Checklist and red list of hornworts (Anthocerotophyta) and liverworts (Marchantiophyta) of Slovakia

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Abstract

The presented checklist and red list include 231 liverwort (Marchantiophyta) and two hornwort species (Anthocerotophyta). Overall, 22.9% of liverworts are evaluated as threatened (CR – 4.3%, EN – 7.8%, VU – 10.8%), while 17 of species (7.4%) are categorized as NT, 11.6% as DD and 3.0% as RE. A total of 128 species (55.4% of the liverwort flora of Slovakia) were assessed as LC. For the liverwort *Lunularia cruciata* the criteria were not applicable (NA), since this species is not native to Slovakia. Currently, only two hornworts are known in Slovakia, of which *Anthoceros agrestis* is assessed as LC and *Phaeoceros carolinianus* as NT. The main factors of the liverwort and hornwort endangerment and retreat are anthropogenic changes in natural conditions and degradation of the ecosystems caused by agriculture, forestry, aquaculture, climatic changes, industry, and traffic pollution.

Keywords Bryophytes · Central Europe · Conservation · IUCN categories

Introduction

Up to date, three editions of the Checklist of liverworts and hornworts (Kubinská et al. 1993; Kubinská and Janovicová 1996, 1998) and two of their updated editions (Kubinská et al. 2001a, b) including the Red list of bryophytes evaluated according to the IUCN criteria (IUCN 2001) have been published in Slovakia. Since then, several species new to Slovakia have been recorded. The revised checklist and red list of hornworts (Anthocerotophyta) and liverworts (Marchantiophyta) follow the latest version of the Checklist of mosses (Bryophyta) (Mišíková et al. 2020). Based on current knowledge, occurrence and threat status of hornworts and liverworts are less processed compared to mosses. At present, data from most areas of Slovakia are absent or are only

partially known with the exception of the Tatra Mountains, where distribution, chorology and the population numbers of some species are well documented (Šoltés 1990, 2002; Górski and Váňa 2014; Górski 2016, 2020). The aim of this work is to present the current state of endangerment and nomenclatural changes of liverworts and hornworts of Slovakia.

Methods

All hornwort and liverwort species that have been recorded in Slovakia up to the end of February 2020 were taken into consideration. The updated checklist and red list are based on previous lists (Kubinská et al. 2001a, b) and are treated according to recently published results. Nomenclature of taxa follows the European checklist of bryophytes (Hodgetts et al. 2020), except *Lophocolea coadunata*. As the dioicous species *Lophocolea coadunata* was not distinguished from the autoicous *Lophocolea bidentata* in Slovakia, we do not treat these species separately. Accepted names are cited in bold. Species varieties are listed by generally distinguished taxa.

Red list

The presented edition of the red list follows the IUCN Species Survival Commission Guidelines (2012) considering the guidelines for bryophytes (Hallingbäck 2006; Hodgetts et al.

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2019). Recommendations provided by Bergamini et al. (2019) were used to define the concept of an adult individual. According to the IUCN (2012), the IUCN Standards and Petitions Subcommittee (2019), Hodgetts et al. (2019) and Mišíková et al. (2020), eight categories were used.

1. Regionally extinct (RE): A species is Regionally Extinct when it is extinct or not confirmed since 1970 within the region assessed (Slovakia), but populations can still be found in areas outside the region. A small chance remains that such species may still persist and be rediscovered.
2. Critically endangered (CR): A species is Critically Endangered when it meets the criteria for this category, indicating that the species is facing an extremely high risk of extinction.
3. Endangered (EN): A species is Endangered when it meets criteria for endangered with a very high risk of extinction in the region.
4. Vulnerable (VU): A species is Vulnerable when it meets the criteria for this category, indicating that the species is facing a high risk of extinction in the region.
5. Near threatened (NT): A species is Near Threatened when it does not meet the criteria for CR, EN or VU, but may likely become at risk of extinction in the near future.
6. Least concern (LC): A taxon is considered to be of Least Concern if it does not qualify for CR, EN, VU or NT. Species classified as Least Concern are considered at low risk of extinction. Widespread and abundant species are typically classified in this category.
7. Data deficient (DD): Includes taxa for which the lack of data does not allow an assessment of its risk of extinction. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.
8. Not applicable (NA): This category includes species occurring outside their natural range, which cannot be evaluated on the basis of the selected criteria.

Due to lack of appropriate information for species classification into threat categories, only IUCN criterion B (subcriteria B1 and B2), C (subcriteria C1 and C2) and criterion D (subcriterion D2) (Table 1) were taken into account in the evaluation process.

Results

Species list

Anthocerotophyta

Anthoceros agrestis Paton LC.
Phaeoceros carolinianus (Michx.) Prosk. NT [B2ab (iii,iv,v)]

Marchantiophyta

Anastrepta orcadensis (Hook.) Schiffn. LC.
Anastrophyllum donnianum (Hook.) Steph. CR [B2ab (iii,iv); C2a (i); D]
Anastrophyllum hellerianum (Nees ex Lindenb.) R. M. Schust. → see under *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl.
Anastrophyllum michauxii (F. Weber) H. Buch LC.
Anastrophyllum minutum (Schreb. ex D. Crantz) R. M. Schust. → see under *Sphenolobus minutus* (Schreb. ex D. Crantz) Berggr.
Anastrophyllum saxicola (Schrad.) R. M. Schust. → see under *Sphenolobus saxicola* (Schrad.) Steph.
Aneura maxima (Schiffn.) Steph. DD¹.
Aneura pinguis (L.) Dumort. LC.
Anthelia julacea (L.) Dumort VU [B2ab (iii,iv)]
Anthelia juratzkana (Limpr.) Trevis. LC.
Apometzgeria pubescens (Schränk.) Kuwah. → see under *Metzgeria pubescens* (Schränk.) Raddi.
Apopellia endiviifolia (Dicks.) Nebel et D. Quandt (syn. *Pellia endiviifolia* (Dicks.) Dumort.) LC.
Asterella gracilis (F. Weber) Underw. → see under *Mannia gracilis* (F. Weber) D. B. Schill et D. G. Long.
Asterella lindenberghiana (Corda ex Nees) Lindb. ex Arnell VU [D2].
Asterella saccata (Wahlenb.) A. Evans EN [B2ab (iii,iv); C1 + C2a(i)]
Athalamia hyalina (Sommerf.) S. Hatt. → see under *Clevea hyalina* (Sommerf.) Lindb.
Barbilophozia atlantica (Kaal.) Müll. Frib. → see under *Orthocaulis atlanticus* (Kaal.) H. Buch.
Barbilophozia attenuata (Mart.) Loeske → see under *Neoorthocaulis attenuatus* (Mart.) L. Söderstr., De Roo et Hedd.
Barbilophozia barbata (Schmidel ex Schreb.) Loeske LC.
Barbilophozia binsteadii (Kaal.) Loeske → see under *Neoorthocaulis binsteadii* (Kaal.) L. Söderstr., De Roo et Hedd.
Barbilophozia floerkei (F. Weber et D. Mohr) Loeske → see under *Neoorthocaulis floerkei* (F. Weber et D. Mohr) L. Söderstr., De Roo et Hedd.
Barbilophozia hatcheri (A. Evans) Loeske LC.
Barbilophozia kunzeana (Huebener) Müll. Frib. → see under *Schljakovia kunzeana* (Huebener) Konstant. et Vilnet.
Barbilophozia lycopodioides (Wallr.) Loeske LC.
Barbilophozia quadriloba (Lindb.) Loeske → see under *Schljakovianthus quadrilobus* (Lindb.) Konstant. et Vilnet.
Barbilophozia sudetica (Nees ex Huebener) L. Söderstr., De Roo et Hedd. (syn. *Lophozia sudetica* (Nees ex Huebener) Grolle) LC.
Bazzania flaccida (Dumort.) Grolle DD.
Bazzania tricrenata (Wahlenb.) Lindb. LC.
Bazzania trilobata (L.) Gray LC.

Table 1 Explanation of applied criteria (IUCN Standards and Petitions Subcommittee 2019)

Criterion B – geographic range in the form of B1 (extent of occurrence) and/or B2 (area of occupancy)			
	CR	EN	VU
B1 (EOO – extent of occurrence)	<100 km ²	<5000 km ²	<20,000 km ²
B2 (AOO – area of occupancy)	<10 km ²	<500 km ²	<2000 km ²
and at least 2 of the following 3 conditions			
a. severely fragmented or number of locations	=1	≤5	≤10
b. continuing decline observed, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) extent, area and/or habitat quality; (iv) number of locations or subpopulations; (v) number of mature individuals			
c. extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			
Criterion C – Small population size and decline			
	CR	EN	VU
Number of mature individuals	<250	<2500	<10,000
and at least one of C1 or C2			
C1. An observed continuing decline of at least:	25% in 3 years or 1 generation	20% in 5 years or 2 generation	10% in 10 years or 3 generation
C2. An observed continuing decline and at least one of the following conditions:			
a. (i) Number of mature individuals in each subpopulation	≤50	≤250	≤1000
(ii) % of mature individuals in one subpopulation	90–100%	95–100%	100%
b. extreme fluctuation in the number of mature individuals			
Criterion D – very small and restricted population			
	CR	EN	VU
D. Number of mature individuals	<50	<250	D1. <1000
D2. Only applies to the VU category	-	-	D2. AOO<20 km ² or
Restricted area of occupancy or number of locations with a possible future threat that could drive the taxon to CR, RE or EX in a short time			number of locations≤5

Biantheridion undulifolium (Nees) Konstant. et Vilnet (syn. *Jamesoniella undulifolia* (Nees) Müll. Frib.) **RE**.

Blasia pusilla L. **LC**.

Blepharostoma trichophyllum (L.) Dumort. **LC**.

Bucegia romanica Radian → see under *Marchantia romanica* (Radian) D. G. Long, Crand.-Stotl., L. L. Forrest et J. C. Villarreal.

Calypogeia azurea Stotler et Crotz **LC**.

Calypogeia fissa (L.) Raddi NT [B2ab (iii)]

Calypogeia integristipula Steph. **LC**.

Calypogeia muelleriana (Schiffn.) Müll. Frib. **LC**.

Calypogeia neesiana (C. Massal. et Carestia) Müll. Frib. **LC**.

Calypogeia sphagnicola (Arnell et J. Perss.) Warnst. et Loeske **DD**.

Calypogeia suecica (Arnell et J. Perss.) Müll. Frib. **LC**.

Cephalozia affinis Lindb. ex Steph. → see under *Fuscocephaloziopsis affinis* (Lindb. ex Steph.) Váňa et L. Söderstr.

Cephalozia ambigua C. Massal. **LC**.

Cephalozia bicuspidata (L.) Dumort. **LC**.

Cephalozia catenulata (Huebener) Lindb. → see under *Fuscocephaloziopsis catenulata* (Huebener) Váňa et L. Söderstr.

Cephalozia connivens (Dicks.) Lindb. → see under *Fuscocephaloziopsis connivens* (Dicks.) Váňa et L. Söderstr.

Cephalozia lacinulata (J. B. Jack ex Gottsche et Rabenh.) Spruce **DD**.

Cephalozia leucantha Spruce → see under *Fuscocephaloziopsis leucantha* (Spruce) Váňa et L. Söderstr.

Cephalozia loitlesbergeri Schiffn. → see under *Fuscocephaloziopsis loitlesbergeri* (Schiffn.) Váňa et L. Söderstr.

Cephalozia lunulifolia (Dumort.) Dumort. → see under *Fuscocephaloziopsis lunulifolia* (Dumort.) Váňa et L. Söderstr.

Cephalozia pleniceps (Austin) Lindb. → see under *Fuscocephaloziopsis pleniceps* (Austin) Váňa et L. Söderstr.

Cephaloziella arctica Bryhn et Douin → see under *Cephaloziella varians* (Gottsche) Steph.

Cephaloziella divaricata (Sm.) Schiffn. **LC**.

Cephaloziella elachista (J. B. Jack ex Gottsche et Rabenh.) Schiffn. **EN** [B1ab (iii) + B2ab (iii)]

Cephaloziella elegans (Heeg) Schiffn. **DD**.

Cephaloziella grimsulana (J. B. Jack ex Gottsche et Rabenh.) Lacout. **DD**.

Cephaloziella hampeana (Nees) Schiffn. ex Loeske **LC**.

- Cephaloziella massalongi* (Spruce) Müll. Frib. **DD**.
Cephaloziella rubella (Nees) Warnst. **LC**.
Cephaloziella spinigera (Lindb.) Jørg. **DD**.
Cephaloziella stellulifera (Taylor ex Carrington et Pearson) Croz. **CR** [B2ab(iii); D]
Cephaloziella varians (Gottsche) Steph. (syn. *Cephaloziella arctica* Bryhn et Douin) **EN** [B2ab (iii,iv); D]
Chandonanthus setiformis (Ehrh.) Lindb. → see under *Tetralophozia setiformis* (Ehrh.) Schljakov.
Chiloscyphus minor (Nees) J. J. Engel et R. M. Schust. → see under *Lophocolea minor* Nees.
Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort. **LC**.
Chiloscyphus polyanthos (L.) Corda **LC**.
Chiloscyphus profundus (Nees) J. J. Engel et R. M. Schust. → see under *Lophocolea heterophylla* (Schr.) Dumort.
Cladopodiella fluitans (Nees) H. Buch → see under *Odontoschisma fluitans* (Nees) L. Söderstr. et Váňa.
Cladopodiella francisci (Hook.) Jørg. → see under *Odontoschisma francisci* (Hook.) L. Söderstr. et Váňa.
Clevea hyalina (Sommerf.) Lindb. (syn. *Athalamia hyalina* (Sommerf.) S. Hatt.) **VU** [C1; D2].
Cololejeunea calcarea (Lib.) Steph. **LC**.
Cololejeunea rossettiana (C. Massal.) Schiffn. **LC**.
Conocephalum conicum (L.) Dumort. **LC**.
Conocephalum salebrosum Szwedk., Buczk. et Odrzyk. **LC**.
Crossocalyx hellerianus (Nees ex Lindenb.) Meyl. (syn. *Anastrophyllum hellerianum* (Nees ex Lindenb.) R. M. Schust., *Sphenobolus hellerianus* (Nees ex Lindenb.) Steph.) **NT** [B2ab (iii)]
Diplophyllum albicans (L.) Dumort. **LC**.
Diplophyllum obtusifolium (Hook.) Dumort. **LC**.
Diplophyllum taxifolium (Wahlenb.) Dumort. **LC**.
Endogemma caespiticia (Lindenb.) Konstant., Vilnet et A. V. Troitsky (syn. *Jungermannia caespiticia* Lindenb.) **DD**.
Eremonotus myriocarpus (Carrington) Lindb. et Kaal. ex Pearson **VU** [D2].
Fossombronia foveolata Lindb. **CR** [B2ab (ii,iii,iv); C2a(i); D]
Fossombronia pusilla (L.) Nees **EN** [B2ab (ii,iii,iv)]
Fossombronia wondraczekii (Corda) Dumort. ex Lindb. **LC**.
Frullania dilatata (L.) Dumort. **LC**.
Frullania fragilifolia (Taylor) Gottsche, Lindenb. et Nees **NT** [B2ab (iii)]
Frullania jackii Gottsche **EN** [B2ab (iii); C2a (i)]
Frullania tamarisci (L.) Dumort. **LC**.
Fuscocephaloziopsis affinis (Lindb. ex Steph.) Váňa et L. Söderstr. (syn. *Cephalozia affinis* Lindb. ex Steph.) **CR** [B2ab (ii,iii); D]
Fuscocephaloziopsis albescens (Hook.) Váňa et L. Söderstr. (syn. *Pleurocladula albescens* (Hook.) Grolle, *Pleurocladula islandica* (Nees) Grolle) **LC**.
Fuscocephaloziopsis catenulata (Huebener) Váňa et L. Söderstr. (syn. *Cephalozia catenulata* (Huebener) Lindb.) **NT** [B2ab (iii,iv)]
Fuscocephaloziopsis connivens (Dicks.) Váňa et L. Söderstr. (syn. *Cephalozia connivens* (Dicks.) Lindb.) **LC**.
Fuscocephaloziopsis leucantha (Spruce) Váňa et L. Söderstr. (syn. *Cephalozia leucantha* Spruce) **LC**.
Fuscocephaloziopsis loitlesbergeri (Schiffn.) Váňa et L. Söderstr. (syn. *Cephalozia loitlesbergeri* Schiffn.) **DD**.
Fuscocephaloziopsis lunulifolia (Dumort.) Váňa et L. Söderstr. (syn. *Cephalozia lunulifolia* (Dumort.) Dumort.) **LC**.
Fuscocephaloziopsis pleniceps (Austin) Váňa et L. Söderstr. (syn. *Cephalozia pleniceps* (Austin) Lindb.) **LC**.
Geocalyx graveolens (Schr.) Nees **EN** [B2ab (iii); C2a(i)]
Gymnocolea inflata (Huds.) Dumort. **LC**.
Gymnomitrium adustum Nees (syn. *Marsupella adusta* (Nees) Spruce) **VU** [D2].
Gymnomitrium alpinum (Gottsche ex Husn.) Schiffn. (syn. *Marsupella alpina* (Gottsche ex Husn.) Bernet) **VU** [D2].
Gymnomitrium apiculatum (Schiffn.) Müll. Frib. → see under *Marsupella apiculata* Schiffn.
Gymnomitrium brevissimum (Dumort.) Warnst. (syn. *Marsupella brevissima* (Dumort.) Grolle) **LC**.
Gymnomitrium commutatum (Limpr.) Schiffn. (syn. *Marsupella commutata* (Limpr.) Bernet) **NT** [B2ab (iii)]
Gymnomitrium concinnatum (Lightf.) Corda **LC**.
Gymnomitrium corallioides Nees **NT** [B2ab(iii)]
Gymnomitrium obtusum Lindb. **RE**.
Gymnomitrium revolutum (Nees) H. Philib. (syn. *Marsupella revoluta* (Nees) Dumort.) **RE**.
Haplomitrium hookeri (Lyell ex Sm.) Nees **RE**.
Harpanthus flotovianus (Nees) Nees **VU** [D2].
Harpanthus scutatus (F. Weber et D. Mohr) Spruce **LC**.
Heterogemma laxa (Lindb.) Konstant. et Vilnet (syn. *Lophozia laxa* (Lindb.) Grolle, *Tritomaria laxa* (Lindb.) Stotler et Crand.-Stotl.) **DD**.
Isopaches bicrenatus (Schmidel ex Hoffm.) H. Buch (syn. *Lophozia bicrenata* (Schmidel ex Hoffm.) Dumort.) **NT** [B2ab (iii)]
Jamesoniella autumnalis (DC.) Steph. → see under *Syzygiella autumnalis* (DC.) Feldberg, Váňa, Hentschel et Heinrichs.
Jamesoniella undulifolia (Nees) Müll. Frib. → see under *Biantheridion undulifolium* (Nees) Konstant. et Vilnet.
Jungermannia atrovirens Dumort. **LC**.
Jungermannia borealis Damsh. et Váňa **DD**.
Jungermannia caespiticia Lindenb. → see under *Endogemma caespiticia* (Lindenb.) Konstant., Vilnet et A. V. Troitsky.
Jungermannia confertissima Nees → see under *Solenostoma confertissimum* (Nees) Schljakov.

Jungermannia exsertifolia Steph. subsp. *cordifolia* (Dumort.) Váňa → see under *Jungermannia eucordifolia* Schljakov.

Jungermannia eucordifolia Schljakov (syn. *Jungermannia exsertifolia* Steph. subsp. *cordifolia* (Dumort.) Váňa) **EN** [B2ab (ii,iii,iv), C2a (i)]

Jungermannia gracillima Sm. → see under *Solenostoma gracillimum* (Mitt.) R. M. Schust.

Jungermannia hyalina Lyell → see under *Solenostoma hyalinum* (Lyell) Mitt.

Jungermannia leiantha Grolle → see under *Liochlaena lanceolata* Nees.

Jungermannia obovata Nees → see under *Solenostoma obovatum* (Nees) C. Massal.

Jungermannia polaris Lindb. **VU** [D2].

Jungermannia pumila With. **LC**.

Jungermannia sphaerocarpa Hook. → see under *Solenostoma sphaerocarpum* (Hook.) Steph.

Jungermannia subelliptica (Lindb. et Kaal.) Levier → see under *Solenostoma subellipticum* (Lindb. ex Kaal.) R. M. Schust.

Kurzia pauciflora (Dicks.) Grolle **DD**.

Kurzia trichoclados (Müll. Frib.) Grolle **VU** [D2].

Lejeunea cavifolia (Ehrh.) Lindb. **LC**.

Lepidozia reptans (L.) Dumort. **LC**.

Leiocolea badensis (Gottsche ex Rabenh.) Jörg. → see under *Mesoptychia badensis* (Gottsche ex Rabenh.) L. Söderstr. et Váňa.

Leiocolea bantriensis (Hook.) Jörg. → see under *Mesoptychia bantriensis* (Hook.) L. Söderstr. et Váňa.

Leiocolea heterocolpos (Thed. ex Hartm.) H. Buch → see under *Mesoptychia heterocolpos* (Thed. ex Hartm.) L. Söderstr. et Váňa.

Liochlaena lanceolata Nees (syn. *Jungermannia leiantha* Grolle) **LC**.

Lophocolea bidentata (L.) Dumort. (incl. *Lophocolea coadunata* (Sw.) Mont.) **LC**².

Lophocolea heterophylla (Schrad.) Dumort. (syn. *Chiloscyphus profundus* (Nees) J. J. Engel et R. M. Schust.) **LC**.

Lophocolea minor Nees (syn. *Chiloscyphus minor* (Nees) J. J. Engel et R. M. Schust.) **LC**.

Lophozia ascendens (Warnst.) R. M. Schust. **LC**.

Lophozia badensis (Gottsche ex Rabenh.) Schiffn. → see under *Mesoptychia badensis* (Gottsche ex Rabenh.) L. Söderstr. et Váňa.

Lophozia bantriensis (Hook.) Steph. → see under *Mesoptychia bantriensis* (Hook.) L. Söderstr. et Váňa.

Lophozia bicrenata (Schmidel ex Hoffm.) Dumort. → see under *Isopaches bicrenatus* (Schmidel ex Hoffm.) H. Buch.

Lophozia collaris (Nees) Dumort. → see under *Mesoptychia collaris* (Nees) L. Söderstr. et Váňa.

Lophozia excisa (Dicks.) Dumort. → see under *Lophozia excisa* (Dicks.) Konstant. et Vilnet.

Lophozia grandiretis (Lindb. ex Kaal.) Schiffn. → see under *Schistochilopsis grandiretis* (Lindb. ex Kaal.) Konstant.

Lophozia guttulata (Lindb. et Arnell) A. Evans (syn. *Lophozia longiflora* auct.) **LC**³.

Lophozia heterocolpos (Thed. ex Hartm.) M. Howe → see under *Mesoptychia heterocolpos* (Thed. ex Hartm.) L. Söderstr. et Váňa.

Lophozia incisa (Schrad.) Dumort. → see under *Schistochilopsis incisa* (Schrad.) Konstant.

Lophozia laxa (Lindb.) Grolle → see under *Heterogemma laxa* (Lindb.) Konstant. et Vilnet.

Lophozia longidens (Lindb.) Macoun → see under *Lophozia longidens* (Lindb.) Konstant. et Vilnet.

Lophozia longiflora auct. → see under *Lophozia guttulata* (Lindb.) A. Evans.

Lophozia obtusa (Lindb.) A. Evans → see under *Obtusifolium obtusum* (Lindb.) S. W. Arnell.

Lophozia opacifolia Culm. ex Meyl. → see under *Schistochilopsis opacifolia* (Culm. ex Meyl.) Konstant.

Lophozia savicziae Schljakov **DD**.

Lophozia silvicola H. Buch **DD**.

Lophozia sudetica (Nees ex Huebener) Grolle → see under *Barbilophozia sudetica* (Nees ex Huebener) L. Söderstr., De Roo et Hedde.

Lophozia ventricosa (Dicks.) Dumort. **LC**.

Lophozia wenzelii (Nees) Steph. **LC**.

Lophozia excisa (Dicks.) Konstant. et Vilnet (syn. *Lophozia excisa* (Dicks.) Dumort.) **LC**.

Lophozia longidens (Lindb.) Konstant. et Vilnet (syn. *Lophozia longidens* (Lindb.) Macoun) **LC**.

Lunularia cruciata (L.) Dumort. ex Lindb. **NA**.

Mannia fragrans (Balbis) Frye et L. Clark **LC**.

Mannia gracilis (F. Weber) D. B. Schill et D. G. Long (syn. *Asterella gracilis* (F. Weber) Underw.) **EN** [B2ab (ii,iii); D]

Mannia pilosa (Hornem.) Frye et L. Clark **VU** [D2].

Mannia triandra (Scop.) Grolle **EN** [B2ab (iii,iv,v); D]

Marchantia polymorpha L.

subsp. *montivagans* Bischl. et Boissel.-Dub. **LC**.

subsp. *polymorpha* **LC**.

subsp. *ruderalis* Bischl. et Boissel.-Dub. **LC**.

Marchantia quadrata Scop. (syn. *Preissia quadrata* (Scop.) Nees) **LC**.

Marchantia romanica (Radian) D. G. Long, Crand.-Stotl., L. L. Forrest et J. C. Villarreal (syn. *Bucegia romanica* Radian) **NT** [B2ab (ii,iii)]

Marsupella adusta (Nees) Spruce → see under *Gymnomitrium adustum* Nees.

Marsupella alpina (Gottsche ex Husn.) Bernet → see under *Gymnomitrium alpinum* (Gottsche ex Husn.) Schiffn.

Marsupella apiculata Schiffn. (syn. *Gymnomitrium apiculatum* (Schiffn.) Müll. Frib.) **CR** [B2ab (iii); D]

Marsupella aquatica (Lindenb.) Schiffn. **DD**.

Marsupella boeckii (Austin) Lindb. ex Kaal. **VU** [D2].

Marsupella brevissima (Dumort.) Grolle → see under *Gymnomitrium brevissimum* (Dumort.) Warnst.

Marsupella commutata (Limpr.) Bernet → see under *Gymnomitrium commutatum* (Limpr.) Schiffn.

Marsupella condensata (Ångstr. ex C. Hartm.) Lindb. ex Kaal. **VU** [D2].

Marsupella emarginata (Ehrh.) Dumort. **LC**.

Marsupella funckii (F. Weber et D. Mohr) Dumort. (syn. *Marsupella ramosa* Müll. Frib.) **LC**.

Marsupella ramosa Müll. Frib. → see under *Marsupella funckii* (F. Weber et D. Mohr) Dumort.

Marsupella revoluta (Nees) Dumort. → see under *Gymnomitrium revolutum* (Nees) H. Philib.

Marsupella sparsifolia (Lindb.) Dumort. **EN** [B2ab (iii); C2a (i)]

Marsupella sphacelata (Gieseke ex Lindenb.) Dumort. **LC**.

Marsupella sprucei (Limpr.) Bernet **NT** [B2ab (iii)]

Mesoptychia badensis (Gottsche ex Rabenh.) L. Söderstr. et Váňa (syn. *Leiocolea badensis* (Gottsche ex Rabenh.) Jørg., *Lophozia badensis* (Gottsche ex Rabenh.) Schiffn.) **LC**.

Mesoptychia bantriensis (Hook.) L. Söderstr. et Váňa (syn. *Leiocolea bantriensis* (Hook.) Jørg., *Lophozia bantriensis* (Hook.) Steph.) **DD**⁴.

Mesoptychia collaris (Nees) L. Söderstr. et Váňa (syn. *Lophozia collaris* (Nees) Dumort.) **LC**³.

Mesoptychia heterocolpos (Thed. ex Hartm.) L. Söderstr. et Váňa (syn. *Leiocolea heterocolpos* (Thed. ex Hartm.) H. Buch, *Lophozia heterocolpos* (Thed. ex Hartm.) M. Howe) **NT** [B2ab (iii,iv)]

Metzgeria conjugata Lindb. **LC**.

Metzgeria fruticulosa auct. non O. F. Müll. (A. Evans) → see under *Metzgeria violacea* (Ach.) Dumort.

Metzgeria furcata (L.) Corda **LC**.

Metzgeria pubescens (Schränk) Raddi (syn. *Apometzgeria pubescens* (Schränk) Kuwah.) **LC**.

Metzgeria violacea (Ach.) Dumort. (syn. *Metzgeria fruticulosa* auct. non O. F. Müll. (A. Evans) **VU** [B1ab (iii) + B2ab (iii)]

Moerckia blyttii (Mørch) Brockm. **VU** [B2ab (iii)]

Moerckia flotoviana (Nees) Schiffn. **DD**⁵.

Moerckia hibernica (Hook.) Gottsche **DD**⁵.

Mylia anomala (Hook.) Gray **LC**.

Mylia taylorii (Hook.) Gray **LC**.

Nardia breidlerii (Limpr.) Lindb. **EN** [B2ab (iii); C2a (i)]

Nardia compressa (Hook.) Gray **CR** [B2ab (iii); C2a (i)]

Nardia geoscyphus (De Not.) Lindb. **LC**.

Nardia insecta Lindb. **DD**.

Nardia scalaris Gray **LC**.

Neoorthocaulis attenuatus (Mart.) L. Söderstr., De Roo et Hedd. (syn. *Barbilophozia attenuata* (Mart.) Loeske, *Orthocaulis attenuatus* (Mart.) A. Evans) **LC**.

Neoorthocaulis binsteadii (Kaal.) L. Söderstr., De Roo et Hedd. (syn. *Barbilophozia binsteadii* (Kaal.) Loeske) **CR** [B2ab (iii,iv); D]

Neoorthocaulis floerkei (F. Weber et D. Mohr) L. Söderstr., De Roo et Hedd. (syn. *Barbilophozia floerkei* (F. Weber et D. Mohr) Loeske, *Orthocaulis floerkei* (F. Weber et D. Mohr) H. Buch) **LC**.

Nowellia curvifolia (Dicks.) Mitt. **LC**.

Obtusifolium obtusum (Lindb.) S. W. Arnell (syn. *Lophozia obtusa* (Lindb.) A. Evans) **LC**.

Odontoschisma elongatum (Lindb.) A. Evans **VU** [B2ab (ii,iii)]

Odontoschisma fluitans (Nees) L. Söderstr. et Váňa (syn. *Cladopodiella fluitans* (Nees) H. Buch) **EN** [B2ab (iii); C2a (i)]

Odontoschisma francisci (Hook.) L. Söderstr. et Váňa (syn. *Cladopodiella francisci* (Hook.) Jørg.) **EN** [B2ab (iii,iv); D]

Odontoschisma sphagni (Dicks.) Dumort. **DD**.

Orthocaulis atlanticus (Kaal.) H. Buch (syn. *Barbilophozia atlantica* (Kaal.) Müll. Frib.) **EN** [B2ab (iii,iv); C2a (i)]

Orthocaulis attenuatus (Mart.) A. Evans → see under *Neoorthocaulis attenuatus* (Mart.) L. Söderstr., De Roo et Hedd.

Orthocaulis floerkei (F. Weber et D. Mohr) H. Buch → see under *Neoorthocaulis floerkei* (F. Weber et D. Mohr) L. Söderstr., De Roo et Hedd.

Orthocaulis kunzeanus (Huebener) H. Buch → see under *Schljakovia kunzeana* (Huebener) Konstant. et Vilnet.

Oxymitra incrassata (Brot.) Sérgio et Sim-Sim (syn. *Oxymitra paleacea* Bisch.) **DD**.

Oxymitra paleacea Bisch. → see under *Oxymitra incrassata* (Brot.) Sérgio et Sim-Sim.

Pallavicinia tyellii (Hook.) Gray **RE**.

Pedinophyllum interruptum (Nees) Kaal. **LC**.

Pellia endiviifolia (Dicks.) Dumort. → see under *Apopellia endiviifolia* (Dicks.) Nebel et D. Quandt.

Pellia epiphylla (L.) Corda **LC**.

Pellia neesiana (Gottsche) Limpr. **LC**.

Peltolepis quadrata (Saut.) Müll. Frib. **VU** [D2].

Plagiochila asplenioides (L.) Dumort. **LC**.

Plagiochila porelloides (Torr. ex Nees) Lindenb. **LC**.

Pleurocladula albescens (Hook.) Grolle → see under *Fuscocephaloziopsis albescens* (Hook.) Váňa et L. Söderstr.

Pleurocladula islandica (Nees) Grolle → see under *Fuscocephaloziopsis albescens* (Hook.) Váňa et L. Söderstr.

Porella arboris-vitae (With.) Grolle **LC**.

Porella cordaeana (Huebener) Moore **LC**.

Porella platyphylla (L.) Pfeiff. **LC**.

Preissia quadrata (Scop.) Nees → see under *Marchantia quadrata* Scop.

- Ptilidium ciliare* (L.) Hampe **LC**.
Ptilidium pulcherrimum (Weber) Vain. **LC**.
Radula complanata (L.) Dumort **LC**.
Radula lindenberghiana Gottsche ex C. Hartm **LC**.
Reboulia hemisphaerica (L.) Raddi **LC**.
Riccardia chamedryfolia (With.) Grolle **DD**.
Riccardia incurvata Lindb. **CR** [B2ab (ii,iii,iv); C2a (i); D]
Riccardia latifrons (Lindb.) Lindb. **LC**.
Riccardia multifida (L.) Gray **LC**.
Riccardia palmata (Hedw.) Carruth. **LC**.
Riccia bifurca Hoffm. **NT** [B2ab(iii)]
Riccia canaliculata Hoffm. **RE**.
Riccia canescens Steph. → see under *Riccia ciliata* Hoffm.
Riccia cavernosa Hoffm. **LC**.
Riccia ciliata Hoffm. (syn. *R. crinita* Taylor, *R. canescens* Steph., *R. trichocarpa* M. Howe) **NT** [B2ab (iii)]
Riccia ciliifera Link ex Lindenb. **LC**.
Riccia crinita Taylor → see under *Riccia ciliata* Hoffm.
Riccia fluitans L. **LC**.
Riccia glauca L. **LC**.
Riccia gougetiana Durieu et Mont. **EN** [B2ab (ii,iii); D]
Riccia papillosa Moris (syn. *Riccia pseudopapillosa* Levier) **EN** [B2ab (ii,iii)]
Riccia pseudopapillosa Levier → see under *Riccia papillosa* Moris.
Riccia rhenana Lorb. ex Müll. Frib. **VU** [B2ab (iii)]
Riccia sorocarpa Bisch. **LC**.
Riccia subbifurca Warnst. ex Croz. **DD**.
Riccia trichocarpa M. Howe → see under *Riccia ciliata* Hoffm.
Ricciocarpos natans (L.) Corda **NT** [B2ab(iii)]
Saccobasis polita (Nees) H. Buch (syn. *Tritomaria polita* (Nees) Jørg.) **VU** [D2].
Sauteria alpina (Nees) Nees **LC**.
Scapania aequiloba (Schwägr.) Dumort. **LC**.
Scapania apiculata Spruce **LC**.
Scapania aspera M. Bernet et Bernet **LC**.
Scapania brevicaulis auct. eur. non Taylor → see under *Scapania degenii* Schiffn. ex Müll. Frib.
Scapania calcicola (Arnell et J. Perss.) Ingham **LC**.
Scapania carinthiaca J. B. Jack ex Lindb. var. *massalongi* Müll. Frib. (syn. *Scapania massalongi* (Müll. Frib.) Müll. Frib.) **RE**.
Scapania compacta (Roth) Dumort. **DD**.
Scapania crassiretis Bryhn **VU** [D2].
Scapania curta (Mart.) Dumort. **LC**.
Scapania cuspiduligera (Nees) Müll. Frib. **LC**.
Scapania degenii Schiffn. ex Müll. Frib. (*Scapania brevicaulis* auct. eur. non Taylor) **VU** [D2].
Scapania gymnostomophila Kaal. **NT** [B2ab (iii)]
Scapania helvetica Gottsche **LC**.

Scapania massalongi (Müll. Frib.) Müll. Frib. → see under *Scapania carinthiaca* J. B. Jack ex Lindb. var. *massalongi* Müll. Frib.

- Scapania irrigua* (Nees) Nees **LC**.
Scapania mucronata H. Buch **LC**.
Scapania nemorea (L.) Grolle **LC**.
Scapania paludicola Loeske et Müll. Frib. **DD**.
Scapania paludosa (Müll. Frib.) Müll. Frib. **EN** [B2ab (iii)]
Scapania parvifolia Warnst. **VU** [B2ab (ii,iii)]
Scapania praetervisa Meyl. **EN** [B2ab (iii); C2a (i)]
Scapania scandica (Arnell et H. Buch) Macvicar **LC**.
Scapania subalpina (Nees ex Lindenb.) Dumort. **LC**.
Scapania uliginosa (Lindenb.) Dumort. **LC**.
Scapania umbrosa (Schrad.) Dumort. **LC**.
Scapania undulata (L.) Dumort. **LC**.
Schistochilopsis grandiretis (Lindb. ex Kaal.) Konstant. (syn. *Lophozia grandiretis* (Lindb. ex Kaal.) Schiffn.) **CR** [B2ab (iii); D]
Schistochilopsis incisa (Schrad.) Konstant. (syn. *Lophozia incisa* (Schrad.) Dumort.) **LC**.
Schistochilopsis opacifolia (Culm. ex Meyl.) Konstant. (syn. *Lophozia opacifolia* Culm. ex Meyl.) **VU** [D2].
Schljakovia kunzeana (Huebener) Konstant. et Vilnet (syn. *Barbilophozia kunzeana* (Huebener) Müll. Frib., *Orthocaulis kunzeanus* (Huebener) H. Buch) **VU** [B2ab (iii)]
Schljakovianthus quadrilobus (Lindb.) Konstant. et Vilnet (syn. *Barbilophozia quadriloba* (Lindb.) Loeske) **VU** [B2ab (iii)]
Solenostoma confertissimum (Nees) Schljakov (syn. *Jungermannia confertissima* Nees) **NT** [B2ab (iii)]
Solenostoma gracillimum (Sm.) R. M. Schust. (syn. *Jungermannia gracillima* Sm.) **LC**.
Solenostoma hyalinum (Lydell) Mitt. (syn. *Jungermannia hyalina* Lyell) **LC**.
Solenostoma obovatum (Nees) C. Massal. (syn. *Jungermannia obovata* Nees) **LC**⁶.
Solenostoma sphaerocarpum (Hook.) Steph. (syn. *Jungermannia sphaerocarpa* Hook.) **LC**.
Solenostoma subellipticum (Lindb. ex Kaal.) R. M. Schust. (syn. *Jungermannia subelliptica* (Lindb. ex Kaal.) Levier) **VU** [D2]⁶.
Sphenolobus hellerianus (Nees ex Lindenb.) Steph. → see under *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl.
Sphenolobus minutus (Schreb. ex D. Crantz) Berggr. (syn. *Anastrophyllum minutum* (Schreb. ex D. Crantz) R. M. Schust.) **LC**.
Sphenolobus saxicola (Schrad.) Steph. (syn. *Anastrophyllum saxicola* (Schrad.) R. M. Schust.) **CR** [B2ab (iii,iv), D]
Szygiella autumnalis (DC.) K. Feldberg, Váňa, Hentschel et Heinrichs (syn. *Jamesoniella autumnalis* (DC.) Steph.) **NT** [B2ab (iii,iv)]

Tetralophozia setiformis (Ehrh.) Schljakov (syn. *Chandonanthus setiformis* (Ehrh.) Lindb.) NT [B2ab (iii,iv)]

Trichocolea tomentella (Ehrh.) Dumort. LC.

Trilophozia quinquedentata (Huds.) Bakalin (syn. *Tritomaria quinquedentata* (Huds.) H. Buch) LC.

Tritomaria exsecta (Schmidel) Schiffn. ex Loeske LC.

Tritomaria exsectiformis (Breidl.) Schiffn. ex Loeske NT [B2ab (iii)]

Tritomaria laxa (Lindb.) Stotler et Crand.-Stotl. → see under *Heterogemma laxa* (Lindb.) Konstant. et Vilnet.

Tritomaria polita (Nees) Jørg. → see under *Saccobasis polita* (Nees) H. Buch.

Tritomaria quinquedentata (Huds.) H. Buch → see under *Trilophozia quinquedentata* (Huds.) Bakalin.

Tritomaria scitula (Taylor) Jørg. DD.

Annotations

¹*Aneura maxima*.

Only one record of this species is known from Slovakia by now (Loskotová 2006). It is highly probable it grows on several localities where it is not distinguished from *Aneura pinguis*. According to Hodgetts et al. (2020) the species is at present lacking a valid name, *Aneura maxima* is a SE Asian taxon which is not conspecific with the European taxon.

²*Lophocolea bidentata* (incl. *Lophocolea coadunata*).

Hodgetts et al. (2020) report *Lophocolea bidentata* (L.) Dumort. (autoicous) and *L. coadunata* (Sw.) Mont. (dioicous) as separate species. As these two species were not distinguished in Slovakia in the past (herbarium documents of literary data are often missing or herbarium items are sterile), we do not treat them separately. *Lophocolea bidentata* probably prefers more acidic and nutrient-poor habitats, while *L. coadunata* often grows in human-influenced habitats (lawns, gardens, parks) (Köckinger 2017).

³*Lophozia guttulata*, *Lophozia longiflora*.

As mentioned by Hodgetts et al. (2020), *Lophozia guttulata* was included in *Lophozia longiflora*, until Bakalin (2016) lectotypified *L. longiflora*. Available herbarium and literary records from Slovakia concern only the species *L. guttulata*, however, *L. longiflora* could probably also occur in our territory. Köckinger (2017) and Hodgetts et al. (2020) report this species as typical for acidic, peaty soil and rocks, while *L. guttulata* grows mostly on dead wood in moist habitats. The main morphological differences between *L. longiflora* and *L. guttulata* are in perianth armature, leaves length and width ratio and leaf shape (Bakalin 2016).

⁴*Mesoptychia bantriensis*, *Mesoptychia collaris*.

Górski and Váňa (2014) accepted broad taxonomical concept of the species *Mesoptychia bantriensis* (Hook.) L. Söderstr. et Váňa (incl. *Mesoptychia collaris* (Nees) L. Söderstr. et Váňa). Based on works by Köckinger (2017), Klama and Górski (2018) and Hodgetts et al. (2020) we present both species separately. *M. collaris* grows mainly on alkaline rocks and it is relatively widespread on limestones of

Slovak mountains. *M. bantriensis* occurs in wet habitats, springs, wetlands and also on wet rocks, e.g. at stream banks, similar to *M. collaris*. As not all herbarium items have been revised and some of them are unavailable for several literature data, real distribution and endangerment of *M. bantriensis* need to be updated.

⁵*Moerckia flotoviana*, *Moerckia hibernica*.

Moerckia flotoviana (Nees) Schiffn. was synonymised with *Moerckia hibernica* (Hook.) Gottsche, both taxa were correctly separated by Crandall-Stotler and Stotler (2007). Most reports of *M. hibernica* from Slovakia belong to *M. flotoviana*. Species *M. flotoviana* grows scatteredly mainly in limestone areas of Slovakia, the distribution of *M. hibernica* is insufficiently known as not all herbarium specimens have been revised. Until the revision is not completely performed, we listed both species in the Data Deficient category.

⁶*Solenostoma obovatum*, *Solenostoma subellipticum*.

Shaw et al. (2015) assigned species *S. subellipticum* (Lindb. ex Kaal.) R. M. Schust to species *Solenostoma obovatum* (Nees) C. Massal. Based on the work Hodgetts et al. (2020) and the known distribution in Slovakia (e.g. Duda and Váňa 1970, 1971; Górski and Váňa 2014) both are listed as separate species.

Discussion

Checklist

The presented checklist and red list include 231 species of liverworts (Marchantiophyta) with three additional subspecies and one variety, and two hornwort species (Anthocerotophyta). The previous checklist of Slovak bryophytes (Kubinská et al. 2001b) contained 221 liverworts and 2 hornworts (Table 2). In comparison with the previous checklist, 11 taxa are reported here as newly accepted (*Marsupella aquatica*, *Moerckia flotoviana*), newly reported (*Fuscocephaloziopsis affinis* (Váňa 2016), *Lophozia silvicola* (Górski and Váňa 2014) or new to Slovakia: *Aneura maxima* (Loskotová 2006), *Cephaloziella stellulifera* (Duda and Duda 2003), *Conocephalum salebrosum* (Górski and Váňa 2014), *Gymnomitrium adustum* (Górski and Váňa 2011), *Lophozia savicziae* (Górski and Váňa 2014), *Nardia compressa* (Górski 2010), *Neoorthocaulis binsteadii* (Górski 2012). Overall, the number of liverworts has increased by ten species since 2001 due to new findings, taxonomic and nomenclatural changes.

In Slovakia, only two hornwort species are recorded – *Anthoceros agrestis* and *Phaeoceros carolinianus*. Other taxa of the division Anthocerotophyta were found in the surrounding countries – *Anthoceros neesii* (Kučera et al. 2012; Köckinger 2017; Klama and Górski 2018), *A. punctatus* (Boiko 2014), *Notothylas orbicularis* (Kučera et al. 2012; Köckinger 2017) and *Phaeoceros laevis* (Boiko 2014;

Table 2 Comparison of the numbers and percentages of liverworts and hornworts in each category between the current and the previous version of the Red List

Category	RE*	CR	EN	VU	NT**	DD	LC	NA	Total
Marchantiophyta									
This work	7 (3.0%)	10 (4.3%)	18 (7.8%)	25 (10.8%)	17 (7.3%)	27 (11.6%)	128 (55.4%)	1 (0.4%)	231
Kubinská et al. (2001a)	9 (4.1%)	24 (10.9%)	34 (15.4%)	24 (10.9%)	18 (8.1%)	10 (4.5%)	102 (46.2%)	0 (0.0%)	221
Anthocerotophyta									
This work	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	2
Kubinská et al. (2001a)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2

Abbreviations: *old category EX, **old category LR:nt

Klama and Górski 2018). Some of these species could possibly be found within the territory of Slovakia.

Redlist

Overall, 231 liverwort species and two hornworts were evaluated (Table 2). A total of 128 species (55.4% of the liverwort flora of Slovakia) were assessed as LC, while 10 species (4.3%) were categorized as CR, 18 (7.8%) as EN and 25 (10.8%) as VU, which represent 22.9% of the flora. A total of 17 species (7.4%) were categorized as NT and 27 species (11.6%) are data deficient (DD). Only for the liverwort *Lunularia cruciata* the criteria were not applicable since this species is not native to Slovakia. Seven species (3.0%) were considered as RE. Out of the two hornwort species, *Phaeoceros carolinianus* was included in the category NT, while *Anthoceros agrestis* is considered as LC.

There are seven liverworts listed in the category **Regionally Extinct**. Most species were found in the Tatra Mts (*Biantheridion undulifolium*, *Gymnomitrium obtusum*, *G. revolutum*, *Haplomitrium hookeri* and *Scapania carinthiaca* var. *massalongi*) (Górski and Váňa 2014), of which the liverwort *Biantheridion undulifolium* is also missing in the Czech Republic (Kučera et al. 2012), Austria (Köckinger 2017) and Poland (Klama and Górski 2018). Species *Pallavicinia lyellii* used to grow in the Záhorská nížina lowland (Janovicová and Kubinská 2002) and *Riccia canaliculata* in the Podunajská nížina lowland (Duda and Váňa 1968).

The category **Critically Endangered** includes mainly liverworts growing only in the Tatra Mts in Slovakia (*Anastrophium donnianum*, *Marsupella apiculata*, *Nardia compressa*, *Neoorthocaulis binsteadii* and *Sphenobolus saxicola*) (Górski and Váňa 2014). Species *Cephaloziella stellulifera* was reported from the Malá Fatra Mts (Duda and Duda 2003), *Fuscocephaloziopsis affinis* from the Muránska

planina plateau (Váňa 2016) and *Schistochilopsis grandiretis* from the Ľubovnianska vrchovina Mts (Duda 1986). *Fossombronia foveolata* and *Riccardia incurvata* were found on a single locality in the Záhorská nížina lowland (Janovicová and Kubinská 2002).

Endangered category includes 18 liverwort species, mainly growing in alpine and mountain habitats (e.g. *Cephaloziella varians*, *Frullania jackii*, *Jungermannia eucordifolia*, *Marsupella sparsifolia*). Peat liverworts (e.g. *Cephaloziella elachista*, *Odontoschisma francisci*, *O. fluitans*) and species of xerothermic habitats (*Asterella saccata*, *Riccia gougetiana*, *R. papillosa*) also belong to this category.

Vulnerable category includes several naturally rare liverworts, mainly growing in alpine and subalpine habitat of the Tatra Mts (e.g. *Asterella lindenberghiana*, *Eremonotus myriocarpus*, *Mannia pilosa*, *Schistochilopsis opacifolia*) and hygrophilous species of wetlands and peatlands (e.g. *Harpanthus flotovianus*, *Odontoschisma elongatum*, *Schizakovia kunzeana*).

A relatively large group is represented by species of the **Data Deficient** category (27 species), which reflected the insufficiently known distribution and endangerment of liverworts, but also taxonomic changes in the status of some species (e.g. *Moerckia hibernica*, *Mesoptychia bantriensis*, *Lophozia silvicola*).

In Europe, there are currently 461 liverwort and eight hornwort species, of which 22.5% and 25%, respectively, are evaluated as threatened (Hodgetts et al. 2019). Among the species occurring in Slovakia, *Cephaloziella lacinulata* is categorized as CR, *Asterella saccata*, *Biantheridion undulifolium*, *Cephaloziella massalongi*, *Scapania carinthiaca* var. *massalongi* as EN and *Cephaloziella elachista*, *Frullania jackii*, *Gymnomitrium alpinum*, *Heterogemma laxa*, *Lophozia savicziae*, *Mannia fragrans*, *M. triandra*, *Marchantia romanica*, *Marsupella condensata*, *Moerckia blyttii*, *M. hibernica*, *Pallavicinia lyellii* and *Scapania*

brevicaulis as VU in the European Red List of mosses, liverworts and hornworts (Hodgetts et al. 2019).

Anthropogenic changes in natural conditions and degradation of the ecosystems (e.g. groundwater decline, waterflow regulation, vascular plant succession, vanishing of wetlands and peatlands) cause decrease in populations of many liverwort and hornwort species or their complete retreat from natural habitats of Central Europe (Staniaszek-Kik and Woziwoda 2011; Dittrich et al. 2016). Factors that lead to these changes are mainly caused by agriculture, forestry, aquaculture, industry and traffic pollution, tourism, and residential development. Climatic changes in recent decades, especially long-term drought and heat, can reduce the population of several hygrophilous species.

In Central European conditions, hornworts as ephemeral plants grow in summer and autumn on bare soil, especially in fields and fallows. Climate changes with hot, dry summers and small amount of autumn rainfalls caused scarcely any records in recent years. However, long-term changes in distribution and chorology of hornworts cannot be evaluated yet, as their spores can survive in the latent state in the soil for long periods (Bisang 1996).

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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