

## *Lamium cappadocicum*, a new species from Central Anatolia, Turkey: evidence from molecular and morphological studies

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Received: 20.04.2022 • Accepted/Published Online: 11.09.2022 • Final Version: 23.11.2022

**Abstract:** *Lamium* is a taxonomically convoluted genus of about 34 species. Within *Lamium*, the *L. garganicum* species complex is particularly challenging. Here, based on morphological and molecular studies, *Lamium cappadocicum* Celep & Karaer sp. nova (Lamiaceae) is separated from *L. garganicum* and *L. bilgilitii* and described as a new species, and *L. garganicum* subsp. *rectum* (= *L. garganicum* subsp. *pulchrum*) is resurrected. The new species is only known from the Hasan Mountain (Aksaray) in Central Anatolia, Turkey. *Lamium cappadocicum* is closely related to *L. garganicum* subsp. *rectum* but differs from it by its mat-forming caespitose habit, reniform (rarely ovate in upper part) and deeply cordate leaves with dense white villous hairs, deeply crenate and undulate leaf margins, subglabrous to sparsely pilose stems, and densely white villous calyces. *Lamium cappadocicum* also differs from *L. bilgilitii* by its mat-forming caespitose habit, smaller corollas (25–33 mm versus 40–52 mm in *L. bilgilitii*), subglabrous to sparsely pilose stems and smaller leaves (3–20 (–30) mm long × 3–20 (–30) mm wide, versus 5–45 mm long × 5–45 mm wide in *L. bilgilitii*). Molecular phylogenetic analyses from nuclear ribosomal (nrITS) and chloroplast (*matK*, *rpoA* and *psbA-trnH*) gene regions support the morphological results. The IUCN conservation status, ecology, phenology, etymology, and notes on biogeography of the new species are also given and diagnostic features are discussed.

**Key words:** New species, Lamiaceae, *Lamium*, phylogeny, taxonomy, Turkey

### 1. Introduction

*Lamium* L. is the type genus of Lamiaceae (mint family). Within Lamiaceae, *Lamium* is a member of the subfamily Lamioideae, and consists of about 34 species primarily distributed in Eurasia (especially Turkey), North Africa (including Macaronesia), and Central and East Asia (Harley et al., 2004; Zhao et al., 2021). In addition, some species have been introduced or naturalized in the Americas, Australia, and tropical and South Africa (Mennema, 1989; Harley et al., 2004). Europe and Turkey together encompass about 90% of the diversity within the genus (Ball, 1972; Mill, 1982, 1993; but see Mennema 1989). *Lamium* typically occur in forest understories, rocky mountain slopes and screes, and cultivated field habitats (Mennema, 1989).

Mennema (1989) published the last monograph of the genus, in which he accepted only 16 species (including 33 taxa), with many previously described species being either synonymized or treated as infraspecific taxa. Subsequently, Mill (1993) prepared a *Lamium* conspectus for the Flora of Turkey and East Aegean Islands, and criticized Mennema's

taxonomic treatment, stating that “it is evident that Mennema's treatment is not simply broad, but sweeping: the number of accepted species having been cut to about half. This drastic pruning does little to clarify the taxonomy [of *Lamium*], particularly in critical groups. The worst of these [instances] is undoubtedly the *L. garganicum* L. complex which is notorious for its variability but within which, nevertheless, various geographically localized, more or less clear-cut taxa can be defined. However, Mennema sinks many of these...”. Indeed, within just the *L. garganicum* complex, Mennema (1989) subsumed over 50 taxa as synonyms or infraspecific taxa.

Recent molecular phylogenetic studies (Bendiksby et al., 2011, Krawczyk et al., 2013, 2014) have lent credence to the findings of Mill (1993), and have not supported Mennema's taxonomic treatment at either the species or infrageneric levels. On the basis of molecular phylogenetic studies, three previously synonymized species (*Lamium aleppicum* Boiss. & Hausskn. ex Boiss., *L. paczoskianum* Vorosch., and *L. armenum* Boiss.) have been resurrected (Bendiksby et al., 2011, Krawczyk et al., 2014). In addition,

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Celep (2017) described *L. bilgilitii* Celep, which is closely related to the *L. garganicum* complex, and resurrected *L. ponticum* along with a new subspecies from Turkey (Celep, 2021).

Ryding (2003) included *Wiedemannia* Fisch. & C.A. Mey. within *Lamium*. This taxonomic treatment was supported by Bendiksby et al. (2011). Morphologically distinct *Lamium galeobdolon* (L.) L. has been included as part of *Lamiastrum* Heist. ex Fabr. and *Galeobdolon* Adanson. Harley et al. (2004) included *L. galeobdolon* in *Lamium*, while Bendiksby et al. (2011) reported that “*L. galeobdolon* is sister to all remaining *Lamium* species” based on molecular phylogenetic evidence using nuclear markers. Bendiksby et al. (2011) studied molecular phylogeny using chloroplast data; however, *L. galeobdolon* was embedded within *Lamium*. Taxonomical, morphological, anatomical, and palynological studies within *Lamium* all indicate that the genus needs extensive taxonomic revision (Celep et al., 2011; Atasagun, 2015; Krawczyk & Glowacka, 2015; Atalay et al., 2016a, b).

Between 2000 and 2012, F. Celep (FC) and F. Karaer (FK) did preliminary taxonomic studies and field surveys for *Lamium* of Turkey. Since 2013, within the scope of a taxonomic revision for Turkish *Lamium*, FC and Dr Bilgehan Bilgili (passed away in 2015) conducted extensive field studies and collected all known *Lamium* taxa from Turkey. In addition, FC examined all known *Lamium* taxa from major Turkish and European herbaria. During our field expeditions, we collected *Lamium garganicum* L. subsp. *pulchrum* R. Mill from its two only known localities. However, even at first glance, specimens from the two localities were clearly different from one another. The type specimen collected in calcareous rocky mountain regions from Aladağlar (Mediterranean area) in Niğde is extremely similar to *L. garganicum* subsp. *rectum* (Schenk) R. Mill. On the other hand, the other specimens collected in volcanic rocks/sand and tuffaceous soils from Hasan Mountain in Aksaray (Irano-Turanian area) are morphologically quite different from not only the type specimens of *L. garganicum* subsp. *pulchrum* but also other known taxa within *L. garganicum*. Therefore, it is described here as a new species based on morphological and molecular evidence. In addition, due to nomenclatural priority, we resurrected *L. garganicum* subsp. *rectum*, and *L. garganicum* subsp. *pulchrum* is included within it as a synonym.

## 2. Materials and methods

### 2.1. Plant materials: sampling and outgroups

Specimens, which were collected as part of a systematic revision of Turkish *Lamium* project, are housed in the ADO herbarium (Kırıkkale, Turkey). In addition, the specimens were cross-checked with type and relevant

material housed in the following herbaria: ADO, ANK, BM, E, G, GAZI, HUB, ISTE, ISTF, K, KATO, KNYA, LE, and OMUB. The specimens were also cross-checked with keys provided by Mill (1982) and *Lamium* descriptions from relevant literature including Flora Orientalis (Boissier 1879), Flora Europaea (Ball 1972), Flora Iranica (Mennema 1982), Flora of the USSR (Gorshkova 1954), and Flora of Cyprus (Meikle 1985). Phylogenetic analyses were conducted using two separate datasets, one based upon nuclear ribosomal DNA (nrDNA) and another consisting of chloroplast (cpDNA) regions. The nrDNA dataset contained a total of 25 taxa, including 22 accessions of *Lamium*, while the cpDNA alignment was comprised of 26 taxa, including 23 accessions of *Lamium*. Both datasets included *Eriophyton wallichii* Benth., *Stachyopsis oblongata* (Schrenk) Popov & Vved., and *Roylea cinerea* Baill. as outgroup taxa based on Bendiksby et al. (2011) and Krawczyk et al. (2013, 2014). Thirty-three accessions of *Lamium* were newly sequenced for this study, with the remainder of sequences downloaded from GenBank (Appendix).

### 2.2. DNA extraction, amplification, and sequencing

We extracted DNA from desiccated field-collected leaf material using the DNeasy Plant Mini Kit (Qiagen, Hilden, Germany) as in Celep et al. (2020). For phylogenetic analyses, we generated two datasets, an nrDNA dataset which consisted of the nuclear ribosomal internal transcribed spacer region (nrITS), and a cpDNA dataset containing the *matK*, *rpoA*, and *psbA-trnH* gene regions. The nrITS region was amplified using the primer pair Leu1 (Vargas et al., 1998) and ITS4 (White et al., 1990). The cpDNA regions were amplified using primers described in Krawczyk et al. (2014). Ingredients for PCR reactions as well as thermal cycler conditions followed those described in Drew et al. (2014). We sequenced samples via capillary electrophoreses on an Applied Biosystems 3730XL DNA Analyzer.

### 2.3. Sequence and phylogenetic analyses

Newly acquired sequences were assembled and edited using Geneious v 11.1.5 (Kearse et al., 2012), combined with analogous regions downloaded from GenBank, and subsequently aligned using Mesquite v. 3.61 (Maddison & Maddison, 2019). Bayesian inference (BI) using MrBayes v. 3.2.7 (Huelsenbeck & Ronquist, 2001) and Maximum likelihood (ML) analyses as calculated with RAxML (Stamatakis, 2014) were used as implemented on CIPRES (Miller et al., 2010). For BI, we used models of evolution as suggested by the Akaike information criterion (AIC) in JModelTest2 (Darriba et al., 2012). For the nrITS dataset we used the general time-reversible (GTR) + I +  $\Gamma$  model of evolution, while for the cpDNA dataset we used the suggested GTR model. We ran both MrBayes analyses for 2 million generations, but otherwise used default

parameters. In both instances, adequate mixing as inferred by the standard deviation of split frequencies falling below 0.01, which was achieved prior to 1 million generations.

Maximum likelihood (ML) analyses were done using RAxML-HPC2 on XSEDE (Stamatakis, 2014) as implemented on CIPRES (Miller et al., 2010), under the GTR model of nucleotide substitution with a gamma distribution of rate variation among sites (GTRGAMMA) with 1000 bootstrap replicates and other default parameters.

### 3. Results

#### 3.1. Morphological results

Our field, herbarium, and literature studies demonstrate that our two collections of *Lamium garganicum* subsp. *pulchrum*, which was treated as *L. garganicum* subsp. *striatum* (Sm.) Hayek var. *striatum* by Mennema (1989), known from only two localities, are morphologically distinct from one another. Thus, the description of *L. garganicum* subsp. *pulchrum* as prepared by Mill (1982) was based on two morphologically different specimens (Aladağlar and Hasan mountain), causing confusion.

*Lamium garganicum* subsp. *rectum*, evaluated as a synonym by Mennema (1989), possesses villous stems and is easily distinguished from most other members of the *L. garganicum* complex. Our studies indicated that the type specimen of *L. garganicum* subsp. *pulchrum* from Niğde, Aladağlar is very similar to *L. garganicum* subsp. *rectum* due to its villous and short stems. However, the other specimens (Aksaray, the Hasan Mountain specimens) are clearly different from both the type specimen of *L. garganicum* subsp. *pulchrum* and the other known *L. garganicum* specimens. Based on the above evidence and nomenclatural priority (Article 11 of the Code), we decided to resurrect *L. garganicum* subsp. *rectum*, and that *L. garganicum* subsp. *pulchrum* should be treated within *L. garganicum* subsp. *rectum* as a synonym. Additionally, the Hasan Mountain specimens must be described as a new species.

***Lamium cappadocicum* Celep & Karaer sp. nova (Figure 1)**

**Type:** TURKEY: Aksaray, above Helvadere, north face of Hasan Mountain, about 1.5 km from Yardıbaşı Plateau (Karbeyaz Otel) towards the Aksaray-Adana main road, among volcanic stones/sand and tuffaceous soils, growing in stream beds, 11 July 2014, 38° 09' 01.08" N, 34° 09' 18.39" E, 2178 m, F.Celep 3629 (holotype: GAZI, isotypes ADO, ANK).

**Diagnosis:** *Lamium cappadocicum* (Figure 1) is morphologically similar to *L. garganicum* subsp. *rectum* (= *L. garganicum* subsp. *pulchrum*) (Figure 2) but differs from it by its mat-forming caespitose habit, reniform (rarely ovate in upper part of plant) and deeply cordate

leaves with dense white villous hairs, and deeply crenate and undulate leaf margins, subglabrous to sparsely pilose stems and densely white villous calyx. *Lamium cappadocicum* differs from *L. bilgilitii* by its mat-forming caespitose habit, smaller corollas (25–33 mm versus 40–52 mm in *L. bilgilitii*), subglabrous stems (not very densely eglandular long white villous with short glandular hairy as in *L. bilgilitii*), and generally smaller leaves (3–20 (–30) mm long × 3–20 (–30) mm wide, versus 5–45 mm long × 5–45 mm wide in *L. bilgilitii*).

**Description:** Perennial, mat-forming caespitose plants. Stems ascending-erect, 6–25 (–30) cm, greenish to brownish, subglabrous to sparsely pilose. Leaves mostly reniform (rarely ovate), 3–20 (–30) mm long × 3–20 (–30) mm wide, blade densely white villous hairy, margin deeply crenate, undulate, apex rotund, base cordate, petiole 5–50 mm long, with eglandular short pilose hairs. Verticillasters 1–2, each 4–8-flowered. Bracts ovate to reniform, similar in shape to stem leaves. Bracteole linear, 3–6 mm long. Calyx green, greenish or light purplish around teeth, (6–) 8–12 mm long, densely eglandular villous, tube 5–10 mm long, teeth triangular, 2–6 mm long, teeth shorter than tube. Corolla whitish to very light pinkish, with purple striations on the tube, 25–33 mm long, tube 15–27 mm long; upper lip 6–17 mm long, deeply bifid (3–7 mm long), each appendage on the upper lip divided in two parts (2–4 mm), eglandular villous on the upper lip, lower lip of corolla 6–20 mm long with small purple blotches, lateral lobes very small with one to two subulate teeth, corolla tube straight or rarely slightly curved at the base of corolla tube, nonannulate. Style 23–31 mm long, stigma placed under the upper lip of corolla, bifid with subequal branches. Stamens 4, long villous hairy. Nutlets triangular-obovate.

**Etymology:** The name of the species is derived from the name of the Cappadocia region where the new species grows on Hasan Mountain.

**Habitat, ecology, and phytogeography:** The newly described species mainly occurs in subalpine and alpine ecosystems. The plant primarily grows among volcanic stones in volcanic sand and tuffaceous soils within stream beds on Hasan Mountain between 2120 and 2900 m (Figure 3). It is also found among or under volcanic rocks in volcanic sand and tuffaceous soil areas on the mountain. Although Aladağlar and Hasan Mountain are relatively proximate (approximately 90 km), the Aladağlar Mountain range is part of the Mediterranean phytogeographical region and is composed of limestone, whereas Hasan Mountain is part of the Irano-Turanian phytogeographic region of Central Anatolia and is a volcanic mountain (Davis, 1965). Therefore, the Aladağlar and Hasan Mountain specimens grow in very different habitats in terms of substrate and climate (Figure 3).





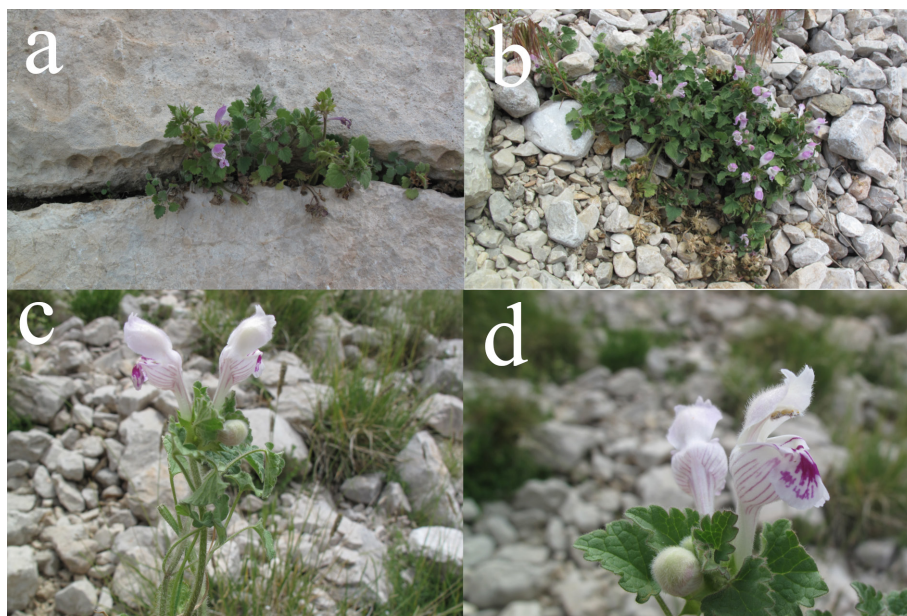
Figure 1. (a) Habitus of *L. cappadocicum*, (b, c, d) flowers and leaves of *L. cappadocicum*.

**Distribution and conservation status:** *Lamium cappadocicum* is known only from the volcanic Hasan Mountain in the Central Anatolia Region of Turkey (Figure 4). *Lamium cappadocicum* should be classified as EN (endangered) according to IUCN (2019) criteria. The estimated area of occupancy is less than 500 km<sup>2</sup> with the number of mature individuals estimated to be less than 2500 (criterion B2abi, ii, iv, v; C2a(ii)). In the area, the most significant threat to the species is habitat destruction through activities such as human encroachment and overgrazing. It is highly possible that a new ski center will be built on Hasan Mountain in the near future. Consequently, the species might be negatively affected by associated road and construction activities.

### 3.2. Molecular results

The topologies recovered in our Bayesian (BI) and maximum likelihood (ML) analyses were mostly congruent for both the nrITS and cpDNA datasets (Figures 5–8).

The nrITS alignment was 680 characters in length. In the nrITS tree of Bayesian (Figure 5) and Maximum Likelihood (ML; Figure 6) analysis, two main clades were recovered within the ingroup. In the first clade, *Lamium galeobdolon* specimens (syn. *Lamiastrum* Heist. Ex Fabr. and *Galeobdolon* Adans) were sister to remaining *Lamium* taxa (Bayesian posterior probability [PP] = 1.00, ML bootstrap [BS] = 100). In the second clade, there were two subclades (PP = 1.00, BS = 100). The first subclade consisted of six species, *L. orvala* L., *L. flexuosum* Ten., *L. tomentosum* Willd., *L. album* L. subsp. *album* L. *gevorense* (Gómez Hern.) Gómez Hern. & A. Pujadas, and *L. bifidum* Cirillo. In the second subclade, there were five species, *L. maculatum* L., *L. macrodon* Boiss. & A. Huet, *L. cappadocicum*, *L. bilgili*, and taxa from *L. garganicum* L. complex. Within the second subclade, *L. maculatum* and *L. macrodon* consisted of a clade (PP = 0.78, BS = 62), and the remaining three species formed a second clade that



**Figure 2.** (a, b) Habitus of *L. garganicum* subsp. *rectum*, (c) stem and flowers of *L. garganicum* subsp. *rectum*, (d) flowers of *L. garganicum* subsp. *rectum*. All photos are from Aladağlar (type locality of *L. garganicum* subsp. *pulchrum*, which now synonym of *L. garganicum* subsp. *rectum*).

included *L. cappadocicum*, *L. bilgilitii*, and *L. garganicum* taxa (PP = 0.96, BS = 76). *Lamium cappadocicum* and *L. bilgilitii* were sister to all *L. garganicum* taxa.

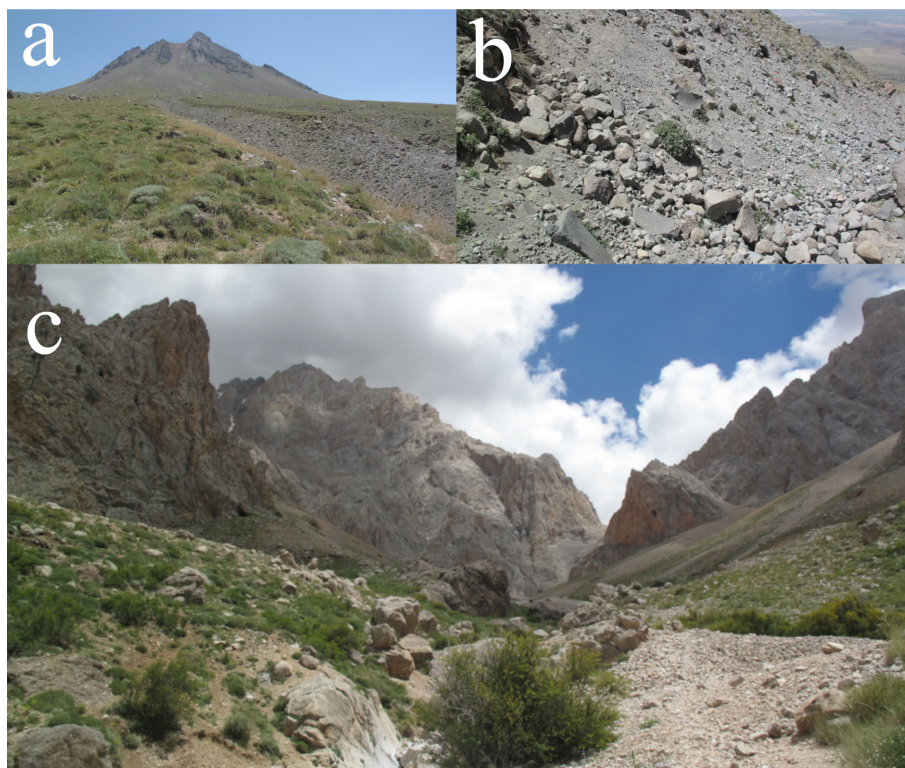
The final combined cpDNA alignment was 1959 characters in length, with *psbA-trnH* accounting for 386 base pairs (we excluded an 18 base pair inversion from all analyses), *rpoA* accounting for 763 base pairs, and *matK* contributing the remaining 810 nucleotides. In the cpDNA BI tree (Figure 7), two clades were recovered (PP = 1, BS = 95). The first clade consisted of only *Lamium album* subsp. *album* and *L. tomentosum*, and the second clade contained the remaining species (PP = 1.00). In this second clade, *L. macrodon* and *L. maculatum* formed one subclade, and the remaining species formed a second subclade (PP = 1.00, BS = 93). In the remaining species, *L. orvala*, *L. galeobdolon*, and *L. flexuosum* formed one clade (PP = 0.81) and *L. bifidum*, *L. amplexicaule* L., *L. gevorense*, *L. bilgilitii*, *L. cappadocicum*, and taxa from the *L. garganicum* complex formed a second subclade. In this second clade, *L. bifidum*, *L. amplexicaule*, and *L. gevorense* formed one subclade (PP = 0.84), BS = 75), the remaining species *L. bilgilitii*, *L. cappadocicum*, and taxa from the *L. garganicum* complex formed a second subclade. In the ML tree (Figure 8), *Lamium cappadocicum* and *L. bilgilitii* were sister species to taxa from the *L. garganicum* complex. On the other hand, in the plastid BI tree (Figure 7), *Lamium cappadocicum* and *L. bilgilitii* were embedded in the *L. garganicum* complex.

#### 4. Discussion

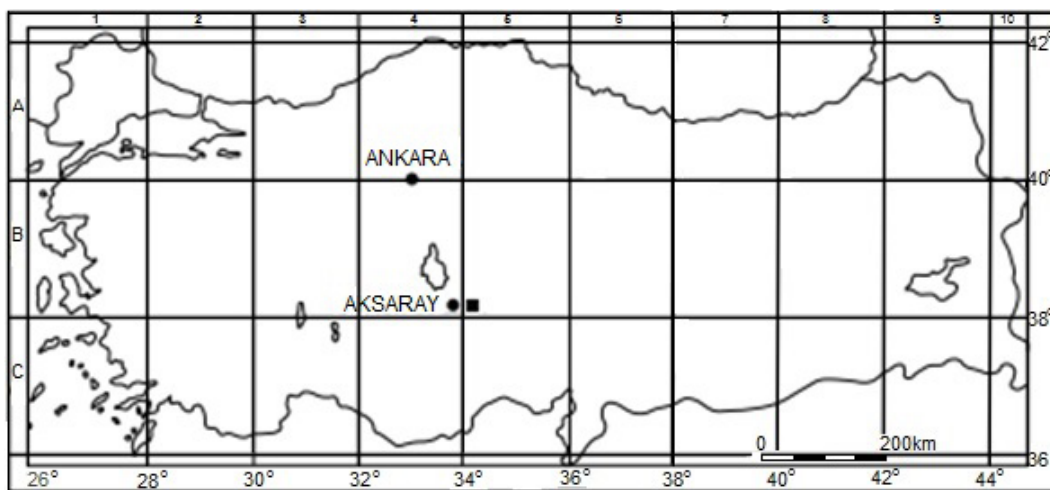
In his monograph, based on mostly herbarium studies, Mennema (1989) amalgamated many taxa (species, subspecies, and varieties) and considerably reduced the number of species and subspecific taxa within *Lamium*. However, our extensive field, literature, and herbarium studies suggest that many taxa should be resurrected, a sentiment previously espoused by Mill (1993).

*Lamium garganicum* is a widely distributed and morphologically variable species. Before Mennema's monograph (1989), the species had several local subspecies with stable geographic distributions and morphological characters (e.g., *L. garganicum* subsp. *nepetifolium* (Boiss.) R. Mill, *L. garganicum* subsp. *laevigatum* Arcangeli, *L. garganicum* subsp. *rectum*). Mennema (1989) also subsumed some local endemic species that only grow at high altitudes in the Mediterranean region of Turkey (*L. cymbalariifolium* Boiss., *L. microphyllum* Boiss., *L. sandrasicum* P.H. Davis) within the *L. garganicum* complex. In addition, some morphologically distinct species such as *L. armenum* Boiss. were treated within *L. garganicum* (as *L. garganicum* L. var. *armenum* Mennema) by Mennema (1989). Thus, *L. garganicum* has a very broad taxonomic circumscription in the Mennema's monograph. While conducting herbarium studies at the Edinburgh herbarium (E), we closely examined specimens of the Turkish endemic *L. garganicum* subsp. *pulchrum* and other *L. garganicum* specimens. Our studies in the Edinburgh





**Figure 3.** (a) Hasan Moutain, (b) habitat of *L. cappadocicum*, volcanic sand and tuffaceous soils (c), Aladağlar, calcareous rock and calcareous soils.



**Figure 4.** Distribution map of *Lamium cappadocicum* (■).

herbarium supported our field observations. There were two morphologically different taxa in the *L. garganicum* subsp. *pulchrum* specimens as stated above. Therefore, the description of *L. garganicum* subsp. *pulchrum* was prepared based on these two morphologically different plant populations, one from Hasan Mountain (Düzenli 3080!) and the other ones from Aladağlar Mountain

(P.W. Wood & W.B. Gibson 117! (holotype), Darrah 379!, Findlay 120!, 161!, Parry 133!). The holotype (P.W. Wood & W.B. Gibson 117!, Edinburgh herbarium) of *L. garganicum* subsp. *pulchrum* was designated from the Aladağlar (Niğde) specimen. All Aladağlar specimens had a noncaespitose habit (plants on Hasan Mountain mat-forming caespitose), sparsely pilose to subglabrous and

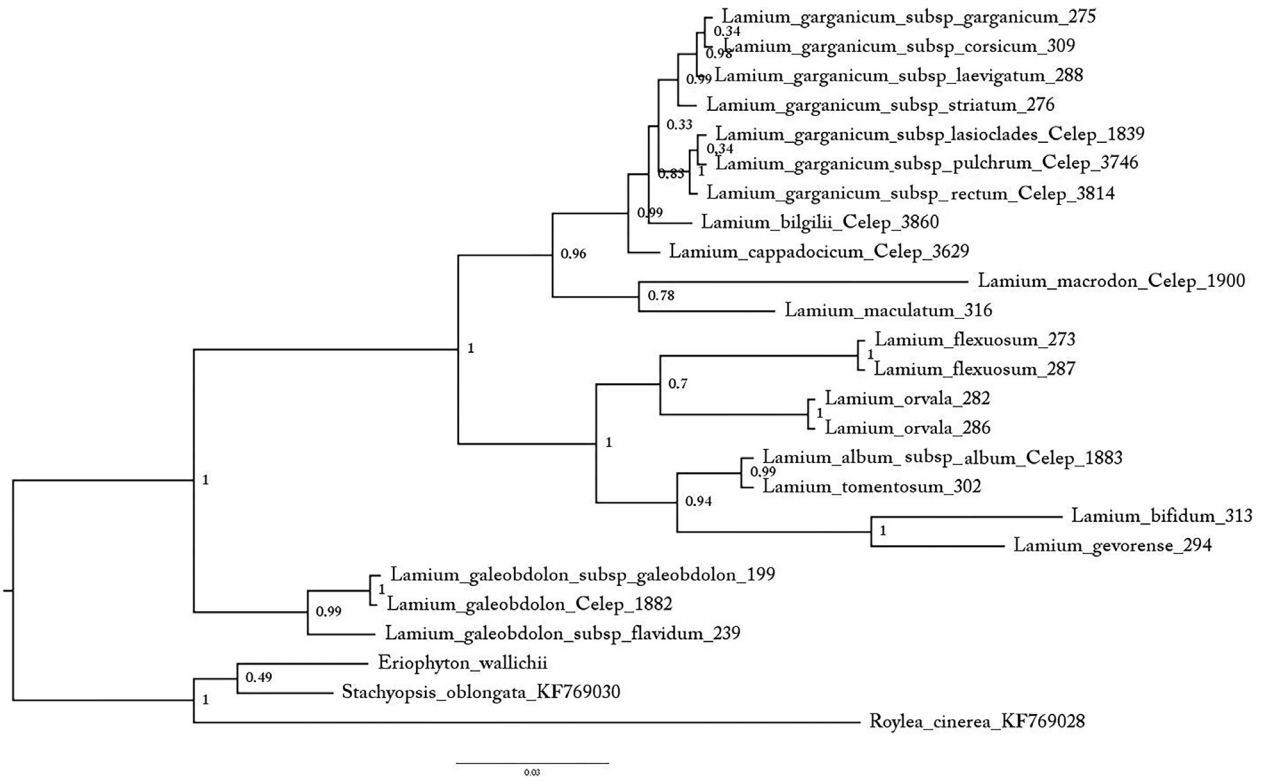


Figure 5. Bayesian inference (BI) analysis of studied *Lamium* species with posterior probability values based on nrDNA data (ITS).

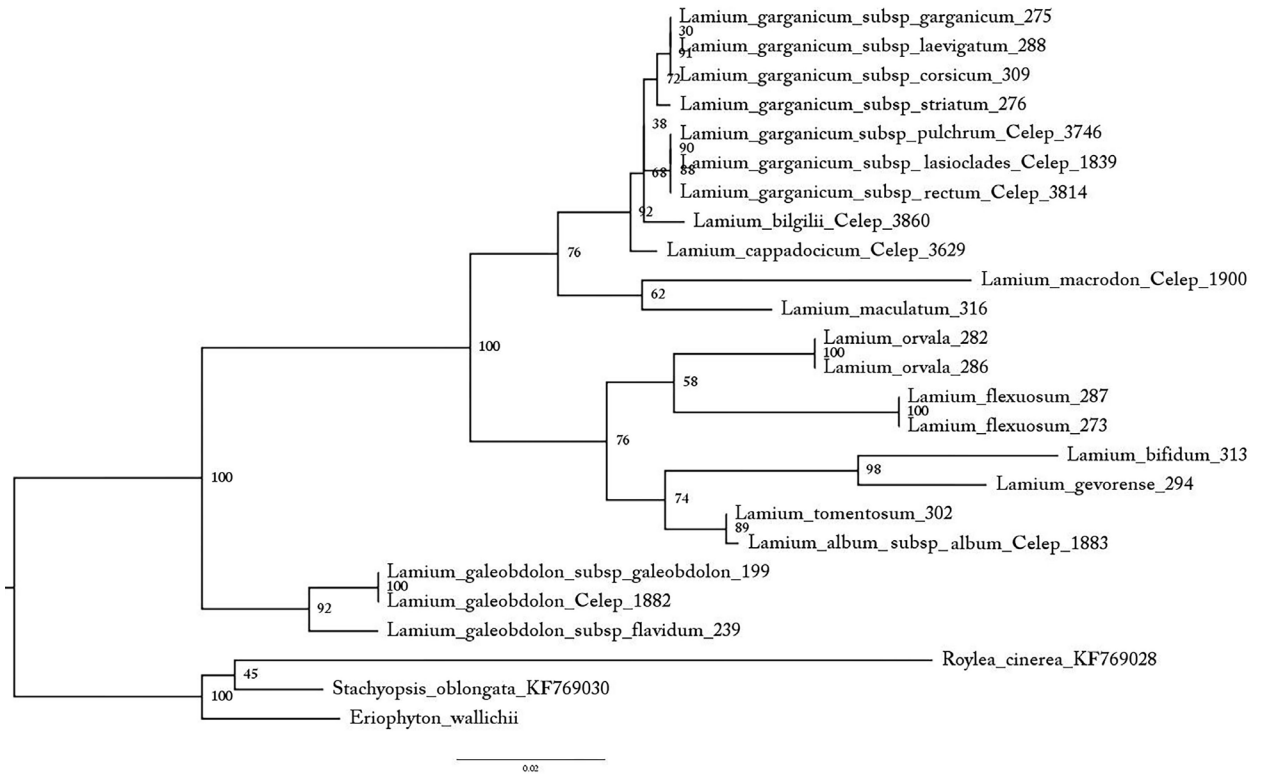


Figure 6. Maximum likelihood (ML) analysis of studied *Lamium* species with bootstrap values based on nrDNA data (ITS).

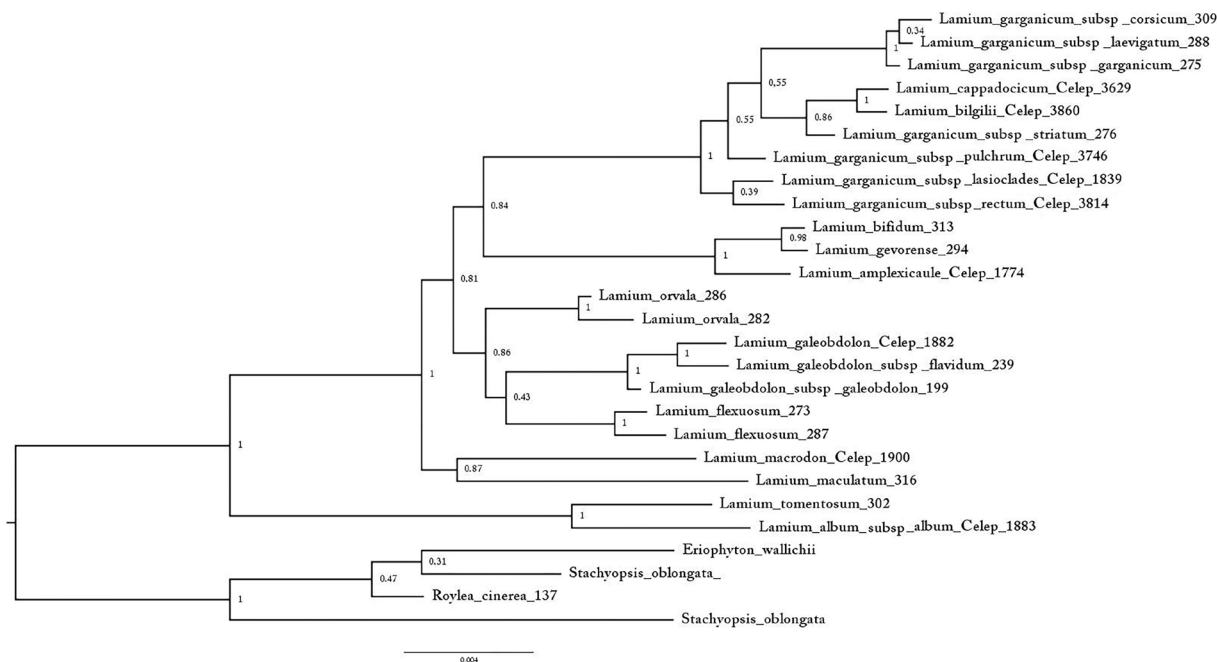


Figure 7. Bayesian inference (BI) analysis of studied *Lamium* species with posterior probability values based on cpDNA data (*matK* + *rpoA* + *psbA-trnH* gene regions).

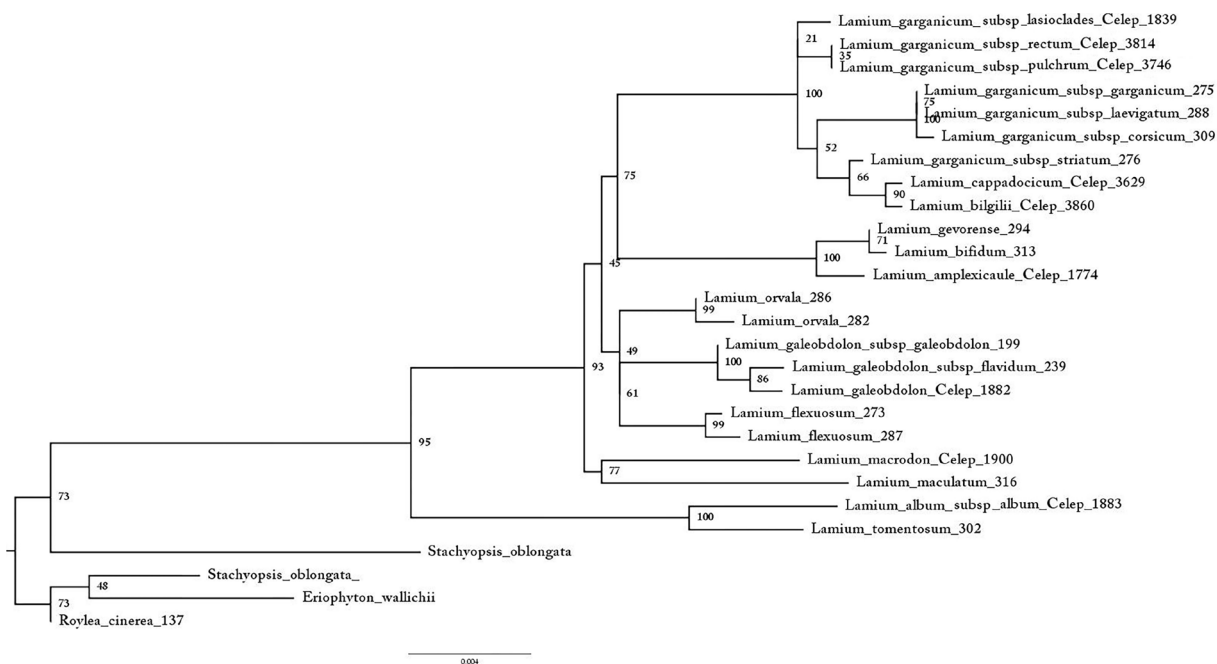


Figure 8. Maximum likelihood (ML) analysis of studied *Lamium* species with bootstrap values based on cpDNA data (*matK* + *rpoA* + *psbA-trnH* gene regions).

ovate leaves (densely white villous and reniform on Hasan Mountain), crenate but nonundulate leaf margins (deeply crenate and undulate on Hasan Mountain), densely white villous stems (subglabrous to sparsely pilose on Hasan Mountain), and glabrous to sparsely pilose calyces (densely white villous in Hasan Mountain). Indeed, Aladağlar

specimens were more similar to *L. garganicum* subsp. *rectum* (Mill, 1982), which was treated as *L. garganicum* subsp. *striatum* by Mennema.

Our morphological (Figures 1–3) and molecular studies (Figures 5–8) demonstrate that *L. garganicum* subsp. *rectum* should be resurrected. Another described



subspecies, *L. garganicum* subsp. *lasioclades* (Stapf) R. Mill. is morphologically very similar to *L. garganicum* subsp. *rectum*. While both taxa have villous stems (except for Bitlis, Van and Mardin specimens of *L. garganicum* subsp. *lasioclades*), the two taxa can be easily differentiated at their morphological extremes. For example, *L. garganicum* subsp. *lasioclades* has larger corollas and stems relative to *L. garganicum* subsp. *rectum* (Mill, 1980). However, during field observations, we noticed that the two subspecies differ along a morphological gradient.

Although we recovered a well or moderately supported phylogeny in the studied species, there are a few discordances between nrDNA and cpDNA phylogenies. One of the main difference between the nrDNA and cpDNA trees is *L. galeobdolon* specimens were sister to remaining *Lamium* taxa in the ITS tree; however, *L. galeobdolon* species were formed a clade with *L. orvala* and *L. flexuosum* in the middle of the tree in the cpDNA trees (Figures 5–8). Similarly, *L. album* and *L. tomentosa* specimens were sister to remaining *Lamium* species in the cpDNA trees; however, they are placed in the middle of the tree in the nrDNA tree (Figures 5–8). These results are congruent with those of Bendiksby et al. (2011). In the ITS tree, *L. cappadocicum* was placed next to *L. bilgii* and *L. garganicum* taxa in both BI and ML trees; however, in the cpDNA tree both *L. cappadocicum* and *L. bilgii* were placed among the *L. garganicum* taxa in both BI and ML trees (Figures 5–8).

Another issue is that Mill (1982) put a note under *L. garganicum* subsp. *reniforme* (Montbret & Aucher ex Benth) RR. Mill, which is now a synonym of *L. garganicum* subsp. *striatum*, that the “two specimens (Hasan Mountain, nr. Taşpınar Y., 2000 m, Davis 18995! and ibid., 2600 m, Davis 18962!) may represent one or two

new taxa but further collections from the area needed”. We visited both localities (in Hasan Mountain) to find cited specimens, and examined these herbarium specimens in the Edinburgh herbarium. The specimens that were collected in the Hasan Mountain from 2000 to 2160 m are very similar to *L. garganicum* subsp. *striatum*. We found specimens with subglabrous to pilose stems and leaves, and with the upper lips of corollas entire, shortly retuse, bifid, or trifid flowers. On the other hand, at higher elevations in the same area, approximately 2600–2650 m, we found both our proposed new species *L. cappadocicum* and some other *L. garganicum* subsp. *striatum* specimens, which grow in shady rocky habitats on north facing slopes.

In conclusion, our long-term field and herbarium studies and recent molecular studies (Bendiksby et al., 2011, Krawczyk et al., 2013, 2014) have shown that further morphological, molecular phylogenetic, and biogeographic studies are needed within *Lamium* (particularly on the *L. garganicum* complex) to elucidate the confusing taxonomy that currently exists. In this way, we can understand and solve the problems on the genus and delimit species boundaries.

#### Acknowledgments

We thank the curators of ADO, ANK, BM, E, G, GAZI, HUB, K, KATO, KNYA, LE, OMUB, and Z herbaria for permitting the examination of their *Lamium* collections, and to the Scientific and Technical Research Council of Turkey (TÜBİTAK) (project no: 112-T-131 and 121Z374, TÜBİTAK) for their financial support. Drew acknowledges support from the United States National Science Foundation (DEB-1655611). This paper is dedicated to the memory of our wonderful colleague, Dr Bilgehan Bilgili, who passed away in 2015.

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**Appendix.** Used accession numbers for phylogenetic analysis.

Accession Numbers ITS	Gene Region	Taxon Name	Collector/Isolate Number
OK166637	ITS	<i>Lamium galeobdolon</i>	Celep 1882
OK166638	ITS	<i>L. garganicum</i> subsp. <i>lasioclades</i>	Celep 1839
OK166639	ITS	<i>L. garganicum</i> subsp. <i>pulchrum</i>	Celep 3746
OK166640	ITS	<i>L. cappadocicum</i>	Celep 3629
OK166641	ITS	<i>L. garganicum</i> subsp. <i>rectum</i>	Celep 3814
OK166642	ITS	<i>L. bilgilitii</i>	Celep 3860
OK166643	ITS	<i>L. album</i> subsp. <i>album</i>	Celep 1883
OK166644	ITS	<i>L. macrodon</i>	Celep 1900
JX073980.1	ITS	<i>L. garganicum</i> subsp. <i>garganicum</i>	275
KC350629.1	ITS	<i>L. garganicum</i> subsp. <i>corsicum</i>	309
KC350631.1	ITS	<i>L. garganicum</i> subsp. <i>laevigatum</i>	288
JX073981.1	ITS	<i>L. garganicum</i> subsp. <i>striatum</i>	276
KF055054.1	ITS	<i>L. maculatum</i>	316
KC350620.1	ITS	<i>L. flexuosum</i>	273
KC350622.1	ITS	<i>L. flexuosum</i>	287
JX073983.1	ITS	<i>L. orvala</i>	282
KF055057.1	ITS	<i>L. orvala</i>	286
KC350641.1	ITS	<i>L. tomentosum</i>	302
KF055052.1	ITS	<i>L. bifidum</i>	313
KC350634.1	ITS	<i>L. gevorense</i>	294
JX073958.1	ITS	<i>L. galeobdolon</i> subsp. <i>galeobdolon</i>	199
JX073961.1	ITS	<i>L. galeobdolon</i> subsp. <i>flavidum</i>	239
KM886719.1	ITS	<i>Eriophyton wallichii</i>	SNJ Exped. 20110814032
KF769030	ITS	<i>Stachyopsis oblongata</i>	I. Roldugin & V. Fissjun 5394
KF769028	ITS	<i>Roylea cinerea</i>	W. Koeltz 4651
ON286905	matK	<i>Lamium galeobdolon</i>	Celep 1882
ON286907	matK	<i>L. garganicum</i> subsp. <i>lasioclades</i>	Celep 1839
ON286909	matK	<i>L. garganicum</i> subsp. <i>pulchrum</i>	Celep 3746
ON286908	matK	<i>L. cappadocicum</i>	Celep 3629
ON286910	matK	<i>L. bilgilitii</i>	Celep 3860
ON286906	matK	<i>L. album</i> subsp. <i>album</i>	Celep 1883
ON286912	matK	<i>L. macrodon</i>	Celep 1900
ON286911	matK	<i>L. amplexicaule</i>	Celep 1774
KF055070.1	matK	<i>L. garganicum</i> subsp. <i>garganicum</i>	275
KF188556.1	matK	<i>L. garganicum</i> subsp. <i>corsicum</i>	309
KF055071.1	matK	<i>L. garganicum</i> subsp. <i>laevigatum</i>	288
KF055073.1	matK	<i>L. garganicum</i> subsp. <i>striatum</i>	276
KF055083.1	matK	<i>L. maculatum</i>	316
KF188548.1	matK	<i>L. flexuosum</i>	273
KF188549.1	matK	<i>L. flexuosum</i>	287
KF188565.1	matK	<i>L. orvala</i>	282



## Appendix. (Continued).

KF055088.1	matK	<i>L. orvala</i>	286
KF055090.1	matK	<i>L. tomentosum</i>	302
KF055065.1	matK	<i>L. bifidum</i>	313
KF055075.1	matK	<i>L. gevorense</i>	294
KF188552.1	matK	<i>L. galeobdolon</i> subsp. <i>galeobdolon</i>	199
KF188551.1	matK	<i>L. galeobdolon</i> subsp. <i>flavidum</i>	239
JF953696.1	matK	<i>Eriophyton wallichii</i>	D990
HQ911463.1	matK	<i>Stachyopsis oblongata</i>	147a
HQ911454.1	matK	<i>Roylea cinerea</i>	W. Koeltz 4651
ON286921	rpoA	<i>Lamium galeobdolon</i>	Celep 1882
ON286923	rpoA	<i>L. garganicum</i> subsp. <i>lasioclades</i>	Celep 1839
ON286926	rpoA	<i>L. garganicum</i> subsp. <i>pulchrum</i>	Celep 3746
ON286924	rpoA	<i>L. cappadocicum</i>	Celep 3629
ON286925	rpoA	<i>L. garganicum</i> subsp. <i>rectum</i>	Celep 3814
ON286927	rpoA	<i>L. bilgii</i>	Celep 3860
ON286922	rpoA	<i>L. album</i> subsp. <i>album</i>	Celep 1883
ON286928	rpoA	<i>L. amplexicaule</i>	Celep 1774
ON286929	rpoA	<i>L. macrodon</i>	Celep 1900
KC350679.1	rpoA	<i>L. garganicum</i> subsp. <i>garganicum</i>	275
KC350678.1	rpoA	<i>L. garganicum</i> subsp. <i>corsicum</i>	309
KC350681.1	rpoA	<i>L. garganicum</i> subsp. <i>laevigatum</i>	288
KC350682.1	rpoA	<i>L. garganicum</i> subsp. <i>striatum</i>	276
KF055147.1	rpoA	<i>L. maculatum</i>	316
KC350662.1	rpoA	<i>L. flexuosum</i>	273
KC350664.1	rpoA	<i>L. flexuosum</i>	287
KC350702.1	rpoA	<i>L. orvala</i>	282
KF055151.1	rpoA	<i>L. orvala</i>	286
KC350708.1	rpoA	<i>L. tomentosum</i>	302
KF055139.1	rpoA	<i>L. bifidum</i>	313
KC350685.1	rpoA	<i>L. gevorense</i>	294
KC350672.1	rpoA	<i>L. galeobdolon</i> subsp. <i>galeobdolon</i>	199
KC350669.1	rpoA	<i>L. galeobdolon</i> subsp. <i>flavidum</i>	239
-	rpoA	<i>Eriophyton wallichii</i>	
-	rpoA	<i>Stachyopsis oblongata</i>	
-	rpoA	<i>Roylea cinerea</i>	
ON286913	psba-trnH	<i>Lamium galeobdolon</i>	Celep 1882
ON286917	psba-trnH	<i>L. garganicum</i> subsp. <i>lasioclades</i>	Celep 1839
ON286915	psba-trnH	<i>L. cappadocicum</i>	Celep 3629
ON286918	psba-trnH	<i>L. garganicum</i> subsp. <i>rectum</i>	Celep 3814
ON286916	psba-trnH	<i>L. bilgii</i>	Celep 3860
ON286914	psba-trnH	<i>L. album</i> subsp. <i>album</i>	Celep 1883
ON286919	psba-trnH	<i>L. macrodon</i>	Celep 1900
ON286920	psba-trnH	<i>L. amplexicaule</i>	Celep 1774
JX074038.1	psba-trnH	<i>L. garganicum</i> subsp. <i>garganicum</i>	275

## Appendix. (Continued).

KC350728.1	psba-trnH	<i>L. garganicum</i> subsp. <i>corsicum</i>	309
KC350730.1	psba-trnH	<i>L. garganicum</i> subsp. <i>laevigatum</i>	288
JX074039.1	psba-trnH	<i>L. garganicum</i> subsp. <i>striatum</i>	276
KF055110.1	psba-trnH	<i>L. maculatum</i>	316
KC350719.1	psba-trnH	<i>L. flexuosum</i>	273
KC350720.1	psba-trnH	<i>L. flexuosum</i>	287
JX074044.1	psba-trnH	<i>L. orvala</i>	282
KF055114.1	psba-trnH	<i>L. orvala</i>	286
KC350746.1	psba-trnH	<i>L. tomentosum</i>	302
KF055100.1	psba-trnH	<i>L. bifidum</i>	313
KC350733.1	psba-trnH	<i>L. gevorense</i>	294
JX074016.1	psba-trnH	<i>L. galeobdolon</i> subsp. <i>galeobdolon</i>	199
JX074019.1	psba-trnH	<i>L. galeobdolon</i> subsp. <i>flavidum</i>	239
JN044480.1	psba-trnH	<i>Eriophyton wallichii</i>	D990
JF780107.1	psba-trnH	<i>Stachyopsis oblongata</i>	I. Roldugin & V. Fissjun 5394
JF780106.1	Psba-trnH	<i>Roylea cinerea</i>	O. Polunin & al. 837