

Nutlet Surface Micromorphology of the Genus *Nepeta* L. (Lamiaceae) in Turkey

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Abstract: Nutlet characters within the genus *Nepeta* L. are of taxonomic significance. In this study, the nutlet morphology of 39 taxa of Turkish *Nepeta* species was examined using both stereoscopic and scanning electron microscopy (SEM). According to surface ornamentations, 3 main types, smooth, partly smooth, and sculptured, and 7 subtypes, undulate-ridged, cellular, reticulate, protuberance, papillate, verrucate, and tuberculate, were defined and illustrated. In addition, the unknown nutlet features of *N. conferta* Hedge & Lamond, *N. crinita* Montbret & Aucher ex Bentham, and *N. viscida* Boiss. are given for the first time here in detail. It is clear that external nutlet characters, especially surface texture, could help in the classification of the species of the complex genus *Nepeta* in the future.

Key Words: *Nepeta*, Lamiaceae, nutlet, micromorphology, SEM

Türkiye'de *Nepeta* L. (Lamiaceae) Cinsinin Tohum Yüzey Mikromorfolojisi

Özet: *Nepeta* L. cinsinin nutlet karakterleri taksonomik öneme sahiptir. Bu çalışmada, Türkiye'de yayılışı olan *Nepeta* türlerinin nutlet morfolojisi stereoskopik ve taramalı electron mikroskobu kullanılarak (SEM) incelenmiştir. Yüzey süs özelliklerine göre, düz, kısmen düz ve yüzeyi şekilli olmak üzere üç ana tip ve dalgalı-damarlı, gözenekli, ağimsi, küçük kabarcıklı, papilli, siğilli ve yumrulu olmak üzere yedi alttip tanımlanmış ve fotoğrafları verilmiştir. Ayrıca *N. conferta* Hedge & Lamond, *N. crinita* Montbret & Aucher ex Bentham ve *N. viscida* Boiss.'nın bilinmeyen nutlet özellikleri ilk kez ayrıntılı olarak burada verilmiştir. Dış nutlet karakterleri, özellikle yüzey yapıları, karmaşık olan *Nepeta* cinsinin sınıflandırılmasına gelecekte katkı sağlayacağı açıktır.

Anahtar Sözcükler: *Nepeta*, Lamiaceae, nutlet, mikromorfoloji, SEM

Introduction

Nepeta L., consisting of about 300 species, is one of the largest genera in Lamiaceae (Pojarkova, 1954; Başer et al., 2000; Jamzad et al., 2003; Jamzad et al., 2005). *Nepeta* species are distributed throughout Southwest and Central Asia, Europe, North Africa, North and Central America, Japan, Korea, China, and the Canary Islands (Pojarkova, 1954; Hedge, 1978; Jamzad et al., 2000), but most of the species are found in Southwest and Central Asia and Transcaucasia. The species grow in various habitats from the seashore to the alpine zone (Pojarkova, 1954).

The genus *Nepeta* is represented by 35 species, comprising 40 taxa, of which 19 are endemic in Turkey

(Hedge & Lamond, 1982; Aytaç & Yıldız, 1996; Güner et al., 2000; Dirmenci, 2005). The endemism rate is 48%. Most of the species are distributed in East Anatolia and the Taurus mountains in Turkey.

Nepeta species are herbaceous perennial, rarely annual. Many of these species are often pleasantly aromatic, rich in essential oils, and of potential economic interest. Several *Nepeta* species are used in folk medicine as diuretic, diaphoretic, antitussive, antispasmodic, anti-asthmatic, febrifuge, emmenagogue, and sedative agents (Tzakou et al., 2000; Rapisarda et al., 2001).

Frequent hybridisation and introgression, together with substantial age or habitat-linked variation, make *Nepeta* a particularly complex genus. The genus *Nepeta* is

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divided into 3 informal groups (designated A, B, and C) based largely on flower colour and inflorescence characters in the *Flora of Turkey*. Group A (consists of 14 species): flowers white, yellow or pinkish, nutlets tuberculate throughout or at apex; group B (consists of 16 species): flowers lilac or deep blue, nutlets tuberculate or smooth; and group C (Sect. *Oxynepeta* Benth., consists of 3 species): flowers white, lilac or purple, nutlets tuberculate, \pm spherical (Hedge & Lamond, 1982).

In systematic revisions of any group of a genus the micromorphological character of nutlet surfaces are either totally ignored or only seldom mentioned in spite of their stability as characters. Various researchers have shown that this microcharacter can be used at generic, specific, and even at varietal level (Husain et al., 1990). In recent times the importance of scanning electron microscopy (SEM) in the study of nutlet surfaces and the taxonomic value of nutlet characters has been described in many genera of the Lamiaceae (Husain et al., 1990; Demissew & Harley, 1992; Marin et al., 1996; Budantsev & Lobova, 1997; Jamzad et al., 2000). Nutlet morphology in the Lamiaceae has proved useful to varying degrees at different levels of the taxonomic hierarchy (Budantsev & Lobova, 1997). Furthermore, the importance of the morphology of nutlet surfaces has already been demonstrated for *Nepeta* (Hedge, 1962; Hedge & Lamond, 1968; Rechinger, 1982; Uebera & Valdes, 1983; Budantsev & Lobova, 1997; Jamzad et al., 2000; Mosquero et al., 2002).

Many morphological characters in *Nepeta* are variable and some of these, such as indumentum, leaf shape and size, calyx and corolla characters can vary among closely related species (Hedge & Lamond, 1968). As a result, diagnostic use of such characters above the species level is problematic. Nutlets are good characters for species recognition (Jamzad et al., 2003).

In the present work, SEM was used to determine the micromorphology of the nutlet surface of *Nepeta* species in Turkey both to improve the present knowledge of the species and to evaluate the usefulness of this feature for systematic purposes.

Materials and Methods

This study is based on dry herbarium specimens deposited in the Herbarium of the Faculty of Pharmacy of Anadolu University in Eskişehir (ESSE) and the

Herbarium of the Faculty of Science & Arts in Balıkesir University, Turkey (see appendix). Measurements and optical observations of nutlet colours were carried out under a stereomicroscope Wild M5. For SEM, dry mature nutlets were mounted directly on stubs, using single-sided adhesive tape, and coated with gold. Photographs were taken with a Cam Scan S4. The terminology of nutlet coat surface sculpturing mainly follows Stearn (1992) and Budantsev and Lobova (1997). The nutlet micromorphology of 39 taxa of *Nepeta* species was examined but only pictures of nutlets showing typical differences are given.

Results

Nutlets of 39 taxa were examined in detail in this study. Nutlets of *Nepeta* are glabrous rarely apically pilose, black, blackish-brown or brown, oblong (1.5-3 \times 0.8-1.4 mm), broadly oblong (1.2-3 \times 0.7-1.8 mm) and \pm rounded (1.8-2.2 \times 1.5-2 mm), trigonous, areole bilobed or straight. Three main types in *Nepeta* species can be distinguished based on surface ornamentation: smooth-type I, partly smooth-type II, and sculptured-type III; within these types, variants can be recognised.

TYPE I: The smooth nutlets may be divided into 3 subtypes.

Undulate-ridged: The nutlet surface has a prominent undulate-ridged pattern formed by hexagonal cells. Taxa with this type of nutlets are: *N. baytopii* Hedge & Lamond, *N. fissa* C.A.Mey. (Figures 1 & 2), *N. macrosiphon* Boiss. (Figures 3 & 4), and *N. cataria* L. (Figures 5 & 6).

Cellular: The cellular pattern consists of regular groups of polygonal cells as a flowered pattern, which is only observed in *N. humulis* Benth. Nutlets of *N. humulis* have a bright surface (Figures 7 & 8). The other cellular type observed in *N. heliotropifolia* Lam. var. *heliotropifolia*, made up deep rounded or polygonal cells within this subtype, may be recognised as pitted-granular (Figures 9 & 10).

Reticulate: The reticulate pattern consists of large rounded-polygonal cells with more prominent walls. Among the species studied, only *N. phyloclamys* P.H.Davis has this subtype of nutlets (Figures 11 & 12).

TYPE II: The partly smooth surface is characterised by the papillate and protuberance, which are especially

located towards the apex, margin and rarely ventral surface, and their length is about 10-40 μm . The epidermal cells of the pericarp appear irregularly rounded and polygonal, sometimes with prominent walls. The partly smooth nutlets have 2 subtypes.

Protuberance: The protuberances are generally rounded and cone-shaped and with a rounded or truncate apex. Taxa included in this subtype are: *N. lamifolia* Willd., *N. obtusicrena* Boiss. & Kotschy ex Hedge, *N. meyeri* Benth. (Figures 13 & 14), *N. congesta* Fisch. & Mey. var. *congesta*, *N. congesta* Fisch. & Mey. var. *cryptantha* (Boiss.) Hedge & Lamond (Figures 15 & 16), *N. betonicifolia* C.A.Mey. (Figures 17 & 18). The apex of nutlets in only *N. betonicifolia* is typically long, acute-acuminate, and with an undulating margin (Figure 18).

Papillate: The epidermal cells of the pericarp are in a papillate pattern, which is observed on the apex margin and ventral surface. The taxa in this subtype are *N. stricta* (Banks & Sol.) Hedge & Lamond var. *curvidens* (Boiss. & Bal.) Hedge & Lamond, and *N. stricta* (Banks & Sol.) Hedge & Lamond var. *stricta* (Figures 19 & 20).

TYPE III: Nutlet surface is sculptured, characterised by having rounded or cone-shaped tubercles. They occur on all surfaces. The length of sculpture is about 20-100 μm . The epidermal cells of the pericarp appear rounded or polygonal, with or without prominent walls. The sculptured nutlets have 2 subtypes.

Verrucate: The epidermal cells of the pericarp are in a verrucate pattern, which is star-shaped in *N. cadmea* Boiss., *N. nuda* L. subsp. *lydiae* P.H.Davis (Figures 21 & 22), and *N. concolor* Boiss. & Heldr. apud Benth., which is with or without hairs on the apex. The papillate-verrucate texture with papillae on the surface of the nutlets can be considered a variant of the verrucate pattern. Among the taxa studied, *N. crinita* Montbret & Aucher ex Benth., *N. conferta* Hedge & Lamond, *N. nuda* L. subsp. *nuda*, *N. nuda* L. subsp. *grandulifera* Hub.-Mor. & Davis, *N. pilinix* P.H.Davis (Figures 23 & 25) and *N. viscida* Boiss. (Figures 26 & 27). The apex of the nutlets of *N. crinita* and *N. pilinix* (Figure 24) is long-haired.

Tuberculate: Tuberculate pattern is characterised by being oblong or cone-shaped (Figures 28 & 39). The tubercles have a rounded, convex, or truncate apex forming one or more layers of radial cells (Figures 32 & 33, 36 & 37). Thorn-like texture can be considered a variant of the tuberculate pattern (Figures 29, 31, 35 &

39). Taxa included in this subtype are *N. aristata* Boiss. & Kotschy ex Boiss., *N. caesarea* Boiss. (Figures 28 & 29), *N. trachonitica* Post (Figures 30 & 31), *N. sorgerae* Hedge & Lamond (Figures 32 & 33), *N. stenantha* Boiss. & Kotschy ex Boiss. (Figures 34 & 35), *N. cilicia* Boiss. apud Benth. (Figures 36 & 37), *N. racemosa* Lam. (Figures 38 & 39), *N. flavida* Hub.-Mor., *N. glomerata* Montbret & Aucher ex Benth., *N. isaurica* Boiss. & Heldr. apud Benth., *N. italica* L., *N. nuda* L. subsp. *albiflora* (Boiss.) Gams, *N. sulfuriflora* P.H.Davis, *N. transcaucasica* Grossh., and *N. sibthorpii* Benth. subsp. *tumeniana* T.Dirmenci.

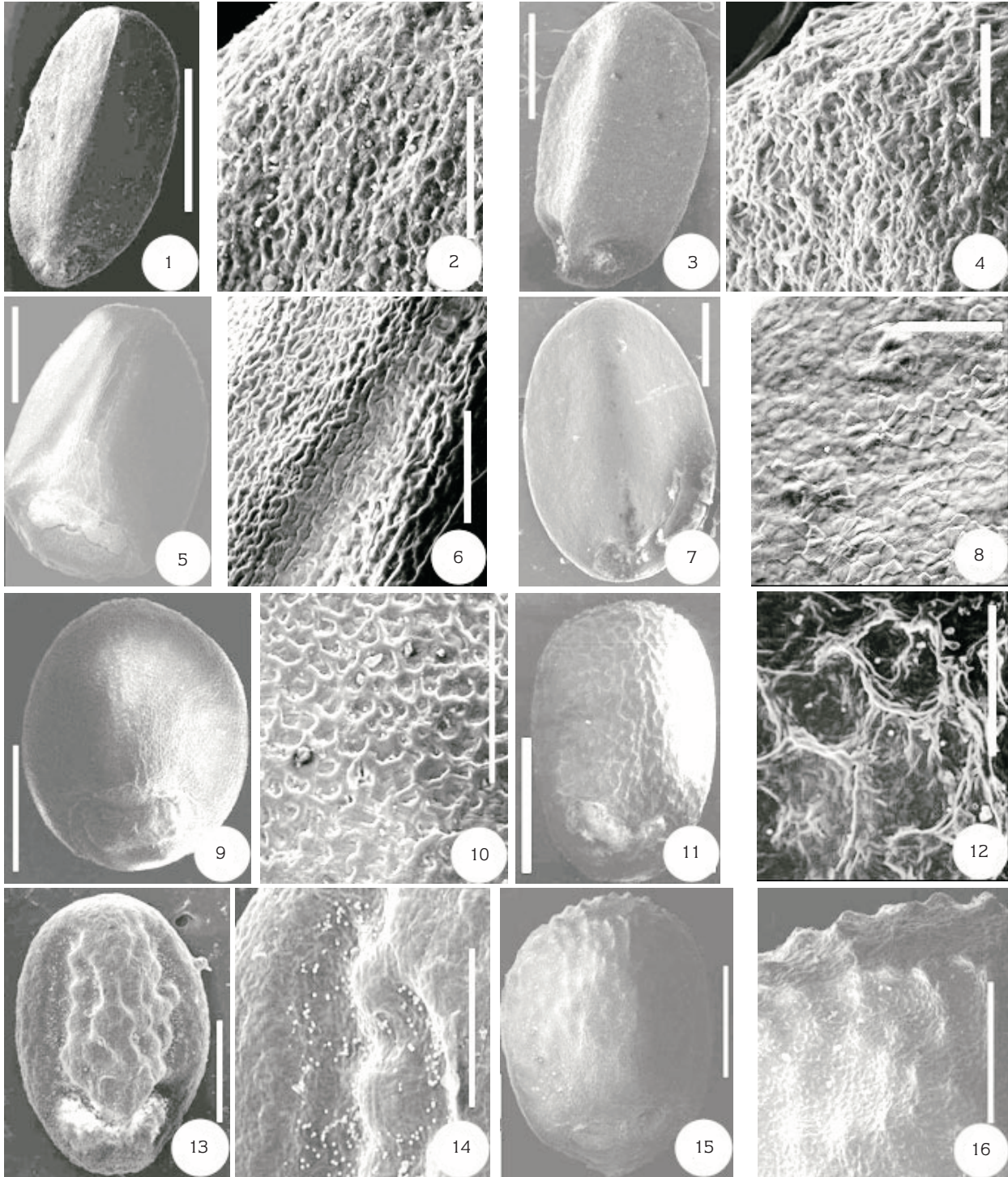
A summary of the distribution of the external nutlet characters (nutlet size, shape, colour, areole type, and surface pattern), sections, and phytogeographical regions are given in the Table. The table shows that the surface of the nutlets has a wide range of variation at section level. Three types of nutlet surfaces occupy 3 different phytogeographical regions. Type I and type II grow in central and east Anatolia and many of them are Irano-Turanian elements. However, type III is usually distributed in south and west Anatolia, and rarely in central, east and south-east; many of them are endemic and East Mediterranean elements. Only one taxon, *N. cataria*, is a Euro-Siberian element in type I.

Discussion

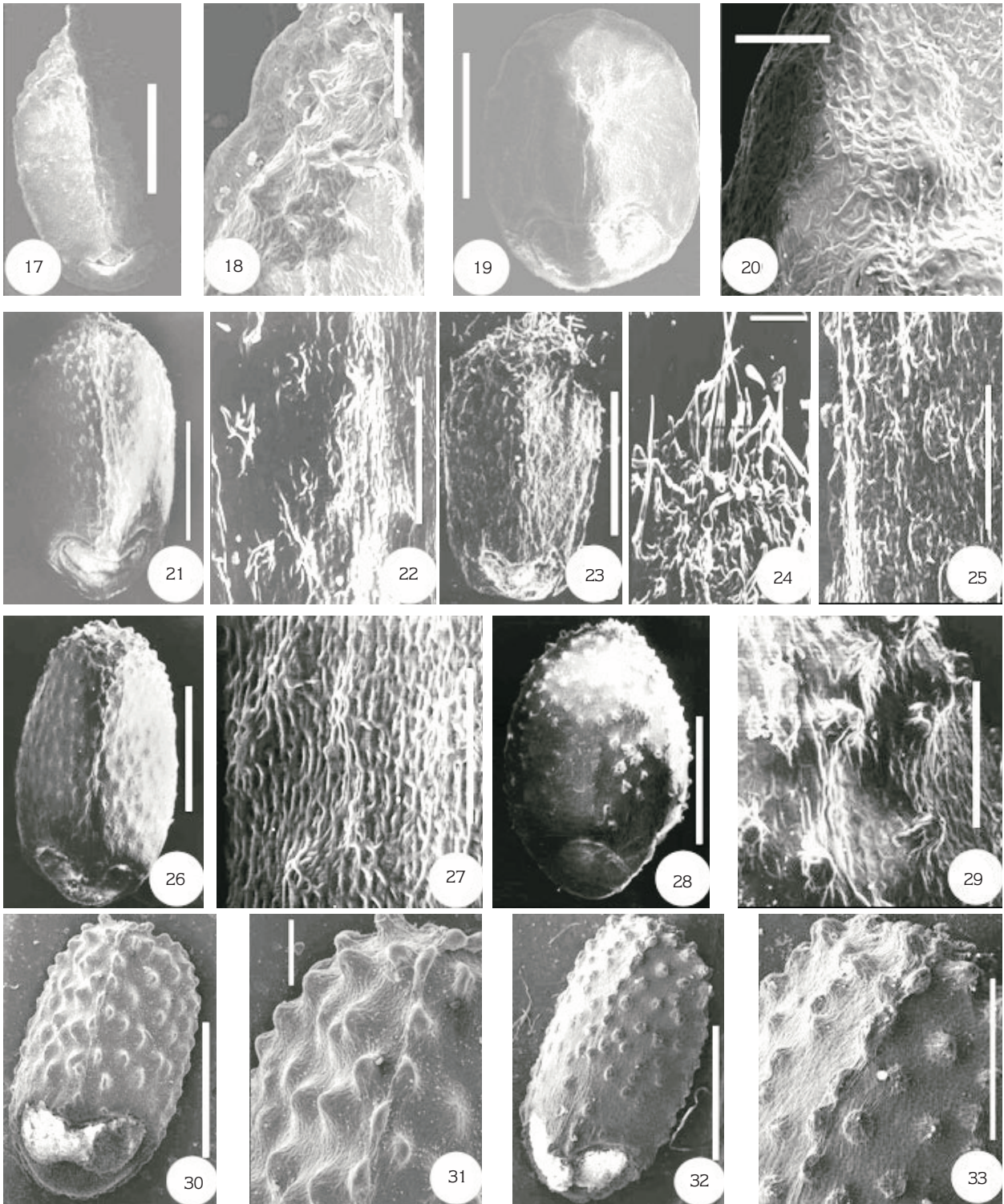
Nutlets of *Nepeta* are glabrous rarely apically pilose, black, blackish-brown or brown, oblong to \pm round trigonous, areole bilobed or straight. The nutlets in *Nepeta* species have generally U- or V-shaped areoles. As a result of the observations carried out using SEM, 3 basic micromorphological nutlet types can be distinguished: smooth, partly smooth, and sculptured. In this study, 2 or 3 subtypes are distinguished based on nutlet epidermal cells.

External nutlet characters, colour, size, shape, and areole, are of limited taxonomic value according to the *Flora of Turkey* and our observations. However, the sculpturing of the nutlet surface patterns as seen by SEM shows a wide range of variation.

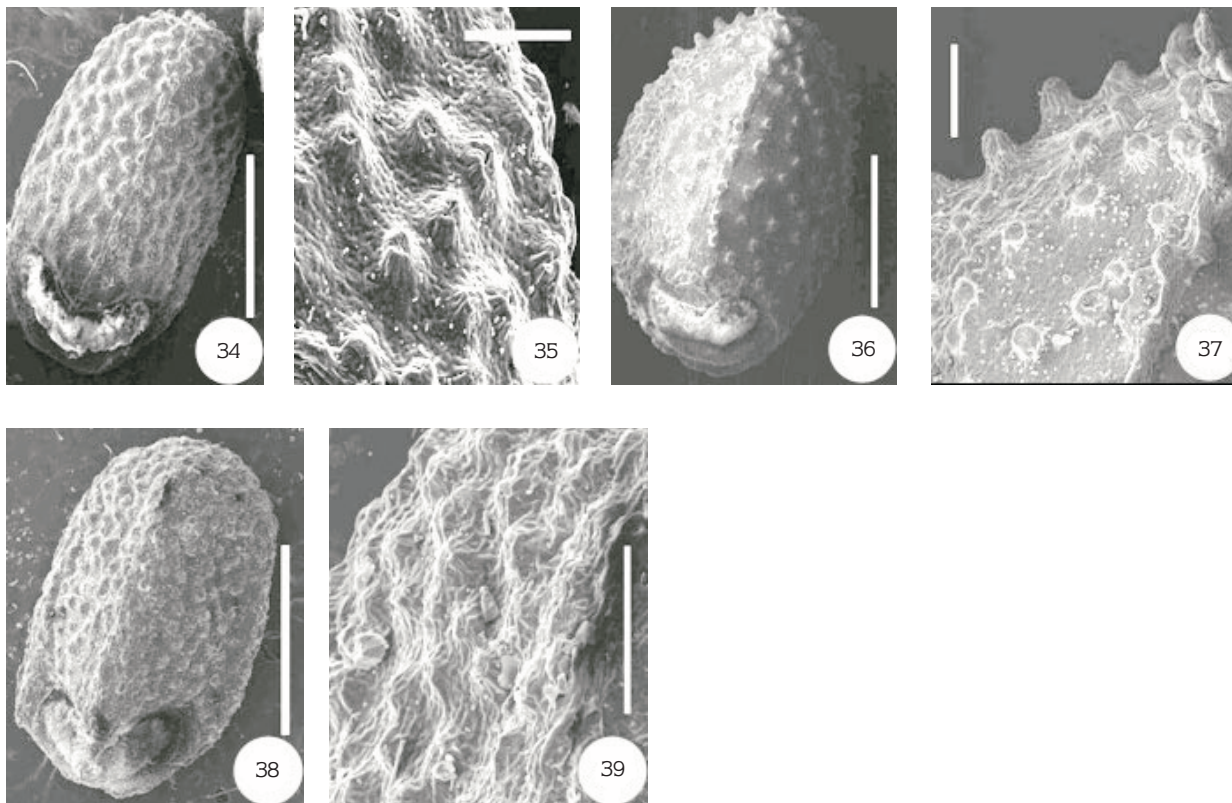
Nutlet surface morphology of some *Nepeta* species growing in Turkey has been investigated previously (Hedge, 1962; Budantsev & Lobova, 1997; Jamzad et al., 2000; Mosquero et al., 2002). Hedge (1962) determined 3 types of nutlet texture, namely smooth without



Figures 1-39: *Nepeta* nutlets and their coat surfaces in SEM. TYPE I: 1, 2-*N. fissa*, 3, 4-*N. macrosiphon*, 5, 6-*N. cataria*, 7, 8-*N. humulis*, 9, 10-*N. heliotropifolia* var. *heliotropifolia*, 11, 12-*N. phyllochlams*. TYPE II: 13, 14-*N. meyeri*, 15, 16-*N. congesta* var. *cryptantha*, 17, 18-*N. betonicifolia*, 19, 20-*N. stricta* var. *stricta*. TYPE III: 21, 22-*N. nuda* subsp. *lydiae*, 23, 24, 25-*N. pilinux*, 26, 27-*N. viscida*, 28, 29-*N. caesarea*, 30, 31-*N. trachonitica*, 32, 33-*N. sorgerae*, 34, 35-*N. stenantha*, 36, 37-*N. cilicia*, 38, 39-*N. rasemosa*. Scale bars: Figures 1, 3, 9, 11, 15, 17, 19, 21, 23, 26, 28, 30, 32, 34, 36, 38 = 1 mm. Figures 2, 4, 6, 8, 24, 27 = 100 mm. Figures 10, 12, 14, 18, 20, 22, 25, 29, 31, 35, 37, 39 = 200 mm. Figures 5, 7, 13, 16, 33 = 500 mm.



Figures 1-39 (Continued).



Figures 1-39 (Continued).

tubercles, flatly tuberculate, and clearly tuberculate especially towards apex. In his study, *N. cilicia* almost always had clearly tuberculate nutlets, *N. fissa* had flatly tuberculate nutlets, and *N. lamiifolia* had partly smooth (prototubercles) nutlets. The nutlet surfaces of *N. cilicia* and *N. lamiifolia* are the same as those of our samples except for *N. fissa*.

Nutlets of 92 species of *Nepeta* in 17 sections were examined by Budantsev & Lobova (1997). They are 1-3 × 0.5-1.5 mm in size, elliptic, ovate or obovate, trigonous or rounded-trigonous, with straight or bilobed areole. Two main types were recognised on surface ornamentation: smooth and sculptured. The smooth nutlets have 3 variants: undulate, reticulate, and bead-like. Moreover, sculptured nutlets contain 4 variants: verrucose, tuberculate, tuberculate cellular, and thorn-like. In their study, 16 investigated species of *Nepeta* including 11 sections grow in Turkey. These species were of 4 variants. *N. supina* is ridged-cellular; *N. cataria* is reticulate; and *N. phyllochlamys*, *N. nuda*, *N. meyeri*, *N. humulis*, *N. macrosiphon*, *N. lamiifolia*, *N. cilicia*, and *N.*

viscida are tuberculate. *N. italica*, *N. racemosa*, *N. stenantha*, *N. betonicifolia*, *N. caesarea*, and *N. trachonitica* are thorn-like. *N. pilinux* has nutlets with an apical tuft of multicellular hairs as our *N. pilinux* samples. The results reported by Budantsev & Lobova (1997) are generally similar to our results.

Jamzad et al. (2000) examined the nutlet surface of the annual species of *Nepeta* from Iran. According to Jamzad et al., *Nepeta* species are divided into 2 sections: *Micrantheae*, nutlet surface coarsely tuberculate to finely granular, and *Micronepeta*, nutlet surface smooth. *N. meyeri* is a member of sect. *Micrantheae*. Its surface is the same as that of our samples.

Mosquero et al. (2002) investigated the nutlets of the 5 *Nepeta* from Spain. *N. cataria* is one of them and its surface is also the same as that of our samples.

Our *Nepeta* species and the 11 sections reported by Budantsev & Lobova (1997) that they are included in are given in the Table. In sect. *Oxynepea* the partly smooth nutlets have a protuberance and papillate pattern except

Table. A comparison of characters studied for *Nepeta* taxa nutlets.

Taxa	Nutlet size / shape	Colour	Areole	Nutlet coat surface	Section	Phytogeographic region
<i>N. baytopii</i> (En.)	2-2.3 × 0.8-1.2 mm, oblong	blackish-brown	bilobed	Type I	Schizocalyx	Ir.-Tur. element
<i>N. fissa</i>	1.5-2 × 0.8-1 mm, elliptic-oblong	blackish-brown	bilobed	Type I	Schizocalyx	Ir.-Tur. element
<i>N. macrosiphon</i>	2.5-3 × 1-1.3 mm, oblong	brown	bilobed	Type I	Schizocalyx	Ir.-Tur. element
<i>N. cataria</i>	1.2-1.6 × 0.8-1 mm, broadly-ellipsoid-oblong	blackish-brown	Str.	Type I	Cataria	Euro-Sib.
<i>N. heliotropifolia</i> var. <i>heliotropifolia</i>	1.8-2.2 × 1.5-2 mm, ± rounded	brown	Str.	Type I	Oxynepeta	Ir.-Tur. element
<i>N. humulis</i>	1.4-1.8 × 1-1.2 mm, broadly oblong	blackish-brown, bright	Str.	Type I	Micranthae	Ir.-Tur. element
<i>N. meyeri</i>	1.2-1.3 × 0.7 mm, ovoid broadly oblong	brown	Str.	Type II	Micranthae	Ir.-Tur. element t
<i>N. congesta</i> var. <i>congesta</i> (En.)	1.5-2 × 1.1-1.6 mm, broadly oblong	brown	Str.	Type II	Oxynepeta	Ir.-Tur. element
<i>N. congesta</i> var. <i>cryptantha</i>	2-2.2 × 1.8-2 mm, ± rounded	brown	Str.	Type II	Oxynepeta	Ir.-Tur. element
<i>N. stricta</i> var. <i>stricta</i>	1.8-2.2 × 1.6-2 mm, ± rounded	brown	Str.	Type II	Oxynepeta	Ir.-Tur. element
<i>N. stricta</i> var. <i>curvidens</i>	2-2.2 × 1.8-2 mm, ± rounded	brown	Str.	Type II	Oxynepeta	Ir.-Tur. element
<i>N. lamifolia</i>	1.8-2.2 × 1 mm, ovate-oblong	brown	Str.	Type II	Schizocalyx	Ir.-Tur. element
<i>N. obtusirena</i> (En.)	1.6-1.8 × 1 mm, ± oblong	black	Str.	Type II	Schizocalyx	Ir.-Tur. element
<i>N. phyllochlamys</i> (En.)	1.8-2.2 × 1-1.2 mm, oblong	blackish-brown	Str.	Type I	Schizocalyx	Ir.-Tur. element
<i>N. cadmea</i> (En.)	1.8 × 1-1.2 mm, oblong	blackish-brown	Str.	Type III	Pycnonepeta	E. Medit. element
<i>N. pilinux</i> (En.)	1.5-1.8 × 1-1.2 mm, ± oblong, ellipsoid	brown	bilobed	Type III	Pycnonepeta	E. Medit. element
<i>N. nuda</i> subsp. <i>glanulifera</i> (En.)	2 × 1.2-1.3 mm, oblong	blackish-brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. nuda</i> subsp. <i>lydiae</i> (En.)	1.8-2.1 × 1-1.2 mm, oblong	brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. nuda</i> subsp. <i>nuda</i>	1.6-2.1 × 0.8-1 mm, oblong	blackish-brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. concolor</i> (En.)	1.8-2.5 × 0.8-1.4 mm, oblong	brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. viscida</i> (En.)	2-2.2 × 1-1.3 mm, oblong	blackish-brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. caesarea</i> (En.)	1.3-1.5 × 0.8-1.1 mm, broadly-oblong	blackish-brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. conferta</i> (En.)	2-2.2 × 1 mm, oblong	brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. crinita</i> (En.)	2-2.2 × 1-1.2 mm, ovoid-oblong	brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. aristata</i> (En.)	2.3-2.7 × 1.2-1.5 mm, broadly oblong	black	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. trachonitica</i>	1.8-2.2 × 1-1.3 mm, oblong	blackish-brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. cilicia</i>	2.2-3 × 1.2-1.8 mm, broadly, ellipsoid-oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. glomerata</i>	2-2.1 × 1.1-1.3 mm, oblong	brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. flavida</i>	1.7-2 × 1-1.2 mm, oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. isaurica</i> (En.)	1.5 × 1 mm, ± oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. italica</i>	1.7-2 × 0.8-1.1 mm, oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. sibthorpii</i> subsp. <i>tumeniana</i>	1.7-2 × 0.8-1 mm, oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. sulfuriflora</i> (En.)	1.5-1.8 × 1-1.2 mm, ± oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. nuda</i> subsp. <i>albiflora</i>	1.5-2 × 1-1.2 mm, ovoid-oblong	brown	Str.	Type III	Orthonepeta	E. Medit. element
<i>N. betonicifolia</i>	2.2-2.6 × 1-1.2 mm, oblong	pale-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. racemosa</i>	1.2-1.8 × 0.8-1.1 mm, broadly oblong	brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. stanantha</i>	1.8-2.2 × 1-1.3 mm, oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. transcaucasica</i>	2-2.5 × 1.2-1.4 mm, broadly oblong	brown	bilobed	Type III	Orthonepeta	E. Medit. element
<i>N. sorgerae</i> (En.)	1.8-2 × 0.8-1 mm, oblong	blackish-brown	bilobed	Type III	Orthonepeta	E. Medit. element

En: Endemic, Stra: Straight, Prom: Prominent, Type I-smooth, Type II-smooth-protuberances, Type III-sculptured

for *N. heliotropifolia* var. *heliotropifolia*, which has a smooth (cellular) pattern, while in sect. *Schizocalyx* the smooth nutlets have an undulate-ridged pattern, except for *N. lamiifolia* and *N. obtusirena*, which have a partly smooth (protuberance) pattern. Sect. *Cataria* is represented by only *N. cataria*, which has a smooth (undulate-ridged) surface. Nutlet surfaces in most of the species of other sections are sculptured (verrucate and tuberculate) except for in *N. betonicifolia* (sect. *Stenostegiae*), which has a partly smooth (protuberance) surface towards the apex, and *N. phyllochlamys* (sect. *Pycnonepeta*), which has a smooth (reticulate) surface. As a result, species in different sections share the same kind of nutlet ornamentation (Jamzad et al., 2003).

According to our observations, many nutlets are oblong. However, the nutlets in *N. congesta* var. *cryptantha*, *N. heliotropifolia* var. *heliotropifolia*, *N. stricta* var. *stricta*, and *N. stricta* var. *curvidens* are ± rounded. The number of nutlets broadly oblong is 9.

According to our results, the nutlets of *N. meyeri* are the smallest and the narrowest (1.2-1.3 × 0.7 mm) although the nutlets of *N. macrosiphon* and *N. cilicia* are the longest (to 3 mm) and the nutlets of *N. congesta* var. *cryptantha*, *N. heliotropifolia* var. *heliotropifolia*, *N. stricta* var. *stricta*, and *N. stricta* var. *curvidens* are the largest (to 2 mm) in all nutlets. Our nutlet lengths are usually similar to those in the *Flora of Turkey* but there are also some differences. For example, the nutlet lengths of *N. rasemosa*, *N. stricta* var. *stricta*, *N. trachonitica*, *N. glomerata*, and *N. lamiifolia* in our results are smaller than those in the *Flora of Turkey* while they are longer in *N. humulis*, *N. heliotropifolia* var. *heliotropifolia*, and *N. macrosiphon*.

Nutlets of the some *Nepeta* species are easily distinguished from the others, that is, the epidermal cells of *N. humulis* exhibit more or less regular groups of polygonal cells in a flowered pattern (Figure 8). Furthermore, the nutlets of *N. humulis* can be distinguished from any other taxa because of their bright surface. The nutlet surface patterns show deep polygonal oval pits and high prominent ridges in *N. heliotropifolia* var. *heliotropifolia* (Figure 10), which is also easily

distinguished from other type I taxa. The nutlet surface of *N. heliotropifolia* var. *heliotropifolia* is similar to that of *Dracocephalum origanoides* Steph., which is the second largest genus in the tribe *Nepeteae* (Budantsev & Lobova, 1997). The epidermal cells are with papillate-protuberances patterns on ventral surfaces in *N. meyeri* (Figure 14). The apex of nutlets in only *N. betonicifolia* is typically long, acute-acuminate, and with an undulating margin (Figures 17 & 18) and therefore it can be easily distinguished from all the others. The nutlets of *N. phyllochlamys* (Figure 12) are also different and their surface has a prominent reticulate pattern. *N. cadmea*, *N. concolor*, and *N. nuda* subsp. *lydiae* (Figure 22) appeared to have star-shaped verrucates. Only *N. pilinux* has multicellular eglandular hairs at the apex of nutlets (Figure 24) while *N. concolor* is with or without hairs. The stalked and sessile glandular hairs are observed in nutlets of *N. isaurica*. These taxa are easily distinguished from the other taxa because of trichomes. The most group with the most taxa is type III. An exact tuberculate pattern, thorn-like, is clearly seen in *N. trachonitica* (Figure 31).

The unknown nutlet features of *N. conferta*, *N. crinita*, and *N. viscida* are given for the first time here in detail. In this study, nutlets of new *Nepeta* species and *N. supina* were not examined because they were immature. However, in Budantsev's study (1997), nutlets of *N. supina* have been determined as smooth.

Nutlet characters within the genus *Nepeta* are of taxonomic significance. It is clear that external nutlet characters, especially surface texture, could help in the species classification of the complex genus *Nepeta* in the future.

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Appendix

Source of Material

- Nepeta aristata* Boiss. & Kotschy ex Boiss.; B7 Malatya: Akçadağ, Dedeyazı village, Koru Y., 17.07.2002, T. Dirmenci 2000 (ESSE 14221)
- N. baytopii* Hedge & Lamond; B8 Diyarbakır: 50 km from Bingöl to Diyarbakır, 1200 m, 16.07.2001, T. Dirmenci 1432 (ESSE 14234)
- N. betonicifolia* C. A. Meyer; A10 Ardahan: Çıldır, W. of Çıldır lake, between Bozyiğit and Taşköprü village, 1950 m, 22.07.2000, B. Yıldız & T. Dirmenci 1229 (ESSE 14227)
- N. cadmea* Boiss.; C2 Muğla: Köyceğiz, Sandras Da., Çövenli, 1350 m, 21.07.1999, T. Dirmenci 1026 (ESSE 14239)
- N. caesarea* Boiss.; C4 İçel: 20 km Arslanköy to Mersin, 1200 m, 06.08.2002, B. Yıldız & T. Dirmenci 2167 (ESSE 14244)
- N. cataria* L.; B7 Malatya: Eski Malatya, 11.08.2001, T. Dirmenci 1569 (ESSE 14231)
- N. cilicia* Boiss.; C4 İçel: Gülnar, S. of Güneşli village, 1300 m, 11.07.2001, T. Dirmenci 1415 (BAUF)

N. concolor Boiss. & Heldr.; C3 Antalya: Gündoğmuş, Geyik Da., 2400-2600 m, 10.08.2002, T. Dirmenci 2183 (ESSE 14250)

N. conferta Hedge & Lamond; C2 Antalya: Elmalı, Çiğlikara forest, Akköprü, 1750 m, 29.06.2000, T. Dirmenci 1055 (ESSE 14226)

N. congesta Fisch. & Mey. var. *congesta*; B3 Eskişehir: between Sivrihisar and Polatlı, 5 km E. of Oğlakçı village, 750 m, 31.05.2002, B. Yıldız & T. Dirmenci 1744 (ESSE 14228)

N. congesta Fisch. & Mey. var. *cryptantha* (Boiss.) Hedge & Lamond; B9 Van: 35 km from Van to Erciş, 1850 m, 08.06.2001, T. Dirmenci 1307 (ESSE 14229)

N. crinita Montbret & Aucher ex Benth.; B7 Malatya: 32 km from Malatya to Pütürge, Kube Da., 1800 m, 14.07.2000, T. Dirmenci 1101 (ESSE 14245)

N. fissa C.A.Mey.; B7 Malatya: 25 km from Pütürge to Malatya, 11.08.2001, T. Dirmenci 1570 (BAUF)

N. flavida Hub.-Mor.; C6 Hatay: 31 km from Antakya to Yayladağ, 500-600 m, 25.06.2001, T. Dirmenci 1372 (BAUF)

N. glomerata Montbret & Aucher ex Benth.; B7 Erzincan: 12 km from Kemaliye to Arapgir, 1200 m, B. Yıldız & T. Dirmenci 1604 (BAUF)

N. heliotropifolia Lam. var. *heliotropifolia*; B9 Van: 6 km E. of Van, Kurubaş pass, 1900 m, 06.08.2001, T. Dirmenci 1315 (ESSE 14238)

N. humilis Benth.; C10 Hakkari: between Yüksekova and Şemdinli, Haruna pass, 2000 m, 25.07.2001, T. Dirmenci 1502 (ESSE 14233)

N. isaurica Boiss. & Heldr.; C4 Antalya: Gazipaşa, Mırıklar Y., 1650 m, T. Dirmenci 1084 (ESSE 14241)

N. italica L.; B9 Bitlis: 22 km from Bitlis to Baykan, above Tutu village, Kambos Da., 1850 m, 30.07.2002, T. Dirmenci 1562-a (BAUF)

N. lamiifolia Willd.; B9 Iğdır: Aralık, W. of Küçük Ağrı Da., 2700 m, 02.08.2002, T. Dirmenci 2123 (ESSE 14224)

N. macrosiphon Boiss.; B8 Bitlis: 22 km from Bitlis to Baykan, above Tutu village, Kambos Da., 1850 m, 30.07.2002, T. Dirmenci 1561 (ESSE 14235)

N. meyeri Benth.; B9/10 Ağrı: 10 km from Çaldıran to Doğubayazıt, W. of Ortaköy village, 1900 m, 12.06.2002, T. Dirmenci 1872 (ESSE 14236)

N. nuda L. *nuda*; C2 Denizli: Honaz Da., 1850 m, 22.06.2001, T. Dirmenci 1351 (BAUF)

N. nuda L. subsp. *albiflora* (Boiss.) Gams; C9 Van: Bahçesaray, 2500 m, 22.07.2001, T. Dirmenci 1490 (BAUF)

N. nuda L. subsp. *glandulifera* Hub.-Mor. & P.H.Davis; C4 Antalya: Gazipaşa, Mırıklar Y., 1650 m, 09.07.2000, T. Dirmenci 1081 (ESSE11622)

N. nuda L. subsp. *lydiae* P.H.Davis; C2 Denizli: Babadağ, Taşdelen, 1450 m, 28.06.1999, T. Dirmenci 1009 (BAUF)

N. obtusirena Boiss. & Kotschy ex Hedge; B9 Bitlis: Tatvan, Nemrut Da., 2250 m, 17.07.2000, B. Yıldız & T. Dirmenci 1105 (ESSE 14225)

N. phyllochlamys P.H.Davis; C3 Antalya: above Kemer, Tahtalı Da., 1080 m, 21.6.1995, (ESSE 11296)

N. plinux P.H.Davis; C4 Antalya: Akdağ, above Gözü Büyük Y., 2100-2200 m, 10.08.2002, B. Yıldız & T. Dirmenci 2181 (ESSE 14230)

N. racemosa Lam.; B8 Erzurum/Erzincan: 20 km from Tercan to Aşkale, 1800-1900 m, 16.06.2002, B. Yıldız & T. Dirmenci 1843 (ESSE 14246)

N. sorgerae Hedge & Lamond; C7 Adıyaman: Nemrut Da., 2250 m, 17.07.2000, B. Yıldız (14905) & T. Dirmenci (BAUF)

N. stenantha Kotschy & Boiss. ex Boiss.; B8 Erzurum: 14 km E. of Varto, 1900 m, 0.07.2001, T. Dirmenci 1568 (BAUF)

N. stricta (Banks & Sol.) Hedge & Lamond var. *stricta*; B3 Eskişehir: between Sivrihisar and Günyüzü, 950 m, 31.05.2002, B. Yıldız & T. Dirmenci 1745 (ESSE 8588)

N. stricta (Banks & Sol.) Hedge & Lamond var. *curvidens* (Boiss. & Bal.) Hedge & Lamond; B8 Erzurum: 38 km from Hınıs to Tekman, 1850 m, 16.6.2002, B. Yıldız 15231b & T. Dirmenci (BAUF)

N. sulfuriflora P.H.Davis; C4 Antalya: 24 km from Gazipaşa to Anamur, 340 m, 23.06.2001, T. Dirmenci 1370 (ESSE 11623)

N. trachonitica Post.; B9 Bitlis: 22 km from Bitlis to Baykan, above Tutu village, Kambos Da., 1850 m, 30.07.2002, T. Dirmenci 1562-b (BAUF)

N. transcaucasica Grossh.; B9 Ağrı: Eleşkirt, 2200-2700 m, 19.07.2000, B. Yıldız & T. Dirmenci 1136 (ESSE 14237)

N. sibthorpii Benth. subsp. *tumeniana* T. Dirmenci; B1 Balıkesir: Kazdağı, Dökük, 1300 m, 10.07.1999, T. Dirmenci 1024 (BAUF)

N. viscida Boiss.; C1 Aydın: Kuşadası, Dilek Peninsula National Park, 800 m, 30.06.1999, T. Dirmenci 1018a (ESSE 14243)