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Karyotype analysis of *Paronychia dudleyi* and *Paronychia pontica*

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Paronychia dudleyi ve *Paronychia pontica*'nın karyotip analizi

Abstract: The polyphyletic genus *Paronychia* includes about 110 species that are distributed throughout the world except in the southern of Africa and Asia. Türkiye is one of the most important distribution centers of genus *Paronychia* represented by 29 species. The basic and diploid chromosome numbers were recorded in 22 species (26 taxa) of Turkish *Paronychia*. The aim of this study is to report for the first time the karyological data of *P. dudleyi* and *P. pontica*. The chromosome number and karyotype formula were $2n = 4x = 36$m in *P. dudleyi* and $2n = 2x = 18$m in *P. pontica*. The karyotype asymmetry values (especially intrachromosomal) were quite low. As a result, the new karyological data were recorded: (i) first report of the basic and diploid chromosome numbers, (ii) ploidy levels of 2*x* and 4*x*, (iii) first detailed chromosomal data, (iv) the most symmetrical karyotypes.

Key words: *Paronychia*, chromosome, karyotype asymmetry, polyploidy

Özet: Polifiletik *Paronychia* cinsi, Afrika Asya'nın güneyi dışında dünyanın her yerine dağılmış yaklaşık 110 türü içerir. Türkiye, 29 türle temsil edilen *Paronychia* cinsinin en önemli dağılım merkezlerinden biridir. Türk *Paronychia*'ların 22 türünde (26 takson) temel ve diploid kromozom sayıları kaydedilmiştir. Bu çalışmanın amacı, *P. dudleyi* ve *P. pontica*'nın karyolojik verilerini ilk kez bildirmektir. Kromozom sayısı ve karyotip formülü *P. dudleyi*'de $2n = 4x = 36$m, *P. pontica*'da $2n = 2x = 18$m'dir. Karyotip asimetri değerleri (özellikle intrakromozomal) oldukça düşük bulunmuştur. Sonuç olarak yeni karyolojik veriler kaydedildi: (i) temel ve diploid kromozom sayılarının ilk raporu, (ii) 2*x* ve 4*x* ploidi seviyeleri, (iii) ilk detaylı kromozomal veriler, (iv) en simetrik karyotipler.

Anahtar Kelimeler: *Paronychia*, kromozom, karyotip asimetrisi, poliploidi

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1. Introduction

The polyphyletic genus *Paronychia* Miller includes about 110 species that are distributed throughout the world except in the southern parts of Africa and Asia. Türkiye is one of the most important distribution centers of genus *Paronychia* represented by 29 species (Bittrich, 1993; Eroğlu et al., 2021). From the species the subject of the study, *P. dudleyi* Chaudhri; perennial, stem branched at the base (diameter 1-3 mm), decumbent to ascending, 2-7(-15) cm, white flowers 12-50. It grows on forest open areas, calcareous plains, and rocky-stony in 710-2230 m. *P. pontica* (Borhidi) Chaudhri; perennial, stem branched at the base (diameter 2-4 mm), decumbent to ascending, 2-7 cm, white flowers 4-8. It grows on forest open areas and stony in 1000-1040 m (Figure 1) (Chaudhri, 1967, 1968; Bittrich, 1993).

The basic and diploid chromosome numbers were recorded in 22 species (26 taxa) of Turkish *Paronychia*. Although the genus showed variations in the basic chromosome number such as $x = 5, 7, 9$, and 13; the basic number was $x = 9$ in the majority of Turkish *Paronychia*. There were very few taxa for which polyploidy had not been reported, namely *P. anatolica* Czecz. subsp *anatolica*, *P. kurdica* Boiss. subsp. *hausknechtii* Chaudhri, *P. kurdica* Boiss. subsp. *montis-munzur* Chaudhri, and *P. macrosepala* Boiss. ($2n = 2x = 18$). However, twenty-three taxa showed polyploidy variations such as tetraploidy ($2n = 4x = 28$, 36, and 52), hexaploidy ($2n = 6x = 54$), and octoploidy ($2n = 8x = 56$, 72, and 104). *P. echinulata* Chater ($x = 5$, 7 and $2n = 10$, 14, 28), *P. kapela* (Hacq.) Kerner ($x = 9$ and $2n = 18$, 36), and *P. polygonifolia* (Vill.) DC. ($x = 7$ and $2n = 14$, 56) were diploid and polyploid. *P. argentea* Lam., *P. chionaea* Boiss. subsp. *chionaea*, *P. chionaea* Boiss. subsp. *kemaliya* Chaudhri, and *P. polygonifolia* were taxa showing high ploidy level (8*x*). (Lorenzo Andreu and García Sanz, 1950; Blackburn and Morton, 1957; Fedorov, 1974; Löve, 1975; Diosdado and Pastor, 1994; Runemark, 1996; Eroğlu et al., 2017; Eroğlu et al., 2020; Eroğlu and Budak, 2020; Eroğlu et al., 2021).

The aim of this study is to report for the first time the karyological data listed below in *P. dudleyi* and *P. pontica*: (i) chromosome number (basic and diploid), (ii) ploidy levels, (iii) detailed chromosomal measurements, (iv) karyotype formula, and (v) karyotype asymmetry (inter- and intrachromosomal).

2. Materials and Method

2.1. Collection Information

Paronychia dudleyi: Türkiye, Ankara, Polatlı, above Sazılar village, 39˚41˙27"N 31˚56˙14"E, 710 m, 08 vii 2014, Budak 3130 & Hamzaoğlu (Bozok Hb.).

Paronychia pontica: Türkiye, Eskişehir, between Eskişehir and Söğüt, near Oluklu village, 39˚53˙28"N 30˚14˙28"E,

Figure 1. *Paronychia dudleyi* (A) and *Paronychia pontica* (B)

1020 m, 08 vii 2014, Budak 3137 & Hamzaoğlu (Bozok Hb.).

2.2. Cytogenetic Procedure

The cytogenetic procedure consists of the following steps. (i) Germination: the process was carried out by leaving the seeds between moist drying papers at room temperature. (ii) Pretreatment: the process was carried out by leaving the germinated seeds in a solution of α-monobromonaphthalene for 16 h at 4ºC. (iii) Fixation: the process was carried out by leaving the material in fixative solution (ethanol:acetic acid, 3:1) for 16 h at 4ºC. (iv) Hydrolysis: the process was carried out by leaving the material in 1 N HCl solution for 12 min at 60ºC. (v) Staining: the process was carried out by stained the material in aceto-orcein (2%). (vi) Preparation: the process was carried out by squashed the material in acetic acid (45%) (Martin et al., 2022).

2.3. Karyological Calculations

The karyological calculations were performed using 10 metaphase plates by clearly spread chromosomes (Figure 2). The short arm (SA) and long arm lengths (LA) of the chromosomes were measured with KaryoType software. Then the total length (TL) = [LA + SA], total and mean haploid length (THL and MHL), arm ratio (AR) = [LA/SA], centromeric index (CI) = [SA/(LA + SA) × 100], and relative length (RL) = [(LA + SA)/THL × 100] were determined. The karyotype formulae and asymmetry index values were detected as described by Levan et al. (1964), Paszko (2006), and Peruzzi and Eroğlu (2013).

3. Results

The chromosomal data of *Paronychia dudleyi* and *P. pontica* were herein recorded for the first time. The chromosome number and karyotype formula were $2n = 4x = 36$m in *P. dudleyi* and $2n = 2x = 18$m in *P. pontica*. The karyotype asymmetry values were quite low (Table 1).

The monoploid ideograms and detailed chromosomal data of *Paronychia dudleyi* and *P. pontica* were represented in Figure 3 and Table 2. In *P. dudleyi*, total chromosome length, relative length, and centromeric index ranged from 1.06-1.99, 4.00-7.50, and 44.09-50.00, respectively. In *P. pontica*, total chromosome length, relative length, and centromeric index ranged from 1.40-1.68, 9.96-11.95, and 46.10-48.57, respectively.

4. Discussions

Different diploid numbers as $2n = 18$ and 36 were detected in studied species. In Turkish *Paronychia*, the chromosome number variations were reported such as $2n = 10$, 14, 18, 28, 36, 52, 54, 56, 72, and 104; however, the most dominant was $2n = 36$ (Lorenzo Andreu and García Sanz, 1950;

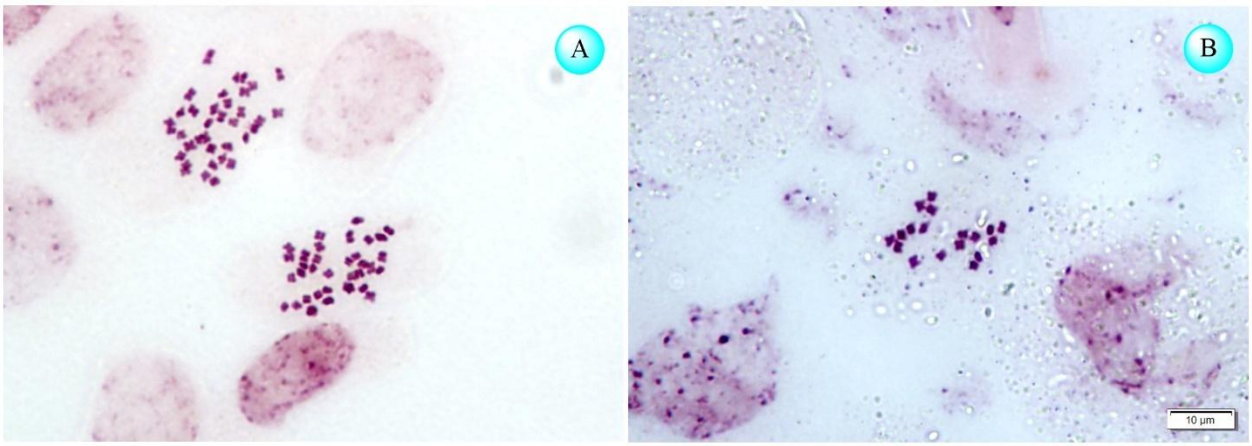

Figure 2. Metaphase chromosomes of *Paronychia dudleyi* (A) and *Paronychia pontica* (B). Scale bar 10 µm

Table 1. The karyological parameters of *Paronychia dudleyi* and *Paronychia pontica*

Karyological parameters	*P.dudleyi*	*P.pontica*
x (basic chromosome number)	9	9
2*n* (diploid chromosome number)	36	18
Karyotype formula	36m	18m
THL (total haploid length, µm)	26.53	14.06
MHL (mean haploid length, µm)	1.47	1.56
A1 (intrachromosomal asymmetry index)	0.10	0.10
A2 (interchromosomal asymmetry index)	0.16	0.06
CV_{CL} (relative variation in chromosome length)	16.46	5.91
CV_{CI} (relative variation in centromeric index)	4.08	1.83
AI (karyotype asymmetry index)	0.67	0.11
M_{CA} (mean centromeric asymmetry)	5.63	5.38

Blackburn and Morton, 1957; Fedorov, 1974; Löve, 1975; Diosdado and Pastor, 1994; Runemark, 1996; Eroğlu et al., 2017; Eroğlu et al., 2020; Eroğlu and Budak, 2020; Eroğlu et al., 2021). After the present results, the chromosome number of five Turkish *Paronychia* are still unknown, which are *P. boissieri* Rouy, *P. euphratica* (Chaudhri) Chaudhri, *P. kocii* Budak, *P. mughlaei* Chaudhri, and *P. sintenisii* Chaudhri.

The basic number was *x* = 9 in *Paronychia dudleyi* with ploidy level 4*x* and *P. pontica* with ploidy level 2*x* such as most Turkish *Paronychia* (Eroğlu et al., 2020). However, *x* = 8 was dominated in some regions such as Macaronesia, Almeria, and Granada (Diosdado and Pastor, 1994; Suda et al., 2003). In addition, the ploidy variations such as 2*x*, 4*x* (the most dominant), 6*x*, and 8*x* were reported in the genus *Paronychia* (Eroğlu et al., 2020).

All chromosomes of studied species were metacentric and the karyotype formulae were 18m and 36m. However, it was reported the submetacentric and subtelocentric chromosomes in the genus. (Diosdado and Pastor, 1994; Eroğlu et al., 2020).

In karyotype asymmetry, the values of A1 and M_{CA} refer the intrachromosomal asymmetry. Besides the values of A2 and CV_{CL} refer the interchromosomal asymmetry. The values of A1, A2, CV_{CL}, and M_{CA} were 0.10, 0.16, 16.46, and 5.63 in *Paronychia dudleyi* and 0.10, 0.06, 5.91, and 5.38 in *P. pontica*. These values referred to quite symmetric karyotypes. The only one species with lower M_{CA} value than studied species was *P. kurdica* subsp. *montis-munzur* (Eroğlu et al., 2020). The A1 value of *P. anatolica* and *P. amani* was higher than *P. pontica* and *P. dudleyi* (Eroğlu and Budak, 2020; Eroğlu et al., 2021). In intrachromosomal asymmetry, *P. pontica* and *P. dudleyi* had the most symmetric karyotypes, respectively. CV_{CL} value varied between 10.00 and 20.00 in most of the Turkish *Paronychia*. In addition, The A2 value of *P. anatolica* and *P. amani* was higher than *P. pontica* and *P. dudleyi* (Eroğlu et al., 2017; Eroğlu et al., 2020; Eroğlu and Budak, 2020; Eroğlu et al., 2021). The CV_{CL} value of *P. dudleyi* was also in this range, however it was quite lower in *P. pontica*, which had the most symmetrical karyotype in interchromosomal asymmetry. Due to low intra- and interchromosomal asymmetry, CV_{CI} and AI values were also low in *P. dudleyi* and *P. pontica*.

In the present study, the new karyological data were recorded listed below in *Paronychia dudleyi* and *P. pontica*: (i) first report of the basic and diploid chromosome number, (ii) ploidy levels of 2*x* and 4*x*, (iii) first detailed chromosomal data, (iv) the most symmetrical karyotypes.

Conflict of Interest

Authors have declared no conflict of interest.

Authors' Contributions

All authors contributed to the study's conception and design. All authors read and approved the final manuscript.

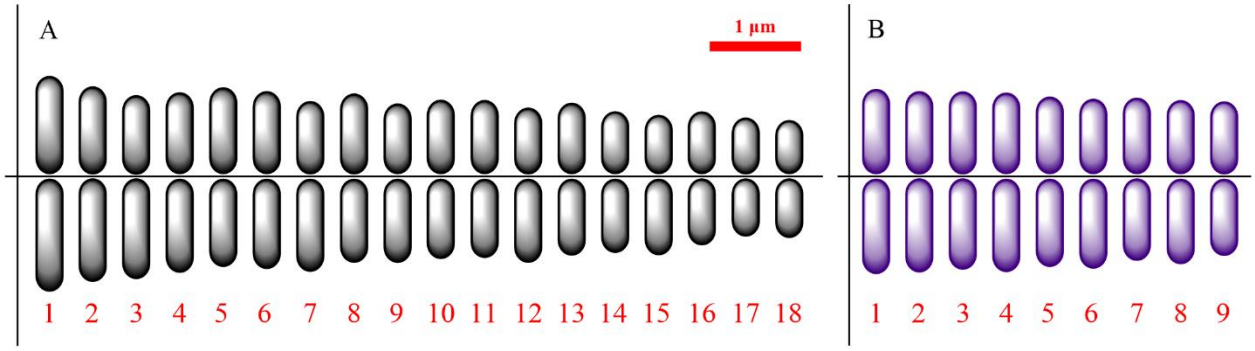

Figure 3. Monoploid ideogram of *Paronychia dudleyi* (A) and *Paronychia pontica* (B). Scale bar 1 µm

Table 2. The detailed chromosomal data of *Paronychia dudleyi* and *Paronychia pontica*

	CP	TL (µm)	LA (µm)	SA (µm)	AR	RL (%)	CI (%)	CT
Paronychia dudleyi	1	1.99	1.06	0.93	1.14	7.50	46.73	metacentric
	2	1.79	0.96	0.83	1.16	6.75	46.37	metacentric
	3	1.69	0.94	0.75	1.25	6.37	44.38	metacentric
	4	1.65	0.88	0.77	1.14	6.22	46.67	metacentric
	5	1.64	0.82	0.82	1.00	6.18	50.00	metacentric
	6	1.62	0.85	0.78	1.09	6.14	47.85	metacentric
	7	1.56	0.87	0.69	1.26	5.88	44.23	metacentric
	8	1.54	0.78	0.76	1.03	5.80	49.35	metacentric
	9	1.45	0.78	0.67	1.16	5.47	46.21	metacentric
	10	1.45	0.75	0.70	1.07	5.47	48.28	metacentric
	11	1.44	0.74	0.70	1.06	5.43	48.61	metacentric
	12	1.41	0.78	0.63	1.24	5.31	44.68	metacentric
	13	1.39	0.71	0.68	1.04	5.24	48.92	metacentric
	14	1.30	0.69	0.60	1.15	4.86	46.51	metacentric
	15	1.28	0.71	0.56	1.27	4.79	44.09	metacentric
	16	1.21	0.62	0.59	1.05	4.56	48.76	metacentric
	17	1.07	0.54	0.53	1.02	4.03	49.53	metacentric
	18	1.06	0.55	0.51	1.08	4.00	48.11	metacentric
Paronychia pontica	1	1.68	0.88	0.80	1.10	11.95	47.62	metacentric
	2	1.65	0.87	0.78	1.12	11.74	47.27	metacentric
	3	1.63	0.85	0.78	1.09	11.59	47.85	metacentric
	4	1.63	0.87	0.76	1.14	11.59	46.63	metacentric
	5	1.55	0.82	0.73	1.12	11.02	47.10	metacentric
	6	1.54	0.83	0.71	1.17	10.95	46.10	metacentric
	7	1.49	0.77	0.72	1.07	10.60	48.32	metacentric
	8	1.49	0.80	0.69	1.16	10.60	46.31	metacentric
	9	1.40	0.72	0.68	1.06	9.96	48.57	metacentric

Abbreviations: chromosome pairs (CP), total length (TL), long arm (LA), short arm (SA), arm ratio (AR), relative length (RL), centromeric index (CI), chromosome type (CT

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