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BRIEF MESSAGES

Natural Populations of the Rare Medicinal Species *Alangium platanifolium* (Alangiaceae) in Russia

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Abstract—Data on the status of two natural populations of the rare, endemic medicinal species *Alangium platanifolium* known from the Russian Federation is provided in this article. Information about one of them is reported for the first time. Geobotanical descriptions of the phytocenoses are presented. In southern Primorskii krai, *A. platanifolium* has been noted to grow in the shrub layer of coniferous/broad-leaved forest with *Pinus koraiensis* and *Abies holophylla*. It has also been found that the area of the population discovered 20 years ago has expanded tenfold and now amounts to 10 ha. The new locality of *A. platanifolium* covers an area of 0.25 ha. The total number of *A. platanifolium* is more than 700 of various-age plants. The data obtained extends the current knowledge of the distribution and life state of *A. platanifolium* and indicates the fact of the growth of subtropical elements in phytocenoses of the Russian Federation.

Keywords: *Alangium platanifolium*, rare species, ornamental plant, East Asian endemic, Russian Far East

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INTRODUCTION

The flora of Primorskii krai of Russia is very diverse and includes more than 2700 species of vascular plants, of which about 550 are recorded only for this territory (Kozhevnikov and Kozhevnikova, 2014; Kozhevnikov et al., 2019). The southern regions of the Russian Far East (RFE) are located on the northern edge of the East Asian floristic region, which covers the bulk of the territory of East Asia (Takhtadzhyan, 1978). This territory is home to many endemic and relict species that have been preserved here since the Tertiary due to the absence of Pleistocene glaciation (Kozhevnikov and Kozhevnikova, 2014). Among them is a representative of the order Magnoliophyta, family Alangiaceae DC., *Alangium platanifolium* (Siebold & Zucc.) Harms. This is the only deciduous shrub in the genus, an East Asian endemic, subtropical view (Urusov, 2015; Milogradov and Urusov, 2021).

The area of *A. platanifolium* covers regions with temperate and cold–temperate continental climates (Shatilova and Kokolashvili, 2014), extends into temperate regions of Eastern China, Korea, and Japan, and goes north into Russia (Ohwi, 1965; Feng, 2009; Ohashi, H. and Ohashi, K., 2009). The plant is a relict of the Tertiary flora, represented in fossils of Tertiary deposits of the northern hemisphere (Feng, 2009). *A. platanifolium* appeared for the first time in domestic herbarium collections in 1897 (herbarium of the KBI RAS: LE01007499; LE01007500; LE 01007701). Herbarium specimens were collected by V.L. Komarov on the border of China and North Korea in the Yalujiang River basin (Komarov, 1950).

The species is listed in the Red Book of the International Union for Conservation of Nature (IUCN) with the status "vulnerable" (VU) (Kim et al., 2020). According to the Order of the Ministry of Natural Resources and Environment of the Russian Federation dated May 23, 2023, no. 320 "On Approval of the List of Flora Listed in the Red Book of the Russian Federation" (Registered July 21, 2023 no. 74362), *A. platanifolium* is protected at the federal level with rarity status category 3 (rare species with a naturally low abundance, found in a limited area, the survival of which requires the adoption of special protection measures).

As a medicinal plant, *A. platanifolium* is used for medicinal purposes in East and Southeast Asia (Jain et al., 2005). Glycosidic compounds from *A. plantanifolium*, represented by salicin, exhibited antipyretic and analgesic effects and were used to treat fever and arthritis (Duan et al., 2012), and terpenoids have anticancer, anti-inflammatory, antiallergic, and hypoglycemic activity (Sun et al., 2017). The plant is an orna-

mental plant, cultivated in botanical gardens in America and Europe (Schulz, 2011).

Several articles have been devoted to study of *A. platanifolium*. Thus, the works present descriptions of fossil finds of *A. platanifolium* (Eyde et al., 1969; Morley, 1982; Shatilova and Kokolashvili, 2014; etc.) and provide data on the leaf shape (Ohashi, H. and Ohashi, K., 2009), the number of petals and stamens in a flower (Ohashi et al., 2009), the stomatal structure (Cheng et al., 2021), and the structure of pollen grains (Reitsma, 1970). Some works are devoted to phylogeny and biogeography (Eyde, 1968; Chandler and Plunkett, 2004; Feng et al., 2009; etc.). The following works present the most complete data on the phytochemistry and pharmacology of the species (Otsuka et al., 1996; Tamaki et al., 1999; Fraga, 2012; Hu et al., 2020; Lian et al., 2023; etc.). For the flora of Russia, *A. platanifolium* was first noted in 2001 (Fedina et al., 2002). However, to date, no research has been carried out on the status of the population discovered. Therefore, the goal of this work is to characterize the biological and phytocenotic features of the rare medicinal plant *A. platanifolium* to solve problems of its conservation.

MATERIALS AND METHODS

Alangium platanifolium is a multi-stemmed shrub up to 3–4 m in height. The leaves are simple (Fig. 1), entire, petioles with sparse pubescence, 7–10 (15) cm long. The leaf blade is thinly membranous, 10–15 (20) cm long and almost the same width, rounded-heart-shaped, slightly asymmetrical at the base, more or less deeply divided at the apex into 3–5 (7) finely pointed lobes. Flowers in axillary few-flowered (1–5) inflorescences. The corolla at the beginning of flowering is tubular, with eight white, narrow belt-shaped petals, which later twist outward into four spirals. There are eight stamens, up to 3 cm in length. Ovary inferior. The fruit is a one-seeded drupe (Fedina et al., 2002).

Previously (Fedina et al., 2002) the only population *A. platanifolium* in the Russian Federation was discovered on the territory of Primorskii krai by employees of the Komarov Ussuriiskii State Natural Reserve in the summer of 2001. The cenopopulation consisted of plants of different ages, including flowering and later fruit-bearing ones. The bulk of the plants grew under the canopy of a native mixed coniferous–deciduous forest in the vicinity of the village of Alekseevka, Nadezhdinskii district, on the watershed between the Perevoznaya River and Smolnyi Stream. At a distance of 3 km from the first coenopopulation on the same watershed on a plateau-like hill in the Kovalevskaya Decay, a second population was found (Fedina et al., 2002).

This study was organized jointly with representatives of the Phoenix Nonprofit Environmental Fund and the Tiger Center in July 2021 and the Vladivostok branch of the Primles Regional State Budgetary Institution in September 2022.

In 2021, 1 km from the previously described first locality of *A. platanifolium* at an altitude of 273 m above sea level, on the eastern rocky slope, a third population was discovered, and the first population was revised in 2022 (Fig. 2).

Work to determine the size of the growing areas of coenopopulations of *A. platanifolium* was carried out using the GPS60CSX navigation device and Map Source Trip Waypoint Manager software. Latin plant names and species authors were checked in the International Plant Names Index database (2012).

The collected plant samples are stored in the herbarium of the Federal Scientific Center for Biodiversity of Terrestrial Biota of East Asia, Far East Branch, Russian Academy of Sciences (Vladivostok).

RESULTS

Characteristics of coenopopulations. The cenopopulation of *A. platanifolium* discovered in 2021 occupies an area of 50 × 50 m (0.25 ha) (Fig. 2), where in the center of this area in a forest clearing three large flowering bushes of this plant with a height of more than 250 cm and a crown projection of up to 300 cm grow. Around this clearing, under the canopy, another ten specimens of pregenerative plants of *A. platanifolium* of different ages up to 150 cm in height were found. This illuminated area of the forest was formed as a result of the breaking of the upper part of the trunk in one and a windfall in another *Betula costata* Trautv. These trunks lie in the center of the clearing, which is overgrown with vines of *Schisandra chinensis* (Turkz.) Baill., *Actinidia arguta* Miq., *A. kolomikta* (Maxim.) Maxim., and numerous shoots.

The vegetation in this area is represented by an intact cedar–broad-leaved forest type, the forest stand composition formula is 3Pine2Linden2Elm2Corktree1Birch: *Pinus koraiensis* Siebold et Zucc. (Korean pine), *Tilia amurensis* Rupr. (Amur linden), *Ulmus laciniata* (Trautv.) Mayr (Manchurian elm), *Phellodendron amurense* Rupr. (Amur corktree), and *Betula costata* (Yellow birch).

In addition to the above tree species, undergrowth grows: *Abies holophylla* Maxim., *Carpinus cordata* Blume, *Micromeles alnifolia* Koehne, *Padus maximowiczii* (Rupr.) Sokolov, *Kalopanax septemlobus* Koidz., *Fraxinus mandshurica* Rupr., *Acer mandshuricum* Maxim., *A. mono* Maxim., and *A. tegmentosum* Maxim. The shrub vegetation consists of *A. platanifolium*, *Eleuth-*

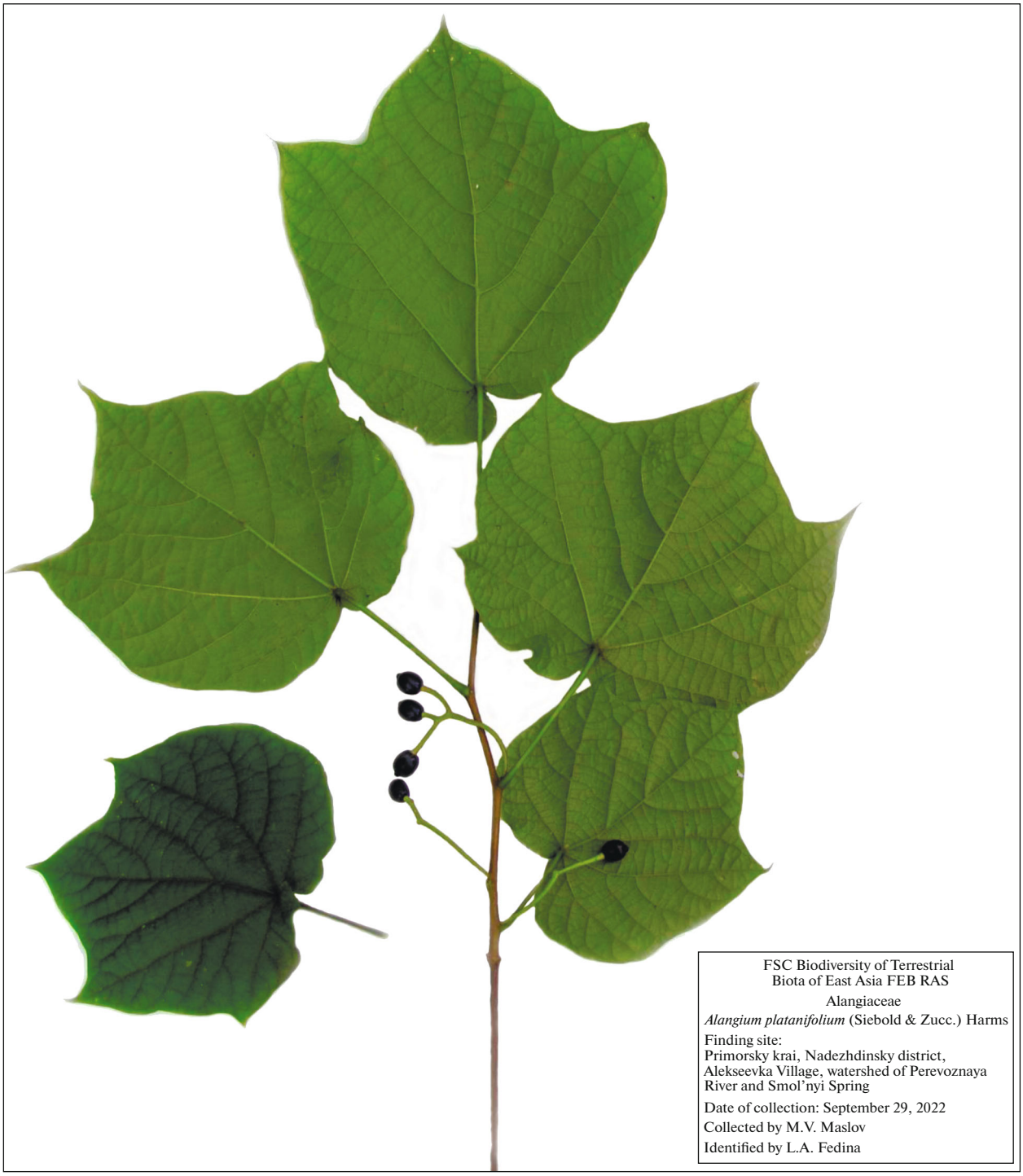

Fig. 1. *Alangium platanifolium*: herbarium specimen. Photo by M.V. Maslov.

erococcus senticosus (Rupr. et Maxim.) Maxim., *Philadelphus tenuifolius* Rupr. et Maxim., *Deutzia amurensis* (Regel) Airy Shaw, *Sambucus coreana* (Nakai) Kom. et Aliss., etc.

The herbaceous layer is represented by the ferns *Dryopteris crassirhizoma* Nakai, *Gymnocarpium dryopteris* Newman, *Polystichum tripteron* (G. Kunse) C. Presl; the vascular plants *Urtica angustifolia* Fisch. ex Hornem., *Hylomecon vernalis* Maxim., *Paris hexaphylla* Cham., *Paeonia obovata* Maxim., *Carex appendiculata* (Trautv. et Mey.) Kiik., and *C. siderosticta* Hance predominate.

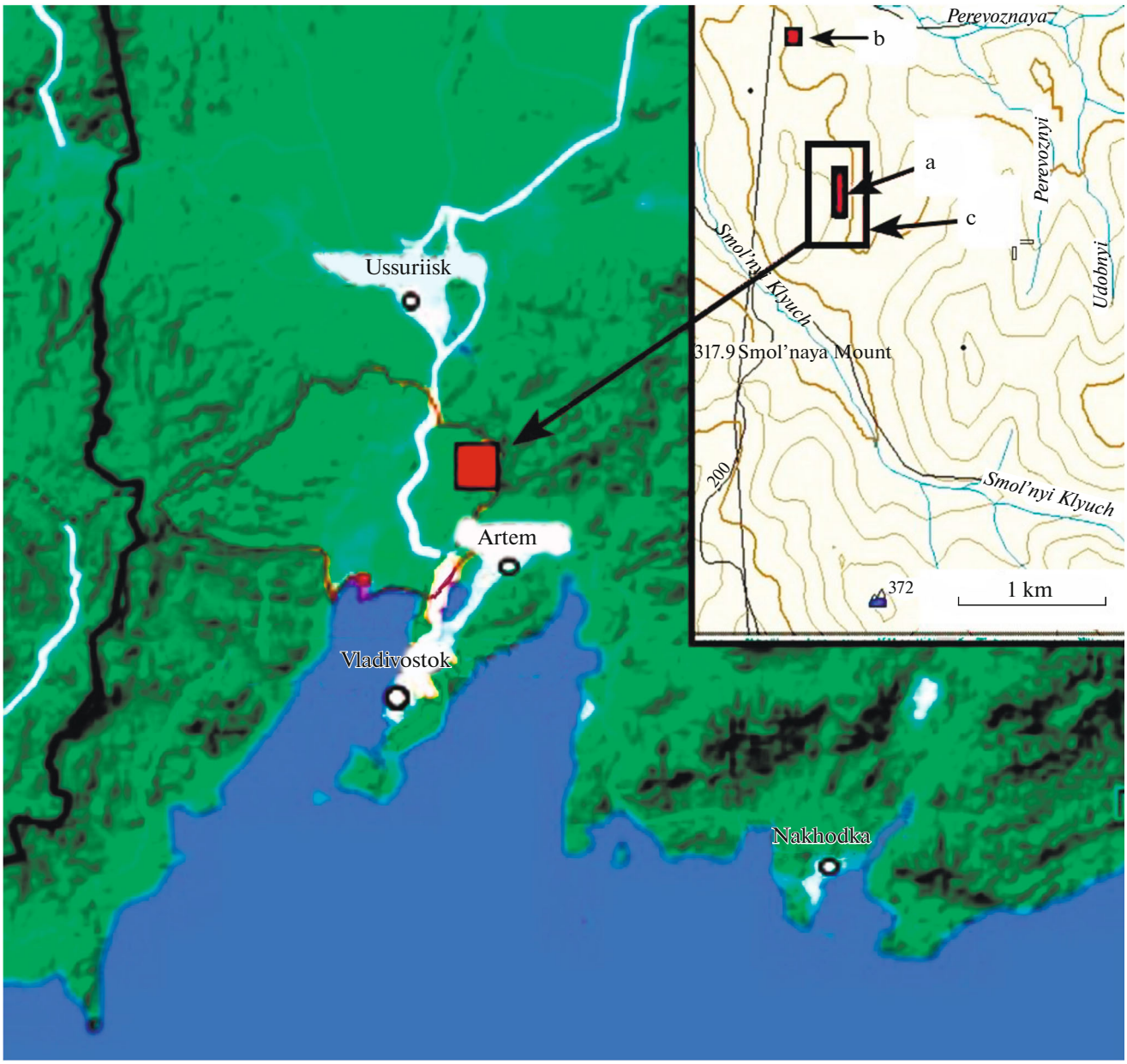

Fig. 2. Location map of *Alangium platanifolium* in Primorskii krai: a, finds of *A. platanifolium* in 2001 (plot size 1.2 hectares); b, new find of *A. platanifolium* in 2021 (plot size 0.25 hectares); c, population revision of *A. platanifolium* in 2022 (current plot size ten hectares).

In 2022, previously discovered populations of *A. platanifolium* were surveyed (Nadezhdinskii district, 10–12 km east of the village of Alekseevka, on the watershed of the Perevoznaya River and Smolnyi Stream (220 m above sea level). The results of the study showed that the area of the first population is much larger than that indicated earlier (Fedina et al., 2002) and amounts to 10 ha (Fig. 2). Bushes of *A. platanifolium* grow at the top of the watershed and partially on both slopes (eastern and western exposures) at an altitude of 220 to 275 m above sea level. The total number of specimens of *A. platanifolium* of different ages numbers more than 700 plants, of which about half bear fruit profusely.

This coenopopulation of *A. platanifolium* is located in a black fir–broad-leaved forest type with a predominance of advanced-age (more than 200 years) coniferous tree species, like *Abies holophylla, Pinus koraiensis,* and *Picea ajanensis* Fisch. ex Carrière, and broadleaf trees, like *Acer mono, A. pseudosieboldianum* Kom., *A. ukurunduense* Trautv. & C.A. Mey., *Carpinus cordata*, *Quercus mongolica* Fisch. ex Turcz., and *Jug-*

lans mandshurica Maxim. In adolescence the following were noted: *Abies nephrolepis* (Trautv.) Maxim., *Betula costata*, and *Kalopanax septemlobus.* The shrub–liana layer is represented by *A. platanifolium*, *Lonicera praeflorens* Batalin, *Ligustrina amurensis* Rupr., *Corylus mandshurica* Maxim., *Philadelphus tenuifolius*, *Ribes mandshuricum* (Maxim.) Kom., *R. maximoviczianum* Kom., *Rubus crataegifolius* Bunge, and *Vitis amurensis* Rupr. The herbaceous layer is formed by the ferns *Adiantum pedatum* L., *Dryopteris crassirhizoma, Leptorumohra amurensis* (Christ) Tzvelev, and *Polystichum tripteron,* as well as the vascular plants *Mitella nuda* L., *Oxalis acetosella* L., *Thalictrum filamentosum* Maxim., *Urtica angustifolia, Paris hexaphylla, Paeonia oreogeton* S. Moore, *Milium effusum* L., *Arisaema amurense* Maxim.; and sedges predominate: *Carex campylorhina* V.I. Krecz., *C. siderosticta,* and *C. ussuriensis* Kom.

The main distinguishing feature of the population discovered in July 2021 is the growth of plants in an open, illuminated area (Fedina et al., 2002). The forest is represented mainly by broad-leaved tree species with dense grass cover. The presence in the forest stand of *Kalopanax septemlobus* and *Micromeles alnifolia* and large vines *Actinidia arguta* was not mentioned in the description of the first population of *A. platanifolium*.

The structure of the reproductive organs. A detailed study of flowers made it possible to supplement the morphological description of the reproductive organs. It has been shown that, after the anthers open, the pistil increases in length and protrudes from the flower by 3–4 mm. Ovary inferior. The fruit (one-seeded drupe) is oval–ovoid. Fruit length from 9.9 to 12.0 mm (11.06 ± 0.21), width from 7.0 to 9.0 mm (8.04 ± 0.24). The length of the achene ranges from 7.8 to 10.5 mm (8.82 ± 0.26), the width of the achene is from 5.9 to 7.3 mm (6.84 ± 0.17). At the beginning of ripening, the drupes are white, then turn blue; mature fruits (late September) are dark purple in color and black when dry (Figs. 1, 3).

DISCUSSION

There are several views regarding the origin of the discovered populations *A. platanifolium* on the territory of the Russian Federation. According to A.E. Kozhevnikov and Z.V. Kozhevnikova (2014), the natural flora of Primorskii krai contains three families, represented here by native species that are not known anywhere else in Russia: Pleurosoriopsidaceae, with the East Asian nemoral-forest *Pleurosoriopsis makinoi* (Maxim.) Fomin; Alangiaceae, with East Asian nemoral-forest *A. platanifolium*; and Loganiaceae, with the East Asian-paleotropical meadow-swamp *Mitrasacme indica* Wight. The authors also indicate that for approximately 200 plant species, the northern border of distribution in the Russian Far East is limited to the territory of Southern Primorye. Many of these species are known in this territory from a few unique localities; their main range is located in the warm temperate, subtropical, and tropical regions of East and South Asia (Kozhevnikov and Kozhevnikova, 2014).

At the same time, there is the version that plants of *A. platanifolium* recently penetrated into Primorskii krai from China or Korea, as was noted for other shrubs, including *Ribes ussuriense* Jancz. (Grossulariaceae) and *Lonicera monantha* Nakai (Caprifoliaceae) (Nechaev, 2015). The author of that work notes that the "southern" settlers have repeatedly penetrated "northern" territories over the past decades and centuries, but not all of them were consolidated in new places. The agents of dispersal of such plants over large areas are migratory carpophagous birds (Nechaev, 2015).

The discovery of the first habitat and the small population size presented 20 years ago in the publication (Fedina et al., 2002) may indicate that the plants recently penetrated into Primorskii krai from neighboring countries. At the same time, the nature of habitats and the general area of *A. platanifolium* suggest its natural growth and the possibility of new finds of this plant in Southern Primorye. The similarity of leaf blades to maples and calopanax (*Kalopanax septemlobus*) probably masked it from researchers (Fedina et al., 2002) and did not allow it to be identified in the flora earlier.

It was revealed that first population area of *A. platanifolium* expanded almost ten times compared to the data given earlier (Fedina et al., 2002). The number of reproductive plants has increased approximately seven times (previously about 40 were identified) (Fedina et al., 2002). The presence of seed regeneration indicates a positive trend towards the spread of plants in a given habitat.

It is likely that several factors influenced successful establishment in the new territory. One of them is the speed of development and resistance to pests, which has been noted for *A. platanifolium* plants native to the northeastern United States (Barnes, 2004). The lengthy life cycle (lives up to 200 years) (Urusov, 2015; Milogradov and Urusov, 2021) contributes to the successful existence of the species and expansion of the population.

Another factor was the suitable habitat conditions, a broad-leaved forest with constant shading necessary for the successful development of plants. It was previously shown that shade is an absolute requirement for the development of the species, and not an adaptive characteristic (Barnes, 2004).

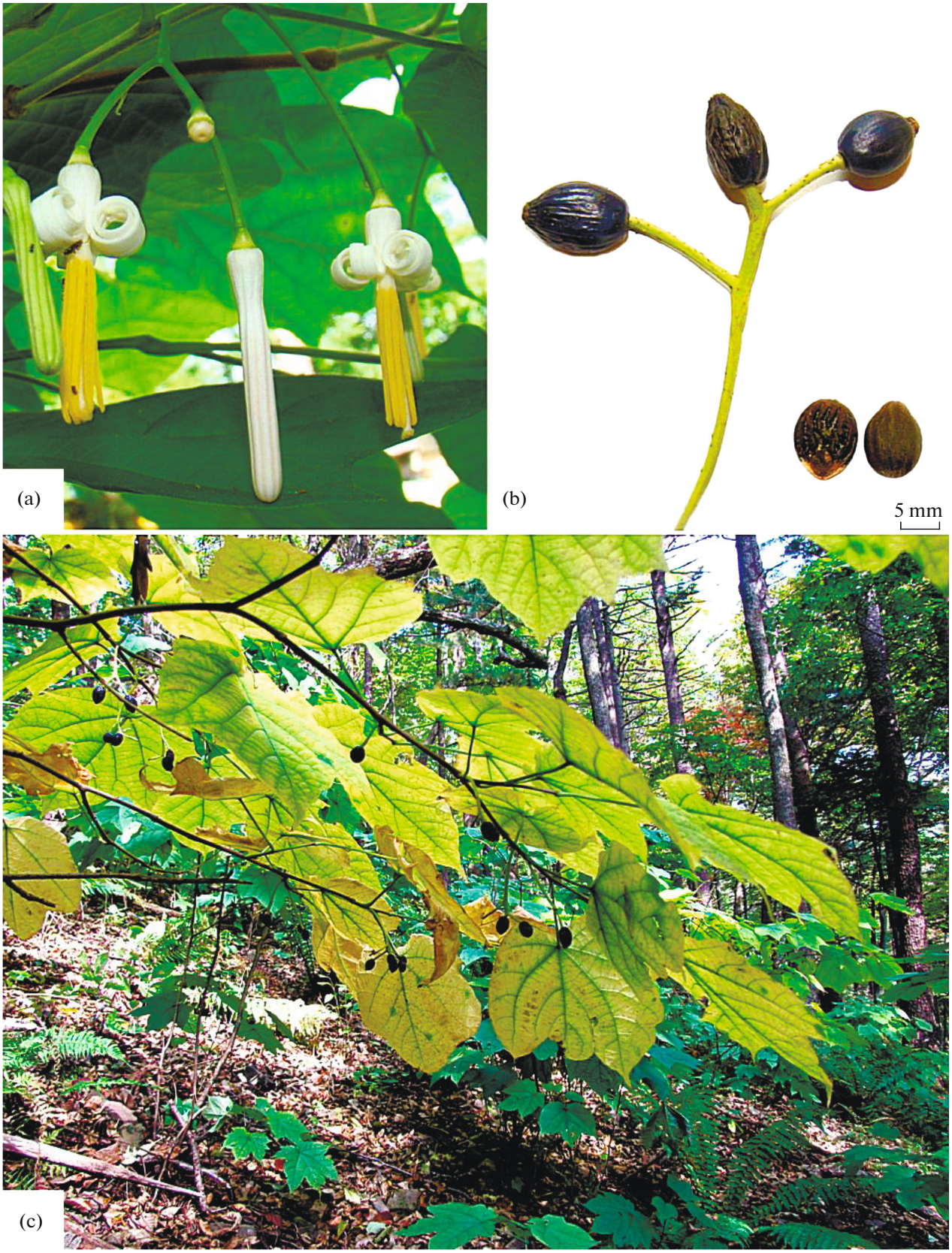

Fig. 3. *Alangium platanifolium*: (a) flowers, (b) fruits, (c) appearance of the bush in autumn. Photo by M.V. Maslov.

It is interesting to note that *A. platanifolium* in Korea it grows in the phytosociological association Corylo-Quercetum mongolicae, which belongs to the Rhododendro-Quercion mongolicae alliance and is found in the northern regions of the cool temperate zone (Takeda et al., 1994). The associations we identified are part of broad-leaved and coniferous–deciduous (Turgai) forests, preserved only in the very southern part of the Russian Far East and adjacent territories of China and North Korea (Kozhevnikov and Kozhevnikova, 2014).

CONCLUSIONS

Thus, it has been established that currently the total number local populations of *A. platanifolium*, growing on an area exceeding ten hectares, there are more than 700 plants of different ages (of which about 40% are flowering and fruiting). The ecological and biological characteristics of this species (mesophytic, shade-tolerant, durable) allow us to recommend it for landscaping both illuminated and shady areas of the landscape. The place of growth of *A. platanifolium* in the southern part of Primorskii krai is the only one in the Russian Federation and needs special protection status. An effective measure could be a ban on any economic activity in the given area and the organization of a natural monument in the vicinity of the village of Alekseevka, Nadezhdinskii district, Primorskii krai, on the watershed between the Perevoznaya River and Smolnyi Stream.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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