Karyotype Analysis of Three Alpine *Taraxacum* Species (Asteraceae) in Japan

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Summary We present the karyotypes of three Japanese alpine *Taraxacum* species (*Taraxacum alpicola*, *T. yatsugatakense* and *T. yuparense*) in order to provide insight into their origins and taxonomic relationships. *T. alpicola* and *T. yatsugatakense* were triploid plants with similar karyotypes ($2n=24=18(M+m)+4m_{cs}+2sm_{cs}$), while *T. yuparense* was a diploid plant with the karyotype $2n=16=12m+4m_{cs}$. The karyotypes of both *T. alpicola* and *T. yatsugatakense* were considered a combination of two chromosome sets of $6m+2m_{cs}$ and one chromosome set of $6m+2sm_{cs}$. Our study reveals that *T. alpicola* and *T. yatsugatakense* are autoallopolyploids.

Key words *T. alpicola*, *T. yatsugatakense*, *T. yuparense*, Karyotype, Autoallopolyploid.

Alpine *Taraxacum* plants residing in the high mountains of Honshu and Hokkaido in Japan were first categorized by Kitamura (1957) into the following five species: *T. yuparense* H. Koidz., *T. trigonolobum* Dahlst., *T. yatsugatakense* H. Koidz., *T. platyepidum* Diels. and *T. alpicola* Kitam. The same classification was followed by Ohwi and Kitagawa (1992). Morita (1995), however, categorized Japanese alpine *Taraxacum* as the four species of *T. yuparense* H. Koidz., *T. trigonolobum* Dahlst., *T. alpicola* Kitam. and *T. venustum* H. Koidz. Following this, Morita (1995) discovered a new alpine species, *T. ohirense* S. Watan. et Morita, in Hokkaido.

Chromosomal information provides insight into the origin and taxonomic relationships between taxa. Thus, a comparative karyotype study of *Taraxacum* species may help clarify their relationships with each other. This paper is the first report of our investigation of alpine *Taraxacum* species in Japan. We report the karyotypes of *T. alpicola* Kitam., *T. yatsugatakense* H. Koidz. and *T. yuparense* H. Koidz. in order to clarify the cytotaxonomic relationships between these species.

Materials and methods

We followed the taxonomic classification proposed by Kitamura (1957). The three alpine species *T. alpicola* Kitam., *T. yatsugatakense* H. Koidz. and *T. yuparense* H. Koidz. were analyzed in the present study (Table 1).

With respect to *T. yatsugatakense*, two plants were collected from Mt. Yatsugatake, and three plants of *Taraxacum yuparense* were preserved in the experimental garden at the Faculty of Science, University of Toyama. For *T. alpicola*, a total of eight plants were collected (two plants from Mt. Tateyama and six plants from Mt. Hakusan).

Newly formed root tips collected from each potted plant were pretreated in a 2.2mM 8-hydroxyquinoline solution at room temperature (about 15°C) for about 1 h and kept at 5°C for 15 h.

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Table 1. Collection localities, numbers of individuals and chromosome numbers of three alpine species examined in the present study.

Taxon	Collection locality	Number of individuals		Total
		2n=16	2n=24	
<i>Taraxacum alpicola</i>	Toyama Pref. Mt. Tateyama		2	2
	Ishikawa Pref. Mt. Hakusan		6	6
<i>T. yatsugatakense</i>	Nagano Pref. Mt. Yatsugatake		2	2
<i>T. yuparense</i>	Origin unknown	3		3

Fig. 1. Karyotypes of somatic metaphase chromosomes of alpine *Taraxacum*. A: *T. alpicola*, B: *T. yatsugatakense*, C: *T. yuparense*. Bar represents 5 μ m.

This was followed by fixation with a mixture of glacial acetic acid and absolute ethyl alcohol (1:3) at room temperature for 1 h. Samples were macerated in 1 N hydrochloric acid at 60°C for 10 min, and then washed in tap water. After staining and squashing in 1.5% lacto-propionic orcein, fully spread metaphase chromosomes in the root tips were studied. Chromosome form was expressed according to the nomenclature of Levan *et al.* (1964).

Results and discussion

Taraxacum alpicola Kitam.

All eight plants examined had $2n=24$ chromosomes, in agreement with the chromosome number reported earlier by Miyaji (1932, as *T. japonense* Nakai), Takemoto (1961) and Yamaguchi (1976). The metaphase chromosomes of somatic cells of this species ranged from 1.9 to 3.1 μ m in length and their arm ratios ranged from 1.1 to 1.8 in somatic cells (Fig. 1A). The 24 chromosomes were divided into two groups: 22 metacentric chromosomes and two submetacentric chromosomes (Table 2). In this chromosome complement, four metacentric chromosomes and the two submetacentric chromosomes had satellites on their long arms. The karyotype of *T. alpicola* was formulated as $2n=24=18m+4m_{cs}+2sm_{cs}$.

Taraxacum yatsugatakense H. Koidz.

The two plants examined had $2n=24$ chromosomes, in agreement with Yamaguchi (1976). The somatic chromosomes at metaphase ranged from 1.9 to 3.1 μ m in length and their arm ratios ranged from 1.0 to 1.8 (Fig. 1B). The 24 chromosomes were divided into two groups: 22 metacentric chromosomes and two submetacentric chromosomes (Table 3). In this chromosome complement, four metacentric chromosomes and the two submetacentric chromosomes had satellites on their long arms. The karyotype of *T. yatsugatakense* was formulated as $2n=24=18(M+m)+4m_{cs}+2sm_{cs}$.

Table 2. Measurements of somatic metaphase chromosomes of *T. alpicola*.

No.	Length (μm)	Total (μm)	A.R.	Form
1	1.1+1.1–0.9*	3.1	1.8	sm
2	1.1+1.1–0.9*	3.1	1.8	sm
3	1.3+0.9–0.8*	3.0	1.3	m
4	1.4+0.8–0.7*	2.9	1.1	m
5	1.2+1.7	2.9	1.4	m
6	1.1+1.8	2.9	1.6	m
7	1.2+1.5	2.7	1.3	m
8	1.3+1.4	2.7	1.1	m
9	1.2+0.8–0.6*	2.6	1.2	m
10	1.1+0.8–0.5*	2.4	1.2	m
11	0.9+1.5	2.4	1.7	m
12	0.9+1.5	2.4	1.7	m
13	0.9+1.5	2.4	1.7	m
14	1.0+1.2	2.2	1.2	m
15	1.0+1.2	2.2	1.2	m
16	1.0+1.2	2.2	1.2	m
17	0.9+1.2	2.1	1.3	m
18	0.9+1.2	2.1	1.3	m
19	0.9+1.2	2.1	1.3	m
20	0.9+1.2	2.1	1.3	m
21	0.9+1.2	2.1	1.3	m
22	1.0+1.1	2.1	1.1	m
23	0.7+1.2	1.9	1.7	m
24	0.8+1.1	1.9	1.4	m

* Arms with secondary constrictions.

Table 3. Measurements of somatic metaphase chromosomes of *T. yatsugatakense*.

No.	Length (μm)	Total (μm)	A.R.	Form
1	1.1+1.1–0.9*	3.1	1.8	sm
2	1.1+1.1–0.9*	3.1	1.8	sm
3	1.3+0.9–0.8*	3.0	1.3	m
4	1.4+0.8–0.7*	2.9	1.1	m
5	1.2+1.7	2.9	1.4	m
6	1.1+1.8	2.9	1.6	m
7	1.2+1.5	2.7	1.3	m
8	1.3+1.4	2.7	1.0	m
9	1.2+0.8–0.6*	2.6	1.2	m
10	1.1+0.8–0.5*	2.4	1.2	m
11	1.2+1.2	2.4	1.0	M
12	0.9+1.5	2.4	1.7	m
13	0.9+1.5	2.4	1.7	m
14	1.0+1.2	2.2	1.2	m
15	1.0+1.2	2.2	1.2	m
16	1.0+1.2	2.2	1.2	m
17	0.9+1.2	2.1	1.3	m
18	0.9+1.2	2.1	1.3	m
19	0.9+1.2	2.1	1.3	m
20	0.9+1.2	2.1	1.3	m
21	0.9+1.2	2.1	1.3	m
22	1.0+1.1	2.1	1.1	m
23	0.7+1.2	1.9	1.7	m
24	0.7+1.2	1.9	1.7	m

* Arms with secondary constrictions.

Table 4. Measurements of somatic metaphase chromosomes of *T. yuparense*.

No.	Length (μm)	Total (μm)	A.R.	Form
1	1.2+0.9–0.7*	2.8	1.3	m
2	1.2+0.9–0.7*	2.8	1.3	m
3	1.1+1.4	2.5	1.3	m
4	1.1+1.4	2.5	1.3	m
5	1.0+1.3	2.3	1.3	m
6	1.0+1.3	2.3	1.3	m
7	1.0+0.6–0.6*	2.2	1.2	m
8	1.0+0.6–0.6*	2.2	1.2	m
9	0.9+1.1	2.0	1.2	m
10	0.9+1.1	2.0	1.2	m
11	0.9+1.1	2.0	1.2	m
12	0.9+1.1	2.0	1.2	m
13	0.8+1.1	1.9	1.4	m
14	0.8+1.1	1.9	1.4	m
15	0.8+1.1	1.9	1.4	m
16	0.8+1.1	1.9	1.4	m

* Arms with secondary constrictions.

Taraxacum yuparense H. Koidz.

All three plants examined had $2n=16$ chromosomes, in agreement with Yamaguchi (1976, 1986). The 16 chromosomes were all metacentric chromosomes. As shown in Table 4, the metaphase chromosomes in somatic cells ranged from 1.9 to $2.8\mu\text{m}$ in length and their arm ratios ranged from 1.2 to 1.4 (Fig. 1C). In the chromosome complement, four chromosomes had satellites on their long arms. The karyotype of *T. yuparense* was thus formulated as $2n=16=12m+4m_{cs}$.

The present study showed that *T. alpicola* and *T. yatsugatakense* were triploid plants and *T. yuparense* was a diploid plant, in agreement with earlier reports (Miyaji 1932, Takemoto 1961, Yamaguchi 1976, 1986). Yamaguchi (1986) showed that the karyotype of *T. yuparense* was identical to the karyotype of *T. platycarpum* s.l., a lowland species that occurs in Kyushu, Shikoku and Honshu in Japan (Serizawa 1986, 1995). The findings of the present study agree with those of Yamaguchi (1986), and suggest that *T. yuparense* and *T. platycarpum* s.l. are closely related species.

The two triploid species of *T. alpicola* and *T. yatsugatakense* had similar karyotypes (formulated as $2n=24=18(M+m)+4m_{cs}+2sm_{cs}$). Morita (1995) considered *T. alpicola* and *T. yatsugatakense* to be from closely related taxa or the same taxon. The karyotypic similarity of *T. alpicola* and *T. yatsugatakense* supports the notion that they are closely related species or from the same species, in agreement with Morita (1995).

The karyotype of *T. yuparense*, expressed as $2n=16=12m+4m_{cs}$, suggests that *T. yuparense* undergoes regular meiosis and propagates by normal sexual reproduction. The karyotypes of *T. alpicola* and *T. yatsugatakense* ($2n=24=18(M+m)+4m_{cs}+2sm_{cs}$) are considered a combination of two chromosome sets of $6m+2m_{cs}$ (similar to the chromosome sets of *T. yuparense*) and one chromosome set of $6m+2sm_{cs}$. Our study reveals that *T. alpicola* and *T. yatsugatakense* are autoallotetraploids.

References

- Kitamura, S. 1957. Compositae Japonicae. Pars sexta. *Taraxacum* Wigg. Mem. Coll. Sci., Univ. Kyoto, Ser. B. **24**: 1–42.
- Levan, A., Fredga, K. and Sandberg, A. A. 1964. Nomenclature for centromeric position on chromosomes. *Hereditas* **52**: 201–220.
- Miyaji, Y. 1932. On the chromosome numbers in the genus *Taraxacum*. *Bot. Mag. Tokyo* **46**: 406–408 (in Japanese).
- Morita, T. 1995. *Taraxacum* Weber ex F. H. Wigg. In: Iwatsuki, K., Yamazaki, T., Boufford, D. E. and Ohba, H. (eds.).

- Flora of Japan. Vol. IIIb. Kodansha, Tokyo. pp. 7–13.
- Ohwi, J. and Kitagawa, M. 1992. New Flora of Japan. Shibundo, Tokyo (in Japanese).
- Serizawa, S. 1986. On the pale-yellow-flowered dandelion found in Chita Peninsula, Aichi prefecture. J. Phytogeogr. Taxon. **34**: 55–59 (in Japanese with English summary).
- Serizawa, S. 1995. Secondary Nature in Rural Area. Hoikusha, Osaka (in Japanese).
- Takemoto, T. 1961. Cytological studies on *Taraxacum* and *Ixeris* I. Some Japanese species of *Taraxacum*. Bull. Sch. Edu. Okayama Univ. **11**: 77–94.
- Yamaguchi, S. 1976. Chromosome numbers of Japanese *Taraxacum* species. J. Jpn. Bot. **51**: 52–58.
- Yamaguchi, S. 1986. Karyotype analysis of the Japanese diploid species of *Taraxacum*, sect. *Mongolica* and sect. *Ceratophora*. La Kromosomo II **43–44**: 1386–1397.
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