

## A phylogenetic analysis and delimitation of *Turanecio* (Asteraceae: Senecioneae)

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**Abstract:** Recently, *Turanecio* Hamzaoğlu was described as a new genus for the scientific world. *Turanecio* has been distributed as far as Asia, Iran, Caucasus, and Iraq. A phylogenetic analysis based on nrDNA and cpDNA gene regions was performed to determine the position of the genus within the subtribe Adenostylinae. Results from Bayesian and parsimony analyses of the nuclear and chloroplast DNA regions of the subtribe Senecioninae concordantly indicated that it is monophyletic and belongs to the Quadridentate group, with 4-lobed disc flowers. Nuclear DNA data revealed that some of the researched taxa should be transferred to *Turanecio* and some taxonomical classifications should be conducted for them. Therefore, *Iranecio massagetovii* and *Dolichorrhiza caucasica* were transferred to *Turanecio* and a new combination nova was suggested for them. Moreover, it was proposed as a monotypic species of a new genus, *Kazbegia*.

**Key words:** Asteraceae, ITS, Senecioneae, *trnL* intron, Türkiye

### 1. Introduction

The genus *Senecio* L. (Asteraceae: Senecioneae) comprises approximately 1200 species (Nordenstam, 2007; Pelser et al., 2007). Because the scope of the genus is quite wide, attempts to classify its species have been challenging. Moreover, in some molecular studies, the genus *Senecio* has been classified as either paraphyletic or polyphetic (Knox and Palmer, 1995; Kadereit and Jeffrey, 1996; Pelser et al., 2002). Therefore, the evolutionary history and taxonomic boundaries of the genus remain poorly known (Jeffrey et al., 1977; Bremer, 1994; Vincent, 1996; Mabberley 1997). The genus and intragenus taxonomic positions of *Senecio* *senso lato* have been changed several times and it has been divided into several genera, namely *Tephrosieris* (Rchb.) Rchb., *Jacobaea* Mill., *Iranecio* Nordenstam, and *Caucasalia* Nordenstam (Jeffrey et al., 1977; Nordenstam, 1978, 1997, 2006, 2007; Nordenstam and Rechinger, 1989; Jeffrey, 1992; Heller and Heyn, 1993; Pelser et al., 2002, 2003, 2004, 2006, 2007; Budak et al., 2007; Hamzaoğlu et al., 2009). Senecioneae is mainly characterized by a 5-lobed disc corolla (pentamerous), and to some extent, by a 4-lobed disc corolla (tetramerous). *Senecio*, *Ischnea* F.Mueller, and *Faujasiopsis* C.Jeffrey have 4- or 5-lobed disc corolla, while *Abrotanella* Cass., *Adenostyles* Cass., *Pojarkovia* Askerova, *Caucasalia*, *Dolichorrhiza* (Pojark.) Galushko, and *Iranecio* all have 4-lobed disc corolla. These taxa belong to *Adenostyles*, *Pojarkovia*, *Caucasalia*,

*Dolichorrhiza*, and *Iranecio*, and are distributed in Türkiye, Caucasus, Iran, and Iraq (Matthews, 1975; Nordenstam and Rechinger, 1989; Pojarkova, 1995; Shishkin, 1995; Nordenstam, 1997, 2007; Özhatay and Kültür, 2006; Özhatay et al., 2009). This distribution indicates that Southwest Asia is one of the most important centers for the spread of the Quadridentate group (Jeffrey, 1992).

Based on morphology and taxonomical research, descriptions of genera *Pojarkovia*, *Iranecio*, and *Caucasalia* in recent years have been based on some floral characteristics, such as the capitulum type and number, involucre diameter, lobe length, and color of the disc corolla, anther bases, filament collar, apex, and the indumentum of the lower surface of the style branches, and pappus persistence (Askerova, 1984; Nordenstam and Rechinger, 1989; Nordenstam, 1997, 2007).

Almost a decade ago, a new genus originating from Türkiye was described by Hamzaoğlu et al. (2011) based only on morphological findings. Previously, the 13 species described under *Senecio*, *Cineraria* Linnaeus, and *Iranecio* were transferred to this new genus (Hamzaoğlu et al., 2011; Hamzaoğlu and Çetin, 2016). In addition, *Senecio massagetovii* Schischkin was reported as a synonym of *Turanecio kubensis* (Grossh.) Hamzaoğlu (Hamzaoğlu and Çetin, 2016). Related research has shown that the taxa are distributed not only in Türkiye, but also in Caucasus, Iran, and Iraq. This genus belongs to the Quadridentate group of

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the subtribe Senecioninae, which has 4-lobed disc florets. *Turanecio* is very similar to the genus *Dolichorrhiza* in the Quadridentate group but differs from it by its thickish rhizome, short-sagittate anther base, style branches with papillate lower surface, and persistent pappus (Hamzaoglu et al., 2011).

The aim of this study was to define the delimitation of the genus using a phylogenetic approach, explain the position of *Turanecio* within the subtribe Senecioninae, and determine its intertaxa relationships by including sister groups. For this purpose, the DNA sequence data of nuclear (ITS) and plastid (*trnL* intron) regions were analyzed. In previous studies, these markers were important in resolving intra- and inter-genera level phylogenetic relationships in the tribe Senecioneae (Pelser et al., 2002, 2004, 2007, 2010; Coleman et al., 2003; Calvo et al., 2013; Dillenberger and Kadereit, 2013). In molecular studies conducted in the family Asteraceae, ITS, ETS, and plastid gene regions were studied (Korolyuk et al., 2015; Liew et al., 2018; Quedensley et al., 2018; Ren et al., 2020; Mapaya and Cron, 2021; Semiz et al., 2022; Tekşen et al., 2022; Escobari et al., 2021, 2023; Naderifar et al., 2023). While ITS analysis is definitely included in the studies, in some of them, ETS data are given in combination with ITS, and it is stated that except for minor incompatibilities, the same topology is generally seen and combining ITS+ETS data does not increase the resolution power (Liew et al., 2018; Quedensley et al., 2018; Ren et al., 2020; Escobari et al., 2023). Considering recent references, it has been reported that ITS data are mostly sufficient for phylogenetic analyses between species or genera. It has also been reported that although the resolution of ITS data is high, that of chloroplast data is low (Mapaya and Cron 2021).

## 2. Materials and methods

The taxa of *Turanecio* and closely related genera, studied within the scope of this study, were provided by Prof. Dr. Ergin Hamzaoglu. The ITS and *trnL* intron regions of the taxa were isolated and amplified (Table 1). The sequences of other taxa in the tree were downloaded from GenBank (NCBI). Additionally, all ETS sequences analyzed in the study were downloaded from the GenBank (NCBI). Total DNA isolation was performed using the 2X CTAB method described by Doyle and Doyle (1987) and modified by Soltis et al. (1991) and Cullings (1992). Primers ITS1 and ITS4 were used for the ITS region (White et al., 1990). The ITS-PCR conditions were applied according to those provided by Garcia-Jacas et al. (2006). For the *trnL* intron region, the *trnc-d* primers and protocol were used (Taberlet et al., 1991). Purification and reading of the PCR products were done using a service (Macrogen, Netherlands). The nucleotide sequences were edited using Bioedit software

(v.7.0.5.3; Hall, 1999), while visual alignment was conducted using sequential pairwise comparison software (Swofford and Olsen, 1990). For the parsimony analysis that was conducted on the ITS and *trnL* intron dataset, heuristic analyses were performed using PAUP software (v.4.0b10; Swofford, 2002), in addition to tree bisection and reconnection branch swapping, and the character states were considered unweighted as well as unordered. For the bootstrap (BS) analyses (Felsenstein 1985), 1000 heuristic search replicates were used and set at the default settings. Both the retention index (RI) and consistency index (CI) were given for the strict consensus tree, with the exclusion of the uninformative characters. The trees used for the Bayesian analyses were chosen randomly. For the ITS, ETS, and *trnL* intron,  $55 \times 10^4$ ,  $16.2 \times 10^4$ , and  $75 \times 10^4$  generations were run, respectively, for 2 independent 4 metropolis-coupled chain runs. For every 1000 generations that were run, only 1 was recorded. The run output was examined for convergence by considering the standard deviation of the split frequencies that were near 0.001. The first 1000 samples (20%) were considered to be burn-in and were removed after they were visually examined in regard to the likelihood score plots. Applying the Akaike information criterion (AIC) to the ModelTest was crucial in identifying the best-fit model regarding the DNA evolution. Features that included the best-fit model, base frequency, proportion of invariable sites, and gamma distribution shape parameters and substitution rates in the AIC were gathered and subsequently recorded in MrBayes in order to complete the phylogenetic analyses. The stationary of the runs, as well as the convergence between the runs, were examined using Tracer software (v.1.5.0; Rambaut and Drummond, 2007). The graphical views of phylogenetic trees were created using the FigTree v1.4.0 program.

## 3. Results and discussion

DNA markers have been used successfully to define the phylogeny of the subclade Senecioninae, and the results reported have been largely consistent with classifications based on morphological characters (Álvarez Fernández et al., 2001; Pelser et al., 2007, 2010; Calvo et al., 2013). While previous studies have attempted to explain the natural demarcation of the genus or the phylogenetic separation of the subtribal groups, detailed phylogenetic relationships among or within the subtribes have not been reported, particularly for the Quadridentate group. In this respect, it was attempted to conduct an in-depth determination of the phylogenetic relationships of the taxa and genera belonging to Adenostylinae in this study. Therefore, this paper also focuses on whether the genus *Turanecio* is a phylogenetically natural genus within the Quadridentate group and attempts to determine the

**Table 1.** Localities, ITS, ETS, and *trnL* intron GenBank numbers belonging to the analyzed taxa.

Taxa	Collector	ITS	<i>trnL</i> intron	ETS
<i>Turanecio cariensis</i>	Türkiye: Denizli; Honaz Dağı, Kayapınarı, 1720 m, 23 Jun 2006, Budak 2070 & Hamzaoğlu, Aksoy ( <i>trnL</i> ) Budak 1724, Aksoy & Hamzaoğlu (Yozgat Türkiye Florası Herbariyumu) (ITS)	GU818561 (Pelser <i>et al.</i> 2010)	OQ941579 (Current study)	GU818189 (Pelser <i>et al.</i> 2010)
<i>Turanecio hypochionaceus</i>	Türkiye: Kastamonu; Ilgaz Dağı, Hacat Tepesi, 2200 m, 10 Aug 2006, Hamzaoğlu 4454 & Budak	OQ756144 (Current study)	OQ941578 (Current study)	
<i>Turanecio lazicus</i>	Türkiye: Rize; İkizdere, south-west of Gölyayla, 2665 m, 2 Aug 2005, Budak 1945 & Hamzaoğlu, Aksoy	OQ756145 (Current study)	OQ941580 (Current study)	
<i>Turanecio pandurifolius</i>	Türkiye: Artvin; Yusufeli, Tekkale Yaylası, 2175 m, 25 Jul 2008, Hamzaoğlu 5238 & Aksoy	OQ756149 (Current study)	OQ941583 (Current study)	
<i>Turanecio lorentii</i>	Lesser Caucasus, Georgia (Dillenberger, and Kadereit 2013)	KC784517	-	KC784468 (Dillenberger and Kadereit 2013)
<i>Turanecio eriospermus</i>	Türkiye: Bitlis; Tatvan, Nemrut Dağı, in crater, 2250–2400 m, 6 Jul 2006, Hamzaoğlu 4747 & Aksoy, Budak	OQ756148 (Current study)	OQ941582 (Current study)	
<i>Turanecio taraxacifolius</i>				KC784470 (Dillenberger and Kadereit 2013)
<i>Turanecio taraxacifolius</i> <i>var. discoideus</i>	Türkiye: Bitlis; Adilcevaz, from Çanakyayla village to Süphan Dağı peak, 3150 m, 20 Aug 2006, Hamzaoğlu 4528 & Aksoy, Budak	OQ756146 (Current study)	OQ941584 (Current study)	
<i>Turanecio farfarifolius</i>	Türkiye: P.H. Davis 16263 E	EF538239 (Pelser <i>et al.</i> 2007)	-	
<i>Turanecio jurineifolius</i>	Türkiye: Kayseri; Tomarza, Aslantaş village, north of Karagöl Dağı, 2050–2250 m, 20 Jul 2006, Hamzaoğlu 4372 & Aksoy, Budak	OQ756150 (Current study)	-	
<i>Turanecio kubensis</i>	Türkiye: Ardahan; between Ardahan and Posof, above Ilgar Dağı pass, 2585 m, 3.8.2005, Ü.Budak 1963, E.Hamzaoğlu & A.Aksoy	OQ756147 (Current study)	OQ941581 (Current study)	
<i>Iranecio massagetovii</i> ( <i>Turanecio massagetovii</i> Comb. Nova)	Lesser Caucasus, Georgia	KC784518 (Dillenberger and Kadereit 2013)	-	KC784469 (Dillenberger and Kadereit 2013)
<i>Dolichorrhiza persica</i>	Iran; Klein 3746 S	EF538186 (Pelser <i>et al.</i> 2007)	-	
<i>Dolichorrhiza caucasica</i> ( <i>Turanecio caucasica</i> Comb. Nova)	Georgia: Khevi	GU818547 (Pelser <i>et al.</i> 2010)	GU817995 (Pelser <i>et al.</i> 2010)	GU818154 (Pelser <i>et al.</i> 2010)
<i>Adenostyles leucophylla</i>		KC784514 (Dillenberger and Kadereit 2013)	AY176085 Liu 2002	KC784466 (Dillenberger and Kadereit 2013)

Table 1. (Continued)

<i>Adenostyles alliariae</i>	Andermatt, Switzerland	KC784502 (Dillenberger & Kadereit 2013)	-	KC784452 (Dillenberger and Kadereit 2013)
<i>Adenostyles alpina</i>	Schwerdtfeger 12251 (B) ( <i>trnL</i> )	KC784513 (Dillenberger & Kadereit 2013)	GU817966 (Pelser <i>et al.</i> 2010)	GU818110 (Pelser <i>et al.</i> 2010)
<i>Iranecio paucilobus</i>	Türkiye: Van; between Van and Çatak, Işınlı (Arganis) village, Yukarımahalle, 1890 m, 22 Jul 2008, Budak 2298, Hamzaoğlu & Aksoy	OQ756151 (Current study)	OQ941585 (Current study)	
<i>Caucasalia parviflora</i>	Georgia, G.M. Schneeweiss, A. Tribsch, M. Staudinger & P. Schönswetter 8643 WU	EF538163 (Pelser <i>et al.</i> 2007)	EF538093 (Pelser <i>et al.</i> 2007)	GU818131 (Pelser <i>et al.</i> 2010)
<i>Caucasalia pontica</i>	Budak 1942 and Hamzaoğlu	OQ756152 (Current study)	OQ941586 (Current study)	
<i>Caucasalia platyphylloides</i>	Lesser Caucasus, Georgia	KC784516 (Dillenberger and Kadereit 2013)		KC784467 (Dillenberger and Kadereit 2013)
<i>Jacobaea racemosa</i>	Türkiye: Kars-Susuz, 5 Jul 1957, Davis 30623 & Hedge specimen 57+ (E)	JX895198 (Calvo <i>et al.</i> 2013)	-	
<i>Jacobaea inops</i>	Türkiye: Mittlerer Taurus, 24 Jul 1992, P. Hein 56 specimen 1073+ (B) (ITS), Türkiye, Tomarza, 12 Aug 2005, Budak 1991, Aksoy & Hamzaoğlu specimen 1112 (Yozgat Türkiye Florası Herbariyumu) ( <i>trnL</i> intron)	JX895504 (Calvo <i>et al.</i> 2013)	JX895102 (Calvo <i>et al.</i> 2013)	
<i>Jacobaea sandrasica</i>	Türkiye: Muğla; Köyceğiz, Ağla üzeri, Sandras dağı, 16 Jul 2005, Budak 1723, Aksoy & Hamzaoğlu (Yozgat Türkiye Florası Herbariyumu)	JX895503 (Calvo <i>et al.</i> 2013)	JX895042 (Calvo <i>et al.</i> 2013)	
<i>Jacobaea cilicia</i>	Türkiye: between Divriği and Arapgir, 15 Jul 1982, M.Nydegger 17168 (MA)	JX895430 (Calvo <i>et al.</i> 2013)	JX895098 (Calvo <i>et al.</i> 2013)	
<i>Kleinia neriifolia</i>		DQ915868 (Pelser <i>et al.</i> 2007)	KX091003 (Sun and Li 2016)	GU818192 (Pelser <i>et al.</i> 2010)
<i>Kleinia squarrosa</i>		-	KR737916 (Kartzinel <i>et al.</i> 2015)	
<i>Kleinia anteuphorbium</i>		DQ915867 (Pelser <i>et al.</i> 2007)	-	
<i>Kleinia longiflora</i>		DQ915870 (Pelser <i>et al.</i> 2007)	-	
<i>Kleinia semperviva</i>		DQ915871 (Pelser <i>et al.</i> 2007)	-	
<i>Kleinia descoingsii</i>		DQ915869 (Pelser <i>et al.</i> 2007)	-	

Table 1. (Continued)

<i>Senecio doria</i>	L., Spain, Barrios de Luna, 24 Jul 2009, J. Calvo 3962 specimen 15 (MA) ( <i>trnL</i> )	KU307469 (Pellegrini and Vischi 2015)	JX895061 (Calvo <i>et al.</i> 2013)	
<i>Senecio pseudoorientalis</i>	Türkiye: Gümüşhane, 20 Jul 1981, M. Nydegger 16993 specimen 74 (MA) ( <i>trnL</i> )	KX280813 (Kandziora <i>et al.</i> 2016)	JX895047 (Calvo <i>et al.</i> 2013)	KX494477 (Kandziora <i>et al.</i> 2016)
<i>Senecio lividus</i>		JN789813 (Pelser <i>et al.</i> 2012)	JN789990 (Pelser <i>et al.</i> 2012)	JN789711 (Pelser <i>et al.</i> 2012)
<i>Senecio vernalis</i>		JN789911 (Pelser <i>et al.</i> 2012)	JN789987 (Pelser <i>et al.</i> 2012)	JN789708 (Pelser <i>et al.</i> 2012)
<i>Senecio pubigerus</i>		EF538368 (Pelser <i>et al.</i> 2007)	MF373835 (Liew 2018)	MF373831 (Liew 2018)
<i>Senecio olympicus</i>		JX895511 (Calvo <i>et al.</i> 2013)	JX895043 (Calvo <i>et al.</i> 2013)	
<i>Senecio trapezuntinus</i>		JX895514 (Calvo <i>et al.</i> 2013)	-	
<i>Senecio castagneanus</i>		JX895508 (Calvo <i>et al.</i> 2013)	JX895062 (Calvo <i>et al.</i> 2013)	
<i>Senecio macedonicus</i>		JX895510 (Calvo <i>et al.</i> 2013)	JX895095 (Calvo <i>et al.</i> 2013)	
<i>Senecio madagascariensis</i>		JN789905 (Pelser <i>et al.</i> 2012)	JN789991	JN789712 (Pelser <i>et al.</i> 2012)
<i>Senecio nemorensis</i>		MH710657 (Xu <i>et al.</i> 2018)	-	GU818278 (Pelser <i>et al.</i> 2010)
<i>Senecio vulgaris</i>		EF538396 (Pelser <i>et al.</i> 2007)	EF538139 (Pelser <i>et al.</i> 2007)	AF319755 (Bayer <i>et al.</i> 2002)
<i>Ligularia sibirica</i>	Hamzaoğlu 4263 & Aksoy, Budak	OQ756153 (Current study)	-	
<i>Ligularia stenocephala</i>				GU818198 (Pelser <i>et al.</i> 2010)
<i>Tephrosieris integrifolia</i> subsp. <i>aucheri</i>	Budak 2052 & Hamzaoğlu	OQ756154 (Current study)	-	GU818319 (Pelser <i>et al.</i> 2010)
<i>Tephrosieris integrifolia</i> subsp. <i>integrifolia</i>		MN625428 (Skokanova <i>et al.</i> 2019)	-	
<i>Doronicum pardalianches</i>				GU818156 (Pelser <i>et al.</i> 2010)
<i>Doronicum hakkiaricum</i>	Budak 2073 & Hamzaoğlu	OQ756155 (Current study)	OQ941587 (Current study)	
<i>Doronicum orientale</i>	Budak 2014 & Hamzaoğlu	OQ756156 (Current study)	MG748534 (Skof <i>et al.</i> 2019)	

natural delimitation of the genus (subtribe Adenostylineae) and comprehensively define their phylogenetical relationships. The settled analyses and built trees clearly revealed that the genus *Turanecio*, which also includes the species *Iranecio massagetovii* and *Dolichorrhiza caucasica*, is resulted therefore by a monophyletic group. In this taxonomic group, the ITS (nuclear DNA) gene regions, analyzed in order to provide a phylogenetic resolution, were quite informative when compared to the plastid DNA. The *trnL* intron (gene region of the chloroplast DNA) showed relatively low resolution in the compared taxa and genera and appeared to be undifferentiated from the Quadridentate group. It exhibited a common pattern of chloroplast sequences in clades consisting of multiple polytomic branches.

Therefore, the presence of incongruence between the nuclear and plastid gene regions can be inferred within Senecioneae, which may have possibly been the result of ancient hybridization events (Pelser et al., 2010; Calvo et al., 2013). The noncoding cpDNA (*trnL* intron) and nuclear rDNA (ITS1-5.8S-ITS2) sequences were analyzed to investigate their phylogenetic relationships. The aligned sequences of the ITS region consisted of 238 parsimony-informative characters and a dataset of 684 base pairs, while the *trnL* intron aligned sequences consisted of 10 parsimony-informative characters and a dataset of 431 base pairs (Table 2). The posterior probabilities (PP)- and bootstrap (BS)-supported nrDNA and cpDNA trees are shown in Figures 1A, 1B, and 2, respectively.

**Phylogeny and taxonomy of *Turanecio*:** Based on morphology, Hamzaoglu et al. (2011) published a new genus named *Turanecio* from Türkiye as a member of the Quadridentate group of the tribe Senecioneae. The findings derived from the nrDNA and cpDNA gene regions supported the natural position of the genus, consistent with the morphological data in this group (Figures 1B and 2). From the applied sequences analyses, the ITS genes supplied more resolution than the plastid ones (cpDNA); therefore, it was decided to use the trees that were sourced from the ITS sequences to determine the phylogenetical relationships regarding the delimitation of *Turanecio* and its close relatives. Different researchers have reported that the sequences of plastid gene regions have poor resolving power in revealing phylogenetic relationships in the tribe Senecioneae (Álvarez Fernández et al., 2001; Pelser et al., 2002). Similarly, in this study, it was revealed that the studied *trnL* intron region provided low resolution because it evolved very slowly and showed low differentiation in different taxonomic groups (subtribe Adenostylineae) and their members in the subtribe (Figure 2). *Turanecio*, which also includes the species *Iranecio massagetovii* and *Dolichorrhiza caucasica*, is positioned in a different genus than the remaining members of Adenostylineae (*Adenostyles*, *Pojarkovia*, *Caucasalia*, *Dolichorrhiza*, and

*Iranecio*) in this group (Figure 1B) and is monophyletic. The tree obtained from the nrDNA-ITS data showed that the genus *Turanecio* consists of four main lineages (PP:1/BS:76). The taxa in the clades were largely consistent with the morphological data (Hamzaoglu et al. 2011; Figure 1B).

#### **Phylogenetic relationships among *Turanecio* and related genera**

##### **Species composition of the genus *Turanecio***

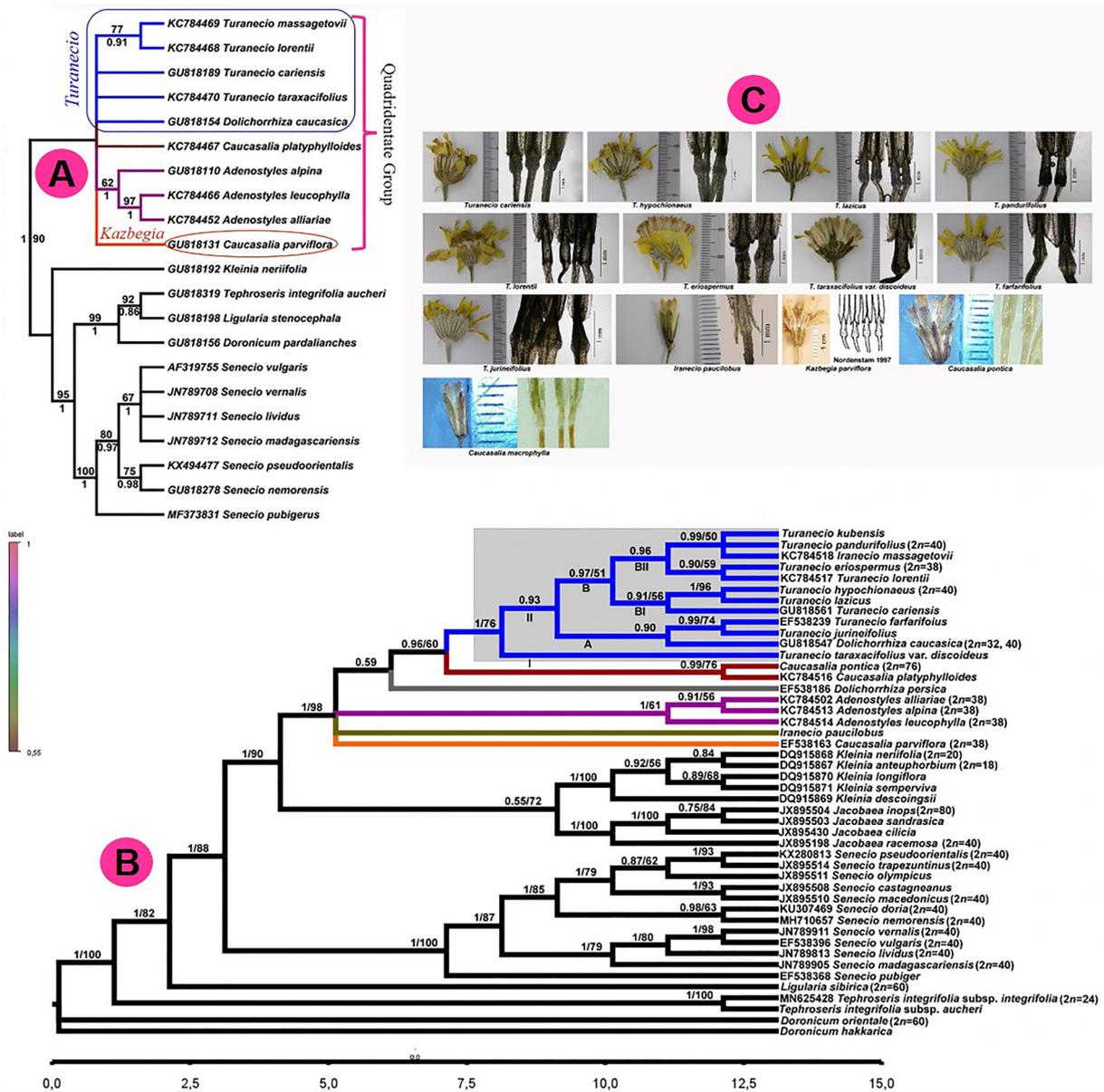
The genus *Turanecio* is divided into two main clades (I and II). The first clade includes *T. taraxicifolius* var. *discoideus*, which is morphologically quite different from the other species. The second clade is divided into two subclades (A and B). In Clade-A, *T. farfarifolius* and *T. jurineifolius* were found to be highly correlated with each other (PP: 0.99/BS:74). *Dolichorrhiza caucasica* is with these species in the same clade (PP: 0.90). Clade- B is divided into subclades. All of the taxa in these subclades are of Caucasian origin (BI and BII). In subclade-BI, *T. hypochionaeus* and *T. lazicus* (PP:1/BS:96) are more closely related to each other than *T. cariensis* (PP:0.91/BS:56). Subclade-BII contains two branches (PP: 0.96). The first of these branches includes *T. kubensis*, *T. pandurifolius*, and *T. massagetovii*, and they are more closely related to each other (PP:0.99/BS:50). Hamzaoglu and Çetin (2016) emphasized by that *Senecio massagetovii* is a synonym for *Turanecio kubensis*. The phylogenetic results support the need for a revival of this species, as it is not compatible with the morphological data. The revived species was also transferred to the genus *Turanecio*. In the other branch, there are *T. eriospermus* and *T. lorentii* species (PP:0.90/BS:59). There are widely distributed taxa (*T. pandurifolius*, *T. lorentii*, *T. eriospermus*, *T. taraxicifolius* var. *taraxicifolius*, *T. davisii*, and *T. kubensis*) within the genus *Turanecio* (Matthews, 1975; Nordenstam and Rechinger, 1989; Schischkin, 1995; Hamzaoglu et al., 2011; Hamzaoglu and Çetin, 2016). Although *T. eriospermus* and *T. lorentii* differ morphologically (for example, their achenes traits), they are located in the same clade. Therefore, it can be said that the tree strongly supports the relationship of the widely distributed and Caucasian origin taxa.

Pelser et al. (2007) reported that ITS sequence data were used to reconstruct the phylogeny for Senecioneae and redefine a previously polyphyletic *Senecio*. They emphasized that the genera in the Quadridentate group belong to a single clade. Within this clade, *I. paucilobus* was reported to be in a different subclade than other *Iranecio* species. It was noted that other species (*I. taraxicifolius*, *I. farfarifolius*, and *I. jurineifolius*) are in a different subclade. The taxa located in a different subclade than *I. paucilobus* were transferred to the genus *Turanecio* by Hamzaoglu et al. (2011). This aligns with our phylogenetic results based on the nrITS data.

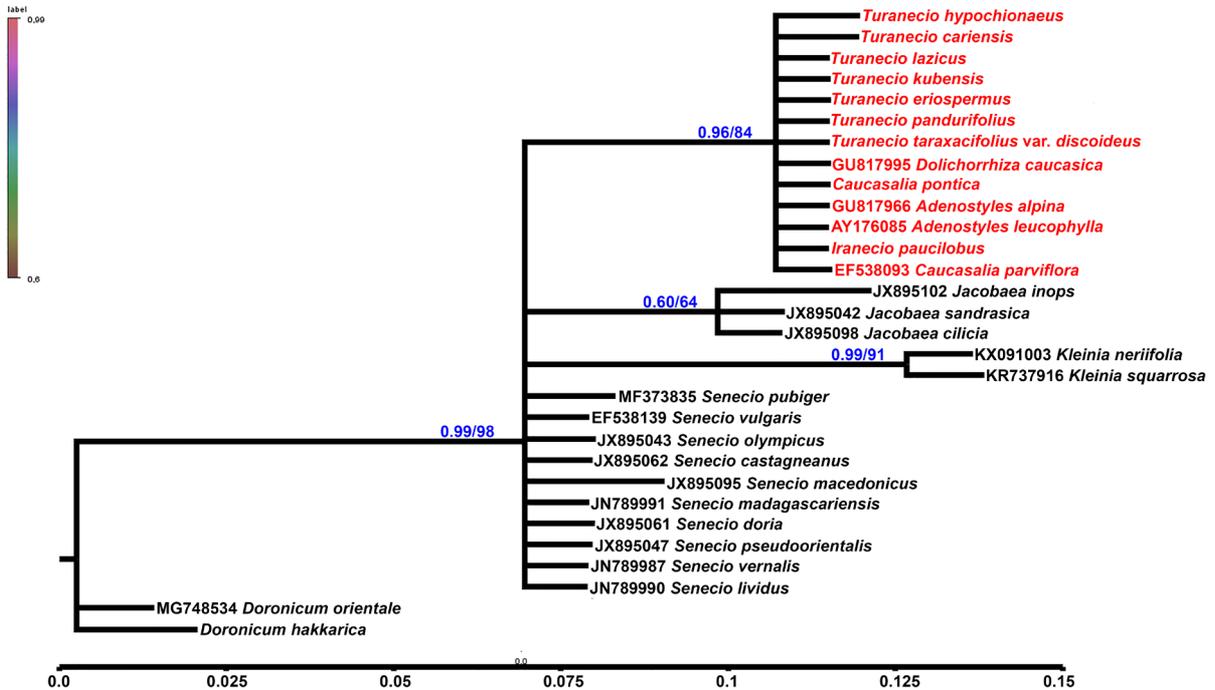
The parsimony and Bayesian analyses based on the ITS data revealed an overlapping and common topology.

**Table 2.** Alignment lengths of all of the taxa (L), constant character numbers (C), variable characters (V), parsimony-informative characters (Pi), best-fit nucleotide substitution model determined by AIC (M), consistency index (CI), retention index (RI), and homoplasy index (HI) values.

Dataset	L	C	V	Pi	M	CI	RI	HI
ITS1-5.8S-ITS2	684	376	70	238	SYM+I+G	0.666	0.826	0.334
ETS	432	250	89	93	TVM+G	0.717	0.745	0.283
<i>trnL</i> intron	425	409	3	13	K81uf	1.000	1.000	0.000



**Figure 1.** Phylogenetic trees obtained from the ETS (A) and ITS (B) regions of the studied taxa and the capitula sizes and anther base shapes in some species of *Turanecio* and its related taxa (C). ITS; Results from the parsimony analyses were combined on a Bayesian inference (BI) tree. ETS; Results from the Bayesian inference was combined on a parsimony analyses.



**Figure 2.** Phylogenetic tree obtained from the *trnL* intron region of the studied taxa. Results from the parsimony analyses were combined on a Bayesian inference (BI) tree.

According to the combined tree, the Quadridentate group (tribe Adenostylinae) is monophyletic and includes several genera that have an ongoing evolutionary process. In the tree, *Dolichorrhiza caucasica* (M.Bieb.) Galushko and *Iranecio massagetovii* (Schischk.) C.Jeffrey are also seen to be included within the genus *Turanecio*, which is the main focus of our phylogenetic study, and their positions indicate a split in the core of the *Iranecio* and *Dolichorrhiza* genera, as well as *Caucasalia*. An important contribution of this work is that *Turanecio*, which also includes the species *Iranecio massagetovii* and *Dolichorrhiza caucasica*, was determined to be a monophyletic genus as a result of this study. Other major clades include *Adenostyles*, *Iranecio paucilobus* (type species of the genus), and *Caucasalia parviflora* and *Dolichorrhiza persica* (the closest species to the type species of *Dolichorrhiza*). According to the topology, it can be inferred that some species of the genera within this tribe seem to be separated phylogenetically; thus, taxonomic reorganization needs to be carried out appropriately.

*Pojarkovia*, a monotypic genus, is another genus traditionally included in the tribe Adenostylinae. In previous phylogenetic analyses (Pelser et al., 2007; Dillenberger and Kadereit, 2013), *P. pojarkovia*, representing the genus, was included and it was located together with the species currently included in the genus *Turanecio*. Similarly, when the sequences belonging to the same sample from the database were included in our

data matrix and analyses were performed, it was seen that this species is similar to the taxa in the core of the genus *Turanecio*. However, since the deep incompatibility seen in the morphology and ITS sequences of the species under consideration created a suspicious situation, and the fact that the herbarium specimen on which it was based was not examined herein, this species was excluded from our analysis. Thus, the mystery of its phylogeny will have to be investigated in a later study.

All of the genera within the subtribe Adenostylinae have 4-lobed disc corolla and are defined as the Quadridentate group. Therefore, this character is a derivative for all of the group members, and it was evaluated as a synapomorphy. From the preliminary studies conducted within this group (Askerova, 1984; Jeffrey, 1992; Nordenstam, 1997; Hamzaoglu et al., 2011), it was seen clearly that the diagnoses of the genera are based on very limited characters, and there is a very close morphological relationship between some of the genera. In the generic characterization of the Quadridentate group performed by Nordenstam (1997), it was seen clearly that the segregation of the genera was based on very limited morphological characters, and there is a very close morphological relationship among the six considered genera. Additionally, these genera share many common characters, and it is very difficult to find an apomorphic character specific to each of them.

Although Nordenstam et al. (2009) reported that the phylogenetic position of the clade consisting of

*Adenostyles*, *Pojarkovia*, *Caucasalia*, *Dolichorrhiza*, and *Iranecio* (Quadridentate group) was inconsistent between the ITS and plastid data, our findings, including the nucleus and chloroplast phylogeny, support the group.

Our phylogenetic analyses revealed that the position of some of the taxa in different genera of this subtribe is completely artificial and some new taxonomic adjustments are needed to reflect a natural relationship. In this sense, *Dolichorrhiza* and *Caucasalia* stand out at first. Currently, *D. caucasica*, which is taxonomically included in the genus *Dolichorrhiza*, is clearly at the core of the genus *Turanecio*. This species is in the same common clade with *T. jurineifolius* and *T. farfarifolius* and is morphologically very similar to them. Currently, the genus *Dolichorrhiza* is represented by 4 species, and the rhizomes of the species included in the genus are slender, except for *D. caucasica*. In addition, the pappus is deciduous, but it is permanent in *D. caucasica*, as in the species of the genus *Turanecio*. In addition to these, the auricles in the bases of the leaves are present in *D. caucasica*, as seen in some *Turanecio* taxa, unlike the remaining *Dolichorrhiza* taxa. In fact, to be accurate, the most appropriate way to make a taxonomic arrangement regarding this group is to include the species representing the genus in this phylogenetic analysis. However, considering the close morphological relationship between *D. renifolia* and *D. persica*, *D. caucasica* was proposed as *Turanecio caucasica* in this article because the second species was in a separate clade with *D. caucasica* in our analyses, in addition to the morphological differences discussed above. The fact that *Caucasalia* species are located in different clades, even in distant positions, clearly indicates the artificial nature of the group. Moreover, Nordenstam (1997) pointed out in his original publication that *Caucasalia parviflora* is quite different from the rest of the genus in its general appearance and radiate capitula, and argued that this explains why the species was not evaluated in that concept, even though the other 3 species were previously transferred to the genus *Pojarkoeva* by Askerova (1984). In the general sense, *C. parviflora* is quite distinct both in its morphology and in terms of the phylogenetic relationships set forth herein and is thus proposed at the end of this study as a currently monotypic species of a new genus, *Kazbegia* (Table 3).

As seen in Figure 1A, although the tree based on ETS data does not reach the desired solution, it overlaps with the ITS data. It supports both the Quadridentate group and clearly shows that *Caucasalia parviflora* (*Kazbegia parviflora*) is positioned too far and in a different clade than *Causalia platyphyllodites*.

Species in the clades *Jacobaea*, *Senecio*, and *Gynura*, which are more basal groups compared to Adenostylinae, appear to have a basic chromosome number of mostly 20 (Nordenstam 1997; Robinson et al., 1997). In the

Quadridentate group, *Turanecio* and closely related genera have a basic chromosome number of  $x = 19$  and 20, which is fairly common. Exceptionally, there is only 1 suspicious count, as 16, for *Dolichorrhiza caucasica* (Gagnidze, 1974). Additionally, the only species reported as polyploid in this subtribe is *C. pontica*. As a general deduction, dysploidy and also more rarely, polyploidy, can be evaluated as 2 mechanisms that are effective in the evolution of these groups from a chromosomal point of view. Therefore, we can say that the number of chromosomes could not be evaluated as an apomorphy within the subtribe, but the commonly seen basic chromosome number,  $x = 20$  might be assessed as a pleisomorphic character for them.

Pollen morphologies of some *Senecio* and *Iranecio* taxa, including *T. taraxacifolius*, *T. eriospermus* (synonym: *Senecio lipskyi*), and *T. davisii*, transferred to *Turanecio*, were studied and it was reported that their pollen characters support the Quadridentate group (Eftekharian et al., 2017).

It has been emphasized that a more detailed understanding of macroevolution can be provided by revealing the consistency or inconsistency between the phylogenies obtained from the analyses of different genes, gene regions, and genomes (Álvarez Fernández et al., 2001; Degnan and Rosenberg, 2009; Pelser et al., 2010). Although the phylogeny of the plastid and ITS/plastid combined dataset provides information about intergeneric relationships in Senecioninae, such a dataset includes a smaller genus selection (Pelser et al., 2007). Therefore, Pelser et al. (2007) reported that they used only the ITS tree as a basis for discussing relationships within the tribe. They improved the understanding of evolutionary relationships at both the inter- and intrageneric levels, especially for *Senecio*. Moreover, they stated that although this tree is not fully resolved and contains clades that are only weakly supported by BS values and PPs, it allows for several conclusions regarding the subtribal delimitation and intergeneric relationships of the tribe.

This paper is based on the ITS phylogeny. Trees based on nrITS and cpDNA sequences have supported the position of the genera in the Quadridentate group (Figures 1A, 1B, and 2). Although the cpDNA tree showing the polytomy supported the Quadridentate group, it was not enough to separate species or genera within the group.

Previously, Pelser et al. (2010) emphasized a strongly supported inconsistency between the plastid and nuclear phylogenies in the tribe Senecioneae and suggested that this was due to hybridization rather than incomplete lineage selection (ILS).

The differences in resolving the power of the cpDNA and nrDNA regions may have been due to the relatively low-resolution power of the *trnL* intron region (Taberlet et al., 2007) or may have occurred due to the low number

of informative characters for cpDNA phylogeny. Or it may have been ILS/hybridization, in line with previous studies (Huson and Bryant 2006; Pelser et al., 2002, 2010).

#### TAXONOMIC NOTES

##### Taxonomical regulations

*Kazbegia* Uysal & Hamzaoglu Genera Nov.

*Kazbegia parviflora* Uysal & Hamzaoglu Basionym Comb. and Stat. Nov.

*Turanecio caucasica* (M.Bieb.) Bozkurt, Uysal & Hamzaoglu, Comb. Nova

*Turanecio massagetowii* (Schischk.) Bozkurt, Uysal & Hamzaoglu, Comb. Nova

***Kazbegia* Uysal & Hamzaoglu, gen. nov.**

*Senecio* L., sect. *Pseudo-oliganthi* Sofieva, Izv. Akad. Nauk Azerb. SSR 1957: 88 (1957) p.p.

**Type:**—*Kazbegia parviflora* (M.Bieb.) Uysal & Hamzaoglu.

**Diagnosis:**—Perennial herbs with a thick rhizome; lower leaves long-petiolate; synflorescence lax and broad, peduncles mostly short, 2–4 cm long; capitula radiate, many; involucre narrow, 3–4 mm in diameter; phyllaries 8–10; disc florets 10–15, shallowly 4-lobed; corolla yellow; anther bases sagittate, filament collar senecioid; style branches linear, short, lower surface papillate; pappus persistent.

**Description:**—Perennial herbs with a thick rhizome. Stem leafy, simple, branching in synflorescence, erect, 30–120 cm tall, glabrous, ribbed, or striate. Leaves cauline, alternate, lower long-petiolate, upper sessile; petiole winged, upper leaves with auricles at base; lamina ovate-cordate to triangular-ovate, flat, herbaceous, pinnately veined; margins dentate with acute to obtuse teeth. Capitula radiate, many, in terminal corymbiform ebracteate or with minute scattered bracts, lax and broad synflorescence. Involucre narrowly campanulate to obconical, 3–4 mm in diameter; involucre bracts uniseriate, free, 8–10, herbaceous, with thinner scarious margins, apically acute, with shortly white-villous-puberulous margins; calycular bracts few or absent, inconspicuous, filiform-subulate, shorter than the involucre. Receptacle scrobiculate-alveolate with small outgrowths. Ray-florets female, 5–8, tubular below, with a linear-narrowly oblong 3-toothed yellow lamina; style branches linear, short. Disc florets 10–15, hermaphroditic; corolla yellow, tubular below, widening above, shallowly 4-lobed. Anthers 4, basally sagittate, apical appendage ovate; filament collar senecioid. Style narrowly midlined, branches linear, short, apically rounded-obtuse with short sweeping-hairs, outside papillate. Cypselas narrowly oblong, glabrous, c. 8-ribbed, with a distinct carpodium. Pappus bristles numerous, pluriseriate, erect, minutely barbellate throughout, off-white to fulvous, basally connate, persistent.

***Kazbegia parviflora* (M.Bieb.) Uysal & Hamzaoglu, comb. nov.**

*Cineraria parviflora* M.Bieb., Fl. Taur.-Caucas. 2: 316 (1808); *Caucasalia parviflora* (M.Bieb.) B.Nord., Pl. Syst. Evol. 206: 29 (1997). **Type.** [Georgia] In alpestribus Caucasi, circa Kasbek, Marschall von Bieberstein (G, LE). = *Senecio lampanoides* DC., Prodr. [A. P. de Candolle] 6: 348 (1838).

**Type:**—[Georgia] Mount Kazbek (G).

**Description:**—Rhizome thick, oblique to ascending. Stem 0.3–1.2 m high, leafy throughout, glabrous, ribbed, or striate. Leaves moderately densely set, erecto-patent, glabrous except for lanate-puberulous margins; lower leaves long-petiolate, upper leaves sessile; petiole of lower leaves 3–8 cm long, widening towards half-clasping base, sheathing; petiole of middle and upper leaves gradually shorter and upper leaves sessile with distinctly auriculate clasping base; lamina ovate-cordate to triangular-ovate, 4–12 cm long, 3–7(–10) cm wide, green with paler lower side, mid-veined and with fainter lateral veins and a fine reticulate venation pattern, shallowly dentate, obtuse, basally cordate to truncate or cuneate, uppermost leaves narrower, ovate-lanceolate to oblong, 2–5 cm long, 0.5–2 cm wide, evenly acutely dentate, apex subacute. Synflorescence laxly corymbiform with 15–30 radiate capitula on slender glabrous branches, ebracteate or with minute scattered bracts in the upper part and a few larger basal bracts. Involucre narrowly campanulate or obconical, 3–4 mm in diameter; involucre bracts 8–10, narrowly oblong to linear-lanceolate, 5.0–7.5 mm long, 1–2 mm wide, green, glabrous, 1–3-veined; tips triangular, acute, black, with shortly white-villous-puberulous margins; calycular bracts inconspicuous, 1–3 or absent, filiform-subulate, up to 1.5 mm long, glabrous, or puberulous. Receptacle scrobiculate-alveolate with small outgrowths. Ray florets 5–6(–8); lamina narrowly oblong, yellow, 8–10 mm long, 2–3 mm wide, 4(–5)-veined. Disc florets 10–15; corolla yellow, tubular, widening above, 6.0–7.5 mm long, 4-veined from the base to the sinuses; lobes triangular-ovate, 0.8 mm long, without midline. Style branches 0.7–1.0 mm long; insides with continuous stigmatic areas or basally narrowly mid-lined; tip rounded-obtuse with short sweeping-hairs; outsides papillate. Anthers 2.5–3.0 mm long, basally sagittate; filament collar somewhat thickened towards the base; apical appendage ovate, obtuse. Cypselas narrowly oblong, 4.5–7.0 mm long, with c. 8 veins; carpodium distinct, of c. 8 cell rows with beadlike cell walls. Ovary wall crystals small, prismatic, of various shapes (similar to those of *C. platyphylloides*). Pappus bristles 5.5–6.0 mm long, basally united and flattened, apically thin, finely barbellate with very short lateral teeth, off-white or pale fulvous. Flowering time and habitat; 7–8, rocks, and pine forest, 1500–2400 m a.s.l.

**Distribution:**—Caucasia (Russia, Georgia, and Azerbaijan).

***Turanecio caucasica*** (M.Bieb.) Bozkurt, Uysal & Hamzaoglu, **comb. nov.**

*Cineraria caucasica* M.Bieb., Fl. Taur.-Caucas. 2: 313 (1808); *Senecio caucasicus* DC., Prodr. 6: 348 (1838); *Ligularia caucasica* (M.Bieb.) G.Don, Hort. Brit.: 382 (1839); *Dolichorrhiza caucasica* (M.Bieb.) Galushko, Novosti Sist. Vyssh. Rast. 6: 210 (1970). Type:—[Caucasia] In Caucaso Iberico.

= *Cineraria caucasica* Schlecht. ex Ledeb., Fl. Ross. 2(2,7): 858 (1846). Type:—In Willd. Herb. Nr. 16,003 (non M. a Bieberst.).

***Turanecio massagetovii*** (Schischk.) Bozkurt, Uysal & Hamzaoglu, **comb. nov.**

*Senecio massagetovii* Schischk., Fl. URSS 26: 722 & 882 (1961); *Iranecio massagetovii* (Schischk.) C.Jeffrey, Kew Bull. 47(1): 103 (1992).

Type:—Georgia. Grusinskaja SSR: In faucibus fluminis Borzhomka prope stationem viae ferreae Sakoczavi, in saxosis, 25.6.1934, Massagetov s.n. (LE!).

#### **The width of the involucre in the genus *Turanecio***

The Quadridentate group, which is located in the subtribe Senecioninae, consists of genera with 4-lobed tubular flowers (Nordenstam, 1997). In the generic classification of the genera in this subtribe, it was determined that the leaf and rhizome characteristics were largely shared among all of the genera and were not diagnostic. Moreover, it was seen that only the genus *Dolichorrhiza* differs from the others with its delicate rhizomes. The genera are roughly divided into 2 groups in terms of synflorescence. Unlike genera (*Iranecio*, *Caucasalia*, *Pojarkowia*, and *Adenostylis*) that have tight and narrow inflorescences, *Turanecio*, *Kazbegia*, and *Dolichorrhiza* have loose and wide inflorescences. Accordingly, the taxa in the 2 groups are also separated in terms of the involucre diameter. In genera with loose inflorescences, the diameter of the involucre is larger, and accordingly, the involucre consists of more bract series and disc flowers. The genus *Turanecio*, which is in the loose-flowered group, draws attention with its species with clearly larger involucre and capitula when compared to other genera of the same group (Figure 1C). With this feature, it can be distinguished not only from the genera in this group, but also from genera with tight inflorescences at first glance. Another feature unique to this genus is that the anthers, a part of the male reproductive organ, are short sagittate at the base (Figure 1C).

To give a diagnosis for *Turanecio* and its relative genera: while *Turanecio* Hamzaoglu has basically larger involucre ((7–)11–18(–22) mm) (Hamzaoglu et al., 2011), its relatives have narrower involucre, which range from 2 to 6 mm (Figure 1C). Chronologically, *Turanecio* was created gradually by transferring some species belonging to previously described genera *Senecio* L., *Cineraria* L., *Ligularia* Cass., *Dolichorrhiza* (Pojark.) Galushko,

*Iranecio* B.Nord., and *Caucasalia* B.Nord (Galushko, 1970; Nordenstam, 1989, 1997; Schischkin, 2000; Hamzaoglu et al., 2011). In a protolog of the genus, it was stated that the involucre width was 8–23 mm in *Dolichorrhiza* species and 3–9 mm in *Iranecio* species (Nordenstam and Rechinger, 1989; Pojarkova, 1995). Especially for the genus *Dolichorrhiza*, the size of the involucre was less than 7 mm, except for only 1 species (the remaining 3 species have narrower involucre, which ranges from 5 to 9 mm). As a conclusion, the taxon with large capitula appears to be clearly different than the others morphologically. This finding indicates a distinction between the genera in this subtribe according to the diameter of the involucre. As a result, in light of both the morphology and molecular data, it was concluded that some new taxonomic arrangements are necessary in this group. Therefore, *Dolichorrhiza caucasica* and *Iranecio massagetovii* were transferred to the genus *Turanecio*. During our herbaria visits and examinations, some important points were noted that should be mentioned. Herbarium specimens of the species with an involucre width that was more than 6 mm were examined in detail. In these samples, it was observed that the capitula were completely opened from maturity or enlarged due to pressing. In addition, it was determined that the width of the receptacula in the herbarium samples was less affected by the expansion due to maturity or pressing. Based on this determination, the herbarium specimens of the species with an involucre width that was wider than 6 mm in the description were reevaluated and it was observed that the receptacula were 3–4 mm wide. In capitula that were not crushed with a press, a width of 1–2 mm was observed laterally from the attachment site of the phyllaries to the receptaculum, and based on this, it was determined that the total involucre width could be at most 6 mm. As a result, it was decided that the involucre width ranges between 7 and 22 mm in the genus *Turanecio* within the Quadridentate group, and between 2 and 6 mm in the other genera (Table 3).

#### **The revival of the *Turanecio massagetovii* species and its transfer to the genus *Turanecio***

*Turanecio kubensis* (*Senecio kubensis*) and *T. massagetovii* are distinguished from each other by characters such as the base shape of the leaf terminal lobe, the length of the involucre, and the number of tongue-tied flowers. Hamzaoglu and Çetin (2016) determined that these characters are fairly variable, and these species should be combined into only 1 species. However, molecular analyses indicated that the questioned species were different, and after detailed morphological examinations, it was decided that the characters in question were stable of at least one. Therefore, some taxonomical assignments were performed within this subtribe. After these taxonomical investigations, *Iranecio* was represented by only 3 taxa;

**Table 3.** Generic characters in the Quadridentate group of genera in the subtribe *Senecioninae* in Southwestern Asia. [The table was taken from Nordenstam (1997) and updated].

Characters	<i>Kazbegia</i>	<i>Turanecio</i>	<i>Dolichorrhiza</i>	<i>Iranecio</i>	<i>Caucasalia</i>	<i>Pojarkovia</i>	<i>Adenostyles</i>
Rhizome	Thick	Thick	Slender	Thick	Thick	Thick	Thick
Lower leaves	Long-petiolate	Short- or long-petiolate	Long-petiolate	Short- or long-petiolate	Long-petiolate	Short-petiolate	Long-petiolate
Synflorescence	Lax and broad	Mostly lax and broad	Mostly lax and broad	Strict and narrow	Strict and narrow	Strict and narrow	Strict and narrow
Peduncle	Mostly short, 2–4 cm	Mostly long, (1–)3–10(–30) cm	Mostly long, 3–13 cm	Very short, 0.5–2 cm	Very short, 0.5–2 cm	Very short, 0.5–2 cm	Very short, 0.5–2 cm
Capitula no.	Solitary, few	Solitary, few-many	Solitary, few	Clustered, few-many	Clustered, many	Clustered, many	Clustered, many
Capitulum type	Radiate	Radiate or discoid	Radiate or discoid	Discoid	Discoid	Discoid	Discoid
Involucre diam.	Narrow, 3–4 mm	Broad, (7–)11–18(–22) mm	Narrow, 4–6 mm	Narrow, 3–5.5 mm	Narrow, 2–4 mm	Narrow, 2–2.5 mm	Narrow, 2–3 mm
Phyllaries	Few, 8–10	Many, 14–30	Many, (7–)9–21	Few, 5–15	Few, 4–10	Few, c. 5	Few, 3–8(–10)
Disc florets	Few, 10–15, shallowly lobed	Many, 30–80, shallowly lobed	Many, 40–80, shallowly lobed	Few, 8–30, shallowly lobed	Few, 5–15(–17), shallowly to moderately lobed	Few, 5–15, deeply lobed	Few, 3–15(–32), shallowly to deeply lobed
Corolla	Yellow	Yellow to orange	Yellow	Yellow	Yellow	Whitish	Purple
Anther bases	Sagittate	Short-sagittate	Ecaudate, obtuse	Caudate	Caudate-sagittate	Ecaudate, auriculate	Ecaudate, obtuse
Filament collar	Senecioid	Senecioid	Senecioid	Senecioid	Senecioid	Dilated basally	Rather slender
Style branches	Linear, short	Linear, short	Linear, short	Linear, short	Linear, short	Linear, long	Subulate, long
Lower surface of style branches	Papillate	Papillate	Papillate, glabrous	Papillate	Papillate	Puberulous	Clavate-papillate
Pappus	Persistent	Persistent	Persistent, caducous	Persistent	Persistent	Persistent	Persistent

*Iranecio paucilobus* (DC.) B.Nord., *I. oligolepis* (Boiss.) B.Nord., and *I. elbrusensis* (Boiss.) B.Nord., respectively. In the original publication of the genus, the genus *Senecio othonnae* M.Bieb. was also transferred to the genus *Iranecio*, even though the tubular flowers were 5-lobed. However, as in the current study, molecular studies have determined that the species should be evaluated within in the genus *Jacobaea* (Pelser et al., 2002; Nordenstam, 2006). These 3 species (*I. paucilobus*, *I. oligolepis*, and *I. elbrusensis*) belonging to *Iranecio* are separated from *Turanecio* species

via some taxonomical characters such as tight and narrow inflorescences, short peduncles (0.5–2 cm), clustered capitula, narrow involucre (3–5.5 mm wide), phyllaries (5–15), few tubular flowers (8–30), and anther bases that are caudate (Table 3).

***Turanecio kubensis*:** Terminal lobe of lyrate pinnate leaf ovate-deltoid, cordate at base; involucre 10 mm long; ligulate florets 12 pieces.

***Turanecio massagetovii*:** Terminal lobe of leaf truncate at base, not cordate; involucre 6 mm long; ligulate florets 13–15 pieces.

### The transfer of *Dolichorrhiza caucasica* to the genus *Turanecio*

*Dolichorrhiza caucasica* was transferred to the genus *Turanecio* based on its rhizome structure (thick), involucre width (7–9 mm), and basal anther shape (short-sagittate). Molecular data also support this determination. Now, the *Dolichorrhiza* genus is represented by *Dolichorrhiza correvoniana* (Albov) Galushko, *Dolichorrhiza persica* (Boiss.) B.Nord., and *Dolichorrhiza renifolia* (C.A.Mey.) Galushko (Nordenstam 1989).

### The Presence of *Kazbegia* genus and transfer of *Caucasalia parviflora* to this genus

*C. parviflora* (M.Bieb.) B.Nord., previously considered in *Caucasalia*, is the only species in the genus with a radiate capitulum (Nordenstam, 1997). The molecular phylogeny data obtained herein infer that the species differs from other *Caucasalia* species. *C. parviflora* differs from other *Caucasalia* species in terms of the type of capitulum, inflorescence (lax and broad), peduncle length (mostly short, 2–4 cm), capitulum density (solitary, few), and anther base shape (sagittate) (Table 2). Herein, a new genus, *Kazbegia*, was defined based on the available molecular and morphological data, and *Caucasalia parviflora* was transferred to this genus (*Kazbegia parviflora*). The type address of *Kazbegia parviflora*, which is the only type species of the genus, is “Kazbegi” mountain. The genus was named *Kazbegia*, inspired by the genus type address.

### Examined samples and accessions

*Kazbegia parviflora*. Exsiccata itineris Caucasici, (address illegible), 1873, Rehmann 603 (G00765335!); (address illegible), (G00765347!).

*Dolichorrhiza correvoniana* (Albov) Galushko. Russia: Black Sea region. Saddle Khach-Katsirka, 2825 m, alpine meadow, 16.8.1894, Alboff 210 (TBI1024651!).

*Dolichorrhiza renifolia* (C.A.Mey.) Galushko. (Address absent or illegible), 1832, Meyer 688 (G00470026!).

*Dolichorrhiza persica* (Boiss.) B.Nordenstam. Iran: Djulfeth, Aucher Eloy 4707 (K000797433!; G00223591!; G00223592!).

*Iranecio paucilobus* (DC.) B.Nordenstam. Türkiye: Van, Işınlı village, Yukarımahalle place, 1890 m, 1.7.2006, Hamzaoğlu 4112, Aksoy & Budak (KNYA!); Van: around Çatak, Çatak Deresi, c. 1500 m, 12.7.1972, Koyuncu 3765 (GAZI!); Hakkâri, after 126 km from Hakkâri, Çuh Dağı (Çuh Gedigi), 2600 m, 19.7.1956, Birand 484 & Karamanoğlu (ANK!).

*Iranecio elbrusensis* (Boiss.) B.Nordenstam. Iran: Alpb. Elbourz, Aucher Eloy 4708 (G00302791!; K000797437!); Iran: Elamont, Aucher Eloy 4910 (K000797436!); Iran: In declivibus septentrionalibus loci Gerdene Geserek dicti prope pagum Asadbar in partibus occidentalibus m. Elbrus, 8.7.1843, Kotschy 460 (S-G-9784!; GOET002038!; K000797438!).

*Iranecio oligolepis* (Boiss.) B.Nordenstam. Iran: Teheran, Aucher Eloy 4709 (K000797456!); Iran: In latere meridionali m. Demawend, 2.8.1843, Kotschy 609 (K000797455!).

*Turanecio caucasica* (Habitat ad Caucasum): Habitat in jugis alpinis ossitias (?) circa Gobi (?), Adams *s.n.* (B-W16003-010!).

*Turanecio massagetovii*. Georgia: In faucibus fluminis Borzhomka prope stationem viae ferreae Sakoczavi, in saxosis, 25.6.1934, Massagetov *s.n.* (LE!).

*Turanecio kubensis*. Azerbaijan: Kuba, Apmut stream, subalpine zone, rock crevices, 27.7.1930, Sachokiya *s.n.* (BAK 23606!).

*Turanecio munzurdaglarensis* (Yıld.) Hamzaoğlu. Türkiye: Tunceli, Ovacık, Munzur Mountains, Kepir Hill, Bellihasan Çukurluğu ridges, 2500–2700 m, 29.7.1979, Yıldırım 2300 (HUB!).

*Turanecio cariensis* (Boiss.) Hamzaoğlu. Türkiye: Denizli, Honaz Dağı, Kayapınarı, 1720 m, 23.6.2006, Budak 2070, Hamzaoğlu & Aksoy (GAZI!); Antalya, Çalbalı Dağı, 2000–2100 m, Davis 15273 (ANK!); *ibid.*, 14.7.1949, Attila 8956 (ISTF!).

*Turanecio hypochionaeus* (Boiss.) Hamzaoğlu. Türkiye: Bursa, Uludağ, Kırkpınar, 2100–2200 m, 29.7.2006, Hamzaoğlu 4391, Aksoy & Budak (GAZI!); Gümüşhane, between Gümüşhane and Zigana Pass, 1500 m, 12.6.2006, Hamzaoğlu 3861, Aksoy & Budak (GAZI!); Kayseri, Erciyes Dağı, from Sütdonduran to Erciyes peak, 2750–3200 m, 04.8.2006, Hamzaoğlu 4432, Aksoy & Budak (GAZI!); Erzincan, between Çayırılı and Yaylakent, Sipikor Pass, 2370 m, 18.7.2007, Hamzaoğlu 4897, Aksoy & Budak (GAZI!).

*Turanecio lazicus* (Boiss. & Balansa) Hamzaoğlu. Türkiye: Trabzon, Uzungöl, Küçük Yayla, 2050 m, 24.7.1996, Terzioğlu (KATO 12765!); Rize, İkizdere, between Gölyayla and Cihantepe, 2450 m, 25.7.1985, Güner 6638 & Vural (HUB!); Artvin, Yusufeli, Öğdem village, from Kapreşet to Ziyaret hill, 1800–2400 m, 27.7.1982, Demirkuş 1575 (HUB!).

*Turanecio pandurifolius* (K.Koch) Hamzaoğlu. Türkiye: Trabzon, Maçka, Altındere Vadisi, around Coşandere village, 620 m, 5.5.2002, Uzun (KATO 15129!); Rize, Çamlıhemşin, 250 m, 27.4.1981, Güner 3484 (HUB!); Artvin, Yusufeli, Tekkale Yaylası, 2175 m, 25.7.2008, Hamzaoğlu 5238 & Aksoy (GAZI!).

*Turanecio lorentii* (Hochst.) Hamzaoğlu. Türkiye: Bayburt, Kop Dağı, around Şehitlik Anıtı, 2460 m, 18.7.2006, Hamzaoğlu 4331, Aksoy & Budak (GAZI!); Erzurum, west of Çamlıca village, 2050 m, 31.7.1976, Tatlı 5128 (HUB!); Ağrı, between Hamur and Tutak, 5–10 km, 1650 m, 2.6.1966, Davis 44126 (ISTO!).

*Turanecio eriospermus* (DC.) Hamzaoğlu. Türkiye: Kayseri, Sarız, above Yalak (Yeşilkent), Binboğa Dağı, 1700–2000 m, 18.7.1992, Aytaç 5251 & Duman (GAZI!);

Erzurum, Aşkale, above Yumruveren village, 2130 m, 17.7.2007, Hamzaoğlu 4882 & Aksoy (GAZI!); Van, Özalp, Pirreşit Dağı, above Gündüzlü village, Çobantaşı, 2350 m, 26.6.1997, Özgökçe 3386 (VANF!).

***Turanecio taraxacifolius* var. *taraxacifolius*** (M.Bieb.) Hamzaoğlu. Türkiye: Trabzon, Çaykara, Haldizan, Uzungöl, Demirkapı village, 2750 m, 26.8.1995, Terzioğlu s.n. (KATO); Rize, between İkizdere and İspir, Ovit Dağı, 2630 m, 1.8.2005, Budak 1937 & Hamzaoğlu (GAZI!); Ardahan, Çıldır, Sabaholdu village, Sabaholdu Yaylası, Kel Dağ, 2600–3040 m, 1.8.2007, Budak 2246, Hamzaoğlu & Aksoy (GAZI!).

***Turanecio taraxacifolius* var. *discoideus*** (V.A.Matthews) Hamzaoğlu. Türkiye: Muş, Bingöl Dağları, around Dağkale Tepe, 3190 m, 7.8.1989, Alpınar & 'tHart s.n. (ISTE!); Bingöl, Bingöl Dağı, Beritan Yaylası, 2500–2800 m, 22.8.1983, Ekim 7895a (ANK!, GAZI!); Bitlis, Adilcevaz, from Çanakyayla village to Süphan Dağı peak, 3150 m, 20.8.2006, Hamzaoğlu 4528, Aksoy & Budak (GAZI!).

***Turanecio davisii*** (V.A.Matthews) Hamzaoğlu. Türkiye: Hakkâri: Sat Dağı, between Yüksekova and Vargöz, 2000 m, 30.6.1966, Davis 45832 (E!, ISTO!).

***Turanecio farfarifolius*** (Boiss. & Kotschy) Hamzaoğlu Türkiye: Antalya, Alanya, south of Gökbel Yaylası, 1800 m, 18.7.1998, Güner 12648 (GAZI!); Mersin [İçel], between

Ermenek and Anamur, Çamurluyayla, c. 2100 m, 15.8.1949, Davis 16263 (ANK!); Adana, Aladağ, Şamadan Gediği, Sulukeler, 1275 m, 20.6.2006, Budak 2062, Hamzaoğlu & Aksoy (GAZI!).

***Turanecio jurineifolius*** (Boiss. & Balansa) Hamzaoğlu. Türkiye: Kayseri, Tomarza, Aslantaş village, north of Karagöl Dağı, 2405 m, 5.8.2005, Budak 1976, Hamzaoğlu & Aksoy (GAZI!); Kahramanmaraş: Göksun, Binboğa Dağı, above Keklikoluk village, 2530 m, 20.7.2005, Budak 1815, Hamzaoğlu & Aksoy (GAZI!); Adana: Karsantı, Söğüt region, c. 1350 m, 26.5.1973, Yurdakuol 79 (ANK!).

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