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Notes on five, mainly high-altitude species of Chinese *Neckera*, with an updated key to *Neckera sensu lato* in China

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Abstract – This paper presents new distributional records of five Chinese species of *Neckera* Hedw.: *N. bhutanensis* Nog. (new to Sichuan and Yunnan), *N. borealis* Nog. (new to Xinjiang), *N. himalayana* Mitt. (Yunnan, new to China), *N. setschwanica* Broth. (new to Bhutan), and *N. xizangensis* Enroth (new to Sichuan and Yunnan, the first reports of the species since type material from Xizang). Maps showing the distributions of the treated species in China and an updated key to the Chinese species of *Neckera sensu lato* are provided.

Bryogeography / distribution / East Asia / floristics / habitat ecology / taxonomy

INTRODUCTION

This paper is a result of my ongoing studies on the taxonomy and systematics of the moss genus *Neckera* Hedw. (Neckeraceae). That genus, in its traditional sense, has already been divided into smaller genera and several of its species have been transferred to other taxa (Olsson *et al.*, 2011). Our group is currently analysing the phylogeny of *Neckera sensu lato* with a more comprehensive species sampling, so it would be premature to provide in this paper a detailed taxonomic or morphological circumscription of *Neckera*. While that work has been in progress, new species from Asia have been described and tentatively placed in *Neckera* over the last two decades or so (Enroth, 1996, 2007, 2012; Enroth & Ji, 2010; Enroth & Touw, 2015).

Since Wu (2011) treated 17 species of *Neckera* in the *Moss Flora of China*, new information of Chinese *Neckera* has turned up when more specimens have been examined. Wu (2011) did not treat species of which he had no voucher specimens available. Therefore, the identification key in that Flora is somewhat inadequate. Enroth (2012) attempted to improve the situation by publishing a complemented key but even that is now obsolete in the light of the new information on the variability and distribution of some rather rare species of Chinese *Neckera*. That information and a new key are provided here. The key includes 26 species, of which 20 are currently placed in *Neckera sensu stricto*. The current name of species transferred to other genera is given in parentheses.

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NEW RECORDS AND NOTES

Neckera bhutanensis Nog.

Fig. 1

The name *Neckera bhutanensis* was treated as a taxonomic synonym of *N. pennata* Hedw. by Long (1994), based on personal communication with me. It has however subsequently become apparent that *N. bhutanensis* is a distinct species (Ji & Enroth, 2010). Alas, it was not treated by Wu (2011). It is very similar to *N. pennata*, but can usually be distinguished by the key below. There will however be some specimens difficult to identify, so further studies are necessary. According to Ji & Enroth (2010) the leaf cell walls in *N. bhutanensis* are thin (and non-porose), but there are some variations in this character. In some specimens of *N. bhutanensis* the walls are somewhat thicker and slightly porose, but not really incrassate or distinctly porose as in some other species with which *N. bhutanensis* could be confused, such as *N. denigricans* Enroth (Enroth, 1996) or *N. xizangensis* Enroth & M.C Ji (Enroth & Ji, 2010).

Neckera bhutanensis was first recorded for China from Xizang (Ji & Enroth, 2010) based on a collection made on *Juniperus* at 4410 m a.s.l. The three additional Xizang specimens studied were collected between 3330 and 3580 m a.s.l., the four from Sichuan between 3600 and 3750 m a.s.l., and the three from Yunnan at 2935, 2565 m and 2300 m a.s.l. Two of the Sichuan samples and all of the Yunnan samples are epiphytic; for the other specimens substrate is not given in the labels. The type material from Bhutan (Noguchi, 1971) came from the altitude of 2150-2250 m a.s.l. He & Nguyen (2012) reported *N. bhutanensis* from considerably lower altitudes in northern Vietnam. I borrowed the specimens from MO and they represent *N. praetermissa* Enroth & Touw, which was only recently described from that same area (Enroth & Touw, 2015).

Specimens examined: China. Xizang, Tsangpo tributary, Nangxian, lower Lilung Chu (Camp 14), 29°2'N 93°54'E, 3330 m a.s.l., *Abies-Picea* forest on N-facing boulder slope, 9 Aug. 1994, G. Miede & U. Wündisch 94-157-9 (H); Tsangpo tributary, Nangxian, Lilung Chu eastern branch (Camp 14 - High Camp), 29°2'N 93°55'E, 3380 m a.s.l., *Picea-Abies* forest with *Quercus* on gravel terrace, 14 Aug. 1994, G. Miede & U. Wündisch 94-179-31 (H); upper Phung Chu (Arun) catchment, Karma Chu E opposite Sakyethang, 27°56'N 87°12'E, 3580 m a.s.l., *Betula utilis* forest on N-facing slope, 1 Aug. 2005, G. & S. Miede 05-068-10:1 (H). – Sichuan, NW Sichuan, 30°59'N 102°52'E, 3710 m a.s.l., *Quercus aquifolioides-Juniperus* forest on steep S-facing slope, 23 Aug. 1994, G. & S. Miede & U. Wündisch 10453 (H); northern Qionglai Shan, Barkam, 31°57'N 102°39'E, 3640 m a.s.l., 35° SE-exp. *Quercus aquifolioides* multi-stemmed forest (charcoal-cutting), epiphyte, 6 Oct. 1994, G. & S. Miede & U. Wündisch 94-513-1 (H); southern Qionglai Shan, NW of Wolong, 30°59'N 102°52'E, 3750 m a.s.l., N-exp- steep slope, 10 Oct. 1994, G. & S. Miede & U. Wündisch 94-571-29 (H). – Yunnan, Weixi County, Yunlingshan Range, along logging access road about 1 km off Xiangwei Highway at km road marker 141 near Weixi, 27°21'03"N 99°16'56"E, 2935 m a.s.l., disturbed mixed conifer forest with *Pinus*, *Picea* and *Tsuga* with hardwood understorey, on hardwood trunk in sun, 10 Oct. 2008, J. R. Shevock 32247 (H 4226151); Yunlong County, Xuepanshan Range, Tianchi Forest Nature Reserve above the lake about 15 km from city of Yunlong, 25°52'10.5"N 99°17'10"E, 2565 m a.s.l., hardwood forest of *Quercus*, *Lithocarpus*, and *Rhododendron* with scattered *Pinus*, on *Lithocarpus* branch in filtered light, 7. Oct. 2008, James R. Shevock 32160 with Li Zhang (H 4226149); same area, about 4 km below entrance station of Tianchi Forest Nature Reserve and about 10 km from city of Yunlong, 25°51'51.6"N 99°17'58.6"E, 2300 m, cut forest area along small streamlet with metamorphic boulders, on trunk of *Jugland* in sun, 7 Oct. 2008, J. R. Shevock 32180 (H 4226150).

Neckera borealis Nog.**Fig. 1**

According to Noguchi (1989) *Neckera borealis* is distributed in Japan (Hokkaido and Honshu) and the Soviet (= Russian) Far East. It is however also known from China (Wu, 2011) and the Korean Peninsula (Jia & He, 2013). It appears to be quite rare throughout its distribution area.

In China *N. borealis* has been reported from Gansu, Hubei, Qinghai, Shaanxi and Sichuan provinces (Wu, 2011). The distribution map in Wu (2011) was based on five collections, one from each of the provinces named above.

Four of the five specimens examined for this report (from Sichuan and Qinghai) came from localities fairly close to those cited and mapped by Wu (2011). The fifth specimen, from Xinjiang, was collected ca 2000 km NE of the closest known locality of *N. borealis* in Qinghai (Fig. 2). The known Russian localities are close to the borders of Mongolia and China, and in Sakhalin and Kuril Islands N of Japan (Bardunov & Cherdantseva, 1982; Ignatov *et al.*, 2006 and the references therein).

Based on this study and previous reports, nearly all Chinese specimens of *N. borealis* have been reported from tree trunks and branches (*Salix* and *Abies*) between 1700 and 3500 m a.s.l. (Wu, 2011; Jia & He, 2013) except the Xinjiang specimen, which was collected on a shaded boulder at c. 1200 m a.s.l. The highest locality reported is at 3500 m a.s.l. in Sichuan (Qionglai Shan; substrate is not given in the label).

When examining the material cited below I discovered some previously unreported variation in *N. borealis*. According to Wu (2011) it has “complanate, not undulate” leaves. Noguchi (1989) stated that the leaves of *N. borealis* are “scarcely undulate”. In fact this character is very variable. In some smaller specimens the

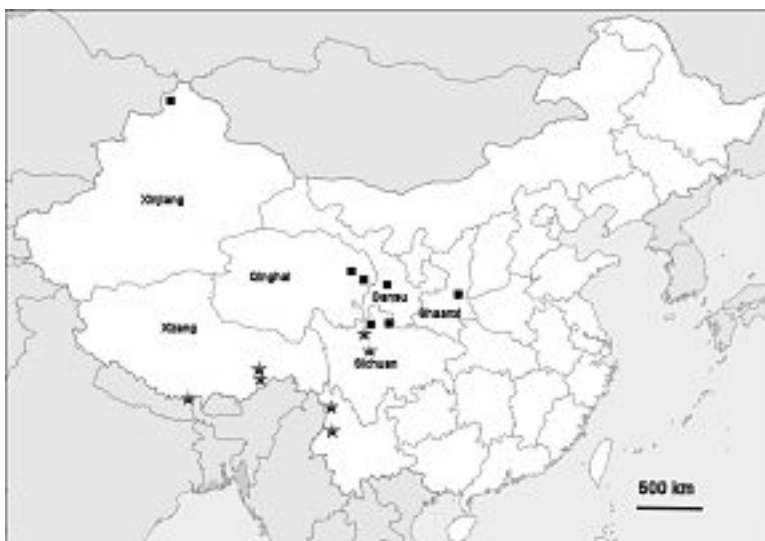


Fig. 1. Distribution of *Neckera bhutanensis* (stars) and *N. borealis* (squares) in China. Based on examined specimens cited in the text, Ji & Enroth (2010) and Wu (2011; only *N. borealis*). Original base map URL: https://commons.wikimedia.org/wiki/Category:Blank_maps_of_China#/media/File:LocationmapChina2.png

leaves are not undulate at all, but especially in larger ones the upper stem leaves and branch leaves may not be undulate, while the lower leaves are undulate to variable degree, sometimes quite distinctly and deeply so. The other characters described by Noguchi (1989) and Wu (2011) do not vary much.

Specimens examined: China. Sichuan, Aba County, Barkam, northern Qionglai Shan, 31°57'N 102°39'E, 3500 m, G. & S. Miehe & U. Wündisch 94-492-47 (H); Nanping County, km 36, highway Zhangla to Jiuzhaigou, N-facing steep slope of *Abies-Picea* forest, some cutting evident, 3320-3360 m, growing on *Abies*, 7 Sept. 1988, P. L. Redfearn 35367 (H 3097474). – Qinghai, Huzhu County, Jiading Xiang, Ningzi, Langshidanggou Valley, 36°55'20"N 102°25'14"E, c. 2560 m, margin of *Betula/Picea* woodland, on dead tree trunk, 23 July 1997, D. G. Long 27186 (H 3214403); near Nanzhangzhagon Village, upper Zhalonggou Valley, 36°46'N 102°32'E, c. 2720 m, *Betula* forest in valley, on *Salix*, 24 July 1997, D. G. Long 27213 (H 3214404). – Xinjiang, Burqin County, 40 km from Baihapa army station/border post on way to Habahe town proper, 48°27'N 86°43'E, c. 1200 m, roadside rocky slope near a river, partly shaded by trees of *Larix*, on boulder surface, shaded, 2 Aug. 1993, B. C. Tan 93-933 (H 3097886).

Neckera himalayana Mitt.

Fig. 2

Neckera himalayana has been known from Nepal, Bhutan, Myanmar, NW Thailand and in India from the Himalayan regions, Sri Lanka, and Kerala (Gangulee, 1976; Manju *et al.*, 2008; <http://www.mobot.org/MOBOT/moss/Thailand/thai-n.shtml>). This is the first record for China.

Neckera himalayana was described and illustrated by Gangulee (1976: fig. 683). It is characterized by robust (for *Neckera*) plants, with the stems to over 10 cm long and loosely pinnately or irregularly branched. The leaves are complanate and undulate, nearly symmetric, and have mostly broadly acute apices with indistinct, unicellular teeth. The costa is single and reaches to midleaf or above, and the leaf cells have incrassate, distinctly porose walls. The Chinese specimens lack mature sporophytes, but *Shevock 45646* has young setae without capsules and calyptrae. The setae are c. 15 mm long and distinctly mammillose in the upper part. Such mammilosity is common in the essentially Asian “*Pinnatella* clade” of the Neckeraceae (Olsson *et al.*, 2010), but not present in *Neckera sensu stricto* or in the genera segregated from it by Olsson *et al.* (2011). The phylogenetic position of *N. himalayana* needs further study by molecular methods.

Specimens examined: China. Yunnan, Yongde Co., Yalian Xiang, Yongde National Nature Reserve, 24°06'49"N 99°36'40"E, 2315 m a.s.l., on trunk in old-growth broadleaved forest, 30 June 2014, W.Z. Ma 14-5594 (CAS); Yunnan, Tengchong Co., western slope of the Gaoligongshan, trail from forestry field station at Linjiapu to Wudaoxi with falls and cascades, Gaoligongshan National Nature Reserve, Linjiapu Unit, 25°18'08.7"N 98°42'33.1"E, 2175 m a.s.l., mixed hardwood forest, on moist metamorphic rock wall along of trail above steam in shade, 11 July 2014, J. R. Shevock 45547 (H, CAS); Jingdong Co., Xujiaba, Ailaoshan Station for Subtropical Forest Ecosystem Studies, along a 2 km trail to ridge from research station, 24°32'26.0"N 101°01'37.7"E, 2450 m a.s.l., mixed hardwood forest with bamboo along lower slopes of ridge, on hardwood trunk in filtered light, 16 July 2014, J. R. Shevock 45646 (H, CAS).

Neckera setschwanica Broth.

Wu (2011) cited and mapped specimens of *Neckera setschwanica* from Sichuan, Yunnan and Xizang. According to Redfearn *et al.* (1996), however, it has been reported also from Guizhou and Henan, but apparently those records need

verification. It is here reported for the first time from western Bhutan, close to Xizang localities mapped by Wu (2011). Thus *N. setschwanica* is no longer an endemic species of China.

Neckera setschwanica can usually be identified by the gradually tapering branch tips and commonly produced flagelliform, microphyllous branchlets. Further typical characteristics are the presence numerous paraphyllia on the stems and branches, asymmetric leaves with an acute apex and a costa that reaches to c. 2/3 of leaf length, and incrassate, porose walls of the laminal cells. Of the Chinese species it resembles especially *N. xizangensis* and *N. denigricans*, but in the former the costa reaches only to c. 1/5 and in the latter to c. 1/3 of leaf length. Filamentous brood-bodies (or gemmae) are sometimes present on the leaves (Gangulee, 1976; Wu, 2011), but I did not observe them in the present specimen. To my knowledge, they have not been reported for any other species of *Neckera*.

Specimen examined: Bhutan. Wangdue Phodrang district, between Gogona and Kothoka, 90°4'N 27°26'E, 3370 m a.s.l., *Abies-Juniperus* forest, grazed, 6 Oct. 1998, G. & S. Miehe 98-378-22 (H).

Neckera xizangensis Enroth & M.C. Ji

Fig. 2

Neckera xizangensis was known only from the type specimen from Xizang (Enroth & Ji, 2010) collected at 3850 m a.s.l. on Gyala Peri (Gyalha Bairi Feng) mountain. It is here reported from fairly similar altitudes (4050 m and 3750 m a.s.l.) from Sichuan and at 2875 m a.s.l. from Yunnan. It appears to be a high-altitude Chinese endemic of conifer (*Abies-Picea-Larix*) and mixed forests.

Wu (2011) considered *N. xizangensis* to be “close to what I consider to be *N. pennata* Hedw. in *Bryoflora of Xizang*” (Li, 1985: 281, 282). In my opinion, the clearest distinction between the two species is the presence of paraphyllia in



Fig. 2. Distribution of *Neckera himalayana* (stars) and *N. xizangensis* (squares) in China. Based on examined specimens cited in the text and Enroth & Ji (2010). Original base map URL: https://commons.wikimedia.org/wiki/Category:Blank_maps_of_China#/media/File:LocationmapChina2.png

N. xizangensis and their absence in *N. pennata*. Moreover, the incrassate and strongly porose apical and median laminal leaf cells of *N. xizangensis* resemble especially those of *N. denigricans* (Enroth, 1996, Ji & Enroth, 2010) and are quite different from the relatively thin, non-porose cell walls of *N. pennata*.

In the specimens of *N. xizangensis* reported here the costa length varies more than the original description would allow. Within a specimen, some leaves lack a costa altogether while it can reach to c. 1/5 of leaf length in others. I have modified the identification key below to more reliably distinguish *N. xizangensis* and *N. denigricans* from each other. They are sympatric in Yunnan.

Specimens examined: China. Sichuan, Northern Qionglai Shan district, Barkam, 31°57'N 102°39'E, 4050 m a.s.l., *Abies* forest, epiphyte, 5 Oct. 1994, G. & S. Miede & U. Wündisch 94-502-1 (H); 30°59'N 102°52'E, 3750 m, *Abies-Picea-Larix* forest on steep N-facing slope, 10 Oct. 1994, G. & S. Miede & U. Wündisch 10462 to 10465 (H). – Yunnan, Weixi County, Yunlingshan Range, along Xiangwei Highway at km road marker 143 near Weixi, 27°19'42.2"N 99°16'39.6"E, 2875 m a.s.l., disturbed mixed hardwood forest with scattered conifers, at base of hardwood snag in forest opening, 10 Oct. 2008, J. R. Shevock 32270 (H 4226152) and 32272 (H 4226153).

Key to Chinese species of *Neckera sensu lato*

1. Upper laminal cells distinctly porose.....2
1. Upper laminal cells solid or faintly porose.....15
 2. Paraphyllia present.....3
 2. Paraphyllia absent.....6
3. Costa reaching to midleaf or above4
3. Costa vanishing below midleaf.....5
 4. Leaves nearly symmetric, obtuse-mucronate at apex; costa commonly reaching at least to 3/4 of leaf length.....*N. polyclada*
 4. Leaves distinctly asymmetric, acute at apex; costa reaching to c. 2/3 of leaf length.....*N. setschwanica*
5. Leaves short-decurrent; costa absent or reaching to c. 1/5 of leaf length; inner perichaetial leaves to 4 mm long; seta 0.5 mm long, capsule immersed; endostome absent.....*N. xizangensis*
5. Leaves long-decurrent (decurrencies to c. 350 µm long); costa reaching to 1/4 (-1/3) of leaf length; inner perichaetial leaves to 5 mm long; seta 1.1-1.2 mm long, capsule immersed but often sticking out to side between perichaetial leaves; endostome present*N. denigricans*
 6. Leaves long-ligulate from ovate base, nearly symmetric.....*N. undulatifolia*
 6. Leaves ovate or ovate -lingulate to ovate-lanceolate, nearly symmetric or asymmetric.....7
7. At least some apical teeth of stem leaves bi- or multicellular.....8
7. Apical teeth of leaves indistinct or, if distinct, unicellular.....10
 8. Some branch tips naked due to caducous leaves; stem leaves to c. 4 mm long*N. serrulatifolia*
 8. Branch leaves not caducous; stem leaves to c. 3 mm long9
9. Fronds (incl. stipe) to c. 5 cm long, irregularly pinnately branched; leaves not undulate; apical teeth of stem leaves mostly multicellular.....
.....*N. neckeroides* (*Homaliodendron neckeroides*)

9. Fronds (incl. stipe) to c. 10 cm long, densely pinnately branched; leaves undulate above; apical teeth of stem leaves mostly bicellular *N. yunnanensis*
 10. Median laminal cells c. 30 μm long *N. perpinnata*
 10. Median laminal cells (35-)40-60(-70) μm long 11
11. Leaf apices obtuse to rounded, sometimes mucronate; capsule long-exserted (seta 5-7 mm long) *N. crenulata* (*Taiwanobryum crenulatum*)
11. Leaf apices (broadly) acute; capsule immersed or long-exserted 12
 12. Most branch tips long-attenuate, nearly flagelliform; seta c. 5 mm long, capsule long-exserted *N. konoii*
 12. Branch tips obtuse or truncate; seta less than 1 mm or more than 15 mm long, capsule immersed or long-exserted 13
13. Leaves complanate, distinctly undulate; seta 15-20 mm long *N. himalayana*
13. Leaves appressed but not complanate, slightly or distinctly undulate; seta less than 1 mm long 14
 14. Stem leaves to 3 mm long, distinctly concave, slightly undulate, apices broadly acute; median laminal cells 35-45 μm long; inner post-fertilization perichaetial leaves to 3 mm long, capsule not deeply immersed (tip often visible between perichaetial leaves) *N. humilis*
 14. Stem leaves to 3.8 mm long, not concave, deeply undulate, apices acute; median laminal cells 40-60(-70) μm long; inner post-fertilization perichaetial leaves to 3.8 mm long, capsule deeply immersed
 *N. yezoana* (*Forsstroemia yezoana*)
15. Leaves not undulate 16
15. At least some leaves distinctly undulate 21
 16. Costa reaching to c. half leaf length 17
 16. Costa nearly absent or reaching to c. 1/3 of leaf length at most 18
17. Plants strongly glossy; leaves not homomallous when dry; leaf margins faintly serrulate above, entire or faintly crenulate at midleaf *N. pusilla*
17. Plants only slightly glossy; distal stem and branch leaves usually homomallous when dry; leaf margins distinctly serrulate from tips c. to midleaf
 *N. goughiana* (*Forsstroemia goughiana*)
18. Fronds (incl. stipe) to 1 cm long; stem leaves 0.9-1.2 mm long; costa absent or reaching to c. 1/10 of leaf length *N. enrothiana*
18. Fronds (incl. stipe) to 5 cm long or more; stem leaves to 2-2.5 mm long; costa reaching to 1/5 of leaf length or more 19
19. Stem leaves to 2.5 mm long; costa often reaching to 1/3 of leaf length; seta less than 0.5 mm long *N. borealis*
19. Stem leaves to c. 2 mm long or less; costa virtually absent or reaching to c. 1/5 of leaf length at most; seta 1.5-10 mm long 20
 20. Flagelliform branches common; stem leaves to 1.5 mm long, often distinctly apiculate or mucronate; seta to 10 mm long, capsule long-exserted
 *N. complanata* (*Alleniella complanata*)
 20. Flagelliform branches uncommon; stem leaves to c. 2 mm long, not apiculate or mucronate; seta 1.5 mm long, capsule immersed *N. laevidens*
21. Leaves symmetric or slightly asymmetric; costa reaching to 1/2-2/3 of leaf length *N. inopinata*
21. Leaves distinctly asymmetric; costa short, sometimes double, only rarely reaching to 1/2 of leaf length 22

22. Upper parts of leaf decurrencies 6-7(-9) cells wide.....*N. decurrens*
 22. Leaf decurrencies lacking or their upper parts no more than 3-4(-5) cells wide.....23
23. Branches often arcuate; stem leaves to 1.5 mm long; seta 3-4 mm long.....
*N. flexiramea*
23. Branches not arcuate; stem leaves to 2.5-3.3 mm long; seta less than 1 mm long.....24
24. Leaves not decurrent; pseudoparaphyllia to (0.5-)0.7-1.0 mm long; endostome absent*N. bhutanensis*
24. Leaves shortly decurrent; pseudoparaphyllia to 0.4 mm long; endostome present but vestigial.....25
25. Upper stem leaves and/or branch leaves or (in small plants) all leaves not undulate; stem leaves to 2.5 mm long, apex rather abruptly narrowed, broadly acute; costa double or single, sometimes reaching to 1/3 leaf length...*N. borealis*
25. All leaves undulate; stem leaves to c. 3 mm long, apex gradually narrowed, acute; costa very short, hardly ever reaching to 1/4 leaf length.....*N. pennata*

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