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Source: *Candollea*, 76(1) : 55-63

Published By: The Conservatory and Botanical Garden of the City of Geneva (CJBG)

URL: <https://doi.org/10.15553/c2021v761a4>

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On the proper type designation for *Camelina microcarpa*, a wild relative and possible progenitor of the crop species *C. sativa* (Brassicaceae)

Sergei L. Mosyakin & Jordan R. Brock

Abstract

MOSYAKIN, S.L. & J.R. BROCK (2021). On the proper type designation for *Camelina microcarpa*, a wild relative and possible progenitor of the crop species *C. sativa* (Brassicaceae). In English, English abstract. *Candollea* 76: 55–63. DOI: <http://dx.doi.org/10.15553/c2021v761a4>

The proper type designation of the name *Camelina microcarpa* Andrzej. ex DC. (Brassicaceae) is discussed. This taxon is currently considered to be a wild relative and possible progenitor of the oilseed crop *Camelina sativa* (L.) Crantz, and thus the proper typification of the name *C. microcarpa* is important for further germplasm research and improvement of the crop species. At present, several (at least four) specimens deposited in herbaria G-DC, KW, and LE, are listed in literature and/or annotated in herbaria or online databases as the type (holotype or lectotype) of *C. microcarpa*. The original material deposited in G-DC [G00203789] is accepted here as the holotype of *C. microcarpa* because it appears to be the only original element used by Candolle when preparing his description of the new taxon. Isotypes from the Besser herbarium at the National Herbarium of Ukraine in Kyiv (KW-BESS) are discussed and illustrated. It is concluded that the holotype from G-DC and two well-preserved isotypes from KW-BESS [KW001003103, KW001003104] are sufficient for precise morphology-based application of the name *C. microcarpa*. Our analysis provided evidence that original material was collected by Andrzejowski no later than 1818 in the Podolian Governorate of the former Russian Empire, most probably in the eastern part of Moldova or adjacent southwestern parts of Ukraine, along the Dnister (Nistru, Dniester) River between the present-day town of Camenca (Kamenka) and the confluence of the Dnister and Yagorlyk (Iagorlic) rivers, probably on limestone outcrops. It means that the type of *C. microcarpa* may belong to the southern Ukrainian populations, which are genetically different from northern and central Ukrainian ones; however, further field and molecular studies are needed because more than one genotype may in fact occur in that area.

Keywords

BRASSICACEAE – *Camelina* – Crop relative – Moldova – Nomenclature – Ukraine

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Submitted on August 7, 2020. Accepted on November 26, 2020.

First published online on February 1, 2021.

ISSN: 0373-2967 – Online ISSN: 2235-3658 – *Candollea* 76(1): 55–63 (2021)

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Introduction

A traditional European oilseed crop *Camelina sativa* (L.) Crantz (Brassicaceae) is becoming increasingly popular as an emerging biofuel source (VOLLMANN & EYNCK, 2015; BLUME & RAKHMETOV, 2017; BROCK et al., 2018, 2020; GUITTET et al., 2018; etc.). Taxa of the genus *Camelina* Crantz also served as classical models for important early studies of microevolution, crop origins, and co-evolution of crops and their specialized weeds. The meticulously detailed 300-page treatment of *Camelina* and *Spergula* L. flax weeds by ZINGER (1909) was followed by studies of taxonomy, geography, speciation, and genetics of oil crops and their relatives by Eugenia N. Sinskaya (also Latinized as Sinskaja, 1889–1965; see BENNETT, 1966; FILATENKO, 1990) and other researchers (e.g., SINSKAJA, 1928; SINSKAJA & BEZTUZHEVA, 1931; etc.) belonging to the famous crop and weed research team of Nikolai I. Vavilov (1887–1943; see COHEN, 1991; LOSKUTOV, 1999; JANICK, 2015). For some period in the 20th century the cultivation of *C. sativa* was very limited and the crop traditions and some local races were lost, which depleted the genetic diversity of the crop. The situation can be improved through the use of modern genetic and biotechnological methods and the genetic material from related taxa. All those factors stimulated recent integral research of *C. sativa* and its wild relatives and possible progenitors, including aspects of their taxonomy, phylogeny, biogeography, genetics, biochemistry, biotechnology, etc. (see MARTIN et al., 2017; BROCK et al., 2018, 2019, 2020; ČALASAN et al., 2019; LUO et al., 2019; MANDÁKOVÁ et al., 2019; CHAUDHARY et al., 2020).

In particular, it has become evident that the species *C. microcarpa* Andr. ex DC. most probably (or even almost certainly) is the direct wild progenitor of *C. sativa*, and thus it is crucial for proper understanding of relationships in the group and the origin of the crop species. Chromosome numbers $2n = 40$ or 38 were reported for allohexaploids identifiable as *C. sativa* and *C. microcarpa* (other chromosome numbers reported earlier may refer to other species), and the polyploidization event (or events?) occurred most probably before the time of domestication of *C. sativa*. Evolution of the allopolyploids was based on hybridization of their diploid progenitors, such as *C. hispida* Boiss. and the newly discovered *C. neglecta* J.R. Brock et al. (see MANDÁKOVÁ et al., 2019; BROCK et al., 2019; CHAUDHARY et al., 2020). As estimated by BROCK et al. (2018), wild populations of *C. microcarpa* harbor about twice as much of genetic diversity as compared to that of the crop species *C. sativa*. Evidently, studies of *C. microcarpa* and other wild crop relatives can potentially result in identification of valuable traits and important genes useful for genetic improvement of the crop species *C. sativa*.

Recent studies, however, indicated that the plants identified as *C. microcarpa* and occurring in Ukraine and the Caucasus (eastern Turkey, Georgia, and Armenia) are genetically non-uniform, and thus some infraspecific entities or even cryptic

species can be probably recognized in the group. In particular, CHAUDHARY et al. (2020) demonstrated that plants from Ukraine, Russia and the Caucasus morphologically classified as *C. microcarpa* belong to at least two genetically different groups (provisionally termed as “Type 1” and “Type 2”) and suggested a cryptic taxon of the *C. microcarpa* group with 19 haploid chromosomes. Considerable differences between western and eastern groups of populations of plants currently classified as *C. microcarpa* were revealed in the Eurasian steppe zone by ČALASAN et al. (2019). Also, two genetically distinct groups of populations can be distinguished in Ukraine, the southern and northern-central ones (BROCK et al., 2020). Thus, for achieving a reliable infraspecific classification of the species and the actual limits of species in the group (which is also important for crop improvement), the proper typification of the name *C. microcarpa* is crucial.

However, conflicting information on typification of the name *C. microcarpa* is currently available from the relevant literature and online herbarium resources. Here we analyze the conflicting opinions on the type of *C. microcarpa* and provide a nomenclatural solution. Additional information on original and other historical specimens in herbaria G-DC, KW, and LE is also provided.

Specimens of Brassicaceae from Ukraine in G-DC

Plants from the territory of Ukraine are well represented in G-DC. For example, an advanced search in the JSTOR Global Plants website [<https://plants.jstor.org>] on 12 April 2020 with the search terms for the country (Ukraine) and the G-DC Herbarium resulted in 660 specimen records. In total, the CHG (2020) accessed 12 April 2020 and 21 July 2020 lists 888 specimens from Ukraine in G-DC (plus there are probably some Ukrainian specimens not precisely located geographically). Also, there were listed 238 specimens collected by Wilibald S.J.G. Besser (1784–1842) and 45 specimens of Antoni L. Andrzejowski (1785–1868) (including 42 of Brassicaceae, which reflected Andrzejowski’s research interests), almost all of them from Ukraine (however, some of their collections might have been made within the present-day territories of Moldova, Belarus, or Lithuania).

Thus, Augustin-Pyramus de Candolle (1778–1841) received in his herbarium most of his Ukrainian specimens from Besser and Andrzejowski (mostly plants from Podolia [Podillya] and Volhynia [Volyn’], but also from other areas in the southern steppe zone and in central and northern parts of Ukraine), from Christian Steven (1781–1863) (mostly specimens from Crimea and some other areas of southern Ukraine, but also many specimens from non-Ukrainian localities, especially the Caucasus, totaling more than 800 specimens), and from some other collectors, providers, and herbarium curators.

It is possible, and even evident for many cases, that at least some specimens of Ukrainian plants in G-DC were obtained indirectly, for example, through the St. Petersburg herbarium (see historical data in: TRAUTVETTER, 1873; LIPSKY, 1908; FEDTSCHENKO, 1913), in particular, from its head curator Friedrich Ernst Ludwig (Fedor Bogdanovich) Fischer (1782–1854).

These main sources of Ukrainian plant specimens in G-DC are also confirmed for the family *Brassicaceae* (see ILYINSKA, 2003). The CHG (2020) provides data for G-DC on 19 identified type specimens for names of various taxa of *Brassicaceae* described from Ukraine. Collectors or providers of these type specimens were Andrzejowski (6 specimens), Besser (2), Steven (10), and Peter Simon Pallas (1).

The main collections of Andrzejowski and Besser are currently deposited in the Besser historical herbarium (informally abbreviated as KW-BESS) at the National Herbarium of Ukraine (KW) (see for example SHIYAN, 2011; MOSYAKIN et al., 2019b; MOSYAKIN & SHIYAN, 2019).

Conflicting data on the type of *Camelina microcarpa* and historical specimens in LE

Camelina microcarpa was published by CANDOLLE (1821: 517) with a brief description: “*C. siliculis pyriformibus bicostatis stylo longiusculo superatis, foliis lanceolatis denticulatis hispidis*”, a diagnostic note providing characters distinguishing the new species from *C. sativa* var. *pilosa* DC. (“Accedit ad var. *pilosam* *C. sativæ* sed differt fructu dimidiò breviorè, binè quadrìcostatò”), the reference to the unpublished name proposed by Andrzejowski (“*C. microcarpa*. Andrzej! cruc. ined.”), and geographical information (“Hab. in Podolia”). An amended description and illustration were published later (DELESSERT & CANDOLLE, 1824: 20–21, tab. 69), and almost the same information was provided in the *Prodromus* (CANDOLLE, 1824: 201). Thus, Candolle used the specimen(s) provided and the name proposed (in a manuscript or letter) by Antoni Andrzejowski, a naturalist of the 19th century who greatly contributed to botanical, zoological, geological and paleontological studies of the present-day territory of Ukraine (see GRABOWSKA, 1989; DASZKIEWICZ & BAUER, 2008; SHEVERA et al., 2018).

In his taxonomic and nomenclatural overview of the genus *Camelina* in the Caucasus, DOROFYEV (1996: 98) designated the type (intended as a lectotype) of *C. microcarpa* as “Lectotypus (Dorofeyev [the name printed in Russian], h.l.): “Podol. austr.” (LE!)”. In that text the abbreviation “h.l.” means “*hoc loco*”, corresponding to the formula “designated here” as defined in Art. 7.11 of the ICN (TURLAND et al., 2018); “Podol. austr.” is the text from the herbarium label meaning *Podolia australis*, southern Podolia (Podillya in Ukrainian). The geographical indication of Southern Podolia may refer to any place in a rather vast area of western, western-central, and/or

southwestern parts of Ukraine and/or adjacent eastern parts of Moldova, within the Podolian Governorate of the former Russian Empire.

DOROFYEV’S (1996) typification was accepted in later publications, e.g. ILYINSKA (2002) and DOROFYEV (2012, 2019). There are three specimens in LE [LE00018170, LE01060001, LE01060002] from Southern Podolia associated with Besser and/or Andrzejowski; of those, DOROFYEV (2019) later explicitly indicated just one [LE01060001] as the lectotype. This could be interpreted as an attempt at a second-step lectotypification but, contrary to Art. 7.11 of ICN (TURLAND et al., 2018), no words “designated here” or their equivalent were used and thus that type designation has no nomenclatural standing.

The three specimens in LE originating from the Besser collection are doubtfully parts of the original material of *C. microcarpa*. None of these specimens is dated (which is a rather common situation with many Besser’s specimens, especially duplicates intended for other herbaria and colleagues) and it is quite possible that they were collected either by Besser himself or by Andrzejowski either in the field or from cultivated plants and either before or after the date of publication in 1821. Also, as evident from herbarium specimens in KW, Besser cultivated *C. microcarpa* in the botanical garden(s) of Kremenets and/or Kiev and shared seeds with other botanists and horticulturalists. At least one of the LE specimen [LE00018170] is clearly annotated as originated from cultivated plants (“Specimen e cultis”; see DOROFYEV, 2019: 20).

The specimen [LE01060001] (image available at <http://re.herbariumle.ru/01060001>) was annotated by Dorofeyev in 2002 as the lectotype. Another annotation label indicates that specimen as an isolectotype (handwriting of M.M. Fedoronchuk of the KW herbarium). The label of Besser, with the text “Herb. W. Besser” at the bottom typographically printed on blue paper identical to the paper used for publication of the first edition of Besser’s *Catalogue* (BESSER, 1810; see also MOSYAKIN et al., 2019b), provides the name (“*Camelina microcarpa* Andr.”) and geographical provenance (“E Podol. austr.”). There are also inscriptions in pencil (“Herb. Ledeb.” and Roman and Arabic numerals “XV.I” and “94.2”) indicating that the specimen was in possession of Carl (Karl) Friedrich von Ledebour (1785–1851) and was used by him in preparation of his *Flora Rossica*.

Another specimen, [LE01060002] (image available at <http://re.herbariumle.ru/01060002>), is from the Fischer herbarium; it was obtained from Besser, as it is evident from Besser’s typical blue-paper label (see above). It should be also noted that *C. microcarpa* was cultivated in the St. Petersburg Botanical Garden and is mentioned in several issues of the St. Petersburg seed catalogue by FISCHER et al. (1837a: 5; 1837b: 5; and later). Fedoronchuk provisionally annotated that specimen as the lectotype on 28.I.2001, but an annotation label by

Dorofeyev (with the reference to his article of 1996) dated by 17.IX.2002 states that it is an isolectotype. In fact, there are two plants mounted on the same sheet, each with its own label, and thus probably there might be two actual specimens.

There is no label information directly associating the specimens [LE01060001] and [LE01060002] with Andrzejowski. We cannot be sure that these specimens were collected by Andrzejowski before 1821. Their status as part of original material cannot be confirmed. Thus, we do not consider the LE specimens discussed above as belonging to original material of *C. microcarpa*. Consequently, the lectotype designation made by DOROFYEV (1996, 2019) should be rejected and reliable original material has to be searched for in G-DC and KW.

Original material of *Camelina microcarpa* in G-DC

The original material in G-DC [G00203789] has the label by Andrzejowski: “*Camelina microcarpa* | Mihi | in Podoliae australi”. Below the text written by Andrzejowski, the words “m. Andrzejowski [sic!] | 1820” (with an incorrect name spelling) were added by Candolle and 1820 is therefore the year of provenance. It is documented that Andrzejowski traveled in Podolia in 1814, 1816, 1818, and then again in 1822–1824 (ANDRZEJOWSKI, 1823, 1830; SHEVERA et al., 2018). Thus, the specimen was most probably collected in 1814, 1816, or 1818.

Since there is just one specimen of *C. microcarpa* associated with Andrzejowski in G-DC, that specimen [G00203789] is the only specimen of the species originally used by Candolle before or when preparing the validating description, and thus it is the holotype as defined by Art. 9.1 of the ICN (TURLAND et al., 2018). For comparison, when considering taxa of *Brassicaceae* described by Pierre Edmond Boissier (1810–1885), AL-SHEHBAZ & BARRIERA (2019) in such or similar cases identified all unique specimens from the *Flora Orientalis* herbarium at G as holotypes.

It should be noted that under the current wording of Art. 9 of ICN (TURLAND et al., 2018) the holotype status in such cases can be disputed (see McNEILL, 2014; MOSYAKIN et al., 2019a; TURLAND et al., 2020a, 2020b). However, a proposal to amend the provisions of the *Code* dealing with the holotype status recognition is under preparation by the first author (S. Mosyakin) in consultations with John McNeill and other experts in nomenclature.

Thus, we know for sure that Candolle used the specimen [G00203789] when preparing his description of the new taxon *C. microcarpa*. Currently there is no evidence that he used at that time any other specimens or illustrations. We think that, until such evidence is available, the only specimen in G-DC matching the protologue data should be accepted as the holotype of *C. microcarpa* by default. If, for any reason (for example, due to changes in a new ICN), the holotype status of that

specimen is challenged in the future, a lectotype should be anyway selected from the unquestionably original specimens of Andrzejowski available at G-DC and KW (see below), for which [G00203789] would be still the evident preferable choice.

Original material of *Camelina microcarpa* in KW-BESS

There are three specimens of *C. microcarpa* directly associated with Andrzejowski deposited in the Besser historical herbarium at the National Herbarium of Ukraine (KW-BESS).

The specimen [KW001003103] (Fig. 1) has the original handwritten label by Andrzejowski: “*Camellina* [sic!] *microcarpa* | Mihi | in Podol. austral.”. The typification note (“*Notae criticae*”) by Antonina P. Ilyinska [Iljinska] is also attached: “lectotypus | *Camelina microcarpa* Andr. ex | DC. | 24.01.00 p. [24 January 2000] | A. Ilyinska [the name written in Ukrainian]”. That type designation has never been published, and later ILYINSKA (2002) accepted Dorofeyev’s lectotypification with a specimen at LE. It is noteworthy that ZINGER (1909) in his classical treatment of flax weeds of the genera *Camelina* and *Spergula* on Table 1 reproduced three plant fragments from that specimen, with an annotation (ZINGER, 1909: 295) that this specimen was collected by Andrzejowski himself in the southern part of the Podolian Governorate, and is deposited in the Besser Herbarium belonging to the St. Vladimir University of Kiev (now part of KW). It is evident from the text that Zinger considered that specimen as morphologically typical (representative) for the species, but not as the nomenclatural type in the modern understanding of the term. However, well before DOROFYEV (1996, 2019) attempted to designate a lectotype, VASSILCZENKO (1939: 599) stated that the type of *C. microcarpa* is deposited in the Besser herbarium in Kiev, but did not cite any actual specimen.

The specimen [KW001003104] (Fig. 2) has two labels, one handwritten (“*Camelina microcarpa* | Andr. | Podol. Austr.”), another typographically printed (“HERBARIUM UNIVERSITATIS S^{ti} VLADIMIRI | HERBARIUM ANDRZEJOWSKII 1841”). Such labels were printed by the St. Vladimir University of Kiev when the major part of the herbarium of Andrzejowski was added to the University herbarium, thus in that case 1841 indicates not the collection year but the year of incorporation of specimens. Judging from that information, this specimen was transferred to the University herbarium directly from the collection of Andrzejowski, and then added to the Besser collection.

We consider the two KW-BESS specimens discussed above as duplicates of the holotype in G-DC (isotypes). Another specimen, [KW001003105], has three plant fragments and a small label slip with the number “1042” and the abbreviated text in Russian meaning “Authentic [or probably



Fig. 1. – Isotype of *Camelina microcarpa* Andr. ex DC.
[KW, Besser herbarium: KW001003103; © National Herbarium of Ukraine, Kiev]

Author's] specimen of Andrzejowski". Most probably that sheet is a fragment from a better preserved specimen. This fragment is accepted here as a possible isotype.

Nomenclature

Camelina microcarpa Andr. ex DC., Syst. Nat. 2: 517. 1821 (Fig. 1, 2).

Holotypus: MOLDOVA or UKRAINE: "in Podoliae australi", s.d., *Andrzejowski s.n.* (G [G00203789]!; iso-: KW-BESS [KW001003103, KW001003104]!; probable iso-: KW-BESS [KW001003105]!).

Notes. – In the book describing his travels and research in Podolia and adjacent areas in 1814, 1816, 1818, and 1822, ANDRZEJOWSKI (1823: 49) discussed "Flora od Jampola do Jaorlika a nawet do morza [...] [the flora from Yampil' to Yagorlyk and down to the sea]" and, following the introductory phrase "Szczególniey od Kamionki przybywają tu: ... [Especially from Kamenka, [the following species start to] appear here: ...]", provided a list of species, including "CAMELINA * *microcarpa* mihi".

The town of "Jampol" [Yampil', also transliterated as Yampol' or Iampol] is located at the border with Moldova in Vinnytsia Region of Ukraine. "Jaorlik" may refer either to the village of Yagorlyk [Iagorlic] in Dubossary [Dubäsari] District of Moldova, or to the Yagorlyk River in Odessa Region of Ukraine and the adjacent part of Moldova. It is more problematic to match the toponym "Kamionka" with a particular place because there are several Kamyanka [Kamianka] settlements in the Odessa and Kherson administrative regions of Ukraine. However, judging from his itinerary, there is little doubt that ANDRZEJOWSKI (1823) mentioned specifically the settlement corresponding to the present-day town of Camenca [Kamenka] in Camenca District of Moldova. Thus, we conclude that Andrzejowski originally collected specimens of *C. microcarpa* somewhere in the eastern part of the present-day Moldova or adjacent parts of Ukraine (probably Odessa Region), along the left (eastern) bank of the Dnister [Nistru in Moldovan/Romanian, also Dniester] River between Camenca town and the confluence of the Dnister and Yagorlyk [Iagorlic] rivers, most probably on limestone outcrops because plants typical for the whole "limestone area" in Andrzejowski's lists in that chapter were marked by asterisks. This suggests that the type of *C. microcarpa* probably belongs to the southern Ukrainian populations, which are genetically different from northern and central Ukrainian ones (BROCK et al., 2020).

Concluding remarks

The holotype [G00203789] and the two well-preserved isotypes available from the Besser herbarium at KW [KW001003103, KW001003104] are sufficient for precise morphology-based application of the name *C. microcarpa*. However, further field surveys and comparative molecular studies are needed because more than one genotype may occur in southwestern Ukraine and adjacent areas in Moldova, from where the original specimens were collected by Andrzejowski. Also, there is much to be done in the future to understand relationships of multiple genetically distinct populations of *C. microcarpa* s.l. from Ukraine and other areas in Europe and Asia, and especially in comparison to those from the Caucasus, which indeed may be separate entities worthy of some taxonomic recognition, at least as infraspecific taxa.

Acknowledgments

We are grateful to Martin Callmänder (Conservatoire et Jardin botaniques de Genève, Switzerland) and an anonymous reviewer for their valuable comments, suggestions and editorial improvements, to Nataila M. Shiyani and Alisa V. Shumilova (KW Herbarium, M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine, Kyiv, Ukraine) for providing assistance during our herbarium research at KW, and to Svitlana I. Antonenko (M.G. Kholodny Institute of Botany) for scanning the original specimens from the Besser collection in KW. The first author discussed with John McNeill (Royal Botanic Garden, Edinburgh, Scotland, U.K. & Royal Ontario Museum, Toronto, Ontario, Canada) various nomenclatural issues related to type designations, and his expertise and useful advice are greatly appreciated. Thanks are also due to Ihsan A. Al-Shehbaz (Missouri Botanical Garden, St. Louis, Missouri, USA) with whom we discussed various issues of taxonomy and nomenclature of *Brassicaceae*.

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Fig. 2. – Isotype of *Camelina microcarpa* Andr. ex DC.
[KW, Besser herbarium: KW001003104; © National Herbarium of Ukraine, Kiev]

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