

Reticulate corm tunic characters in the genus *Crocus* (Liliiflorae, Iridaceae) and their taxonomical value

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Abstract: The systematic arrangement of the genus *Crocus* was mainly based on morphological features until the last revision of the genus by MATHEW (1982). This also includes the corm tunics with their diversity. New insights into this parameter could be gained indirectly through the reorganization of the genus using molecular genetics. In this work it can be shown that the reticulate corm tunics occur in a multitude of different shapes, compositions, sizes and combinations. The main aim of the present work is therefore to find the parameters that correspond to the molecular phylogeny in order to be able to better distinguish closely related species. Many of the examined and also newly defined parameters show full or very good agreement with molecular phylogeny and are therefore suitable for taxonomic differentiations.

Zusammenfassung: Die systematische Bearbeitung der Gattung *Crocus* basierte bis zur letzten Revision der Gattung durch MATHEW (1982) im Wesentlichen auf morphologischen Merkmalen. Hierzu gehören auch die Knollenhüllen mit ihrer Vielfalt. Neue Erkenntnisse bei diesem Parameter konnten indirekt durch die Neuordnung der Gattung mittels molekularer Genetik gewonnen werden. In dieser Arbeit kann gezeigt werden, dass die retikulaten Knollenhüllen in einer Vielzahl von unterschiedlichen Formen, Zusammensetzungen, Größen und Kombinationen vorkommen. Das Hauptziel der vorliegenden Arbeit ist daher, die Parameter ausfindig zu machen, die mit der molekularen Phylogenie übereinstimmen um mit diesen nahe verwandte Arten besser unterscheiden zu können. Viele der untersuchten und auch neu definierten Parameter zeigen eine volle oder sehr gute Übereinstimmung mit der molekularen Phylogenie und sind daher für taxonomische Differenzierungen geeignet.

Key words: *crocus*, reticulated corm tunic, new parameter, phylogeny

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INTRODUCTION

The genus *Crocus* is scientifically studied since more than 300 years and uncountable publications appeared since that time. However, some are really important dealing with the systematic relationships of species in the genus like e.g. by HERBERT (1847), MAW (1886), and MATHEW (1982). The time between these contributions is considerably long so that improved systems between them can be recognized but all of them are based on morphological and phenotypic characters and some even consider flowering time.

As molecular analysis became more widespread in botany, a new systematic gate opened which in many cases revealed more

necessary changes than existent knowledge could be confirmed, as is the case with the genus *Crocus*. The correlation between molecular results and morphological parameters of a species is evident. In cases where it is possible to define a species by molecular results it is also possible to find its morphological peculiarities - but not vice versa since morphological differences can be influenced by epigenetics, too. Unfortunately the genus *Crocus* presents itself with an extremely high infra-specific degree of variability which let some recent descriptors suggest that morphological differences between distant populations already represent different species. In plain English: without a molecular and/or karyological species definition it is not possible to define new species with certainty in *Crocus*.

Table 1: Investigated tunics of crocuses with their phylogenetic position and provenance.

taxonomic affiliation	species investigated	provenance
<i>Verni</i>	<i>C. etruscus</i>	HKEP 1310, I, Massa Maritima, type area
	<i>C. ilvensis</i>	HKEP 1919, I, Elba, type area
	<i>C. longiflorus</i>	HKEP 1622, I, Sicily, Etna, Zafferana, type area
	<i>C. longiflorus</i>	HKEP 1623, I, Sicily, Tarderìa
unplaced in Sect. <i>Crocus</i>	<i>C. ligusticus</i>	HKEP 1402, I, Liguria, Comuneglia
Ser. <i>Crocus</i>	<i>C. thomasii</i>	HKEP 1317, I, Monte Gargano, Rignano
	<i>C. thomasii</i>	HKEP 1326, I, Puglia, Martina Franca
	<i>C. hadriaticus</i>	HKEP 1818, GR, Lefkada, type area
Ser. <i>Crocus</i>	<i>C. baytopiorum</i>	HK 1988/3, TR, Antalya, Karaculha
<i>Reticulati</i> ¹	<i>C. variegatus</i>	HKEP 1311, I, Latium, Corvaro
	<i>C. variegatus</i>	HKEP 1315, I, L'Aquila, Barisciano
	<i>C. danubensis</i>	HKEP 1344, SRB, Negotin, type
	<i>C. ancyrensis</i>	HKEP 0927, TR, Divriği
	<i>C. micranthus</i>	HKEP 0919, TR, Cilician gate, type area
	<i>C. micranthus</i>	HKEP 1351, TR, Mersin, Bolkar Dağları, type area
	<i>C. filis-maculatis</i>	HKEP 1357, TR, Adana, Aladağlar, type locality
	<i>C. hittiticus</i>	HKEP 0037, TR, Gülnar, type area
	<i>C. hittiticus</i>	HKEP 1112, TR, Güzeloluk
<i>C. sieberi</i> group	<i>C. sublimis</i>	HKEP 1720, GR, Evvia, Dyrphis, type area
	<i>C. atticus</i>	HKEP 1608, GR, Attica, Pendeli, type area
	<i>C. nivalis</i>	HKEP 1735, GR, Peloponnes, Taygetos, type area
	<i>C. dalmaticus</i> cf.	HKEP 1828, ALB, Kruja
	<i>C. robertianus</i>	HKEP 1728, GR, Nafpaktos
unplaced in Sect. <i>Crocus</i>	<i>C. niveus</i>	HK 1989/34, GR, Peloponnes, Mani Peninsula
<i>C. cancellatus</i> group	<i>C. cancellatus</i>	HKEP 1354, TR, Pozanti, near type area
	<i>C. damascenus</i> cf.	HK 1989/23, TR, Mazıkıran Geç.
	<i>C. damascenus</i> cf.	HKEP 1543, IRI, Alligudarz
	<i>C. lycius</i>	HKEP 9284, TR, Elmalı, type area
	<i>C. mazziaricus</i>	HKEP 1817, GR, Levkas island, type area
<i>Orientales</i>	<i>C. michelsonii</i>	HKEP 1556, IRI, Faruj
<i>C. serotinus</i> group	<i>C. serotinus</i>	HKEP 1379, PT, Algarve, Sagres
	<i>C. serotinus</i>	HKEP 1372, E, Andalusia, Hinojos
<i>Carpetani</i>	<i>C. carpetanus</i>	HKEP 1559, E, Castile, Navacerrada, type
unplaced in Sect. <i>Nudiscapus</i>	<i>C. gargaricus</i>	HKEP 0208, TR, Muğla
<i>Aleppici</i>	<i>C. fleischeri</i>	HKEP 0205, TR, İzmir, type area

¹(lit)

The high number of new species and their often near relationships represents, together with an almost infinite spectrum of morphological and phenotypical varieties, a difficult task to separate them. All new species recently described have now to be checked molecularly before integration into the genus to see

if they are not identical to species already described which unfortunately is the case and could be proofed several times. This will be a detailed matter in our revision of the genus.

In the course of the work on a revised system of *Crocus* also a contrary situation to the one described above occurs quite of-

ten where only little morphological or phenotypical differences appear between near allied but molecularly secured species. This can make their recognition difficult and for describing these species it is necessary to find their characteristics in which they differ. This means to look closer at former often neglected or not known morphological details and increase the number of parameters for descriptions significantly. The ones presented here belong to the corm tunic, still a parameter in which characteristics to better distinguish crocuses are hidden.

The kind of corm tunic is an important feature in the genus and was used by several authors to separate some major groups of species and was, until the knowledge of detailed genetic alliance between species came to light, one of the more important morphological parameters to define series in the genus like e.g. series *Reticulati*. As our genetic results show, series and species correspond well to certain details of this parameter. Important is to mention, that reticulated corm tunics can be found in section *Crocus* and section *Nudiscapus* but “annulate” corm tunics, having rings at base, only exist in section *Nudiscapus*. Also, in a broader sense, the differentiation into these sections also reflects a correlation between this morphological parameter and the molecular genetics.

Reticulate corm tunics in *Crocus* are found in several series of the genus, although not every species of an otherwise „reticulate“ series has to have a reticulate tunic or vice versa. Most of the species considered here have distinctly reticulate main tunics but sometimes only anastomosing ones towards the apex and otherwise mostly parallel fibres or bands to the basal tunic and the neck. Neck fibres are in all investigated species always parallel and never netted. The following series are considered here with selected species (Tab. 1). The investigation of basal tunics and main tunics is not to a 100% congruent because material was lacking in very few cases. It might be also surprising that *C. fleischeri* is included in the comparison but its tunic revealed interesting properties which were previously overlooked.

COMPARISON OF BASAL TUNICS

“The tunics of crocuses are homologous with the foliage.... the expanded bases of the proper-leaves and sheathing-leaves, with a structure adapted to the protection of the new corm as it annually expands” (MAW 1886). The term “basal tunic” was also introduced by him: “In the early stages of the new growth, the foliage completely environs the incipient corm, and is articulated to its base within the mass of the old corm. As the new corm becomes free from the parent mass and expands, the main tunic, forming the base of the foliage, disarticulates from the base of the corm in successive layers, and slips upwards (Fig. 19.4); this would leave the bottom of the corm exposed, but for the existence of an organ I have termed the “basal tunic”....it would represent a number of growth points (Fig. 19.1) united together at the base and adhering the base of the corm....” To these findings of Maw some of our results can be added as a) in several species not all successive (annual) layers of the tunic can be separated from one another, as they are interconnected to one or more older layers, b) not every reticulate species has a basal tunic with wiry star-like rays which is documented in Figs. 1-7.

RESULTS

The results of the investigated basal tunics show a wide spectrum of morphological differences which is divided into the following main groups:

1. The basal tunic consists mainly of the central disc, embedded in a flat, often irregularly shaped conglomerate of earlier basal tunics. This shape arises when the new corm expands and the fibre connections with the main tunic, more or less single and filiform in this part, are almost all torn off from the basal tunic (Fig. 19.3)
2. The mostly non-reticulated thread-like main fibres in the base area are individually or in bound groups of 2-3 fibres connected to the central disc, often with a residual membrane in between around the central disc (Fig. 19.3). If the new corm expands as it grows and the fibre connections break mainly at the central disc, remnants appear similar to those in case one (Fig. 19.3). If they break mainly at some distance from the central disc, in consecutive years star-shaped structures of the basal tunic may appear as remnants (Fig. 19.2).
3. Single fibres of the main tunic widen and connect at their ends to build a ring that is firmly connected to the central disc of the new tunic. If the new corm expands as it grows, the rings from the previous year break and their fragments are pulled upwards (Fig. 19.6). The expansion pressure of the growing corm only can tear off fibres of the main tunic in some distance to the ring which creates star-shaped structures of the basal tunic.
4. The new ring and all of the rings from earlier years are stable and not firmly attached to the central disc. Two things can happen more or less simultaneously as the new corm is expanding. The fibres of the main tunic break in some distance from the basal tunic and the stable rings are detached from the central disc as a whole in which the remnant fibres of the main tunic build teeth around it. (Fig. 6).

Group 1 can be found in series *Crocus* (*C. thomasi*, *C. hadriaticus*, and *C. baytopiorum*), in *C. michelsonii* (series *Orientalis*), in *C. serotinus* (*Serotini* group), in *C. carpetanus* (series *Carpetani*) and in *C. gargaricus* (currently unplaced in section *Nudiscapus*; found in a separate position in the phylogenetic position).

Group 2 is represented by species of series *Verni* (*C. etruscus*, *C. ilvensis*, *C. longiflorus*) and *C. ligusticus*, and the *C. sieberi* group (all investigated ones).

Group 3 is found only in series *Reticulati* (all investigated species).

Group 4 is found only in *C. cancellatus* group (all investigated species).

DISCUSSION

To figure out correlations of molecularly established series and the morphological results a comparison was made between both (Fig. 20). It is interesting to see how the groups are distributed in the phylogeny (colours of groups are equivalent to colours in the phylogeny).

Except for species of series *Scardici* and *C. abantensis*, which could not be investigated, all series of the genus with species having reticulated tunics were compared. Reticulated corm tunics neither build the majority in section *Crocus* nor in section *Nudiscapus*. In section *Crocus* only one or few members in the investigated series have reticulated corm tunics with the exception of the *C. sieberi* group (including *C. niveus*) in which all members have reticulated tunics. The *Crocus sieberi* group is quite remarkable as it is the only series in section *Crocus* in which the members have no prophyll which is of course contradictory to the present morphologically based system with two sections. In one a prophyll is present (section *Crocus*) and in the other one it is absent (section *Nudiscapus*). This will certainly be taken into account in a new system for *Crocus*.

In section *Nudiscapus* the situation is comparable in having only two series with reticulate corm tunics (series *Reticulati*; new circumscription, HARPKE et al. (2014) and the *Cancellati* group), including the somewhat isolated positioned species *C. gargaricus* and *C. abantensis*. Members of series *Reticulati* and *C. cancellatus* group have distinctly reticulate corm tunics but with significant differences concerning their basal tunics as are described in the groupings.

The relationship of *C. cancellatus* and its relatives, all of which have fibrous reticulate corm tunics, with members of series *Reticulati* (in the revised sense) seems to be much closer than to species of series *Speciosi* or *Biflori*, both with annulated corm tunics. As can be seen molecular phylogenetic groupings (Fig. 20) show a very different picture.

C. cancellatus and relatives are in fact closely allied to and attached directly to species of series *Speciosi* and *Biflori* and are genetically quite distant to other series with reticulate corm tunics (Fig. 20). Up to now, from the morphological point of view, the close relationship of these three series was not explainable. The toothed basal corm tunic rings only to be found with all relatives of *C. cancellatus* provide now a distinct morphological connection to series *Biflori* and *Speciosi* which is much closer than previously assumed. The teeth on rings of annulated species are, if present, mostly not as long as in species of *C. cancellatus* group as can be seen in the comparison with *C. incognitus* an annulated species of section *Nudiscapus* (Fig. 19.7). Last but not least the finding that stable annulated rings only exist in section *Nudiscapus* is again proofed but in a broader sense now.

COMPARISON OF MAIN TUNICS

Earlier systematic work on *Crocus*, where the type of tunic was used for taxonomic separation of groups or species, primarily the state of the main tunic was considered. For a complete description of the tunic, of course, basal tunic and main tunic are required. For this reason, we document the main tunic of almost all reticulated tunics in the genus from the side, from above and from below. As with basal tunic, there are still hidden traits that are of taxonomic value. The aim of this work is to find and document them. We concentrate on the following properties, the reticulated area of the tunic type, of fibre connection to the basal tunic, the nature of individual (annually accumulated) tunic layers, and the size and type of net space. In most cases of the investigated samples the basal tunic is not attached to the main tunic anymore but how it was connected can be still characterized by the resulted parts of the division.

RESULTS

According to our findings the reticulated area of the tunic around the corm is divided in three groups (Tab. 2):

1. The tunic is (almost) reticulated throughout or only the fibres close to the base are not reticulated.

Series *Verni* (*C. longiflorus* HKEP 1625, *C. ligusticus*), series *Reticulati* (new circumscribed) (*C. variegatus* HKEP 1311, *Sieberi* group (*C. nivalis*, *C. dalmaticus*, *C. robertianus*), *Cancellati* group (*C. cancellatus*, *C. damascenus*, *C. lycius*, *C. mazziaricus*), and *C. serotinus*.

2. The upper 2/3 of the tunic is reticulated.

Series *Verni* (*C. etruscus*, *C. longiflorus* 1622), series *Crocus* attached (*C. baytopiorum*), series *Reticulati* (*C. variegatus* HKEP 1315, *C. danubensis*, *C. ancyrensis*, *C. micranthus* 1351, *C. filis-maculatis*), *C. carpetanus*, and *C. fleischeri*.

3. The upper 1/2 of the tunic is reticulated.

Series *Verni* (*C. ilvensis*), series *Crocus* (*C. thomasii*, *C. hadriaticus*), series *Reticulati* (*C. micranthus* HKEP 0919, *C. hittiticus*), *Sieberi* group (*C. sublimis*, *C. atticus*), *Sieberi* group attached (*C. niveus*), *C. michelsonii*, and *C. gargaricus*.

DISCUSSION

Most of the species having reticulated corm tunics are found in group two and three in which the reticulated tunic covers only 2/3rd or 1/2 of the corm. Reticulated corm tunics throughout are confined to some species of series *Verni* and *Reticulati* and to all investigated species of *Sieberi* group and *Cancellati* group. In all investigated species of all groups the non-reticulate parts surprisingly have in most cases parallel fibres, only very few have anastomosing or reticulate ones to the basal tunic as this is documented in Figs. 8-18 and Tab. 2. As the results show, the coverage of the corm with reticulated tunics is not correlated to systematic units, which means that different coverages occur independently of the position of the species in the molecular phylogeny.

C. fleischeri still has an outstanding position but in a different sense now. Its fibres are not interwoven as single ones but are netted and build a very complex three dimensionally interwoven net which connects two or more annual tunic layers (Fig. 19.8). Its interwoven fibres are angled at 90 degrees at regular intervals which seems unique in the genus. According to molecular results its place in the phylogeny is in series *Aleppici*. Other members of this series like *C. veneris*, *C. aleppicus* and *C. boulosii* have more or less membranous corm tunics often with parallel fibres in between. A closer inspection of the tunic of *C. veneris* revealed anastomosing fibres similar to those of *C. fleischeri* although much less frequent (Fig. 19.12). There is another similarity between *C. fleischeri* and *C. boulosii* as both have fairly yellow corms, a feature only to be found in this series.

TYPE OF FIBRE CONNECTION FROM THE MAIN TO THE BASAL TUNIC

If the new corm expands as it grows the main fibres can break at the central disc, a little bit above it or from a ring which

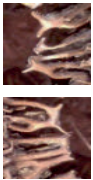
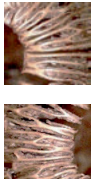
Table 2: Characters of reticulated corm tunics.

<i>Crocus</i>	area of reticulated tunic fibres around the corm	fibre connection to the basal tunic			basal discs surrounded by rings	single or interwoven reticulated layers	net-space +/- regular (r) or irregular (ir)	size of net-space
Figure 8								
<i>etruscus</i> HKEP 1310	upper 2/3 reticulated, lower 1/3 mixed with parallel fibres		single or up to 3 fibres combined broadening at end		formerly connected to central disc	no	(r) broadens from apex to base	medium
<i>ilvensis</i> HKEP 1919	upper 1/2 reticulated, parallel towards the base		mostly single or two fibres joined, slightly broadened at end		formerly connected to central disc	no	(ir) broadens and opens towards base	medium
<i>longiflorus</i> HKEP 1622	upper 2/3 reticulated, lower 1/3 parallel fibres		many filiform parallel fibres combined at end		formerly connected to central disc	no	(ir) longer and partly opening towards base	medium
Figure 9								
<i>longiflorus</i> HKEP 1625	reticulated throughout		3-6 fibres distinctly combined before connected to a broad bases		formerly connected to central disc	no	(ir) all over the tunic	medium
<i>ligusticus</i> HKEP 1402	reticulated throughout		single or two fibres connected, not broadening at end		formerly connected to central disc	no	stretched vertically	medium
<i>thomasi</i> HKEP 1317	upper half reticulated, lower half parallel fibres, slightly anastomosing		many filiform parallel fibres combined to bundles		formerly connected to central disc	no	(ir) upper half	small
Figure 10								
<i>hadriaticus</i> HKEP 1818	upper 1/2 reticulated, lower half parallel, fibres slightly anastomosing		mostly single filiform fibres not combined or connected		formerly connected to central disc	no	(ir) decreasing towards the middle	small
<i>baytoplorum</i> HK 1988/3	upper 2/3 reticulated, lower 1/3 parallel		single or two fibres connected, no broadening at end		formerly connected to central disc	no	(ir) opening towards the base	medium
<i>variegatus</i> HKEP 1311	reticulated throughout		2-5 fibres partly combined connected to wide ring parts		formerly connected to a basal ring	yes	(r) +/- oval	medium
Figure 11								
<i>variegatus</i> HKEP 1315	upper 2/3 reticulated, lower 1/3 parallel, anastomosing		mostly single broad fibres widening at end		formerly connected to a basal ring	yes	(r) opening towards base	medium
<i>danubensis</i> HKEP 1344	upper 2/3 reticulated, lower 1/3 parallel		mostly single narrow fibres widening at end		formerly connected to a basal ring	yes	(r) becoming larger and opening towards base	medium
<i>ancyrensis</i> HKEP 0927	upper 2/3 reticulated, lower 1/3 parallel		single or several fibres connected broader at end		formerly connected to a basal ring	yes	(r) becoming larger towards middle and then opening	medium

Table 2: Continued.

[illegible]

Table 2: Continued.

Figure 16	<i>damascenus</i> cf HK 1989/23	almost reticulated throughout	fibres more parallel towards the end	 	connected to basal rings	yes, loose rings with teeth	single	long at end rounded cells	large
	<i>damascenus</i> cf HKEP 1543	almost reticulated throughout	fibres more parallel towards the end	 	connected to basal rings	no, rings are loose with teeth	single	(r) rhombus-like (depressed)	very large
	<i>lycius</i> HKEP 9284	almost reticulated throughout	fibres more parallel towards the end	 	connected to basal rings	yes, loose rings with teeth	single	(r) long at end rounded cells	large

surrounds the central disc. Depending on these different kinds of previous connections it results in different shapes of the fibre-ends of the main tunic (Tab. 2). Basically the following cases can be distinguished.

RESULTS

1. The fibers of the main tunic, which are mostly parallel and filiform in their lower parts, are connected to the central disc in the early stages of the growing corm. As the new corm grows, the fibers of the main tunics are constantly stretched, which is possible for a longer period of time due to the flexible reticulate structure of the tunic. If the stretch becomes too strong, individual or connected fibers of the main tunic tear off from the basal tunic or central disc.
2. The fibers of the main tunic are not filiform and usually widen and connect at their lower ends to the central disc. They may also be connected to a ring around the central disc. As the new corm expands, the fibre-connections to the central disc or to the ring can break into separate pieces which are pulled upwards with the main tunic a little bit every season (Fig. 19.5 and 19.6).

DISCUSSION

Case one is found with the following crocuses: series *Crocus* and attached species (*C. thomasi*, *C. hadriaticus*, *C. baytopiorum*), all investigated species of the *Sieberi* group and attached *C. niveus*, *C. michelsonii*, *C. serotinus*, *C. carpetanus*, *C. gargaricus*, and *C. fleischeri*. The broken fibre-ends of their main tunics are more or less alike (broken threads) and of no taxonomic value.

In case two are species with different types of broken fibre-ends. They almost all belong to section *Nudiscapus* (series *Reticulati* and the *C. cancellatus* group) except for one series of section *Crocus*, series *Verni* (*C. etruscus*, *C. ilvensis*, *C. longiflorus* HKEP 1622/1625). Most interesting is that the fibre-ends of these species can have different shapes which are of taxonomic value (table 2) and can be used as additional distinguishing parameter for taxa. These results show that, for the most part, there is also a phylogenetic separation of species with different fibre-ends from those with the same, since they all belong to section *Crocus*.

TYPE OF NET-SPACES

The net-spaces of reticulated corm-tunics can be differentiated in terms of size, regularly or irregularly shaped net-spaces, and whether the layers built annually are individual (separable) or interwoven (not separable without destruction). Detailed results for these parameters are presented in table 2.

It is noteworthy that several species with a reticulate corm tunic have interwoven nets, which was not previously recognized. The interwoven nets are comparable to those of *C. fleischeri* but there are differences in the net spaces and the fibre arrangement, which in *C. fleischeri* is very regular because the fibres are angled at around 90 degrees at regular intervals, probably build

very complex and large 3-dimensional net-spaces connected over several layers of tunics (Fig. 19.11). Interwoven reticulated fibres are found in *C. thomasi*, *C. hadriaticus* (series *Crocus*), *C. michelsonii* (series *Orientalis*), *C. serotinus* (*Serotini* group), *C. carpetanus* (series *Carpetani*), and *C. fleischeri* (series *Aleppici*). All of those belong to section *Crocus* except for *C. fleischeri* which is attached to series *Aleppici* and therefore belongs to section *Nudiscapus*.

Most species have medium-sized net-spaces, the ones of *C. thomasi*, *C. hadriaticus*, and *C. niveus* are small, those of *C. robertianus*, *C. cancellatus*, *C. damascenus*, *C. lycius*, *C. mazzaricus*, *C. michelsonii*, *C. serotinus*, (*C. carpetanus*), and (*C. fleischeri*) are large or very large. An interesting connection arises from the fact that all species of the *Cancellati* group have the largest net-spaces in addition to their rings.

CONCLUSION

The reticulated corm tunics of the genus *Crocus* come in a variety of different shapes, arrangements, sizes, and combinations. The main goal of this work was to find parameters of those correlating with the molecular phylogeny in order to better distinguish closely related species morphologically. Many of the parameters examined show full or partial agreement with molecular phylogeny (Fig. 20) and are therefore suitable for morphologically based differentiations of taxa. Most impressive are of course the toothed “annulated” rings at the basal tunic of all

species of the “*Cancellati*” group and the different fibre-ends of species belonging to series *Reticulati*, the “*Cancellati*” group, and series *Verni*. Important is also the finding of interconnected annual tunic layers of several species which was previously not known. Of lesser taxonomic value is the surface covered by reticulated fibres, and the kind and size of the net-spaces.

ACKNOWLEDGEMENTS

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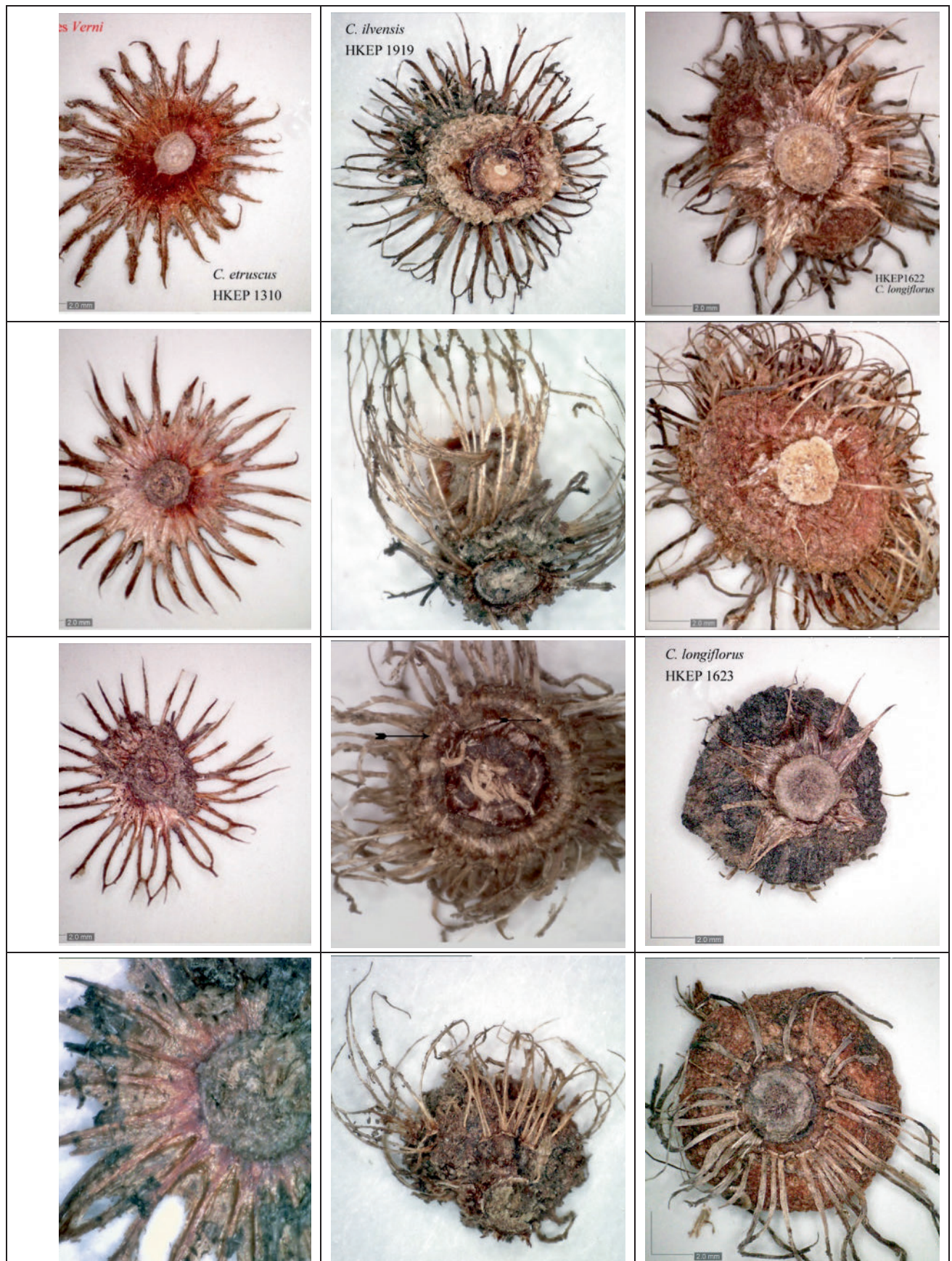


Fig. 1: Basal tunics of species of series *Verni*.



Fig. 2: Basal tunics of species of series *Verni* attached, *Crocus*, and *Reticulati*.



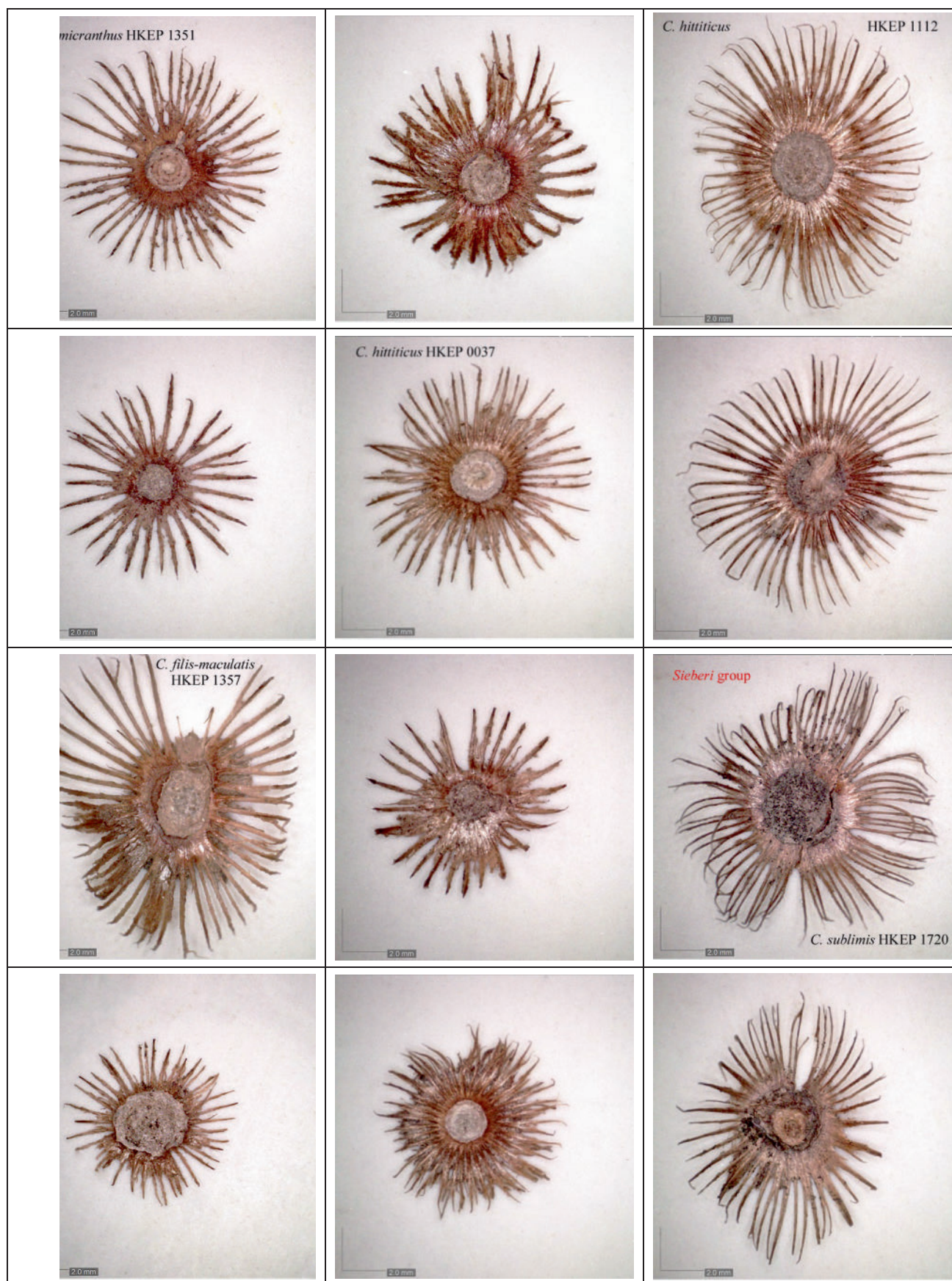


Fig. 4: Basal tunics of species of series *Reticulati* and *Sieberi* group..

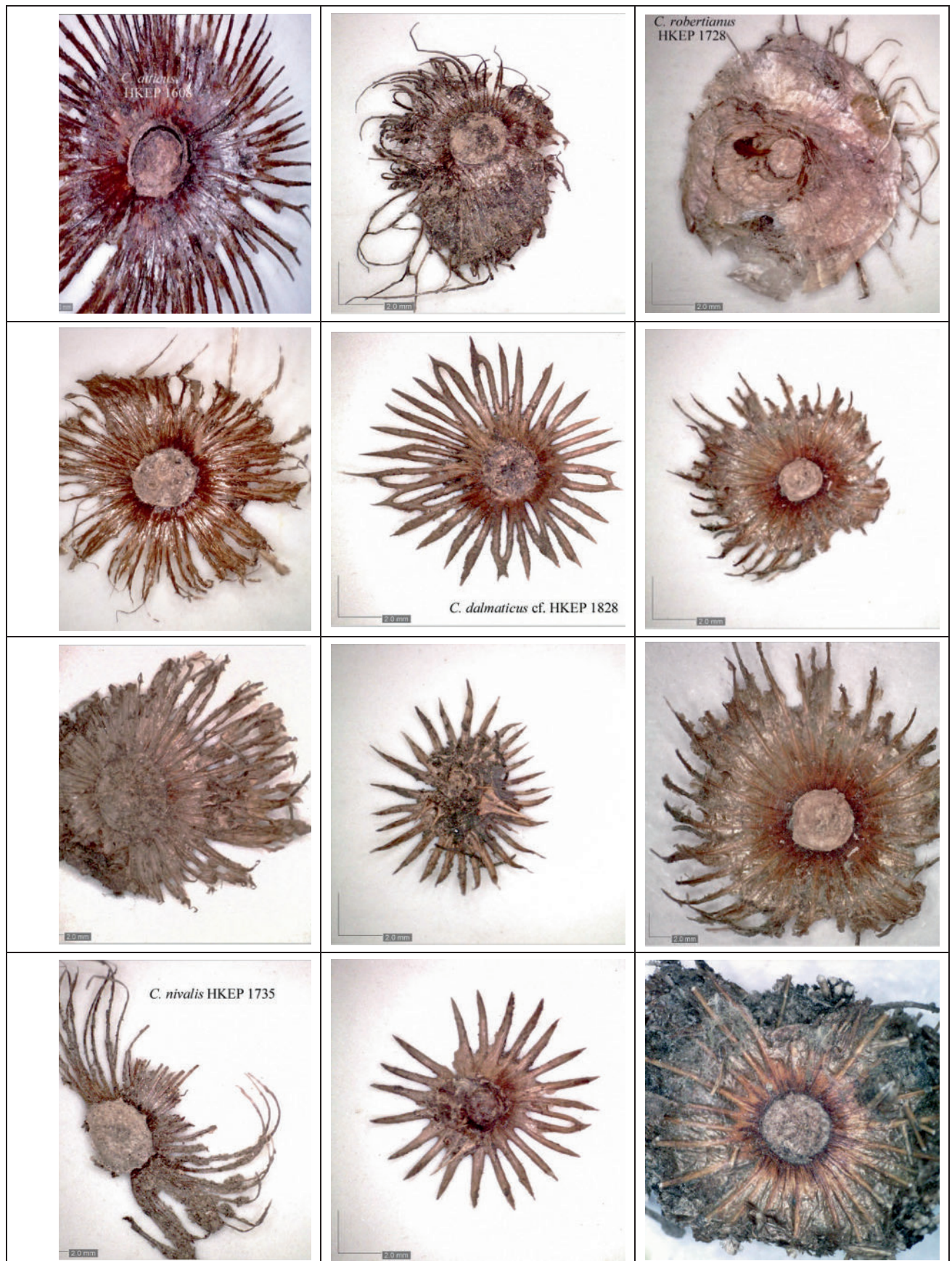


Fig. 5: Basal tunics of species of *Sieberi* group.

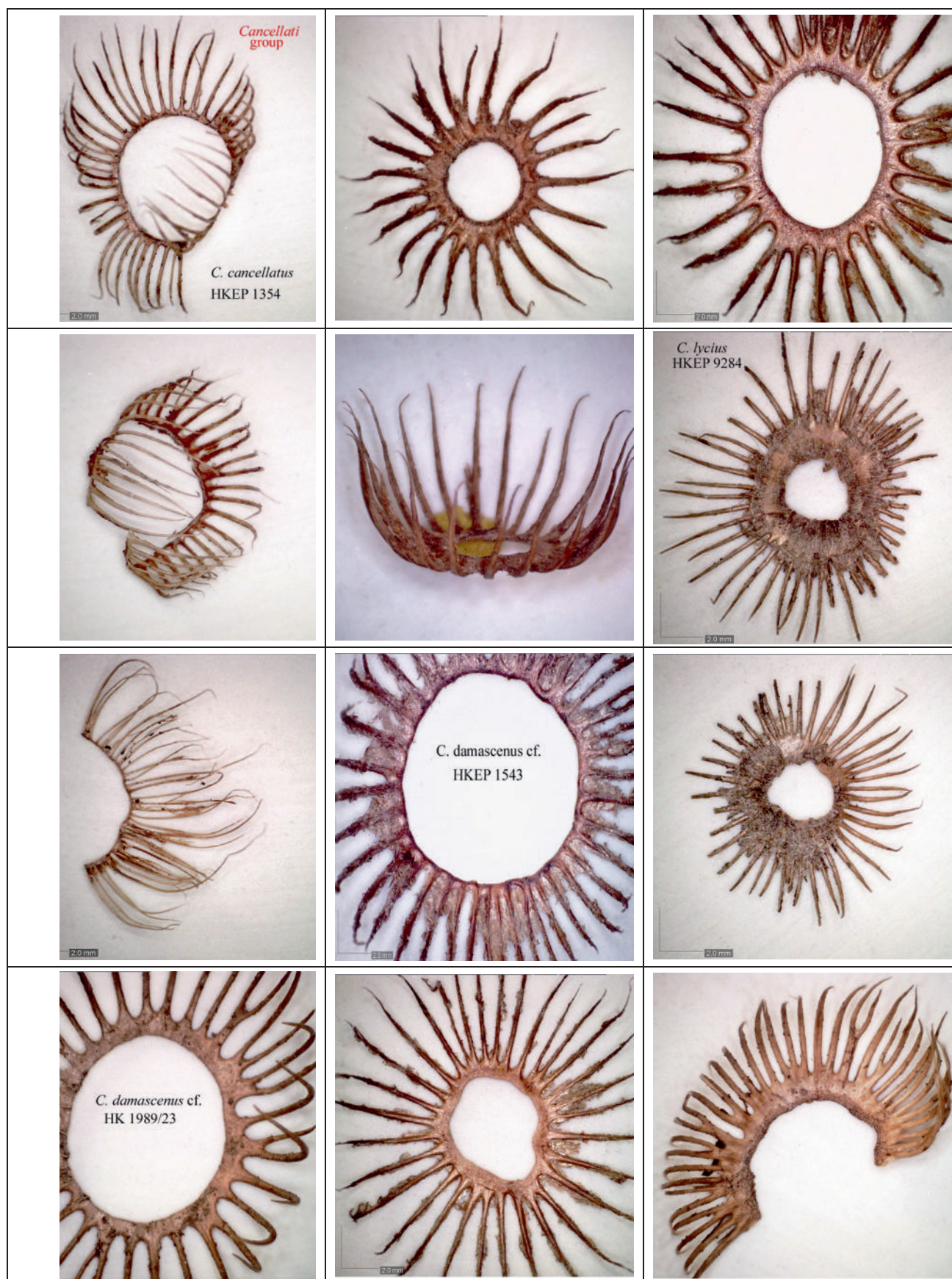


Fig. 6: Basal tunics of species of *Cancellati* group.

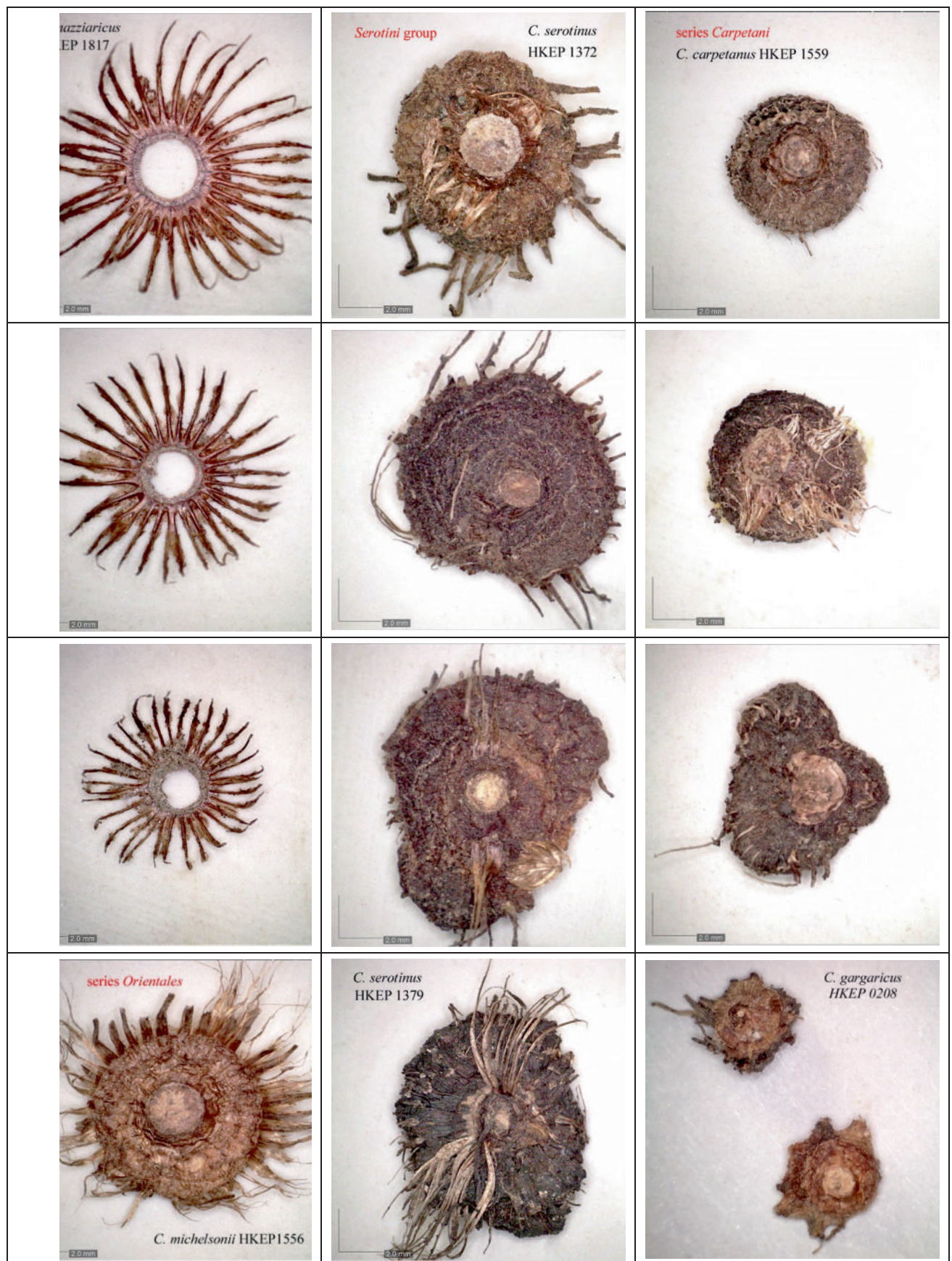
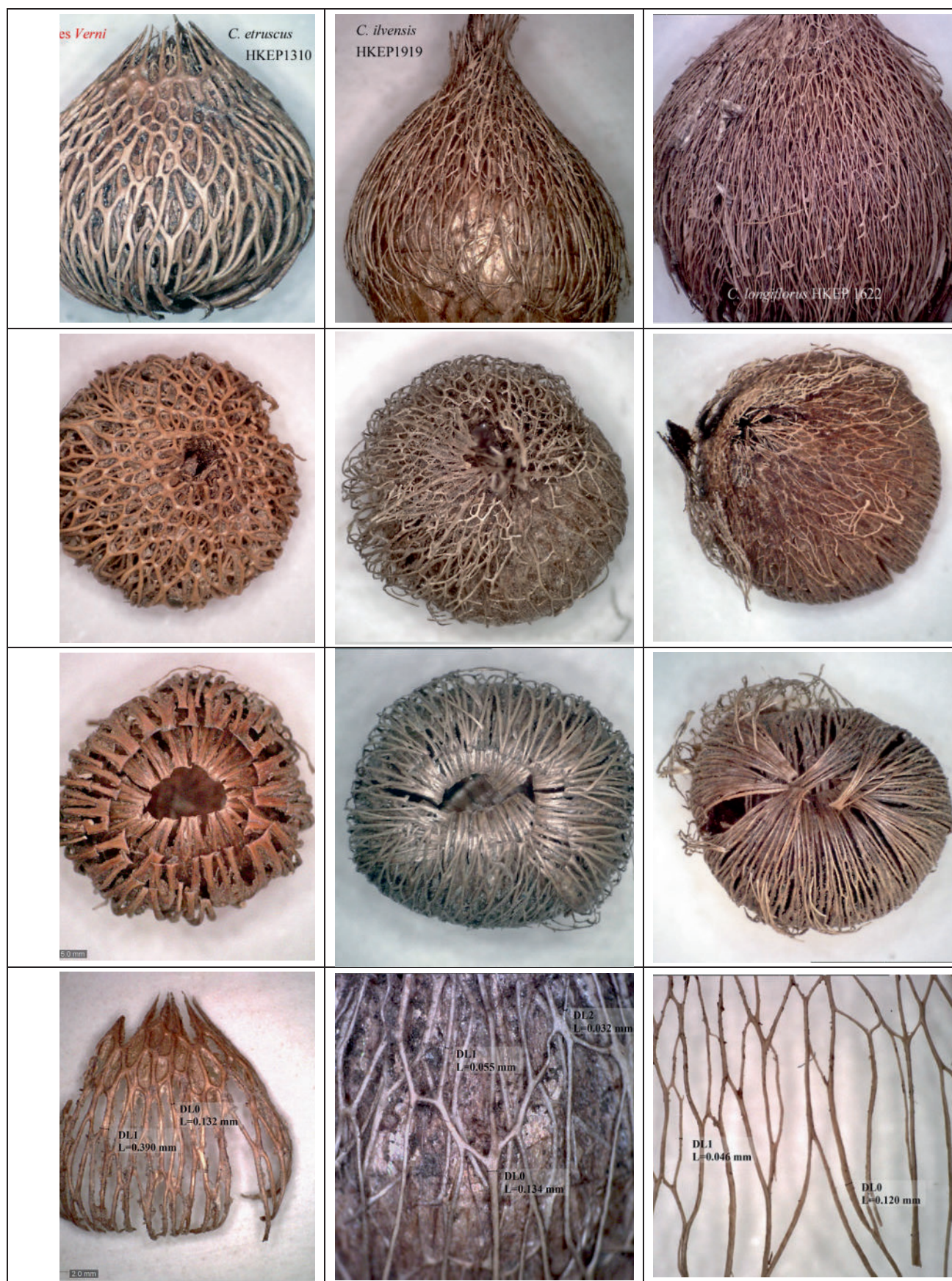


Fig. 7: Basal tunic characters of species of *Cancellati* group, series *Orientales*, *Serotini* group, and *C. gargaricus*.

Fig. 8: Main tunics of species of series *Verni*.

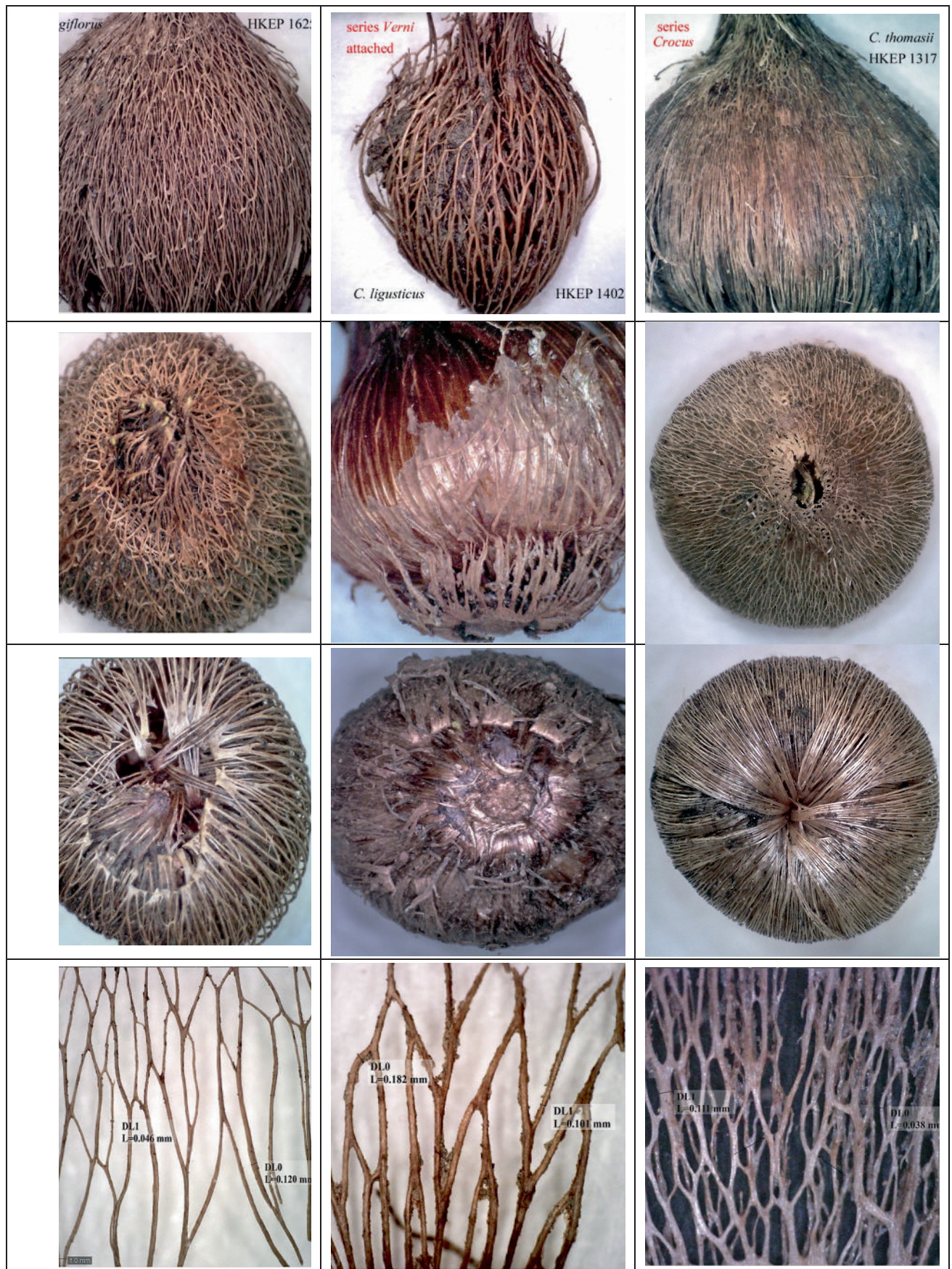


Fig. 9: Main tunics of species of series *Verni* attached, and series *Crocus*.

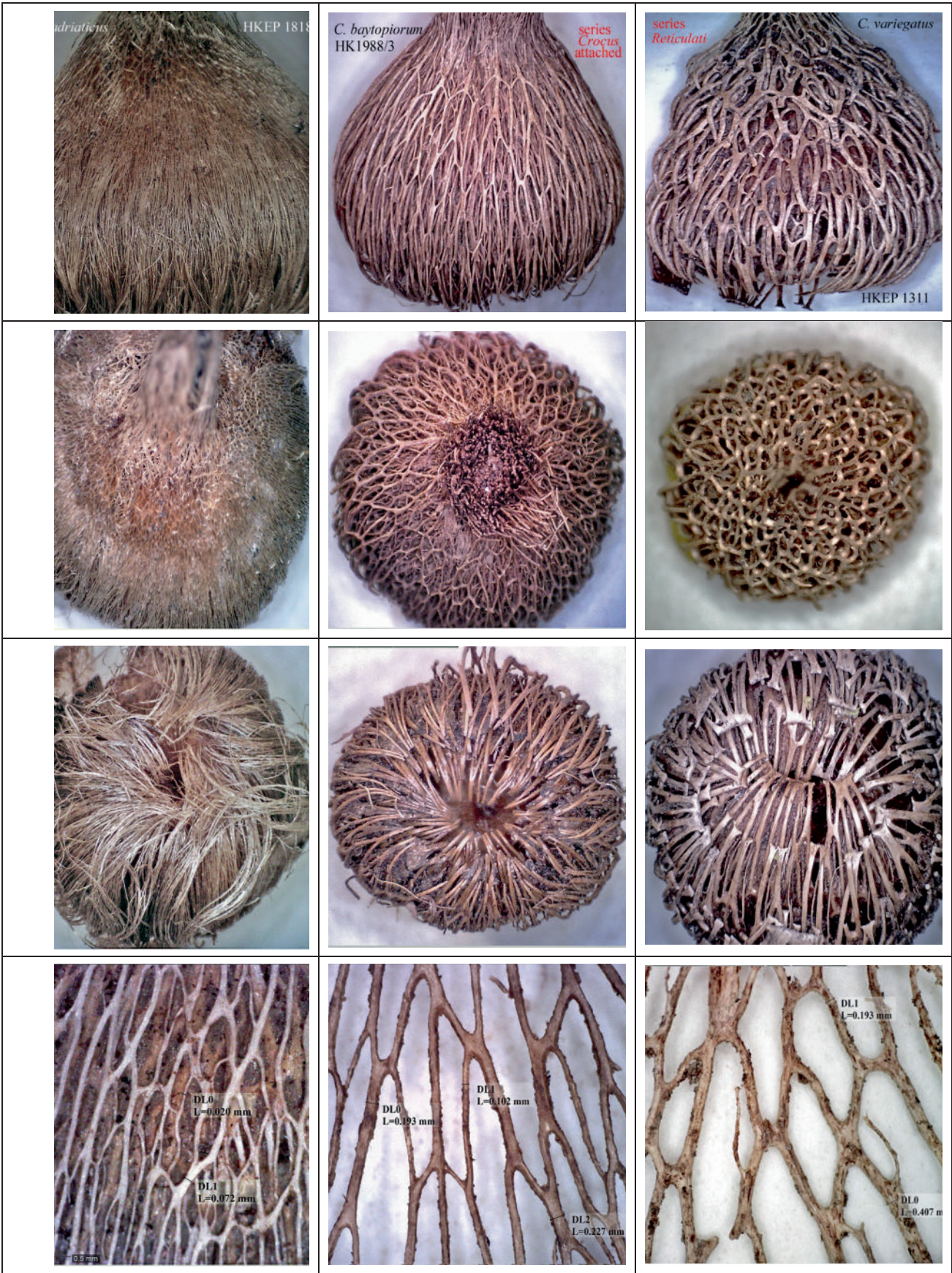


Fig. 10: Main tunics of species of series *Crocus* and *Reticulati*.

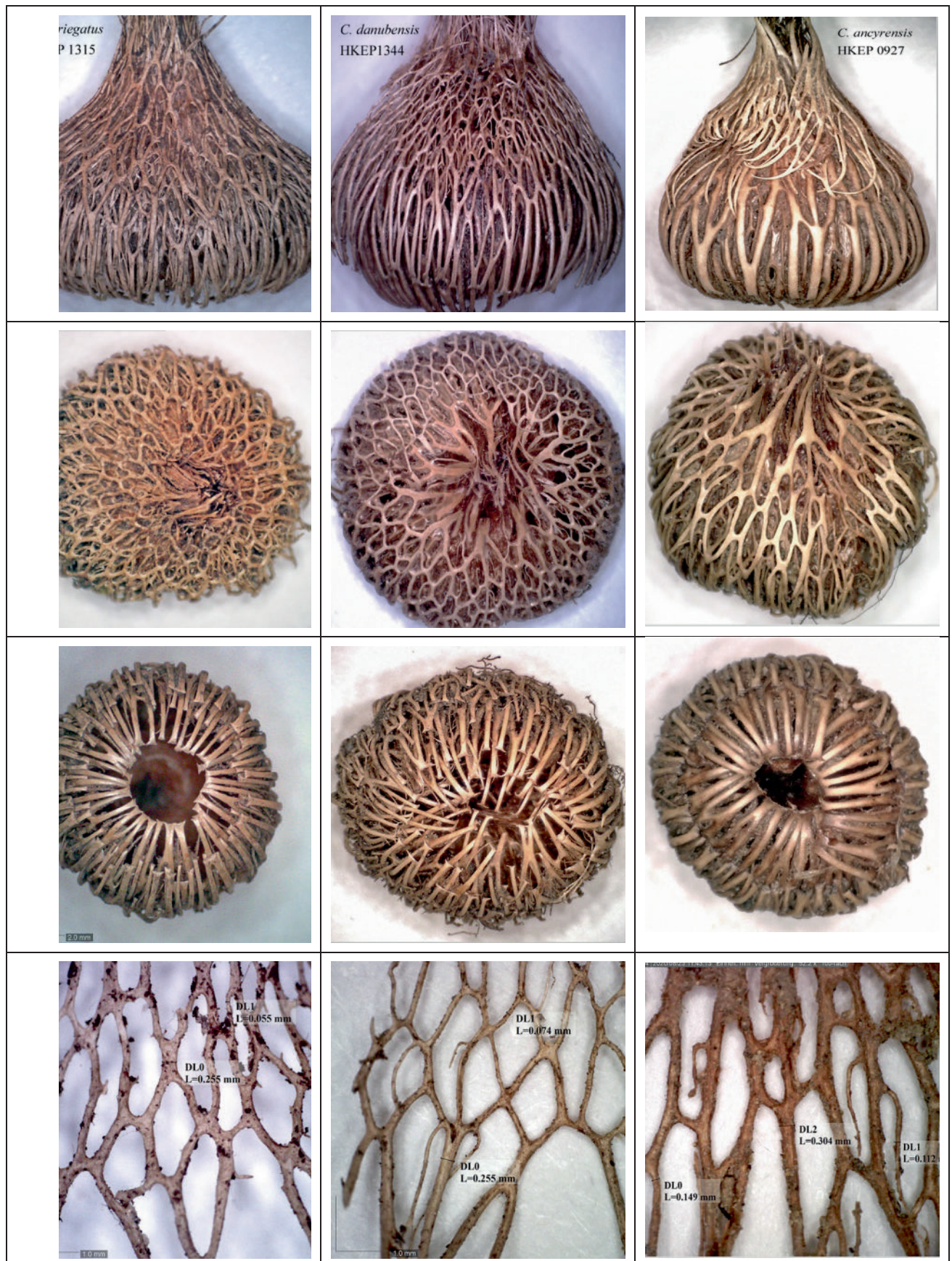
Fig. 11: Main tunics of species of series *Reticulati*.



Fig. 12: Main tunics of species of series *Reticulati*.

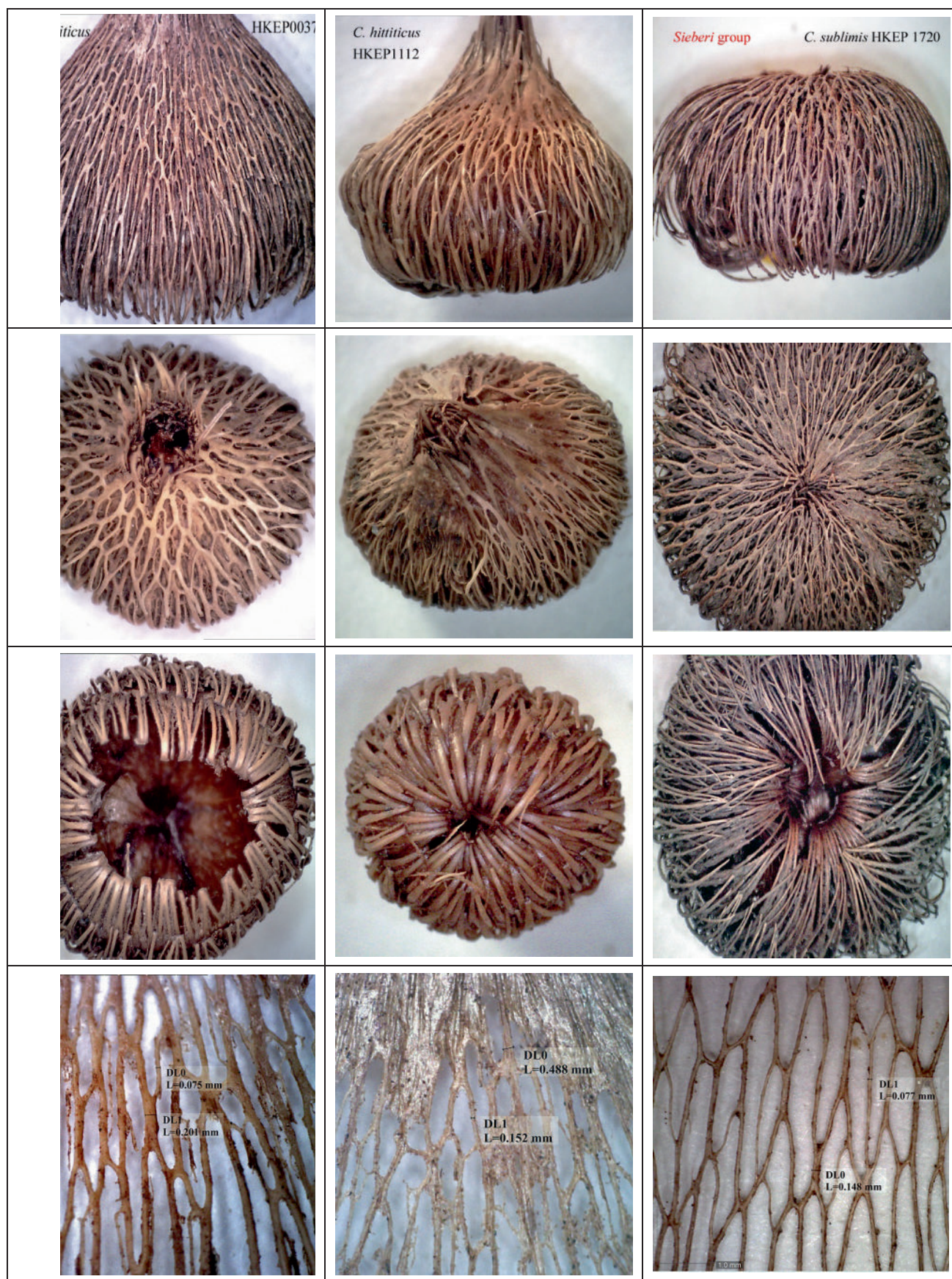


Fig. 13: Main tunics of species of series *Reticulati* and *Sieberi* group.

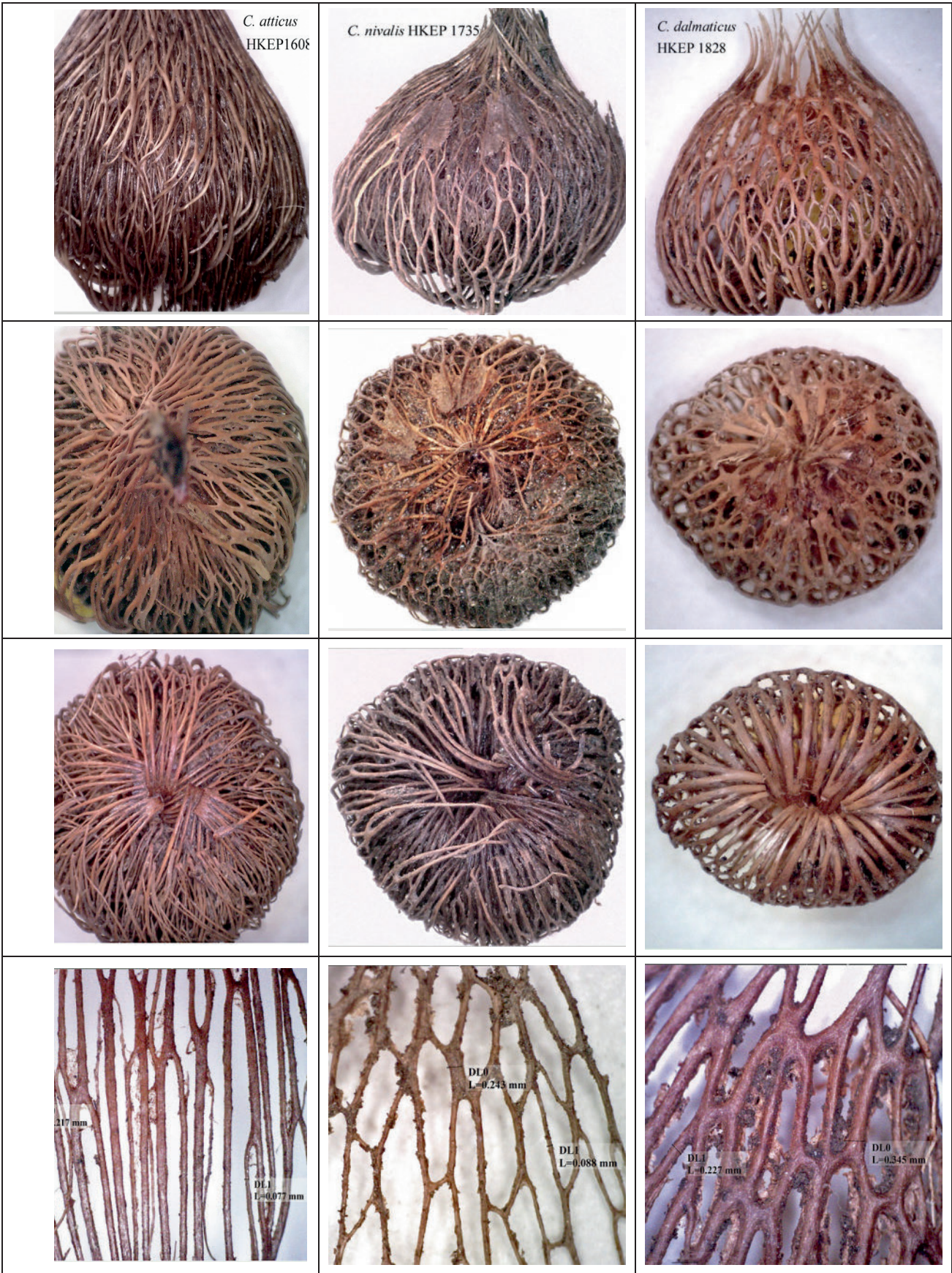


Fig. 14: Main tunics of species of *Sieberi* group.

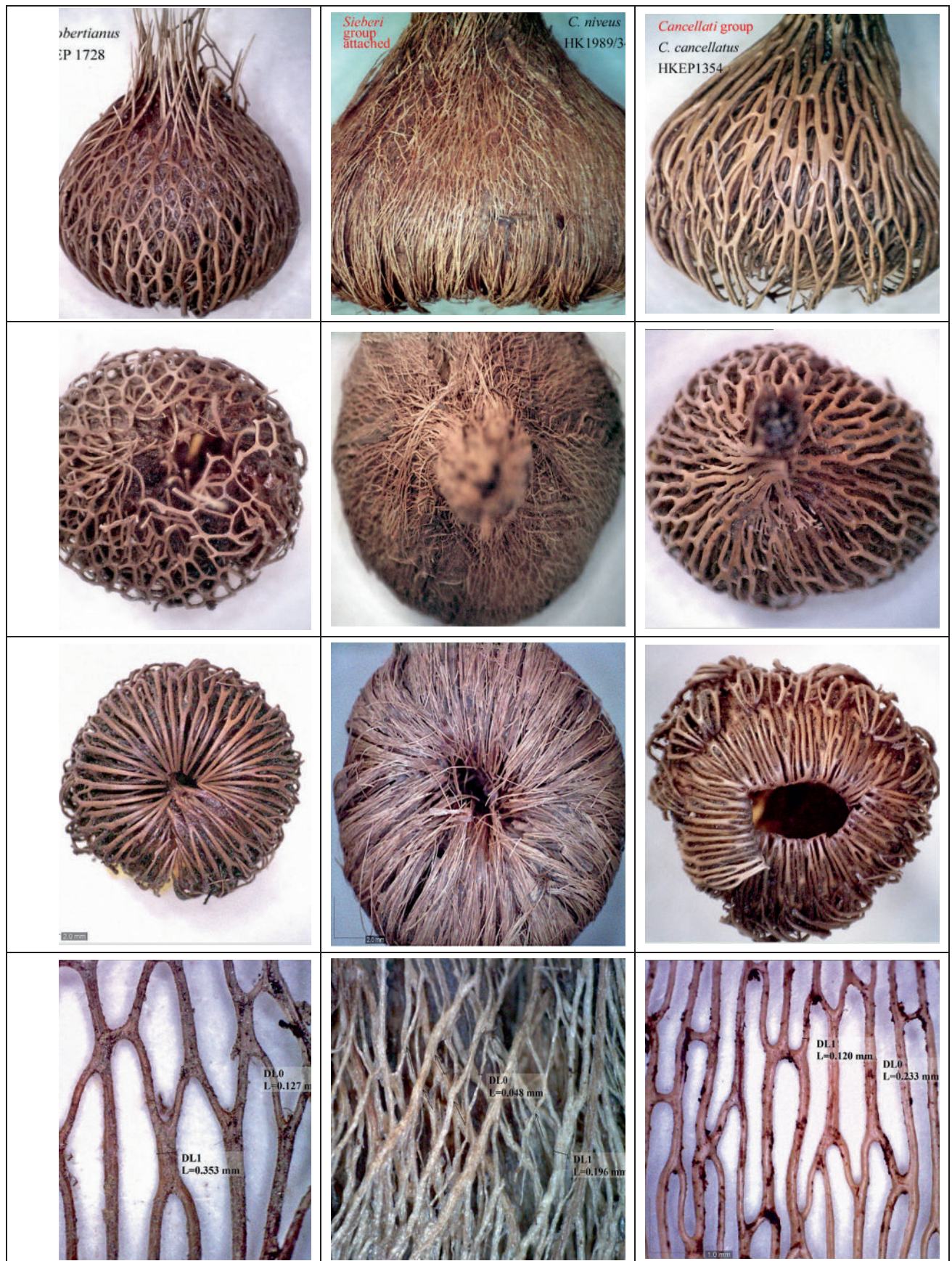


Fig. 15: Main tunics of species of *Sieberi* group and *Cancellati* group.

Fig. 16: Main tunics of species of *Cancellati* group.

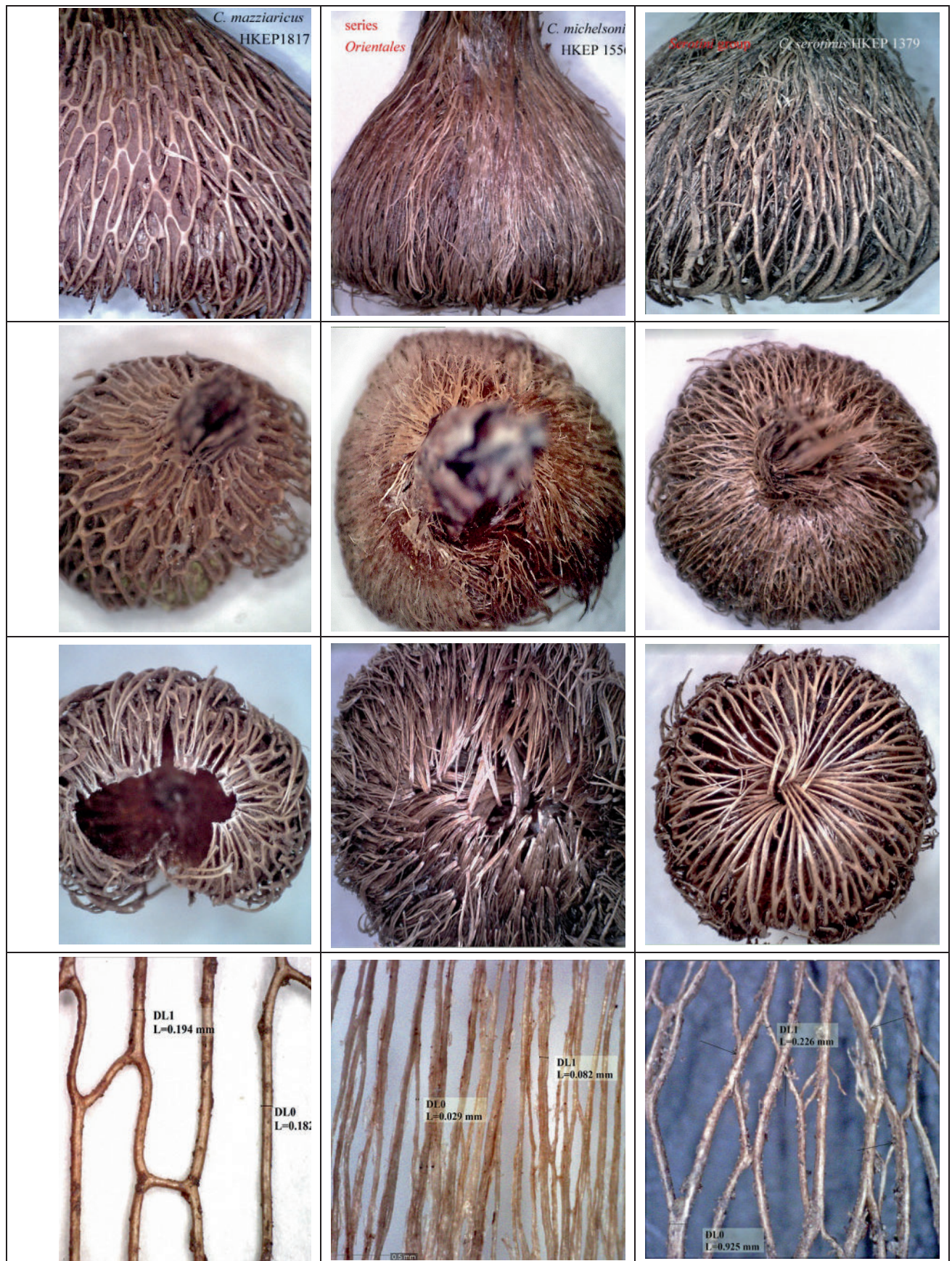


Fig. 17: Main tunics of species of *Cancellati* group, series *Orientales*, and *Serotini* group.

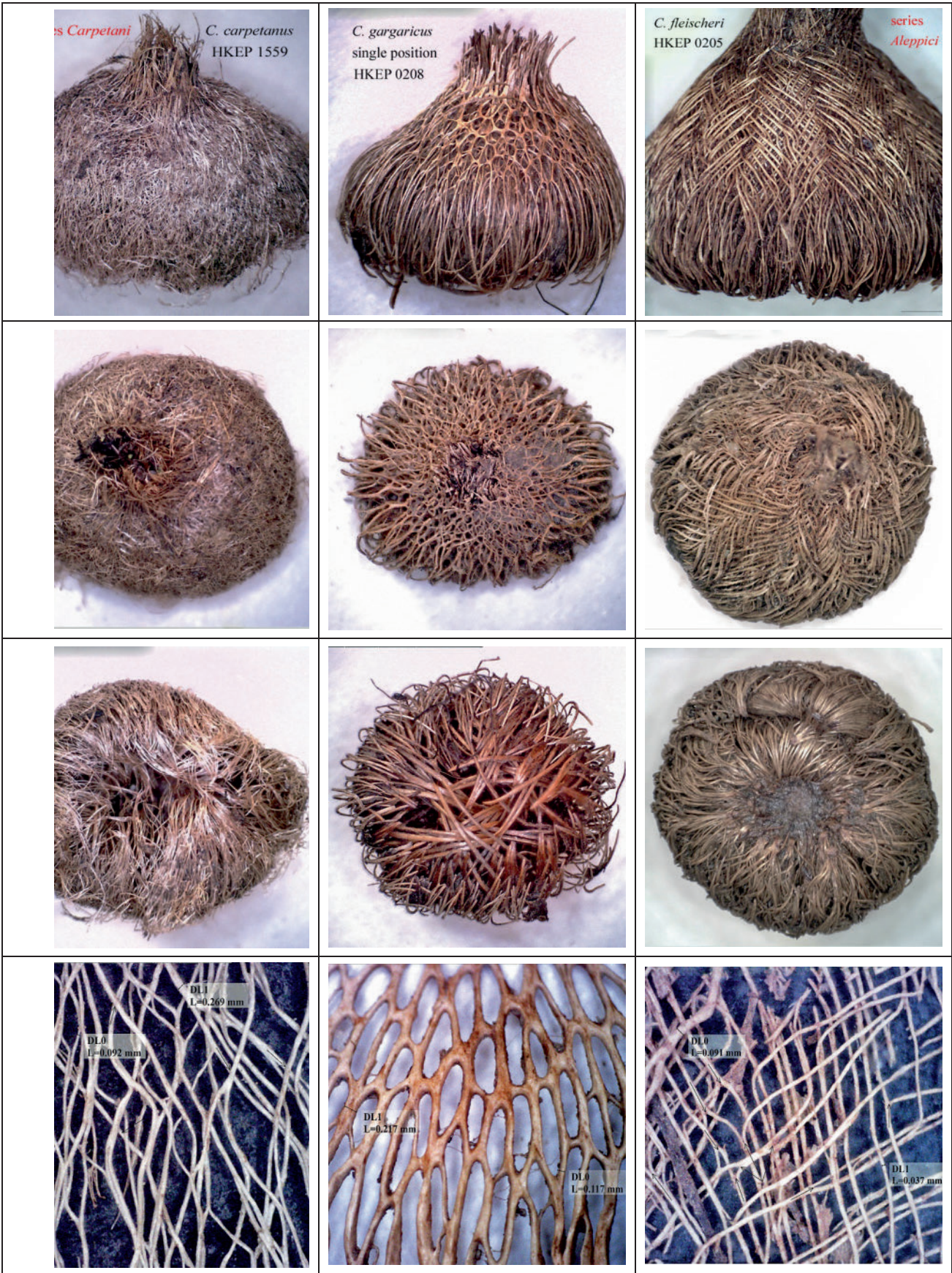


Fig. 18: Main tunics of species of series *Carpetani*, *C. gargaricus*, and *C. fleischeri*.

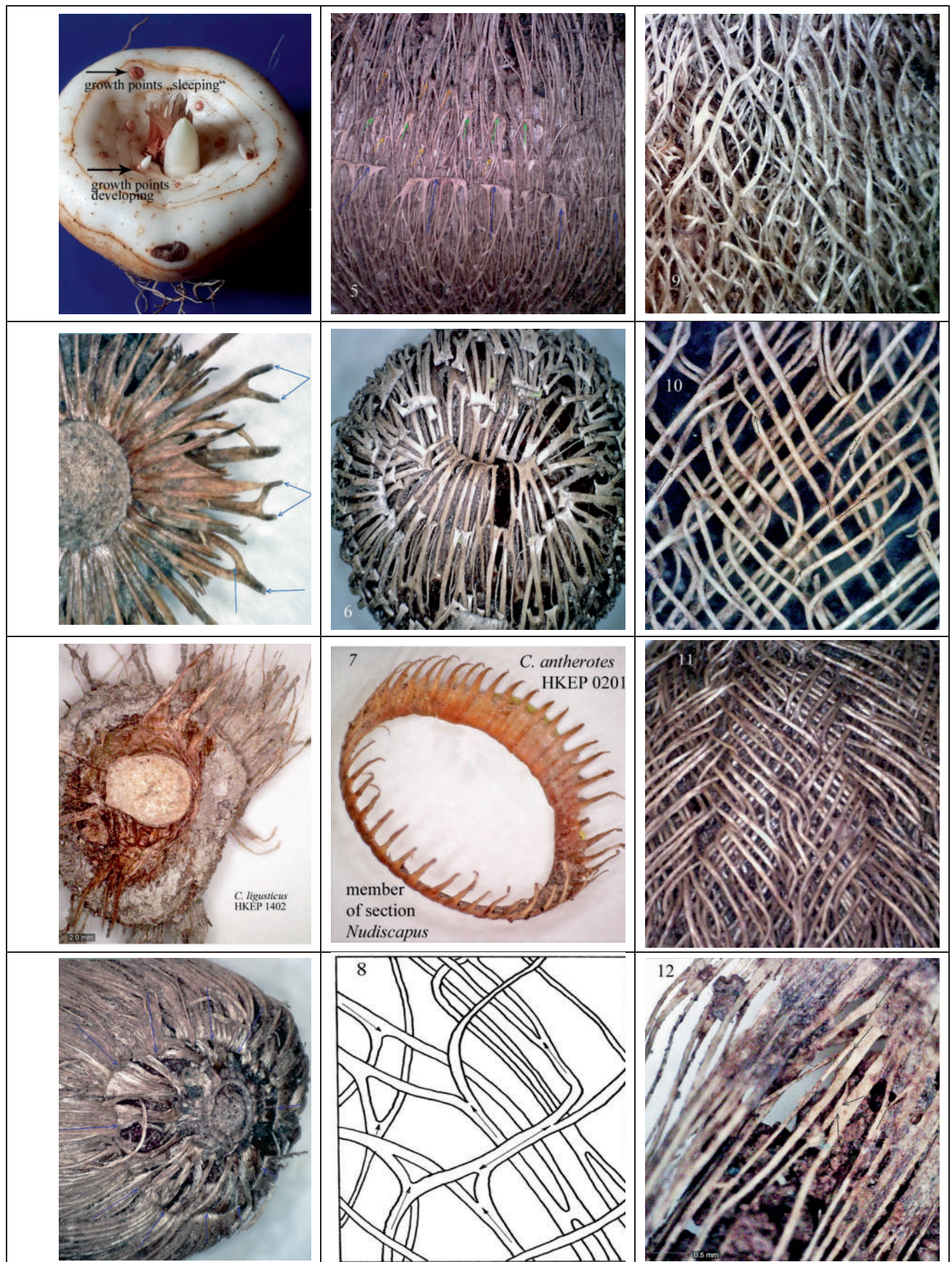


Fig. 19: Characteristics of reticulated corm tunics (photograph 1 by Dirk Schanbel).

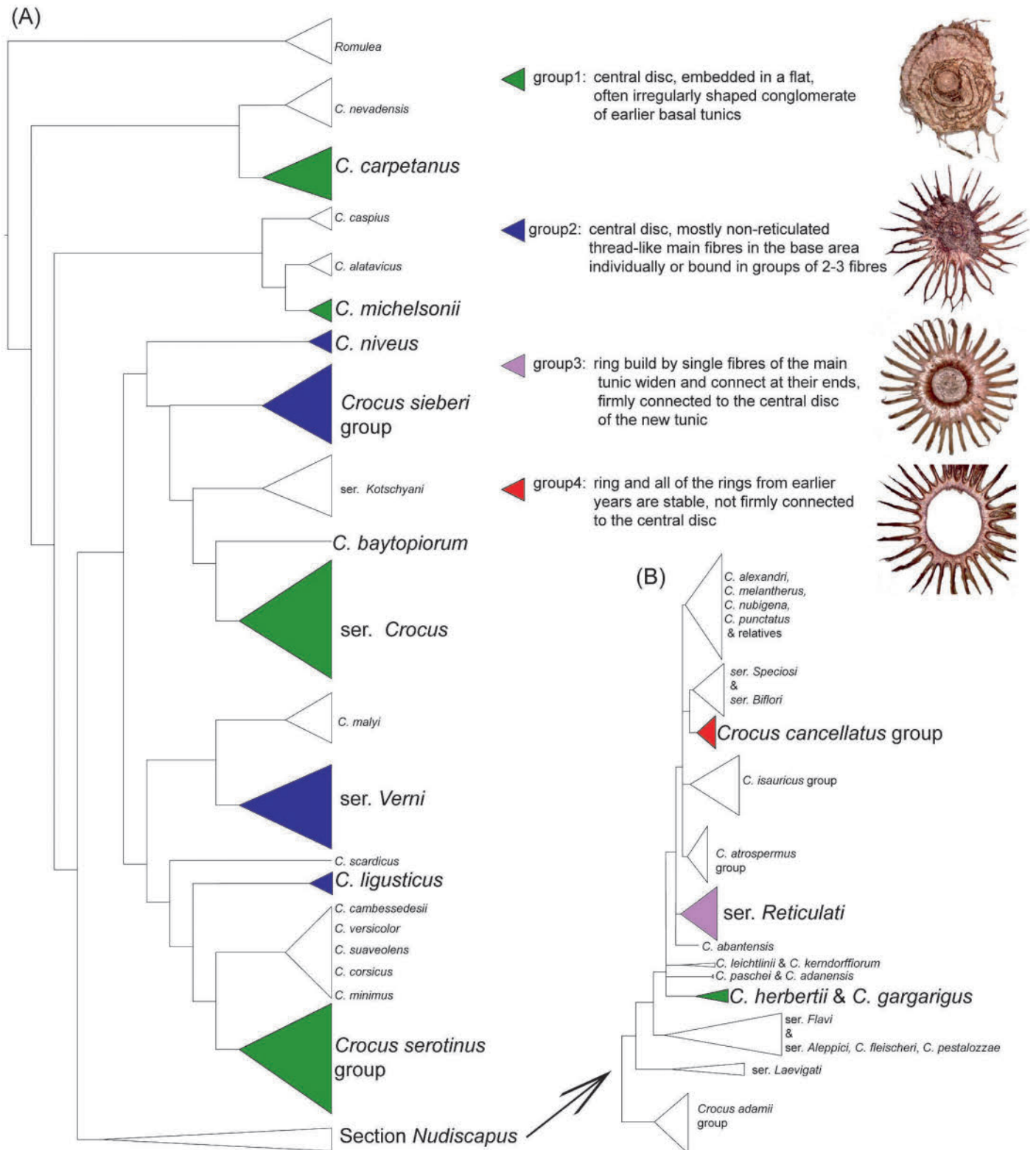


Fig. 20: Schemes of phylogenetic trees of the genus *Crocus*. Tree (A) representing the whole genus was obtained by a maximum parsimony analysis of 3 chloroplast regions (matK-trnQ, trnL-trnF, ycf1). Tree (A) was derived from a Bayesian Analysis using the nuclear ribosomal DNA region of the external transcribed spacers (ETS) and internal transcribed spacers (ITS). Clades with species with reticulated corm tunic are marked in four different colors according to their specific characteristics.

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