

DOI: 10.1515/plass-2015-0018

Anatoliy A. Khapugin<sup>1,2</sup>

<sup>1</sup>Department of Botany, Physiology and Ecology of Plants, Mordovia State University, 430005, Bolshevistskaya Street, 68, Saransk, Republic of Mordovia, Russia; <sup>2</sup>Mordovia State Nature Reserve, 431230, Pushta, Temnikov District, Republic of Mordovia, Russia; e-mail: hapugin88@yandex.ru.

SEED MASS AND SEED YIELD OF SIX ROSES (*ROSA* L., *ROSACEAE* ADANS.)  
FROM CENTRAL RUSSIA (REPUBLIC OF MORDOVIA)

ABSTRACT

Genus *Rosa* L. is one of most critical taxa within European flora. Majority works is devoted to phylogeny, taxonomy and nomenclature of roses. Investigations of morphology and ecology of roses are still relatively few in number. The aim of this study was to evaluate seed mass and seed yield of six rose species (*Rosa cinnamomea*, *R. spinosissima*, *R. rugosa*, *R. rubiginosa*, *R. glauca* and *R. canina*) from populations in Central Russia (Republic of Mordovia). As a result of the study, it was revealed that *Rosa rugosa* has maximal number of seeds per rosehip among all investigated roses. Roses from section *Caninae* are characterized by large number of achenes per rosehip too. In contrast, among all investigated species, *Rosa cinnamomea* have most minimal seed yield. Origin of *Rosa spinosissima* population in Ruzaevka district (Republic of Mordovia, Central Russia) was proposed as uncertain according to number of seeds per rosehip. At first time, the seed mass of *Rosa cinnamomea*, *R. glauca* and *R. rubiginosa* was revealed.

Key words: Republic of Mordovia., *Rosa* L., *Rosaceae* Adans., seed mass, seed yield,

INTRODUCTION

The Republic of Mordovia is located in Central Russia. This territory covers 26,200 sq. km. Coniferous and mixed forests are distributed in the west, north-west and north of the region. Broad-leaved forests are distributed in the central and eastern parts of this area. Forest-steppe landscapes are dominated in the east and south-east of the Republic of Mordovia (Yamashkin, 1998). All this diversity of natural landscapes leads to a wide variety of habitat types in the area.

At present, study of plant morphology is still relevant. It allows revealing general patterns of plants structure and degree of their adaptation to environmental conditions. Particularly, it applies to a study of the seed ecology. After all, the seeds have a significant impact on the plant population regeneration and the distributing area of plants (Lv *et al.*, 2012). Studies of seeds of wild and cultural plants play significant role in the study of plant ecology and evolutionary biology (Harper, 1967; Heydecker, 1972; Abrahamson, 1979; Solbrig, 1981; Baskin and Baskin, 2004). The seed stage of the plant ontogenesis has significant effect on the distribution pattern of population, on the population dynamics, on the population management (Steven, 1991; Xie *et al.*, 1998). Investigations of the physical characteristics of seeds (Pahlavani *et al.*, 2009; Gladunova *et al.*, 2014), the seed germination (Bisht *et al.*, 2012; Greiner and Köhl, 2014), the seed yield (Ambika *et al.*, 2014; Nadeem *et al.*, 2014) show the traits of spatial distribution, the ecological preferences of plants, including medicinal, threatened and invasive species.

Seed size is a key determinant of the mobility, survival and success of plant propagules (Harper, 1997). Variations in seed size also lead to substantial changes in seed mass. In its turn, seed mass has a negative correlation with seed yield, namely, a ten-fold increase in seed mass is associated with a ten-fold decrease in the number of seeds that a plant can produce per unit canopy per year (Henery and Westoby, 2001). Thus, plants producing seeds of different mass have different implications on germination, the ability to emerge from different burial depths (Ruiz de Clavijo, 2001) and dispersal (Morse and Schmitt, 1985). However, there is little done for study of seeds of wild plants (Bustamante-García *et al.*, 2014; Miroshnichenko, 2014; Zhaldak *et al.*, 2014; Pradhan and Badola, 2010).

The genus *Rosa* L. is one of 35 genera of the *Rosaceae* family in European flora (Kurtto *et al.*, 2004, 2007, 2010, 2013). Roses are distributed widely throughout the temperate and subtropical habitats of the northern hemisphere (Rehder, 1940). At present, the number of wild roses identified in Europe is estimated as 46 species and several groups of species (Kurtto *et al.*, 2004). According to I.O. Buzunova (2001, 2014), V. Kereny-Nagy (2012), this number is even more. Moreover, huge number of cultivars has been developed either as garden plants or for the cut rose market, and more recently as indoor pot plants. Roses are recognized as a source of ornamental, medicinal and food value (Nybom, 2009). Throughout this time, numerous hybrids, forms, varieties were described as separate species. As a result, currently it highly difficult to create uniform generally approved classification of the genus *Rosa* L. Due to this problem, most part of publications is devoted to systematics and taxonomy of the genus *Rosa* L.

Publications devoted to the morphology of species of genus *Rosa* L. are not numerous (Ercisli and Esitken, 2004; Sorokopudov *et al.*, 2009; Rous *et al.*, 2011; Rezanova *et al.*, 2012; Nevidomova, 2013; Nadeem *et al.*, 2014). Particu-

larly, it was done little relatively to study of seeds of the genus *Rosa* L. (Avdeyev and Minayeva, 2005; Najda and Buczkowska, 2013). Thus, aim of this study was to compare and evaluate both seed yield and mass of 6 species of genus *Rosa* L. known in the Republic of Mordovia (Central Russia). Currently, 18 species are known in the Republic of Mordovia (Khapugin, 2014). They are inhabited mainly in non-woodland habitats and on the roadsides of transportation ways (Khapugin and Labutin, 2013; Khapugin and Silaeva, 2012, 2013).

#### MATERIAL AND METHODS

For our study, we select some species from 4 sections of the genus *Rosa* L.: *Rosa cinnamomea* L. (syn. *Rosa majalis* Herrm.) from section *Rosa* (former *Cinnamomeae* DC.), *Rosa spinosissima* L. (syn. *Rosa pimpinellifolia* L.) from section *Pimpinellifoliae* DC., *Rosa rugosa* Thunb. from section *Rugosae* Chrshan. and three species of section *Caninae* DC.: *Rosa glauca* Pourr. from subsection *Rubrifoliae* Crép., *Rosa canina* L. s. lato from section *Caninae* Christ, *Rosa rubiginosa* L. from section *Rubiginosae* Crép. Among them, *Rosa cinnamomea* and *Rosa canina* are roses widely spread in Europe. *Rosa glauca* is relatively new alien species for the Republic of Mordovia which was found in 2009 year here (Khapugin, 2012). *Rosa rugosa* is invasive plant at coastal ecosystems of Europe (Jørgensen and Kollmann, 2009; Kollmann *et al.* 2009; Kelager *et al.*, 2013). Nevertheless, within the Republic of Mordovia, *R. rugosa* not shows a high level of invasiveness, and it occurs only in disturbed habitats (Silaeva and Levin, 2010). *Rosa rubiginosa* is included in the Red Data Book of the Republic of Mordovia (Barmin, 2003). *Rosa spinosissima* is considered as an alien species in the Republic of Mordovia. In this region, *Rosa spinosissima* is widely cultivated and rarely found in wild.

These species was selected for the study for several reasons. Firstly, data on the seed mass and the seed yield for *R. cinnamomea*, *R. glauca* and *R. rubiginosa* are absent. It is especially important because *R. cinnamomea* is a species widely spread in Europe. *Rosa rubiginosa* is rare species in East Europe (Kurtto *et al.*, 2004; Buzunova, 2014) but, in contrast, it is invasive species in South America (Zimmermann *et al.*, 2014). Relatively to *R. glauca*, just one fertile population of this species is known in the Republic of Mordovia (Romodanovo district). Other populations of *R. glauca* in this region not contain plants which produce fruits. Secondly, there is poor information about the seed mass of a widespread *Rosa canina* (Verma *et al.*, 2013). That's why this rose was selected for the study. Finally, seed characteristics of *Rosa rugosa* and *Rosa spinosissima* were presented in two reviews in relation to the flora of Great Britain (Bruun, 2005; Mayland-Quellhorst, 2012). These species were selected for the study for further comparing with known results.

Rosehips were harvested in October – November 2013 year from shrubs wild / run wild (Table 1). *Rosa glauca* was harvested from most large shrubs

from well-known population in the Romodanovo district of the Republic of Mordovia (Khapugin, 2012): on meadow near the roadside. *Rosa spinosissima* and *Rosa cinnamomea* were harvested on south-western slope from Ruzaevka district. *Rosa rugosa* was harvested near the abandoned garden from urban district Saransk. *Rosa canina* s. lato was harvested on meadow at the deciduous forest edge from Romodanovo district. *Rosa rubiginosa* was harvested on the meadow along the slope of ravine in the locality recently founded within Romodanovo district (Buzunova *et al.*, 2012).

Most ripe and undamaged rosehips were selected among total number of those within populations. From 45 (*Rosa rubiginosa*) to 399 (*Rosa glauca*) rosehips were be harvested for further investigations. Harvesting was carried out from different plants (Table 1).

Table 1

Origin and number of harvested rosehips

Species	The Republic of Mordovia District	Coordinates	Number of harvested rosehips /studied plants per population
<i>Rosa cinnamomea</i>	Ruzaevka district	54.095365 N, 45.110753 E	151 / 23
<i>Rosa spinosissima</i>	Ruzaevka district	54.094996 N, 45.110408 E	153 / 5
<i>Rosa rugosa</i>	Saransk urban district	54.156703 N, 45.131834 E	50 / 11
<i>Rosa canina</i>	Romodanovo district	54.411045 N, 45.139198 E	305 / 13
<i>Rosa glauca</i>	Romodanovo district	54.417635 N, 45.147878 E	399 / 8
<i>Rosa rubiginosa</i>	Romodanovo district	54.468696 N, 45.333849 E	45 / 7

Average values of seed mass and seed yield were measured on base of the Laboratory of Plant Systematics and Phytogeography. For detecting of the seed mass, samples of 50 achenes were randomly selected and weighted to the nearest 0.1 mg.

Achieved results were statistically processed by using R packages (R Core Team, 2014) and Microsoft Excel.

## RESULTS

### *Seed yield*

Large values of seed yield were shown for roses from section *Caninae* DC. compared to other studied species (Table 2). It is shown at Fig. 1, where graphic of density parameter have a strongly pronounced spike for each of dog-rose species.

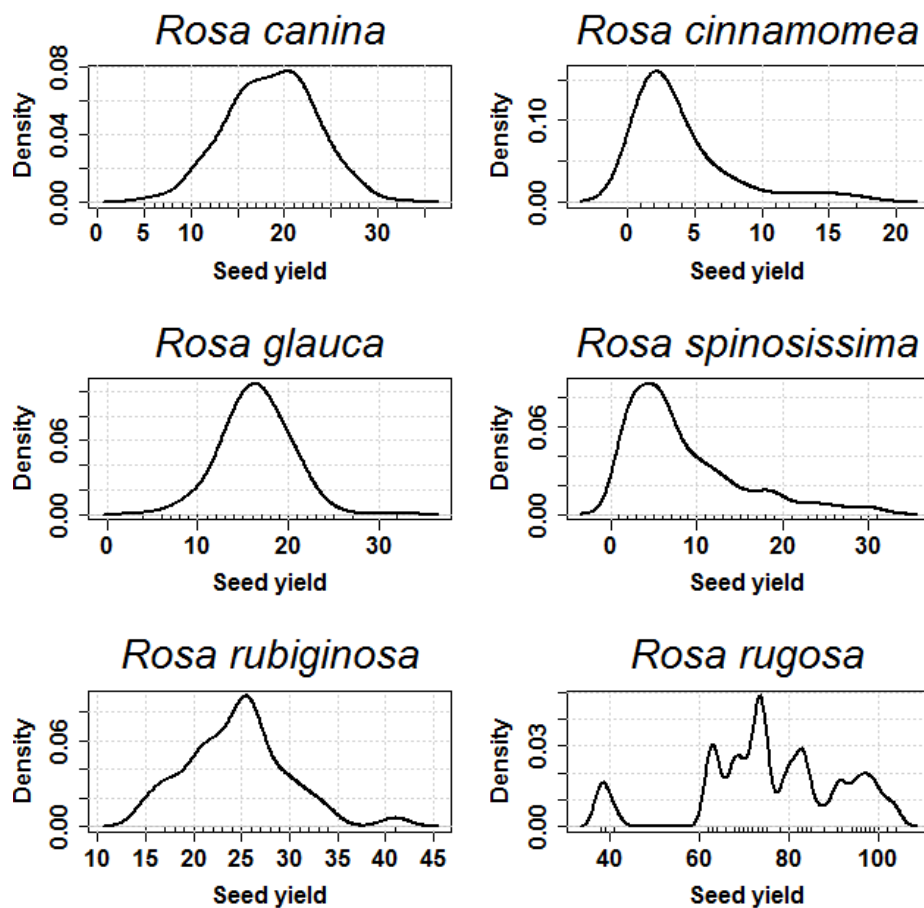


Fig. 1. Probability density function for the seed yield using a Gaussian distribution

Among dog-roses, average seed yield was varied from 16.4 (*Rosa glauca*) to 24.6 (*Rosa rubiginosa*) achenes per rosehip. In general, this parameter was similar for all dog-roses species independently from their origin. For example, similar values of seed yield were shown both for alien species *Rosa glauca* and for rare native species *Rosa rubiginosa* (Fig. 1). In contrast, seed yields of *Rosa cinnamomea* and *R. spinosissima* were the smallest and non-stable among other rose species. Among them, the seed yield of *R. spinosissima* was widely ranged (from 1 to 31 achenes per rosehip). Main part of rosehips contains 3–6 seeds (Fig. 1). The highest seed yield was shown for *Rosa rugosa*. It was widely ranged (from 38 to 104 achenes per rosehip).

**Seed mass**

Maximal value of the seed mass (mass of one achene was 20.3 mg) was shown for *R. spinosissima* (Table 2, Fig. 2). In contrast, minimal value of the seed mass was shown for *R. rugosa* (mass of one achene was 5.8 mg).

Table 2

**Average values of the seed mass and the seed yield for species of genus *Rosa* L.**

Species	Seed yield ( $M\pm m$ )	Seed mass, g <sup>1</sup> ( $M\pm m$ )
<i>Rosa cinnamomea</i>	3.9±0.3	0.6828±0.0119 <sup>a</sup>
<i>Rosa spinosissima</i>	8.4±0.5	1.0141±0.0112 <sup>b</sup>
<i>Rosa rugosa</i>	76.3±2.3	0.2920±0.0037 <sup>c</sup>
<i>Rosa rubiginosa</i>	24.6±0.8	0.8996±0.0080 <sup>c</sup>
<i>Rosa glauca</i>	16.4±0.2	0.6253±0.0058 <sup>d</sup>
<i>Rosa canina</i>	18.6±0.3	0.6997±0.0037 <sup>c</sup>

<sup>1</sup>Based on a sample of 50 randomly selected seeds from each target, where  $n^a = 13$ ,  $n^b = 25$ ,  $n^c = 21$ ,  $n^d = 31$ ,  $n^e = 61$ ;  $M$  – average value,  $m$  – error of the mean

Intermediate values of the seed mass were shown for dog-roses. There are *R. glauca* (mass of one achene was 12.5 mg), *Rosa canina* (mass of one achene was 14.0 mg) and *R. rubiginosa* (mass of one achene was 18.0 mg).

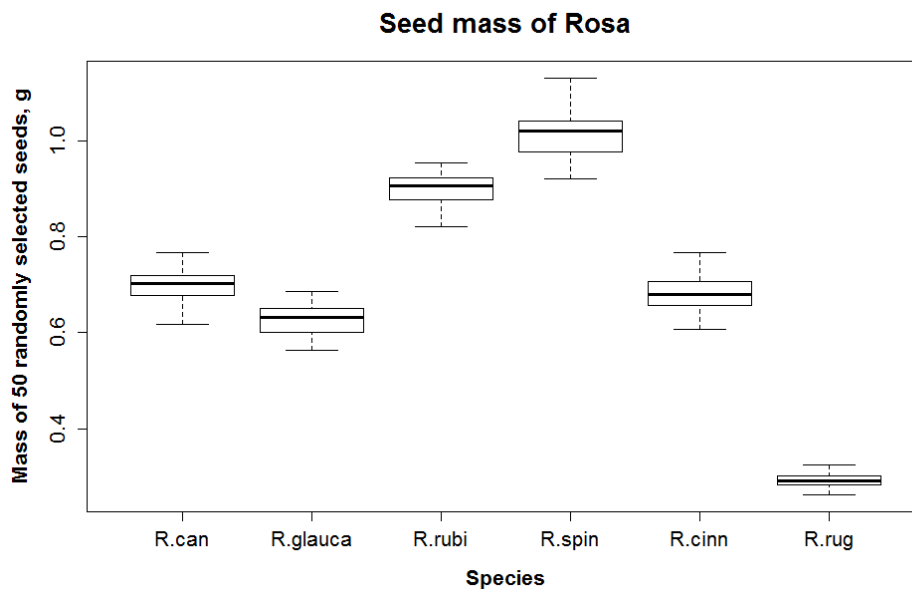


Fig. 2. Seed mass of *Rosa* studied. R.can – *Rosa canina*, R.glauca – *R. glauca*, R.rubi – *R. rubiginosa*, R.cinn – *R. cinnamomea*, R.rug – *R. rugosa*

#### DISCUSSION

The present study showed that all detected values of the seed yield of *Rosa rugosa* were into the limits noted by H.H. Bruun (2005) for this species. Similarly, the seed mass of *R. rugosa* was similar to data (6.6 mg; ranging from < 4 mg to > 10 mg) shown by H.H. Bruun (2005: from Junttila, 1974). However, studies of the seed mass were carried out by Najda and Buczkowska (2013) and Avdeyev and Minayeva (2005). But they have been measured the total mass of achenes per rosehip. That's why we can not to compare our data with those obtained by authors listed above. Thus, *Rosa rugosa* is characterized by both the smallest the seed mass and the highest the seed yield. It is known that achenes of *Rosa rugosa* have the floating ability (Jessen, 1958). As a result of Jessen's experiments, it was conducted that over-ripe hips of *Rosa rugosa* have a maximal floating time (time until the last hip sank) of 26, 40 and 42 weeks. Individual achenes were able to float up to 46 weeks (Jessen, 1958). That's why, in our opinion, combination of the smallest the seed mass and the highest the seed yield is a manifestation of the floating ability of achenes of *Rosa rugosa*.

The seed mass of *R. spinosissima* was most large among rose's species selected. However, obtained data are near the lower limit of the values range (18–50 mg) shown by Schroeder and Braun (1945). Similarly, they are less, than value shown by Kovács, Tóth and Facsar (2004) for this species (35.5 mg). In contrast, the average seed yield of *Rosa spinosissima* was rather low among studied roses. Its value was similar to the data (4.5 achenes per rosehip) shown by Kovács, Tóth and Facsar (2004). However, automatic autogamy, geitonogamy, geitonogamy and xenogamy are typical for this species (Mayland-Quellhorst *et al.*, 2012). Taking into account such diversity of pollination ways, the low seed yield may be the proof of hybrid origin of investigated population. Moreover, this is supported by results of Schroeder and Braun (1945) which have shown that seed yield of *R. spinosissima* is 10–15 and 2–3 achenes per rosehip for wild and nursery plants, respectively. Due to this, average seed yield of *R. spinosissima* in our study was between these ranges. Thereby, we suppose that origin of this *R. spinosissima* population should consider as uncertain, as it was assumed earlier (Mayorov, 1993; Kurtto *et al.*, 2004).

Low value of the seed yield of *Rosa cinnamomea* is explained by direct cross-pollination in ontogenesis of this rose (Schanzer and Vagina, 2007). Thereby different ecological factors are often influenced and limited the seed productivity of this rose's species.

All species of section *Caninae* (*Rosa canina*, *R. glauca*, *R. rubiginosa*) form stable large number of achenes. This fact is largely explained by a combination of cross-pollination with apomixis, which was shown in several works (Werlemark, 2000; Schanzer and Vagina, 2007). It should be noted that the seed mass of *Rosa canina* is comparable only with data of Verma *et al.*, Lal, Ahmed

and Sagoo (2013). They have revealed that mass of *R. canina* seeds in North Western Himalayan region of Kashmir is equal  $23.96 \pm 2.42$ . This value is slightly more than it was revealed in our study. In any case, at present, there are little data about weighted indexes of seeds from different places of the wide range of *Rosa canina*. Usually, researchers measure total weight of seeds per fruits or weight of fruit, but mass of one seed is not measured. And it is a problem for revealing and comparing of the mass of a single seed of different roses.

Comparison of the seed yield and the seed mass of *Rosa cinnamomea*, *R. glauca* and *R. rubiginosa* is not possible due to lack of published comparable data. That's why our data on the seed mass and the seed yield for these species will be the first step to study of seed ecology of roses in Central Russia. In future, study of the seed germination is needed.

#### ACKNOWLEDGEMENTS

This work was supported by the Ministry of Education and Science of Russia (project № 6.783.2014K).

#### REFERENCES

- Abrahamson W.G. 1979. Patterns of resources allocation in wildflower population of fields and woods. *Am. J. Bot.* 66: 71-79.
- Ambika S., Manonmani V. and Somasundaram G. 2014. Review on Effect of Seed Size on Seedling Vigour and Seed Yield. *Research Journal of Seed Science* 7(2): 31-38.
- Avdeyev V.I. and Minayeva O.A. 2005. Ecological variability of *Rosa* L. species characters. *Trudy Orenburgskogo gosudarstvennogo agrarnogo universiteta* 1(5-1): 88-90. (In Russian).
- Barmin N.A. 2003. *Rosa rubiginosa* L. In: Red Book of the Republic of Mordovia: Rare species of plants, lichens and fungi, Silaeva, T.B., (Ed.). Publisher of the Mordovian State University, Saransk, pp. 144. (In Russian).
- Baskin J.M. and Baskin C.C. 2004. A classification system for seed dormancy. *Seed Sci. Res.* 14: 1-16. DOI:10.1079/SSR2003150.
- Bisht H., Prakash V. and Nautiyal A.R. 2012. Factors Affecting Regeneration Potential of *Quercus semecarpifolia*, Smith: A Poor Regenerated Oak of Himalayan Timberline. *Research Journal of Seed Science* 5(2): 63-70.
- Bruun H.H. 2005. Biological Flora of the British Isles: *Rosa rugosa* Thunb. *J. Ecol.* 93: 441-470.
- Bustamante-García V., Prieto-Ruiz J.Á., Carrillo-Parra A., Álvarez-Zagoya R., González-Rodríguez H. and Corral-Rivas J.J. 2014. Seed production and quality of *Pinus durangensis* Mart., from seed areas and a seed stand in Durango, Mexico. *Pak. J. Bot.* 46(4): 1197-1202.
- Buzunova I.O. 2001. *Rosa* L. In: Flora Europae Orientalis, N.N. Tzvelev (Ed.). Vol. 10, Mir i semia, Saint-Petersburg, pp. 329-361. (In Russian).
- Buzunova I.O. 2014. *Rosa* L. In: Flora of the middle of european part of Russia, P.F. Maevsky. Moscow, pp. 164-170. (In Russian).
- Buzunova I.O., Khapugin A.A., Ageeva A.M. and Vargot E.V. 2012. New records of the *Rosa* L. species (*Rosaceae*) in Middle Russia. *Bulleten Moskovskogo obshchestva ispytateley prirody. Otdel biologicheskiiy* 117(6): 76. (In Russian with English title).
- Ercisli S. and Esitken A. 2004. Fruit characteristics of native rose hip (*Rosa* spp.) selections from the Erzurum province of Turkey. *New Zeal. J. Crop. Hort.* 32: 51-53.
- Gladunova N.V., Vargot E.V. and Khapugin A.A. 2014. *Oenothera biennis* L. (*Onagraceae*) in the Republic of Mordovia (Russia). *Russ. J. Biol. Invasions* 5(1): 12-17.
- Greiner S. and Köhl K. 2014. Growing evening primroses (*Oenothera*). *Front Plant Sci.* 5: 38.



- Harper J.L. 1967. A darwinian approach to plant ecology. *J. Ecol.* 55: 247-270.
- Harper J.L. 1997. *The Population Biology of Plants*, Academic Press, London.
- Henery M.L. and Westoby M. 2001. Seed mass and seed nutrient content as predictors of seed output variation between species. *Oikos* 92: 479-490.
- Heydecker W. 1972. *Seed Ecology*. London: Butterworths.
- Jessen K. 1958. Om vandspredning af *Rosa rugosa* og andre arter af slægten. *Botanisk Tidsskrift (Copenhagen)* 54: 353-366 [In Danish].
- Jørgensen R.H. and Kollmann J. 2009. Invasion of coastal dunes by the alien shrub *Rosa rugosa* is associated with roads, tracks and houses. *Flora* 204: 289-297.
- Junttila O. 1974. Seed quality and seed production of woody ornamentals in Scandinavia. *Meldinger fra Norges Landbrukshøgskole* 53(12): 1-41. (In Dutch).
- Kelager A., Pedersen J.S. and Bruun H.H. 2013. Multiple introductions and no loss of genetic diversity: invasion history of Japanese Rose, *Rosa rugosa*, in Europe. *Biol. Invasions* 15: 1125-1141.
- Kerényi-Nagy V.A. 2012. Történelmi Magyarország területén élő őshonos, idegenhonos és kultúr-reliktum rózsák kis monográfiája [A small monograph of autochthon, allochthon and cultur-relict roses of Historical Hungary]. *Nyugat-magyarországi Egyetem Kiadó, Budapest*, 431 pp. (In Hungarian).
- Khapugin A.A. 2012. About Finding of *Rosa glauca* Pourr. (*Rosaceae*) in the Republic of Mordovia. *Russ. J. Biol. Invasions* 3(1): 56-57. DOI: 10.1134/S2075111712010043.
- Khapugin A.A. 2014. History of investigations of the genus *Rosa* L. (*Rosaceae*) in the Republic of Mordovia. *Proceeding of the Mordovian State Nature Reserve* 12: 383-394. (In Russian).
- Khapugin A.A. and Silaeva T.B. 2012. Species of genus *Rosa* L. in the Moksha river basin. In: II (X) International Botanical Conference of Young Specialists. Saint-Petersburg, 11-16 November 2012, pp. 103. (In Russian).
- Khapugin A.A. and Silaeva T.B. 2013. Roses (*Rosa* L.) in the anthropogenic habitats in the Republic of Mordovia. In: XIII Congress of Russian Botanical Society. Togliatti, pp. 103-104. (In Russian). DOI: 10.13140/RG.2.1.1091.2806.
- Khapugin A.A. and Labutin D.S. 2013. Species of genus *Rosa* L. on transportation ways within north-western part of the Volga Uplands. In: "Forest-steppe of the Eastern Europe": Structure, dynamics and protection. Penza, pp. 133-135. (In Russian). DOI: 10.13140/RG.2.1.3188.4328.
- Kollmann J., Jørgensen R.H., Roelsgaard J. and Skov-Petersen H. 2009. Establishment and clonal spread of the alien shrub *Rosa rugosa* in coastal dunes. A method for reconstructing and predicting invasion patterns. *Landscape and Urban Planning* 93: 194-200.
- Kovács S., Tóth M. and Facsar G. 2004. Evaluation of fruit quality parameters of *Rosa* taxa from the Carpathian basin. *Int. J. Hort. Sci. Technol.* 10: 81-87.
- Kurto A., Lampinen R. and Junikka L. (Eds.) 2004. *Atlas Florae Europaeae. Distribution of vascular plants in Europe. 13. Rosaceae (Spiraea to Fragaria, excl. Rubus)*. – In: Kurto, A., Lampinen, R., Junikka, L. (eds.) *Rosaceae (Spiraea to Fragaria, excl. Rubus)*. The Committee for Mapping the Flora of Europe, Societas Biologica Fennica, Vanamo, Helsinki, 320 pp.
- Kurto A., Fröhner S.E. and Lampinen R. (Eds.) 2007. *Atlas Florae Europaeae. Distribution of Vascular Plants in Europe. 14. Rosaceae (Alchemilla and Aphanes)*. The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo, Helsinki, 200 pp.
- Kurto A., Weber H.E., Lampinen R. and Sennikov A.N. (Eds.) 2010. *Atlas Florae Europaeae. Distribution of Vascular Plants in Europe. 15. Rosaceae (Rubus)*. The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo, Helsinki, 362 pp.
- Kurto A., Sennikov A.N., and Lampinen R. (Eds.) 2013. *Atlas Florae Europaeae. Distribution of Vascular Plants in Europe. 16. Rosaceae (Cydonia to Prunus, excl. Sorbus)*. The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo, Helsinki, 168 pp.
- Lv C., Zhang X., Liu G. and Deng C. 2012. Seed yield model of *Haloxylon ammodendron* (C.A. Meyer) Bunge in Junggar Basin, China. *Pak. J. Bot.* 44(4): 1233-1239.
- Mayland-Quellhorst E., Föller J. and Wissemann V. 2012. Biological Flora of the British Isles: *Rosa spinosissima* L. *J. Ecol.* 100: 561-576.
- Mayorov S.R. 1993. *Flora of the Republic of Mordovia*. PhD thesis. Moscow State University, Moscow, Russia. (In Russian).
- Miroshnichenko N.N. 2014. Toward the seed reproduction of some species from genus *Campanula* L. *Modern Phytomorphology* 6: 135-136. (In Russian with English title and abstract).
- Morse D.H. and Schmidt J. 1985. Propagule size, dispersal ability and seedling performance in *Asclepias syriaca*. *Oecologia* 67: 372-379.
- Nadeem M., Akond M., Riaz A., Qasim M., Younis A. and Farooq A. 2014. Pollen Morphology and Viability Relates to Seed Production in Hybrid Roses. *Plant Breeding and Seed Science* 68(1): 25-38. DOI: 10.2478/v10129-011-0078-y.

- Najda A. and Buczkowska H. 2013. Morphological and chemical characteristics of fruits of selected *Rosa* sp. *Modern Phytomorphology* 3: 99-103.
- Nevidomova E.V. 2013. Coenopopulations of *Rosa majalis* Herrm. in the associations of Nizhegorodsk Povetluja (Crasnobacovski district). *Modern Phytomorphology* 4: 159-164. (In Russian with English title and abstract).
- Nybohm H. 2009. Introduction to *Rosa*. Part 16. In: *Genetics and Genomics of Rosaceae*. Folta K.M. and Gardiner S.E. (Eds.). In: *Plant Genetic and Genomics: Crops and Models*. Springer New York, 6: 339-351.
- Pahlavani M., Miri A. and Kazemi G. 2009. Response of oil and protein content to seed size in cotton (*Gossypium hirsutum* L., cv. Sahel. *Plant Breeding and Seed Science* 59(1): 53-64. DOI: 10.2478/v10129-009-0004-8.
- Pradhan B.K. and Badola H.K. 2010. Chemical Stimulation of Seed Germination in ex situ Produced Seeds in *Swertia chirayita*, A Critically Endangered Medicinal Herb. *Research Journal of Seed Science* 3(3): 139-149.
- R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from: <http://www.R-project.org/> [Accessed 5 May 2015].
- Rehder A. 1940. *Manual of Cultivated Trees and Shrubs*. 2nd. Edition. McMillan, New York, USA. pp. 426-451.
- Rezanova T.A., Sorokopudov V.N., Svinarev E.N., Evtukhova M.V., Sorokopudova O.A. and Ntrebenko N.N. 2012. Adaptation of species of genus *Rosa* L. in conditions of the Belgorod region. *Fundamental research* 11: 309-312. (In Russian with English title and abstract).
- Rous C.M., Manzu C., Olteanu Z., Oprica L., Oprea A., Ciornea E. and Zamfirache M.M. 2011. Several fruit characteristics of *Rosa* sp. genotypes from the northeastern region of Romania. *Not. Bot. Horti. Agrobiol.* 39(2): 203-208.
- Ruiz De Clavijo E. 2001. The role of dimorphic achenes in biology of the annual weed *Leontodon longirostris*. *Weed Research* 41: 275-286.
- Schanzer I.A. and Vagina A.V. 2007. ISSR (Inter Simple Sequence Repeat) markers reveal natural inter-sectional hybridization in wild roses [*Rosa* L., sect. *Caninae* (DC.) Ser. and sect. *Cinnamomeae* (DC.) Ser.]. *Wulfenia* 14: 1-14.
- Schroeder H. and Braun H. 1945. *Die Hagebutte ihre Geschichte, Biologie und ihre Bedeutung als Vitamin C-Träger*. Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart, Germany. (In German).
- Solbrig O.T. 1981. Studies on the population biology of the genus *Viola*. II. The effect of plant size on fitness in *Viola sororia*. *Evolution* 35: 1080-1093.
- Sorokopudov V.N., Ntrebenko N.N., Evtukhova M.V. and Pisarev D.I. 2009. Morphological and anatomical aspects of some representatives of genus *Rosa* L. *Vestnik Krasnoyarskogo gosudarstvennogo agrarnogo universiteta* 11: 50-54 (In Russian with English title and abstract).
- Steven D.D. 1991. Experiments on mechanisms of establishment in old-field succession: seedling emergence. *Ecology* 72: 1066-1075.
- Verma M.K., Lal S., Nazeer A. and Sagoo P.A. 2013. Character association and path analysis in hip rose (*Rosa* sp.) genotypes collected from North Western Himalayan region of Kashmir. *Afr. J. Agric. Res.* 8 (39): 4949-4955. DOI:10.5897/AJAR2013.6950.
- Werlemark G. 2000. Evidence of apomixis in hemisexual dogroses, *Rosa* section *Caninae*. *Sex. Plant Reprod.* 12(6): 353-359.
- Xie Z.Q., Chen L.W., Hu D. and Zhu R.G. 1998. The fruiting characteristics of an endangered plant, *Cathaya argyrophylla* and the impact of animals on fruit. *Chinese Journal of Plant Ecology* 22: 319-326.
- Yamashkin A.A. 1998. *Physical and geographical conditions of the Republic Mordovia*. Publisher of the Mordovian State University, Saransk. [in Russian].
- Zhaldak S., Kucharska A., Piyrecki N. and Bugara I. 2014. Evaluation of morphometric parameters of *Cornus mas* L. fruits from coenopopulations in Crimea. *Modern Phytomorphology* 6: 137-139. (In Russian with English title and abstract).
- Zimmermann H., Brandt P., Fischer J., Welk E. and Von Wehrden H. 2014. The Human Release Hypothesis for biological invasions: human activity as a determinant of the abundance of invasive plant species [v2; ref status: indexed, <http://f1000r.es/4wpj>]. *F1000Research* 3: 109. DOI: 10.12688/f1000research.3740.2.