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A contribution to the knowledge of epiphyllous bryophytes in Tianmushan National Nature Reserve (Zhejiang, China), with remarks on climate warming and nature conservation

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Five epiphyllous liverwort species, all members of the family Lejeuneaceae, are newly reported from Tianmushan National Nature Reserve, Zhejiang Province, China. The locality constitutes the northernmost occurrence of epiphyllous bryophytes in eastern China. It is proposed that the establishment of the epiphyllous species in the reserve was the result of a recent dispersal event influenced by climate warming. The site where the species occur is increasingly impacted by ecotourism and forest ecology teaching. Limitation of teaching at the site, reduction of the number of trails and stricter conservation is recommended in order to protect the fragile local epiphyllous community.

Epiphyllous bryophytes mainly occur on leaves of vascular plants, in the understory of moist tropical and subtropical forests (Richards 1984, Jiang et al. 2014), and more than 95% of the species are members of the liverwort family Lejeuneaceae (Pócs 1996, Gradstein 1997). They occur in 21 floristic regions of Asia, Australia, Africa, America and Europe, with Asia having the highest diversity with more than 500 known species of epiphylls (Pócs 1996). Outside the tropics and subtropics, epiphyllous bryophytes are rare (Duckett 2008). In China, the distributional ranges of epiphyllous liverworts are restricted to south of 31° N, including 11 provinces (Anhui, Fujian, Guangdong, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Taiwan, Yunnan and Zhejiang) as well as the regions of Guangxi, Xizang and Hong Kong, at elevations ranging from sea level to 3000 m (Zhu and So 2001, p. 27). Highest species numbers are found in cloud forests of Yunnan, Hainan and Taiwan between 700 – 1600 m (Zhu and So 2001).

Being negatively affected by direct sunlight and reduction of air humidity, epiphyllous bryophytes are very sensitive to climate change and forest modification, and hence are potential indicators of forest health (Alvarenga et al. 2009, Frego 2007, Pócs 1996, Zartman 2003). Negative impacts on the structure of the canopy or other layers of the forest may result in impoverishment or loss of the epiphyllous communities. The invasion of weedy angiosperm species unsuitable as hosts for epiphylls may also negatively influence the epiphyllous bryophyte flora (Pócs 1996).

Over the past 30 years, China has experienced rapid economic development, accompanied by increased emission of greenhouse gases, ozone precursors and aerosols, and made a contribution to global radiative forcing (Li et al. 2016). The rapid economic growth as well as the increased tourism activities had a significant impact on the environment (Jiang and Shao 2016).

Tianmushan National Nature Reserve (TNNR) in the province of Zhejiang (119°23′47″–119°28′27″E, 30°18′30″–30°24′55″N), lies at the northern limit of mid-subtropical zone and covers a total area of 4284 hm^2. The reserve is part of the International Biosphere Reserve (MAB) network and is located in the Yangtze River Delta region, which is the most populous and fastest growing area in China. The area has a damp monsoon climate with an annual precipitation of 1390–1870 mm and an annual temperature of 8.8–14.8°C. The reserve is one of the sites with the richest subtropical higher plant flora in China. More than 2000 species of plants have been recorded from the reserve, including the last surviving wild population of *Ginkgo* trees. Animal resources of the reserve are also very rich, including 341 vertebrate and 4209 insect species according to current

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knowledge (Chen 2006). In addition, the reserve has been a famous mountain for Tao religion since the West Han dynasty (around 2000 years ago).

The scenery, rich biodiversity and religious constitution have made TNNR a famous ecotourism destiny in east China (Li 2004). The number of annual visitors has increased from 40 000 to 210 000 in the last 30 years (Wang et al. 2013). In addition, the reserve serves as an important field practice base for more than seventy universities in east China. These activities have had negative influences on the environment of TNNR and its biodiversity (Yan et al. 2009, Zhu et al. 2006). For example, bird song in the reserve has become reduced (Li 2004) and bryophyte diversity, especially liverwort diversity, has declined since 1977 (Li et al. 2006, Wang et al. 2012, 2013).

In order to better understand the impact of rapid economic development and tourism activities on the environment and the declining biodiversity, we are conducting surveys of bryophyte diversity in TNNR and other mountain areas in east China with support of the Ministry of Science and Technology, China. Bryophytes have been inventoried in TNNR on a regular basis since 1981 (Hu and Wang 1981). In the course of the field investigation in TNNR in the spring of 2017, we found five epiphyllous species, all belonging to Lejeuneaceae (Fig. 1, 2). This is the first observation of epiphylls in TNNR and the northernmost known occurrence of epiphyllous bryophytes in eastern China. Previously, the

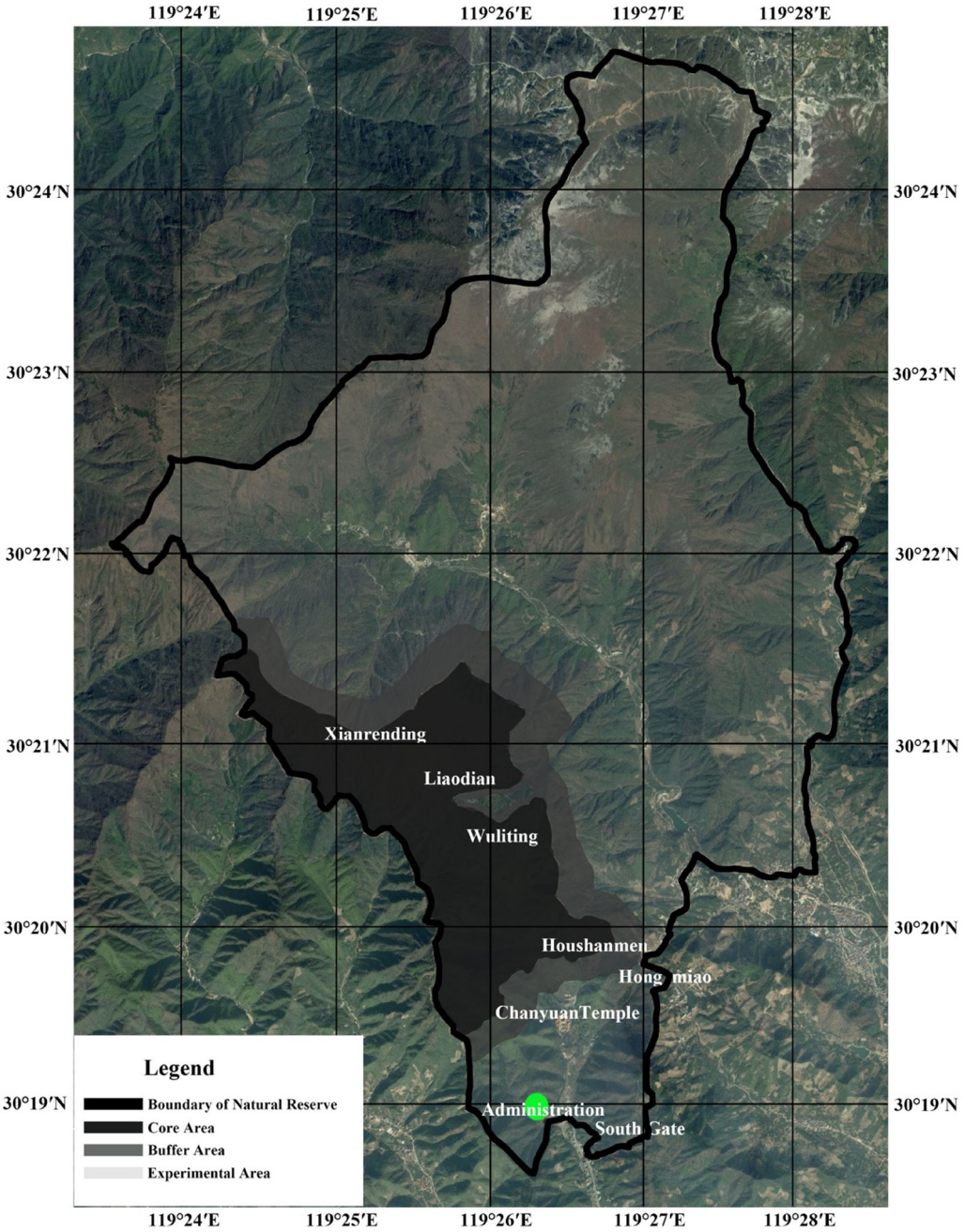


Figure 1. The locality of epiphyllous bryophytes in TNNR (green dot).

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Figure 2. The locality of epiphyllous bryophytes in TNNR where the habitat has become a forest ecology teaching point.

northernmost location of epiphyllous bryophytes in eastern China was in Qimen County (29°39′N, 117°31′E), Anhui Province, about 200 km south of TNNR (Fig. 3, 4). In view of the declining bryophyte diversity in TNNR, the discovery of epiphyllous bryophytes in this reserve was unexpected.

The five epiphyllous species detected in TNNR are listed below together with details on locality, elevation, habitat and voucher number. The importance of the new records is discussed with reference to climate warming and nature conservation.

List of epiphyllous bryophyte species found in TNNR

Cololejeunea japonica (Schiffn.) Mizut.
Near the protection bureau, 30°19′03.3″N, 119°26′90.0″E, 333 m, on *Trachycarpus fortune*, 26 Apr 2017, *J. Wang et al. 20170426-10B* (HSNU); 30°18′60.0″N, 119°26′65.5″E, 320 m, on *T. fortune*, 26 Apr 2017, *J. Wang et al. 20170426-20, 20170426-22, 20170426-23,* 27 Apr 2017, *20170427-6A, 20170427-8B, 20170427-9, 20170427-10, 20170427-11, 20170427-12, 20170427-13, 20170427-14* (HSNU).

Cololejeunea japonica often occurs near human habitation. The species is easily confused with *C. magnistyla* but differs in its 1–2-celled stylus (Mizutani 1961, Zhu and So 2001).

Range: China (Fujian, Jiangsu, Shanghai and Zhejiang), Japan and Korea (Jia and He 2013, Zhu and So 2001).

Cololejeunea longifolia (Mitt.) Mizut.
Near the protection bureau, 30°19′03.3″N, 119°26′90.0″E, 333 m, on *Camellia sinensis*, 26 Apr 2017, *J. Wang et al. 20170426-7, 20170426-8, 20170426-9,* 27 Apr. 2017, *20170427-3* (HSNU).

Range: Bhutan, China (Anhui, Chongqing, Fujian, Guizhou, Guangdong, Guangxi, Hainan, Hubei, Hunan, Jiangxi, Shandong, Sichuan, Taiwan, Xizang, Yunnan and Zhejiang), India, Japan and Korea (Jia and He 2013, Zhu and So 2001).

Cololejeunea raduliloba Steph.
Near the protection bureau, 30°19′03.3″N, 119°26′90.0″E, 333 m, on *T. fortune* and *Lithocarpus harlandii*, 27 Apr 2017, *J. Wang et al. 20170427-6D, 20170427-8A* (HSNU).

Range: Africa (east African islands), Australia (Thiers 1988), China (Fujian, Guangxi, Guizhou, Hainan, Hong Kong, Hubei (nov.), Hunan, Jiangxi, Shanghai, Taiwan, Yunnan and Zhejiang), Fiji (Pócs et al. 2011), India (Assam), Indonesia, Japan, Korea, Micronesia, Nepal, New Caledonia (Hürlimann 1987), and Vietnam (Jia and He 2013, Zhu and So 2001).

Cololejeunea spinosa (Horik.) Pandé & Misra.
Near the protection bureau, 30°19′03.3″N, 119°26′90.0″E, 333 m, on *T. fortune*, 26 Apr 2017, *J. Wang et al. 20170426-10C* (HSNU), on *T. fortune* and *L. harlandii*, 27 Apr 2017, *J. Wang et al. 20170427-4, 20170427-6C* (HSNU).

Cololejeunea spinosa is a very common species in several provinces of China. The species is characterized by its narrowly ovate leaves, spinose dorsal protrusions of leaf cells, more or less reduced leaf lobule, erect-spreading first tooth and smooth ventral surface of leaf lobule (Zhu and So 2001).

Range: China (Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hong Kong, Hunan, Jiangxi, Sichuan, Taiwan, Xizang, Yunnan and Zhejiang), India, Japan, Korea, Nepal and Philippines (Jia and He 2013, Zhu and So 2001).

Microlejeunea punctiformis (Taylor) Steph.
Near the protection bureau, 30°19′03.3″N, 119°26′90.0″E, 333 m, on *T. fortune*, 26 Apr 2017, *J. Wang et al. 20170426-10D* (HSNU), on *L. harlandii*, 27 Apr 2017, *J. Wang et al. 20170427-6B* (HSNU).

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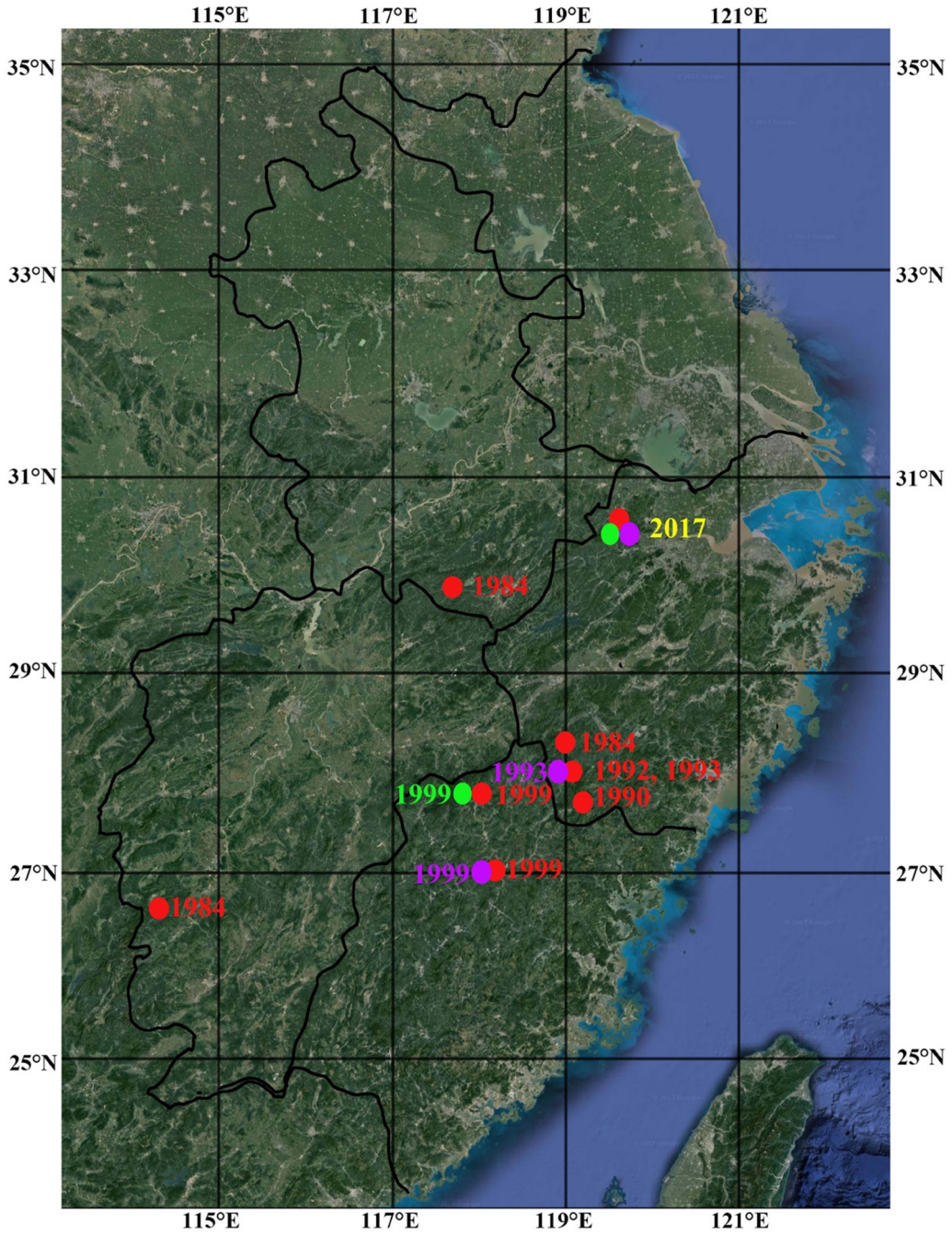


Figure 3. Distribution of *Cololejeunea japonica* (green dot), *C. longifolia* (red dots) and *C. raduliloba* (purple dots) in eastern China.

Range: Bhutan, China (Anhui, Chongqing, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hong Kong, Hubei, Hunan, Jiangxi, Sichuan, Taiwan, Xizang, Yunnan and Zhejiang), India, Japan, Nepal, Thailand, Sri Lanka and Vietnam (Jia and He 2013, Zhu and So 2001).

Discussion

Not surprisingly, all five epiphyllous species found in this study are members of Lejeuneaceae. The taxonomic diversity of epiphyllous bryophytes is highly restricted and contains members of mainly three families – the liverwort families Lejeuneaceae (containing more than 95% of the species) and Radulaceae, and the moss family Hookeriaceae s.l. (Gradstein 1997). All epiphyllous species found in this study, with exception of *Microlejeunea punctiformis*, are members of the genus *Cololejeunea*. With almost 500 accepted species worldwide, *Cololejeunea* is the largest genus of the Lejeuneaceae and the third-largest genus of the liverworts, after *Plagiochila* and *Frullania* (Söderström et al. 2016). The species of this genus frequently grow epiphyllous and may freely produce spores and gemmae, enhancing dispersal and survival of these taxa in the ephemeral epiphyllous habitat. The common occurrence of neotenic evolution in the genus, including primary neoteny and protonemal neoteny (Gradstein et al. 2003,

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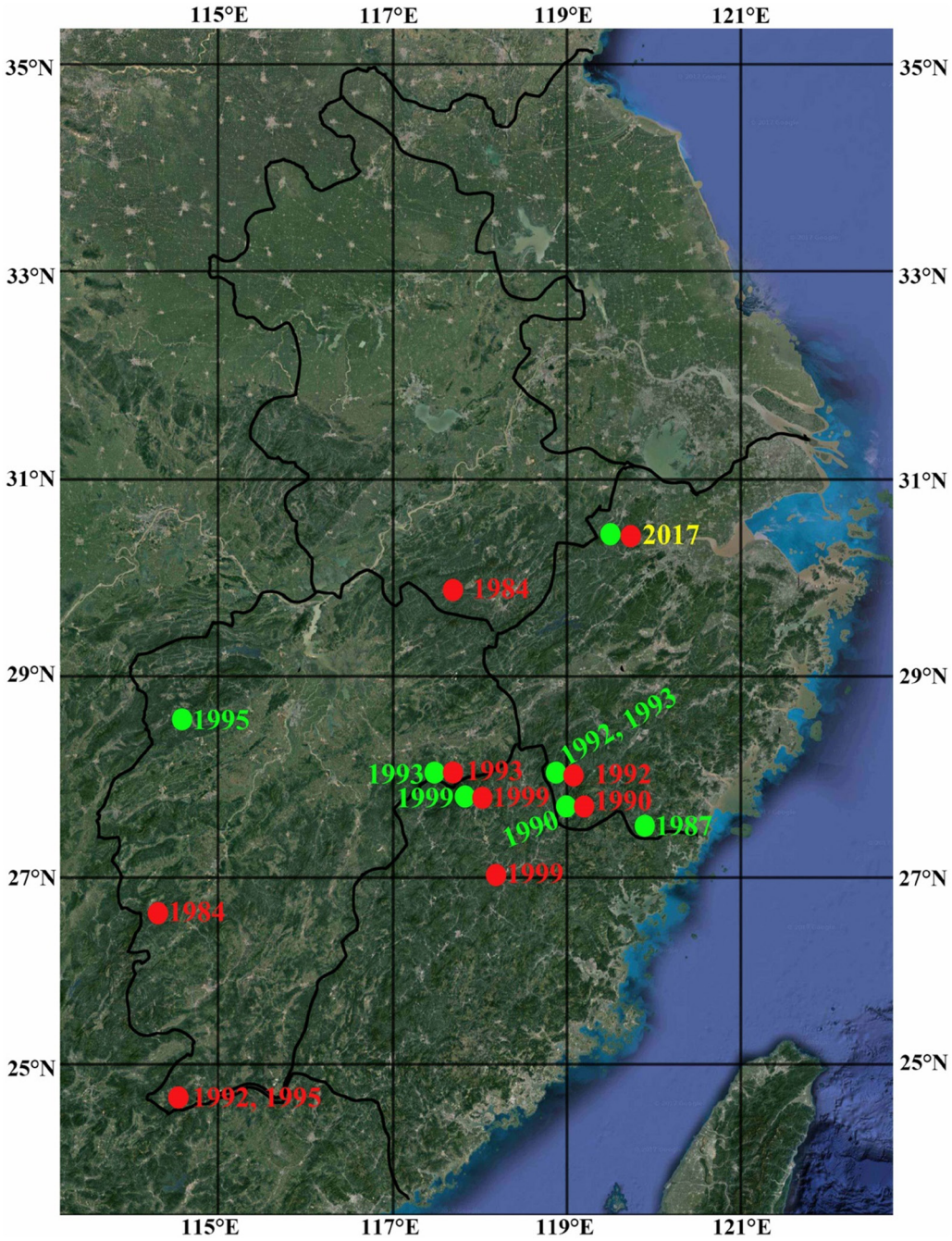


Figure 4. Distribution of *Cololejeunea spinosa* (red dots) and *Microlejeunea punctiformis* (green dots) in eastern China.

2006, Yu et al. 2013), are unique evolutionary adaptations of *Cololejeunea* species to their ephemeral habitat (Gradstein 1997).

Of the four *Cololejeunea* species found in TNNR, three were found with sporophytes and gemmae, only *Cololejeunea raduliloba* was found just with gemmae. Bryophytes are easily dispersed by diaspores of spores or gemmae (Vanderpoorten and Goffinet 2010). We postulate that the colonization of leaves in TNNR by these *Cololejeunea* species was the result of a recent dispersal event by spores or gemmae, while *Microlejeunea punctiformis*, a species in which sporophytes and gemmae are unknown, could have arrived by means of caducous stem fragments. We also suggest that the establishment of the epiphyllous liverworts detected in TNNR may have been a recent event influenced by climate warming. This prediction is based on the assumption that species distributional patterns are strongly influenced by temperature changes and that the distribution area of epiphyllous bryophytes is hence expected to shift northward in the Northern Hemisphere caused by climate warming (Alsos et al. 2007, Guralnick 2007). Mean annual temperatures in eastern China have risen by 1.5°C between 1980 and 2016 (data from NOAA's National Climatic Data Center, calculated from 23 selected grid). Shifts of species towards higher latitudes due to climate warming have been shown in many species of animals and plants (Colwell et al.

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2008), including bryophytes of Europe (Frahm and Klaus 2001, Pócs 2011, Bates and Preston 2011), but have rarely been shown for epiphyllous liverworts. A first possible case of northwards shift of epiphyllous bryophytes in Europe distribution was reported by Duckett (2008) who recorded extensive patches of three liverwort species on living leaves in a nature reserve in the vicinity of the city of London, UK at 51°N.

Of the five epiphyllous species found in TNNR, four have been collected sporadically over the past 30 years in eastern China except for *Cololejeunea japonica* which was found only once in the past and no more until recently (Fig. 3, 4). *Cololejeunea longifolia* and *C. spinosa* have been collected since 1984 in Qimen County, Anhui Province. *Cololejeunea raduliloba* and *Microlejeunea punctiformis* have been collected since 1993 in Fengyangshan Nature Reserve, Zhejiang Province. *Cololejeunea japonica* has been collected since 1999 in Wuyishan Nature Reserve, Fujian Province. These sites were the northernmost occurrences of the five epiphyllous species in eastern China before. It is improbable that they had in the past been overlooked in TNNR, as Chinese epiphyllous liverworts have been intensively collected and studied by Zhu and So (2001), and bryophytes had already been inventoried in the reserve on a regular basis since 1981. We are very well-informed about the bryoflora of TNNR, where bryologists have collected and published their results for more than 30 years. Recent distribution data on epiphyllous bryophytes from elsewhere in China, such as Guan County in Sichuan Province (31°N) and Houhe Nature Reserve in Hubei Province (30.08°N) (Luo 1990, Peng et al. 2002), also suggest that the ranges of epiphyllous bryophytes in China may have shifted northwards there since 1964 (Chen and Wu 1964).

Since most epiphyllous liverworts are dependent on the environment created by vascular plants of moist, tropical and subtropical forests, the conservation of epiphyllous bryophytes is dependent on the strict protection of these forests (Zhu and So 2001). The Tianmushan National Nature Reserve was established in 1956 for protecting its forest ecosystem and is one of the first forest areas where logging was forbidden in China. The strict management conditions of TNNR are presumably beneficial to the establishment and growth of epiphyllous liverworts, but may also degrade the natural resources at the same time. By monitoring the native moso bamboo population dynamics in native Chinese fir and evergreen broadleaved forest bordering moso bamboo in TNNR for ten years, Bai et al. (2016) found that native moso bamboo may encroach adjacent natural forest gradually without human intervention and lead to the drastic disturbance of the surrounding natural forest. Such vegetation changes may alter forest floor microclimate with respect to light, temperature, and moisture (Liu et al. 2011). Microclimate factors, including temperature, relative humidity and light, are very important for epiphyllous distribution and growth. Slight changes in the local microclimate may alter the composition of the epiphyllous communities and result in the disappearance of species (Zhu and So 2001). The invasion by exotics or the replacement of the original canopy by planted trees often leads to the total loss of the epiphyllous flora and invasion of alien species in the understory of the rainforest can have a negative impact on the epiphyllous bryophyte communities.

In TNNR, the epiphyllous liverworts occur along the banks of a little shaded brook in the experimental area of the reserve (Fig. 1). In spite of intensive, repeated field searches, epiphyllous bryophytes were not found in the buffer zone and core zone of the reserve even though the latter area has been regarded as a key area for bryophyte diversity protection in TNNR (Wang et al. 2013). In a study of soil properties along the elevation gradient in TNNR, Yang et al. (2009) found that soil PH value decreases with increase in altitude, leading to the decline of the ancient *Cryptomeria japonica* var. *sinensis* trees. Presumably, the absence of epiphyllous bryophytes in the buffer zone and core zone of TNNR is due to the lack of microhabitats suitable for the growth of epiphyllous liverworts affected by acid deposition.

The future occurrence of the epiphyllous species detected in TNNR may not be guaranteed. As mentioned in the introduction, ecotourism in TNNR has strongly expanded in the past 20 years and has resulted in vegetation loss and shortage of water supply (Li 2004). Moreover, the epiphyllous liverworts occur exclusively in the experimental area of TNNR, which is less strictly protected than the buffer zone and core zone and is intensively used for forest ecology teaching (Fig. 2). These activities may threaten the continued occurrence of the epiphyllous species in TNNR. It is therefore recommended that measurements are taken for limitation of teaching, reduction of the number of trails and stricter conservation of the area where the species occur. The establishment in the area of a system for regular monitoring of water and air quality as well as quality of the environment, is also recommended.

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References

Alsos, I. G., Eidesen, P. B., Ehrich, D. et al. 2007. Frequent long-distance plant colonization in the changing Arctic. – Science 316: 1606–1609.

Alvarenga, L. D. P., Porto, K. C. and Silva, M. P. P. 2009. Relations between regional–local habitat loss and metapopulation properties of epiphyllous bryophytes in the Brazilian Atlantic forest. – Biotropica 41: 682–691.

Bai, S.-B., Wang, Y.-X., Conant, R. T. et al. 2016. Can native clonal moso bamboo encroach on adjacent natural forest without human intervention? – Sci. Rep. UK doi:10.1038/srep31504.

Bates, J. W. and Preston, C. D. 2011. Effects of climate change on British bryophytes. –In: Tuba, Z., Slack, N. G. and Stark, L. R. (eds), Bryophyte ecology and climate change. – Cambridge Univ. Press, pp. 359–370.

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Chen, J.-X. 2006. Fifty years of scientific research work in Tianmushan National Nature Reserve, Zhejiang (1956–2006). – Administration of TNNR, Zhejiang.
Chen, P.-C. and Wu, P.-C. 1964. Study on epiphyllous liverworts of China (I). – Acta Phytotaxon. Sin. 9: 213–276.
Colwell, R. K., Brehm, G., Cardelús, C. L. et al. 2008. Global warming, elevational range shifts, and lowland biotic attrition in the wet tropics. – Science 322: 258–261.
Duckett, J. G. 2008. Epiphyllic and epifungal liverworts on Hampstead Head, London. – Field Bryol. 95: 8–10.
Frahm, J. P. and Klaus, D. 2001. Bryophytes as indicators of recent climatic fluctuations in central Europe. – Lindbergia 26: 97–104.
Frego, K. A. 2007. Bryophytes as potential indicators of forest integrity. – For. Ecol. Manage. 242: 65–75.
Gradstein, S. R. 1997. The taxonomic diversity of epiphyllous bryophytes. – Abstr. Bot. 21: 15–19.
Gradstein, S. R., Reiner-Drehwald, M. E. and Schneider, H. 2003. A phylogenetic analysis of the genera of Lejeuneaceae (Hepaticae). – Bot. J. Linn. Soc. 143: 391–410.
Gradstein, S. R., Wilson, R., Ilkiu-Borges, A. L. et al. 2006. Phylogenetic relationships and neotentic evolution of *Metzgeriopsis* (Lejeuneaceae) based on chloroplast DNA sequences and morphology. – Bot. J. Linn. Soc. 151: 293–308.
Guralnick, R. 2007. Differential effects of past climate warming on mountain and flatland species distributions: a multispecies North American mammal assessment. – Global Ecol. Biogeogr. 16: 14–23.
Hu, R.-L. and Wang, Y.-F. 1981. A survey on the bryophytes from the Tianmu Mountain in Zhejiang Province. – J. E. China Norm. Univ. (Nat. Sci.): 86–104.
Hürlimann, H. 1987. Hepaticae aus dem Gebiete des sudlichen Pazifik. IX. – Bauhinia 8: 221–234.
Jia, Y. and He, S. (eds) 2013. Species catalogue of China. Vol. 1. Plants. Bryophytes. – Science Press.
Jiang, Y.-B. and Shao, X.-M. 2016. Diversity and distribution pattern of epiphyllous liverworts and its ecological determinants. – Chin. J. Plant Ecol. 40: 523–532.
Jiang, Y.-B., Wang, T.-J., de Bie, C. A. J. M. et al. 2014. Satellite-derived vegetation indices contribute significantly to the prediction of epiphyllous liverworts. – Ecol. Indic. 38: 72–80.
Li, B.-G., Gasser, T., Ciais, P. et al. 2016. The contribution of China's emissions to global climate forcing. – Nature 531: 357–361.
Li, F.-X., Wang, Y.-F., Liu, L. et al. 2006. Species diversity of bryophytes in West Tianmu Mountain of Zhejiang Province. – Chin. J. Appl. Ecol. 17: 192–196.
Li, W.-J. 2004. Environmental management indicators for ecotourism in China's nature reserves: a case study in Tianmushan Nature Reserve. – Tourism Manage. 25: 559–564.
Liu, S., Zhou, G. M. and Bai, S. B. 2011. Light intensity changes on *Cunninghamia lanceolata* in mixed stands with different concentrations of *Phyllostachys pubescens*. – J. Zhejiang A & F Univ. 28: 550–554.
Luo, J.-S. 1990. A synopsis of Chinese epiphyllous liverworts. – Trop. Bryol. 2: 161–166.
Mizutani, M. 1961. A revision of Japanese Lejeuneaceae. – J. Hattori Bot. Lab. 24: 115–302.
Peng, D., Liu, S.-X. and Wu, P.-C. 2002. Studies on the epiphyllous liverworts of China VIII – the epiphyllous liverworts of Houhe National Nature Reserve. – J. Wuhan Bot. Res. 20: 199–201.
Pócs, T. 1996. Epiphyllous liverworts diversity at worldwide level and its threat and conservation. – Anales Inst. Biol. Univ. Nac. México, Ser. Bot. 67: 109–127.
Pócs, T. 2011. Signs of climate change in the bryoflora of Hungary. – In:Tuba, Z., Slack, N. G. and Stark, L. R. (eds), Bryophyte ecology and climate change. Cambridge Univ. Press, pp. 359–370.
Pócs, T., Sass-Gyarmati, A., Naikatini, A. et al. 2011. New liverwort (Marchantiophyta) records for the Fiji Islands. – Telopea 13: 455–494.
Richards, P. W. 1984. The ecology of tropical forest bryophytes. – In: Schuster, R. M (ed.), New manual of bryology, Vol. 2 – J. Hattori Bot. Lab., pp. 1233–1270.
Söderström, L., Hagborg, A., von Konrat, M. et al. 2016. World checklist of hornworts and liverworts. – PhytoKeys 59: 1–828.
Thiers, B. 1988. The Australian species of *Cololejeunea*. – Nova Hedwigia Beih. 90: 113–146.
Vanderpoorten, A. and Goffinet, B. 2010. Introduction to bryophytes. – Cambridge Univ. Press.
Wang, D.-H., Wang, Y.-F., Zuo, Q. et al. 2012. Bryophyte species diversity in seven typical forests of the West Tianmu Mountain in Zhejiang, China. – Chin. J. Plant Ecol. 36: 550–559.
Wang, D.-H., Wang, Y.-F., Zuo, Q. et al. 2013. Comparison of bryophyte diversity in West Tianmu Mountain from 1977 to 2011. – Biodiversity Science 21: 170–176.
Yan, X.-L., Bao, W.-K. and Zhu, Z. 2009. Effect of tourism disturbance on bryophytes growing on *Abies faxoniana* in original forests in the Jiuzhaigou National Scenic Spot, China. – Chin. J. Appl. Environ. Biol. 15: 469–473.
Yang, S.-Z., Ma, Y., Jiang, P. et al. 2009. Soil physical and chemical properties along altitudes of Western Tianmushan, Zhejiang. – J. E. China Normal Univ. (Nat. Sci. Ed.): 101–107.
Yu, Y., Pócs, T., Schäfer-Verwimp, A. et al. 2013. Evidence for rampant homoplasy in the phylogeny of the epiphyllous liverwort genus *Cololejeunea* (Lejeuneaceae). – Syst. Bot. 38: 553–563.
Zartman, C. E. 2003. Habitat fragmentation impacts on epiphyllous bryophyte communities in central Amazonia. – Ecology 84: 948–954.
Zhu, R.-L. and So, M.-L. 2001. Epiphyllous liverworts of China. – Beih. Nova Hedwigia 121: 1–418.
Zhu Z., Bao, W.-K., Pang, X.-Y. et al. 2006. Tourism effect on species composition and diversity of understory plants in *Abies fargesii* var. *faxoniana* forest in Jiuzhaigou, Sichuan. – Biodivers. Sci. 14: 284–291.

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