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CYTOTAXONOMIC STUDIES ON SOME *VICIA* L. SPECIES GROWING IN THE EASTERN MEDITERRANEAN AND SOUTHERN AEGEAN REGIONS II.

S. TABUR[1], Ş. CİVELEK[2] and E. BAĞCİ[2]

[1]*Dept Biology, Fac. Science and Letter, Süleyman Demirel University, Isparta, Turkey*
[2]*Dept Biology, Fac. Arts and Sciences, Fırat University, Elazığ, Turkey*
E-mail: ebagci@firat.edu.tr

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In this study, some natural *Vicia* L. species growing naturally in eastern Mediterranean and southern Aegean Regions have been investigated morphological and cytotaxonomic point of view. Morphology, chromosome number and morphometries of the 9 taxa belonging to the *Vicia* L. genus including *Vicia peregrina, V. lutea* var. *hirta, V. anatolica, V. hybrida, V. grandiflora* var. *grandiflora, V. grandiflora* var. *dissecta, V. cuspidata, V. sativa* subsp. *sativa, V. sativa* subsp. *nigra* var. *segatalis* have been studied by using karyological and numerical taxonomic techniques. Data obtained chromosome measurements were analysed by using cluster analysis. The chromosome number of studied *Vicia* species have been found as $2n = 10$, 12 and 14. The member of *Vicia* section, related taxa were compared with respect to their chromosomal and morphological characteristics. Some karyological relationships among the studied *Vicia* taxa were discussed with help of taxonomic history and evolutionary data.

Key words: chromosome, cytotaxonomy, karyotype, numerical taxonomy, *Vicia*

INTRODUCTION

The economically important and widespread genus *Vicia* L. (Leguminosae, Vicieae) comprises appr. 170 species (Allkin *et al.* 1986) chiefly located in Europe, Asia and North America. The genus is represented by 67 taxa in the level of species, subspecies and variety in "Flora of Turkey" (Davis 1970). The "Flora Europaea" (Tutin *et al.* 1981) consists of 54 species. It is reported that *Vicia* genus have some taxonomic problems and there is no monograph on this genus (Davis 1970). Like in many variable cultivated plants, the taxonomy and nomenclature of *Vicia* species are very confused (Guidetta 1986). Taxonomic history of subgenus *Vicia* is extensive and contentious, there being 26 major classifications of the group produced since the work of Linneaus (Maxted *et al.* 1991). Studied *Vicia* taxa were important as belong to this subgenus. The number of species recognized in the subgenus varies from about 20 to over 38, depending on the species concept and the criteria used for delimitation. Most of

the species are autogamous annuals, except *V. grandiflora* Scop. and *V. faba* L. which are outcrossing annuals (Jaaska 1997).

Although, Kupicha (1976) argued convincingly that the division of the species into four groups is artificial, she then indicated a group of strongly correlated characters that divide the species more naturally into two subgeneric clusters, *Vicia* and *Vicilla* (Schur) Rouy in Rouy and Fouc. and 22 sections. Maxted (1991) began this process of refinement by reporting a revision of subgenus *Vicia* which places the 38 species of subgenus *Vicia* into nine sections and includes five species not known to Kupicha (1976).

Vicia peregrina L. is a very polymorphic taxon and varies in some following characters. The size of leaflets, length of pedicels, dimensions of floral parts, colour and shade of corolla, dimensions and pubescence of pods and colour and size of seeds (Davis 1970). *Vicia lutea* is represented in the Turkish flora with two varieties (var. *hirta* (Balbis) Lois. and var. *lutea*). Var. *hirta* a very polymorphic taxon, highly variable in the density and morphology of its indumentum. This variety varies in corolla colour (violet to yellow) from one population to another. Transitional forms between the two varieties occur. *Vicia anatolica* allied to *V. pannonica*, but resembling *V. melanops* in flower colour. *Vicia hybrida* is a very polymorphic species. It varying mainly in size and shape of leaflets, length of floral parts and dimensions of fruits.

V. grandiflora is also polymorphic species. This species are represented with two varieties, var. *grandiflora* and var. *dissecta*. Two varieties are distinguished with each other by these characters; all leaflets entire, linear to obovate, calyx teeth slightly to much shorter than tube in var. *grandiflora* and some leaflets (usually the lower) serrate-dentate to incised, infrequently linear, calyx teeth almost as long to a little longer than tube is in var. *dissecta*.

It is reported that *V. sativa* is a cosmopolitan species is one of the most variable (genetically and phenotypically) in the genus. Five main taxa at subspecific rank can be distinguished in the complex. The variability in all taxa or populations of *V. sativa* is homologous, parallel and consequently overlapping; many of the subdivisions are known to interbreed with each other at least some extent. The species shows considerable variation in almost every trait, but particularly in leaflet morphology and in basic chromosome number. Some intermediate specimens between *V. sativa* subsp. *nigra* var. *segatalis* and var. *nigra* were found. Var. *segatalis* is actually intermediate between var. *nigra* and var. *cordata* (Davis 1970). The group is characterized by decreasing aneuploid chromosome series ($2n$ = 14, 12, 10) and wide variation in karyotypes.

Since wild specimens may be a source of genetic variation for improving cultivated plants, karyological differences may be found in different geographical and environmental conditions. Yamamoto (1973) reported that some karyological characters and the external morphological characteristics of

Vicia species were in agreement with the characteristic of the karyotype among the related species or species group. For this reason it is more reasonable to consider along with their karyotype besides the morphological characteristics. Studied all of the *Vicia* taxa were represented in the same section *Vicia* in *Vicia* genus.

In this study, some *Vicia* taxa have been investigated by using morphological, karyological and numerical taxonomic techniques. Chromosome characteristics of most of these taxa have been shown for the first time in this study. It is purposed with this study, to determine to what extent karyotype morphology is correlated with the other major taxonomic characters and to indicate the chromosome numbers and chromosome morphologies of studied *Vicia* species and also aimed to reveal the karyology of some *Vicia* species and compare them cytotaxonomically. The analysis results are considered in conjunction with a literature review of the taxonomic history, cytology of the taxa involved.

MATERIAL AND METHODS

Collecting of samples

In this research, *Vicia* L. specimens and seeds were collected from natural habitats during 1995–1996. The localities and field information are given in Table 1. Localities of the studied species were shown in Figure 1. Collected samples were analysed morphologically and karyological techniques were ap-

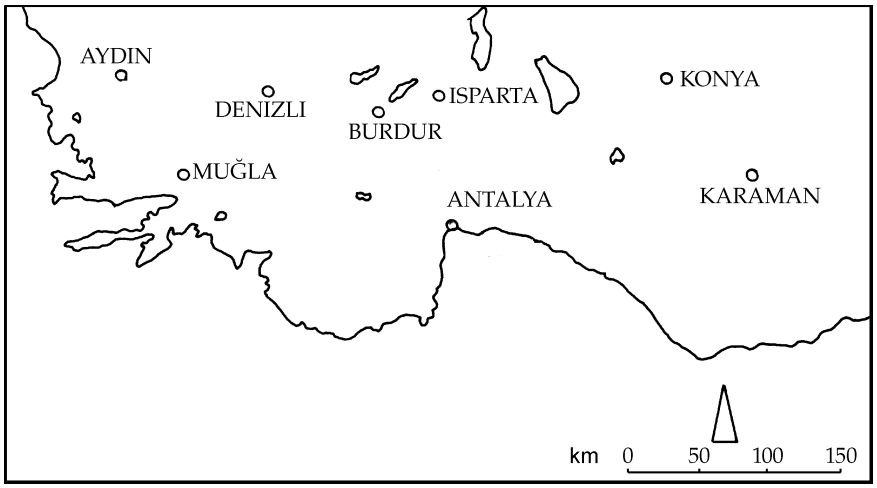

Fig. 1. Localities of the studied *Vicia* species

Table 1
Accessions provenance and field knowledge details of studied *Vicia* sp.

Species	Region	Locality	Altitude (m)	Lat. (N)	Long. (E)
V. peregrina L.	C3, Denizli	Denizli	900	37°46′	29°6′
V. lutea var. *hirta* (Balbis) Lois.	C3, Isparta	Eğirdir	910	37°52′	30°51′
V. anatolica Turrill.	C3, Denizli	Denizli	900	37°46′	29°6′
V. hybrida L.	C3, Antalya	Finike	900	36°17′	30°8′
V. grandiflora Scop. var. *grandiflora*	C1, Isparta	Aksu	1400	37°47′	31°4′
V. grandiflora Scop. var. *dissecta* Boiss.	C1, Muğla	Muştak hill	1350	37°12′	28°22′
V. cuspidata Boiss.	C3, Burdur	Yazıköy	900	37°37′	30°6′
V. sativa L. subsp. *sativa*	C2, Muğla	Gökçeören village	900	36°13′	29°33′
V. sativa L. subsp. *nigra* (L.) Ehrh. var. *segatalis* (Thuill.) Ser. ex DC.	C3, Antalya	Serik	75	36°55′	31°6′

plied on the seeds. Collected specimens and seeds were stored in the Süleyman Demirel University, Burdur Education Faculty, Biology Department.

Karyological analysis

Chromosome number determination and karyotype analysis were performed at mitotic metaphase. Seeds were germinated in Petri dishes, inner side covered with cotton at room temperature. When root tips, reached 1–1.5 cm at the end of germination, they were cut off and pretreated with paradichlorobenzene for 4 hours and fixed with acetic alcohol (1:3) for 24 hours and stored in 70% alcohol at 2–4 °C. Then root tips washed and hydrolysed in 1 N HCl for 15 min at 60 °C. Feulgen method was used for staining (Sharma and Gupta 1982, Elçi 1982). To confirm staining quality root tips were kept in water for 15 min and squashed preparations were prepared. In determining centromer location, Levan *et al.* system was used (Levan *et al.* 1964). Chromosome morphology and morphometry were shown as karyograms and idiograms in Figures 2–3. Karyological analysis techniques were applied on this *Vicia* species like as other studies (Şahin *et al.* 1998, 2000).

Average chromosome measurements were calculated on 10 metaphase plates. The quantitative values were obtained from chromosome character measurements (Tables 2–8). They are chromosome number, total length (C), long arm length (L), short arm length (S), arm ratio (r = L/S), centromeric index (I = 100 × S/C), relative length (RL) (RL = total length (C)/total haploid length × 100), and chromosome type.

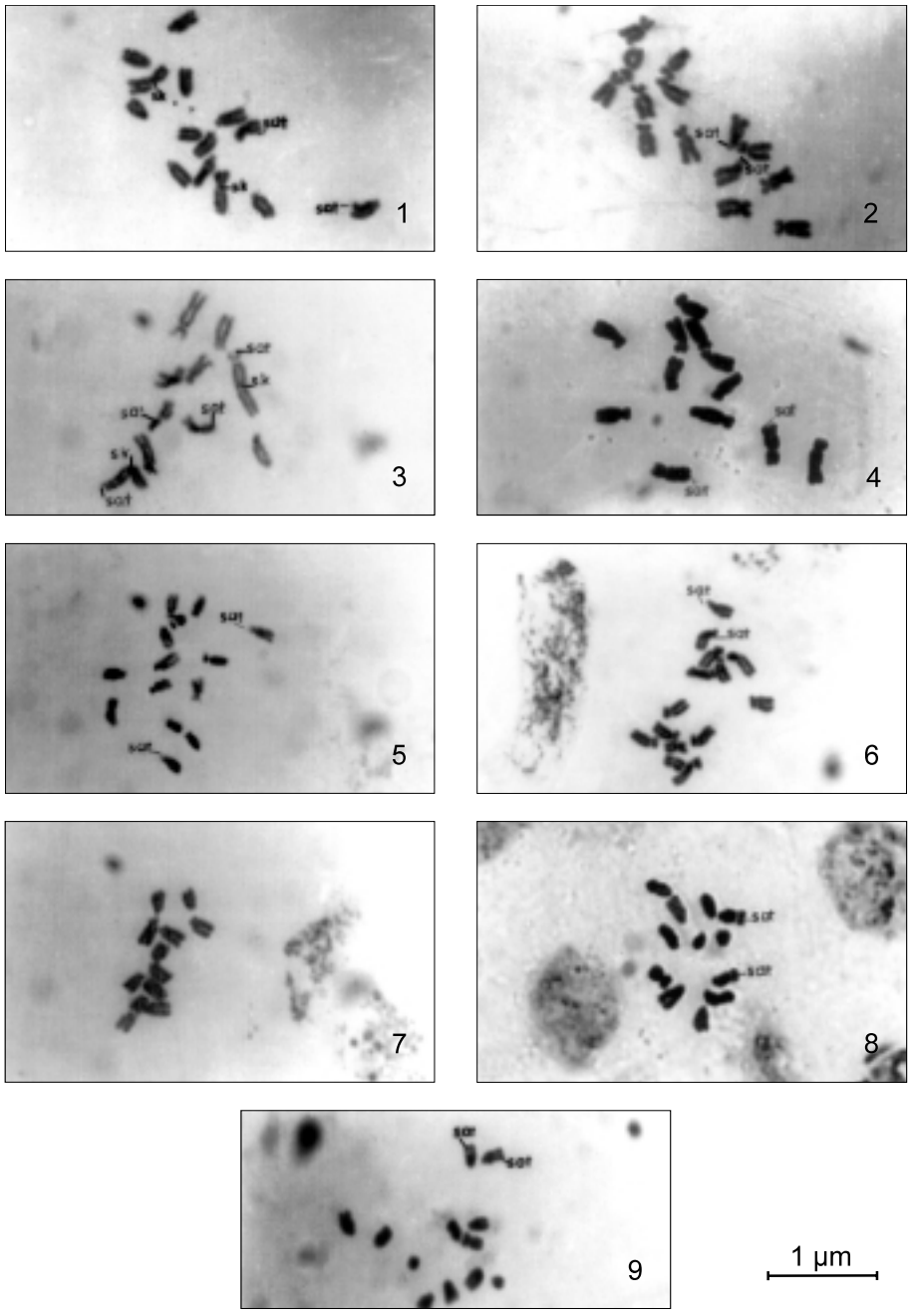

Fig. 2. Karyograms of the studied *Vicia* L. species. 1 = *V. peregrina*, 2 = *V. lutea* var. *hirta*, 3 = *V. anatolica*, 4 = *V. hybrida*, 5 = *V. grandiflora* var. *grandiflora*, 6 = *V. grandiflora* var. *dissecta*, 7 = *V. cuspidata*, 8 = *V. sativa* subsp. *sativa*, 9 = *V. sativa* subsp. *nigra* var. *segatalis*

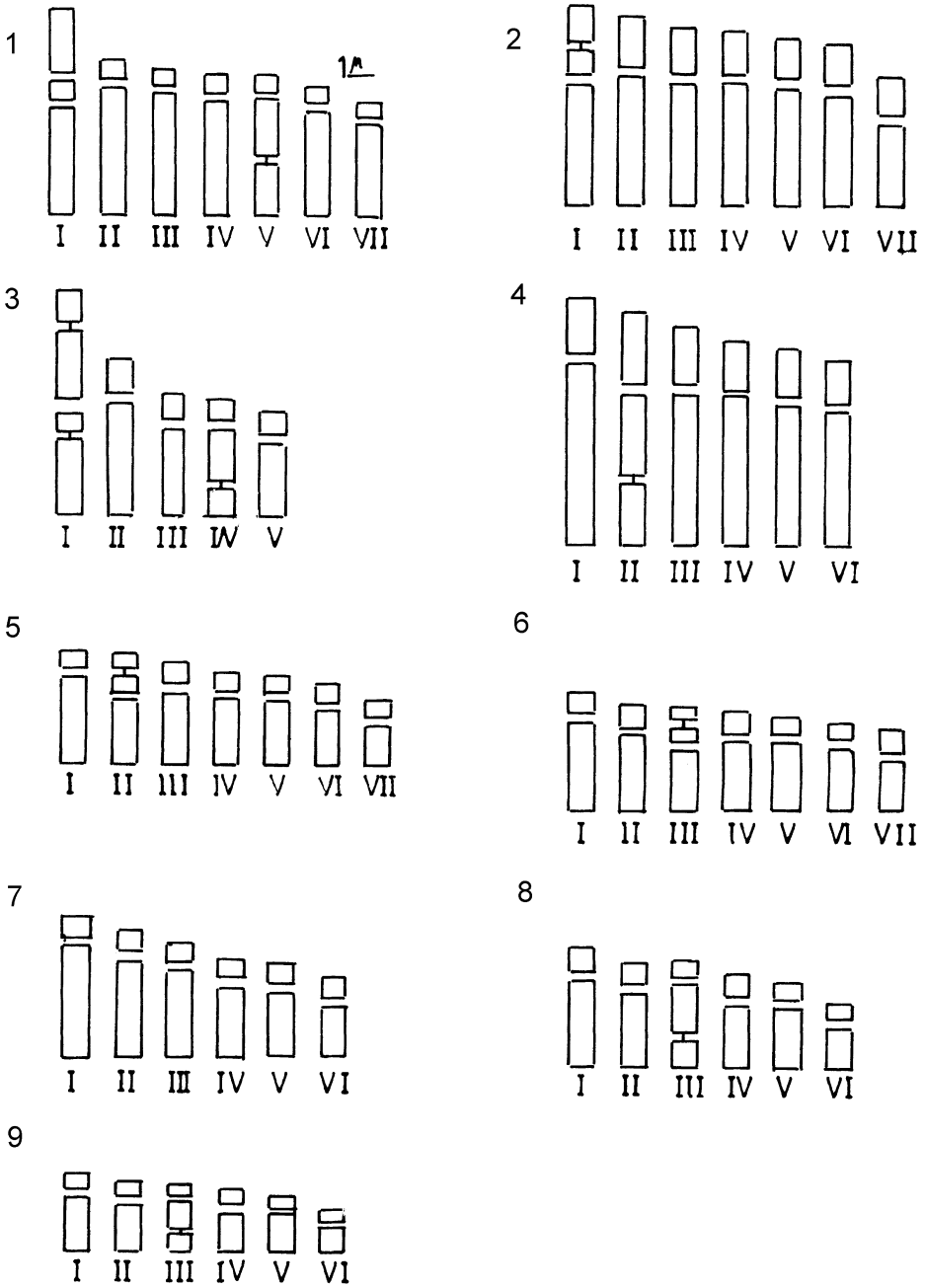

Fig. 3. Idiograms of the studied *Vicia* L. species. 1 = *V. peregrina*, 2 = *V. lutea* var. *hirta*, 3 = *V. anatolica*, 4 = *V. hybrida*, 5 = *V. grandiflora* var. *grandiflora*, 6 = *V. grandiflora* var. *dissecta*, 7 = *V. cuspidata*, 8 = *V. sativa* subsp. *sativa*, 9 = *V. sativa* subsp. *nigra* var. *segatalis*

Table 2
The chromosome types and length in karyotype of *V. peregrina*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	7.79	4.34	3.45		1.25	49.42	19.72	m^{sk}
II	6.03	5.16	0.87		5.93	14.42	15.26	st
III	5.62	4.80	0.82		5.85	14.59	14.22	st
IV	5.35	4.55	0.80		5.68	14.95	13.54	st
V	5.27	2.29	0.74	2.24	3.09	14.04	13.34	st^{sat}
VI	5.02	4.22	0.80		5.27	15.93	12.70	st
VII	4.39	3.69	0.70		5.27	15.94	11.12	st

For chromosome character measurements (Tables 2–10), totally 6 characters were analysed by using cluster analysis – one of the numerical taxonomic methods – Euclidean Distance methods in the SPSS computer program. The chromosomal characters measurements and morphological analysis quantitative results were evaluated as dendrogram in Figures 4–5.

RESULTS AND DISCUSSION

The karyograms and the idiograms of the studied *Vicia* species were shown in Figures 2–3. The morphological and morphological-karyological dendrogram of these species were shown in Figures 4–5. Chromosome morphometries and character measurements of the *Vicia* species have been shown in Tables 2–10.

Vicia peregrina L.

Morphological features: Plant length 20–60(–100) cm, leaf length 10–50 mm, number of leaflets 4–6 pairs, length of leaflets (3–)5–35 mm, stipule length 3–4 mm, number of flowers 1(–2), fruit length 20–40 mm, fruit width 4–10 mm, beak length 2–2.5 mm, seed number (2–)3–5, flower colour violet have been determined.

Karyological features: Chromosome number: $2n = 14$ (x = 7). Karyotype formula: K (x = 7): I m^{sk}+ II st + III st + IV st + V st^{sat} + VI st + VII st. Chromosomal morphology: All of the chromosomes of this species have determined as subterminal except I numbered chromosomes. I numbered chromosome were

Table 3
The chromosome types and length in karyotype of *V. lutea* var. *hirta*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	7.34	4.71	1.07	1.56	4.40	14.57	15.62	sm^{sat}
II	7.18	5.13	2.05		2.50	28.55	15.28	sm
III	6.90	4.92	1.98		2.48	28.69	14.68	sm
IV	6.72	4.86	1.86		2.61	27.67	14.30	sm
V	6.50	4.71	1.79		2.63	27.53	13.84	sm
VI	6.30	4.52	1.78		2.53	28.25	13.40	sm
VII	6.02	4.37	1.65		2.64	27.40	12.80	sm

median centromered. V numbered chromosome was subterminal and had a satellite connected long arm (Table 2).

V. lutea var. *hirta*

Morphological features: Plant length 65–75 cm, leaf length 30–70 mm, number of leaflets 5–9 pairs, length of leaflets 5–23 mm, stipule length 1–3 mm, number of flowers 1, fruit length 15–35 mm, fruit width 7–12 mm, beak length 3–3.5 mm, seed number 3–5, flower colour light yellow have been determined.

Karyological features: Chromosome number: $2n = 14$ (x = 7). Karyotype formula: K (x = 7): I st^{sat} + II sm + III sm + IV sm + V sm + VI sm + VII sm. Chromosomal morphology: This variety's chromosomes were determined as submedian centromered except I numbered chromosome. It is observed that I numbered chromosome was subterminal centromered and it has satellite connecting with small arm.

Table 4
The chromosome types and length in karyotype of *Vicia anatolica*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	8.04	3.98	2.88	1.18	1.38	35.82	29.46	$sm^{sk\ sat}$
II	6.10	4.52	1.58		2.86	25.90	22.36	sm
III	4.67	3.49	1.18		2.95	25.26	15.90	sm
IV	4.45	2.16	1.05	1.24	2.05	23.59	16.30	sm^{sat}
V	4.02	2.99	1.03		2.90	25.62	14.72	sm

Table 5
The chromosome types and length in karyotype of *Vicia hybrida*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	9.53	7.19	2.34		3.07	24.55	19.44	st
II	8.78	3.41	2.89	2.48	1.17	32.91	17.90	m^{sat}
III	8.36	6.07	2.29		2.65	27.39	17.06	sm
IV	7.84	5.82	2.02		2.88	25.76	16.00	sm
V	7.48	5.50	1.98		2.77	26.47	15.26	sm
VI	7.01	5.19	1.82		2.85	25.96	14.30	sm

Vicia anatolica Turrill.

Morphological features: Plant length 25–40 cm, leaf length (4–)15–55 mm, number of leaflets (3–)6–8 pairs, length of leaflets (4–)5–20 mm, stipule length 1–2 mm, number of flowers 1, fruit length (15–)20–35 mm, fruit width (7–)8–10 mm, beak length 2–4 mm, seed number (3–)4–5, flower colour yellowish and has dark brown dots have been determined.

Karyological features: Chromosome number: $2n = 10$ (x = 5). Karyotype formula: K (x = 5): I $sm^{sk\ sat}$ + II sm + III sm + IV sm^{sat} + V sm. Chromosomal morphology: It is determined that all of the chromosomes of this subspecies were submedian except I numbered chromosome. I numbered chromosome was median centromered. It has in one arm a satellite and in another arm has secondary construction. With this specifications it is easily distinguished from other chromosomes. There are second satellite on the V numbered chromosome connecting long arm.

Table 6
The chromosome types and length in karyotype of *Vicia grandiflora* var. *grandiflora*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	4.27	3.45	0.82		4.20	19.20	17.32	st
II	4.03	2.62	0.73	0.68	3.58	18.11	16.36	st^{sat}
III	3.82	2.93	0.89		3.29	23.29	15.50	st
IV	3.55	2.75	0.80		3.43	22.53	14.40	st
V	3.37	2.59	0.78		3.32	23.14	13.68	st
VI	3.06	2.29	0.77		2.97	25.16	12.42	sm
VII	2.53	1.75	0.78		2.24	30.83	10.26	sm

Vicia hybrida L.

Morphological features: Plant length 25–80 cm, leaf length 15–60 mm, number of leaflets 4–7(–8) pairs, length of leaflets (3–)4–20 mm, stipule length 1.5–2(–3) mm, number of flowers 1, fruit length 30–40 mm, fruit width 8–12 mm, beak length 2–3 mm, seed number 2–5, flower colour yellow have been determined.

Karyological features: Chromosome number: $2n = 12$ (x = 6). Karyotype formula: K (x = 6): I st + II m^{sat} + III sm + IV sm + V sm + VI sm. Chromosomal morphology: I numbered chromosome were subterminal centromered. II numbered chromosome was median centromered and had a satellite. All of the other chromosomes were submedian.

Vicia grandiflora Scop. var. *grandiflora*

Morphological features: Plant length 35–60 cm, leaf length 3–7(–8) mm, number of leaflets 3–7 pairs, length of leaflets (2–)5–20 mm, stipule length 3–5 mm, number of flowers 1, fruit length 25–50 mm, fruit width 5–6 mm, beak length 3–4 mm, seed number 3–4, flower colour orange and yellow have been determined.

Karyological features: Chromosome number: $2n = 14$ (x = 7). Karyotype formula: K (x = 7): I st + II st^{sat} + III st + IV st + V st + VI sm + VII sm. Chromosomal morphology: VI and VII numbered chromosomes were submedian centromered. The others were subterminal. A satellite connected short arm and approximately equal with its long was observed. VII numbered chromosome was differentiated from the others by its short length.

Table 7
The chromosome types and length in karyotype of *Vicia grandiflora* var. *dissecta*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	4.39	3.46	0.93		3.72	21.18	17.14	st
II	4.02	3.06	0.96		3.18	23.88	15.70	st
III	3.82	2.50	0.66	0.66	3.78	17.27	14.92	st^{sat}
IV	3.72	2.83	0.89		3.17	23.92	14.52	st
V	3.51	2.69	0.82		3.28	23.36	13.70	st
VI	3.24	2.43	0.81		3.00	25.00	12.66	sm
VII	2.89	1.97	0.92		2.14	31.83	11.28	sm

Table 8
The chromosome types and length in karyotype of *Vicia cuspidata*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	5.16	4.10	1.06		3.86	20.54	21.60	st
II	4.54	3.57	0.97		3.68	21.36	19.00	st
III	4.18	3.28	0.90		3.64	21.53	17.50	st
IV	3.67	2.74	0.93		2.94	25.34	15.36	sm
V	3.41	2.52	0.89		2.83	26.09	14.28	sm
VI	2.91	2.04	0.87		2.34	29.89	12.18	sm

Vicia grandiflora Scop. var. *dissecta* Boiss.

Morphological features: Plant length 25–40 cm, leaf length 2–4(–9) mm, number of leaflets (2–)3–6 pairs, length of leaflets (3–)5–20 mm, stipule length (2–)3–5 mm, number of flowers 1, fruit length 20–45 mm, fruit width 5–6 mm, beak length 3–4 mm, seed number 3–4, flower colour orange yellow have been determined.

Karyological features: Chromosome number: $2n = 14$ (x = 7). Karyotype formula: K (x = 7): I st + II st + III st^{sat} + IV st + V st + VI sm + VII sm. Chromosomal morphology: VI and VII numbered chromosomes were submedian centromered. The others were subterminal. Chromosome morphology of this subspecies were very similar to *V. grandiflora* var. *grandiflora*. Only difference between both of them was satellite connecting with III numbered chromosome's short arm in this variety.

Table 9
The chromosome types and length in karyotype of *Vicia sativa* subsp. *sativa*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	4.48	3.52	0.96		3.66	21.42	20.68	st
II	3.92	3.03	0.89		3.40	22.70	18.10	st
III	3.88	1.97	0.71	1.20	2.77	18.29	17.92	sm^{sat}
IV	3.64	2.62	1.02		2.56	28.02	17.80	sm
V	3.34	2.49	0.85		2.92	25.44	15:42	sm
VI	2.39	1.79	0.60		2.98	25.10	11.02	sm

Table 10
The chromosome types and length in karyotype of *Vicia sativa* subsp. *nigra* var. *segatalis*

Chr. number	Total length (C)	Long arm length (L)	Short arm length (S)	Satellite (Sat)	Arm ratio (r = L/S)	Centromeric index (I = 100 × S/C)	Relative length (%)	Chr. type
I	2.84	2.16	0.68		3.17	23.94	20.86	st
II	2.51	1.83	0.68		2.69	27.09	18.44	sm
III	2.36	1.08	0.54	0.74	2.00	22.88	17.24	sm^{sat}
IV	2.30	1.62	0.68		2.38	29.56	16.88	sm
V	2.11	1.51	0.60		2.51	28.43	15.50	sm
VI	1.49	1.00	0.49		2.04	32.88	10.94	sm

Vicia cuspidata Boiss.

Morphological features: Plant length 5–30 cm, leaf length 5–35 mm, length of leaflets (1–)4–6 mm, stipule length 1–3 mm, number of flowers 1, fruit length 20–35 mm, fruit width 3–5(–6) mm, beak length 3–5(–6) mm, seed number (2–)4–6, flower colour light yellow and violett have been determined.

Karyological features: Chromosome number: $2n = 12$ (x = 6). Karyotype formula: K (x = 6): I st + II st + III st + IV sm + V sm + VI sm. Chromosomal morphology: I, II and III numbered chromosomes were subterminal centromered and the others were submedian centromered. It is not observed a satellite in this species. The former chromosomes were approximately similar in size and the latter were the same by the length.

Vicia sativa L. subsp. *sativa*

Morphological features: Plant length 20–100 cm, leaf length 4–7 mm, number of leaflets (2–)4–6(–8) pairs, length of leaflets 10–20(–25) mm, stipule length 3–4(–5) mm, number of flowers 1–2, fruit length 30–65 mm, fruit width 5–6(–8) mm, beak length 2–3 mm, seed number 4–6(–7), flower colour dark violett have been determined.

Karyological features: Chromosome number: $2n = 12$ (x = 6). Karyotype formula: K (x = 6): I st + II st + III sm^{sat} + IV sm + V sm + VI sm. Chromosomal morphology: I and II chromosomes of this subspecies were subterminal. The others were submedian centromered. A satellite were determined connected with long arm of III numbered chromosome. VI numbered chromosome was very small. There were no big differences among the other chromosome sizes.

Vicia sativa subsp. *nigra* var. *segatalis*

Morphological features: Plant length 20–80 cm, leaf length 30–60(–70) mm, length of leaflets 5–30 mm, stipule length 3–4 mm, number of flowers 1–2, fruit length 25–50 mm, fruit width 4–6 mm, beak length 2–3 mm, seed number 4–6(–8), flower colour violett have been determined.

Karyological features: Chromosome number: $2n = 12$ (x = 6). Karyotype formula: K (x = 6): I st + II sm + III sm^{sat} + IV sm + V sm + VI sm. Chromosomal morphology: Size order were the same as subsp. *nigra.* The whole chromosome of this variety smaller than subsp. *nigra.* II numbered chromosome was submedian centromered and only I numbered chromosome had subterminal centromere.

DISCUSSION AND CONCLUSION

Chromosomal features of the studied *Vicia* taxa were shown in Tables 2–10, karyograms in Figure 2 and idiograms in Figure 3.

The morphological features of the studied *Vicia peregrina* were shown congruence with Davis (1970). The chromosome number of *V. peregrina* was determined as $2n = 14$. Yamamoto (1973), Şahin *et al.* (1997) reported the same chromosome number. But Yamamoto I numbered chromosome reported as submedian centromered and the others were subterminal centromered. Although, this findings were shown consistent with Raina and Rees (1983), Löve (1972), Şahin and Babaç (1990) by the position of the satellite chromosome, it was found different by I numbered chromosome submedian and VII num-

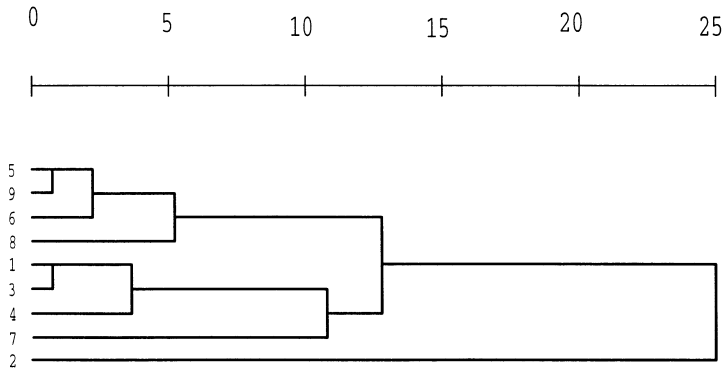

Fig. 4. Morphological dendrogram of the studied *Vicia* L. species. 1. *Vicia peregrina*, 2. *Vicia lutea* var. *hirta*, 3. *V. anatolica*, 4. *V. hybrida*, 5. *V. grandiflora* var. *grandiflora*, 6. *V. grandiflora* var. *dissecta*, 7. *V. cuspidata*, 8. *V. sativa* subsp. *sativa*, 9. *V. sativa* subsp. *nigra* var. *segatalis*

bered chromosome terminal and the others subterminal centromered (Table 2, Figs 2–3).

Some morphological features – like plant length, length of stipule, fruit length, beak length – of *V. lutea* var. *hirta* was different from Davis (1970). *V. lutea* var. *hirta* were determined as $2n = 14$ chromosome. A bigger satellite than short arm of the I numbered chromosome was observed. Chromosome number of this variety was the same as Löve (1976), Raina and Rees (1983). According to Yamamoto (1973), Sveschnikova and Sveschnikova (1927, from Kuta (1980)), Cincura (1962, from Kuta (1980)) reported that they did not find the chromosome with satellites.

Morphological characters of *V. anatolica* determined in this study were consistent with Davis's (1970) studies. The chromosome number of *V. anatolica* was determined as $2n = 10$. A satellite was observed on the I numbered chromosome. It is determined that there was a second satellite on the long arm of IV numbered chromosome. These results were shown congruence with Şahin and Babaç (1995). But these researchers were not reported the second satellite. Maxted *et al.* (1991) also determined the chromosome number of *V. anatolica* as $2n = 10$.

The morphological features of *V. hybrida* species, leaf length as 15–60 mm, beak length as 2–3 mm was found. The other features were consistent with the literature (Davis 1970). Chromosome morphology and number of the *V. hybrida* were consistent with the results of Yamamoto (1973) and Guidetta and Caffaro (1984). These researchers determined that the chromosome with satellite as subterminal. But in this study, the II numbered median chromosome with satellite was found as median, I numbered chromosome was subterminal

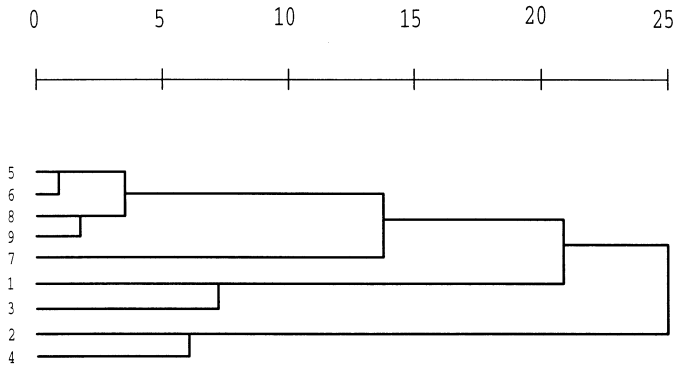

Fig. 5. Karyological-morphological dendrogram of the studied *Vicia* L. species. 1. *Vicia peregrina*, 2. *Vicia lutea* var. *hirta*, 3. *V. anatolica*, 4. *V. hybrida*, 5. *V. grandiflora* var. *grandiflora*, 6. *V. grandiflora* var. *dissecta*, 7. *V. cuspidata*, 8. *V. sativa* subsp. *sativa*, 9. *V. sativa* subsp. *nigra* var. *segatalis*

and the others were subterminal. Raina and Rees (1983) and Löve (1976) were reported the chromosome number of this species was the same as ours.

In Guidetta and Caffaro (1984) studies the chromosome number of *V. hybrida* L. were determined $2n = 12$, *V. lutea* $2n = 14$. They stated that morphological resemblence between these two species can be extended to their external spermoderm structure. According to several authors of recent Floras, *Vicia hybrida* L. and *V. lutea* L. belong to the same section within the genus *Vicia* according to Ball (1968) and Plitmann (1973) like in "Flora of Turkey" (Davis 1970).

The morphological features of *V. grandiflora* var. *grandiflora* were consistent with Davis (1970) except leaf length 3–7(–8) and beak length 3–4 mm characters. The chromosome morphology and number of *V. grandiflora* var. *grandiflora* were found consistent with Kuta (1980) and Yamamoto (1973). Hanelt and Mettin (1970) reported that the chromosome with satellite was I numbered chromosome, otherwise we found that chromosome with satellite was II numbered chromosome. VI and VII numbered chromosomes were submedian and the others were subterminal centromered. These results were the same with Kuta's (1980) findings in view of the chromosome number and morphology.

Morphological characters of *V. grandiflora* var. *dissecta* were found to be similar to var. *grandiflora.* It is determined that the chromosome number of *V. grandiflora* var. *dissecta* as $2n = 14$. A satellite connected to short arm of the III numbered chromosome was observed in contrary var. *grandiflora*. VI and VII numbered chromosomes submedian and the others subterminal centromered like var. *grandiflora*.

Studied morphological characters of *V. cuspidata* showed congruence with Davis description in "Flora of Turkey" (1970). The chromosome number of *V. cuspidata* was reported as $2n = 14$ by Mettin and Hanelt (1968). But in this study, it was found as $2n = 12$. Satellite was not found in this species. According to Şahin and Babaç (1990) results, the whole chromosomes were subterminal and satellite not observed. Maxted *et al.* (1991) results were congruence with ours.

Leaf length of *V. sativa* subsp. *sativa* was found as 4–7 mm, length of stipule 3–4–(–5) mm, beak length 2–3 mm and seed number 4–6–(–7) were determined. The other features were showed congruence with Davis's (1970). It is determined that the chromosome number of *V. sativa* subsp. *sati*va as $2n = 12$. While chromosome morphology of this subspecies were congruence with Mettin and Hanelt's (1968) results, it is reported that I and IV numbered chromosomes had a satellite connected with long arm, III numbered chromosomes was submedian and the others subterminal centromered. Löve (1972), Kuta (1980), Raina and Rees (1983), Yamamoto (1973), Maxted *et al.* (1991), Zohary and Plitman (1979) reported that the chromosome number of this subspecies

was 2*n* = *12*. According to Şahin and Babaç (1990), III numbered chromosome median centromered and the others subterminal. A satellite connected to long arm of IV numbered chromosome was reported.

The chromosome number of *V. sativa* subsp. *nigra* var. *segatalis* was found as 2*n* = 12. Chromosome morphology of two taxa were the same except II numbered chromosome. Kanısanlı and Oflas (1991) reported that the chromosome of *V. sativa* subsp. *nigra* var. *segatalis* was smaller than *V. sativa* subsp. *sativa* chromosomes. This result was supported by this study. Morphology of this taxa was found very similar to *V. sativa* subsp. *sativa*. It is reported that this taxon is a highly variable group widely distributed over the Mediterrenean basin and deeply penetrating into central Europe (Zohary and Plitman 1979). *Vicia sativa* group has a descending aneuploid series (2*n* = 10, 12, 14), as it is known from many other annual plant groups. The most conspicuous variability is represented on the 2*n* = 12 level (Hanelt and Mettin 1966).

The data obtained from morphological measurements of the studied *Vicia* species belonging to the *Vicia* section formed two big clusters and a single species, *Vicia lutea* var *hirta*. Morphological analysis phenogram showed that *Vicia grandiflora* subsp. *grandiflora* and subsp. *dissecta* were very closely related subspecies as foreseen. *V. sativa* subsp. *sativa* and subsp. *sativa* var. *nigra* were carried out in same cluster but at different similarity level. These four subspecies were very similar to each other morphologically. *Vicia peregrina* and *Vicia anatolica* were found closely related species in dendrogram and settled as single group (Fig. 4). In the big cluster *V. hybrida* was connected to this small bilateral cluster at the higher level and *V. cuspidata* belonged to this cluster at the upper level. It is said that these four species in this big cluster were closely related species by studied morphological characters. *V. lutea* var. *hirta* were remained as a single. This taxon showed the least morphological similarity among the studied *Vicia* taxa.

In the karyological-morphological analysis dendrogram showed very different clustering shown in Figure 5. Two subspecies of the studied *V. grandiflora* and subspecies of *V. sativa* were found as sister taxa connecting with each other in the dendrogram. This foreseen grouping is showed that the morphological and karyological results might be evaluated with each other. *V. cuspidata* was connected with these big four clusters. These species were connected with this cluster at high and the same similarity level in former dendrogram. *V. peregrina* and *V. anatolica* were sound as similar in view of studied characters. *V. lutea* var. *hirta* and *V. hybrida* were connected with each other at the high similarity level.

Karyological-morphological phenogram showed that the studied *Vicia* species were formed three clusters and a single species. Similarity level among the taxa were found high except the *V. sativa* and *V. grandiflora* group. This

phenograms (Figs 4–5) are very important to show differences and similarities among the morphological analysis and karyological analysis results.

The karyological differentiation processes which may be responsible for the evolution within the *V. sativa* group (Hanelt and Mettin 1966). Plants with different chromosome numbers or different karyotypes are loosely interconnected by occasional hybridisation, particularly in disturbed habitats. It is reported that *V. sativa* L. comprises an extraordinarily variable ensemble of annual vetches distributed over the Mediterranean basin and its adjacent territories (Zohary and Plitmann 1979).

It is said that the data of the present investigation are more or less in agreement with earlier reports the chromosome morphology of the taxa within this complex genus. In Eken *et al.* (1999) studies, phenetic classification were then compared with the traditional sectional orders and classification of the Davis and Plitmann and Kupicha. In the result, it is determined more fitting to the Kupicha's traditional classification of section at the higher levels of chemotaxonomic classification and at the lower similarity levels, it showed similarities to the Davis and Plitman's order of sections published in the "Flora of Turkey" (Davis 1970).

This study showed that the chromosome number of the studied *Vicia* taxa were different among each other and the same section *Vicia*. Three chromosome numbers were determined in the studied taxa. $2n = 10$ (*V. anatolica*), $2n = 12$ (*V. hybrida, V. cuspidata, V. sativa* subsp. *sativa, V. sativa* subsp. *nigra* var. *segatalis*) and $2n = 14$ (*V. peregrina, V. lutea* var. *hirta, V. grandiflora* var. *grandiflora, V. grandiflora* var. *dissecta*) heterogeneous chromosome number was determined in this section of *Vicia* genus. All of which are numbers that have been reported for other species in the genus *Vicia* (Moore 1967–1974, Bolkhovskikih *et al.* 1969, Goldblatt 1974–1985, Goldblatt and Johnson 1986–1987).

It is reported that one of the questions highlighted by many authors working on the genus *Vicia* is the direction of chromosome change during its evolution. Several authors (Plitmann 1967, Mettin and Hanelt 1973, Schaffer 1973) noted that speciation process in *Vicia* is accompanied by karyotype differentiation of chromosome number and morphology. Chromosome changes may have contributed towards the erection of interspecific hybridisation barriers in this plant group. Senn (1938) identified $x = 8$ as the base number for the Leguminosae as a whole for with $x = 7$ for the subtribe *Viciae*, arising through hypoploidy. Similarly Raina and Rees (1983) accept the somatic chromosome number of $2n = 14$ as the most primitive in the genus *Vicia* with $2n = 10$ and 12 arising later through chromosome rearrangements. In genus *Vicia* the most common basic chromosome number is $x = 7$, though also other basic number have been reported, $x = 6$ in the sections *Cracca, Vicia* and *Faba* and $x = 5$ in the sections *Cracca* and *Vicia*.

It is reported that the *Vicia* genus contains species with $2n = 10, 12, 14, 24$ and 28. $2n = 12$ and 14 are very common but the other numbers are much less so. It seems very likely that the tetraploids with $2n = 24$ are derived from diploid ancestors with $2n = 12$, and those with $2n = 28$ from ancestors with $2n = 14$. But generally, the species are characterized by a single chromosome number, which thus serves as a useful additional taxonomic characters (Stace 1980).

Seal and Rees (1982) stated that there is a correlation between the chromosomal DNA amount within a nucleus and the size of the chromosomes. In addition to, Akpınar and Bilaloğlu (1997) reported that the variation in the nuclear DNA content may be related to the divergence and evolution of *Vicia* species. According to Akpınar and Bilaloğlu studies, there was a correlation between nuclear DNA content and total chromosome length. It was found that *Vicia peregrina* has the highest nuclear DNA content and the largest chromosomes among the studied 11 *Vicia* taxa. The subspecies of *V. sativa* have smaller chromosomes and lower DNA contents than other *Vicia* species.

It is reported that the Mediterranean region represents a centre of variability of the genus *Vicia* L. caused by the frequency of annuals of the subgenus *Vicia*. *Vicia* has been interpreted as phylogenetically more advanced, it has been derived from the older subgenus *Cracca* of the Holarctic broad leaved forest zone. They may have been happened in the younger Tertiary when by the decline of the Tethys, large territories in the Mediterranean and oriental regions could be newly colonized (Hanelt and Mettin 1970).

The present cytological results, as argued below often support the recent taxonomic classification of the genus which is based on morphology. The chromosomal phylogenetic affinities in Figure 5 show a good congruence with assumed relationship between *Vicia* taxa and with their grouping into sections by morphology, providing at the same time new evidence about affinities between species of different sections.

A good correspondence between the results of morphological and karyological analysis and their phenetic analyses indicates that karyological characters may be effectively used for the estimation of phenetic affinities and the extent of chromosomal divergence between vetch species. Evidently, additional data for evolutionary important karyological characters as well as evidence from the DNA characters are needed for more sound phylogenetic and taxonomic conclusions. In general the chromosome number and structure (besides the traditional morphological characters) have been proved as extremely valuable for taxonomic considerations within the genus (Mettin and Hanelt 1968). Therefore we think further cytotaxonomic investigations as especially suitable for explaining the evolution and the evolutionary mechanism within the genus. Phylogenetic relationship among the *Vicia* species will be widely determined in the future by revision and monograph studies.

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