MISCELLANEOUS NOTES ON THE GENUS FORSTSTROEMIA (NECKERACEAE, BRYOPHYTA) IN RUSSIA

ZAMETKI О РОДЕ FORSTSTROEMIA (NECKERACEAE, BRYOPHYTA) В РОССИИ

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Abstract

Molecular phylogenetic analysis supports the position on the species known as Neckera konoi in the genus Forstroemia, therefore it is transferred to this genus with a new combination, F. konoi (Broth.) Enroth, Fedosov & Ignatov. Molecular data also confirm the position of F. stricta Laz. described from the Russian Far East in F. producta, a pantropical species. Forstroemia neckeroides is reported from Russia, Primorsky Territory, for the first time.

KEYWORDS: mosses, Neckera, Forstroemia, taxonomy, East Asia, Russia

INTRODUCTION

Recent revisions of pleurocarpous mosses with molecular phylogenetic methods have brought new insights on the systematics of the group (e.g. Frey & Stech, 2009; Huttunen et al., 2012). Neckeraceae is among the families which underwent one of the most drastic changes, and that work continues (Enroth et al., 2010; Olsson et al., 2009a,b, 2010, 2011, 2016).

The genus Forstroemia Lindb. was monographed worldwide by Stark (1987) and then revised for Russia (Ignatov & Cherdantseva, 1995). However, new observations on the genus continue to appear, especially since a completely new approach to the genus was introduced by Olsson et al. (2011). Among others, one common Far Eastern species, Neckera yezoana (Besch.) S. Ols-son, Enroth & D. Quandt and also a rare species, N. goughiana Mitt. were transferred to Forstroemia (Ols-son et al., 2010). The genus was in the focus of molecular phylogenetic studies two more times (Olsson et al., 2012; Akiyama, 2016), but some unresolved problems still remains.

The immediate aim of the present paper is to elucidate the species diversity of the genus Forstroemia in Russia, bringing the nomenclature to follow the modern classification of the Neckeraceae, and correcting errors of previous authors.

MATERIAL AND METHODS

The material used in the present study was sampled from MW and MHA and supplemented by sequences available in GenBank. For the molecular phylogenetic study we used two markers, nuclear ITS1,2 and 5.8 rRNA gene and plastid region trnS-F, which were successfully used by Olsson et al. (2009a,b, 2011) and thus are available in GenBank for suite of "reference specimens" of Forstroemia and related lineages of the family, involved as outgroups. We added in the dataset some originally studied specimens of F. cryphaeoides Cardot, F. japonica (Besch.) Paris, F. noguchi L.R. Stark, F. producta (Hornsch.) Paris and F. yezoana, as well as two samples of Neckera konoi Broth. Some species, being currently classified in Neckera Hedw. s.str., Exsertotheca S. Ols-
son, Enroth & D. Quandt and Alleniella S. Olsson, Enroth & D. Quandt were included as an outgroup. Specimen details and GenBank accession numbers are given in Appendix 1.

The laboratory protocol was essentially the same as in previous moss studies, described in detail by, e.g., Gardiner et al. (2005). Sequences were aligned using MAFFT v. 7.402 (Katoh & Standley, 2013) with standard settings. At first, ITS (837 bp), and trnS-F (1820 bp) were analyzed separately to check congruence of resulting trees. As separate analyses of nuclear and chloroplastic datasets showed subidentical topologies, the concatenated ITS and trnS-F dataset was used for the final analysis (27 taxa, 2657 positions), performed by MrBayes 3.2.6 (Ronquist et al., 2012), on the Cipres Science Gateway (http://www.phylo.org/portal2) on XSEDE with 20 000 000 generations, the chain temperature was set at 0.02. Convergence of each analysis was evaluated using Tracer1.4.1 (Rambaut & Drummond, 2007). Consensus trees were calculated after omitting the first 25% trees as burn-in. Trees were rooted on Neckera pennata Hedw., according to the topologies published by Olsson et al. (2009a,b, 2011). In addition, maximum parsimony analysis was completed with Nona (Goloboff 1994) within the Winclada shell (Nixon 1999), using the same alignment with a bootstrap calculation with 2000 replications (Parameter: number of search reps 10, starting tree per-rep 10, max tree 100, do max*, Save consensus).

**RESULTS**

The obtained Bayesian tree resolves the genus *Forsstroemia* as monophyletic (PP=0.99) and sister to *Alleniella*, although MP analysis left subclades of *Forsstroemia* and *Alleniella* unresolved. Within *Forsstroemia*, species are grouped in two clades. The first clade includes species around *F. trichomitria* (Hedw.) Lindb., the type of the genus, and it is well supported (PP=0.99) in Bayesian analysis, although MP bootstrap is low (64). These species are characterized by larger leaves, and have

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**Fig. 1.** Bayesian molecular phylogenetic tree of nrITS region and plastid region trnS-F, showing position of *Neckera konoi* within the genus *Forsstroemia*, and *F. stricta* in a maximally supported clade of *F. producta*. Posterior probabilities from Bayesian analysis and MP bootstrap support are shown at branches. Specimen details are given in Appendix 1.
mostly lustrous plants. It includes, among others, highly supported clade of Neckera konoi and F. neckeroides (PP=1, BS=93), otherwise the supported clades are monospecific. The second clade includes three groups, which are all characterized by smaller leaves. It received a very weak support even in Bayesian tree (PP=0.54), but within this clade all three subclades are maximally supported in Bayesian analysis, and have also high MP support: maximal for monospecific clades of (1) Forsstroemia noguchii (Chinese and Siberian specimens); (2) F. producta + F. stricta (Asian and American specimens), and high support (BS=94) from the clade of F. cryphaeoides + F. japonica (PP=1).

**DISCUSSION**

Obtained tree (Fig. 1) in general repeats the topologies published by both Olsson (2009a,b, 2010, 2011) and Akiyama (2016). The position of Neckera konoi in Forsstroemia is not especially surprising: after the transfer of Neckera yezoana and N. goughiana to Forsstroemia it became clear that the presence of costa is more important than the transversely undulate leaves, which may be totally absent in Neckera, e.g. in N. californica Hook. & Arn., formerly being referred to the monospecific genus Alsia Sull.

Neckera konoi expectedly was found among Forsstroemia, and again expectedly near a Forsstroemia with undulate leaves, F. yezoana, and therefore has to be transferred to Forsstroemia too.

The second problematic species of Forsstroemia is F. stricta. The species was described by Lazarenko (1941) and then accepted by Ignatov & Cherdantseva (1995) and Ignatov et al. (2006). Cherdantseva et al. (2018) suggested that this species is not distinct from F. producta, but with only brief comments, which will be complemented here.

Forsstroemia noguchii was described by Stark (1983) from Japan, with two paratypes from China and from Siberia. The species is rather rare, thus Stark (1987) reserved a possibility of its identity with F. tripinnata (Dixon) Nog. However, Akiyama (2016) found that F. tripinnata is closely related neither to F. noguchi, nor to the whole genus Forsstroemia but belongs to a relatively distant genus in the Neckeraeae, and has to be called Pseudopterobryum tenuicuspis Broth. An attempt to include the sequences of this species in the present analysis was given up, as its differences from Forsstroemia manifold exceed the differences between e.g. Forsstroemia with Alleniella and Neckera. The present study found that Chinese and Siberian specimens, including sequenced paratype, are genetically closest, thus the unity of disjunct population of F. noguchi is proved.

Lazarenko (1941) reported for Russian Far East, near Vladivostok, Isothecium alopecuroides (as “I. viviparum”), a species of amphiatlantic distribution, reaching in Eurasia to the east Caucasus. In the Middle European Russia all its localities are west of Moscow. We found that the specimen of Lazarenko from Vladivostok belongs to another species, and interestingly it is the first record of F. neckeroides in Russia. Previously this species was known from China, Korea and Japan.

**TAXONOMY**


Protologue: “Japon: mont Ishizuchi (G. Kono, Herb. Brotherus); Tsurugizan (n. 1152); Koma-ga-take (n. 3554)”.

Lectotype: “Japanese Musci, Gakuichi Kono, No 257, Neckera Konoi Broth. n. sp., M. Ishizushi (Shikoku), Coll. G. K. Sept. 5 1906” (H-BR 2892007!, with sporophytes) (Fig. 2).

Neckera konoi was described from Japan and later reported from Anhui and Sichuan in China (Wu, 2011) and from Primorsky Territory in Russia (Ignatova et al., 2009), with description and illustrations. Forsstroemia konoi is known in Russia only from a locality near Benevskie Waterfalls, on cliffs beside waterfall, in a restricted area.


Holotype: Russia, Primorsky Territory: Shkotovo Distr., Upper Maikhe River, Peishula, on rotten log, 10.X.1933, A. Lazarenko (KW!) [description and illustration of this specimen were provided by Ignatov & Cherdantseva, 1995].

Comment: Ochyra (1988) mentioned this specimen as lectotype. However, only one specimen is cited in the protologue, and Kiev’ Institute of Botany (KW) is the main depositarium of Lazarenko collections, thus we designate the specimen as the holotype.

**Forsstroemia stricta** was described from a small spec-

**Fig. 2. Neckera konoi lectotype label, H-BR 2892007.**
imen, and male gemetangia were not found by Lazarenko, so the species was assumed to be dioicous. Ignatov & Cherdantseva (1995) confirmed this. However, subsequently we found this species in two localities and richer material showed an autoicous sexual condition in all collections. Quite many plants, either collected or seen in forest, had sporophytes.

DNA analysis of two specimens from two localities resolved them in a clade with *F. producta* from Mexico and U.S.A., confirming their identity. *Forsstroemia producta* is a pantropical and subtropical species, and the name has numerous synonyms used for plants from Asia, Africa, North America and Australia (Stark, 1987).


Lectotype (selected by Stark, 1987): [China] “Mandshuria, prope stantionem Hantoheva (Handahoezdi) viae ferrafiae, ad rupe”, coll. Litvinov s.n., 20 Jun 1903 (H-
BR 1742008!; isolecotypes H-BR 1742011!, H.BR 1742012!).

Description: Plants robust, in loose brownish-green, somewhat lustrous tufts. Secondary stems up to 2 cm long, curved, densely terete foliate, remotely and irregularly pinnately branched, branches up to 8 mm long, curved, similarly foliate as secondary stems. Stem leaves ovate to ovate-lanceolate, shortly acuminate, concave, 1.8–2.8 mm long, 0.7–1.1 mm wide; margin plane, entire to minutely crenulate; costa reaching 0.4–0.7 the leaf length; lamina cells ovate-elongate, 20–45 × 7–11 μm. Auticous. Perigonia and perichaetia present. Sporophytes not available in Russian collection [Capsules immersed (Stark, 1987)].

Differentiation: The concave leaves of *F. neckeroides* with “oily luster” resemble *F. trichomitria*, but in that species the shoots are not so much curved, the leaves are less concave, not plicate, the costa reaches only 0.2–0.4 (–0.5) the leaf length, and the commonly present sporophylls are exserted. Sympatric species of Lembophylaceae that resemble *F. neckeroides*, i.e. *Dolichomitriopsis diversiformis* (Mitt.) Nog., *Dolichomitria cymbifolia* (Lindb.) Broth. and *Isothecium hakkodense* have a still longer costa, 0.6–0.8 the leaf length, not conspicuously curved shoots, and all of them are dioicus.

**Specimen examined:** [Russia, Primorsky Territory] Oceanekskaya, Koreiskaya Sopka [“Corean Hill”], 6 Aug 1930, coll. A.S. Lazarenko, KW #12964.

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**LITERATURE CITED**


OCHYRA, R. 1988. New tax and new combinations of mosses proposed by Ignatov was conducted in the course of institutional project (19-119012390082-6).

Appendix 1. Specimens used in the molecular phylogenetic analysis, ITS / trnS-F (for newly generated ones, the specimen voucher information is added).

*Alleniella complanata* JF690788 / AM990413; *A. remota* FM161171 / AM990415; *A. urnigera* FM161174 / AM990416;

*Forsstroemia goughiana* FM161162 / FM210300; *F. trichomitria* FM161103 / AM990365; *F. yezoana* (Russia, Kuril Islands, Kunashir, Ignatov 06-1333 MHA, isolate AnomF15) MN011954 / MN031374; *F. yezoana* FM161177 / FM210312; *F. konoi* (Russia, Primorsky Territory, 6.IX.2013, Ignatov, s.n. MHA, isolate OK587) MN011955 / MN031375; *F. konoi* (Russia, Primorsky Territory, 5.IX.2013, Ignatov, s.n. MW 9049684, isolate NF62) MN011956 / MN031376; *F. neckeroides* FN868972 / FN868963;

*F. producta* (Russia, Primorsky Territory, 16.X.2008, Ignatov. MW9039963, isolate AnomF5) MN011957 / MN031377; *F. stricta* (Russia, Primorsky Territory, 6.IX.2006, Ignatov, s.n. MW9039961, isolate AnomF6) MN011958 / MN031378; *F. producta* (USA, Arkansas, W. R. Buck 37442 NY00586485, isolate OK538) MN011959 / MN031379; *F. producta* 539 (Mexico, C. Delg-adillo Moya 7390 NY01475937, isolate OK539) MN011960 / MN031380; *F. noguchii* (Russia, Buryatia, East Sayans, 13.VI.1962, Bardunov. MHA 9033172, isolate AnomF10) MN011961 / MN031381; *F. japonica* 1 LC041112 / LC041071 & LC041097; *F. japonica* 2 (Russia, Primorsky Territory, 1.IX.2006, Ignatov, s.n. MW9039960, isolate AnomF4) MN011962 / MN031382; *F. cryphaeoides* 1 (Russia, Primorsky Territory, Ignatov & Ignatova 06-3416 MHA 9033133, isolate AnomF14) MN011965 / MN031383; *F. cryphaeoides* 2 (Russia, Primorsky Territory, Ignatov & Ignatova 06-3416 MHA 9033133, isolate AnomF14) MN011965 / MN031383; *F. cryphaeoides* 3 (Russia, Primorsky Territory, Ignatov 08-214 MHA 9033118, isolate AnomF13) MN011964 / MN031384; *F. cryphaeoides* 4 FN868970 / FN868967; *Neckera menziesii* FM161167 / FM210305; *N. douglasii* FM161161 / FM210299; *N. pennata* (Austria, Kuèera. SBFS 16367, isolate NF45) MN010515 / MN031368.