456 .422	.458 .432	.459 .429	.465 .431	.484 .458	.464 .429	.458 .424	.571 .561	.573 .564	.569 .557	.577 .568	.569 .571	.580 .571	.560 .552	.549 .539	.566 .556	.572 .561	
38 Kyeongju	.441	.436	.431	.429	.432	.432	.439	.458	.437	.431	.605	.608	.604	.610	.602	.618	.591	.584	.596	.604	
39 Kangnung 40 Koseong	.431 .419	.427 .417	.421 .412	.420 .411	.422 .413	.423 .414	.429 .419	.448 .439	.427 .418	.422 .412	.606 .595	.609 .597	.605 .592	.613 .594	.606 .594	.618 .596	.593 .584	.587 .573	.600 .583	.608 .593	
R. tsushimensis	400	400	400	404	400	400	400	400	400	400	070	070	075	000	007	075	000	075	000	005	
41 Tsushima Isl.	.430	.426	.422	.424	.429	.429	.433	.430	.429	.426	.372	.378	.375	.382	.367	.375	.390	.375	.389	.385	
Population	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
R. huanrenensis																					
R. huanrenensis 1 Jangseong 2 Pohang	.610 .623	.586 .598	.561 .568	.570 .584	.588 .602	.587 .593	_ _	.385	.445 .417	.813 .824	.769 .784	.827 .830	.638 .648	.751 .762	.756 .779	.738 .752	.810 .819	.809 .825	.841 .855	.872 .878	.834 .841
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong	.610 .623 .621	.586 .598 .597	.561 .568 .565	.570 .584 .581	.588 .602 .602	.587 .593 .589	- - -	.385 .364 .377	.445 .417 .434	.813 .824 .826	.769 .784 .787	.827 .830 .828	.638 .648 .646	.751 .762 .759	.756 .779 .780	.738 .752 .751	.810 .819 .819	.809 .825 .827	.841 .855 .858	.872 .878 .882	.834 .841 .839
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang	.610 .623 .621 .628 .627	.586 .598 .597 .604	.561 .568 .565 .572 .574	.570 .584 .581 .586 .593	.588 .602 .602 .607 .609	.587 .593 .589 .596 .603	- - - -	.385 .364 .377 .378 .363	.445 .417 .434 .433 .415	.813 .824 .826 .835 .836	.769 .784 .787 .796 .793	.827 .830 .828 .837 .846	.638 .648 .646 .656	.751 .762 .759 .769 .774	.756 .779 .780 .791 .788	.738 .752 .751 .762 .760	.810 .819 .819 .832 .824	.809 .825 .827 .837 .836	.841 .855 .858 .868 .865	.872 .878 .882 .890 .890	.834 .841 .839 .844 .843
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri	.610 .623 .621 .628 .627 .631	.586 .598 .597 .604 .602	.561 .568 .565 .572 .574 .576	.570 .584 .581 .586 .593 .589	.588 .602 .602 .607 .609	.587 .593 .589 .596 .603 .599	- - - - -	.385 .364 .377 .378 .363 .356	.445 .417 .434 .433 .415 .406	.813 .824 .826 .835 .836 .830	.769 .784 .787 .796 .793 .788	.827 .830 .828 .837 .846 .834	.638 .648 .646 .656 .656	.751 .762 .759 .769 .774 .763	.756 .779 .780 .791 .788 .784	.738 .752 .751 .762 .760 .757	.810 .819 .819 .832 .824 .822	.809 .825 .827 .837 .836 .831	.841 .855 .858 .868 .865	.872 .878 .882 .890 .890 .887	.834 .841 .839 .844 .843
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje	.610 .623 .621 .628 .627 .631 .626	.586 .598 .597 .604 .602 .606 .601	.561 .568 .565 .572 .574 .576 .572	.570 .584 .581 .586 .593 .589 .586 .514	.588 .602 .602 .607 .609 .609 .605	.587 .593 .589 .596 .603 .599 .596	- - - - - -	.385 .364 .377 .378 .363 .356 .346	.445 .417 .434 .433 .415 .406 .393 .369	.813 .824 .826 .835 .836 .830 .818	.769 .784 .787 .796 .793 .788 .777	.827 .830 .828 .837 .846 .834 .822	.638 .648 .646 .656 .656 .651 .642	.751 .762 .759 .769 .774 .763 .754	.756 .779 .780 .791 .788 .784 .773	.738 .752 .751 .762 .760 .757 .748	.810 .819 .819 .832 .824 .822 .811	.809 .825 .827 .837 .836 .831 .818	.841 .855 .858 .868 .865 .862 .847	.872 .878 .882 .890 .890 .887 .873	.834 .841 .839 .844 .843 .834 .816
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong	.610 .623 .621 .628 .627 .631 .626 .553	.586 .598 .597 .604 .602 .606 .601 .530	.561 .568 .565 .572 .574 .576 .572 .499	.570 .584 .581 .586 .593 .589 .586 .514	.588 .602 .602 .607 .609 .609 .605 .533	.587 .593 .589 .596 .603 .599 .596 .522 .603	- - - - - -	.385 .364 .377 .378 .363 .356 .346 .317	.445 .417 .434 .433 .415 .406 .393 .369 .399	.813 .824 .826 .835 .836 .830 .818 .752	.769 .784 .787 .796 .793 .788 .777 .714	.827 .830 .828 .837 .846 .834 .822 .756	.638 .648 .646 .656 .656 .651 .642 .582	.751 .762 .759 .769 .774 .763 .754 .688 .753	.756 .779 .780 .791 .788 .784 .773 .712	.738 .752 .751 .762 .760 .757 .748 .680 .744	.810 .819 .819 .832 .824 .822 .811 .740 .811	.809 .825 .827 .837 .836 .831 .818 .753	.841 .855 .858 .868 .865 .865 .847 .783 .848	.872 .878 .882 .890 .890 .887 .873 .806	.834 .841 .839 .844 .843 .834
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii	.610 .623 .621 .628 .627 .631 .626 .553 .634	.586 .598 .597 .604 .602 .606 .601 .530 .608	.561 .568 .565 .572 .574 .576 .572 .499 .578	.570 .584 .581 .586 .593 .589 .586 .514 .592	.588 .602 .602 .607 .609 .609 .605 .533 .612	.587 .593 .589 .596 .603 .599 .596 .522 .603	- - - - - -	.385 .364 .377 .378 .363 .356 .346 .317 .348	.445 .417 .434 .433 .415 .406 .393 .369 .399	.813 .824 .826 .835 .836 .830 .818 .752 .816	.769 .784 .787 .796 .793 .788 .777 .714 .775	.827 .830 .828 .837 .846 .834 .822 .756 .823	.638 .648 .646 .656 .656 .651 .642 .582 .645	.751 .762 .759 .769 .774 .763 .754 .688 .753	.756 .779 .780 .791 .788 .784 .773 .712 .770	.738 .752 .751 .762 .760 .757 .748 .680 .744	.810 .819 .819 .832 .824 .822 .811 .740 .811	.809 .825 .827 .837 .836 .831 .818 .753 .818	.841 .855 .858 .868 .865 .862 .847 .783 .848	.872 .878 .882 .890 .890 .887 .873 .806 .870	.834 .841 .839 .844 .843 .834 .816 .840 .827
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590	.588 .602 .607 .609 .609 .605 .533 .612 .608	.587 .593 .589 .596 .603 .599 .596 .522 .603 .599	- - - - - - - -	.385 .364 .377 .378 .363 .356 .346 .317 .348 .368	.445 .417 .434 .433 .415 .406 .393 .369 .399 .411	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841	.841 .855 .858 .868 .865 .862 .847 .783 .848 .872	.872 .878 .882 .890 .890 .887 .873 .806 .870 .897	.834 .841 .839 .844 .843 .834 .816 .840 .827 .838
R. huanrenensis  1 Jangseong  2 Pohang  3 Cheongsong  4 Yeongdeok  5 Pyeongchang  6 Hanso-ri  7 Oban-ri  8 Inje  9 Kapyeong  10 Donghae  R. dybowskii  11 Yangpyeong  12 Cheongyang  13 Muju	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590	.588 .602 .602 .607 .609 .605 .533 .612 .608	.587 .593 .589 .596 .603 .599 .596 .522 .603 .599	- - - - - - - - - - - - - - - - - - -	.385 .364 .377 .378 .363 .356 .346 .317 .348 .368	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .509 .498	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .508	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .481	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .503	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794 .526 .519	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483	.841 .855 .858 .868 .865 .862 .847 .783 .848 .872 .487 .482 .484	.872 .878 .882 .890 .890 .887 .873 .806 .870 .897	.834 .841 .839 .844 .843 .834 .816 .840 .827 .838
R. huanrenensis  1 Jangseong  2 Pohang  3 Cheongsong  4 Yeongdeok  5 Pyeongchang  6 Hanso-ri  7 Oban-ri  8 Inje  9 Kapyeong  10 Donghae  R. dybowskii  11 Yangpyeong  12 Cheongyang  13 Muju  14 Jangseong	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590	.588 .602 .602 .607 .609 .605 .533 .612 .608	.587 .593 .589 .596 .603 .599 .522 .603 .599	- - - - - - - - - - - 0.056 .063 .062	.385 .364 .377 .378 .363 .356 .346 .317 .348 .368	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .509 .498	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .508 .512	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .481 .484	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .503 .508	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794 .526 .519 .522	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834 .535 .531 .536	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483 .486	.841 .855 .858 .868 .862 .847 .783 .848 .872 .487 .482 .484	.872 .878 .882 .890 .890 .887 .873 .806 .870 .897 .507 .504 .506	.834 .841 .839 .844 .843 .834 .816 .840 .827 .838
R. huanrenensis  1 Jangseong  2 Pohang  3 Cheongsong  4 Yeongdeok  5 Pyeongchang  6 Hanso-ri  7 Oban-ri  8 Inje  9 Kapyeong  10 Donghae  R. dybowskii  11 Yangpyeong  12 Cheongyang  13 Muju  14 Jangseong  15 Kurye  16 Haenam	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628	.586 .598 .597 .604 .606 .601 .530 .608 .604 .005 .004 .005	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .000 .001	.588 .602 .602 .607 .609 .605 .533 .612 .608	.587 .593 .589 .596 .603 .599 .596 .522 .603 .599		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462 .491	.445 .417 .434 .433 .415 .406 .393 .369 .399 .411 .504 .509 .498 .514 .515 .533	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486 .490 .478	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .508 .512 .504 .514	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .481 .484 .486	.638 .648 .646 .656 .651 .642 .582 .645 .660 .442 .443 .446	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .503 .508 .508 .508	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794 .526 .519 .522 .511 .524	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .540 .544 .542 .544	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834 .535 .531 .536 .525 .533	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483 .486 .481 .488	.841 .855 .858 .868 .865 .862 .847 .783 .848 .872 .487 .482 .484 .481 .486 .475	.872 .878 .882 .890 .890 .887 .873 .806 .870 .507 .504 .506 .503 .507	.834 .841 .843 .844 .843 .834 .816 .827 .838 .991 .971 .971 .971
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575	.570 .584 .581 .586 .593 .589 .514 .592 .590 .001 .001 .001	.588 .602 .602 .607 .609 .605 .533 .612 .608	.587 .593 .589 .596 .603 .599 .522 .603 .599	- - - - - - - - - 0.056 .063 .062 .058	.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462	.445 .417 .434 .433 .415 .406 .393 .369 .399 .411 .504 .509 .498 .514	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .508 .512 .504	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .481 .484 .486	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .446 .435	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .507 .503 .508	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794 .526 .519 .522 .511 .524 .501	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .540 .544 .532 .544 .527	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834 .535 .531 .536 .525 .533	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483 .486 .481	.841 .855 .858 .868 .865 .862 .847 .783 .848 .872 .487 .487 .482 .484 .481	.872 .878 .882 .890 .897 .873 .806 .870 .897 .507 .504 .504 .503	.834 .841 .839 .844 .843 .834 .816 .840 .827 .838
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Mujiu 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .005 .012 .010	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .004 .005 .001 .011 .023 .023	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575 .006 .003 .004 .006 .008 .034 .010	.570 .584 .581 .586 .593 .586 .514 .592 .590 .001 .000 .001 .004 .008 .023 .001	.588 .602 .607 .609 .605 .533 .612 .608	.587 .593 .596 .603 .596 .522 .603 .599 .000 .000 .000 .000 .002 .001 .026 .019		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462 .491 .533 .410 .462	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .504 .515 .533 .535 .473 .491	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486 .490 .478 .519 .505	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .508 .512 .505 .523 .542 .514	.827 .830 .828 .837 .846 .834 .756 .823 .845 .483 .481 .484 .486 .502 .521 .500	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .446 .435 .442 .440	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .503 .508 .508 .508 .499 .526 .546 .517	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794 .526 .519 .522 .511 .524 .501 .535 .551	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .540 .544 .532 .544 .527 .569 .579	.810 .819 .832 .824 .822 .811 .740 .811 .834 .535 .531 .536 .525 .533 .524 .552 .570 .545	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483 .486 .481 .488 .475 .502 .516	.841 .855 .858 .868 .865 .865 .847 .783 .848 .872 .487 .482 .484 .481 .486 .475 .504	.872 .878 .882 .890 .890 .887 .873 .806 .870 .507 .504 .506 .503 .507 .538 .524	.834 .841 .839 .844 .843 .816 .840 .827 .838 .991 .971 .971 .971 .971 .996 .947
R. huanrenensis  1 Jangseong  2 Pohang  3 Cheongsong  4 Yeongdeok  5 Pyeongchang  6 Hanso-ri  7 Oban-ri  8 Inje  9 Kapyeong  10 Donghae  R. dybowskii  11 Yangpyeong  12 Cheongyang  13 Muju  14 Jangseong  15 Kurye  16 Haenam  17 Jeju  18 Keoje  19 Hadong  20 Yangsan	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .004 .005 .002 .011 .028 .023 .006	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575 .006 .003 .004 .004 .006 .008	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .001 .001 .004 .008	.588 .602 .602 .607 .609 .609 .605 .533 .612 .608	.587 .593 .596 .596 .603 .599 .596 .522 .603 .599 .000 .000 .000 .000 .002		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462 .491 .533 .410	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .509 .498 .514 .515 .535 .473	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486 .490 .478 .512	.769 .784 .787 .796 .793 .788 .777 .714 .509 .512 .508 .512 .504 .514 .505 .523	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .481 .486 .484 .486 .502 .521	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .446 .435 .442 .440	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .508 .508 .502 .508 .499 .520	.756 .779 .780 .791 .788 .784 .773 .712 .770 .794 .526 .519 .522 .511 .524 .501 .535 .551	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .532 .544 .532 .544 .527 .560	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834 .535 .531 .536 .525 .533 .524 .552	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483 .486 .481 .488 .475 .502	.841 .855 .858 .868 .865 .862 .847 .783 .848 .872 .487 .487 .484 .481 .486 .475 .504	.872 .878 .882 .890 .890 .887 .873 .806 .870 .507 .504 .503 .507 .503 .531	.834 .841 .839 .844 .843 .816 .840 .827 .838 .991 .971 .971 1.015 .996 .947
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .029 .029 .029 .029	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .004 .005 .010 .011 .023 .006 .005	.561 .568 .565 .572 .574 .576 .572 .499 .575 .006 .003 .004 .006 .008 .034 .010 .005 .000	.570 .584 .581 .586 .593 .586 .514 .592 .001 .001 .004 .008 .020 .023 .001 .001	.588 .602 .602 .607 .609 .605 .533 .612 .608 .001 .000 .000 .004 .003 .024 .016 .000 .000	.587 .593 .589 .596 .603 .599 .500 .000 .000 .000 .001 .026 .019 .003 .000 .000		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462 .491 .533 .410 .462 .464 .474 .478	.445 .417 .434 .433 .415 .406 .393 .369 .399 .411 .504 .509 .498 .515 .533 .535 .473 .491 .496 .513 .492	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .489 .478 .512 .505 .492 .496 .479	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .508 .512 .505 .514 .505 .523 .542 .518 .513 .514 .496	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .481 .484 .486 .502 .521 .500 .491 .495 .480	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .446 .435 .440 .461 .478 .452 .448 .452 .448	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .503 .508 .499 .520 .546 .517 .512 .514	.756 .779 .780 .791 .784 .773 .712 .770 .526 .519 .522 .511 .524 .501 .535 .551 .531 .522 .523	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .532 .544 .532 .544 .527 .560 .579 .552 .546 .546 .547	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834 .535 .536 .525 .533 .524 .552 .572 .545 .537 .535 .525	.809 .825 .827 .837 .836 .831 .818 .753 .818 .449 .483 .486 .481 .502 .516 .500 .488 .489 .473	.841 .855 .858 .868 .865 .865 .847 .783 .848 .872 .487 .482 .484 .475 .501 .486 .514 .501 .487 .489	.872 .878 .882 .890 .890 .887 .873 .806 .870 .507 .504 .506 .503 .507 .531 .531 .531 .531 .531 .524 .510 .512 .493	.834 .841 .839 .844 .843 .834 .816 .827 .838 .991 .971 .971 .971 .971 .947 .947 .947 .950 .981
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .024 .007	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .002 .010 .011 .028 .023 .006 .005	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575 .006 .003 .004 .006 .008 .034 .018 .010 .005	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .001 .004 .008 .023 .001 .004	.588 .602 .607 .609 .605 .533 .612 .608	.587 .593 .596 .603 .596 .596 .522 .603 .599 .000 .000 .000 .000 .002 .001 .026 .019 .003		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462 .491 .533 .410 .462 .491 .464 .478	.445 .417 .434 .433 .415 .406 .393 .369 .399 .411 .504 .504 .515 .535 .473 .491 .496 .513	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486 .490 .478 .519 .505 .492 .496	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .504 .514 .505 .523 .542 .518 .513 .514	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .483 .484 .486 .484 .486 .484 .486 .502 .521 .500 .491 .495	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .446 .435 .442 .446 .478 .452 .448	.751 .769 .769 .774 .763 .754 .688 .753 .775 .507 .508 .499 .546 .517 .517	.756 .7780 .791 .788 .784 .773 .712 .770 .794 .526 .511 .524 .501 .535 .551 .531 .522 .523	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .532 .544 .532 .544 .527 .560 .579 .552	.810 .819 .832 .824 .822 .811 .740 .811 .535 .531 .536 .525 .533 .525 .570 .545 .537	.809 .825 .827 .837 .836 .831 .818 .753 .818 .441 .489 .483 .484 .485 .516 .500 .488 .489	.841 .855 .858 .868 .865 .865 .847 .783 .848 .872 .487 .482 .484 .481 .486 .475 .504 .514 .501 .487	.872 .878 .882 .890 .890 .887 .873 .806 .870 .507 .504 .503 .507 .503 .531 .538 .524 .512	.834 .841 .839 .844 .843 .816 .840 .827 .838 .991 .971 .971 .971 .971 .971 .971 .971
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .002 .012 .012 .029 .029 .029 .029 .029 .029 .029 .02	.586 .598 .597 .604 .602 .606 .601 .530 .005 .004 .005 .001 .011 .028 .006 .005 .006 .005 .006 .007 .009 .009 .009 .009 .009 .009 .009	.561 .568 .565 .572 .574 .576 .578 .575 .006 .003 .004 .004 .008 .034 .018 .010 .005 .000	.570 .584 .581 .586 .593 .589 .589 .514 .592 .590 .001 .001 .004 .020 .023 .021 .001 .001	.588 .602 .602 .607 .609 .609 .605 .533 .612 .608 .001 .000 .000 .000 .003 .024 .016 .000 .000 .000	.587 .593 .599 .596 .603 .599 .596 .000 .000 .000 .000 .001 .026 .019 .003 .000 .000 .000 .000 .000 .000 .00		.385 .364 .377 .378 .363 .356 .346 .317 .456 .480 .491 .533 .462 .491 .462 .464 .478 .454 .434 .464 .434 .454 .434 .454	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .515 .513 .535 .491 .496 .479 .489 .489	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486 .490 .478 .512 .519 .492 .496 .479 .468 .479 .468	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .504 .514 .505 .523 .542 .542 .548 .513 .513 .514 .549 .490 .495 .503	827 830 828 837 846 834 822 756 823 845 481 484 486 502 521 550 491 495 480 465 474 484	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .445 .440 .445 .442 .448 .452 .448 .452 .448 .453 .443 .443 .443 .444 .452 .448 .452 .452 .452 .452 .452 .452 .452 .452	.751 .762 .759 .769 .774 .688 .753 .775 .507 .508 .508 .499 .520 .517 .512 .514 .500 .488 .494 .505	.756 .779 .780 .791 .784 .773 .770 .794 .526 .511 .524 .535 .551 .531 .522 .523 .501 .535 .501	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .532 .544 .532 .545 .527 .560 .575 .546 .547 .552 .546 .547 .522 .537	.810 .819 .819 .832 .824 .822 .811 .740 .811 .834 .535 .531 .525 .533 .552 .570 .552 .570 .510 .510 .510 .528	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .484 .481 .485 .502 .516 .502 .516 .488 .489 .473 .464 .473 .478	.841 .855 .868 .868 .865 .862 .847 .783 .848 .872 .484 .481 .501 .487 .504 .475 .489 .471 .463 .471 .476	.872 .878 .890 .890 .897 .873 .806 .870 .507 .504 .503 .507 .500 .531 .531 .532 .510 .510 .510 .510 .510 .510 .510 .510	.834 .841 .839 .844 .816 .827 .838 .991 .971 .971 .971 .971 .975 .940 .950 .981 .975 .979 .950
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .002 .010 .029 .010 .029 .029 .037 .055 .955	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .004 .005 .010 .011 .023 .006 .006 .000	.561 .568 .565 .572 .574 .576 .572 .499 .578 .575 .006 .003 .004 .006 .008 .034 .010 .010 .010 .000 .000 .000 .000	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .001 .004 .008 .023 .001 .004	.588 .602 .602 .607 .609 .605 .533 .612 .608	.587 .593 .589 .596 .603 .599 .596 .522 .603 .599 .000 .000 .002 .001 .026 .019 .003 .004 .004		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .456 .480 .462 .491 .533 .410 .462 .464 .478 .454 .454 .454 .454 .454 .454 .454 .45	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .515 .533 .535 .473 .491 .496 .498 .499 .498 .498 .498 .498 .498 .498	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .490 .478 .519 .505 .496 .479 .468 .479	.769 .784 .787 .796 .793 .788 .777 .714 .508 .512 .508 .512 .508 .514 .514 .505 .523 .542 .514 .496 .496	.827 .830 .828 .837 .846 .834 .822 .756 .823 .845 .481 .484 .486 .502 .521 .500 .491 .495 .480 .465 .474	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .446 .435 .442 .440 .461 .478 .452 .448 .450 .433 .421 .430	.751 .762 .759 .769 .774 .688 .753 .775 .507 .503 .508 .499 .520 .517 .514 .500 .488 .494	.7566 .779 .780 .791 .784 .773 .712 .770 .794 .526 .511 .524 .501 .531 .524 .501 .531 .522 .531 .531 .523 .508	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .540 .544 .532 .544 .527 .560 .579 .552 .547 .531 .521	.810 .819 .819 .832 .824 .811 .740 .811 .834 .535 .536 .525 .533 .524 .5525 .570 .545 .535 .525 .535 .525 .535 .535 .535 .53	.809 .825 .827 .837 .836 .831 .818 .753 .818 .841 .489 .483 .486 .481 .488 .475 .500 .488 .473 .489 .473	.841 .855 .858 .868 .862 .847 .783 .848 .872 .484 .481 .486 .475 .501 .487 .489 .471	.872 .878 .882 .890 .897 .873 .806 .870 .897 .507 .506 .503 .507 .500 .531 .531 .531 .534 .512 .493 .483 .493	.834 .841 .839 .844 .843 .834 .816 .827 .838 .991 .971 .971 .975 .996 .947 .940 .950
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .002 .012 .010 .029 .029 .029 .029 .055 .975 .950 .965 .970	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .005 .002 .010 .028 .023 .005 .005 .005 .005 .005 .005 .005 .00	.561 .568 .568 .572 .572 .576 .576 .578 .578 .006 .003 .004 .004 .004 .008 .003 .004 .005 .002 .005 .949 .952 .873	.570 .584 .584 .583 .589 .589 .586 .514 .592 .590 .001 .001 .001 .004 .002 .023 .001 .004 .001 .004 .001 .004 .001 .885 .885	.588 .602 .602 .607 .609 .609 .605 .533 .612 .608 .001 .000 .000 .000 .000 .000 .000 .0	.587 .593 .598 .596 .603 .599 .596 .000 .000 .000 .000 .001 .002 .001 .004 .004 .004 .004 .000 .000 .000		.385 .364 .377 .378 .363 .356 .346 .317 .348 .368 .466 .475 .491 .533 .410 .462 .464 .478 .454 .433 .456 .474 .474	.445 .417 .434 .433 .415 .406 .393 .399 .411 .504 .504 .514 .515 .533 .535 .473 .496 .479 .499 .499 .504	.813 .824 .826 .835 .836 .830 .818 .841 .492 .487 .498 .512 .519 .496 .479 .468 .479 .468 .479 .479 .468 .478	.769 .784 .787 .796 .793 .788 .777 .714 .775 .509 .512 .504 .515 .505 .523 .542 .505 .523 .542 .496 .490 .495 .503 .504	.827 .830 .828 .837 .846 .834 .823 .845 .483 .481 .484 .486 .502 .521 .495 .491 .495 .484 .486 .484 .486 .502 .521 .494 .495 .497 .497 .497 .497 .497 .497 .497 .497	.638 .648 .646 .656 .651 .642 .645 .660 .442 .443 .444 .441 .478 .442 .444 .452 .448 .452 .444 .433 .421 .433 .421 .434 .434 .435 .442 .443 .443 .444 .444 .443 .444 .443 .444 .444 .444 .444 .445 .444 .445 .446 .446	.751 .762 .759 .769 .774 .763 .754 .753 .775 .507 .508 .502 .508 .546 .512 .514 .512 .514 .500 .488 .494 .494	.756 .779 .780 .791 .788 .784 .773 .770 .794 .526 .511 .522 .551 .551 .551 .501 .502 .503 .501 .502 .501	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .540 .532 .544 .527 .560 .579 .552 .546 .545 .545 .545 .547 .552 .546 .547 .553 .548 .549 .553 .554 .553 .554 .553 .554 .553 .554 .553 .554 .555 .555	.810 .819 .819 .824 .822 .811 .834 .535 .536 .535 .536 .5525 .570 .510 .510 .510 .510 .525 .525	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .484 .485 .502 .516 .5502 .488 .489 .473 .464 .472 .473 .474 .472	.841 .855 .858 .868 .862 .847 .783 .848 .872 .487 .481 .486 .471 .463 .471 .476 .474 .474	.872 .878 .898 .890 .897 .873 .806 .870 .507 .504 .503 .507 .500 .531 .531 .531 .544 .510 .512 .493 .494 .499 .496	.834 .841 .839 .844 .816 .827 .838 .991 .971 .971 .971 .971 .971 .940 .947 .950 .981 .975 .979 .950
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl.	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .024 .007 .024 .007 .950 .950	.586 .598 .597 .604 .606 .601 .530 .608 .604 .005 .001 .002 .001 .002 .003 .006 .005 .000 .001 .009 .009 .009 .009 .009 .009	.561 .568 .568 .572 .574 .576 .578 .578 .578 .006 .003 .004 .006 .008 .018 .010 .005 .002 .000 .002 .949 .952	.570 .584 .584 .585 .593 .589 .589 .592 .590 .001 .001 .004 .002 .023 .001 .004 .001 .004 .001 .004 .001 .001	.588 .602 .607 .609 .605 .533 .612 .608 .001 .000 .004 .016 .000 .000 .000 .000 .000 .000 .000	.587 .593 .598 .596 .603 .599 .596 .000 .000 .000 .001 .002 .001 .002 .001 .003 .004 .004 .004 .004 .000 .000		.385 .364 .377 .378 .363 .356 .346 .317 .456 .480 .491 .533 .462 .491 .462 .464 .478 .454 .434 .464 .434 .454 .434 .454	.445 .417 .434 .433 .415 .406 .393 .369 .411 .504 .515 .513 .535 .491 .496 .479 .489 .489	.813 .824 .826 .835 .836 .830 .818 .752 .816 .841 .492 .487 .488 .486 .490 .478 .512 .519 .492 .496 .479 .468 .479 .468	.769 .784 .787 .796 .793 .788 .777 .714 .775 .799 .512 .504 .514 .505 .523 .542 .542 .548 .513 .513 .514 .549 .490 .495 .503	827 830 828 837 846 834 822 756 823 845 481 484 486 502 521 550 491 495 480 465 474 484	.638 .648 .646 .656 .656 .651 .642 .582 .645 .660 .442 .443 .445 .440 .445 .442 .448 .452 .448 .452 .448 .453 .443 .443 .443 .444 .452 .448 .452 .452 .452 .452 .452 .452 .452 .452	.751 .762 .759 .769 .774 .688 .753 .775 .507 .508 .508 .499 .520 .517 .512 .514 .500 .488 .494 .505	.756 .779 .780 .791 .784 .773 .770 .794 .526 .511 .524 .535 .551 .531 .522 .523 .501 .535 .501	.738 .752 .751 .762 .760 .757 .748 .680 .744 .765 .544 .532 .544 .532 .545 .527 .560 .575 .546 .547 .552 .546 .547 .522 .537	.810 .819 .832 .822 .811 .740 .535 .531 .536 .535 .536 .552 .570 .545 .557 .557 .557 .557 .557 .557 .557	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .484 .481 .485 .502 .516 .502 .516 .488 .489 .473 .464 .473 .478	.841 .855 .868 .868 .865 .862 .847 .783 .848 .872 .484 .481 .501 .487 .504 .475 .489 .471 .463 .471 .476	.872 .878 .890 .890 .897 .873 .806 .870 .507 .504 .503 .507 .500 .531 .531 .532 .510 .510 .510 .510 .510 .510 .510 .510	.834 .841 .839 .844 .843 .834 .816 .827 .838 .991 .971 .971 .971 .971 .940 .947 .950 .981 .975 .979
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .010 .029 .029 .029 .029 .975 .975 .970 .965 .970 .958 .884	.586 .598 .597 .604 .602 .606 .603 .608 .604 .005 .002 .010 .028 .023 .005 .005 .005 .005 .005 .959 .967 .967 .967 .968	.561 .568 .568 .572 .572 .576 .576 .578 .578 .006 .003 .004 .004 .004 .008 .034 .010 .005 .002 .000 .000 .000 .000 .000 .00	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .001 .004 .002 .023 .001 .004 .001 .004 .001 .975 .965 .885 .599	.588 602 602 602 607 609 609 609 609 600 605 602 600 000 000 000 600 600 600 600 600	.587 .593 .598 .596 .603 .599 .596 .000 .000 .001 .026 .019 .004 .004 .000 .000 .000 .000 .000 .00		.385 .364 .377 .378 .363 .356 .346 .473 .456 .480 .462 .491 .533 .410 .462 .464 .478 .454 .433 .404 .465 .474 .474 .478	.445 .417 .434 .433 .369 .399 .411 .504 .515 .533 .473 .491 .492 .479 .489 .498 .504	.813 .824 .826 .835 .836 .830 .818 .841 .492 .487 .498 .512 .515 .515 .492 .496 .479 .488 .478 .478 .478 .478 .478 .478	.769 .784 .787 .796 .793 .788 .777 .714 .775 .509 .512 .504 .515 .505 .523 .541 .513 .496 .490 .503 .504 .505 .503 .504	.827 .830 .828 .837 .834 .832 .756 .823 .845 .481 .484 .486 .491 .495 .471 .495 .475 .475 .565 .509	.638 .648 .646 .656 .651 .642 .645 .660 .442 .443 .446 .435 .444 .452 .448 .452 .448 .452 .443 .437 .421 .437 .437	.751 .762 .769 .769 .774 .763 .754 .688 .753 .775 .507 .508 .502 .548 .549 .520 .544 .550 .499 .591 .591	.756 .779 .780 .791 .788 .784 .773 .770 .794 .526 .511 .524 .501 .535 .551 .551 .525 .525 .551 .521 .521 .52	.798 .752 .751 .760 .757 .748 .680 .744 .766 .544 .527 .552 .554 .545 .557 .552 .528 .533 .534 .527 .534 .527 .533 .534 .535 .534 .535 .536 .537 .538 .538 .538 .538 .538 .538 .538 .538	.810 .819 .832 .824 .822 .811 .834 .535 .536 .525 .536 .525 .570 .535 .525 .575 .535 .525 .535 .525 .535 .536 .525 .537 .536 .537 .537 .537 .537 .538 .539 .539 .539 .539 .539 .539 .539 .539	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .484 .485 .502 .516 .516 .516 .484 .475 .472 .478 .476 .476 .572 .572	.841 .855 .858 .868 .862 .847 .783 .848 .872 .487 .481 .486 .475 .504 .514 .451 .474 .474 .474 .474 .567 .521	.872 .878 .898 .890 .897 .873 .806 .870 .507 .504 .503 .507 .500 .531 .531 .531 .524 .510 .512 .493 .483 .494 .499 .496	.834 .841 .839 .844 .816 .827 .838 .991 .971 .971 .971 .975 .996 .947 .975 .950 .950 .953 .956
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .024 .007 .024 .007 .955 .975 .955 .975	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .002 .001 .001 .011 .028 .003 .006 .005 .009 .967 .967 .967 .949 .886	.561 .568 .568 .572 .572 .576 .576 .575 .006 .003 .004 .004 .008 .018 .010 .002 .000 .000 .000 .000 .000 .000	.570 .584 .584 .585 .593 .589 .586 .514 .592 .590 .001 .001 .004 .008 .020 .001 .004 .001 .004 .001 .004 .001 .005 .885 .885 .885	.588 602 602 602 609 609 609 605 533 612 608 000 000 000 000 000 000 000 000 000	.587 .593 .598 .596 .603 .599 .596 .603 .599 .000 .000 .000 .001 .026 .019 .003 .004 .004 .004 .000 .000 .000 .000		.385 .364 .377 .378 .363 .356 .346 .346 .347 .348 .468 .491 .455 .451 .451 .452 .491 .462 .491 .464 .478 .454 .464 .478 .454 .465 .465	.445 .417 .434 .433 .406 .399 .411 .504 .498 .514 .515 .533 .473 .491 .492 .498 .498 .499 .498 .498 .498 .498 .498	.813 .824 .826 .835 .836 .830 .818 .8416 .841 .492 .487 .488 .486 .477 .483 .496 .479 .496 .477 .483 .496 .477 .483 .496 .477 .487 .496 .496 .496 .496 .496 .496 .496 .496	.769 .784 .787 .796 .793 .788 .777 .714 .775 .508 .512 .504 .505 .514 .505 .514 .505 .514 .505 .514 .505 .514 .505 .514 .505 .514 .505 .516 .506 .506 .506 .506 .506 .507 .507 .507 .507 .507 .507 .507 .507	.827 .830 .828 .837 .756 .823 .845 .483 .484 .484 .486 .502 .521 .500 .491 .495 .474 .484 .475 .505 .509	.638 .648 .646 .656 .651 .642 .582 .645 .640 .442 .440 .461 .478 .450 .433 .442 .443 .433 .442 .443 .433 .443 .436 .437 .437 .437 .437 .437 .437 .437 .437	.751 .762 .759 .769 .774 .763 .753 .753 .775 .507 .503 .508 .508 .499 .520 .546 .517 .514 .505 .494 .505 .494 .505 .499 .505 .506 .506 .507 .508 .508 .508 .508 .508 .508 .508 .508	.756 .779 .780 .791 .788 .784 .772 .772 .779 .522 .511 .535 .551 .531 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508	.798 .752 .751 .760 .757 .748 .680 .744 .765 .544 .532 .554 .554 .554 .557 .558 .531 .531 .531 .531 .531 .532 .533 .534 .533 .534 .533 .534 .535 .534 .535 .534 .535 .534 .535 .536 .536 .537 .537 .538 .538 .538 .538 .538 .538 .538 .538	.810 .819 .832 .824 .822 .811 .834 .535 .523 .524 .552 .552 .553 .524 .555 .525 .525 .525 .525 .525 .525	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .486 .481 .502 .502 .502 .502 .473 .473 .474 .474 .476 .476 .476	.841 .855 .858 .868 .862 .847 .783 .848 .872 .484 .481 .501 .487 .504 .514 .501 .471 .476 .471 .476 .476	.872 .878 .882 .890 .887 .873 .806 .870 .507 .504 .503 .507 .500 .538 .524 .512 .493 .494 .499 .496	.834 .841 .839 .844 .818 .834 .816 .840 .827 .838 .991 .971 .971 .971 .971 .940 .950 .981 .975 .975 .975 .975
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Niinxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 31 Kangwha	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .029 .024 .005 .950 .950 .950 .958 .884 .589 .589	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .002 .010 .011 .028 .006 .005 .000 .019 .006 .009 .009 .009 .009 .009 .009 .00	.561 .568 .568 .572 .574 .576 .572 .499 .578 .575 .006 .003 .004 .018 .010 .002 .000 .002 .000 .002 .873 .873 .614 .598	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .001 .004 .002 .001 .004 .001 .004 .001 .000 .004 .001 .593 .885 .885 .594 .594 .595 .596 .596 .596 .596 .596 .596 .596	.588 .602 .602 .607 .609 .609 .605 .533 .612 .608 .001 .000 .000 .000 .000 .000 .000 .0	.587 .593 .598 .596 .596 .592 .603 .599 .000 .000 .000 .001 .002 .001 .003 .004 .004 .000 .000 .000 .000 .000		.385 .364 .377 .378 .363 .356 .346 .346 .346 .475 .456 .480 .462 .491 .462 .491 .462 .491 .462 .491 .474 .454 .474 .474 .474 .475 .476 .476 .476 .476 .476 .476 .476 .476	.445 .417 .434 .433 .369 .399 .411 .504 .515 .533 .473 .491 .492 .479 .489 .504 .515 .535 .473 .491 .492 .479 .504 .505 .509 .509 .509 .509 .509 .509 .509	.813 .824 .826 .835 .836 .838 .818 .841 .492 .487 .488 .486 .479 .478 .478 .478 .478 .478 .478 .478 .478	.769 .784 .787 .793 .788 .793 .788 .777 .771 .775 .508 .512 .508 .514 .505 .523 .542 .514 .496 .495 .495 .504 .505 .506 .506 .507 .507 .508 .508 .508 .509 .509 .509 .509 .509 .509 .509 .509	.827 .830 .828 .837 .846 .834 .848 .822 .756 .823 .845 .484 .486 .484 .486 .502 .521 .500 .495 .480 .475 .475 .509 .509 .509 .509 .509 .509 .509 .50	.638 .648 .646 .656 .651 .642 .582 .645 .660 .442 .443 .444 .443 .444 .435 .431 .431 .431 .431 .431 .431 .431 .431	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .503 .508 .508 .499 .520 .546 .517 .514 .504 .514 .505 .499 .516 .517 .507 .503 .504 .504 .505 .506 .506 .507 .507 .507 .508 .508 .508 .508 .508 .508 .508 .508	.756 .779 .780 .791 .788 .784 .773 .712 .770 .526 .519 .522 .511 .531 .535 .551 .531 .532 .523 .501 .501 .502 .501 .502 .501 .501 .502 .501 .501 .502 .501 .502 .501 .502 .501 .501 .501 .501 .501 .501 .501 .501	.798 .752 .751 .760 .757 .748 .680 .744 .766 .544 .527 .552 .528 .528 .537 .534 -637 .582 .023 .012	.810 .819 .819 .824 .824 .821 .740 .811 .535 .525 .533 .524 .555 .525 .550 .510 .519 .525 .525 .525 .525 .526 .526 .527 .538 .527 .538 .528 .529 .539 .539 .539 .539 .539 .539 .539 .53	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .486 .481 .502 .516 .502 .516 .502 .473 .473 .474 .472 .476 .572 .527	.841 .855 .858 .868 .862 .867 .783 .848 .872 .484 .481 .504 .514 .504 .514 .504 .471 .463 .471 .471 .571 .471 .571 .471 .571 .471 .471 .571 .471 .471 .471 .471 .471 .471 .471 .4	.872 .878 .882 .890 .887 .873 .806 .877 .504 .506 .503 .507 .500 .531 .538 .524 .493 .494 .499 .75 .75 .75 .75 .75 .75 .75 .75 .75 .75	.834 .841 .839 .844 .814 .814 .814 .814 .827 .838 .991 .971 .971 .971 .971 .971 .947 .950 .950 .955 .956 -
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Kéoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 32 Sorae 33 Yangpyeong	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .002 .010 .024 .017 .007 .007 .965 .975 .958 .884 .589 .584	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .002 .001 .001 .001 .005 .002 .006 .005 .009 .009 .009 .009 .009 .009 .009	.561 .568 .568 .572 .572 .576 .572 .576 .575 .006 .003 .004 .004 .004 .004 .004 .005 .002 .000 .002 .949 .949 .949 .949 .952 .873 .614 .598	.570 .584 .584 .583 .589 .586 .514 .592 .590 .001 .001 .004 .000 .000 .001 .001 .00	.588 602 602 609 609 609 600 600 600 600 600 600 600	.587 .593 .598 .596 .603 .599 .596 .603 .599 .000 .000 .000 .000 .001 .004 .004 .004		.385 .364 .377 .378 .363 .356 .346 .346 .486 .486 .491 .533 .410 .462 .491 .478 .454 .478 .454 .478 .456 .474 .478 .456 .474 .478 .475 .475 .475 .475 .475 .475 .475 .475	.445 .445 .434 .433 .369 .399 .411 .509 .498 .514 .553 .535 .535 .535 .547 .491 .496 .499 .509 .509 .509 .509 .509 .509 .509 .5	.813 .824 .826 .835 .836 .838 .818 .841 .492 .487 .492 .487 .493 .478 .494 .479 .496 .479 .483 .478 .479 .496 .479 .496 .479 .496 .496 .496 .496 .496 .496 .496 .49	.769 .784 .787 .796 .793 .788 .777 .714 .775 .508 .512 .504 .505 .523 .514 .496 .495 .503 .504 .503 .504 .503 .504 .505 .504 .505 .506 .506 .507 .507 .508 .508 .509 .509 .509 .509 .509 .509 .509 .509	.827 .828 .830 .828 .837 .756 .823 .845 .483 .484 .486 .502 .491 .500 .491 .495 .495 .495 .495 .509 .019 .020 .019	.638 .648 .646 .656 .651 .642 .582 .645 .645 .442 .443 .445 .4440 .441 .478 .452 .448 .435 .435 .437 .437 .437 .437 .437 .437 .437 .437	.751 .762 .769 .769 .763 .754 .763 .754 .753 .775 .507 .503 .508 .502 .508 .502 .504 .517 .512 .514 .505 .499 .520 .489 .520 .546 .546 .546 .546 .546 .546 .546 .546	.756 .779 .780 .791 .798 .784 .773 .770 .794 .522 .511 .522 .511 .522 .511 .523 .523 .523 .523 .521 .523 .521 .521 .521 .523 .522 .523 .523 .524 .525 .526 .527 .527 .528 .528 .529 .529 .529 .529 .529 .529 .529 .529	.798 .752 .751 .760 .757 .748 .680 .744 .765 .544 .532 .545 .547 .560 .579 .579 .579 .579 .579 .579 .579 .579	.810 .819 .832 .824 .822 .811 .834 .535 .531 .524 .553 .524 .555 .520 .510 .510 .528 .525 .526 .527 .536 .528 .529 .529 .536 .529 .537 .536 .529 .537 .537 .537 .538 .539 .539 .539 .539 .539 .539 .539 .539	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .484 .481 .489 .475 .502 .478 .478 .474 .478 .476 .502 .478 .476 .502 .478 .476 .478 .476 .478 .476 .478 .478 .478 .478 .478 .478 .478 .478	.841 .855 .858 .868 .862 .847 .783 .848 .872 .484 .481 .504 .475 .504 .475 .474 .476 .474 .476 .477 .476 .477 .476 .471 .476 .471 .476 .471 .471 .471 .471 .471 .471 .471 .471	.872 .878 .882 .890 .887 .873 .806 .870 .507 .504 .506 .503 .507 .500 .512 .493 .494 .499 .496 .577 .527	.834 .841 .839 .844 .843 .834 .816 .827 .838 .991 .971 .971 .971 .971 .940 .950 .981 .975 .975 .975 .975 .975 .975 .975 .975
R. huanrenensis 1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 32 Sorae 33 Yangpyeong 34 Cheongjiu 35 Yeongdong	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .024 .007 .05 .950 .965 .975 .958 .884 .691 .589	.586 .598 .597 .604 .602 .606 .601 .005 .002 .000 .001 .001 .001 .003 .006 .000 .009 .967 .967 .967 .969 .969 .588 .603 .592 .605 .588 .608 .608	.561 .568 .568 .572 .574 .576 .572 .578 .578 .575 .006 .003 .004 .004 .018 .010 .002 .000 .002 .949 .952 .873 .614 .598 .614 .598	.570 .584 .584 .583 .589 .593 .589 .594 .001 .001 .004 .003 .001 .004 .001 .004 .001 .004 .001 .004 .001 .005 .885 .594 .596 .596 .596 .596 .596 .596 .596 .596	.588 602 602 609 609 609 605 533 612 608 001 000 000 000 000 000 000 000 000 0	.587 .593 .598 .596 .603 .599 .596 .603 .599 .000 .000 .000 .000 .001 .026 .019 .003 .004 .004 .004 .000 .000 .000 .000		.385 .364 .377 .378 .363 .356 .346 .346 .346 .475 .456 .480 .447 .454 .491 .462 .491 .462 .491 .474 .474 .474 .474 .474 .474 .475 .476 .475 .476 .475 .476 .475 .476 .476 .476 .476 .476 .476 .476 .476	.445 .445 .434 .433 .369 .393 .411 .504 .498 .514 .533 .473 .491 .489 .499 .504 .515 .535 .473 .491 .504 .515 .535 .473 .491 .505 .473 .495 .479 .496 .505 .479 .496 .505 .505 .479 .496 .505 .505 .479 .496 .505 .496 .505 .496 .496 .496 .496 .496 .496 .496 .496	.813 .824 .826 .835 .836 .838 .818 .752 .816 .841 .492 .496 .478 .519 .505 .479 .488 .477 .483 .477 .483 .477 .483 .477 .483 .477 .483 .478 .479 .479 .479 .479 .479 .479 .479 .479	.769 .784 .787 .793 .788 .777 .714 .775 .512 .508 .512 .508 .514 .505 .514 .503 .514 .496 .495 .503 .504 .504 .504 .504 .504 .505 .506 .506 .507 .507 .508 .508 .508 .508 .508 .508 .508 .508	.827 .830 .828 .837 .846 .823 .845 .823 .845 .484 .486 .484 .486 .502 .521 .495 .400 .495 .475 .509 .019 .020 .019 .020 .019 .020 .019 .020 .030 .030 .030 .030 .030 .030 .030	.638 .648 .646 .656 .651 .642 .582 .645 .645 .442 .440 .441 .435 .433 .442 .433 .442 .433 .447 .437 .737 .74 .060 .072 .72 .74 .898	.751 .762 .759 .769 .774 .763 .754 .753 .755 .507 .503 .508 .508 .499 .520 .546 .517 .505 .541 .500 .544 .505 .508 .541 .500 .544 .505 .506 .506 .506 .507 .507 .508 .508 .508 .508 .508 .509 .509 .509 .509 .509 .509 .509 .509	.756 .779 .780 .791 .778 .778 .7712 .770 .794 .526 .551 .535 .551 .535 .551 .535 .551 .535 .551 .535 .512 .523 .508 .512 .512 .512 .512 .512 .513 .523 .514 .515 .525 .516 .517 .526 .517 .527 .527 .528 .528 .529 .529 .529 .529 .529 .529 .529 .529	.738 .752 .751 .760 .757 .748 .680 .744 .765 .544 .532 .545 .545 .547 .552 .546 .537 .552 .546 .537 .538 .537 .538 .537 .538 .537 .538 .538 .537 .538 .538 .538 .538 .538 .538 .538 .538	.810 .819 .819 .824 .822 .811 .834 .535 .531 .533 .524 .555 .520 .519 .525 .525 .525 .526 .525 .526 .525 .526 .525 .526 .525 .527 .538 .528 .528 .529 .529 .529 .529 .529 .529 .529 .529	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .486 .481 .502 .516 .502 .516 .502 .478 .478 .472 .478 .476 .572 .527	.841 .855 .858 .868 .862 .867 .783 .848 .872 .484 .481 .501 .474 .501 .474 .474 .474 .471 .572 .572 .001 .010 .002 .021 .019	.872 .878 .882 .890 .887 .873 .806 .877 .504 .506 .503 .507 .500 .531 .538 .524 .512 .493 .494 .499 .7 .507 .507 .507 .507 .507 .507 .507	.834 .841 .839 .844 .818 .838 .834 .816 .827 .838 .991 .971 .971 .971 .971 .971 .971 .971
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 32 Sorae 33 Yangpyeong 34 Cheongju	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .002 .010 .029 .024 .007 .005 .975 .970 .975 .970 .958 .884	.586 .598 .597 .604 .602 .606 .601 .005 .002 .010 .005 .002 .010 .005 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .006 .007 .007	.561 .568 .568 .565 .572 .576 .576 .578 .575 .006 .003 .004 .004 .004 .008 .034 .000 .009 .000 .000 .000 .000 .000 .00	.570 .584 .584 .583 .589 .586 .514 .592 .590 .001 .001 .001 .001 .001 .001 .001 .0	.588 602 602 609 609 609 609 609 609 609 609 609 609	.587 .593 .598 .596 .599 .596 .603 .599 .000 .000 .000 .000 .000 .001 .004 .004		.385 .364 .377 .378 .363 .356 .346 .475 .480 .462 .481 .491 .533 .410 .462 .464 .478 .454 .478 .454 .478 .454 .478 .454 .478 .455 .474 .478 .455 .474 .478 .455 .474 .478 .455 .474 .478 .478 .478 .478 .478 .478 .478	.445 .417 .434 .433 .415 .406 .393 .369 .399 .411 .504 .519 .498 .514 .515 .533 .535 .533 .473 .491 .496 .479 .479 .479 .479 .504 .516 .517 .517 .518 .518 .518 .519 .519 .519 .519 .519 .519 .519 .519	.813 .824 .826 .835 .836 .838 .818 .841 .492 .487 .492 .487 .498 .478 .479 .468 .479 .468 .479 .468 .479 .479 .483 .478 .479 .483 .478 .479 .484 .485 .486 .490 .490 .490 .490 .490 .490 .490 .490	.769 .784 .787 .796 .793 .788 .777 .714 .775 .509 .512 .508 .514 .505 .523 .518 .513 .496 .490 .490 .490 .503 .504 .503 .504 .503 .504 .503 .504 .503 .504 .503 .504 .504 .505 .503 .504 .505 .504 .505 .505 .506 .506 .507 .507 .507 .507 .507 .507 .507 .507	.827 .830 .828 .834 .834 .823 .845 .823 .845 .484 .484 .486 .502 .491 .495 .480 .485 .487 .495 .495 .490 .491 .495 .495 .490 .491 .495 .495 .495 .495 .495 .495 .495 .495	.638 .648 .646 .656 .651 .642 .645 .660 .442 .443 .446 .435 .442 .448 .450 .433 .421 .437 .7 .074 .060 .072 .072	.751 .762 .769 .769 .763 .754 .763 .755 .508 .508 .508 .508 .508 .508 .508 .5	.756 .779 .780 .791 .793 .784 .773 .770 .794 .522 .511 .522 .511 .523 .551 .523 .551 .523 .551 .521 .523 .523 .523 .523 .523 .524 .523 .524 .525 .523 .526 .527 .527 .527 .528 .528 .529 .529 .529 .529 .529 .529 .529 .529	.738 .752 .751 .760 .757 .748 .680 .744 .765 .544 .532 .544 .552 .546 .557 .552 .546 .547 .553 .522 .546 .063 .552 .546 .003 .012 .041 .065 .0012	.810 .819 .832 .824 .822 .8111 .536 .525 .533 .524 .552 .5570 .545 .537 .535 .525 .537 .535 .525 .537 .536 .525 .537 .536 .525 .537 .537 .538 .529 .539 .539 .539 .539 .539 .539 .539 .53	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .486 .481 .489 .475 .502 .478 .476 .516 .500 .448 .475 .502 .478 .476 .500 .700 .700 .700 .700 .700 .700 .700	.841 .855 .858 .868 .862 .847 .783 .848 .872 .487 .482 .484 .481 .451 .451 .451 .471 .463 .471 .476 .474 .501 .010 .022 .082 .021	.872 .878 .898 .890 .897 .873 .806 .870 .897 .507 .506 .503 .507 .500 .531 .538 .524 .510 .512 .493 .483 .499 .496 .7 .506 .7 .7 .7 .7 .7 .7 .7 .7 .7 .7 .7 .7 .7	.834 .841 .839 .844 .843 .834 .816 .827 .838 .991 .971 .971 .971 .940 .947 .940 .950 .953 .956 - .953 .956 - .956 .956 - .958 .958 .958 .958 .959 .959 .959 .959
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 32 Sorae 33 Yangpyeong 34 Cheongju 35 Yeongdong 36 Cheongyang 37 Yangsan 38 Kyeongju	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .024 .007 .975 .975 .975 .975 .975 .975 .975 .97	.586 .598 .597 .604 .602 .606 .601 .005 .002 .000 .001 .001 .001 .003 .006 .000 .005 .002 .000 .005 .000 .009 .009 .009 .009 .009	.561 .568 .568 .572 .574 .576 .572 .578 .575 .006 .003 .004 .004 .008 .018 .010 .002 .000 .000 .000 .000 .000 .001 .002 .873 .873 .614 .598 .598 .598 .598 .598 .598 .598 .598	.570 .584 .584 .583 .589 .593 .589 .594 .000 .001 .001 .004 .001 .004 .001 .001	.588 602 602 609 609 609 600 000 000 000 000 000 000	.587 .593 .598 .596 .603 .599 .596 .603 .599 .000 .000 .000 .001 .026 .019 .003 .004 .004 .004 .000 .000 .000 .000		.385 .364 .377 .378 .363 .356 .346 .346 .481 .475 .456 .481 .462 .491 .478 .454 .478 .454 .478 .454 .478 .456 .467 .475 .533 .410 .462 .491 .475 .456 .486 .487 .475 .475 .475 .475 .475 .475 .475 .47	.445 .445 .434 .433 .369 .393 .411 .504 .498 .514 .553 .473 .491 .492 .492 .493 .493 .504 .513 .593 .593 .593 .593 .593 .593 .593 .59	.813 .824 .826 .835 .836 .830 .818 .848 .487 .488 .486 .477 .483 .477 .483 .477 .483 .477 .483 .477 .483 .477 .483 .477 .483 .477 .483 .496 .496 .496 .496 .496 .496 .496 .496	.769 .784 .787 .793 .788 .777 .714 .775 .508 .512 .504 .514 .505 .514 .503 .514 .496 .503 .504 .504 .503 .504 .504 .505 .504 .505 .506 .506 .507 .507 .508 .508 .508 .508 .508 .508 .509 .509 .509 .509 .509 .509 .509 .509	.827 .828 .830 .828 .837 .756 .823 .845 .484 .484 .486 .502 .521 .500 .491 .495 .474 .484 .475 .509 .019 .019 .019 .019 .019 .019 .019 .0	.638 .648 .646 .656 .651 .642 .582 .645 .645 .442 .440 .461 .478 .452 .433 .442 .440 .431 .430 .442 .447 .431 .431 .431 .431 .431 .431 .431 .431	.751 .762 .759 .769 .763 .754 .763 .753 .775 .507 .503 .508 .499 .520 .546 .517 .514 .505 .494 .505 .494 .505 .494 .505 .501 .501 .501 .501 .503 .503 .504 .505 .506 .506 .507 .507 .508 .508 .508 .509 .509 .509 .509 .509 .509 .509 .509	.756 .779 .780 .791 .778 .778 .7712 .770 .521 .551 .535 .551 .535 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .512 .523 .508 .509 .509 .509 .509 .509 .509 .509 .509	.798 .752 .751 .762 .751 .762 .751 .760 .757 .748 .680 .744 .765 .544 .532 .527 .552 .528 .537 .582 .012 .017 .90938	.810 .819 .832 .824 .822 .811 .533 .524 .553 .525 .570 .545 .552 .570 .545 .525 .520 .519 .528 .529 .529 .529 .529 .529 .529 .529 .529	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .486 .481 .500 .488 .473 .472 .478 .479 .479 .001 .007 .010 .021 .011 .021	.841 .855 .858 .868 .862 .847 .783 .848 .872 .484 .481 .501 .474 .501 .474 .474 .474 .521 .001 .010 .021 .031 .001 .001 .001	.872 .878 .882 .890 .887 .873 .806 .877 .504 .506 .503 .507 .500 .538 .524 .510 .512 .493 .494 .499 .496 .577 .527 .006 .012 .025 .036 .036 .036 .012	.834 .841 .839 .844 .818 .834 .816 .840 .827 .838 .991 .971 .971 .971 .971 .971 .940 .950 .981 .975 .950 .950 .956 -
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 32 Sorae 33 Yangpyeong 34 Cheongju 35 Yeongdong 36 Cheongyang 37 Yangsan 38 Kyeongju 39 Kangnung	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .005 .006 .002 .012 .010 .029 .024 .005 .950 .950 .958 .884 .589 .584 .601 .616 .658 .601 .616 .658 .601 .616 .658 .601 .616 .658 .601 .616 .616 .616 .616 .616 .616 .616	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .002 .001 .011 .028 .023 .006 .006 .007 .967 .949 .886 .603 .592 .605 .588 .608 .608	.561 .568 .568 .572 .574 .576 .572 .499 .578 .575 .006 .003 .004 .018 .010 .002 .000 .002 .002 .873 .614 .598 .614 .598 .615 .628 .599 .591 .591 .591	.570 .584 .581 .586 .593 .589 .586 .514 .592 .590 .001 .001 .004 .002 .001 .004 .001 .000 .001 .001 .001 .001	.588 602 602 602 609 609 609 605 605 605 605 605 605 605 605 605 605	.587 .593 .598 .596 .603 .599 .592 .603 .599 .000 .000 .000 .001 .003 .004 .004 .000 .000 .000 .000 .000		.385 .364 .377 .378 .363 .356 .346 .346 .475 .456 .480 .491 .462 .491 .464 .478 .454 .474 .474 .474 .474 .474 .474 .475 .474 .475 .476 .476 .477 .476 .477 .476 .477 .476 .477 .476 .477 .476 .477 .477	.445 .417 .434 .433 .369 .393 .411 .504 .515 .533 .473 .491 .479 .489 .479 .504 .515 .535 .473 .491 .492 .479 .504 .515 .535 .475 .475 .475 .475 .475 .475 .475 .47	.813 .824 .826 .836 .836 .836 .818 .752 .816 .841 .492 .498 .478 .479 .479 .479 .479 .479 .479 .479 .479	.769 .784 .787 .793 .788 .793 .788 .777 .714 .775 .508 .512 .508 .512 .514 .505 .523 .542 .518 .513 .544 .505 .523 .542 .518 .508 .519 .496 .496 .496 .504 .506 .506 .507 .707 .709 .707 .709 .709 .709 .709 .7	.827 .830 .828 .836 .834 .832 .756 .823 .845 .481 .484 .486 .502 .521 .500 .465 .474 .475 .565 .509 .266 .276 .276 .276 .276 .276 .276 .276	.638 .648 .646 .656 .651 .642 .582 .645 .660 .442 .443 .444 .443 .444 .451 .433 .431 .437 .741 .741 .741 .741 .741 .741 .741 .74	.751 .762 .759 .769 .774 .763 .754 .688 .753 .775 .507 .508 .508 .592 .594 .517 .512 .514 .514 .514 .515 .509 .549 .517 .512 .514 .516 .517 .517 .517 .517 .517 .518 .519 .519 .519 .519 .519 .519 .519 .519	.756 .780 .781 .782 .783 .784 .773 .772 .770 .526 .551 .531 .535 .551 .531 .535 .551 .531 .53	.798 .752 .751 .762 .7551 .762 .760 .757 .748 .680 .744 .766 .544 .527 .552 .528 .534 .522 .528 .528 .528 .528 .023 .012 .0017 .005 .012 .017 .930	.810 .819 .819 .824 .824 .821 .740 .811 .536 .525 .531 .524 .552 .570 .545 .552 .510 .510 .525 .520 .520 .520 .520 .520 .521 .526 .525 .520 .520 .520 .520 .520 .520 .520	.809 .825 .827 .837 .836 .831 .818 .841 .489 .483 .486 .481 .488 .475 .502 .478 .476 .516 .500 .478 .478 .476 .500 .720 .001 .001 .001 .001 .001 .001	.841 .855 .858 .868 .862 .862 .4847 .783 .848 .872 .484 .475 .504 .514 .501 .514 .504 .471 .463 .471 .471 .463 .471 .521 .001 .010 .022 .082 .092 .001 .019 .019	.872 .878 .882 .890 .887 .873 .806 .870 .507 .504 .506 .503 .507 .503 .521 .538 .524 .510 .512 .493 .494 .496 .7 .577 .527 .006 .012 .025 .036 .036 .036 .036 .036	.834 .841 .839 .844 .816 .840 .827 .838 .991 .971 .971 .971 .971 .971 .975 .996 .950 .950 .955 .979 .953 .956 -
R. huanrenensis  1 Jangseong 2 Pohang 3 Cheongsong 4 Yeongdeok 5 Pyeongchang 6 Hanso-ri 7 Oban-ri 8 Inje 9 Kapyeong 10 Donghae R. dybowskii 11 Yangpyeong 12 Cheongyang 13 Muju 14 Jangseong 15 Kurye 16 Haenam 17 Jeju 18 Keoje 19 Hadong 20 Yangsan 21 Donghae 22 Inje 23 Kanseong 24 Keojin 25 Kapyeong 26 Wonju 27 Tsushima Isl. R. chensinensis 28 Ninxia 29 Quing R. amurensis 30 Haenam 31 Kangwha 32 Sorae 33 Yangpyeong 34 Cheongju 35 Yeongdong 36 Cheongyang 37 Yangsan 38 Kyeongju 39 Kangnung	.610 .623 .621 .628 .627 .631 .626 .553 .634 .628 .006 .002 .010 .029 .010 .029 .010 .029 .975 .975 .965 .970 .958 .884 .601 .638 .631 .638 .638 .638 .638 .638 .638 .638 .638	.586 .598 .597 .604 .602 .606 .601 .530 .608 .604 .005 .002 .010 .001 .001 .005 .002 .006 .006 .006 .007 .967 .949 .949 .886 .603 .592 .588 .608 .608 .608 .608 .609 .609 .609 .609 .609 .609 .609 .609	.561 .568 .568 .565 .572 .576 .576 .578 .575 .006 .003 .004 .004 .008 .034 .010 .005 .002 .000 .000 .000 .000 .000 .00	.570 .584 .584 .583 .589 .586 .514 .592 .590 .001 .000 .000 .001 .001 .001 .004 .001 .000 .001 .001	.588 602 602 609 609 609 609 600 600 600 600 600 600	.587 .593 .599 .596 .603 .599 .596 .603 .599 .000 .000 .000 .000 .000 .000 .000		.385 .364 .377 .378 .363 .346 .346 .475 .456 .480 .462 .491 .462 .491 .478 .454 .474 .478 .454 .474 .478 .454 .474 .478 .454 .478 .475 .475 .475 .475 .475 .475 .475 .475	.445 .417 .434 .433 .369 .393 .313 .369 .393 .411 .504 .498 .515 .533 .535 .535 .535 .547 .491 .496 .748 .748 .748 .748 .748 .748 .748 .748	.813 .824 .826 .835 .836 .838 .818 .841 .492 .487 .487 .490 .478 .490 .479 .4483 .478 .479 .496 .477 .483 .478 .512 .519 .505 .492 .496 .479 .496 .479 .496 .496 .496 .496 .496 .496 .496 .49	.769 .784 .787 .796 .793 .788 .777 .714 .775 .505 .512 .508 .512 .508 .512 .508 .514 .505 .523 .518 .513 .496 .495 .503 .504 .503 .504 .505 .503 .504 .505 .503 .504 .505 .506 .506 .507 .507 .507 .508 .508 .509 .509 .509 .509 .509 .509 .509 .509	.827 .828 .830 .828 .837 .756 .823 .845 .481 .484 .486 .502 .502 .491 .495 .480 .467 .495 .495 .495 .500 .019 .020 .019 .020 .019 .020 .030 .030 .030 .030 .030 .030 .030	.638 .648 .646 .656 .651 .642 .645 .660 .442 .443 .446 .445 .448 .452 .448 .452 .448 .452 .448 .452 .448 .452 .449 .451 .477 .740 .074 .074 .074 .074 .074 .074	.751 .762 .769 .769 .763 .754 .763 .755 .507 .503 .508 .508 .508 .508 .508 .508 .509 .520 .549 .514 .505 .499 .514 .505 .499 .514 .505 .012 .012 .012 .012 .012 .012 .012 .013 .014 .014 .015 .014 .015 .014 .015 .014 .015 .015 .016 .017 .017 .017 .018 .018 .019 .019 .019 .019 .019 .019 .019 .019	.756 .779 .780 .791 .791 .792 .772 .770 .794 .522 .511 .531 .522 .511 .531 .523 .508 .551 .523 .508 .519 .522 .511 .523 .523 .501 .521 .523 .523 .523 .523 .523 .523 .523 .523	.738 .752 .751 .760 .757 .748 .680 .744 .765 .544 .527 .560 .579 .552 .546 .579 .573 .531 .528 .537 .534 .758 .758 .758 .758 .758 .758 .758 .758	.810 .819 .832 .824 .822 .811 .536 .525 .533 .524 .552 .552 .552 .552 .552 .552 .505 .506 .525 .506 .525 .507 .508 .509 .509 .509 .509 .509 .509 .509 .509	.809 .825 .827 .837 .836 .831 .818 .841 .483 .483 .484 .475 .502 .488 .475 .500 .488 .473 .474 .478 .479 .502 .010 .010 .011 .010 .021 .011 .011	.841 .855 .858 .868 .862 .847 .783 .848 .872 .487 .484 .481 .451 .451 .451 .471 .471 .473 .471 .476 .474 .501 .010 .022 .021 .019 .001 .001 .001 .001 .001 .001 .00	.872 .878 .882 .890 .887 .873 .806 .870 .507 .504 .506 .503 .507 .500 .531 .531 .531 .54 .512 .493 .493 .494 .499 .577 .527	.834 .841 .839 .844 .814 .814 .816 .827 .838 .991 .971 .971 .971 .940 .950 .953 .955 .953 .956 - .981 .975 .975 .975 .975 .976 .981 .991 .991 .991 .991 .991 .991 .991