

Morphological characteristics as a key attribute for a successful determination of selected *Cotoneaster* species

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In this paper, morphological features, such as the number of pyrenes in pome and the number of pomes in infructescence, were used for determination of closely related tetraploid *Cotoneaster* species. Samples were collected from various localities in the Western Carpathians. The collection of samples, designed for counting of pyrenes in pome, included 2353 pomes of >130 individuals. Number of pyrenes in pome ranged from 1 to 5. Statistical analysis revealed a significant difference in pyrenes per pome mean values between *C. integerrimus* (3.01), *C. melanocarpus* agg. (2.46; including *C. matrensis*) and *C. tomentosus* (3.93). The collection of samples, designed for counting of pomes in infructescence, included 1019 infructescences of 141 individuals. Number of pomes in infructescence ranged from 1 to 5. Statistical analysis also revealed a significant difference in pomes per infructescence mean values between *C. integerrimus* (1.14) and *C. melanocarpus* agg. (1.54; including *C. matrensis*), and between *C. integerrimus* and *C. tomentosus* (1.50).

Keywords: pyrenes, pomes, infructescence, *Cotoneaster*, Western Carpathians

1 Introduction

According to the latest research, the *Cotoneaster* genus belongs to *Rosaceae* family, *Spiraeoideae* subfamily and tribe *Pyreae* (Potter et al., 2007). Overall, it includes approximately 300 species (Bartish et al., 2001). Many species, included in *Cotoneaster* genus, are cultivated as ornamental plants (Dickoré and Kasperek, 2010). Latest research also confirmed a presence of phenolic compounds and flavonoids in *Cotoneaster integerrimus*. Therefore, *C. integerrimus* has a great potential in health promotion. Novel food ingredients and medication could be developed from its twigs and fruit (Uysal et al., 2016; Kicel et al., 2019).

A total of 81 *Cotoneaster* species were recorded in Europe – 17 native and 64 alien species (Kurtto et al., 2013). The western part of Carpathian Mountains includes 3 native *Cotoneaster* species – *Cotoneaster integerrimus* Medik., *Cotoneaster melanocarpus* (Bunge) Fisch. et C. A. Mey

and *Cotoneaster tomentosus* Lindl. (Marhold and Hindák 1998). Some authors distinguish *Cotoneaster matrensis* Domokos from *Cotoneaster melanocarpus* (Bunge) Fisch. et C. A. Mey. However, in this case, further research is needed (Baranec, 1992). The occurrence of a hybrid species *Cotoneaster alaunicus* × *integerrimus* in the area of the Low Tatras Mts., was also recorded (Baranec and Eliáš ml., 2004).

Cotoneaster tomentosus individuals usually grow in the community of *Prunion spinosae* and *Calamagrostion variae* from sub-montane to montane level. *Cotoneaster integerrimus* individuals grow in the community of *Seslerio-Festucion duriusculae* and *Prunion fruticosae* from colline to alpine level. *Cotoneaster melanocarpus* individuals typically grow in the community of *Seslerio-Festucion duriusculae* and *Prunion spinosae* from colline to montane level (Baranec, 1992).

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The classification of taxa included in *Cotoneaster* genus is relatively problematic. Morphological features, such as colour of fruit and bark or shape and size of leaves, are not always reliable attributes. A pome is a type of fruit specific to subfamily formerly known as *Maloideae*. In *Cotoneaster*, the ovary develops into the pyrene (Rohrer, 1991). The total amount of pyrenes in a single pome is variable. The number of pyrenes in pome and the number of pomes in infructescence are the most important morphological features for determination of previously mentioned *Cotoneaster* species. Other features include the presence of trichomes on leaves and pomes, and the colour of pomes (Baranec, 1992). Since we believe, that there is a lack of information and available data from contemporary articles, we decided to prove, whether these morphological characteristics are reliable for identification of selected *Cotoneaster* species. We also wanted to prove, whether it is possible to rely only on these selected characteristics. And last but not least, it should be mentioned, that such a large-scale study in the Western Carpathians has been lacking so far.

2 Material and methods

The majority of collected individuals grew in dry habitat with a permanent sunlight, mainly on grassy steppes or cliff edges. Some of the individuals grew in forest in the community of other shrubs and larger trees. Each population was relatively small and it included 1–5 individuals, rarely 6–10(–15). Pomes and infructescences were collected from various localities in four countries situated in the Western Carpathians – the Czech Republic, Hungary, Poland and Slovakia (Figure 1, 2). Infructescences were calculated in the field and from herbarium specimens stored in the herbarium NI (Herbarium Collection of Slovak University of Agriculture in Nitra). The list of localities selected for counting of pyrenes in pome and for counting of pomes in infructescence is listed in Appendix 1 and 2, respectively. Individuals were assigned to different species by the colour of pomes and the presence of trichomes according to determination key of Baranec (1992).

Samples were divided in two groups, one designed for counting of pyrenes in pome and the other for counting

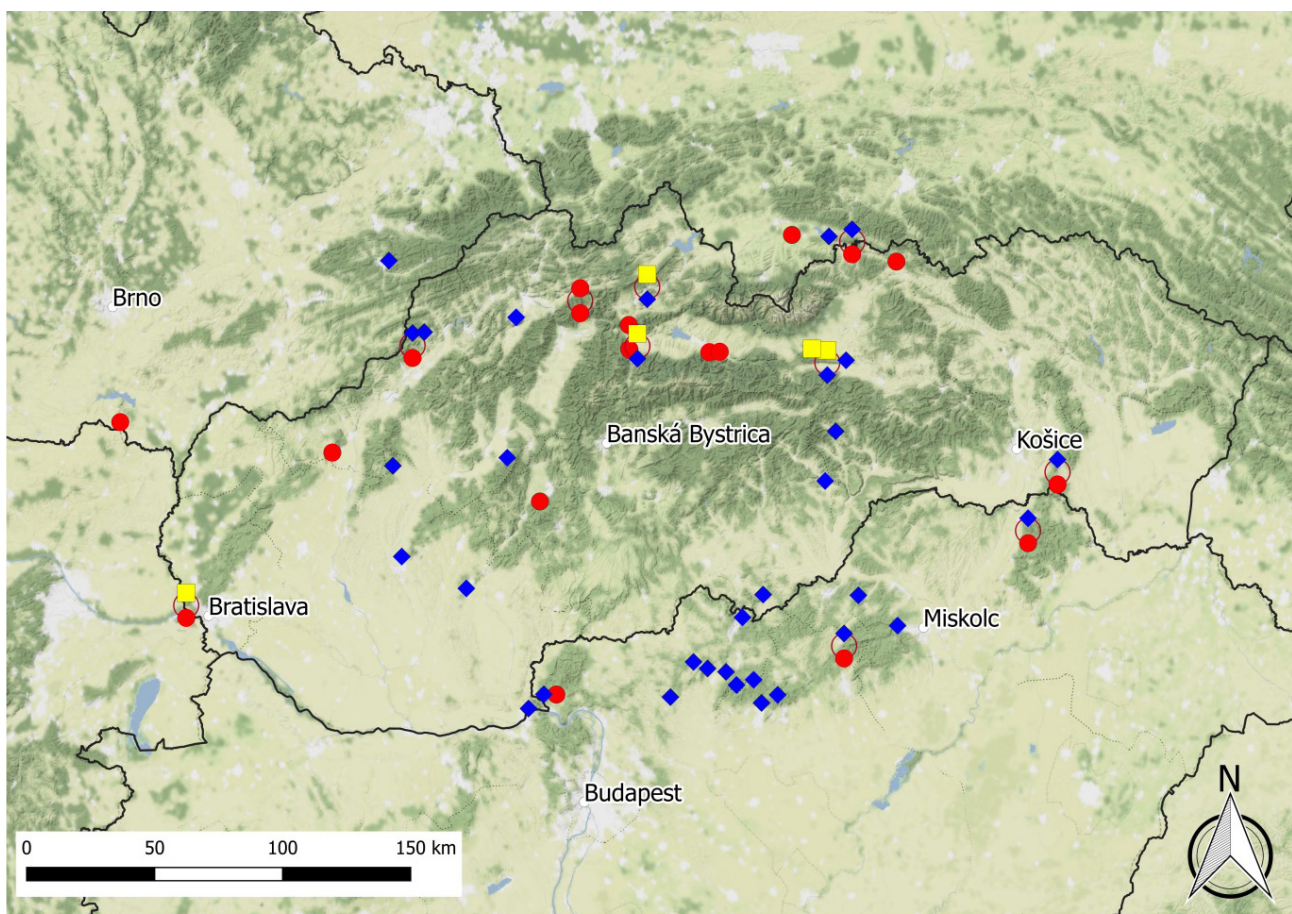


Figure 1 Localities within the Western Carpathians selected for counting of pyrenes in pome: red circles – *Cotoneaster integerrimus*, blue diamonds – *C. melanocarpus* agg., yellow squares – *C. tomentosus*. Background terrain layer is from Stamen Design with data by OpenStreetMap.

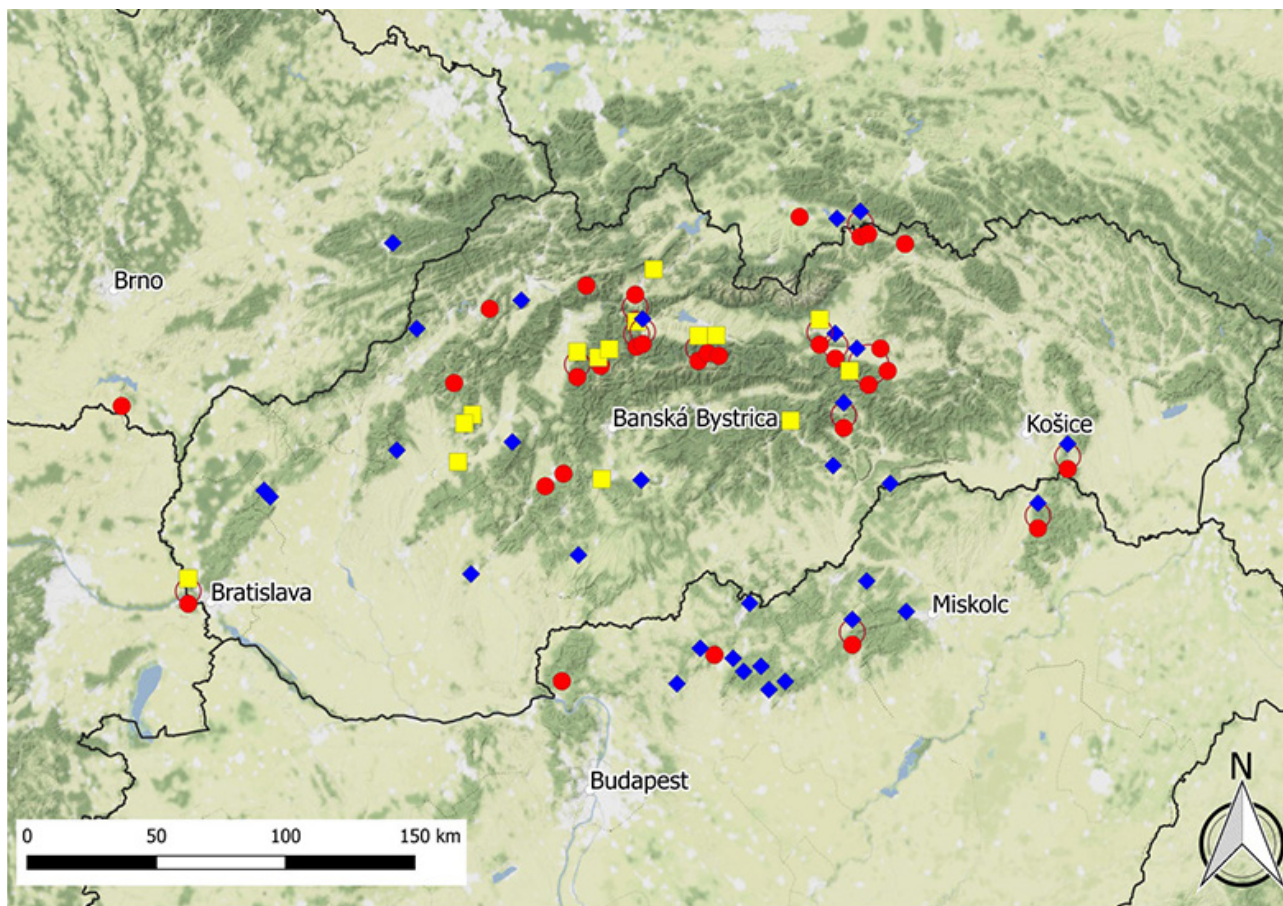


Figure 2 Localities within the Western Carpathians selected for counting of pomes in infructescence: red circles – *Cotoneaster integerrimus*, blue diamonds – *C. melanocarpus* agg., yellow squares – *C. tomentosus*. Background terrain layer is from Stamen Design with data by OpenStreetMap.

of pomes in infructescence. Overall, we collected 3–4 twigs per individual. Herbarium specimens from NI herbarium (Herbarium Collection of Slovak University of Agriculture in Nitra) were also used to increase the total amount of infructescences. The collection of samples, designed for counting of pyrenes in pome, included 2,353 pomes of >130 individuals. The collection of samples, designed for counting of pomes in infructescence, included 1019 infructescences of 141 individuals. The data were collected and further statistically analysed by Microsoft® Excel 2010 and STATISTICA, version 10 (StatSoft, Inc., 2011) data analysis software system (Tukey’s HSD test). Values were calculated as a mean per species.

Herbarium abbreviations are according to Thiers (2019). Nomenclature of flowering plants follows Marhold and Hindák (1998). The map was created by the software QGIS, version 3.2 (QGIS Development Team, 2018) with QuickMapServices plug-in and terrain background layer from Stamen Design with data by OpenStreetMap.

3 Results and discussion

Statistical analysis (Tukey’s HSD test; $\alpha = 0.01$) revealed a significant difference in pyrenes per pome mean values between *C. integerrimus* (3.01), *C. melanocarpus* agg. (2.46; including *C. matrensis*) and *C. tomentosus* (3.93). These results along with standard deviation are listed in Table 1.

Table 1 A difference in pyrenes per pome mean values between selected species

Species	Mean per species	Standard deviation
<i>C. integerrimus</i>	3.01	0.67
<i>C. melanocarpus</i> agg.	2.46	0.60
<i>C. tomentosus</i>	3.93	0.73

Table 2 Number of pyrenes in pome presented in this paper, compared with other published data

Species	This paper	Baranec (1992)	Kovanda (1992)	Bartha (2009)
<i>C. integerrimus</i>	(2–)3(–4)	3(–4)	(2–)3(–4)	2–3(–5)
<i>C. melanocarpus</i> agg.	2–3	2(–3)	2(–3)	2(–4)
<i>C. tomentosus</i>	3–5	3–5	–	3–5

Table 3 A difference in pomes per infructescence mean values between selected species

Species	Mean per species	Standard deviation
<i>C. integerrimus</i>	1.14	0.38
<i>C. melanocarpus</i> agg.	1.54	0.71
<i>C. tomentosus</i>	1.50	0.74

Table 4 Number of pomes in infructescence presented in this paper, compared with other published data

Species	This paper	Baranec (1992)	Kovanda (1992)	Bartha (2009)
<i>C. integerrimus</i>	1(–2–3)	1(–2)	–	–
<i>C. melanocarpus</i> agg.	1–2(–3–5)	(1–)2–5	–	–
<i>C. tomentosus</i>	1–2(–3–4)	3–7	–	–

Results, obtained by counting of pyrenes in pome of selected *Cotoneaster* species, compared with other published data, are listed in Table 2.

The majority of *C. integerrimus* pomes had 3 pyrenes (55.90 %), 2 pyrenes were present in 21.57 % of pomes and 4 pyrenes were present in 22.25 % of pomes. Both, 1 and 5 pyrenes in pomes represented only 0.14 % of the

collection. Number of pyrenes in *C. melanocarpus* agg. pomes ranged mainly from 2 to 3. Pomes with 2 pyrenes represented 56.01 % of the collection and pomes with 3 pyrenes represented 38.39 % of the collection. Pomes with 1 pyrene (1.32 %), 4 pyrenes (4.22 %) and 5 pyrenes (0.06 %) were also present in the collection. Number of pyrenes in *C. tomentosus* pomes ranged from 3 to

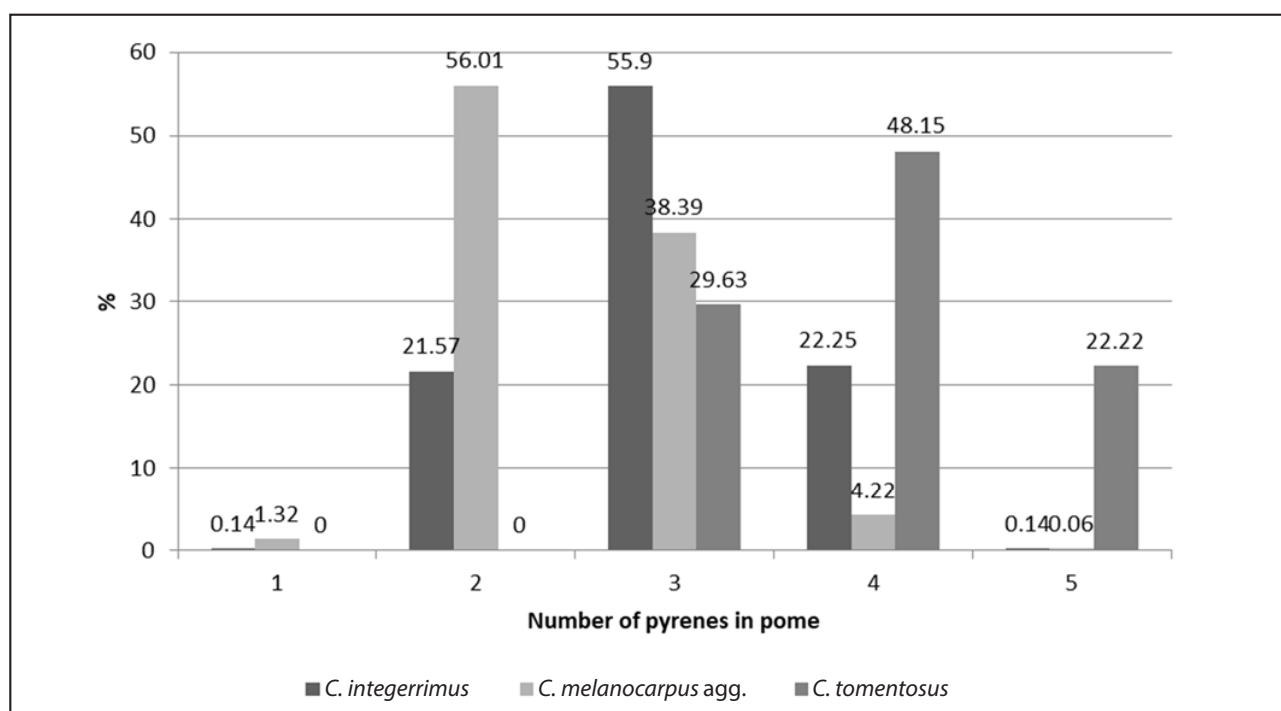


Figure 3 Number of pyrenes in pome of selected *Cotoneaster* species

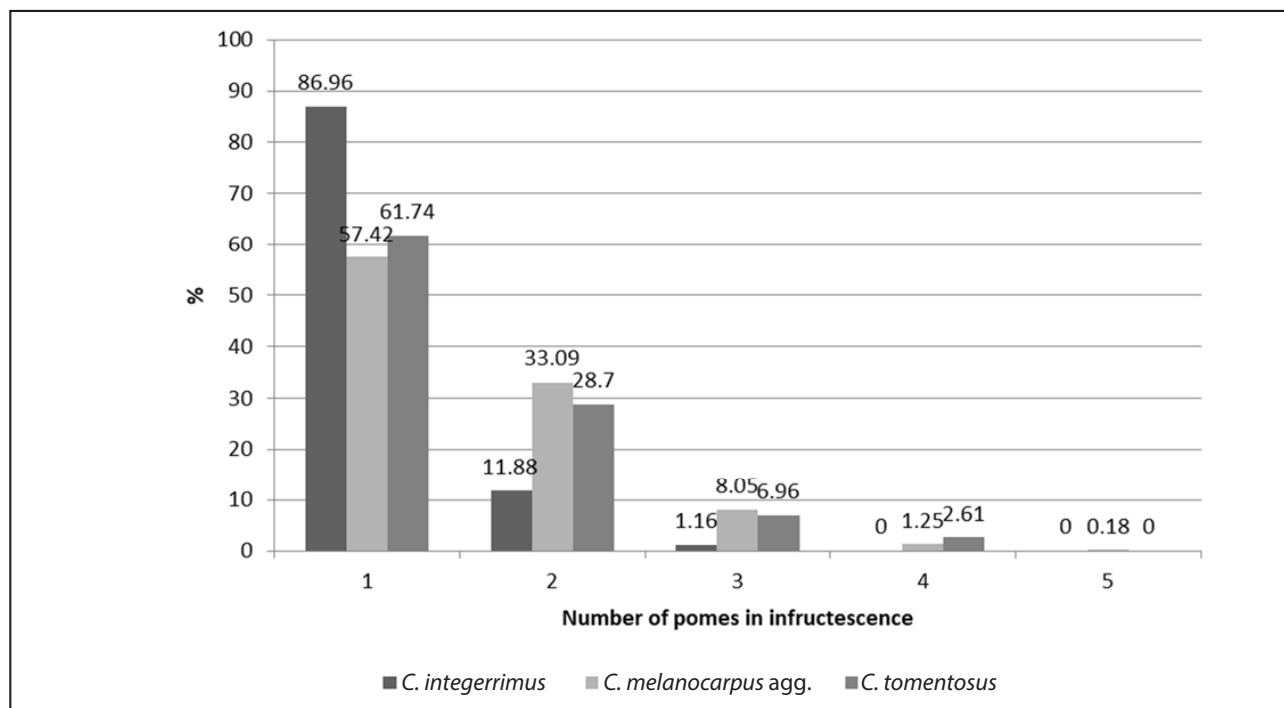


Figure 4 Number of pomes in infructescence of selected *Cotoneaster* species

5. Pomes with 3 pyrenes represented 29.63 % of the collection, 4 pyrenes were present in 48.15 % of pomes and 5 pyrenes were present in 22.22 % of pomes.

A significant difference (Tukey's HSD test; $\alpha = 0.01$) in pomes per infructescence mean values was also recorded between *C. integerrimus* (1.14) and *C. melanocarpus* agg. (1.54; including *C. matrensis*), and between *C. integerrimus* and *C. tomentosus* (1.50). There was no significant difference in pomes per infructescence mean values between *C. melanocarpus* agg. and *C. tomentosus*. However, the determination of these two species is not problematic. *C. tomentosus* individuals have hairy and red pomes while pomes of *C. melanocarpus* agg. individuals are glabrous and dark red-violet or black (Baranec, 1992; Bartha, 2009). These results along with standard deviation are listed in Table 3.

We also compared results from this paper, obtained by counting of pomes in infructescence, with other published data. These results are listed in Table 4.

The vast majority of *C. integerrimus* pomes grew one by one and did not form infructescences. Single pome represented 86.96 % of the collection. Infructescences with 2 pomes represented 11.88 % and infructescences with 3 pomes represented only 1.16 % of the collection. Number of pomes in infructescences of *C. melanocarpus* agg. ranged mainly from 1 to 2. Single pome represented 57.42 % of the collection and infructescences with 2 pomes represented 33.09 % of the collection. Infructescences with 3 pomes (8.05 %), 4 pomes (1.25 %)

and 5 pomes (0.18 %) were also present. Number of pomes in infructescences of *C. tomentosus* ranged mainly from 1 to 2. Single pome represented 61.74 % of the collection. Infructescences with 2 pomes represented 28.70 % of the collection. Infructescences with 3 pomes (6.96 %) and 4 pomes (2.61 %) were also present.

Nowadays, modern methods, such as flow cytometry method, are very important in taxonomy of plants (Hajrudinović et al., 2015; Macková et al., 2017; Žabka et al., 2018), which is a big step forward in systematic botany. These methods in combination with classic morphological and population biology research (Rohrer et al., 1991; Ďurišová, et al., 2016; Ďurišová and Baranec, 2016) give us the opportunity to solve many different problems in complicated groups, like *Rosaceae*.

The purpose of these morphological analyses was to determine a difference between two closely related tetraploid species *C. integerrimus* and *C. melanocarpus* agg.) (Rothleitner et al., 2016), since *C. tomentosus* is considered to be pentaploid (Macková et al., 2018). Flow cytometry method, used in the last study, revealed no significant difference in the genome size of tetraploid *C. integerrimus* and *C. melanocarpus* agg., including *C. matrensis* (Kšišňan et al., 2019). Therefore, we decided to prove, if these morphological characteristics are reliable for identification of selected tetraploid *Cotoneaster* species.

4 Conclusion

Results from this paper proved, that even in the era of modern cytological and molecular methods, classic morphological methods are still relevant in the field of botany. However, we do not recommend relying only on morphological characteristics, because in some cases a determination of problematic closely related species can be more complicated. We suggest a combination of available methods, from classic morphological research to modern methods, or at least a combination of several morphological characteristics.

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Appendix 1 List of localities selected for counting of pyrenes in pome (sorted by different species, by country and alphabetically. Sites are listed in order: geomorphological unit name, village, local site name, geographic coordinates)

Cotoneaster integerrimus:

Czech Republic (1 locality)

Pavlovské vrchy hills, Mikulov, Svatý kopeček hill, 48° 48' 23.2" N 16° 38' 48.3" E

Hungary (3 localities)

Börzsönyi Mts., Kóspallag, Só-hegy, 47° 52' 28.0" N 18° 53' 29.4" E

Bükk Mts., Bélapátfalva, Bél-kő hill, 48° 02' 33.5" N 20° 22' 33.2" E

Zempléni-hegység hills, Hejce, Sólyom-kő hill, 48° 26' 12.7" N 21° 19' 09.5" E

Poland (2 localities)

Pieniński Pas Skałkowy hills, Gronków, Skalka Cisowa hill, 49° 26' 13.1" N 20° 06' 13.6" E

Pieniny Mts., Trzy Korony, Okraglica 49° 24' 50.4" N 20° 24' 49.8" E

Slovakia (12 localities)

Biele Karpaty Mts., Vršatské Podhradie, ruins of the Vršatec castle, 49° 03' 55.9" N 18° 09' 04.5" E

Chočské vrchy Mts., Studničná, Sedem kostolov site, 49° 08' 04.8" N 19° 15' 52.5" E

Lubovnianska vrchovina hills, Jarabina, rocks NW from the village, 49° 20' 51.6" N 20° 38' 30.4" E

Malá Fatra Mts., Terchová, Baraniarky hill, 49° 13' 23.0" N 19° 00' 42.0" E

Malá Fatra Mts., Terchová, Kraviarske hill, 49° 12' 34.2" N 19° 01' 00.5" E

Malé Karpaty Mts., Čachtice, Veľký Plešivec hill, 48° 42' 11.1" N 17° 44' 17.8" E

Malé Karpaty Mts., Devín, the foothills of the Devínska Kobyla hills, 48° 10' 50.2" N 16° 59' 15.3" E

Nízke Tatry Mts., Liptovský Hrádok, Skalka site, 49° 02' 39.6" N 19° 43' 56.6" E

Nízke Tatry Mts., Liptovský Ján, near the cemetery, 49° 02' 35.6" N 19° 40' 45.0" E

Slanské vrchy Mts., Slanec, slopes under the ruins of the Slanec castle, 48° 38' 12.99" N 21° 28' 15.66" E

Štiavnické vrchy Mts., Lehôtka pod Brehmi, Szabóova skala site, 48° 32' 12.2" N 18° 48' 24.5" E

Veľká Fatra Mts., Ružomberok, Malinô Brdo hill, 49° 03' 09.1" N 19° 16' 02.9" E

Cotoneaster melanocarpus agg.:

Czech Republic (1 locality)

Hostýnsko-vsetínská hornatina hills, Vsetín, Valova skála rock, 49° 21' 02.9" N 18° 01' 47.0" E

Hungary (14 localities)

Börzsöny Mts., Letkés, Nagy Galla hill, 47° 52' 31.5" N 18° 49' 37.4" E

Bükk Mts., Alsóhámor, Molnár-szikla hill, 48° 06' 42.8" N 20° 38' 52.2" E

Bükk Mts., Bélapátfalva, Bél-kő hill, 48° 02' 28.7" N 20° 22' 07.5" E

Bükk Mts., Uppony, SW slopes of Kalica-tető, 48° 12' 57.0" N 20° 26' 45.3" E

Cserhát Mts., Bér, Nagy hegy hill, 47° 51' 56.65" N 19° 28' 42.25" E

Cserhát Mts., Mátraszőlős, Függekő, 47° 57' 51.63" N 19° 40' 10.66" E

Cserhát Mts., Hollókő; Szár hegy hill, 47° 59' 12.5" N 19° 35' 50.3" E

Karancs-Medves hills, Salgóhánya, Kis Salgó (Boszorkánykő), 48° 8' 24.40" N 19° 50' 57.86" E

Mátra Mts., Mátraálmás, ruins of the Gyala-vár castle, 47° 55' 31.40" N 19° 54' 24.65" E

Mátra Mts., Mátraháza, Sas-kő hill, 47° 52' 24.63" N 20° 1' 50.12" E

Mátra Mts., Mátrakerestes, Bárány-kő hill, 47° 54' 27.00" N 19° 49' 6.17" E

Mátra Mts., Sástó, 47° 50' 44.06" N 19° 56' 50.48" E

Mátra Mts., Tar, Fehérkő-bánya stone pit, 47° 57' 9.89" N 19° 45' 52.50" E

Zempléni-hegység hills, Hejce, Sólyom-kő hill, 48° 26' 12.7" N 21° 19' 09.5" E

Poland (2 localities)

Pieniny Mts., Falsztyn, Zielone Skałki hills, 49° 25' 55.5" N 20° 17' 40.5" E

Pieniny Mts., Trzy Korony, Okraglica 49° 24' 50.4" N 20° 24' 49.8" E

Slovakia (16 localities)

Biele Karpaty Mts., Lednica, ruins of the Lednický hrad castle, 49° 06' 38.0" N 18° 12' 40.8" E

Biele Karpaty Mts., Vršatské Podhradie, ruins of the Vršatec castle, 49° 03' 55.9" N 18° 09' 04.5" E

Burda hills, Kamenica nad Hronom, Skaly site, 47° 49' 34.00" N 18° 44' 53.68" E

Cerová vrchovina hills, Hajnáčka, ruins of the Hajnáčka castle, 48° 13' 06.5" N 19° 57' 20.4" E

Muránska planina hills, Brdárka, Malý Radzim hill, 48° 46' 31.1" N 20° 19' 44.4" E

Nízke Tatry Mts., Hranovnica, Hranovnická dubina Nature Reserve, 49° 00' 26.8" N 20° 17' 09.0" E

Oravská vrchovina hills, Oravský Podzámok, Oravský hrad castle, 49° 15' 46.9" N 19° 21' 32.9" E

Podtatranská kotlina basin, Primovce, Primovské skalky Nature Reserve, 49° 00' 56.2" N 20° 22' 57.5" E

Podtatranská kotlina basin, Ružomberok, memorial of the Slovak National Uprising, 49° 03' 47.6" N 19° 18' 30.6" E

Podunajská nížina lowland, Čifáre, Podskalie site, 48° 14' 22.5" N 18° 25' 40.9" E

Považský Inovec Mts., Podhradie, ruins of the Topoľčiansky hrad castle, 48° 39' 29.6" N 18° 02' 59.8" E

Slanské vrchy Mts., Slanec, slopes under the ruins of the Slanec castle, 48° 38' 12.99" N 21° 28' 15.66" E

Slovenský kras karst, Gemerské Teplice, Stráň hill, 48° 36' 23.3" N 20° 16' 29.2" E

Strážovské vrchy Mts., Lietava, ruins of the Lietavský hrad castle, 49° 09' 36.8" N 18° 41' 03.1" E

Tribeč Mts., Nitra, Zoborská lesostep Nature Reserve, 48° 20' 54.8" N 18° 05' 43.5" E

Vtáčnik Mts., Podhradie, ruins of the Sivý Kameň castle, 48° 41' 08.8" N 18° 38' 19.8" E

Cotoneaster tomentosus:

Slovakia (5 localities)

Malé Karpaty Mts., Devín, Devínska Kobyla hills, 48° 10' 54.9" N 16° 59' 04.5" E

Nízke Tatry Mts., Hranovnica, Hranovnická dubina Nature Reserve, 49° 00' 26.8" N 20° 17' 09.0" E

Oravská vrchovina hills, Oravský Podzámok, Oravský hrad castle, 49° 15' 46.9" N 19° 21' 32.9" E

Podtatranská kotlina basin, Ružomberok, memorial of the Slovak National Uprising, 49° 03' 47.6" N 19° 18' 30.6" E

Nízke Tatry Mts., Svit, near the cemetery, 49° 03' 15.5" N 20° 12' 22.2" E

Appendix 2 List of localities selected for counting of pomes in infructescence (sorted by different species, by country and alphabetically. Sites are listed in order: geomorphological unit name, village, local site name, geographic coordinates, collector of herbarium specimen, year of collection)

Cotoneaster integerrimus:

Czech Republic (1 locality)

Pavlovské vrchy hills, Mikulov, Svatý kopeček hill, 48° 48' 23.2" N 16° 38' 48.3" E

Hungary (4 localities)

Börzsönyi Mts., Kóspallag, Só-hegy, 47° 52' 28.0" N 18° 53' 29.4" E

Bükk Mts., Bélapátfalva, Bél-kő hill, 48° 02' 33.5" N 20° 22' 33.2" E

Cserhát Mts., Mátraszőlős, Függekő, 47° 57' 51.63" N 19° 40' 10.66" E

Zempléni-hegység, Hejce, Sólyom-kő, 48° 26' 12.7" N 21° 19' 09.5" E

Poland (2 localities)

Pieniński Pas Skałkowy hills, Gronków, Skalka Cisowa hill, 49° 26' 13.1" N 20° 06' 13.6" E

Pieniny Mts., Trzy Korony, Okraglica 49° 24' 50.4" N 20° 24' 49.8" E

Slovakia (24 localities)

Chočské vrchy Mts., Studničná, Sedem kostolov site, 49° 08' 04.8" N 19° 15' 52.5" E

Chočské vrchy Mts., Studničná, forest edge, 49° 08' 21.1" N 19° 15' 58.5" E, Eliáš jun. 2015 NI;

Ľubovnianska vrchovina hills, Jarabina, rocks NW from the village, 49° 20' 51.6" N 20° 38' 30.4" E

Malé Karpaty Mts., Devín, the foothills of the Devínska Kobyla hills, 48° 10' 50.2" N 16° 59' 15.3" E

Malá Fatra Mts., Terchová, Kraviarske hill, 49° 12' 34.2" N 19° 01' 00.5" E

Muránska planina hills, Brdárka, Malý Radzim hill, 48° 46' 31.1" N 20° 19' 44.4" E

Nízke Tatry Mts., Demänová, Siná hill, 48° 59' 58.9" N 19° 35' 15.7" E, Talapka 1996 NI

Nízke Tatry Mts., Hranovnica, Hranovnická dubina Nature Reserve, 49° 00' 26.8" N 20° 17' 09.0" E

Nízke Tatry Mts., Liptovský Ján, Krakova hoľa hill, 48° 59' 00.5" N 19° 38' 01.5" E, Talapka 1996 NI

Nízke Tatry Mts., Liptovský Ján, Ohnište hill, 48° 58' 28.7" N 19° 41' 34.7" E, Tóth 2004 NI

Nízke Tatry Mts., Svit, near the cemetery, 49° 03' 15.5" N 20° 12' 22.2" E

Pieniny Mts., Haligovce, Haligovské skaly site, 49° 22' 50.7" N 20° 27' 12.6" E, Eliáš jun. 2005 NI

Slanské vrchy Mts., Slanec, slopes under the ruins of the Slanec castle, 48° 38' 12.99" N 21° 28' 15.66" E

Slovenský raj region, Spišské Tomášovce, Tomášovský výhľad site, 48° 56' 42.3" N 20° 27' 34.3" E, Eliáš jun. 2017 NI

Slovenský raj region, Letanovce, Čertova sihoť hill, 48° 56' 42.9" N 20° 26' 25.2" E, Eliáš jun. 2017 NI

Slovenský raj region, Spišské Tomášovce, Tomášovský výhľad site, 48° 56' 42.3" N 20° 27' 34.3" E, Eliáš jun. 2017 NI

Strážovské vrchy Mts., Čierna Lehota, Sokolie skaly site, 48° 53' 01.4" N 18° 20' 31.1" E, Eliáš jun. 2003 NI

Strážovské vrchy Mts., Kostolec, Kavčia skala hill, 49° 07' 54.5" N 18° 31' 25.6" E, Palík 1997 NI

Štiavnické vrchy Mts., Lehôtka pod Brehmi, Szabóova skala site, 48° 32' 12.2" N 18° 48' 24.5" E

Štiavnické vrchy Mts., ruins of the Šášovský hrad castle, 48° 34' 44.2" N 18° 53' 58.2" E, Eliáš jun. 2017 NI

Veľká Fatra Mts., Blatnica, Tlstá hill, 48° 56' 02.3" N 18° 58' 17.0" E, Talapka 1996 NI

Veľká Fatra Mts., Necpaly, Borišov, 48° 56' 28.0" N 19° 05' 23.4" E, Talapka 1996 NI

Veľká Fatra Mts., Ružomberok, Malinô Brdo hill, 49° 03' 09.1" N 19° 16' 02.9" E

Veľká Fatra Mts., Ružomberok, Biely Potok city part, 49° 02' 55.6" N 19° 17' 52.5" E, Eliáš jun. 2015 NI

Cotoneaster melanocarpus agg.:

Czech Republic (1 locality)

Hostýnsko-vsetínská hornatina hills, Vsetín, Valova skála rock, 49° 21' 02.9" N 18° 01' 47.0" E

Hungary (12 localities)

Bükk Mts., Alsóhámar, Molnár-szikla hill, 48° 06' 42.8" N 20° 38' 52.2" E

Bükk Mts., Bélapátfalva, Bél-kő hill, 48° 02' 28.7" N 20° 22' 07.5" E

Bükk Mts., Uppony, SW slopes of Kalica-tető, 48° 12' 57.0" N 20° 26' 45.3" E

Cserhát Mts., Bér, Nagy hegy hill, 47° 51' 56.65" S 19° 28' 42.25" V

Cserhát Mts., Hollókő; Szár hegy hill, 47° 59' 12.5" N 19° 35' 50.3" E

Karancs-Medves hills, Salgóháza, Kis Salgó (Boszorkánykő) 48° 8' 24.40" N 19° 50' 57.86" E

Mátra Mts., Mátraalmás, ruins of the Gyala-vár castle, 47° 55' 31.40" N 19° 54' 24.65" E

Mátra Mts., Mátraháza, Sas-kő hill, 47° 52' 24.63" N 20° 1' 50.12" E

Mátra Mts., Mátrakerestes, Bárány-kő hill, 47° 54' 27.00" N 19° 49' 6.17" E

Mátra Mts., Sástó, 47° 50' 44.06" N 19° 56' 50.48" E

Mátra Mts., Tar, Fehérkő-bánya stone pit, 47° 57' 9.89" N 19° 45' 52.50" E

Zemplényi-hegység hills, Hejce, Sólyom-kő hill, 48° 26' 12.7" N 21° 19' 09.5" E

Poland (2 localities)

Pieniny Mts., Falsztyn, Zielone Skałki hills, 49° 25' 55.5" N 20° 17' 40.5" E

Pieniny Mts., Trzy Korony, Okraglica 49° 24' 50.4" N 20° 24' 49.8" E

Slovakia (16 localities)

Biele Karpaty Mts., Vršatské Podhradie, ruins of the Vršatec castle, 49° 03' 55.9" N 18° 09' 04.5" E

Muránska planina hills, Brdárka, Malý Radzim hill, 48° 46' 31.1" N 20° 19' 44.4" E

Malé Karpaty Mts., Driny hill, 48° 30' 03.3" N 17° 24' 14.3" E, Eliáš jun. 2014 NI

Malé Karpaty Mts., Buková, near ruins of the Ostrý Kameň castle, 48° 31' 20.0" N 17° 22' 24.2" E, Eliáš jun. 2010 NI

Podunajská nížina lowland, Čifáre, Podskalie site, 48° 14' 22.5" N 18° 25' 40.9" E

Podtatranská kotlina basin, Ružomberok, memorial of the Slovak National Uprising, 49° 03' 47.6" N 19° 18' 30.6" E

Považský Inovec Mts., Podhradie, ruins of the Topoľčiansky hrad castle, 48° 39' 29.6" N 18° 02' 59.8" E

Slanské vrchy Mts., Slanec, slopes under the ruins of the Slanec castle, 48° 38' 12.99" N 21° 28' 15.66" E

Slovenský kras karst, Gemerské Teplice, Stráň hill, 48° 36' 23.3" N 20° 16' 29.2" E

Slovenský kras karst, Silica, Sokolia skala site, 48° 32' 44.93" N 20° 33' 56.51" E

Strážovské vrchy Mts., Lietava, ruins of the Lietavský hrad castle, 49° 09' 36.8" N 18° 41' 03.1" E

Štiavnické vrchy Mts., Hontianske Nemce, Dianiš hill, 48° 18' 13.8" N 18° 58' 32.3" E

Nízke Tatry Mts., Hranovnica, Hranovnická dubina Nature Reserve, 49° 00' 26.8" N 20° 17' 09.0" E

Slovenský raj region, Spišské Tomášovce, Tomášovský výhľad site, 48° 56' 42.3" N 20° 27' 34.3" E, Eliáš jun. 2017 NI

Vtáčnik Mts., Podhradie, ruins of the Sivý Kameň castle, 48° 41' 08.8" N 18° 38' 19.8" E

Zvolenská kotlina basin, Víglaš, elevation point 419 m, 48° 33' 26.5" N 19° 17' 45.4" E

Cotoneaster tomentosus:

Slovakia (15 localities)

Kremnické vrchy Mts., Zvolen, Poštárka hill, 48° 33' 37.7" N 19° 05' 40.6" E, Galváneč 2018 NI

Malé Karpaty Mts., Devín, Devínska Kobyla hills, 48° 10' 54.9" N 16° 59' 04.5" E

Muránska planina hills, Muráň, Cigánka hill, 48° 45' 27.5" N 20° 03' 27.2" E, Baranec and Eliáš jun. 1999 NI

Nízke Tatry Mts., Liptovský Ján, near the cemetery, 49° 02' 35.6" N 19° 40' 45.0" E

Nízke Tatry Mts., Demänová, Siná hill, 48° 59' 58.9" N 19° 35' 15.7" E, Talapka 1996 NI

Nízke Tatry Mts., Svit, near the cemetery, 49° 03' 15.5" N 20° 12' 22.2" E

Oravská vrchovina hills, Oravský Podzámok, Oravský hrad castle, 49° 15' 46.9" N 19° 21' 32.9" E

Strážovské vrchy Mts., Rokoš – Košútova skala, 48° 46' 39.3" N 18° 26' 06.5" E, Eliáš jun. 2003 NI

Strážovské vrchy Mts., Uhrovske Podhradie, Zrubiská site, 48° 44' 52.6" N 18° 23' 35.1" E, Eliáš jun. 2003 NI

Slovenský raj region, Spišské Tomášovce, Tomášovský výhľad site, 48° 56' 42.3" N 20° 27' 34.3" E, Eliáš jun. 2017 NI

Tribeč Mts., Partizánske, Podbralie site, 48° 37' 07.0" N 18° 21' 43.5" E, Eliáš jun. 2003 NI

Veľká Fatra Mts., Belianska dolina, near the cottage of Havranovo, 48° 58' 08.8" N 19° 04' 39.0" E, Širáň 2003 NI

Veľká Fatra Mts., Morávková hill, 48° 59' 48.9" N 19° 07' 59.8" E, Talapka 1995 NI

Veľká Fatra Mts., Folkušová, Pekárová hill, 48° 57' 28.4" N 18° 58' 07.9" E, Talapka and Jelšovský 1996 NI

Veľká Fatra Mts., Vlkolínec, 49° 02' 30.6" N 19° 16' 36.3" E, Baranec and Eliáš jun. 2003 NI