Теоретичні та прикладні питання

The state and prospects of preservation of some rare and relic species *Lycopodiophyta* at southern megaslope of the Ukrainian Carpathians (Transcarpathia)

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The results of researches are represented for three species of divisio *Lycopodiophyta (Diphasiastrum issleri* (Rouy) Holub, *Lycopodiella inundata* (L.) Holub), *Selaginella helvetica* (L.) Spring, which are rare in Ukrainian Carpathians. Detailed description is provided for the habitats and plant communities, where these species occur; the number of individuals in the populations is detected. Their sozological status is defined with the forecast of populations' development for the nearest years.

Keywords: Ukrainian Carpathians, Transcarpathia, Diphasiastrum issleri, Lycopodiella inundata, Selaginella helvetica, habitat, areal dynamics, community characteristic, sozological state

ФЕЛЬБАБА-КЛУШИНА Л.М., ВОТКАЛЬЧУК К.А. (2015). **Стан та перспективи збереження деяких рідкісних реліктових видів *Lycopodiophyta* на південному мегасхилі Українських Карпат (Закарпаття).** *Чорноморськ. бот. ж.,* **11** (2): 138-145. doi:10.14255/2308-9628/15.112/1.

Представлені результати досліджень трьох видів відділу *Lycopodiophyta (Diphasiastrum issleri* (Rouy) Holub, *Lycopodiella inundata* (L.) Holub), *Selaginella helvetica* (L.) Spring, які є рідкісними в Українських Карпатах. Наведені детальні описи місцезростань та угруповань, у яких ці види трапляються, а також вивчена чисельність особин у популяціях. Визначено їх созологічний статус та зроблено прогноз розвитку популяцій у найближчі роки .

Ключові слова: Українські Карпати, Закарпаття, Diphasiastrum issleri, Lycopodiella inundata, Selaginella helvetica, місцезростання, динаміка ареалу, характеристика угруповання, созологічний статус

ФЕЛЬБАБА-КЛУШИНА Л.М., ВОТКАЛЬЧУК К.А. (2015). **Состояние и перспектива охраны некоторых редких реликтовых видов *Lycopodiophyta* на южном мегасклоне Украинских Карпат (Закарпатье).** *Черноморск. бот. ж.*, **11** (2): 138-145. doi:10.14255/2308-9628/15.112/1.

Представлены результаты исследований трех видов отдела *Lycopodiophyta* (*Diphasiastrum issleri* (Rouy) Holub, *Lycopodiella inundata* (L.) Holub), *Selaginella helvetica* (L.) Spring, которые являются редкими в Украинских Карпатах. Приведенные подробные описания местопроизростаний и сообществ, в которых эти виды встречаются, а также изучена численность особей в популяциях. Определен их созологичний статус и сделан прогноз развития популяций в ближайшие годы.

Ключевые слова: Украинские Карпаты, Закарпатье, Diphasiastrum issleri, Lycopodiella inundata, Selaginella helvetica, местопроизростания, динамика ареала, характеристика сообщества, созологический статус

There are 12 species of divisio *Lycopodiophyta* [MOSYAKIN, FEDORONCHUK, 1999; EKOFLORA…, 2000] in Ukrainian flora. 9 species occur in Ukrainian Carpathians as well as on their southern megaslope, i.e. on Transcarpathian territory: *Diphasiastrum alpinum* (L.) Holub,. *Diphasiastrum complanatum* (L.), *Diphasiastrum issleri* (Rouy) Holub*, Lycopodiella inundata (L.) Holub, Lycopodium annotinum* L*., Huperzia selago* (L.) Bernh. ex Schrank et Mart., *Selaginella helvetica* (L.) Spring, *Selaginella selaginoides* (L.), P. Beauv.ex Mart. et Schrank, *Lycopodium clavatum* L. [FODOR, 1974; VYZNACHNYK…, 1977; OPREDELITEL…, 1999]. All these species, except *Lycopodium clavatum*, are included into the Red Book of Ukraine (2009). Our publication is dedicated to three rare species the growth of which had not been proved by herbarium specimens over 30 years (*Diphasiastrum issleri, Lycopodiella inundata*) and one species was supposed to be extinct (*Selaginella helvetica*). We succeed to prove the habitat of all these three species and start monitoring researches of their populations' development.

Materials and Methods

The researches had been held during 2006–2014 on the southern megaslope of Ukrainian Carpathians.

In order to clarify the expansion of researched species in Ukrainian Carpathians we worked up the herbarium collections from M.G. Kholodny Institute of Botany of NASU (KW), Institute of Ecology of the Carpathians (LWKS), Uzhgorod National University (UU), Y. Fedkovych Chernivtsi National University (CHER).

The names of the plants are cited S.L. Mosyakin, M.M. Fedoronchuk [MOSYAKIN, FEDORONCHUK, 1999]. Geobotanical descriptions were done using classic methodic with the usage of the scale of projective covering J. Brown-Blanke.

The results and their discussioins

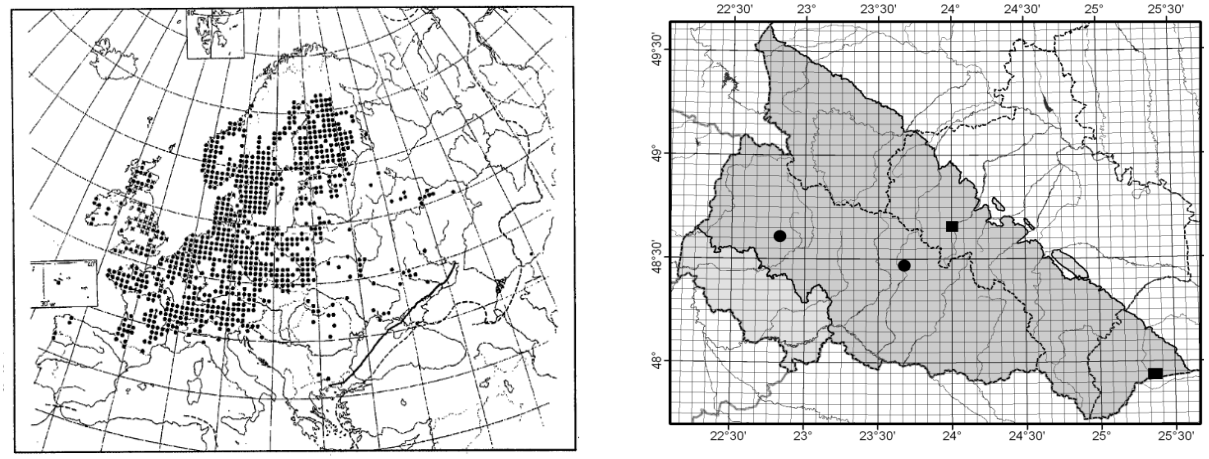
Lycopodiella inundata is holarctic circumpolar species and its areal embraces South America, Middle and Atlantic Europe, Scandinavian countries, Far East, Western and Eastern Siberia, the Caucasus [MEUSEL, JÄGER, WEINERT, 1965]. It is well-known in all Carpathian regions except Hungary [TASENKEVICH, 1998]. Inside its areal the species grows on the peat marshes, marshy meadows and wet sands. In Carpathians it grows mainly on the peat marshes in plant communities of classes *Scheuchzerio-Caricetea nigrae (Nordh. 1937)* R. Tx. 1937 of union *Rhynchosporion albae* Koch 1926 [COLDEA, 1997; HAJEK, HABEROVA, 2001].

Lycopodiella inundata is one of the rarest species of marshes flora in Ukrainian Carpathians which is included to the Red List of Ukraine under the category of rare [CHERVONA…, 2009], to the Red List of Transcarpathian region as extinct [KRICHFALUSHIJ, BUDNIKOV, MYHAL, 1999] and to the Carpathian List of Endangered Species as endangered [TASENKEVICH, 2003].

According to the herbarium data the species had been found in four floristic regions of Ukrainian Carpathians: in the Vyhorlat-Hutyn mountain range and in the Horhans (Southern megaslopes of Ukrainian Carpathians, Transcarpathian region) as well as in the Chyvchyn-Grynyava Mountains (Chernivtsi region) and in Precarpathians (Ivano-Frankivsk region), which is situated on the North-Eastern megaslopes of Ukrainian Carpathians (fig. 1).

The species is well-known by location on the Vyhorlat-Hutyn mountain range from the lake Synye (Mukachiv distr., environs of Synyak village), with the area of 3,0 ha. It has nature protection status hydrological natural memorial from 1984 [PRYRODJ-ZAPOVIDNYI…, 2011]. The data about the species growth on this territory is represented by Popovych S.Y. and Andriyenko T.L. [POPOVYCH, ANDRIENKO, 1998], which is proved by herbarium sample (Popovych, 25.05.1980 KW). During further years the growth of this species on this territory had not been proved [MYHAL, 2006]. It was resulted in missing data about the state of the population during last 30 years. In summer 2012 we proved again the habitat of the species on

this territory (N 48°36'37,58" E 22°52'02,78"). The species grows near the mountain lake surrounded by beech-hornbeam forests on the height of 650 m a.s.l. The lake is on its final stage of growth and active forming of marshes phytocoenosis that is why a water surface is represented only by separate small water reservoirs with the area up to 2 m^2 and depth up to 30–40 sm. *Lycopodiella inundata* grows in the first layer of community with projective covering 1–2 % among mosses with the domination of *Sphagnum capillifolium* (Ehrh.) Hedw. (30 %). Less projective covering have *Aulacomnium palustre* (Hedw.) Schwägr. (10 %), *Polytrichum strictum* Brid. (7–10 %), *Sphagnum palustre* L. (5 %), *Sphagnum magellanicum* Brid. (5 %), *Calliergon stramineum* (Brid.) Kindb(5 %), *Bryum pseudotriqueter* (Hedw.) G. Gaertn (4 %). The second layer is sparse and it is represented mainly by *Carex echinata* Murr. (3 %), *Drosera rotundifolia* L. (1–2 %), *Carex nigra* (+), *Trientalis europaea* L. (+). The third layer is also sparse, not closed, with such representatives as *Rubus caesius* L.(1–3 %), *Solanum dulcamara* L. (1 %), *Doronicum austriacum* Jacq. (+), *Gentiana asclepiadea* L. (+). The highest fourth layer is formed by *Phragmites australis* (Cav.) Trin. ex Steud. (7–10 %) and separate individuals of *Betula pendula* Roth, *Frangula alnus* Mill., *Picea abies* (L.) Karst., *Populus tremula* L. Population *Lycopodiella inundata* is scanty, it is compounded by 21 individuals and it is in danger of extinction because the lake's overgrowing with weeds becomes more active during last year's due to increased drought duration resulted by climate warming and breakdown of hydrological regime in the basin of Tysa River.



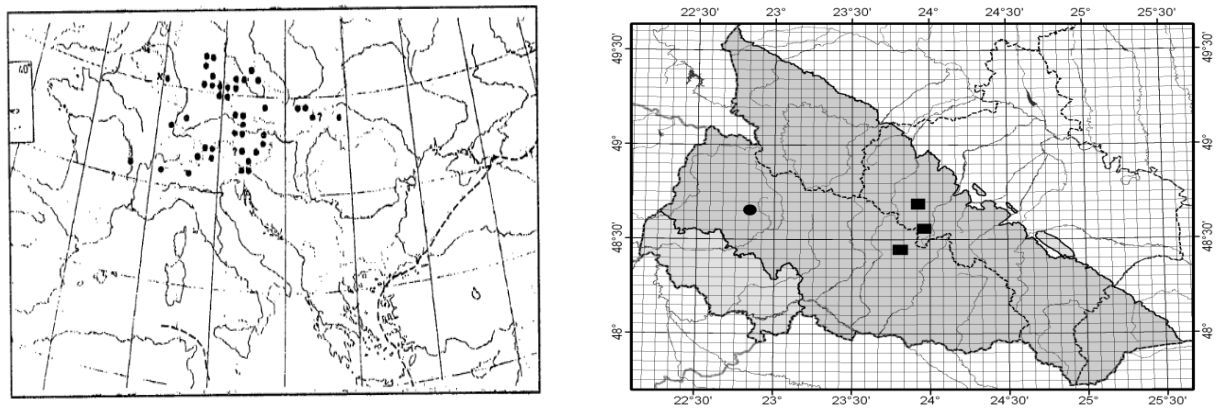
A B

Fig. 1. Areal *Lycopodiella inundata* in Europe (A) (ATLAS…, 1972 [14]) and location in Ukrainian Carpathians (B): ■ – based on herbarium samples and literature data, ● – herbarium samples and literature data are proved by own collections.

The species is well-known in the Horhans. It grows in oligotrophic marshes Glukhanya situated on the height of 650 m a.s.l with the area 24 ha (Myzhyrsky distr., environs of Nehrovec village). The territory is the part of National Nature Park «Synevyr» from 1999 [PRYRODJ-ZAPOVIDNYI…, 2011]. Herbarium specimens were gathered by different collectors in 1963-1979 pp. (UU, KW). *Lycopodiella inundata* was detected by us in this location in 2009 in small water hollows surrounded by sphagnum mosses (*Sphagnum capillifolium* (25 %), *S. magellanicum* (3 %), *S. papillosum* (+), *Polytrichum strictum* (5 %) and *Rynchospora alba* (10 %), *Carex limosa* (2 %). The geographical coordinates – N 48°28'45,04" E 23°38'10,57". The data of previous researchers inform that in 60-th years of 20th century the species was one of the dominants on this marsh in community *Rhynchospora alba – Lycopodiella inundata,*which was also formed in water hollows [BRADIS, ANDRIENKO, LYHOBABINA, 1969]. Separate individuals *Lycopodiella inundata* sometimes occur even now on the whole area of the marsh which is also dries up with increasing of projective cover *Molinia caerulea* [FELBABA-KLUSHINA, 2010].

So, the transformation of oligotrophic and mesotrophic mosses, where *Lycopodiella inundata* is located, into peat meadows and shrubby groups results into extinction of the species from the researched territory. That's why the species should be considered as extincting in Transcarpathian territory.

Diphasiastrum issleri (Rouy) Holub is rare European species (*D. alpinum* × *D. tristachyum*) [CHERVONA…, 2009], which occurs in Central Europe, south of Northern Europe (fig. 2) [MEUSEL, JÄGER, WEINERT, 1965].



A B

Fig. 2. Areal *Diphasiastrum issleri* in Europe (A) [ILLUSTRIRTE…, 1984] and location in Ukrainian Carpathians (B): ■ – based on herbarium specimens and literature data; ● – a new habitat of the species.

The species is spread in three locations in the Horhans. So, A. Pacyna informed about the location of this species on the mount Yayko Ilemske (Ivano-Frankivsk region) and mount Popadya (Transcarpathian region) [PACYNA, 1972]. There are data about herbarium specimens from mount Strymba in the researches of V.V. Protopopova. The specimens had been gathered by F. Hryn' in 1948 (herbarium of AS USSR) and they are the intermediate form between *D. alpinum* and *D. issleri* [PROTOPOPOVA, 1974].

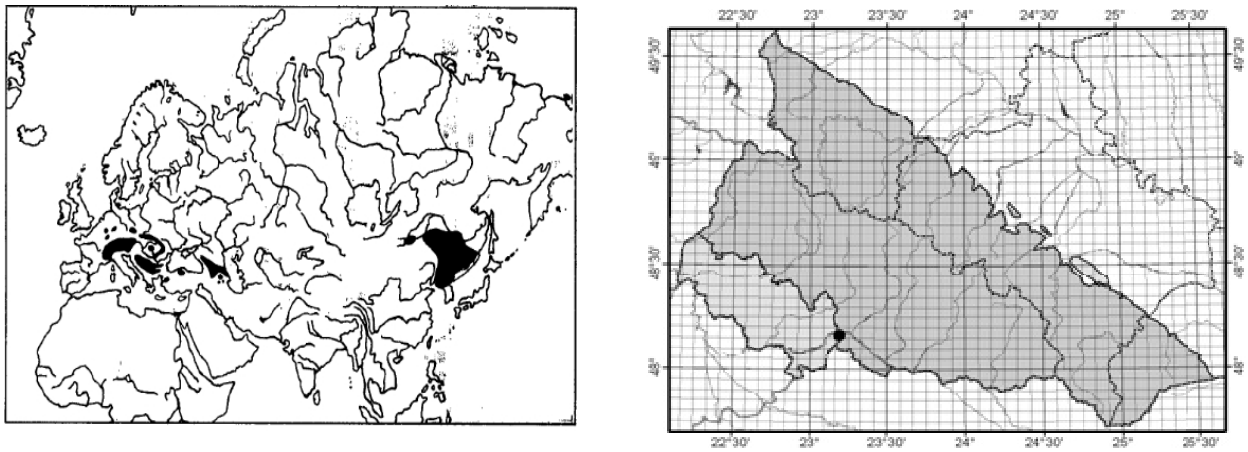
In 2012 we detected *Diphasiastrum issleri* on the slopes of mount Dunauka environs of Olenevo village, Svalyavskyy district (the Vyhorlat-Hutyn mountain range) on the hight of 680 m a.s.l. (N 48°39'07,07" E 22°52'03,25"). The species grows in the plantation of *Sorbus domestica* L. (60 %), *Betula pendula* Roth (20 %) and *Acer platanoides* L. (+). The crown closure is around 70 %. The population *Diphasiastrum issleri* has 4 individuals growing on the area of 300 m^2 together with *Rubus caesius* L.(15 %), *Senecio fuchsia* C.C. (+), *Majanthemum bifolium* (L.) F.W.Schmidt (+), *Gymnocarpium dryopteris* (L.) Newm. (2–3 %), *Huperzia selago* (L.) Bernh. ex Schrank & C.Mart. (5 %), *Lycopodium annotinum* L. (5 %), *Polygonatum odoratum* (Mill.) Druce (1 %), *P. verticillatum* (L.) All. (1 %), *Oxalis acetosella* L. (+), *Gentiana asclepiadea* L. (3 %), *Dryopteris carthusiana* (Vill.) H.P.Fuchs (10 %).

The population is not endangered and we consider it as rare due to its infrequency.

Selaginella helvetica – is characterized by disjunctive areal that embraces Central and North-Eastern Europe, Asia Minor, the Caucasus, Eastern Siberia, the Far East [MEUSEL, JÄGER, WEINERT, 1965; FLORA…, 1974]. In Carpathians *Selaginella helvetica* occurs on the territory of Slovakia, Ukraine and Romania [TASENKEVICH, 1998]. The Vyhorlat-Hutyn mountain range (Volcanic Carpathians) is the only reliable habitat of the species in Ukraine. Here the species was found in the environs of Veryatsya village of Vynogradivskyy district and it is proved by number of herbarium specimens gathered by different collectors (fig. 3) [CHERVONA…, 2009]. In 1931 the species was detected and gathered by I. Bucek in Verytsya village on the height of 350 m a.s.l. [DOMIN, 1931]. A. Margitay informs about the collected

specimens of *Selaginella helvetica* on this territory [MARGITTAI, 1938]. K.N. Ihoshyna [IHOSHYNA, 1955] provides the data about the growth of the species near the foot of the mountain ridge on the height of 170 m. There are no specimens of this species in the worked up herbarium collections of Ukraine (KW, LWKS, UU).

There are data about the growth of the species in Uzhgorod, v. Korolevo, on Chorna Hora as well as on the mountain ridge Svydovets [OPREDELITEL…, 1999; FODOR, 1974; FLORA…, 1974]. It is clear that such kind of information about species habitat require firm proof but we failed to find this species across mentioned settlements due to inaccurate literature data.



A B

Fig. 3. Areal *Selaginella helvetica* in Eurasia (A) [MEUSEL, JÄGER, WEINERT, 1965] **and location in Ukrainian Carpathians (B): ● – herbarium specimens and literature data proved by own collections.**

There were no herbarium proofs of *Selaginella helvetica* habitat more than 50 years and its presence in the flora of Ukraine and Ukrainian Carpathians was doubtful.

As was already mentioned, *Selaginella helvetica* is usually spread out over the mountain regions. In neighbour Slovakia the species occurs on the height diapason of 130–180 m a.s.l. in wet grass thickets, on shaded rocks but near Bratislava it grows on meadows, pastures, in gardens and forests with the plantations of *Robinia pseudoacacia* L. [FLÓRA…, 1966]. In Romania the species occurs on the mountain rocks in subalpine and alpine climatic zone [FLORA..., 1952] the same as in the Caucasus [HROSSHEJM, 1936]. So, *Selaginella helvetica* has relatively wide diapason of highland habitat and spreading.

The species is included into the Red Book of Ukraine under the category of extinct [CHERVONA…, 2009], into the Red List of Transcarpathian region as endangered [KRICHFALUSHIJ, BUDNIKOV, MYHAL, 1999], and into the Carpathian List of Endangered Species as vulnerable [TASENKEVICH, 2003].

In 2013 we detected *Selaginella helvetica* on the slopes of the left bank of Tysa River on the height of 265 m a.s.l. environs of Veryatsya village of Vynogradiv district (N 48°10'38,09" E 23°09'54,67") (fig. 3). The researched slopes are characterized by the outcrop of volcanic rocks of andesites and andesite-basalts [FODOR, 1974].

The data about phytocenotic confined of the species are very limited. Such information is absent in the scientific work of H. Ellenberg et al. [ELLENBERG at al., 1991]. It was informed that the species occurs in the plant communities of union *Seslerion* in ecologic characteristics of vulnerable species of vascular plants represented by V.V. Krichfalushiy and others [FODOR, 1974]. We failed to determine the syntaxonomic status of communities with *Selaginella helvetica* due to insufficient quantity of geobotanical descriptions. But our description can be included into according data-base after the collection of data from other regions.

Mean slope gradient – 30˚. Mycrorelief is hilly. The projective covering of harbage is around 80% and individual covering of *Selaginella helvetica* does not exceed 1 %. The following separate young trees are also available *Pinus sylvestris* L. (+) and *Betula pendula* Roth. (+) with the height up to 3 m. We detected in harbage *Poa pratensis* L. (7 %), *Festuca pseudovina* Hackel ex Wiesb. (5 %), *Centaurea jacea* L. – (10 %), *Thymus alternans* Klokov (10 %), *Leucanthemum vulgare* Lam. (5 %), *Hypochaeris glabra* L. (5 %), *Galium verum* L. (3 %), *Briza media* L. (3 %), *Euphorbia cyparissias* L. (3 %), *Pilosella officinarum* F.Schultz & Sch.Bip. (1 %), *Linum catharticum* L. (1 %), as well as *Aristolochia clematitis* L., *Agrimonia eupatoria* L., *Carlina vulgaris* L., *Achillea millefolium* L., *Equisetum arvense* L. and *Kohlrauschia prolifera* (L.) Kunth. – occasionally.

So, the community is full of the species most of which are typical components of meadows. But there are also species which have no clear phytocoenotic confined and give to phytocoenos the features of synantropization.

The slope where the researched species was found is being trampled down by people and cattle. Moreover, the territory is fragmented by number of paths. Taking into account that *S. helvetica* is stress-tolerant it can maintain its positions in the community during some time. But the nearby location of andesite-stone processing plant creates the risk of possibility to create new open pit on the slope which is the only known place of location of this species in Ukrainian Carpathians. That is why we proposed to create botanic zakaznik “Veryatsya” with the area of 0,5 ha in order to protect the population *Selaginella helvetica* from direct negative impact of human activities and to create appropriate conditions for monitoring researches focused on the population state. So, the status of the species meets the status ’rare’.

Conclusions

Three representatives of divisio *Lycopodiophyta – Lycopodiella inundata, Diphasiastrum issleri* and *Selaginella helvetica* are very rare on the southern megaslope of Ukrainian Carpathians. They have only one or two known habitats with relict characteristics of their areal.

Selaginella helvetica is known on the whole Ukrainian territory only from the one habitat detected by us in Volcanic Carpathians and it is affected by anthropogenic factors. Due to these facts it is rare and endangered at the same time.

Diphasiastrum issleri was not found in the locations mentioned in literature sources but was detected for the first time on Volcanic ridge in the artificially created community of brushwood. This is also the only known habitat of the species in Ukrainian Carpathians. There are no direct dangers for the population in terms of human activities. It is considered by us as rare in Ukrainian Carpathians.

Lycopodiella inundata located in meso- and oligotrophic marshes is known by four locations in Ukrainian Carpathians, two of them belong to the southern megaslope of Ukrainian Carpathians. Its habitat was confirmed in both locations but a drastic reduction of population size was observed as the result of marshes transformations into types of phytocoenoses. That is why the species is endangered despite of the location on nature-protected territories.

The researches gave the possibility to start the monitoring of the populations state of rare relict species *Lycopodiella inundata, Diphasiastrum issleri* and *Selaginella helvetica.* It can significantly supplement the scientific data about the strategy of the species and their reaction on protected measures.

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