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رهیزیخت شناسی فندقچه سرده فراسیون و خوش‌اکناران و اهمیت سازگاری شناختی آن
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چکیده. فندقچه‌های ۲۰ آبیار از طایفه فراسیون‌های توسه‌ی میکروسکوپی می‌تواند بررسی قرار گیرد که توضیحاتی درباره ویژگی‌های ریزدانه، شکل‌دهنده ناشی می‌دهد. شکل‌دهنده‌ها توصیف شده در اندازه، شکل، و ریزدانه سطحی تنوی خویش نشان می‌دهند. شکل‌دهنده‌های مختلف تشویقی در اغلب گونه‌های مورد بررسی تخم‌مرغی است که در این مطالعه نیز مورد بررسی قرار گرفتند. سلول‌های تنوی خویش نشان می‌دهند. تواجه این نوع اصلی الگوی تزئینات سطحی برای دیگر فندقچه‌ها قابل تشخیص است که شامل: شبکه، ارگونداکتی، نرمالی نیرویی، جویده، نهادی، نکات‌دار و پیش‌بنی‌‌یای ریزدانه‌ای است. رایج‌ترین نوع ریزدانه سطحی تنوی خویش فندقچه در بین گونه‌های مورد مطالعه توسه‌ی شبکه‌ای است. اما توجه به اندازه و شکل‌دهنده سطحی تنوی این گونه‌ها سفید و Marrubium کلیدی. آرایه‌شناسی، تزئینات سطحی، صفات تشخیصی، لب‌دانی، میکروسکوپی میکروسکوپی نگاره

واژه‌های کلیدی. آرایه‌شناسی، تزئینات سطحی، صفات تشخیصی، لیپدانی، میکروسکوپی الکترونیکی نگاره

Nutlet micromorphology of the genus Marrubium L. and allies and its systematic implication (Lamiaceae: tribe Marrubieae)

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Abstract. Nutlets of 20 taxa of the tribe Marrubieae were examined by scanning electron microscopy (SEM) and detailed descriptions of nutlet micromorphological features for all examined taxa are provided. The nutlets exhibited variation in size, shape, color and surface sculpturing. The nutlets shape of most species studied is ovate, but rounded, broad ovate, elliptic, lanceolate, triangular and oblong can also be found in a few species. Six basic types of the sculpturing pattern of nutlet surface can be distinguished: reticulate, foveolate, scalariform, ruminate, pustulate and colliculate-granulate. The most common type of nutlet sculpturing among the studied species is reticulate, but the variation in size and shape of their composing cells provided useful diagnostic characters. Our investigation revealed that the type of sculpturing was more useful in taxon delimitation among Marrubium species and allies at the species rank.

Keywords. diagnostic characters, Labiatae, surface sculpturing, scanning electron microscopy, taxonomy

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INTRODUCTION

Marrubiaceae Vis., with five genera and ca. 91 species, is one of the 10 Lamioidae tribes distributed mainly in southern Europe and North Africa (Siadati et al., 2018). They are mostly nonaromatic herbs or subshrubs with campanulate to rotate calyx and often with secondary calyx lobes, zygomorphic and 2-lipped corolla and stamens included or shortly exerted from the corolla (Siadati et al., 2018; Harley et al., 2004). According to one of the most recent phylogenetic studies, the monophyletic Marrubiaceae contains four major clades: the first one including member of Acanthoprasium (Benth.) Spach and Moluccella L., the second one comprising species of Ballota L., the third clade containing Pseudodictamnus Fabr. and related species and the fourth one including Marrubium L. species (Siadati et al., 2018). Acanthoprasium, with two species, is a European genus with a woody habit, spiny bracteoles and upper lip of corolla totally hairy. According to Bendiksby et al. (2011), the annual or short-lived perennials Moluccella, contains eight species in southwestern Asia and the Mediterranean regions, are characterized by a zygomorphic calyx more or less expanded at the mouth, internally glabrous, and usually lobed with both primary and secondary indentations. The genus Ballota are subshrubs to perennial herbs with herbaceous bracteoles and shortly exerted stamens from the corolla and extend from Macaronesia, Europe to Mediterranean and Western Asia (Siadati et al., 2018). According to Bentham (1832-1836), the genus Ballota had traditionally been divided into three sections based on two main morphological characters, woody against herbaceous habit and the type of bracteoles (spinosus against herbaceus): (1) sect. Acanthoprasium Benth., which is raised to generic rank by Bendiksby et al. (2011), (2) sect. Beringeria (Neck.) Benth., which is recently raised to generic rank by Siadati et al. (2018) and (3) sect. Ballota Benth. (Bentham 1832-1836). Based on recent phylogenetic studies, the genus Ballota re-circumscribed to encompass the members of sect. Ballota with about three species. Moreover, members of sect. Beringeria recently raised to generic rank as Pseudodictamnus, which accommodates perennial herbs with herbaceous bracteoles, expanded calyx limb with 6-20 teeth and widely distributed from Eurasia to North Africa (Siadati et al., 2018). The genus Marrubium with about 50 species have usually toothed and petiolate leaves, 5-15 (~30) lobed calyx covered by dense stellate trichomes, corolla tube shorter than calyx and stamens included in the corolla tube (Harley et al., 2004).

Studies on nutlet micromorphology within Lamiaceae showed that nutlets features e.g., shape, morphology of the abscission scar and surface sculpturing, were potentially useful at different taxonomic levels (e.g. Demissew & Harley, 1992; Marín et al., 1994; Ryding, 1995; Oran, 1996; Ryding, 1998; Salmaki et al., 2008; Moon et al., 2009; Satil et al., 2012; Krawczyk & Glowacka, 2015; Eyvaz?zadeh Khosroshahi & Salmaki, 2018). Among different nutlet characters, type of sculpturing has been considered to be taxonomically most important (Oran, 1996; Kahraman et al., 2011), however, color, size and shape of nutlets were considered unimportant, either because they did not vary or the variation was random or too great (Oran, 1996). Abscission scars were invariable, but the variation at higher levels may be significant (Guerin, 2005). There are no reports on the taxonomic significance of the nutlets micromorphology among different genera of Marrubiaceae, except that by Mosquero et al. (2007), who provided a description of the morphology and anatomy structure in Marrubium vulgare L. Akgül et al. (2008) illustrated the range of variability in seed characters in Marrubium species found in Turkey and Hassan & Al-Thobaiti (2015) provided a detailed description of the morphological nutlet characteristics of Marrubium vulgare in Saudi Arabia. Thus, the main goal of this study was to provide a detailed description of nutlet micromorphology of the genus Marrubium and allies.

MATERIALS AND METHODS

Nutlets of 20 species representing all five genera of tribe Marrubiaceae were selected to investigate the value of seed characters in the classification of genera and species. Nutlets were collected from herbarium specimens, deposited in the herbaria M (Botanische Staatssammlung München), MSB (Münch Systematic Botany), and TUH (Central Herbarium of Tehran University). A list of voucher specimens is presented in Table 1. A total of two species of Acanthoprasium, two species of Moluccella, four taxa representing three species of Ballota, two species of Pseudodictamnus and 10 species of Marrubium were analyzed. Nutlets were observed in advance, using a stereomicroscope to ensure that they were of normal size and maturity. Nutlets observations were made using scanning electron microscopy.

For SEM observations, dried nutlets were mounted on aluminum stubs using double-sided adhesive and sputter-coated with a thin layer (ca. 30 nm) of gold and examined by means of a Hitachi SU3500 (Japan) scanning electron microscope at an accelerating voltage of 5-30 kV. This paper follows the terminology of Bojnanský & Fargašová (2007) and Stearn (1983) for the seed shape and surface ornamentation.
Nutlets of investigated taxa exhibited six types of surface sculpturing patterns. The most common type was ovate (e.g., *Marrubium* *peregrinum* Fig. 1H; *M. persicum* Rech. f., Fig. 1D) and elliptic (e.g., *Acanthoprasium frutescens* (L.) Spenn) to lanceolate (e.g., *B. nigra* subsp. *anatolica* (Boiss.) Salmaki & Siadati, Fig. 2I and *M. astracanicum* Desr., Fig. 3B). The size of nutlet ranged from 1.34 × 1.07 mm (in *Siadati* Pania, ca 500 m. 11230 (M)) to rounded (e.g., *P. aucheri* (Boiss.) Salmaki & Siadati, Fig. 1L) and elliptic (e.g., *A. frutescens* (L.) Spenn) to lanceolate (e.g., *B. nigra* subsp. *anatolica* (Boiss.) Scheen).

### RESULTS AND DISCUSSION
Several main features of the investigated nutlets *i.e.* shape, length, width, as well as sculpturing patterns, projections of outer periclinal walls and anticlinal walls are summarized in Table 2. Selected SEM micrographs of nutlets studied were presented in Figures 1-3. In general, the color of nutlets in all studied species was dark brown to black. The nutlets were oblong (e.g., *M. catarifolium* Desr., Fig. 2G), triangular (e.g., *Mo. laevis* L., Fig. 3H), broad ovate (e.g., *B. nigra* subsp. *ruderatis* (Sw.) Briq., Fig. 1F)
of sculpturing pattern was reticulate (e.g., *A. frutescens*, Fig. 1A), however, other types of sculpturing patterns, like scalariform (*A. integrifolium* (Benth.) Ryding, Fig. 1C), foveolate (*M. persicum*, Fig. 3C), ruminate (*M. alyssoides* Pomel, Fig. 2B), pusticulate (*M. astracanicum* Jacq., Fig. 2F) and colliculate-granulate (*Mo. laevis*, Fig. 3I), were observed.

Our study represents the first investigation on nutlet micromorphology on the genus *Marrubium* and its allied genera. Variation in shape, size, presence or absence of trichomes at the apex of nutlets and particularly surface sculpturing appeared to have taxonomic value in some groups of Lamiaceae (Husain et al., 1990; Oran, 1996; Navarro & El-Qualidi, 2000; Moon & Hong, 2006; Moon et al., 2009; Kahraman et al., 2011). Özkan et al. (2009) found that variation of shape, size, surface sculpturing and color were useful in distinguishing groups, species and subspecies among 12 examined species of *Salvia*. In *Stachys* (Salmaki et al., 2008) nutlet micromorphology provided valuable data in separating the related species within sections, although these characters were not useful in

### Table 2. Details of nutlet characteristics of the studied taxa of *Marrubium* and its allied genera.

| Taxon                  | Nutlet Shape | Nutlet length (mm) | Nutlet width (mm) | Surface Sculpturing | Apex Bearded | Outer Periclinal Wall | Anticlinal Wall | Figures |
|------------------------|--------------|--------------------|-------------------|---------------------|--------------|-----------------------|----------------|---------|
| *Acanthoprasium frutescens* | Elliptic     | 2.75               | 1.38              | Reticulate +        | Deep         | Concave               | Rised          | Fig. 1  |
| *Acanthoprasium integrifolium* | Triangular   | 2.75               | 1.39              | Scalariform +       | Shallow       | Concave               | Rised          | Fig. 1  |
| *Ballota nigra subsp. anatolica* | Lancelate    | 2.09               | 0.9               | Foveolate –         | Concave      | Rised                 |                | Fig. 1  |
| *Ballota nigra subsp. ruderalis* | Broad ovate  | 1.85               | 1.16              | Reticulate –        | Flat         | –                     |                | Fig. 1  |
| *Ballota platyloma*      | Ovate        | 1.85               | 1.05              | Reticulate –        | Flat         | Rised                 |                | Fig. 1  |
| *Ballota saxatilis*      | Ovate        | 2.3                | 1.29              | Reticulate –        | Concave      | Rised                 |                | Fig. 1  |
| *Pseudodictamnus aucheri* | Rounded      | 1.78               | 1.32              | Reticulate –        | Concave      | Rised                 |                | Fig. 1  |
| *Pseudodictamnus hispanicus* | Ovate        | 2.22               | 1.27              | Reticulate –        | Concave      | –                     |                | Fig. 1  |
| *Marrubium alyssoides*   | Ovate        | 1.86               | 1.01              | Reticulate –        | Concave      | Rised                 |                | Fig. 2  |
| *Marrubium anisodon*     | Oblong       | 1.78               | 0.99              | Reticulate –        | Shallow      | Concave               | Rised          | Fig. 2  |
| *Marrubium astracanicum* | Ovate        | 1.79               | 1.07              | Pusticulate –       | Convex       | –                     |                | Fig. 2  |
| *Marrubium catarifolium* | Oblong       | 2.28               | 1.22              | Reticulate –        | Deep         | Concave               | Rised          | Fig. 2  |
| *Marrubium cineatum*     | Ovate        | 2.21               | 1.21              | Reticulate –        | Flat         | Rised                 |                | Fig. 2  |
| *Marrubium leonuroides*  | Ovate-lanceolate | 1.34         | 1.08              | Reticulate –        | Concave      | Rised                 |                | Fig. 2  |
| *Marrubium litardieri*   | Ovate        | 2.09               | 1.1               | Reticulate –        | Shallow      | Concave               | Rised          | Fig. 2  |
| *Marrubium peregrinum*   | Oblong       | 1.65               | 0.96              | Reticulate +        | Concave      | Rised                 |                | Fig. 3  |
| *Marrubium persicum*     | Ovate        | 1.79               | 1                 | Foveolate –         | Concave      | Rised                 |                | Fig. 3  |
| *Marrubium propinquum*   | Oblong       | 1.81               | 1.03              | Reticulate –        | Concave      | Raised and Wavy       |                | Fig. 3  |
| *Moluccella aucheri*     | Triangular   | 4.04               | 1.45              | Reticulate –        | Concave      | Rised                 |                | Fig. 3  |
| *Moluccella laevis*      | Triangular   | 3.04               | 2.13              | Colliculate-Granulate | Convex       | Represented by channels |                | Fig. 3  |

* Due to lack of sufficient evidence, *Ballota saxatilis* has not yet been assigned to *Pseudodictamnus*, but it shares several morphological features with the members of this genus.
separating large natural groups. Variations in size and the type of sculpturing as well as the shape of its composing cells had been considered to provide the most valuable characters at species level (e.g., Kahraman et al., 2011; Tarimcilar et al., 2013; Salmaki et al., 2008; Eyvazadeh Khosroshahi & Salmaki, 2018). For instance, the polygonal cells in *M. peregrinum* L. (Fig. 3A) were much smaller than those in *M. leonuroides* (Fig. 2L). Moreover, *M. anisodon* K.Koch (Fig. 2D) and *M. litardierei* (Fig. 2N) were different in the depth of pits on surface. Due to the particular value of microsculpturing, a comprehensive discussion is given below, indicating the importance of sculpturing patterns and its
systematic importance in the genus *Marrubium* and its allied genera.

Fig. 2. Scanning electron micrographs of *Marrubium* and its allied genera. A, B. *Marrubium alyssoides*; C, D: *M. anisodon*; E, F. *M. astracanicum*; G, H. *M. catariifolium*; I, J: *M. cuneatum*; K, L. *M. leonuroides*; M, N. *M. litardierei*, O. *M. peregrinum*. 
Fig. 3. Scanning electron micrographs of Marrubium and its allied genera. A. Marrubium peregrinum; B, C. M. persicum; D, E. M. propinquum; F, G. Moluccella aucheri; H, I. Mo. laevis.

Acanthoprasium– This genus includes two species based on the latest phylogenetic study (Bendiksby et al., 2011), characterized by simple hairs and broadly campanulate calyx with spiny lobes. Both species of Acanthoprasium are well distinguished by having bearded nutlets. The present study showed that the presence of trichomes at the apex of nutlets could be used as a taxonomic marker in the delimitation of Acanthoprasium nutlets from the rest of Marrubieae. However, these two species were different in shape and sculpturing pattern. While, A. frutescens is characterized by elliptic nutlets as well as reticulate pattern of nutlet sculpturing (Fig. 1A), A. integrifolium is distinguished by triangular nutlets and scalariform sculpturing (Fig. 1B–C).

Moluccella– The genus Moluccella, characterized by glabrescent stems and leaves as well as an expanded calyx, is distributed from southern Europe to central Asia, Pakistan and Kashmir (Scheen et al., 2010; Bendiksby et al., 2011). In the present study, two out of eight species of this genus were examined. Although both of these species were similar in shape and possession of the largest nutlets (Fig. 3F–H), they were different in the pattern of nutlet sculpturing. Moluccella aucheri, distinguished by reticulate pattern of nutlet sculpturing, differs from Mo. laevis with colliculate-granulate pattern of nutlet sculpturing. In addition, the type of anticlinal walls was different between these two species. While Mo. aucheri possesses raised anticlinal walls, Mo. laevis is characterized by anticlinal walls represented by channels. Due to the limited taxon sampling on the genus Moluccella, a more comprehensive study needs to be done for indicating the taxonomic importance of nutlet characters.

Ballota– Recently, a narrower circumscription of the genus Ballota was proposed by Siadati et al. (2018) to encompass the members of sect. Ballota (sensu Patzak, 1958) with about three species. These three species are characterized by the following morphological features: five main calyx teeth, rarely with a few additional minute teeth as well as simple and glandular indumentum (Siadati et al., 2018). Although nutlet morphology was not useful in the recognition of the genus Ballota from the other...
genera of the tribe Marrubieae, it was helpful in the delimitation of taxa at species level. *Ballota nigra* subsp. *anatolica* with lanceolate nutlets was characterized by foveolate pattern of nutlet sculpturing (Fig. 1D–E). On the other hand, *B. nigra* subsp. *ruderalis* (Fig. 1F–G) and *B. platycoma* (Fig. 1H–I) have broadly ovate and ovate nutlets, respectively, and possess reticulate pattern of nutlet sculpturing.

**Pseudodictamnus**– The genus *Pseudodictamnus*, with about 28 species, comprises perennial herbs with herbaceous bracteoles, expanded calyx limb with 6-20 teeth and corolla tube shorter than or equaling the calyx with branched and simple hairs (Siadati et al., 2018). This genus, which is phylogenetically known to be the closest relative of *Ballota* and *Marrubium*, shares similar nutlet features with them. For instance, the pattern of nutlet sculpturing among all three species of the genus *Pseudodictamnus* was reticulate, which is a common type among the species of *Ballota* and *Marrubium*. Moreover, these three species were similar in the following characters: reticulate pattern of nutlet sculpturing with concave projection in outer pericinal wall and raised anticinal walls. However, they were different in the shape of nutlets (Fig. 1J, L, N).

**Marrubium**– *Marrubium*, with ca. 50 species, is morphologically well characterized by the following features: usually toothed and petiolate leaves, thyrsoid inflorescence; calyx 5-15(-30)-lobed, corolla tube shorter than calyx; stamens included in corolla-tube, posterior corolla lip 2-lobed (Harley et al., 2004). In addition, several characters, such as rounded or subtruncate nutlets at apex and glabrous or with sessile glands at apex, have been mentioned in previous studies (Harley et al., 2004).

It is not surprising that *Marrubium*, the largest genus of the tribe Marrubiaceae, shows considerable diversity in nutlet characters such as size, shape, and sculpturing pattern. *Marrubium leonuroides* and *M. catarifolium* possessed the smallest and biggest nutlets among the examined species, respectively. The common nutlet shapes among the *Marrubium* species were ovate and oblong. The common sculpturing pattern of nutlet in *Marrubium* species was reticulate, however, they showed some variation in shape and size of the composing cells.

Based on morphological characters the genus *Marrubium* has been divided into six sections by Seybold (1978). *Marrubium* sect. *Microdonta*, which was represented here by *M. astracanicum*, *M. catarifolium*, *M. leonuroides* and *M. propinquum*, morphologically characterized by five straight or curved calyx teeth and purple corolla. Although all the species attributed to this section were different in shape, they showed similar type of sculpturing, except in *M. astracanicum*, which possessed pustulate sculpturing. While *Marrubium alyssoides* and *M. persicum*, belonging to *Marrubium* sect. *Stellata*, were similar in shape of nutlets but differed in the type of sculpturing, both studied species of *Marrubium* sect. *Marrubium* (*M. anisodon* and *M. cuneatum*) differed in the shape of nutlets but possessed a similar reticulate type of sculpturing. *Marrubium peregrinum*, belonging to sect. *Ramosa*, possessed the smallest oblong nutlets (1.65×0.96 mm) among the studied species and simple hairs at apex.

This section is morphologically well characterized by widely branched stems and few-flowered verticillasters with white corolla (Davis, 1982). Nutlet sculpturing feature was helpful in the separation of species, however, it appeared uninformative at the level of section.

**CONCLUSION**

Nutlet micromorphology provided valuable data in the separation of the related species within genera of the tribe. Our findings revealed that the nutlet shape, sculpturing pattern and the absence/presence of simple hairs at apex of nutlet were the most significant features in the separation of taxa at species level. However, these characters were not useful in the separation of sections within genera. Our results, in accordance with previous studies of Lamiaceae (*e.g.*, Oran, 1996), showed that the shape of the nutlets were insignificant in assessing the relationships among *Marrubium* species and its relatives in the tribe Marrubiaceae. It seemed also that, contrary to other genera of Lamiaceae (*e.g.*, Guerin, 2005), nutlet characters were of low phylogenetic value in Marrubiaceae.

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**REFERENCES**

Akgül, G., Ketenöglu, O., Pınar, N. M. and Kurt, L. 2008. Pollen and seed morphology of the genus *Marrubium* (Lamiaceae) in Turkey. – Ann. Bot. Fennici 45: 1-10.

Bendiksby, M., Thorbek, L., Scheen, A.-C., Lindqvist, C. and Ryding, O. 2011. An updated phylogeny and
classification of Lamiaceae subfamily Lamioideae. – Taxon 60: 471-474.
Bentham, G. 1832-1836. Labiatarum generae et species. – James Ridgway & Sons, London, 582 pp.
Bojnanský, V. and Fargasaová, A. 2007. Atlas of seeds and fruits of central and eastern European flora: the Carpathian Mountains region. – Springer Science & Business Media, Netherlands, 1046 pp.
Davis, P.H. 1982. Flora of Turkey and east Aegean islands 7. Edinburgh University Press, Edinburgh, 964 pp.
Demissew, S. and Harley, M.M. 1992. Trichome, seed surface and pollen characters in Stachys, Lamioideae (Labiatae) in tropical Africa. In: Harley RM, Reynolds T (eds) advances in Labiatae science. – Royal Botanic Gardens, Kew. 149-166.
Eyvazadeh Khosroshahi, E. and Salmaki, Y. 2018. Nutlet micromorphology and its systematic implications in Phlomoides Moench. – Nova Biol. Rep. 5: 82-94.
Guerin, G. R. 2005. Nutlet morphology in Hemigenia R. BR. Microcorys R. BR. (Lamiaceae). – Pl. Syst. Evol. 254: 49-68.
Harley, R.M., Atkins, S., Budantsev, A.L., Cantino, P.D., Conn, B.J., Graye, R., Harley, M.M., De Kok, R., Krestovskaya, T.V., Morales, R., Paton, A.J., Ryding, O. and Upson, T. 2004. Labiatae. – in: Kubitzki, K. & Kadereit, J.W. (eds.). The families and genera of vascular plants, 7: 167-275 – Berlin, Heidelberg: Springer.
Hassan, S. and Al-Thobaiti, A. 2015. Morphological nutlet characteristics of some Lamiaceae taxa in Saudi Arabia and their taxonomic significance. – Pak. J. Bot. 47: 1969-1977.
Husain, S.Z., Marin, P.D., Šilic, C., Qaiser, M. and Petković, B. 1990. A micromorphological study of some representative genera in the tribe Saturejae (Lamiaceae). – Bot. J. Linn. Soc. 103: 59-80.
Kahraman, A., Celep, F., Doğan, M., Guerin, G.R. and Bagherpour, S. 2011. Mericarp morphology and its systematic implications for the genus Salvia L. section Hymenopaceae Benth. (Lamiaceae) in Turkey. – Plant Syst. Evol. 292: 33-39.
Krawczyk, K. and Glowacka, K. 2015. Nutlet micromorphology and its taxonomic utility in Lamium L. (Lamiaceae). – Plant Syst. Evol. 301: 1863-1874.
Marin, P.D., Petković, B. and Ducleit, S. 1994; Nutlet sculpturing of selected Teucrium species (Lamiaceae): a character of taxonomic significance. – Plant Syst. Evol. 192: 199-214.
Moon, H. K. and Hong, S.P. 2006. Nutlet morphology and anatomy of the genus Lycopus (Lamiaceae, Mentheae). – Pl. Res. J. 119: 633-644.

Moon, H. K. Hong, S.P., Smets, E. and Huysmans, S. 2009. Micromorphology and character evolution of Nutlets in tribe Mentheae (Nepetoideae, Lamiaceae). – Sys. Bot. 34: 760-776.
Mosquero, A.M. and J. Pastor, R.J.Y. 2007. Morfología y anatomía de núcules de Marrubium (Lamiaceae) en el suroeste de España. – Lagascalia 27: 23-29.
Navarro, T. and El-Ouaïlidi, J. 2000. Trichomes morphology in Teucrium L. (Labiatae), A taxonomic review. – An. Jard. Bot. Madrid 57: 277-297.
Oran, S.A. 1996. Ultrastructure of nutlet surface of the genus Salvia L in Jordan and the neighbouring countries. – Dirasat. Nat. Eng. Sci. 23: 393-408.
Özkan, M., Aktaş, K., Özdemir, C. and Guerin, G. 2009. Nutlet morphology and its taxonomic utility in Salvia (Lamiaceae: Mentheae) from Turkey. – Acta Bot. Croat. 68: 105-115.
Patzak, V.A. 1958. Revision der Gattung Ballota Section Ballota. – Ann. Naturhist. Mus. Wien. 62: 57-86.
Ryding, O. 1995. Pericarp structure and phylogeny of Lamiaceae- Verbenaceae complex. – Plant Syst. Evol. 198: 101-141.
Ryding, O. 1998. Phylogeny of the Leucas Group (Lamiaceae). – Syst. Bot. 23: 235-237.
Salmaki, Y., Zarre, S. and Jamzad, Z. 2008. Nutlet morphology of Stachys (Lamiaceae) in Iran and its systematic implication. – Feddes Repert. 119: 631-645.
Satul, F. Kaya, A, Akçicek, E. and Dirmenci, T. 2012. Nutlet micromorphology of Turkish Stachys sect. Eriostomum (Lamiaceae) and its systematic implications. – Nordic J. Bot. 30: 352-364.
Scheen, A.-C Bendiksys, M., Ryding, O., Mathiesen, C., Albert, V.A. and Lindqvist, C. 2010. Molecular phylogenetics, character evolution and suprageneric classification of Lamioidae (Lamiaceae). – Ann. Missouri Bot. Gard. 97: 191-219.
Seybold, S. 1978. Revision der Persischen Marrubium-Arten (Labiatae) Vorarbeiten zur Flora Iranica. – Stuttgartter Beitr. zur Naturkunde Ser. A (Biol.) 310: 1-31.
Siadati, S., Salmaki, Y., Saeedi Mehrvarz, S., Heubl, G. and Weigend, M. 2018. Untangling the generic boundaries in tribe Marrubieae (Lamiaceae: Lamioideae) using nuclear and plastid DNA sequences. – Taxon 67: 770-783.
Stearn, W.T. 1983. Botanical Latin, Chapter XXV. – David & Charles, Newton Abbot, London and North Pomfret, Vermont, 153 pp.
Tarimciar, G. Yilmaz, Ö., Daşkin, R. and Kaynak, G. 2013. Nutlet morphology and its taxonomic significance in the genus Mentha L. (Lamiaceae) from Turkey. – Bangladesh J. Plant Taxon. 20: 9-18.

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