New Chromosome Counts in Five *Alyssum* Species from Turkey

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Summary Chromosome numbers of five *Alyssum* species (*A. aizoides* Boiss., *A. aureum* (Fenzl) Boiss., *A. baumgartnerianum* Bornm. ex Baumg. *A. constellatum* Boiss. and *A. xanthocarpum* Boiss.) from Turkey have been reported for the first time. *A. aizoides* and *A. baumgartnerianum* are tetraploid ($2n=4x=32$) while *A. aureum*, *A. constellatum* and *A. xanthocarpum* are diploid ($2n=2x=16$).

Keywords *Alyssum*, Brassicaceae, Chromosome number, Polyploid, Turkey.

Karyological data are of great importance when studying plant systematics and evolution, and are an effective tool used to establish the boundaries of the relationships between species (Stebbins 1971).

The main distribution areas of Brassicaceae are the Mediterranean, Irano-Turanian and Saharo-Sindian regions (Hedge 1976). Turkey having 653 native species belonging to 61 genera is one of the richest countries in terms of their abundance (Al-Shehbaz *et al.* 2007). In the Brassicaceae family, chromosome numbers are known for 232 of the 338 genera (68.6%) and 1559 of the 3709 species (42%). The basic numbers vary from 4 to 13, however, $x=8$ has a surprisingly high percentage (37%) (Warwick *et al.* 2006).

Alyssum is one of the largest genera with approximately 230 species in Brassicaceae and its main distribution areas are Eastern Europe and Turkey (Al-Shehbaz and Beilstein 2006). This genus is the largest among genera in Flora of Turkey and is represented by 90 species. Of these species, 54 are endemic and approximately one-third of these are endangered and require preservation (Babaoglu *et al.* 2004).

The aims of the present study are to reveal the chromosome numbers of *Alyssum* species and investigate the degree of chromosomal variation of the studied at the

interspecies level.

Materials and methods

The studied *Alyssum* samples were collected at least 10 individuals of each species from various localities in Turkey in 2018 (Table 1). Mature seeds were selected and periodically germinated for chromosome analysis. About the five seedlings were investigated in each individual. Vouchers are stored in Herbarium of Science Faculty, Selçuk University (KNYA) or the collection of E. Şirin. Chromosome counts were carried out during the somatic metaphase using a squashing technique. Root meristems obtained from the germinated seeds were used. The samples were pre-treated with a 2mM 8-hydroxyquinoline for 8 h at 4°C and then fixed for 24 h at 4°C using Carnoy fixative. Before the staining process, the material was hydrolyzed for 20 min using 5M HCl at room temperature. The samples were then stained with 1% aceto-orcin and placed in 45% acetic acid. At least 10 metaphases were examined for each plant of species. The best metaphase image was recorded using an Olympus DP-72 digital camera attached to an Olympus BX53 microscope.

Table 1. Localities of the *Alyssum* taxa.

Species	Locality, altitude and collection date	Voucher
<i>A. aizoides</i>	Antalya: Geyik Mountain, 2300 m, 24.07.2018	EŞ-766 (KNYA)
<i>A. aureum</i>	Konya: Çumra, 980 m, 25.07.2018	EŞ-768-HG (KNYA)
<i>A. baumgartnerianum</i>	Karaman: Yelibel Mountain, 2000 m, 24.07.2018	EŞ-767-HG (KNYA)
<i>A. constellatum</i>	Burdur: Tefenni, 1100 m, 25.07.2018	EŞ-769-HG (KNYA)
<i>A. xanthocarpum</i>	Kastamonu: Ilgaz Mountain, 1550 m, 26.07.2018	EŞ-770 (KNYA)

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Fig. 1. The mitotic metaphase chromosomes of studied taxa. (A) *A. aizoides*, (B) *A. aureum*, (C) *A. baumgartnerianum*, (D) *A. constellatum*, and (E) *A. xanthocarpum*. Arrows indicate satellites. Scale bar=10 μ m.

Table 2. Chromosome numbers reported in *Alyssum* taxa.

Taxa	Chromosome number	References
<i>A. aizoides</i>	$2n=4x=32$	Present study
<i>A. argyrophyllum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. aurantiacum</i>	$2n=16$	Strid (1987)
<i>A. aureum</i>	$2n=16$	Present study
<i>A. baumgartnerianum</i>	$2n=4x=32$	Present study
<i>A. bornmuelleri</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. borzaeanum</i>	$2n=4x=32$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. callichroum</i>	$2n=6x=48$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. cassium</i>	$2n=4x=32$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. cilicicum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. condensatum</i> subsp. <i>condensatum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. condensatum</i> subsp. <i>flexible</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. constellatum</i>	$2n=16$	Present study
<i>A. contemptum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. corsicum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. desertorum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. erosulum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. floribundum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. giosnanum</i>	$2n=4x=32$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. huber-morathii</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. huetii</i>	$2n=14$	Ancev <i>et al.</i> (1998)
<i>A. lepidoto-stellatum</i>	$2n=4x=32$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. masmenaeum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. menioides</i>	$2n=14$	Ancev <i>et al.</i> (1998)
<i>A. minutum</i>	$2n=16$	Aryavand (1975)
<i>A. mouradicum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. oxycarpum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. pateri</i>	$2n=4x=32$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. praecox</i>	$2n=4x=32$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. stapfii</i>	$2n=6x=48$	Aryavand (1975)
<i>A. strigosum</i>	$2n=16$	Contandriopoulos and Afzal-Rafii (1973)
<i>A. umbellatum</i>	$2n=14$	Strid (1987)
<i>A. xanthocarpum</i>	$2n=16$	Present study

Results and discussion

The chromosome set of *A. aizoides* was composed of 32 chromosomes (Fig. 1A). The chromosome number was reported for the first time. This endemic species is different from the others because of having satellites. In *A. aureum* the chromosome number was determined to be $2n=16$ (Fig. 1B). Our report is the first chromosome study for this species. In *A. baumgartnerianum* the chromosome number was determined to be $2n=4x=32$ (Fig. 1C). The chromosome number of this species was reported for the first time here. In *A. constellatum* the chromosome number was determined to be $2n=16$ (Fig. 1D). Our report is the first chromosome study for this species. The chromosome set of *A. xanthocarpum* comprised of 16 chromosomes (Fig. 1E).

The chromosome number is an important parameter used to explain the phylogenetic relationships observed among species (Eroğlu *et al.* 2013, Uysal *et al.* 2017). In the Brassicaceae family, the chromosome numbers are significantly different among the taxa in the genera and this is of importance for the evolutionary and systematic evaluation of the family (Karaismailoğlu 2018).

The basic chromosome count for the Alyseae species is $x=8$ (Warwick *et al.* 2008, Rešetnik *et al.* 2013). Alyseae species contains 24 genera and 277 taxa, and the polyploid levels were determined for 171 of these taxa (Marhold and Lihová 2006). Of these, 95 (55.6%) were diploids, 43 (25.1%) were polyploids and 33 (19.3%) were diploid-polyploids. Both polyploids and aneuploids play an important role in the evolution of Brassicaceae (Marhold and Lihová 2006). The most common chromosome count in this genus was $x=8$, while $x=7$ is less common (Table 2). Higher chromosome counts may represent a more primitive state (Lysak and Lexer 2006). In this study, all taxa have the basic $x=8$ chromosome number. Also, three of the taxa have diploid chromosomes, whereas *A. aizoides* and *A. baumgartnerianum* are tetraploid and also *A. aizoides* is different from the others because of having satellites. Karyological observations in our study might contribute to the differentiation of Turkish *Alyssum* taxa.

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