Fruit morphology of some species of the Lamiaceae in the flora of Mongolia

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Summary. Nutlet morphology in the family Lamiaceae was examined using scanning electron microscopy (SEM) to identify distinct characters for 20 species belonging to 12 genera in the subfamilies: Ajugoideae, Scutellarioideae, Nepetoideae and Lamioideae. Nutlet morphology in the family Lamiaceae showed considerable variation in size, color (light orange-yellow, light nut-brown, pale grey, black and all that), shape (subglobose, obovoid, subobovoid, elliptic), surface ornamentation (type I, type II), nutlet apex (rounded, triangle) and base (truncate, acute, rounded). The described types have been collected in the territory of Mongolia. In Lamiaceae two main types can be recognized based on surface ornamentation: sculptured – type I (including 8 species) and smooth – type II (including 12 species). Within these types subtypes were recognized. Type I: Sculptured nutlets are characterized by having oblong, cone-shaped and ellipsoid tubercles occurring on all surfaces. The tubercles densely covered with longish mastoid white color in apex and covered by white hairs, with white mastoids under hairs. Five subtypes can be recognized based on the shape of the tubercles: colliculate-reticulate, wrinkled-colliculate-tuberculate, wrinkled-tuberculate, colliculate-tuberculate, hairy. Type II: The smooth nutlets may be divided in 4 subtypes: irregularly reticulate, reticulate, undulate, wrinkled-colliculate.

Морфология плодов некоторых видов Lamiaceae флоры Монголии

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Introduction

The Mint family (Lamiaceae) is one of the largest Angiosperm families, comprising approximately 240 genera and more than 7000 infrageneric taxa distributed throughout the world and economically very important (Harley, 2003). In the flora of Mongolia Lamiaceae is one of the ten largest plant families represented by 89 taxa belonging to 24 genera and four subfamilies (Badamtsetseg, 2010).

Fruit of Lamiaceae is coenobium, thereof named tetraeremum based on nutlets number, and 18 variants based on nutlets forma, 22 variants based on nutlets surface features (Artyushenko, Fedorov, 1986). Fruit of Lamiaceae is included in coenobium group by the fruit classification and has different forms and surface features (Levina, 1987).

Ultrastructure features of nutlets surface can be used in the taxonomy of the genus Nepeta, and selected group of genera represents the branches of the tribe Nepeteae differentiation which took place in the early stages of its evolution (Budantsev, 1993a, b). Nutlet morphology in the Lamiaceae has been proved useful in varying degrees at different levels of the taxonomic hierarchy (Budantsev, Lobova, 1997). Nutlet characters within the genus Nepeta has a taxonomic significance (Kaya, Dirmenci, 2008).

Material and methods

This study is based on nutlets taken from herbarium specimens, mostly from UBU, ALTB and MMNH (Mongolian Museum of Natural History), and original collections made during expeditions to Khentii, Khubsugul, Uvurkhangai, Tov and Dornogovi provinces. For SEM studies nutlets were coated with carbon using a Hitachi E-1010 ion sputter, observed in a Hitachi S-3400N and photographed. All photomicrographs were made at the department of SEM laboratory, National Science Museum, city Deajeon of South Korea. Nutlet color was defined using color chart. Measurements of nutlet were carried out by reiteration 15–20 times under a microscope Olympus BX 40. The nutlet shape and surface ornamentation were studied under a microscope Olympus BX 40. The nutlet characters within the genus Nepeta were carried out with the method Joongku Lee et al. (2009).

Results

We studied nutlet morphology of 20 species belonging to 12 genera of Lamiaceae found in Mongolia. Morphological variation of the size, shape, color, surface type, hilum lay of the seeds in Lamiaceae is described below. We wrote seed morphology descriptions for all these 20 species.

Nutlet color varies from light orange-yellow, light nut-brown, medium buff, pale grey, grey nut-brown, light brown, dark brown, red-brown to black. Nutlet shapes vary from ovoid, subovoid, elliptic, subglobose. Nutlet apex varies from rounded to triangle and base varies from truncate, acute to rounded. Nutlet surface varies from sculptured and smooth to glabrous and covered by hairs.

In Lamiaceae two main types can be recognized based on surface ornamentation: sculptured – type I, and smooth – type II. Within these types subtypes can be recognized.

TYPE I: Sculptured nutlets are characterized by having oblong, cone-shaped and ellipsoid tubercles occur on all surfaces. The tubercles densely covered with longish mastoid white color in apex and covered by white hairs, with white mastoids under hairs. Five subtypes can be recognized based on the shape of the tubercles:

- **Sculptured-loculicate** (fig. 1–1 a, b, c, d): Oblong shaped tubercles covered on all surfaces of lateral view. Anticlinal walls (AW) slightly raised, periclinal walls (EPW) slightly depressed, fine-granular (Amethystea coerulea L.).

- **Wrinkled-loculicate-tuberculate** (fig. 1–2 a, b, c, d; 1–6 a, b, c, d) covered on all surfaces tubercule with mastoids between tubercles (Scutellaria galericulata L.), and tubercles ellipsoid, apex truncate, densely covered by tubercles. Tubercles oblong shaped (Scutellaria tuvensis Juz.).

- **Wrinkled-tuberculate** (fig. 1–3 a, b, c, d) covered on all surfaces by tubercles cone-shaped, apex truncate. The tubercles densely covered with longish mastoid white color in apex (Scutellaria baikalensis Georg.).

- **Colliculate-tuberculate** (fig. 1–4 a, b, c, d) covered on all surfaces by tubercles ellipsoid, apex rounded, densely covered with tubercles. The tubercles have shortish mastoid white in apex (Scutellaria scordifolia Fisch. ex S. sieversii Bunge., S. supina L.).

- **Colliculate-loculicate** (fig. 1–5 a, b, c, d; 1–7 a, b, c, d; 1–8 a, b, c, d) covered on all surfaces by hairs and hairs with white mastoids under hairs (Scutellaria grandiflora Sims., S. sieversii Bunge., S. supina L.).

- **Hairy** (fig. 1–5 a, b, c, d; 1–7 a, b, c, d; 1–8 a, b, c, d) covered on all surfaces by hairs and hairs with white mastoids under hairs (Scutellaria grandiflora Sims., S. sieversii Bunge., S. supina L.).

- **Irregularly reticulate** (fig. 2–10 a, b, c, d; 2–13 a, b, c, d; 3–17 a, b, c, d; 3–18 a, b, c, d) – has a raised network on the surface, often cells formed indistinctly shaped. Anticlinal walls raised, cells

**Reticulate** (fig. 2–9 a, b, c, d; 3–14 a, b, c, d; 3–15 a, b, c, d; 3–19 a, b, c, d; 3–20 a, b, c, d) – has a raised network on the surface, often cells flat shaped. Anticlinal walls raised or slightly depressed, cells tetra, penta- or hexagonal, periclinal walls slightly depressed or slightly raised (*Lophanthus chinensis* Georg.: “River Shuus, Bayan-Adarga soum, Khentii province, 980 m, raised (fig. 1–2 a, b, c, d). Type I-2. Anticlinal walls deeply depressed, periclinal walls raised (fig. 1–3 a, b, c, d). Type I-3.

**Scutellaria scordifolia** Fisch. ex Scranck.: “River Toil, Jargalan soum, Khuvsgul province, 985 m, 22 VII 2009. B. Badamtsetseg” (MMNH).

Nutlets length 1.28 mm, width 1.05 mm, subobovoid, dull, dark in color. Surface rough, glabrous, wrinkled-tuberculate, tubercles cone-shaped, apex truncate. The tubercles densely covered with longish mastoid white color in apex. Anticlinal walls deeply depressed, periclinal walls raised (fig. 1–4 a, b, c, d). Type I-4.


Nutlets subobovoid, dull, pale grey. Surface rough, covered by white hairs, with white mastoids under hairs (fig. 1–5 a, b, c, d). Type I-4.


Nutlets length 1.25 mm, width 0.96 mm, subobovoid, dull, black. Surface rough, glabrous, wrinkled-colliculate-tuberculate. Tubercles ellipsoid, apex truncate, densely covered tubercles. The tubercles have shortish mastoids white in apex. Anticlinal walls deeply depressed, periclinal walls raised (fig. 1–6 a, b, c, d). Type I-2.


Nutlets length 1.38 mm, width 1.08 mm, subobovoid, dull, pale grey in color. Surface rough, densely covered with white hairs, hairy (fig. 1–7 a, b, c, d). Type I-4.


Nutlets length 1.24 mm, width 0.98 mm, subobovoid, dull, pale grey in color. Surface rough, densely covered with white hairs, hairy (fig. 1–8 a, b, c, d). Type I-4.
Fig. 1. SEM micrographs of nutlets of subfamily Ajugoideae and Scutellarioideae: 1 – Amethystea coerulea, 2 – Scutellaria galericulata, 3 – S. baicalensis, 4 – S. scordifolia, 5 – S. grandiflora, 6 – S. tuvensis, 7 – S. sieversii, 8 – S. supine, a – lateral view, b – ventral view, c-d – ornamentation of surface.
Subfamily Nepetoideae Burnett


Nutlets length 1.87 mm, width 1 mm, obovoid, apex rounded, base almost rounded, light nut-brown in color. Surface smooth, glabrous, reticulate. Anticlinal walls raised, cells tetra-pentagonal, periclinal walls slightly depressed, smooth (fig. 2–9 a, b, c, d). Type II-2.


Fig. 3. SEM micrographs of nutlets of subfamily Lamioideae: 14 – Galeopsis bifida, 15 – Leonurus sibiricus, 16 – L. deminutus, 17 – Panzerina lanata, 18 – Lagochilus ilicifolius, 19 – Lagopsis marrubiastrum, 20 – Stachys palustris, a – lateral view, b – ventral view, c-d – ornamentation of surface.
Nutlets length 1.70 mm, width 0.70 mm, elliptic, with 3 flattened faces, apex rounded, dark brown in color. Surface smooth, glabrous, lateral surface irregularly reticulate. Anticlinal walls raised, cells indistinctly shaped, periclinal walls depressed by little area. Ventral surface undulate (fig. 2–10 a, b, c, d). Type II-1.


Nutlets length 1.40 mm, width 0.68 mm, elliptic, apex rounded, base almost rounded, slightly flattened, grey nut-brown in color. Surface smooth, glabrous, undulate. Anticlinal walls raised indistinctly shaped, periclinal walls striate-furrowed (fig. 2–11 a, b, c, d). Type II-3.

**Thymus gobicus** Tschern.: “River Tuul, Erdene soum, Tov province, 1543 m, N48.06436, E107.51347. 20 VII 2006. B. Badamtsetseg” (MMNH).

Nutlets length 0.75 mm, width 0.65 mm, subobovoid, slightly curved, apex and base rounded, red-brown in color. Surface smooth, glabrous, wrinkled-colliculate. Anticlinal walls depressed, periclinal walls low raised tubercles, tubercles indistinctly shaped and strongly wrinkled (fig. 2–12 a, b, c, d). Type II-4.


Nutlets length 0.82 mm, width 0.58 mm, obovoid, 3 flattened faces, apex rounded, light brown in color. Surface smooth, glabrous, reticulate. Anticlinal walls raised cells indistinctly shaped, periclinal walls flat depressed (fig. 2–13 a, b, c, d). Type II-1.

**Subfamily Lamioideae Harley**

**Galeopsis bifida** Boenn.: “Gorkhi-Terelj national park, Sergelen soum, Tov province. 22 VII 2004. B. Badamtsetseg” (MMNH).

Nutlets length 2.96 mm, width 2.08 mm, obovoid, base truncate, apex rounded, light nut-brown with black spots. Surface smooth, glabrous, reticulate, anticalinal walls testa cell penta-hexagonal, pericalinal walls slightly depressed, and raised in the spots (fig. 3–14 a, b, c, d). Type II-2.


Nutlets length 2.12 mm, width 1.07 mm, obovoid with 3 flattened faces, apex and base truncate, medium buff in color. Surface smooth, glabrous, only apex hairy, undulate. Anticalinal walls slightly raised, testa cells indistinctly shaped, pericalinal walls wrinkling pronounced as sinuate (fig. 3–16 a, b, c, d). Type II-3.

**Panzerina lanata** (L.) Sojak.: “Near of Dresden camp, river Kherlen, Mungunmorit soum, Tov province, 1645 m, N47.49916, E107.37457. 04.VIII 2009. B. Badamtsetseg” (MMNH).

Nutlets length 3.11 mm, width 1.85 mm, obovoid with 3 angular faces, dark brown in color. Surface smooth with granules, glabrous, irregularly reticulate. Anticalinal walls strongly raised, testa cells indistinctly shaped. Pericalinal walls depressed, smooth (fig. 3–17 a, b, c, d). Type II-1.


Nutlets length 3.3 mm, width 2.01 mm, elliptic with 3 flattened faces, base truncate, black in color. Surface rough, glabrous, irregularly reticulate. Anticalinal walls raised, testa cells indistinctly shaped. Pericalinal walls flat depressed (fig. 3–18 a, b, c, d). Type II-1.

**Lagopsis marrubiastum** (Steph.) Ik.-Gal.: “Mountain Gurbanbulag, Gurvanbulag soum, Bayankhongor province. N47.15, E98.15. 07 VII 1977. E. Ganbold” (UBU).

Nutlets length 2.1 mm, width 1.05 mm, obovoid with 3 angular faces, glabrous, pale grey, surface reticulate. Anticalinal walls strongly raised, testa cells tetra-pentagonal, pericalinal flat depressed (fig. 3–19 a, b, c, d). Type II-2.


Nutlets length 1.25 mm, width 1.01 mm, subglobose, brown. Surface smooth, glabrous, reticulate. Anticalinal walls capillary, slightly depressed, testa cells penta-hexagonal, pericalinal walls slightly raised by penta-hexagonal granules with bordering (fig. 3–20 a, b, c, d). Type II-2.
Conclusions

We studied the seed morphology of 20 species belonging to 12 genera of family Lamiaceae found in Mongolia and wrote descriptions for them.

Nutlets have obovoid, suboboviod, elliptic, subglobose shapes; surface could be rough and smooth, glabrous and covered by hairs; light orange-yellow, light nut-brown, medium buff, pale grey, grey nut-brown, light brown, dark brown, red-brown, black in color.

The surface ornamentation of nutlets of Lamiaceae was classified into 2 types, 9 subtypes: colliculate-reticulate (1 species of subfam. Ajugoideae), wrinkled-colliculate-tuberculate, wrinkled-tuberculate, colliculate-tuberculate, hairy (7 species of subfam. Scutellarioideae), irregularly reticulate, reticulate, undulate, wrinkled-colliculate (5 species of subfam. Nepetoideae and 7 species of subfam. Lamioideae).

We consider that nutlet morphology has varying degrees at subfamily, genera and species levels of the taxonomic hierarchy. Fruit characters are consistent at generic or species level and therefore it is demanded to study nutlet characters of other genus and species of family Lamiaceae.

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