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Seeking Nettle Textiles – Utilizing a Combination of Microscopic Methods for Fibre Identification

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ABSTRACT

Bast fibres have been commonly used as a textile material in Northern Europe since Neolithic times. However, the process of identifying the different species has been problematic, and many important questions related to their cultural history are still unanswered. For example, a modified Herzog test and the presence of calcium oxalate crystals have both been used in identification. In order to generate more reliable results, further research and advancement in multi-methodological methods is required. This paper introduces a combination of methods which can be used to identify and distinguish flax (*Linum usitatissimum*), hemp (*Cannabis sativa*), and stinging nettle (*Urtica dioica*). The research material consisted of reference fibres and 25 fibre samples obtained from 12 textiles assumed to be made of nettle. The textiles were from the Finno-Ugric and Historical Collections of The National Museum of Finland. The fibre samples were studied by observing the surface characteristics and cross sections with transmitted light microscopy, and by using a modified Herzog test with polarized light, in order to identify the distinguishable features in their morphological structures. The study showed that five out of 25 samples were cotton, 16 nettle, one flax, and one hemp. Findings from two samples were inconsistent. The results show that it is possible to distinguish common north European bast fibres from each other by using a combination of microscopic methods. Furthermore, by utilizing these combined methods, new and more reliable information could be obtained from historical ethnographic textiles, which creates new vistas for the interpretation of their cultural history.

Introduction

Bast fibres have been used as a textile material since Neolithic times (Harris 2014, 2–3). In Northern Europe and Scandinavia, flax (*Linum usitatissimum*), hemp (*Cannabis sativa*), and nettle (*Urtica dioica*) have been the most common bast fibres used in textile production (Geijer 1979, 1). Because they fare well in low nutrition soils, and are able to survive in harsh climatic conditions, they were popular fibre plants. Nettle is the only indigenous fibre plant in Scandinavia. In the Northern Hemisphere it grows as a weed (Geijer 1979, 9), and in Finland it was presumably replaced by flax in the Iron Age (Riikonen 2011, 199).

Nettle, flax, and hemp were utilized long before the arrival of cotton in the north. Their use, however, diminished radically in the industrial era which came to Northern Europe in the nineteenth century. This reduction in use was caused by the introduction of imported cotton, with its easy availability and easier manufacturing processes (Skoglund, Nockert, and Holst 2013; Skoglund 2016, 99).

Even though flax, hemp, and nettle were once the most commonly used cellulose fibres in the Northern

Hemisphere, their identification in museum textiles has been imprecise in many cases. In particular, our knowledge of nettle is lacking, and only a few stray remarks are available in the literature. The latest research, however, reveals that nettle might have been a more commonly used textile material during historic and prehistoric times than has been assumed (Geijer 1979; Bergfjord et al. 2012; Vajanto 2014). Our lack of knowledge about the utilization of nettle is likely a consequence of the limited resources for research in textile history and the difficulty in material identification. Another reason may well be the lost craftsmanship of processing nettle fibre and in its limited contemporary use.

One interesting aspect of historical material research is the etymology of words connected to textiles. Specifically regarding bast fibres, the words used for flax, hemp, and nettle are confusing. In the Finnish language, the word 'liina' could have been used for all of these, depending on the geographical region and the period of time. In the Finno-Ugric languages, according to Kaukonen (1946, 23), the word 'liina' means nettle, and it originates from the Greek word

linteum. Even today, in Mordva and other Ob-Ugrian languages, the etymological equivalents for flax actually refer to nettle. Riikonen (2011) instead suggest that the word 'liina' is a loan word from German, and that the word has a different meaning in the Western and Eastern parts of Finland. In the West, 'liina' is the word used for linen (flax), and in the East for hemp. The picture becomes even more complicated when all of the early variations of the word 'liina' that occur in church registers and historical documents are taken into account. There, they can mean any fabric made from plant fibres. The possible significance of nettle as a textile material is indicated by the nettle derived terms 'Nettledug', 'Neslelin', and 'Nesseltuch', which were used for cotton and linen textiles (Kaukonen 1946, 24).

The identification of specific bast fibres is problematic, because the differences in their morphological structures are difficult to detect with an optical microscope. For instance, all of the bast fibres appear the same when viewing their morphological surface features in transmitted light microscopy (TLM). The uniform features of flax, hemp, and nettle include the appearances of cross markings and dislocations. There can be differences, but they are more likely related to the growth conditions and harvesting time of the fibres than to species-specific characteristics.

Bergfjord et al. (2010) state that the causes for these dislocations and cross markings are uncertain and still debated. Indeed, even the concepts of 'dislocation' and 'cross marking' are widely confused. Depending on the author, these concepts are mixed up, or sometimes referred only by the term dislocation. Perry (1985, 16) talk about transverse dislocation in the form of an X, clearly referring more accurately to the concept of a cross marking. Similarly, Nayak, Padhye, and Fergusson (2012, 316, 323–327) talk about cross marking, and fissures and nodes, and like the previous work, dislocation in the form of an X. However, in the field of wood chemistry it is common to use images of kinks and nodes instead (Hänninen 2011, 17). Catling and Grayson (1982, 1–4)

distinguish an actual difference between the concepts dislocation and cross marking, and additionally explain the interpretations in the older literature. Likewise, in this study, the nature of a dislocations and cross markings are understood as follows: a cross marking appears as transverse striation on the surface of the fibre without interfering with the overall structure (Figure 1 (a)), whereas a dislocation, as the name refers, dislocates the structure of the fibre as whole, by creating a joint-like angle of variable degree that changes the course of the fibre (Figure 1(b)).

The surface characteristics, such as the frequency of the cross markings or the thickness (Bergfjord and Holst 2010, 1194) or length of a single fibre, are not the characteristics on which the identification of the fibre type can be grounded, as can be seen in Table 1. The variation in the results of thicknesses and lengths among and within various researchers' work aptly demonstrates the uselessness of these characteristics as an identification method for bast fibres. Observation of the surface features can be applied to distinguish bast fibres from other textile fibres, for example cotton or wool, but not to distinguish the species from each other. The difference between cotton is easy to observe, because of cotton's unique features. The cotton fibre is flat, ribbon-like, and it has a habit of irregular twisting around the axis. Wool and hairs, on the other hand, are covered with scale patterns.

The twist of the fibres, or their microfibrillar orientation to be more precise, is one of the fundamental differences among bast fibres. The cell wall of bast fibres consists of three microfibrillar layers, which can twist in opposite directions. The middle layer, S2, is usually the thickest, and therefore the dominant one. There are a few ways to detect the orientation of bast fibres. A commonly used method is the simple drying twist test (Perry 1985, 225; Carr et al. 2008, 78), although its results can be ambiguous.

Another and more advanced method is the modified Herzog test, which was developed in the 1950s by A. Herzog but has never been widely used in
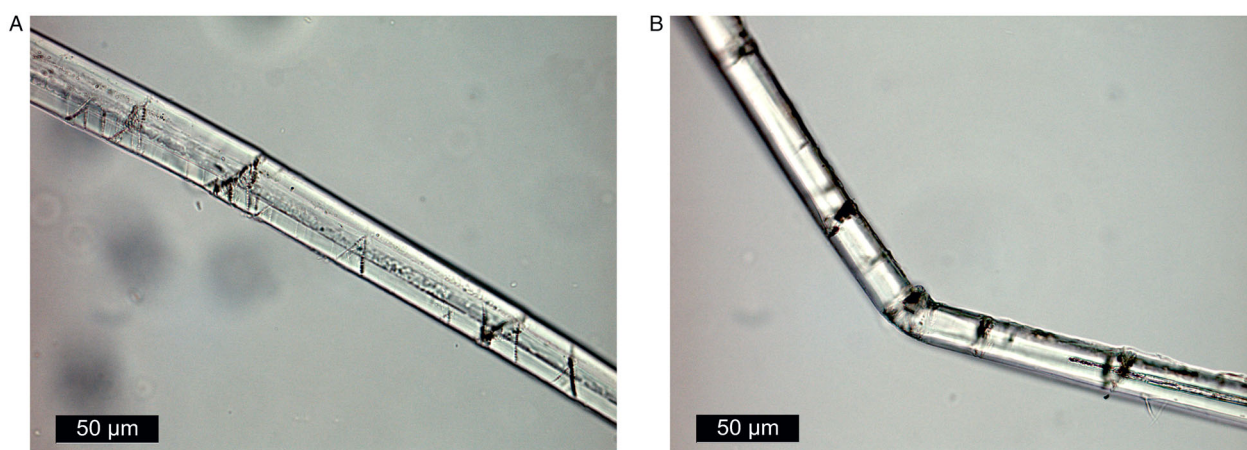
Figure 1. (a). Cross markings in nettle fibre (PM1). (b) Dislocation in flax fibre (N1).

Table 1. Fibre lengths (mm) of a single bast fibre according to the research literature.[a]

|	Carr et al. (2008, 80–83)	McDougall et al. (1993, 3)	Wiener, Kovačič, and Dejlová (2003, 59)	Perry (1985, 244)
Flax	1–120[b]	2.1–40	3–60	27.4–36.1
Hemp	5–55[b]	8.5–20	4–55	8.3–14.1
Ramie	60–600[b]	39–150		125–26

[a]Range of means.
[b]From Luniak (1953).

textile analyses. The procedure is thoroughly explained by Haugan and Holst (2013). The modified Herzog test is based on the birefringent qualities of the bast fibres and the reflection of light from the microfibrils in the dominant cell wall. In this method, single bast fibre is set to its extinction point under polarized light, i.e. in horizontal or vertical position, and the microscope is focused on the top of the fibre. The combination of the polarized light and full-wave length[1] plate reveals the twist of the dominant microfibrillar layer S2 in the variance of the blue or yellow colours (Figures 2 and 3). When the fibre is turned 90°, the colour will change to the opposite. From the order of the colours, yellow in horizontal and blue in vertical, or the opposite, it is possible to interpret the twist of the fibre.

Even though observing the twist in the fibres can provide clear and distinctive information about the fibres, it cannot be used as a sole method of identification. The modified Herzog test identifies only two characteristics, the S- or Z-twist. Unfortunately, some bast fibres have the same twist. In the study of Skoglund, Nockert, and Holst (2013), the identification of specific bast fibres was based solely on the modified Herzog test. As the authors admit themselves, the study showed the weakness of relying on only one test: the modified Herzog test could not differentiate between flax and nettle, because the fibres have the same microfibrillar orientation, the S-twist.

Other fundamental differences in the morphological structures of bast fibres can be identified through observation of cross sections. Flax is described as polygonal-shaped, with five to seven angles, and the outline is sharper and clearer than in hemp. The lumen in flax is very narrow, and the cell walls are thick (Catling and Grayson 1982, 16; Wiener, Kovačič, and Dejlová 2003, 58; Nayak, Padhye, and Fergusson 2012, 323–27). Hemp is also angular, but there is a
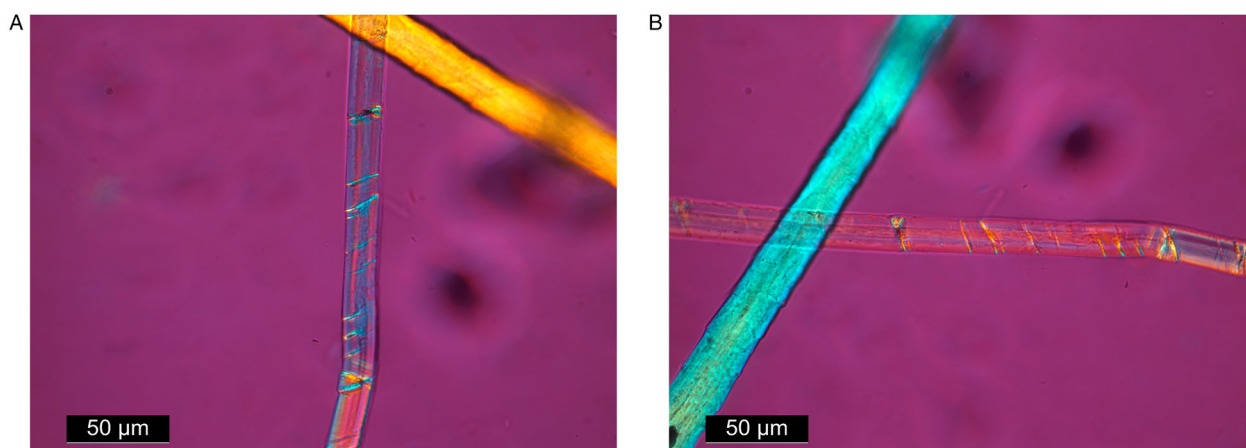
Figure 2. (a, b) Showing the hue changes in an S-twisted nettle (PM1).
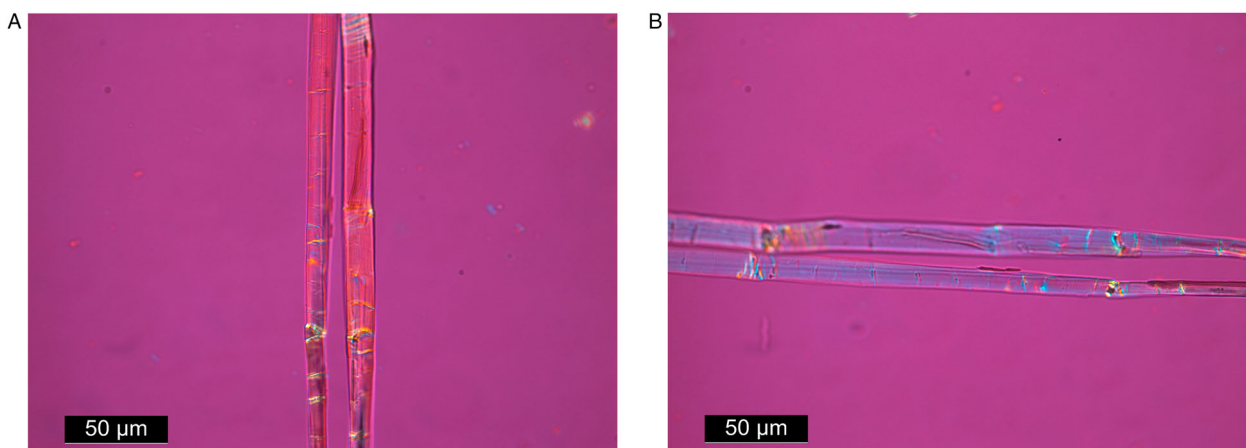
Figure 3. (a, b) Showing the hue changes in a Z-twisted hemp (H2).

larger variation in shape compared to flax. The lumen is wider, and it varies in shape as well (Catling and Grayson 1982, 67; Wiener, Kovačič, and Dejlová 2003, 58). Hemp and flax can be difficult to distinguish from each other by examining cross sections of fibres. Nettle, however, has a unique form compared to the previously mentioned fibres. Its cross section is oval or kidney-shaped, including a long and flattened lumen which sometimes looks like there are cracks passing through the cell wall (Lanzilao, Goswami, and Blackburn 2016, 202). Nettle's cross-sectional features closely resemble those of cotton (Rast-Eicher 2016, 78).

Cross sections of textile fibres are commonly prepared by pulling the fibres through a small 0.75 mm hole in a metal plate, and then cutting the fibres with a razor blade parallel to the plate (Greaves and Saville 1995, 39). This procedure is problematic when studying museum textiles, where the sample sizes are usually relatively small. A more sophisticated means of preparing thin cross sections is by using Hardy's microtome, the functioning of which is explained for instance by Greaves and Saville (1995, 40). Goodway (1987, 31) presents a method to prepare cross sections without a microtome. The fibres are clamped between two cork sheets and thin slices are shaved off with a razor blade. Gluing the fibres to the cork with a mounting medium aids the process.

As seen from the issues described above, the identification of bast fibres can be challenging – or even impossible – when using just a single method. Therefore, a multi-methodological approach is recommended. For example, Bergfjord and Holst (2010) and Lukešová, Palau, and Holst (2017) have introduced a combined approach based on observing the presence of calcium oxalate crystals and a modified Herzog test to identify bast fibres from each other. Mutually exclusive characteristics are the Z-twist in hemp and the absence of the crystals in flax. Another interesting study was conducted by Paterson et al. (2017). Their multi-methodological approach utilized different polarized light microscopic methods to achieve accurate plant material identifications from plants used in Māori textiles.

The aim of this research is to further develop a combination of microscopic methods to achieve more specific and reliable results for fibre identification. By combining the observation of surface characteristics and cross sections with the modified Herzog test, it is possible to identify bast fibre species, especially nettle, from historical textile samples.

Materials

The research materials used in this study consist of modern reference fibres and a textile sampling from the collections of The National Museum of Finland. Twelve museum textiles were chosen, all of which were thought to be made of nettle.[2] Altogether, 25 samples from the textiles were examined and analysed. Sample sizes were small, consisting of 1–3 mm of yarn, taken from both warp and weft whenever it was possible.

The background information on the 12 museum textiles can be seen in Table 2. Three textiles (Table 2, No. 1–3) were from the Historical Collection of The National Museum of Finland. The origin of these textiles (an apron, curtains, and a tablecloth, respectively) is unknown: they were received as a donation to the collection. Their dating is also unknown, except for the apron (No. 1; Figure 4), which is from the early eighteenth century and has been previously studied by Pylkkänen (1970).

Nine textiles (Table 2: Nos. 4–12) were from the Finno-Ugric collections, and their backgrounds are better known. They were collected by a group of ethnologists during their field trips (August Ahlqvist in 1877, I. K. Inha in 1894, Uuno Sirelius in 1899, and Artturi Kannisto in 1905–06). They are all, with exception of the shirt from Karelia (No. 11), from the Khanty and Mansi people of Western Siberia, next to Ural Mountains. Most of these textiles were offering cloths (Nos. 6–10; Figure 5), but there was also a shirt (No. 12), a miniature fishing seine (No. 4), and a rabbit snare (No. 5; Figure 6).

In general, all of the textiles were in relatively good condition. No extensive signs of wear were visible. The conclusion can be drawn that the textiles had seen little or no actual use before they were stored in the museum collections. Some of them were even collected unfinished. Only in a few samples did the degradation process in the fibres hinder the analysis.

In addition to reference material found in the literature to support the identification, this study also used reference samples to test the methodology and to add to the available information. The reference samples were obtained from different sources: their background information is presented in Table 3. These fibres were selected to be representative samples of bast fibres, corresponding with various textile processing methods. In addition to samples of flax, nettle, and hemp, fibres from Himalayan giant nettle, also known as allo (*Girardinia diversifolia*) and ramie (*Boehmeria nivea*) were also studied to obtain more information about nettle-related plants.

Methods

The samples were referred to only by numeric codes during the analysis, in order to avoid the possibility that assumed nature of the textiles could affect the results. The combined microscopic procedure had three stages (Figure 7). The first stage included observation of the surface characteristics of the fibres by using TLM. Cross markings and dislocations were

Table 2. The analysed textile samples and the results of the identification process.

No.	Object	Sample No.	Location	Surface characteristics	The modified Herzog test, S/Z twist	Cross section, F/H/N	Identification
1.	Apron, H5633:10	1a.	Horizontal yarn system	Bast fibre	S	N	Nettle
		1b.	Vertical yarn system	Cotton (?)/Bast fibre	S	N	Nettle
2.	Curtains, H65050:986	2a.	Top of item A	Cotton	–	–	Cotton
		2b.	Top of item B	Cotton	–	–	Cotton
3.	Tablecloth, H70001:2	3a.	Yarn system A	Cotton	–	–	Cotton
		3b.	Yarn system B	Cotton	–	–	Cotton
4.	Miniature of a fishing seine, SU187049	4.a	End of the net	Bast fibre	S	F	Flax
		4b.	Middle of the net	Nettle (?)	S	N	Nettle
5.	Rabbit snare, SU3904:573	5.	End of the cord	Bast fibre	S	N	Nettle
6.	Offering cloth, SU4518:125	6a.	Warp	Bast fibre	Z	N	Nettle or Hemp
		6b.	Blue strip	Cotton	–	–	Cotton
7.	Unfinished offering cloth, SU4518:126	7a.	Weft	Bast fibre	Z	H (?)	Hemp
		7b.	Warp	Bast fibre/Nettle (?)	S	N	Nettle
8.	Unfinished offering cloth, SU4518:127	8a.	Weft	Nettle (?)	S	N	Nettle
		8b.	Warp	Bast fibre	Z	N	Nettle or Hemp
9.	Unfinished offering cloth, SU4518:128	9a.	Weft	Nettle (?)	S	N	Nettle
		9b.	Warp (?)	Bast fibre	S	N	Nettle
10.	Unfinished offering cloth, SU4518:129	10a.	Warp	Nettle (?)	S	N	Nettle
		10b.	Weft	Nettle (?)	S	N	Nettle
11.	Upper part of a shirt, SU4522:18	11a.	Middle of the right sleeve	Bast fibre/Nettle (?)	S	N (?)	Nettle
		11b.	Back of the left sleeve	Bast fibre	S	N (?)	Nettle
		11c.	Backside, bottom	Nettle (?)	S	N	Nettle
		11d.	Left sleeve, front bottom	Bast fibre	S	F (?) / N	Nettle
12.	Woman's shirt, SU4810:283	12a.	Bodice	Bast fibre/Nettle (?)	S	N	Nettle
		12b.	Hem	Bast fibre	S	N (&F?)	Nettle (& Flax?)

identified to ensure that the fibres under study were definitely bast fibres. After this initial step, the modified Herzog test, which showed the S- or Z-twisted orientation in the microfibrils, was performed. The third stage was the observation of fibre cross sections, to identify any differences in the morphological structures. Cross-sectional observation was essential for the final identification of nettle fibre. The results had to be consistent across all three methods in order to achieve confidence in the fibre identifications.

Observation of surface characteristics

The fibres were carefully separated from each other with the aid of tweezers, to ensure study of individual fibres instead of the fibre bundles. For the observation

of surface characteristics, the fibres were mounted on glass slides with the permanent mounting medium Entellan New®, which has a refractive index (RI 1.49–1.50), and was found suitable for studying textile fibres. Cross markings and dislocations were identified in the samples by using a TLM Leica DM4500P with rotating stage and polarized light features. The microscope was integrated with the Leica application suite LAS Core 4.5.0 software and Leica DFC420 camera with 5 megapixel resolution. Both transmitted and polarized light were used in the analysis.

Some of the reference fibres (Table 3: PL1, PM1, N1, V1, H1, and Rami2) were also studied with a scanning electron microscope JEOL JSM-7500FA. An acceleration voltage of 5.0 kW was used, and images were created by collecting secondary electrons. Samples were

Figure 4. Apron (No. 1; H5633:10).

Figure 5. Unfinished offering cloth (No. 10; SU4518:129).

Figure 6. Rabbit snare (No. 5; SU3904:573).

sputter-coated for SEM using Emitech K100X (gold coating, one minute, 25 mA). When observed with TLM, cross markings appeared to be cracks or scalloping on the surface of the fibre, but SEM examination revealed that the cross markings were actually thicker stripes around the fibres, and could be interpreted as having been formed by the surrounding plant tissues (Figure 8). SEM examination was only carried out on some of the reference samples and, because it did not seem to provide supplementary information about the species-specific bast fibre structures compared to TLM, it was not used on the actual museum samples.

Polarized light

Using polarized light to view morphological features on the surfaces of the fibres was found to be very helpful, because of the birefringent nature of the bast fibres. Polarized light improved the visibility of the cross markings and dislocations, especially in case of the fibres for which the degradation process had already hampered
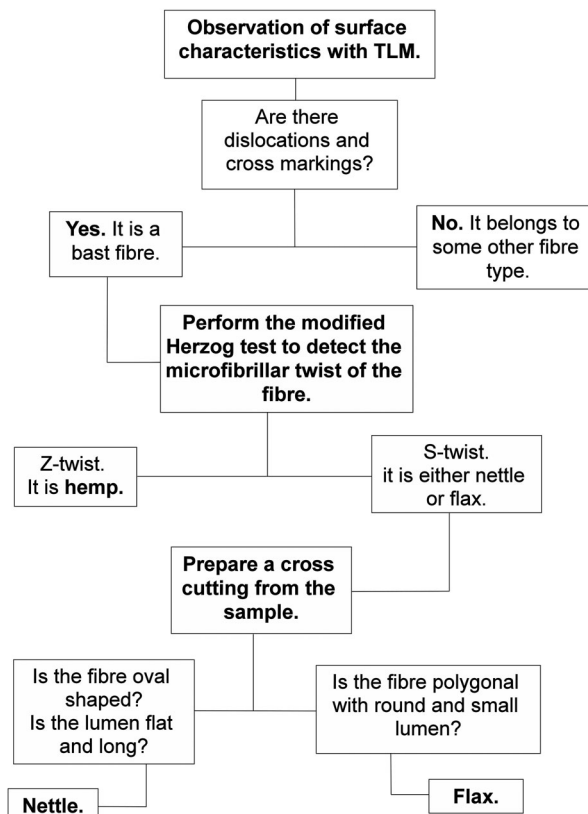

Figure 7. Process chart of the methodological combination (Suomela 2015).

the observability of the morphological features. The single fibres were more easily discerned from the fibre bundles. When the fibre was at the extinction point, i.e. parallel to the polarizer or analyser, the cross markings became fairly visible. In addition, it was possible to designate fibre types (cellulose and protein fibres), because they behave differently under the polarized light according to how ordered their molecular structures are (Jakes 2000, 56). More organised structures, such as the ones in bast fibres, are seen in rainbow colours, whereas less ordered structures, for example protein fibres, are seen as grey or yellowish.

Table 3. Reference fibres.

| Code	Fibre	Processing	Appearance	Origin
PL1	Nettle	Peeled from the stems fresh and boiled in sodium carbonate water (10 l of water and 1.5 dl of soda ash) for 20–30 minutes, 10 minutes too long. Carded	Fragile and brittle from over boiling	Puolanka, Finland. 6/2013
PM1	Nettle	Stems were dried as whole and fibres were detached after drying. Processed with comb and carding	Shiny and straight	Puumala, Finland. 7/2013
N1	Flax	Dew-retted. Organic. Machine hackled	Silver-grey, fine fibres	Norholm farm, Närpiö, Finland. 1990s
V1	Flax	Water-retted. For household needs	Light-yellow. Some shives attached	Liukkonen, Ristiina, Finland. Decades ago
H1	Hemp	Potato flour was used in machine spinning. Yarn	Fine and even	House of Hemp, UK, 2013. Fibres grown in Europe
H2	Hemp	Sample material from modern fibres. Processing unknown	Extra-fine	Unknown
H3	Hemp	Enzyme retted in China	Fine, soft	India, before 1984
Nepal1	Hemp	Machine spun yarn	Yarn was harsh and uneven	Amma Craft. Nepal
Rami1	Ramie	Highly processed	Shiny and white	Wingham Wools, UK. Fibres grown in China?
Rami2	Ramie	Fibres processed by hand from small piece of a dried stem. First soaked in hot water for 30 minutes	Straight, some shivers attached	Finland, 2014
Allo1	Allo	Fabric. Processing unknown	–	Sirinä Design, Finland. Fibres grown in Nepal
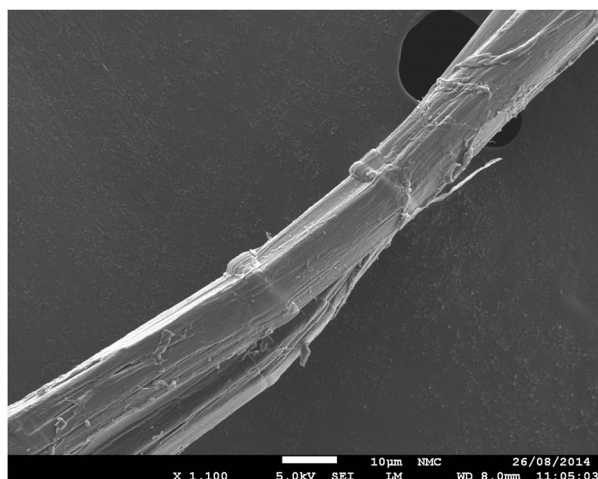
Figure 8. SEM image of H1 (hemp), showing the cross markings as thicker stripes on the surface of the fibre.

On a practical note, long-term work with a microscope was less strenuous on the eyes when fibres were displayed against a black background.

Microfibrillar orientation and the modified Herzog test

Microfibrillar orientation was detected following the protocol introduced by Haugan and Holst (2013). Accordingly, a magnification of 400× was used, and both the polarizer and analyser were enabled. A single fibre was placed exactly in the middle of the view, and then turned parallel to the polarizer or analyser. It was important to find a section of the fibre which appeared as dark as possible. The lambda plate was then inserted into the microscope in 45° angle in relation to the polarizer and analyser. For the microscope model Leica DM4500, it was possible to insert the lambda plate at two different angles, which were 90° apart from each other. This 90° change was critical in turning the yellow and blue hues into their opposites. Thus, it was essential to use the same settings for all analyses. In this study, the lambda plate was always pointed to the northeast direction. This yielded blue colour in vertical and yellow in horizontal position, when it was an S-twisted fibre that was being analysed. In contrast, the Z-twisted fibre was seen as blue in horizontal position and yellow in vertical position.

Cross sections

The cross sectioning used in this study was a modification of the method explained by Goodway (1987, 31). In our study, sectioning was carried out with the aid of a 2 mm thick cork sheet and the permanent mounting medium Entellan New®. Pieces of 2 × 1 cm were cut out from the cork, and one to two drops of Entellan® were applied to each piece and then allowed to dry. The fibres were carefully arranged in a

Figure 9. Cork sheet cuttings.

longitudinal position on top of the dried Entellan®, and a new drop was then applied to the fibres. After the sample was fully dry, the placement of the fibres was checked with a stereomicroscope and as thin as possible slices were cut transversely with a razor blade (Figure 9). The cross sections were placed on glass slides without any mounting or coverslips, and observed with careful focusing to find the surfaces of the fibres. This method is suitable for small sample sizes, because at a minimum only a few millimetre pieces of fibres are required.

Results

Our study showed that by utilizing a combination of microscopic methods it is possible to distinguish flax, hemp, and nettle from each other. The microfibrillar orientation, i.e. S- or Z-twist, and the cross section of a single fibre are the key factors in the identification process. As they are S-twisted, flax and nettle will yield similar colours in the analysis of the modified Herzog test. In contrast, Z-twisted hemp will show exactly the opposite colours in the horizontal and vertical positions, compared to the colours seen in the S-twisted flax and nettle, respectively. With the cross-sectional method utilized it was difficult to make a clear differentiation between flax and hemp, but nettle was easily distinguishable (Figures 10 –12).

The mutually exclusive characteristics can be combined, and the identification is based on the differences between fibres, as shown in Table 4.

It was also possible to identify the materials that the historical objects were made of. Five out of the 25 samples (Table 2: Nos. 2, 3, 6b) were identified as cotton by observation of surface characteristics with TLM. By using the combination of the modified Herzog test and cross-sectional analysis, 16 of the samples were identified as nettle. Flax was identified from a single sample (No. 4a), as was hemp (No. 7a).

Figure 10. Cross section of flax (N1).

Figure 11. Cross section of hemp (H3).

Two of the samples (Nos. 6a and 8b) remained unidentified – they were either nettle or hemp. For these samples, the cross-sectional observations and modified Herzog test gave opposite, inconsistent results: the modified Herzog test showed the Z-twist, but the cross-sections of the fibres appeared as nettle.
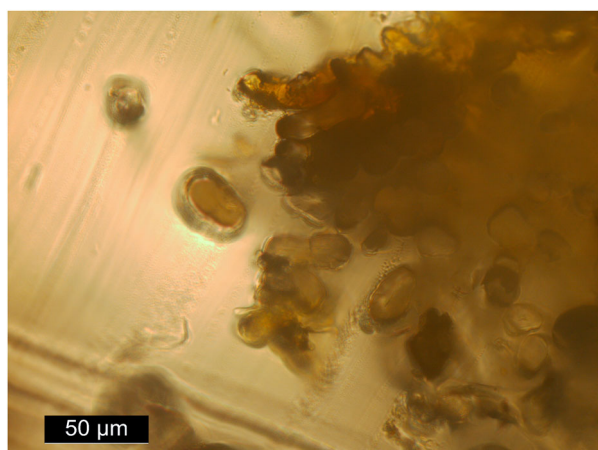

Figure 12. Cross section of nettle (PL1).

Table 4. Mutually exclusive characteristics of the bast fibres.

	Flax	Hemp	Nettle
Microfibrillar orientation	S	Z	S
Cross section of a single fibre	Polygonal	Polygonal	Oval

Five of the textiles, the offering cloths (Nos. 6–10; SU4518:125–29) from the Finno-Ugric Collection, had been previously analysed with a microscope in the 1950s. At that time, only one of the items (No. 7; SU4518:126) was identified as being made of nettle fibre (Vahter 1953). Our research proved that at least four of the offering clothes were made completely or partially from nettle.

Two of the three textiles from the Historic Collection were cotton (Nos. 2 and 3), but one, the apron (No. 1), was made from nettle. The apron had been studied earlier, and it was dated to the early eighteenth century (Pylkkänen 1970, 308–309). Now, after the re-analysis, its material has been confirmed. It is a beautiful example of high-quality craftsmanship from historical times, and exemplifies what was meant by the ethnographic expression 'Northern silk'. This vernacular expression referred to a textile material that is fine, shiny, soft, and delicate.

Nettle fibre was used for clothing material in Karelia in the nineteenth century (No. 11). This has now been proven for the first time with scientific methods. Before, there had been only speculations about the use of different bast fibre materials in Karelia. It is possible that with further research of historic Karelian garments, our whole understanding of the textile materials in use in that region might change.

Discussion

This study demonstrated that further development is required for the analysis of the microfibrillar orientation of the plant fibres, especially because the results from the modified Herzog test are obtained by visual observation of changes in colour, and therefore the results are open to subjective interpretation. The analysis must be conducted carefully, and carried out several times and on various parts of the sample for confirmation, because this analytical method is very sensitive to false interpretations. The fibre must be exactly in the middle of the view, and even slight changes of a few degrees in its position may cause incorrect hues to be identified, and thus change the results to the opposite of what they should be.

Another essential element in interpretation of the modified Herzog test's results is the importance of checking the settings of the microscope with a known reference fibre. The opposite colours will appear if the lambda plate is inserted in the north-east-to-southwest position as compared to north-west-to-southeast position, depending on the model

of the microscope. Similarly, the resulting images and their colours are comparable within one study, but not between different studies.

In this study, the fibre identification was based on the mutually exclusive characteristics identified through the applied methods. Historic studies of Northern European textiles do not recognise other bast fibres than flax, nettle, and hemp. As all museum items in this study were Northern European in origin, the primary assumption suggested that these three species were the sole options for the materials. If the research material had included artefacts from Asia, then Himalayan giant nettle and ramie would have been taken into account. The cross sections of nettle, Himalayan giant nettle, and ramie are all similarly oval with a long and flattened lumen (Nayak, Padhye, and Fergusson 2012, 324; Lanzilao, Goswami, and Blackburn 2016, 202). In addition, the testing of the methods was conducted with a relatively small number of samples, so testing on larger scale would enhance the reliability of the methodology.

For all of the samples, including both reference and museum samples, calcium oxalate crystals were found only in one reference hemp sample (H2). Lukešová, Palau, and Holst (2017) are grounding their identifications of flax fibre on the absence of oxalate crystals. Calcium oxalate crystals are situated in the plant tissues surrounding the fibres, and not in the fibres themselves. Based on this, it can be assumed that the existence of the crystals is dependent on the environmental conditions, or the efficiency of the fibre processing method, i.e. how vigorously the fibres have been processed from plants into textiles. Especially in older and archaeological textiles, however, the calcium oxalate crystals can be considered to be less likely to survive. For this reason, it is recommended that cross sectioning be included in the identification process.

In general, the past usage of nettle fibres in ethnographic textiles is not very well established, and is characterized by uncertainty. In Finland, there is very little material evidence on the usage of nettle fibres as textiles. Riikonen (2011, 203–204) lists 69 archaeological textile finds from the collections of The National Museum of Finland that are made of plant fibres, and only two of those are identified – although with doubt expressed by the author herself – as nettle. The identification methods used in the article are not specified, and therefore not comparable.

Hence, attention should be paid to the open communication of the identification processes utilized in these attributions and the overall results in general. When historical or archaeological textile findings are reviewed in scientific articles, the material identification is often made with no transparency or further explanation about the analytical methods used. As a result, fibre identification methods are also not often open to discussion, repetition, or further development.

Reliability in research is, among other issues, based on repeatability. Identification methods for bast fibres are improving, and should be cumulatively grounded on previous studies.

Regrettably, database-listings of museum items are often made without opportunity for any analysis, or in a hurry. The material identification might be based on visual identification alone, or inaccurate supplied information. There is often no time or equipment to identify the materials by other means than through arbitrary conjecture. Additionally, the identification methods used in the past, such as solubility, staining (Greaves and Saville 1995, 12–17), or burning tests (Nayak, Padhye, and Fergusson 2012, 320) were not able to differentiate between bast fibre species. The analysis and re-analysis of museum textiles would increase the amount of reliable information available to all database users.

In this study, all the research material was in a relatively good condition. Only in seven samples were small signs of degradation detected, and none of them were severe. Demand for identification methods suitable for archaeological and degraded textile samples is genuine. When the fibres start to decay, changes in molecular structures and visual appearance occur, which may have a negative effect on the identification process.

Conclusion

This study introduced a methodological combination to distinguish flax, nettle, and hemp fibres from each other. The combination and its components are open to further development. The aim was to explore and introduce analytic methods that provide reliable results, for both other textile researchers and conservators to utilize. The combination of microscopic methods presented in this paper is grounded on, and in agreement with, the research literature and previous studies. The equipment requirements are tolerable. Also, cross sections produced in the suggested manner are an especially easy way to conduct analyses on small sample sizes, without expensive apparatus.

A surprising part of the results was that, for certain, nine out of the twelve museum objects were made of nettle. The results give high prospects for further research. Apparently, nettle was not only a curiosity when compared to the use of other bast fibres, but rather an important and appreciated textile material, as the old textile terminology also suggests. By re-analysing and studying museum textiles, it is possible to gain significant new information on the history, materials, and cultivation of fibre plants.

Looking to the past can also offer us alternative solutions for the future of textile fibre production. By exploring craftsmanship and materials lost for centuries, unexpected and useful information may be

revealed. There is currently a high demand for finding substitutes for unsustainable cotton production, and nettle, as a nutrient-rich multifunctioning food and fibre crop, could be one of the alternatives.

Notes

1. Also known as lambda-plate, λ-plate, first order retardation plate, full wave plate, and red plate.
2. The textiles were chosen by the long-term Intendent of the Finno-Ugric Collection Ildikó Lehtinen.

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