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Taxonomy of the Genus *Peganum* L. (Peganaceae Van Tieghem) in Mongolia

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Abstract

This paper deals with the species of the *Peganum* found in Mongolia based on morphological structure of seeds. A depressed-hollow surface of seeds was found for *Peganum harmala* and smooth surface for *P. nigellastrum* Bge, while convex surface was found for *P. harmala* var. *multisecta*. Seeds of *P. harmala* var. *multisecta* disperse only by water flow, whereas seeds of *P. harmala* disperse only by the effects of human activities and those of *P. nigellastrum* disperse by both human activities and wind. *P. harmala* and *P. nigellastrum* are distributed in Mongolia and Tibet, but *P. harmala* var. *multisecta* are also distributed in Mongolia. We suggest that *P. multisectum* (Maxim.) Bobr is distributed in Mongolia, but no *P. harmala* var. *multisecta* Maxim, based on morphological, ecological and areal differences.

Key words: *Peganum harmala* var. *multisecta*, *Peganum harmala*, *Peganum nigellastrum*, Peganaceae, Central Asia

Introduction

Linneaus (1753) described *Peganum harmala* L., and later Maximovicz (1839) distinguished it the *P. harmala* var. *multisecta* Maxim, from the former taxon, based on the calyx leaves that are incised into 3-5 lobes. Subsequently, Bobrov (1949) combined *P. harmala* var. *multisecta* with *P. multisectum* (Maxim) Bobr.

Grubov (1998) consider that *P. harmala* var. *multisecta* was distributed in Central Asia, but Bobrov (1949) considered it as *P. multisectum*, based on the differences of morphology and distribution (Table 1).

Morphology and hystology of the vegetative and generative organs of *P. harmala* and *P. nigellastrum* were studied by Saphina (1977), Ligaa (1997), Shiirevdamba (1990), Tserenbaljid (1996) and Tserenkhand (1999). These results show that the classification in *Peganum* L genus is still incomplete.

P. harmala is distributed from the Mediterranean sea to Central Asia. In Central Asia, this species is found in the subprovinces of Mongolia, Kashgaria, Tsaidam, Dzungaria and Tibet (southern). *P. nigellastrum* is distributed in China (west and west north of Pekin) and east Siberia (near Khyagt village). This species has also been recorded in the subprovinces of Mongolia and Tsinhai. *P. harmala* var. *multisecta* is widely distributed from Dzungaria, Mongolian Altai to Ordos, Hesi, Tsaidam, Tsinhai regions

Table 1. Classification of the genus *Peganum* L. distributed in Euroasia by different authors

№	Species	Subspecies	Morphology	References
1	*P. harmala* L.	-	Calyx leaves entire, glabrous plant	Bobrov (1949); Grubov (1982, 1998)
		var. *stenophyllum* Boiss.	Leaves with narrow lobes	Bobrov (1949);
		var. *multisecta* Maxim.	Calyx leaves incise into 3-5 lobes, leaves bi- or tripalmatisected	Grubov (1998)
2	*P. nigellastrum* Bge.	-	Calyx leaves incised into 5-7 linear lobes, setose plant	Bobrov (1949); Grubov (1982, 1998)
3	*P. multisectum* (Maxim.) Bobr.	-	Calyx leaves incise into 3-5 lobes, leaves bi- or tripalmatisected	Bobrov (1949)

(Grubov, 1998) and from Alasha to Gansu region (Bobrov, 1949).

The purpose of this study is to compare the species, *P. harmala* var. *multisecta* Maxim with *P. harmala* L. and *P. nigellastrum* Bge, by morphology, ecology and distributional area.

Materials and methods

The seed collection of the Institute of Botany was used for the morphological and dispersal analysis of seeds. The herbarium of the Institute of Botany were used for areal analysis. In total, 30 samples of seeds and 89 sheets of plant specimens were examined, which had been collected by various scientists between 1948 and 2006.

The shape, color and surface of seeds was observed under magnification (1x8 times) on MBS-1 microscope.

Morphological diversity of seeds, as well as distances between populations and individuals are necessary to define seed dispersal mechanisms. Levina (1987) classified seed dispersal into the following groups: animal-dispersal, wind-dispersal, water-dispersal, auto-dispersal and human dispersal. Animal-dispersal seeds are juicy, hooked and have a bright color; wind-dispersal seeds are small, light weight, and have a wing; water-dispersal seeds are covered by hair and oily substances and have a hollow on the coat; auto-dispersal seeds are disseminated by the promotion of ovary functions. Some plant seeds can disperse by the direct and indirect effects of human activities. Seeds of this group have various kinds of morphology. The distances among populations and individuals are necessary to distinguish the human-dispersal from other groups of seed dispersal.

P. harmala grows near alkaline banks of rivers and springs, dry debris slopes, needle-grass stands, nomad camp and ruderal places, while *P. nigellastrum* is found in sandy steppes, sandy-pebble river banks, alkaline banks of rivers and brooks, needle-grass stands, ruderal places, and near wells and springs in desert and desert steppe (Bobrov, 1949; Yunatov, 1950; Grubov, 1982, 1998).

Distribution of *Peganum* L species in Mongolia was given according to the plant-geographical regions as stated by Grubov (1982).

Results

Seed morphology

Seeds with blunt-top or sharp-top and brown or dark-brown color dominantly found in the species of the genus *Peganum*. Seeds of *P. harmala* have a dark-brown color in the Dzungaria, Trans-Altai Gobi regions, but were brown in other regions. Brown *P. nigellastrum* seeds were found in the

Figure 1. Seeds of the species of *Peganum* in Mongolia. A. *P. harmala*, B. *P. nigellastrum*, C. *P. harmala var. multisecta*

Gobi-Altai and East Gobi regions, excluding Valley of Lakes. *P. harmala* var. *multisecta* had brown seeds in all distributional regions.

Diversity of seed surface was related to volume of the air hollow on the external integument of the seed coat. The depressed-hollow and smooth surfaces of seeds were found in *P. harmala* and *P. nigellastrum* in all distributional regions, but convex surface was found in *P. harmala* var. *multisecta* (Figure 1).

Seed dispersal ecology

P. nigellastrum regrows by stolon and originates from patches. Distance between two patches varied from 100 to 200 m. This fact illustrates that seeds of *P. nigellastrum* can disperse up to 200 m away from the mother patch. However, in the case of desert and desert steppe wind flow is necessary for the dispersal of its seeds. The effects of human activities were necessary for dispersion of seeds to the steppe and forest-steppe. For instance, this species is distributed near the cities of Kharakhorum, Ulaanbaatar and Khyagt. This shows that seeds were dispersed at least 300 km away from desert steppe by human activities.

P. harmala occurs near oases and springs in the deserts of Mongolia. Distances between oases vary from 300 to 1000 km. This fact illustrates that the seeds of *P. harmala* disperse by human activities.

P. harmala var. *multisecta* is found in desert-steppe and grows in the moist depression of a valley. Distance between individuals varies from 50 to 100 m, illustrating that seeds can disperse by rain water flow. The air hollows on the external integument of the seed coat became bigger, resulting in water dispersal of seeds. *P. harmala* var. *multisecta* was found in moist depressive valleys with stony soils.

Distribution of the species of Peganum *L. in Mongolia*

P. harmala is distributed in the Mongolian Altai, Depression of Great Lakes, Valley of Lakes, East Gobi, Trans-Altai Gobi, and Dzungarian Gobi regions, and *P. nigellastrum* in the Mongol-Daurian, Middle Khalkh, Valley of Lakes, Gobi Altai, East Gobi, and Alasha Gobi regions. *P. harmala var. multisecta* occurred in the Trans-Altai Gobi and Gobi Altai regions (Figure 2).

Discussion

Hairiness, palmatisection of leaf and incision of calyx have been used to distinguish species of the genus *Peganum* (Bobrov, 1949; Yunatov, 1950; Grubov, 1982, 1998). *P. harmala* is morphologically different from *P. nigellastrum* by glabrous leaves and stems, leaves palmatisected, and entire calyx leaves. Seed dispersal ecology was different between these species. Based on differences of morphology and ecology, the taxa in the genus *Peganum* could be classified into two species.

P. harmala var. *multisecta* is distinguished by the bi- or tripalmatisected leaves, calyx leaves incised into 3-5 lobes (Grubov, 1998).

Morphological study: The results showed that shape and color of seeds are insufficient to distinguish species of the genus *Peganum*, because seed shape and color were different in the distributional regions of all species. No difference

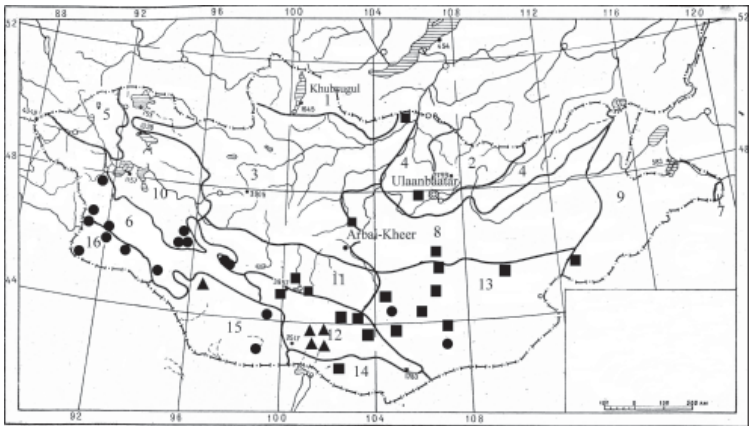

Figure 2. Distribution of the species of *Peganum* L. in Mongolia.
● - *P. harmala*, ▲ - *P.harmala var. multisecta*, ■ - *P. nigellastrum*
1-Huvsgul, 2-Hentii, 3-Hangai, 4-Mongol-Daurian, 5-Khovd, 6-Mongolian Altai, 7-Great Khingan, 8-Middle Khalkh, 9-Eastern Mongolia, 10-Depression of Great Lakes, 11-Valley of Lakes, 12-Gobi Altai, 13-East Gobi, 14-Alasha Gobi, 15-Trans-Altai Gobi, 16-Dzungarian Gobi.

of seed surface was found in the distributional regions of all species. The depressed-hollow surface of seeds was found in *P. harmala* and smooth surface was in *P. nigellastrum*, but convex surface of seeds was observed in *P. harmala* var. *multisecta*.

Key to species of the genus *Peganum* L. by the morphology of seeds

1. Depressed surface of seeds, calyx leaves entire. . . . . *P. harmala* L.

- Convex or smooth surface of seeds, calyx leaves incised into 3-7 linear lobes. 2

2. Convex surface of seeds, calyx leaves incised into 3 linear lobes . . . . . *P. multisectum* (Maxim.) Bobr.

- Smooth surface of seeds, calyx leaves incised into 5-7 linear lobes . . . . . *P. nigellastrum* Bge.

1. *P. harmala* L. 1753, Sp. Pl.: 444; Ledeb.1843, Fl. Ross. 1:489; Boiss. 1867, Fl. Or. 1: 917; Henders. a. Hume, 1873, Lahore to Jarkand: 315; Hance, 1882, Journ. Bot. (London), 20: 258; Diels, 1903, in Futterer, Durch Asien, 3: 12, Danguy, 1911, in Bull. Mus. Hist. Nat. (Paris), 17: 268; Simpson, 1913, Journ. Linn. Soc. London (Bot.), 41: 409; Rehder, 1933, Journ. Arn. Arb. 14: 22; Flora West Sib. 8:1850; Persson, 1938, Bot. Not. (Lund), 4: 232; Walker, 1941, Contr. U. S. Nat. Herb. 28: 640; Pei, 1948, Bot. Bull. Acad. Sin. 1:103; Bobr. 1949, in Flora USSR, 14:148; Grub. 1955, Conspectus Flora of Mong: 200; 1982, Key to Vascular Plants of Mongolia: 175; 1998, in News of vascular plants; Nikitin. 1957, in Flora Kyrgyz. 7:490; 1963, in Flora Kazakhstan. 6: 32; Ikonnikov. 1963, Key to Plants of Pamir. : 49; 1979, Fl. Intramong. 4:18 et 1989, ed. 2, 3: 418; Adjilov, 1985, Claves pl. Xinijiang. 3: 231; 1986, Pl. vasc. Helanshan.: 166; 1986, Fl. Xizang. 3: 20; 1987, Fl. desert. Sin. 2: 308.

Perennial, glabrous plant branched into 5-13 stems, 40-45 cm in hight; leaves palmatisected into 3-5 linear lobes, 3-6 cm long; lobes 1.5-3.0 mm wide; flowers by 1-3 on apexes of branches; petals whitish-yellow in color; calyx leaves entire or slightly incised; capsule is globular in shape, 0.9-1.3 cm in diameter, with 35-47 seeds; seeds with blunt-top, sharp-top of shape, dark-brown color and depressed hollow surface.

2. *P. multisectum* (Maxim.) Bobr., 1949, in Flora USSR, 14: 149; 1987, Fl. desert. Sin.2: 308; *P. harmala* var. *multisecta* Maxim., 1839, Fl. Tangut.: 103; Diels, 1908, in Filchner, Wissensch. Ergebn. 10: 254; 1979, Fl. Intramong. 4: 18 et 1989, ed. 2, 3: 418.

Perennial, sparse setose plant branched into 70-100 stems, 20-65 cm in hight; leaves bi or tripalmatisected into linear lobes; lobes 0.4-1.0 mm in width; flowers by 1-3 on apexes of branches, 2-4 cm in diameter, whitish-yellow color; calyx leaves incised into 3 linear lobes; capsule with globular shape, 0.9-1.3 cm in diameter, and 16-32 seeds; seeds with blunt-top and sharp-top shape, brown color, and convex surface.

3. *P. nigellastrum* Bunge, 1832, Mem. Sav. Etr. Petersb. 2: 87, (seors. impr.); id. 1835, l. c.; Kanitz, 1891, *A. novenitani* ... : 12; Palibin, 1904. 7, 3: 48; Danguy, 1911, Bull. Mus. Hist. Nat. (Paris), 17: 268; Hao, 1938, Bot. Jahrb. 68: 616; Walker, 1941, Contr. U. S. Nat. Herb. 28: 641; Pei, 1948, Bot. Bull. Acad. Sin. 1: 103; Bobr. 1949, in Flora USSR, 14: 149; Grub. 1955, Conspectus Flora of Mongolia: 200; 1982, Key to Vascular Plants of Mongolia.: 175; 1979, Fl. Intramong. 4:18; 1986, Pl. vasc. Helanshan.: 166; 1987, Fl. Desert. Sin. 2: 306; 1989, Fl. Intramong., ed. 2, 3: 420.

Perennial, dense setose plant little branched or without branch; leaves bi- or tripalmatisected into linear lobes; lobes 1.2-1.8 mm in width, with pungent-acute lobes; flowers by solitary on apexes of stems, 1.5-2.0 cm in diameter; calyx leaves incised into 5-7 linear lobes; petals whitish-yellow color, 1.2-1.5 cm in length; capsule with globular shape, 0.8-1.1 cm in diameter and 22-34 seeds; seeds with blunt-top and sharp-top shape, brown color and smooth surface.

Ecological differences: The results of this study show that seeds of *P. harmala* var. *multisecta* only can disperse by water flow; seeds of *P. nigellastrum* disperse by both wind and human activities and those of *P. harmala* can be dispersed only by human activities.

Areal differences: Bobrov (1949) reported that *P. harmala* var. *multisecta* was distributed only in the province of Mongolia, while Grubov (1998) reported that it is distributed not only in the province of Mongolia, but also in Tibet. *P. harmala* and *P. nigellastrum* are distributed in the province of Mongolia and Tibet (Bobrov 1949; Grubov 1998).

Yunatov (1950), Grubov (1982, 1998) and Gubanov (1996) have recorded *Peganum harmala* L. and *P. nigellastrum* Bge in Mongolia (Fig 3). *P. harmala* var. *multisecta* Maxim occurred in the Gobi Altai and Trans-Altai Gobi regions of Mongolia according to the present study. We suggest that *Peganum multisectum* (Maxim.) Bobr is distributed in Mongolia, but no *P. harmala* var.

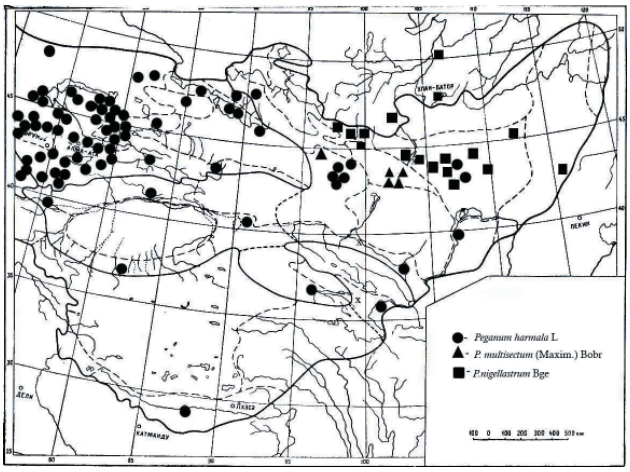

Figure 3. Distribution of the three species of *Peganum* L. in Central Asia
— Province border; ----- Regional border

multisecta, based on morphological, ecological and areal differences.

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Хураангуй

Монгол оронд тэмдэглэгдсэн *Peganum* төрөлд хамаарах зүйлүүдийн үрийн бүтцийг судалсан дүнг энэхүү өгүүлэлд тусгав. *P. harmala* зүйлийн үр хавтгайвтар хонхор бүхий гадаргуутай, *P. nigellastrum* зүйлийн үр гөлгөр гадаргуутай байхад *P. harmala* var. *multisecta*-ийн үр төвгөрүүд бүхий гадаргуутай байгаагаараа нэг нэгнээсээ ялгагдана. *P. harmala* var. *multisecta*-ийн үр зөвхөн усны урсгалаар зөөгддөг бол *P. harmala* зүйлийн үр хүний янз бүрийн үйл ажллагаагаар тараагддаг ажээ. Харин *P. nigellastrum* зүйлийн үр хүний үйл ажиллагаа болон салхиар тардаг. *P. harmala*, *P. nigellastrum* зүйлүүд Монгол, Түвдэд тархсан бол *P. harmala* var. *multisecta* мөн Монголд тэмдэглэгджээ. Бид тус оронд *P. harmala* var. *multisecta* биш харин *Peganum multisectum* (Maxim.) Bobr. зүйл тархсан байх магадлалтай хэмээн үзэж байгаа бөгөөд үүнийг тэдгээрийн морфологи, экологи, тархалтын ялгаан дээр үндэслэн дурьдаж байгаа болно.

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