Is *Ptarmica* independent genus or attached to *Achillea ptarmica*, tribe Anthemideae, Asteraceae?

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ABSTRACT: *Ptarmica impatiens* L. (diploid; 2n=18), *P. ledebouri* (Heimerl.) Serg. (tetraploid; 2n=36) and *P. salicifolia* (Bess.) Serg. (tetraploid; 2n=36) taxonomically close relatives with and are sometimes placed in the genus *Achillea* grown commonly in the well northern colder region. The karyotypic comparison showed *Ptarmica* is somewhat different from *Achillea* although they were placed in the tribe Anthemideae, the family Asteraceae. *Ptarmica* should be independent genus separated from *Achillea* and more meritorious in an ornamental and horticultural purposes.

Achillea, commonly called yarrow, consists of approximately 100 species and grows naturally throughout Europe, Asia and North America and have been used for medicinal herbs and vegetable (Hiecke 1976; Shin and Fu 1983; Bremer and Humphries 1993; Krasnoborov *et al.* 2003). Only four to five species of the genus have somewhat gigantic plant forms just like *Chrysanthemum* with large ligulate flowers named as *Achillea ptarmica* including large white flowers are commonly distributed in Europe mainly in Scandinavia and Baltic States, Alaska of the U.S.A. most of the places in Canada and a few places in Asia including Japan, Korea and China and Syberian Russia. White, double ligulate-flowered cultivars namely 'Pearl Achillea', 'Russian Daisy Seward', 'Alaska August 2002' and so on in Europe and North America are common to horticultural world, Liberty Hyde Bailey Hortorium (1976), although many species of *Achillea* are found in certain places in Mts. Altai, Altai Republic, Russian Federation, and very weedy in many temperate areas such as Japan and is taxonomically named as *Achillea millefolium* Ledeb. Thus, some members of *Achillea* in the Asteraceae, tribe Anthemideae such as *A. impatiens* L., *A. japonica* Heimerl., *A. ledebourii* Heimerl., *A. ptarmica* L., *A. salicifolia* Besser (= *A. cartilaginea* Ledeb. ex Reichenb.) and so on (e.g., Bremer and Humphries 1993) can be placed in *Ptarmica* such as *P. impatiens* (L.) DC., *P. japonica* (Heimerl.) Vorosch., *P. ledebouri* (Heimerl.) Serg., *P. salicifolia* (Bess.) Serg., *P. vulgaris* Blakw. ex DC. mainly by Russian taxonomists in order [Afanasyev and Bochantsev 1961]. The genus *Achillea* // Flora of the USSR. - Vol. 26. - p. 70-124 (in Russian)] mostly by Russian botanists. *Ptarmica* and *Achillea* might cross hybridize with each other and perform such different flower coloration as 'Dwarf Pink Pearl', 'Dwarf Pink

Sneezewort', 'Nana Compacta' 'Red Velvet', red colored 'Terra Cotta', 'Yellow' and so on.

Only a difference between *Ptarmica* and *Achillea* is plant sizes; the genus *Ptarmica* is much taller in stem length than 130 cm, much bigger in leaf size, ray flowers or ligulate flower much bigger just like chrysanthemums. Such cultivars as 'Yellow Pearl', 'Giant Yarrow', 'Giant Gold Yarrow' *Achillea Ptarmica* L. performs white, multi-ligulate flowered cultivars such as 'Aunt Stientje', 'Crocus', 'Noblessa', 'Gipi Whit' = 'Gypsy White', 'The Pearl Group' = 'The Pearl', 'Sneeze Wort' and so on. They have quite large ray or ligulate flowers and thus, they are horticulturally very meritorious (Liberty Hyde Bailey Hortorium (1976). These species of *Ptarmica* have been cytologically well studied mainly in chromosome numbers with the basic chromosome number of X=9 mostly by Russian researchers such as Kartashova *et al.* (1974), Belaeva and Siplivinsky (1975), Sokolovskaya and Probatova (1985), Dmitrieva (1987), Probatova and Sokolovskaya (1990), Lavrenko *et al.* (1992) and so on, while numerous chromosome data mainly chromosome numbers of *Achillea* have been reported (Dabrowska 1974; Khandzhyan 1975; Klovov and Kritskaya 1984 Pullariah 1977; Samutina 1978; Tril' 1979 and many others). However, those data of the chromosome numbers reported could not isolate one out of the two genera.

MATERIALS AND METHODS

The materials of *Ptarmica ledebouri* (Heimerl.) Serg. and *P. salicifolia* (Besser) Serg. *cartilaginea* (Ledeb. ex Rchb) Tzvelev both approximately ca 1.50 m tall grew together in rather wet delta area of the river-side in Russian Federation, Tuva Republic, Kakasiya Region, Minusinsk District, near Izykhskie Kopi Village, Abakan River

Valley; 53°33'13"N, 91°13'75"E, alt. 270 m. When their habitats of the population were observed they were both at the early stage of the flowering season in the middle of August 2010. They showed some flowers but no hybrid flower was recognized. In contrast, the plants of *P. impatiens* grew commonly in root-stocks in water as the aquatic plant in the shallow stream in the southeast of Lake Baikal, the Zabaikalsky National Park, Yablonovy Range, Buryat Republic, Russian Federation, where was different in habitats from those of *P. ledebouri* and *P. salicifolia*. However, these three species were grown in hot summer in the greenhouse on Atsugi campus of Tokyo University of Agriculture, and had no flower due to too hot summer.

For a karyotypic comparison, the commonest species of *Achillea*, dispersed widely all over the temperate to colder zones of the northern hemisphere, *A. millefolium* L. was collected in Altai Republic: Onguday District, Vicinity of Chuya River, 50°23'86"N; 86°40'44"E, alt. 830 m Ulagan District, ca 29 km from Aktash to Ulagan. This plant of the species grew together with other Asteraceous species, such as *Tanacetum vulgare* L.

Growing roots of well grown plants of the three species of *Ptarmica* and *Achillea millefolium* were collected and pretreated in 2 mM 8-hydroxyquinoline at 18°C for 2 h. Then, they were fixed in 45% acetic acid at 4°C. They were macerated in the mixture of 1N HCl and 45% acetic acid=2:1 at 60°C. Root tips less than 1 mm long was cut and stained by 1% aceto-orcein on glass slides for 30 min in a chamber moistened by 45% acetic acid. Then, they were covered by cover-slips and were tapped as usual by stick to spread chromosomes in respective cell.

Karyotype formulae of three species of *Ptarmica* and *Achillea millefolium* were based on the size data of chromosome characters of ten somatic metaphase cells per species. Position classification of the primary constriction in chromosome followed Levan *et al.* (1964): Arm ratio was calculated by long arm/short arm; 1.0-1.7 was

grouped as median centromere, 3.1-7.0 subterminal centromere, and 7.1 or more terminal centromere.

RESULTS AND DISCUSSION

Fig. 1 shows common white flowers of three species of *Ptarmica* taken in the natural habitats in Russia: 1. *Ptarmica impatiens* (L.) DC. taken at the shallow stream in the southeast of Lake Baikal, Lake Baikal, the Zabaikalsky National Park, Yablonovy Range, Buryat Republic, Russian Federation; 2. *Ptarmica ledebouri* (Heimerl.) Serg. and 3. *P. salicifolia* both approximately ca 1.50 m tall grew together in rather wet delta area of the river-side in Russian Federation, Tuva Republic, Kakasiya Region, Minusinsk District, near Izykhskie Kopi Village, Abakan River Valley; 53°33'13"N, 91°13'75"E, alt. 270 m.

The chromosome complements of *Ptarmica impatiens*, *P. ledebouri* and *P. salicifolia* are shown in Fig. 2 (1-3) and their karyotypes are tabulated in Table 1, while the karyotype of *Achillea millefolium* was $2n=36=18m+4m^{sat}+14sm$ (Table 1). Thus, their karyotypes were not the same to each other at the same ploid level and were not proportional to the diploid karyotype.

Species of *Ptarmica* are mostly tetraploid ($2n=36$) except for only one diploid (*Ptarmica impatiens*; $2n=18$), while those of *Achillea* are varied from diploid ($2n=18$), tetraploid ($2n=36$), pentaploid ($2n=45$), hexaploid ($2n=54$) to octoploid ($2n=72$) (Index to plant chromosome numbers 1975-2008). The karyotype of *Ptarmica impatiens* was $2n=18=12m+6sm$, that of *P. ledebouri* was $2n=36=29m+6sm+1^{st}$, and that of *P. salicifolia* was $2n=36=29m+1m^{sat}+5sm+1sm^{sat}$ (Table 1; Fig. 2). Those tetraploid karyotypes were somewhat similar to each other. The karyotypes of the three species of *Ptarmica* were compared with those of *Achillea* and it was found to be very different from each other (Table 1).

Ptarmica might have been well isolated in colder region and might be more primitive than *Achillea*. *Ptarmica* is erect in habit while *Achillea* is mat-like in

Fig. 1. Flowers of three species of *Ptarmica* in natural conditions in their native habitats. A. *P. impatiens* L., B. *P. ledebouri* (Heimerl.) Serg., C. *P. salicifolia* (Bess.) Serg. *cartilaginea* (Ledeb.ex Rchb) Tzvelev.

Table 1. Karyotypes of three species of *Ptarmica* collected in a certain localities in Siberia, Russia

Species	Karyotype	Locality
<i>Achillea millefolium</i> L.	$2n=36=18m+4m^{sat}+14sm$	Altai Republic: Onguday District, Vicinity of Chuya River, 50°23'86"N; 86°40'44"E, alt. 830 m Ulagan District, ca 29 km from Aktash to Ulagan
<i>Ptarmica impatiens</i> L.	$2n=18=12m+6sm$	Buryat Republic: Southeast of Lake Baikal, The Zabaikalsky National Park
<i>P. ledebouri</i> (Heimerl.) Serg.	$2n=36=29m+6sm+1^{st}$	Tuva Republic: Kakasiya Region, Minusinsk District, near Izykhskie Kopi Village, Abakan River Valley; 53°33'13"N, 91°13'75"E, alt. 270 m
<i>P. salicifolia</i> Bess.Serg. <i>cartilaginea</i> (Ledeb.ex Rchb) Tzvelev.	$2n=36=29m+1m^{sat}+5sm+1sm^{sat}$	Tuva Republic: Kakasiya Region, Minusinsk District, near Izykhskie Kopi Village, Abakan River Valley; 53°33'13"N, 91°13'75"E, alt. 270 m

*The majority of the monograph papers lists those species as *Achillea* excepting those listed for the Russian species in the Russian literatures are classed as *Ptarmica*.

Fig. 2. Chromosome sets of three species of *Ptarmica*. A. *P. impatiens* L., $2n=18$. B. *P. ledebouri* (Heimerl.) Serg., $2n=36$. C. *P. salicifolia* Bess.Serg. *cartilaginea* (Ledeb.ex Rchb) Tzvelev., $2n=36$. X 600.

habit. Several cultivars of *Ptarmica* has been horticulturally registered such as 'Angel's Breath', 'Aunt Stientje', 'Crocus', 'Gipi Whit'='Gypsy White' 'Noblessa', 'The Pearl Group'='The Pearl', 'Sneeze Wort' mostly white flowers but some pink and yellow and so on. Those horticulturally meritorious plants of *Ptarmica* have been mostly cultivated in Scandinavia to Baltic areas and to North America down to North Carolina, U.S.A. and so on. *Ptarmica* was not distinctly but poorly isolated from *Achillea*.

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