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# *Hookeria acutifolia* (Hookeriaceae, Bryophyta), a new species for the moss flora of Russia

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## ABSTRACT

*Hookeria acutifolia* Hook. & Grev. was found on Kunashir Island (South Kuril Islands, East Asia). This is the northernmost locality of the species in Asia and the first record for Russia. A description and illustrations of the species based on the Russian specimen are provided. Details on its ecology and distribution in comparison with *Hookeria lucens* (Hedw.) Sm., the other Russian species of the genus, are discussed on the basis of bioclimatic modelling by MaxEnt.

**Key words:** Far East, mosses, bryoflora, rare species

## РЕЗЮМЕ

Писаренко О.Ю., Бакалин В.А., Игнатова Е.А. *Hookeria acutifolia* (Hookeriaceae, Bryophyta) – новый вид для флоры мхов России. *Hookeria acutifolia* Hook. & Grev. найдена на Кунашире (Южные Курилы, Восточная Азия). Это самое северное местонахождение вида в Азии и первое указание для России. Приводятся описания и иллюстрации вида. Особенности экологии и распространения вида сравнительно с *Hookeria lucens* (Hedw.) Sm., вторым видом рода в России, проанализированы с использованием метода биоклиматического моделирования MaxEnt.

**Ключевые слова:** Дальний Восток, мхи, бриофлора, редкие виды

The Kuril Islands Chain is exceptional in its biogeographic aspect because it spans the border between the Circumboreal and East Asian floristic regions (Takhtajan 1986). Due to fluctuations in sea level during the Quaternary geological period the Chain repeatedly provided a migration bridge from warm-temperate insular East Asia to north-east Asia and Beringia. Many temperate vascular plant genera have their northern limit within this area: *Actinidia*, *Hydrangea*, *Magnolia*, *Phellodendron*, *Psilotum*, *Quercus*, *Sasa*, *Skimmia*, *Toxicodendron*, etc. The same applies to some bryophyte species that are known in Russia only from the Kuril Islands: *Brachydontium olympicum* (E. Britton) T.T. McIntosh & J.P. Spence, *Brotherella benonii* (Duby) M. Fleisch., *Dichelema japonicum* Cardot, *Fissidens nobilis* Griff., *Filibryum ogatae* (Broth. & Yasuda) W. Kim & T. Yamag., *Hypnum fujiyamae* (Broth.) Paris, *Tortula edentula* Ignatova & Ignatov (Bardunov & Cherdantseva 1984, Bakalin & Cherdantseva 2006, Bakalin et al. 2009). The recent finding of *Hookeria acutifolia* in this region adds to this list.

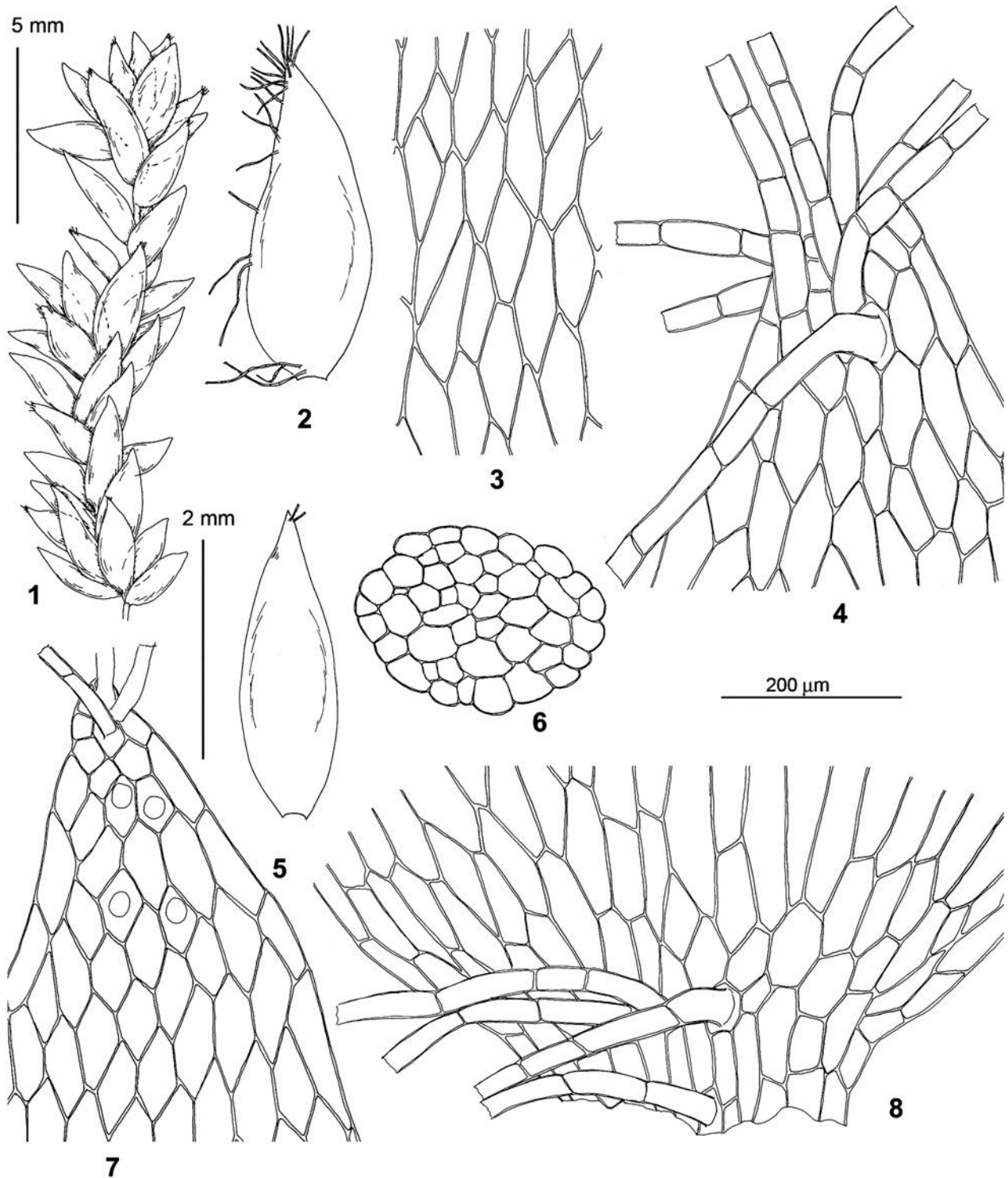
***Hookeria acutifolia* Hook. & Grev.**, Edinburgh J. Sci. 2: 225. 1825. – *Pterygophyllum acutifolium* (Hook. & Grev.) Müll. Hal., Linnaea 21: 194. 1841. – *Hookeria sullivantii* Müll. Hal., Man. Mosses N. America 293. 1884. – *Pterygophyllum nipponense* Besch., Ann. Sci. Nat., Bot., sér. 7, 17: 362. 1893. – *Hookeria lucens* var. *acuminata* Müll. Hal., Syn. Musc. Frond. 2: 202. 1851

**Description.** Plants complanate, pale-green. Stems prostrate, about 2 cm long with sparse, light-brown, finely

granulose rhizoids on ventral surfaces; cells in transverse section thin-walled and mostly equal in size, slightly smaller in central part. Leaves heteromorphic: dorsal leaves symmetrical, lateral ones slightly asymmetrical, ecostate, flattened, ovate to broadly lanceolate, 3–4 × 2–2.5 mm, tapered to acute or, when rhizoids present, bluntly rounded-acute apices; margins plane, entire, often with rhizoids and filamentose, unbranched, uniseriate gemmae, especially at leaf apices; laminal cells more or less homogeneous throughout, large, lax, thin-walled, smooth, ellipsoidal-hexagonal, 80–170 × 40–60 µm, becoming shorter toward the apices, marginal cells in one row slightly longer and narrower than median cells. Autoicous. Sporophytes not seen; the species seldom fruiting (Lawton 1971). [Setae long, 10–20 mm long, reddish brown to yellow, smooth; capsules oblong-ovoid, horizontal to pendulous, 1–2 mm long; opercula long-rostrate; exostome teeth lanceolate, striate below, papillose above; endostome segments as long as the exostome, basal membrane high. Calyptrae mitriform. Spores 12–16 µm, slightly papillose].

**Specimen examined:** Sakhalin Province, Kunashir Island, Ptichii stream in the middle course (44°25'46.6"N 146°13'50.6"E, ca 110 m. a.s.l.), slope with SE-exposure, on stones 31.VIII.2018, Bakalin & Pisarenko op7503 (NSK, MW).

**Differentiation.** There are nine species presently recognized in the genus *Hookeria* (Crosby et al. 2000). However,



**Figure 1** *Hookeria acutifolia* (from: Russian Far East, Kunashir Island, Bakalin & Pisarenko op7503, NSK). 1: habit, dry; 2, 5: leaves; 3: mid-leaf cells; 4, 7: upper leaf cells; 6: stem transverse section; 8: basal leaf cells. Scale bars: 5 mm for 1; 2 mm for 2, 5; 200  $\mu\text{m}$  for 3–4, 6–8

seven of those species are little known, untested and may or may not be properly placed in *Hookeria*. There are two widespread species in the genus: *Hookeria lucens* (Hedw.) Sm. and *H. acutifolia* (Eckel 2014). These species are clearly morphologically different: *H. lucens* has obtuse leaves with marginal cells that are equal in width to the median cells; *H. acutifolia* has broadly acuminate leaves with marginal cells that are narrower than the median cells. In Russia *H. lucens* is known only in the Caucasus (Akatova 2002, Ignatov et al. 2006).

The genus *Plagiotbecium* is similar to *H. acutifolia* in size as well as having complanate leaves and a whitish color. However, the combination of flat, blunted leaves and a lax, net-like areolation that is visible with a hand-loupe make the species unique among the Russian moss flora.

**Ecology.** In the Asian part of its distribution *H. acutifolia* occurs in moist, shady sites, mainly in valleys, on the ground, decaying logs and humus covered rocks. In its Ku-



nashir Island locality the species was found on low lava outcrops in *Abies sachalinensis* forest on vertical shaded surfaces as a small admixture in a moss cushion.

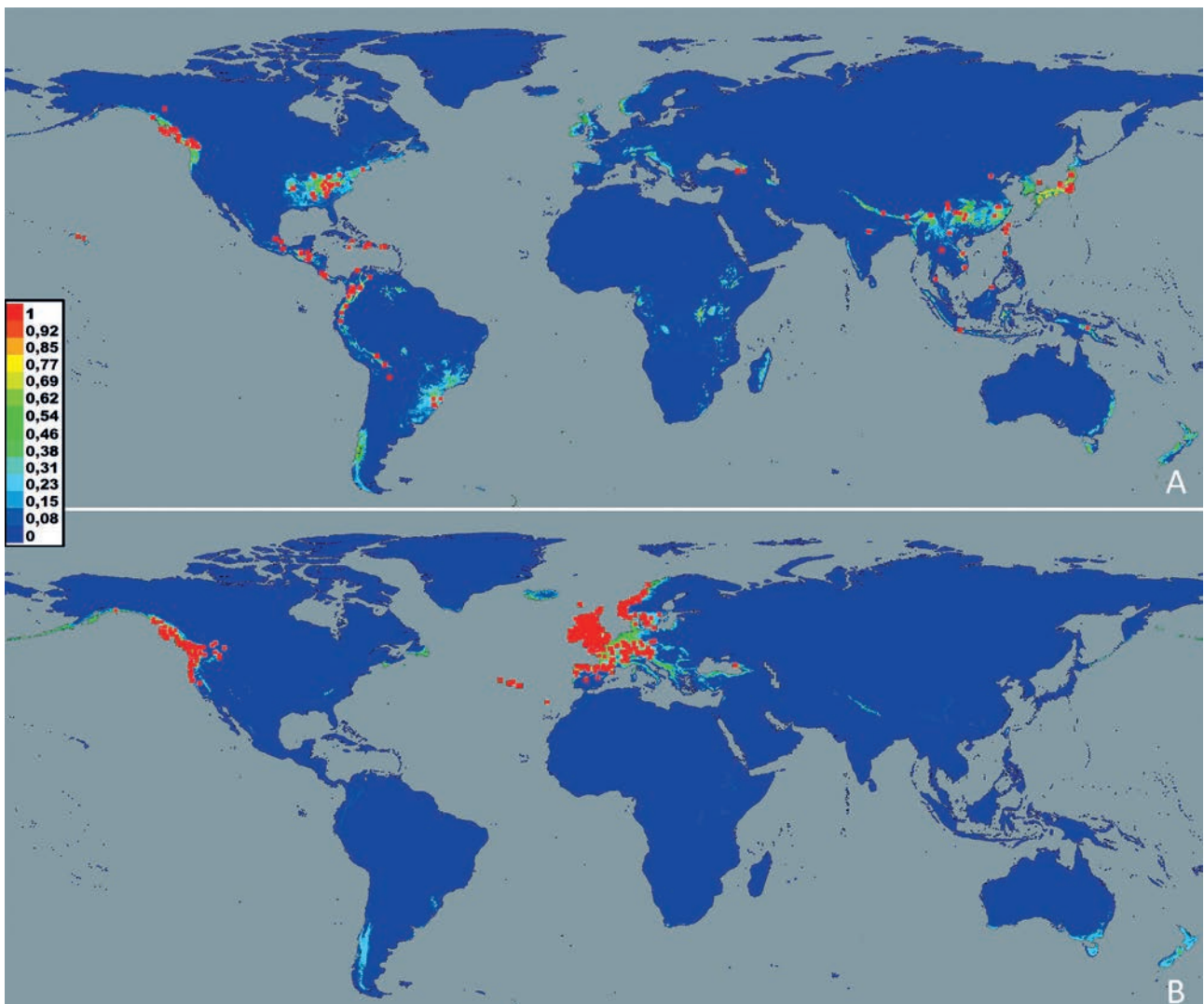
**Distribution.** *Hookeria acutifolia* has a warm-temperate to tropical distribution. Its area core is in East Asia: it is rather common in Japan (Iwatsuki 1991), occurs in continental China and Taiwan (Peng-cheng et al. 2002); it is recorded for Korea, Vietnam, Myanmar, Malaysia, Bhutan, India, the Philippines, Indonesia, Papua New Guinea (GBIF.org) and recently for Thailand (Juengprayoon et al. 2016). It is known throughout the New World: scattered in eastern North America, disjunctive to British Columbia and Washington state (Eckel 2014); Cuba, Dominican Republic, Mexico, Belize, Honduras, El Salvador, Costa Rica, Colombia, Venezuela, Ecuador, Brazil, Bolivia (GBIF.org). There are also two records of the species from Europe: eastern Black Sea regions of Georgia (Abramova & Abramov 1968) and Turkey (Uyar & Ören 2013).

On the basis of the aforementioned papers list of points with geographical coordinates was arranged for *H. acutifolia* and then it was supplemented by GBIF-downloads; duplicate points were deleted. The same was done for

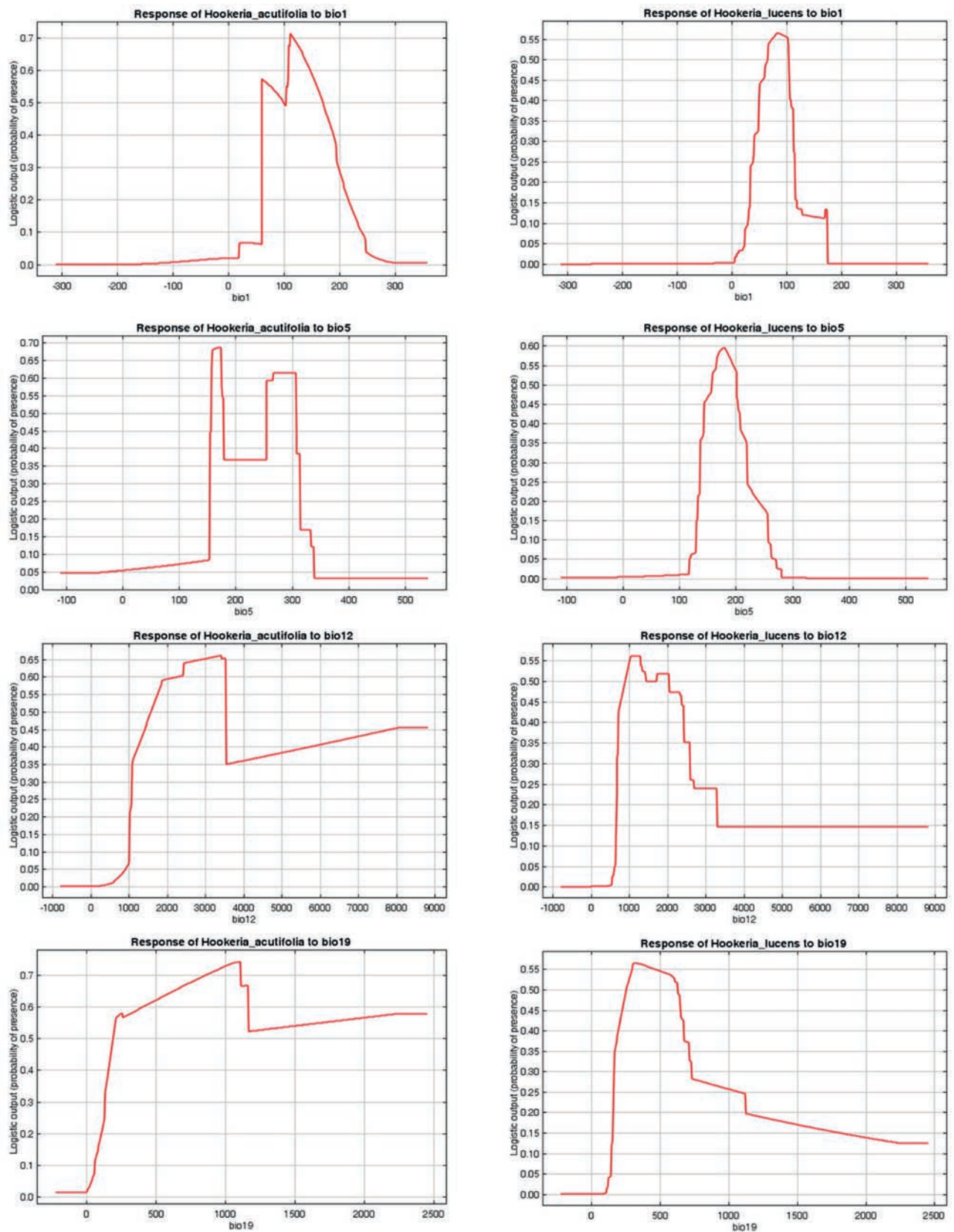
*H. lucens*. Resulting lists include 280 localities for *H. acutifolia* and 6743 for *H. lucens*. Picked datasets were analyzed in MaxEnt 3.3.3k (Phillips & Dudik 2008) for 19 bioclimatic variables with 5 arc-min resolution from Worldclim (Hijmans et al. 2005). Selected parameters utilized were: percentage of test sample = 25 %, maximum number of iterations = 1500, cross-validation procedure. MaxEnt models performed well for both species with Area Under the ROC Curve (AUC) values: it is 0.983 (training) and 0.970 (test) for *H. acutifolia*; 0.904 (training) and 0.906 (test) for *H. lucens*. Therefore, the models are reliable and belong to the category "excellent" (Swets 1988).

The results are displayed on circuit maps (Fig. 2). On the maps the probability of the species presence is reflected by a logarithmic color scale (see lower left corner): blue unlikely conditions, probability less than 0.38; green 0.38–0.69; yellow to orange area with suitable conditions, probability of species occurrence 0.69–0.90.

The two *Hookeria* species are "complementary" in distribution. Both species occur in the middle Pacific coast of North America and both have solid records from the eastern Black Sea area. Nowhere else do their ranges



**Figure 2** Localities (squares) and MaxEnt model of potential distribution of *Hookeria acutifolia* (A) and *Hookeria lucens* (B)



**Figure 3** Response curves of some environmental variables in Maxent models for *Hookeria acutifolia* and *Hookeria lucens*. (BIO1 = Annual Mean Temperature; BIO5 = Max Temperature of Warmest Month; BIO12 = Annual Precipitation; BIO19 = Precipitation of Coldest Quarter)

intersect. *Hookeria lucens* is rather common in amphiatlantic north-western Europe, but absent in the southeast. *Hookeria acutifolia* is widespread in Central/South America, and in south-east Asia.

It is interesting that the calculated potential areas of the species also slightly overlap. As climatically “potentially suitable” areas for both species MaxEnt analysis showed the Atlantic coast of Europe, the southern part of the Andes,

**Table 1.** The most variable contributions for MaxEnt models of *Hookeria* species.

Variable	<i>Hookeria acutifolia</i>		<i>Hookeria lucens</i>	
	Percent contribution	Permutation importance	Percent contribution	Permutation importance
BIO1	<b>14.5</b>	4.8	0.4	4.7
BIO5	7.4	0.8	<b>17.4</b>	<b>13.6</b>
BIO12	<b>38.7</b>	<b>48.4</b>	0	5
BIO19	0	0.4	<b>22.3</b>	<b>13.4</b>

Australia, Tasmania and New Zealand, all areas in which these *Hookeria* species are at present absent.

Different sets of bioclimatic variables are distinguished as the most significant for the MaxEnt-models of the species (table 1). Thus, the most informative bioclimatic predictor of *H. acutifolia* distribution is BIO12 (Annual Precipitation). For *H. lucens* those are BIO19 (Precipitation of Coldest Quarter) and BIO5 (Max Temperature of Warmest Month).

According to response curves *H. acutifolia* is a more thermophilic species than *H. lucens* regarding both mean annual temperature and maximum temperature of Warmest Month (Fig. 3: BIO1, BIO5). In addition, *H. acutifolia* requires more precipitation, both annual and in the cold period. The combination of the distribution and ecology of the two species seems to indicate a sympatric type of speciation in *Hookeria*.

The occurrence of *Hookeria acutifolia* on Kunashir Island marks the northern boundary of the species. The presence of the species in the Black Sea region appears to be the result of invasion, perhaps in the course of the extensive introduction of East Asian plants into Batumi Botanical Garden (officially opened in 1912) and the acclimatization of *Camellia chinensis* Kuntze for the commercial production of tea.

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