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The Red-Blue Conundrum: an Archaeo-linguistic Approach to Red Dyes and Blue Flowers in Prehistory

Abstract

Plants from the Rubiaceae family (*Rubia*, *Galium*, and *Asperula*) are often grouped together as *madder* because they have been used for dyeing red since at least the Bronze Age. The English plant name *madder* can be traced through the Germanic language all the way back to Proto-Indo-European (PIE), as spoken by pastoralists on the Pontic-Caspian steppes c. 4500 to 2500 BC. The word can be reconstructed as PIE **mod^h-r-* by the comparative linguistic method. However, there is a difficulty with this. The other Indo-European language branches indicate an original meaning of ‘blue’ for this word, which is hard to reconcile with the appearance and use of Rubiaceae. In the search for the missing link between madder-red and the original PIE meaning of “blue”, this paper widens the scope of dyeplants to others with pigmented roots. It suggests that the missing link could be a blue-flowered plant species from the Boraginaceae family which has red-pigmented roots, perhaps originally used for cosmetics.

Introduction

This study explores the linguistic origins of the English word *madder* in Proto-Indo-European (PIE). The reconstructed PIE language is the ancient mothertongue of such language branches as Germanic, Italic (with Latin), Greek, Celtic, Slavic, Baltic, Hittite, Tocharian and many others.

When investigating cultural words in the Indo-European languages and comparing them with archaeological findings, it is important to consider where and when the speakers of the Proto-Indo-European language, as well as its descendants, lived. This matter has been the subject of great debate. One group of archaeologists claimed an Indo-European “homeland” in Anatolia 8000 to 6000 BC (Renfrew 1995, but recently largely conceded, Renfrew 2017). Another group of comparative linguists (and other archaeologists) claimed a homeland in the Pontic-Caspian steppes 4500 to 2500 BC (Mallory 1989; Anthony 2007). Recently, two major independent studies (with more to follow) in the new field of ancient genomics have provided strong support for the steppe-hypothesis,

and a large migration of Indo-European speakers of the Pontic-Caspian semi-nomadic pastoralist Yamnaya culture into Central and Northern Europe forming the Corded Ware culture around 3000 BC (Allentoft et al. 2015; Haak et al. 2015) (fig. 2).

This paper adopts the steppe hypothesis in order to discuss the etymological origins of the English plant name *madder*, and crossreference it with archaeological finds.

Proto-Germanic (the latest reconstructable stage of all the historical Germanic language branches) is thought by most linguists to have been spoken from c. 500 BC to AD 200, probably in southern Scandinavia (Ringe 2006, 67; Schrijver 2014, 158).

The main objective of this paper is to find the missing link between the English plant name *madder*, associated with the colour red, and the word’s etymological origins, which point to an original meaning of ‘blue’. Another family of red-pigmented plant roots, the Boraginaceae, could be important witnesses in explaining the semantic shift from blue to red.

Some of the Boraginaceae have blue or purple flowers



and their pigmented roots are known for their use as cosmetics. Most of these contain naphthoquinone pigments such as alkanin, shikonin and their many derivatives, but only some Boraginaceae genera have species with concentrations high enough to be used in dyeing. The best known are *Alkanna*, *Lithospermum*, *Onosma*, and *Arnebia* (Cardon 2007, 60–74). Dyed textiles exist from the southern end of the Pontic-Caspian region (late 4th millennium BC), but their specific dyestuffs are unknown. If people in this region dyed with Rubiaceae, Boraginaceae or completely different plants there is no evidence of which plants they used (Shishlina et al. 2003). The English word *madder* can be traced back to PIE through sound laws (see info box on p. 52 for an explanation of sound laws), which makes it worth exploring in the quest for the origins of early Indo-European dyestuffs.

Madder and its wild sisters

The madder-plant has been important across Eurasia for obtaining a red textile dye from different red anthraquinone dyestuffs, primarily alizarin, purpurin and rubiadin. “Madder-plants” and “madder-type plants” refer here to any of the dyestuffs or plants from the Rubiaceae family specifically *Rubia*, *Galium*, or *Asperula*.

There are different species of which one in particular has been cultivated (*Rubia tinctorum* containing primarily alizarin). It is native to the Middle East and the eastern Mediterranean, but also cultivated in southern and central Europe. Others have been gathered from the wild, and are also known as wild madder, bedstraw and woodruff (*Rubia peregrina*, *Galium* and *Asperula*). They contain primarily pseudopurpurin, purpurin and rubiadin. The wild species are native to most of Europe, and some to many parts of Asia (Cardon 2007, 108, 112, 122–28).

The roots of madder are usually harvested in early



Fig. 1. Textile from Hallstatt salt mine, dyed with madder, 1500 BC to 1200 BC (Image: Natural History Museum Vienna, A. Rausch).

autumn when the plant is three years old, and then washed and dried. They are best used crushed or ground finely to free as much of the colourants as possible in the dye bath. A madder dyeing recipe is found on a Babylonian tablet as early as the 7th century BC, describing how red wool can be obtained by boiling it in water with alum, and then boiling it again with madder in water mixed with bran water. However, it is normally only heated slowly to 75 °C or 80 °C, because the wool can turn brown at too high a temperature. The use of alum opens the scales of the wool so the pigment is better fixed to the fibres (Cardon 2007, 113–14, 127).

A wide range of colours can be obtained with madder, depending on the age of the plant and the soil conditions and whether the roots are fresh, dried or fermented. Other factors such as the pH value, natural wool colour, dyeing method (heating, fermentation or double dyeing), and the choice of mordant (copper, iron, tin, chromium or aluminum from plants or minerals) also play a role in the final result. The colour range is especially wide when madder is combined with other dyes, such as weld (*Reseda luteola*) for orange yellows, with tannins for browns or with woad (*Isatis tinctoria*) for violets and blacks, as found in textiles from Masada, Israel (AD 66 to 74). The madder dye technology was especially refined by dyers in Medieval Europe with the rise of the wool cloth industry (Cardon 2007, 113–16).

Before the dyestuff alizarin was synthesised in the 19th century (Chenciner 2000, 258–66), the red dyes produced with madder were a luxury product, emphasising status and identity for hundreds of years. Apart from other subspecies of the *Rubia* genus, some of which have been detected through textile dye analyses (*Rubia cordifolia*, *Rubia peregrina* and *Rubia akane* in

Symbols and abbreviations

- * = reconstructed word in a proto-language
- ' ' = used for the translated meaning of a word
- “ ” = literal translation
- () = botanical name
- > = developed into
- < = developed from
- >>> = borrowed into
- <<< = borrowed from
- PIE = Proto-Indo-European
- s.v. = Latin *sub verbo/voce* ‘(see) under the word X’, used in database references

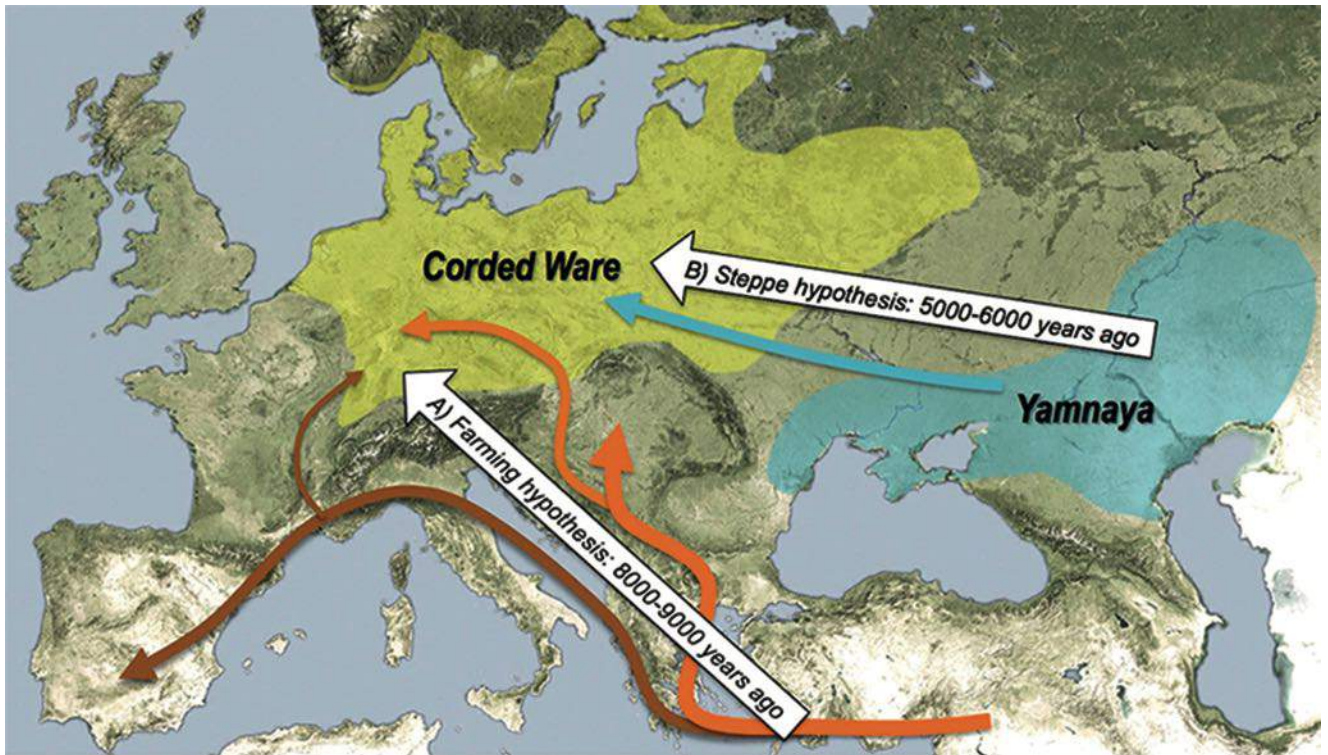


Fig. 2. The two competing hypotheses of the Indo-European homeland (After Haak et al. 2015).

Japan) (Mouri & Laursen 2012), also the wild genera *Galium* and *Asperula* have been used for dyeing red. These are characterised by their much lower alizarin content compared to purpurin and/or rubiadin (Cardon 2007, 127).

According to various literary and ethnographical sources, *Galium boreale* and *G. mollugo* are preferable as substitutes for the cultivated *Rubia tinctorum*. Others recommend *Galium verum* (fig. 3), *G. sylvaticum* or *G. aparine*. These options may depend on availability and soil conditions in different regions (Grierson 1986, 77; Cardon 2007, 127–28).

The use of woodruff (*Asperula* sp.) instead of *Rubia tinctorum* has also been reported (Don 1834, 638) and Linné has similar accounts for *Asperula* in 1742 (Anderberg & Anderberg 2016, s.v. "Asperula tinctoria") (fig. 4). An underinvestigated species in the Rubiaceae-family in terms of dyeing, is field madder (*Sherardia arvensis*) (fig. 5) which, according to one author, should give a pinkish dye (Riley 1997). Thus far, no further information about it as a dye plant and no chemical dye analysis has come to light. It grows across Europe and in the Caucasus (fig. 5). *Asperula arvensis*, native to southern Europe and *Asperula orientalis/azurea*, native to Mediterranean and Middle Eastern regions have blue flowers (fig. 6), but there is no evidence for either as a dye plant. Suggesting they were used for dyeing

in prehistory is therefore problematic (Anderberg & Anderberg 2016, s.v. "Asperula").

Reddish dyes in prehistory

One method of determining whether prehistoric textiles were dyed with them or any other plant is by performing dye analyses such as high performance liquid chromatography (HPLC). These techniques have shown that, at least since the Early Iron Age in Scandinavia (c. 500 BC to AD 400), organic dyes from plants have been used to dye textiles (Vanden Berghe et al. 2009). Similar analyses have been carried out on textiles from the Iron Age in Hallstatt, Austria, and the Bronze Age in Xinjiang, China, both showing (among others) the dyestuff alizarin, which is predominant in *Rubia tinctorum* (Zhang et al. 2008; Grömer 2013, 193; Hoffmann-de Keijzer et al. 2013; Kramell et al. 2014). See table 1 for a list of madder-dye finds.

Apart from the many instances of alizarin detected in prehistoric textiles, some Hallstatt textiles from the Bronze Age (HallTex 205 (fig. 1) and HallTex 242), contain predominantly purpurin, indicating the use of other Rubiaceae, such as *Galium verum*, *Asperula* sp., or *Rubia peregrina* (Hoffmann-de Keijzer et al. 2013, 147–49). The same is true for a textile in Högom, Sweden from the Migration Period (AD 400 to 540) (Vanden Berghe et al. 2009, 1920) and for a silk rope from

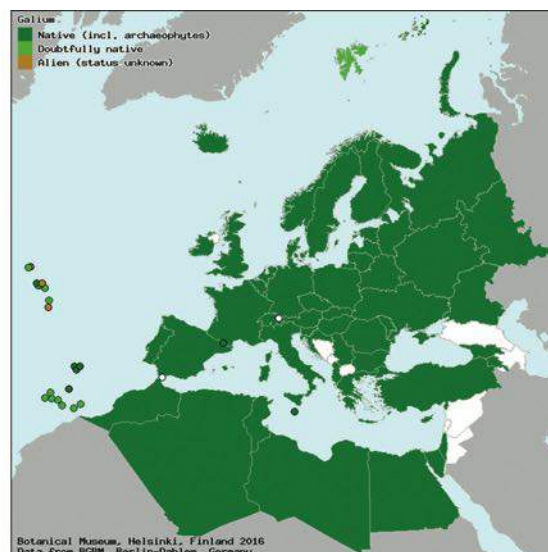
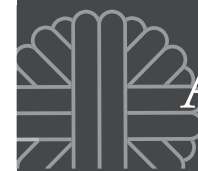


Fig. 3. *Galium* sp. and their distributions. *Galium verum* (Image: wiki-user Tetcu Mircea Rareş). Distribution of *Galium* species in Europe (Euro+Med Plantbase).

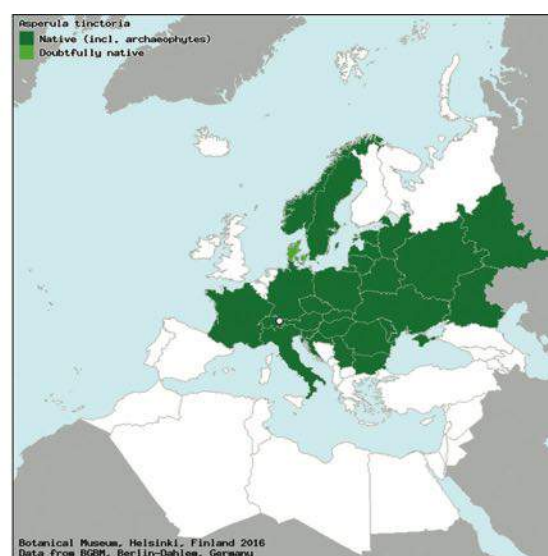


Fig. 4. *Asperula tinctoria* and its distribution. *Asperula tinctoria* (Image: wiki-user Nova). Distribution of *Asperula* species in Europe (Euro+Med Plantbase).

Yingpan (206 BC to AD 618), Xinjiang, China, which is (tentatively) assigned to a local species of madder, *Rubia cordifolia* or *Rubia peregrina* (Liu et al. 2013, 4445–4447). *Rubia cordifolia* was also detected in a Xiongnu silk textile from the 1st to 2nd centuries AD, which was probably imported from China as tribute, where the plant was cultivated for its dye at least 3,000 years ago (Mouri & Laursen 2012, 112). There is evidence for the gathering of *Galium* for dyeing in Scotland from the red-embroidered early 16th century Fetternear Banner (Cardon 2007, 128).

The earliest detectable example of any madder colour, however, is as madder lake on an Egyptian leather

quiver from the Middle Kingdom, 2124 to 1981 BC (Leona 2009). The earliest securely dated madder-dyed textile, dyed without the use of alum mordant, is in Egypt from Tel-el-Amarna c. 1350 BC. A later find with madder fixed on alum-mordanted linen textiles from the royal hoard at Deir el-Bahri, Egypt, is dated to c. 1050 BC (Cardon 2007, 119).

The earliest madder-type dye in Scandinavia is from the Early Iron Age, in the Skærsø textile (1st century BC), but other unspecified red dyes, although heavily degraded were also detectable at trace level (Vanden Berghe et al. 2009, 1912, 1919). Further, ellagic acid, probably tannin, was detected in some of the textiles,

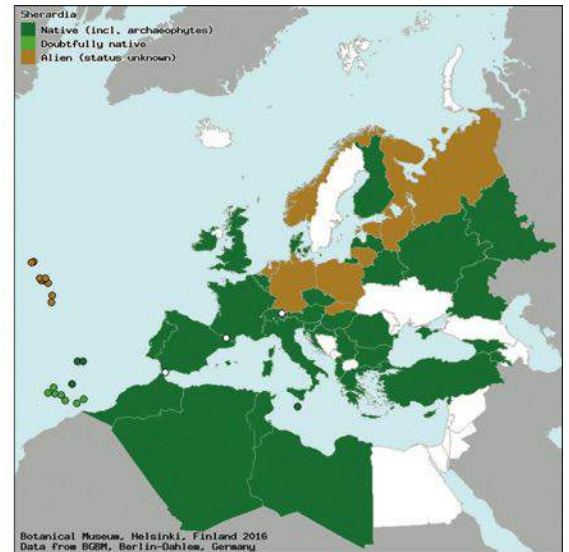


Fig. 5. *Sherardia arvensis* (Image: Mikkel Nørtoft) and its distribution in Europe (Euro+Med Plantbase).

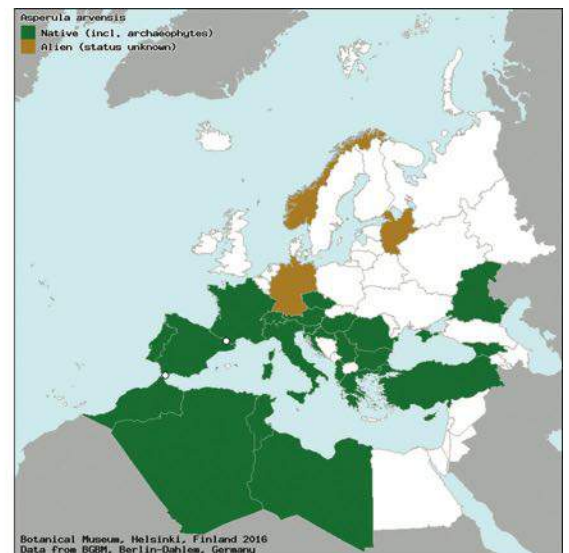


Fig. 6. *Asperula arvensis* (Image: biolib.de) and its distribution in Europe (Euro+Med Plantbase).

likely from a mordant or a dye. In one sample (Huldremose I), only ellagic acid was detected which could be because the original dye had degraded below trace level. Ellagic acid could also be attributed to the *Sphagnum* of the bog environment, but since it was only found sporadically, it is more likely to have been deliberately added as mordant or as dye (Vanden Berghe et al. 2009, 1913, 1918).

In contrast, the Danish Bronze Age oak coffin textiles show no dyes, but some of them tannins (Frei et al. 2017, supplementary data), which could also indicate a mordant or dye (Vanden Berghe et al. 2009, 1918). Therefore, as with Huldremose I, it is possible

that they were dyed, but that the dyestuffs had been degraded enough to fall below trace level, since the oak coffins also have an acidic environment, and are considerably older. Thus, the dyeing of textiles could have taken place in Scandinavia contemporarily with the Hallstatt and Xinjiang textiles of the Bronze Age, although the specific dyestuffs in Bronze Age Scandinavia are unknown.

Occasionally, a red colour can be observed on a textile but with no dyestuff being detected in HPLC analysis, as is the case with the red textiles from Hammerum, c. AD 200 (Mannering & Ræder Knudsen 2013, 158) and Lønne Hede, 1st century AD (Scharff & Sommer



Early evidence for madder-type dyes on textiles in prehistory			
Site	Region	Period/date	Comments
el-Khokha, Thebes	Upper Egypt	Middle Kingdom, 2124-1981 BC	Madder lake on leather quiver, alizarin
Tablet	Larsa region, Mesopotamia	c. 1900 BC	Akkadian <i>hurratu</i> 'madder' ¹
Tel-el-Amarna	Egypt	18th dynasty, c. 1350 BC	no alum mordant
Yanghai graveyard	Turfan region, Xinjiang, China	Bronze Age, 1261-1041 BC	Alizarin, purpurin and rubiadin (Several Rubiaceae sp. possible)
Hallstatt textiles	Austria	Bronze Age 1500-1200 BC	Only wild madder (<i>Rubia perigrina</i>) or bedstraw/woodruff (<i>Galium/Asperula</i>)
Deir el-Bahri	Egypt	21st dynasty, c. 1050 BC	first alum mordant on linen
Hallstatt textiles	Austria	Iron Age (800-400 BC)	Cultivated madder (<i>Rubia tinctorum</i>)
Chärchän	Xinjiang, China	Bronze Age, c. 1000 BC	madder (probably <i>Rubia tinctorum</i>)
Loulan	Xinjiang, China	Bronze Age, c. 1000 BC	Madder (<i>Rubia tinctorum</i>)
Neo-Babylonian tablets	Babylonia	7th century BC	Madder dyeing recipes, one combining woad and madder to imitate Tyrian purple, 3 different madder types
Pazyryk textiles	Altai Mountains, Siberia	Iron Age, c. 500-200 BC	Alizarin, Purpurin (possibly <i>Rubia</i> sp.)
South Stoa	Corinth, Greece	2nd century BC	Pink pigment, mostly purpurin
Skaerød textile	Denmark	Pre-Roman Iron Age, 1st century BC	Mostly alizarin and some purpurin, probably <i>Rubia tinctorum</i> , perhaps imported
Zanjan	Iran	Around the Common Era	Madder (<i>Rubia tinctorum</i>)
Masada	Israel	AD 66-74	Madder in combination with many other dyes
Xiongnu tomb	Mongolia	1st-2nd centuries AD	Silk with purpurin and pseudopurpurin (<i>Rubia cordifolia</i> or <i>Rubia perigrina</i>)
Yingpan	China	206 BC-AD 618	Perhaps local species of madder (<i>Rubia cordifolia</i> , <i>Rubia perigrina</i>)
Högom	Sweden	Migration Period, AD 400-550	Mostly purpurin (wild Rubiaceae)
Tegle	Norway	Migration Period, AD 400-575	Alizarin (<i>Rubia tinctorum</i>) together indigotin (woad, <i>Isatis tinctoria</i>)
Earliest unspecified dyed textiles			
Cave of the Warrior	Jericho, Palestine	4th millennium BC	large linen textile dyed with a dark-brown colour dyed prior to weaving
Majkop/Novosobodnaya	Southern Russia	Late 4th millennium BC	Earliest wool textile. Unidentified dark-brown dyestuff
Oak log coffins	Denmark	Nordic Bronze Age	Only tannins detected
Hammerum	Denmark	c. AD 200	Red colour, but undetected dyestuff
Lønne Hede	Denmark	1st century AD	Red colour, but undetected dyestuff
			Reference
			Leona 2009
			Cardon 2007, 119
			Cardon 2007, 119
			Kramell et al. 2014
			Grömer et al. 2013
			Cardon 2007, 119
			Grömer et al. 2013
			Zhang et al. 2007
			Mouri and Laursen 2012, 112
			Cardon 2007, 119
			Balakina et al. 2005
			Leona 2009
			Vanden Berghe et al. 2009
			Mouri and Laursen 2012, 112
			Mouri and Laursen 2012, 112
			Cardon 2007, 115
			Mouri and Laursen 2012, 112
			Liu et al. 2013
			Vanden Berghe et al. 2009
			Vanden Berghe et al. 2009
			Vanden Berghe et al. 2009
			Koren 2006, 182-184
			Shishlina et al. 2003
			Frei et al. 2017 (supplementary data)
			Mannering and Røder Knudsen 2013
			Scharf and Sommer 2016

Table 1. Early evidence for madder-type dyes on textiles in prehistory.



2016). In these cases, it can be difficult to determine the source of the dyestuff (if present). However, an experiment with the roots of the tannin dye plant *Potentilla erecta* has been carried out in order to dye red by fermentation instead of boiling. This yielded a bright red colour, but only ellagic acid (and its equivalents) was detected in the dye analysis. Furthermore, *Potentilla erecta* has been known in ethnographical sources from Finland to be used as a source for dyeing and tanning red colours (Vajanto 2015, 49–50, 103, 104 (App. 5); Scharff & Sommer 2016). Thus, it is evident that a wide range of red dyestuffs, some still unknown, could have been used in prehistory.

It is possible to trace the practise of colouring and dyeing textiles back to the 4th millennium BC. In the Cave of the Warrior in Wadi el-Makkukh, near Jericho, Palestine, a large textile is sprinkled with red spots of haematite (red ochre) and iron oxide. It also has a decorative weft thread on the end of the warp with a dark brown colour that, although unidentified, was shown to have been dyed prior to weaving (Koren 2006, 182–84).

A similar find has been made in the Majkop/Novosvobodnaya textiles in the steppes of Southern Russia north of the Caucasus, i. e. on the edge of the Indo-European “homeland”. These textiles are indirectly dated to c. 3400–3100 BC (Anthony 2007, 63). They contain the oldest wool found to date, dyed with an unidentified dark-brown tannin dyestuff in the fibres and a mineral (montroydite) red colour painted or sprinkled on the textile. There are, however, some indications that the textile could have been imported to northern Caucasus. The evidence for this is the spin direction, tablet-weaving technique, raw materials, and the similarity of this textile to the textiles of the Cave of the Warrior (Shishlina et al. 2003, 331, 337). Apart from wool, the finds from this site also contained linen fibres, as well as cotton-like fibres. Since cotton cultivation is not reported in the northern Caucasus for this period, but in Mehrghar, Pakistan (c. 5000 BC) and North Arabia (4450–3000 BC), it could be another indicator of import (Betts et al. 1994; Shishlina et al. 2003, 338–39). Although the specific dyestuff has not been tested in the early steppe textiles, it is clear that dyeing of textiles took place at least in the second half of the 4th millennium BC, whether or not it was local or imported to the northern Caucasus. Unfortunately, no dye analyses have been made on the dyed steppe textiles from Novosvobodnaya/Klady. A textile from Sugokleya Kurgan in Ukraine, examined by Margarita Gleba was unfortunately impregnated with acrilate (Gleba 2009, 7), which may present problems for dye analyses in the future.

Nevertheless, all of these examples demonstrate that dyeing with red plant roots was an established part of European prehistoric textile production

Plant name research

Plant names can be very difficult to research historically and etymologically. Wild plants often have many synonyms. A name for one species spreads to another species because of similarity in appearance, usage or folk tales. Sometimes, the spread of a plant name across species can originate from an earlier nomenclatural prototype. One example is the spread of the names *marzanilla/chamomilla* in Spain from an original group of “proto-species”. These two names went from being used in Spain about species with similar flowers, of which some were herbal remedies, to being used about a total of 62 different species whether grouped by appearance or similar use (Morales & Pardo-de-Santayana 2010).

Another issue is the loss of local plant names due to the influence of literary tradition. Examples are the dominant literary languages Latin and Greek, which by means of great literary works from Dioscorides, Pliny and Theophrastus, influenced plant names in many languages, and were used by later authors such as Carl von Linné. Local plant names in languages with less literary traditions were often undocumented and forgotten when other more industrial plants were imported from other countries.

The best case for researching the deeper origins of a plant name occurs when a word apparently defies analysis. The name of a plant can retain and follow regular sound laws, or even retain older pronunciations. Such a word in English is *madder* and its cognates (= related words). Its name does not relate to any other original lexemes in Germanic vocabulary.

Cognates of English *madder*

Germanic cognates

The Germanic language branch comprises the sub branches:

- West Germanic (English, Dutch, Frisian, and the German dialects)
- North Germanic (Old Norse and its descendants Danish, Swedish, Norwegian, Icelandic, and Faroese)
- East Germanic (Gothic, now extinct).

The historical spread of the words in this section can be seen in fig. 7. English *madder* (*Rubia*) is recorded in Old English with the variants *mæddre*, *mædre*, *mædere*, *mæderu*, *medere*, *meder* (*Rubia* and *Galium*). The



blue-flowered Rubiaceae *Sherardia arvensis*) is known in Modern English as *madderlen* (a term coined in 1786), and as (*blue*) *field madder* with older forms in Old English *fældmædere*, *feldmedere* (here with an unexplained mistranslation ‘rosemary’) (Bierbaumer & Sauer 2007, s.v. “madder”, “feldmædere”). Old English is part of the West Germanic branch which also includes Old High German with the cognate *matara* (*Rubia*) (Britten & Holland 1886, 318; Toller & Bosworth 1921, 654; Vasmer 1955, II:106; De Vries 1962, 375; Holthausen 1974, 210; Orel 2003, 252). There could be an *r*-less variant in Proto-Germanic **madō-* to explain the problematic form in West Frisian *mīde* ‘madder’, which perhaps spread to Middle Low German and Middle Dutch *mēde*, ‘madder’, and Dutch *mee-krap* ‘madder’ (Kroonen 2013, 346). In the North Germanic branch, we have Norwegian *maure*, New Norwegian *modre*, *modra*, *mora*, Swedish *måra*, *madra* (*Galium*, *Asperula tinctoria*), and *blå-madra* for another Rubiaceae (*Sherardia arvensis*). All these North Germanic names go back to Old Norse *maðra* (and in place names in Norway and Iceland) from an earlier Proto-Norse **maðrō* (Fritzner 1954, 618; Falk & Torp 1960, 705–6; De Vries 1962, 375; Kylstra et al. 1996, 2:254; Magnússon 2008, 597; Anderberg & Anderberg 2016, s.v. “Rubiaceae”).

From all these, it is possible to reconstruct a Proto-Germanic **mad(a)rō-*, showing variants with (for West Germanic), or without (for North Germanic), an internal *-a-*. This variation is still seen in Old English *mædere*, *mædre*.

An internal Proto-Germanic **-a-* is also suggested by borrowings from Germanic to some Finno-Ugric languages in the Baltic area (Kroonen 2013, 346), perhaps already at a Proto-Germanic stage into the Iron Age Proto-Fennic **matara*. This developed into Finnish *matara* (*Galium*), *sini-matara* (“blue madder”, *Sherardia arvensis*), Estonian *madar* (genitive *madara*) (*Galium*), *madarik* (the blue *Sherardia arvensis*), *lõhnava madar* (“scented madder”, *Asperula*), Ludian *madaro* ‘orange/reddish-dyeing lichen species (*Parmelia saxatilis*)’ (Lönnrot 1802, 1047; Kujola 1944, 226; Tamm 1981, 286; Saagpakk 1982, 470; Grierson 1986, 186–87), Karelian *mataro*, *matara* ‘plant, from which a red or yellow dyestuff is recovered’, and Ingrian *mattāra* ‘dyestuff (lichen or moss)’ (Virtaranta & Virtaranta 1983, 278; Kylstra et al. 1996, 2:254). The name has been further borrowed into Latvian as *madaras* and into Russian as *matura* (*Galium boreale*) (Berneker 1913, 67). It is evident from the material presented here that this word has come to be associated with both Rubiaceae and lichen species in the languages of northern Europe.

As the evidence suggests, many of these names denote

Sound laws

The historical linguist compares related languages systematically to set up a system of regular sound laws for the language changes in each language branch. The sound laws are applied to reconstruct proto-languages. The most famous of these (actually a set of sound laws) is called The Germanic Sound Shift, stating a set of developments from PIE to Proto-Germanic:

**p* > **f*, **t* > **þ* (pronounced *th* as in English *thorn*), **k* > **h* and **k^w* > **h^w* (*w* = labial pronunciation), **b* > **p*, **d* > **t*, **g* > **k*, **b^h* (*h* = aspiration) > **b*, **d^h* > **d*, **g^h* > *g* (Kroonen 2013, xvii–xxix).

Many other sound laws can be proven from PIE to Proto-Germanic and in the other Indo-European branches as well, and all these sound laws, applied together systematically, make up the basis for reconstructing their common mother-tongue, Proto-Indo-European (see for example Mallory and Adams 2006, 39–53).

the cultivated *Rubia tinctorum*, but as the same name seems to appear for other Rubiaceae species, such as *Galium*, *Asperula* and *Sherardia*, it may be that the literary tradition produced the names for the cultivated *Rubia* species, and thus the prehistoric equivalent of the word could have been assigned to the wild Rubiaceae. Anthony Esposito (2003, 233) goes as far as stating: “The word in [Old English] and [Old Norse] could not originally have denoted the exotic *Rubia*, but probably belonged to various species of the allied genera *Asperula* and *Galium*, some of which are still used as substitutes for madder.”

However, as the Iron Age textiles from Hallstatt and one of the Pre-Roman Iron Age textiles from Denmark show predominantly alizarin (= *Rubia tinctorum*) in one sample, as well as alizarin + purpurin (= *Galium*, *Asperula*, *Rubia peregrina* or similar) in a tassel (Vanden Berghe et al. 2009, 1917, 1918), it is likely that this word was used about both the wild and cultivated plants, in the sense ‘red-dyeing plant/root’ at the time of Proto-Germanic.

From Proto-Germanic **maðrō-*, it is possible to work way backwards by means of sound laws to Pre-Proto-Germanic/late PIE **mod^hrā-* (regularly **a* < **o*, **ō* < **ā*, **d* < **d^h*) and further back to PIE **mod^h-r-eh₂* (regularly **-ā* < **-eh₂*) (see e. g. Kroonen 2013, xv–xli (phonological introduction), and 2013, 346). The suffix **-eh₂* is typical of feminine formations of masculine *o*-stem adjectives, e. g. in the suffix **-ro-* > feminine **-r-eh₂* in the Proto-Indo-European system (Beekes & De Vaan 2011, 199, 220).



Cognates to Proto-Germanic **madrō-*

There are formal cognates (i. e. related words conforming to the sound laws) to the Proto-Germanic **mad(a)rō-* in the Slavic branch of Indo-European, e.g. in the West Slavic sub branch: Czech *modrý*. However, Slovakian *modrý*; Polish *modry*, Slovianic *modrī*, Upper Sorbian *módry*, they all mean 'blue', and not 'red', which is problematic for the reconstructed meaning of the PIE word.

The same meaning can be seen in the South Slavic branch, e. g.: Serbo-Croatian *mòdar*, f. *mòdra*, n. *mòdro*; *mòdar* (Croatian), f. *mòdra*, n. *mòdro* and Slovene *mòdar*, f. *mòdra*, also meaning 'blue'. All these words would go back to a Proto-Slavic **modrǔ* 'blue' (Berneker 1913, 66–67; Derksen 2008, 320–21).

More Indo-European branches can be identified. In the Tocharian branch: Tocharian B *motār-tstse* 'green' borrowed into Tocharian A as *motartstsi* 'some sort of dark colour'. The Tocharian suffix *-tstse* is secondary, so an original Proto-Tocharian **motar-* can be assumed, which, according to Douglas Adams (2013, 511–12), could go back to a Proto-Indo-European *u*-stem **mod^h-r-u-*, perhaps meaning 'colour(ing agent), dye-stuff(?)' derived from a Proto-Indo-European verbal noun **mod^hr-* 'colour(ing)'.⁵

In the oldest branch, Anatolian, there might also be a cognate in Hittite *an-ta-ra-* (pronounced with syllabic *n-*, i.e. *ṅdrā-*). Again, the meaning is 'blue', and also exhibits a **ro*-adjective, but here with a zero-grade in the PIE root. The development seems to have gone from (early) PIE **mḡ^h-ró-* > **mḡ^h-rā-* > Hittite *an-ta-ra-* (i.e. /*ṅdrā-*/) (Machek 1949, 131–32; Kloekhorst 2008, 186).

Thus, there is an **-r-* suffix in all four branches:

- Proto-Germanic **mad(a)r-ō* 'Rubiaceae species' < **mod^h-r-eh₂-* (feminine)
- Proto-Slavic **modrǔ* 'blue' < **mod^h-r-o-* (masculine *o*-stem),
- Proto-Tocharian **motar-* 'green' < **mod^h-r-u-* (masculine *u*-stem)
- Hittite *antara* (*ṅdrā-*) 'blue' < **mḡ^h-r-ó-* (zero-grade).

According to the consensus model of the chronology of the split of the Indo-European languages, the Hittite branch broke off from the Indo-European proto-language and homeland around 700 to 1000 years (c. 4300 to 4000 BC) before Tocharian (c. 3300 BC), and the rest of the branches (c. 3300 to 2500 BC) (Mallory 1989; Anthony 2007; Allentoft et al. 2015; Haak et al. 2015). Therefore, it is perhaps not so problematic to accept that a secondary *o*-grade **mod^h-r-o/eh₂* (masculine/feminine) could have formed in these intermediary 700 to 900 years from an earlier zero-grade **mḡ^h-r-ó-*. On that

basis, the most likely original meaning for this word is 'blue'.

The next, and much more difficult problem, is determining why this word went from meaning 'blue' to meaning 'red', or 'red-dyeing root, Rubiaceae'. Adams (2013, 512) suggests that: "It is possible the bedstraws were originally named for their characteristic yellow-green flowers". This has some problems: 1) yellow and green are perhaps the most common colours of plants in the wild, 2) *Galium* or *Asperula* species usually do not have green flowers (most plants have green stems and leaves), and 3) why would plants with yellow flowers be named after the colour blue?, and 4) only Tocharian has the meaning 'green'.

Other Indo-European Rubiaceae names

Two other widely used names for several Rubiaceae species are the French *garance* and Slavic *broč*. Their origins do not seem to go back to Indo-European, but to a confusion of words in Vulgar Latin *bractea/brattea/blattea* 'gold foil', from where it is not further traceable (Niedermann (1921, 436–40). Slavic also has the word *mareña* (*Rubia tinctorum* or other Rubiaceae), which could be secondarily derived from a PIE root **mōr-* 'to smear' (Berneker 1913, 18).

Other names for the madder plants which seem to be secondary derivations are Old English *wrætte* and Old High German *rezza* 'madder' < PIE **urod-i-eh₂* 'root' (Kroonen 2013, 595). In Greek, *ereuthé-danon* 'red dye, *Rubia tinctorum*' and *eruthró-dano-* seem to be secondary derivations from a PIE root **h₁reud^h-* 'red', a widespread root in Indo-European. The same root is found in Old Irish *ruam* 'red dye' < Proto-Celtic **rowd-smon-* 'red dye' perhaps from PIE **h₁reud^h-smon-* (but this formation is only seen in Celtic), which could have been used about the red (possibly Celtic) Hallstatt textiles (Stifter 1998, 208, 211).

The fact that the dye-related names for the madder plants in Indo-European languages have a variety of different origins could suggest that madder was only used as a dye-plant after the Indo-European languages split up. These names often seem to have been derived from existing and relatable PIE vocabulary such as colour-terms ('red'), or borrowed in historical times from unknown sources.

An alternative to Rubiaceae

If the Germanic names for Rubiaceae with dyeing abilities are only associated with 'red' in Germanic but other Indo-European language branches point to an original meaning 'blue', there is still a need for an explanation for this semantic change in the prehistory of Germanic. As it seems to have been associated with



Boraginaceae						
Species	Flower colour (where available)	Root colourant (alkannin/shikonin and derivatives)	Vernacular name (English unless otherwise stated)	Distribution	Reference (all including Papageorgiou et al. 1999)	
<i>Alkanna/Anchusa tinctoria</i>	blue	alkannin (1.24-1.47%)	Alkanet	Mediterranean, Balkans, Middle East, Central Europe	Akgun et al. 2011	
<i>Arnebia hispidissima</i>	yellow	alkannin, shikonin	Arabic primrose, Nigerian: Jinin mutum 'the blood of man'	North Africa to northern India	Cardon 2007, 73-74	
<i>Arnebia nobilis</i>	purple/dark brown, later yellow	alkannin	Hindi: Ratanjot 'ruby red'	High mountains of eastern Afghanistan	Arora et al. 2012, 178; Cardon 2007, 65	
<i>Arnebia/Macrotomia densiflora/tinctoria</i>	yellow	alkannin (57 mg/g, 5.7% of air-dry material)	Arnebia	Greece, Anatolia	Bozan et al. 1997	
<i>Arnebia euchroma</i>	dark purple	shikonin (1.5 mg/g, 0.15%), acetylshikonin (19.7 mg/g, 1.97%)	Uigur: Soghagul, Chinese: Zicao	Central Asia	Hu 2007, 152; Cardon 2007, 65-67	
<i>Arnebia guttata</i>	yellow	shikonin (0.078 mg/g, 0.0078%)	Purple herb (not official)	Central Asia to Mongolia	Hu 2007, 152; Cardon 2007, 65-67	
<i>Cynoglossum officinale</i>	reddish-purple	shikonin	Hound's tongue	Most of Europe		
<i>Echium plantagineum/lycopsis</i>	purplish blue to purple	shikonin	Purple viper's bugloss, Paterson's curse, Salvation Jane	Western and southern Europe, Middle East and Crimea		
<i>Echium rubrum/russicum</i>	red	shikonin (0.0044-0.16 mg/g air-dry material, 0.00044-0.016%)	Red bugloss, Red-flowered viper's grass	Russia	Dresler et al. 2015, 700; Dresler et al. 2017, 693	
<i>Echium vulgare</i>	blue	shikonin (0.0048-0.28 mg/g air-dry material, 0.00048-0.028%)	Viper's bugloss, Blueweed	Pontic-Caspian steppes, Europe, Anatolia	Dresler et al. 2015, 700; Dresler et al. 2017, 693	
<i>Lappula squarrosa</i>	light blue	shikonin	Stickseed	Most of Europe, Russia, Anatolia		
<i>Lithospermum arvense</i>	white (with blue subsp.)	acetylshikonin	Field gromwell, German: Schminckwurz	Europe		
<i>Lithospermum/Buglossoides purpureoaeeruleum</i>	blueish purple	maclurin-equivalent	Purple gromwell	Britain, Central Europe, South Russia, Mediterranean, Anatolia	Grömer et al. 2013, 263	
<i>Lithospermum erythrorhizon</i>	white	shikonin (0.472-30 mg/g, 0.0472-3.0%)	Red-root gromwell, purple gromwell	Eastern Eurasia	Hu 2007, 152; Krivoshechkova et al. 1976;	
<i>Lithospermum officinale</i>	white	shikonin (0.079 mg/g, 0.0079%)	Stone gromwell	Pontic-Caspian steppes, Europe, Mediterranean	Dresler et al. 2017	
<i>Onosma/Arnebia echioides</i>	pale yellow	alkannin/shikonin (0.063-67.1 mg/g, 0.63-6.71%)	Prophet's flower, Hairy onosma	Mediterranean Europe, Iran, Himalayas, Kashmir, Siberia	Cardon 2007, 63-65	
<i>Onosma paniculata</i>	purplish flowers	alkannin (0.057 mg/g, 0.0057%), acetylshikonin (2.86 mg/g, 0.286%)	Onosma, Chinese: Zicao	Southern China	Hu 2007, 152; Cardon 2007, 63-65	
<i>Onosma hookeri</i>	blueish purple	shikonin (0.093 mg/g, 0.0093%), acetylshikonin (0.747 mg/g, 0.0747%)	Onosma, Chinese: Zicao, Hindi: Ratanjot	Afghanistan	Hu 2007, 152; Cardon 2007, 63-65	

Table 2. Boraginaceae mentioned in the article with their respective dyestuffs (and concentration, as available), and flower colour.



a 'red dyeing root' in Proto-Germanic, another family of plants with similar red-pigmented roots, the Boraginaceae, offer some helpful evidence. These yield highly concentrated red/purple dye in species of the genera *Alkanna/Anchusa*, *Arnebia*, *Onosma*, and *Lithospermum* (Cardon 2007, 60–74).

Boraginaceae

One Boraginaceae species described for its red and purple root-pigment in antiquity is *Alkanna*, or *Anchusa* (Dioscorides, c. AD 77, Theophrastus, 4th to 3rd century BC), and for its medicinal uses by Hippocrates, c. 400 BC) (Papageorgiou et al. 1999, 271–73). The word *poni-ki-jo/a* in Mycenaean refers to a red colour or red plant substance, possibly madder or alkanet, suggesting it may have been used as a dyestuff in Europe in the Bronze Age (Bendall 2017, 315, note 55).

Other genera from the same family are used in different parts of Asia. *Arnebia nobilis*, for example, can dye textiles (Arora et al. 2012) and *Arnebia guttata* is still used for its pigment by Pamir nomads today (Soelberg 2016, 30–31). *Lithospermum erythrorhizon* ("red-root") was cultivated for its dye and medicinal properties in China, probably from the beginning of the Common Era (Papageorgiou et al. 1999, 274).

Alkanna/Anchusa is a main source of the dyestuff alkanin, and *Arnebia* sp., *Lithospermum erythrorhizon* and *Lithospermum officinale* are sources of shikonin, two dyestuffs that are red at pH 6.8, purple at pH 8.8, and blue at pH 10, or deep red in an oily or greasy media and violet in an alkaline media (Khattak et al. 2015, 903). The related species *Lithospermum arvense* contains acetylshikonin and other derivatives (Papageorgiou

et al. 1999, 277). These, and many other plants in the Boraginaceae family are known to be used as dye, pigment, and cosmetics in history and folklore. A list of the many variants of alkanin and shikonin, and their occurrences in Boraginaceae-species can be found in Papageorgiou et al. (1999, 276–78), and some of their reported dyestuff concentrations from the literature are compiled in table 2. A few other genera of Boraginaceae are *Onosma* sp., *Echium* sp., *Cynoglossum* sp., and *Lappula* sp. Some species of *Onosma* and *Arnebia* are grouped together in India as *ratanjot*, meaning 'ruby red', because of their red root pigment, and are imported to Indian markets from Afghanistan (Cardon 2007, 65; Arora et al. 2009).

The different genera are widespread in most of Eurasia, especially *Echium* and *Lithospermum* (figs 8-12).

Many of the names of these species are associated with cosmetic or red-colouring properties (Table 3) and seem to be grouped together and intertwined in the nomenclature as well, often taking each other's names, such as Danish *sminkerod*, Swedish *sminkrot*, German *Schminkwurz* ("cosmetic root"), *Bauernschminke* ("peasant cosmetic") about *Lithospermum arvense*, *Alkanna tinctoria*, and *Onosma paniculata* (Marzell 1943, 193; 1951, 1341–42; 1963, 408). There are similar references to pigment shared between the red-rooted *Potentilla* sp. and Boraginaceae: such as *Blutkraut* "blood weed", *Rothwurz* "red wort", *Färwekraut* "dye weed", Spanish *sanguinaria* 'bloodroot' (*Lithospermum arvense*) (Marzell 1951, 1341–42; 1963, 183–94, 408).

The fresh roots of *Lithospermum arvense* were used as a cosmetic for its red-colouring by "country girls" in Finland and Lapland as described by Linné in *Flora*

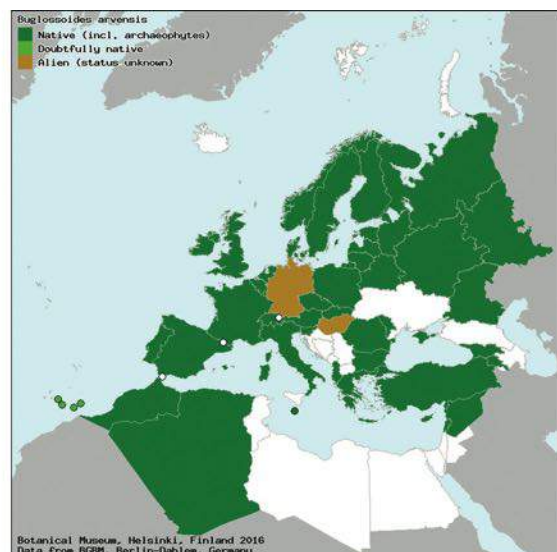


Fig. 8. *Lithospermum arvense/Buglossoides arvensis* var. *coeruleascens*, southern Sweden (Image: Jan Thomas Johansson). Distribution of *Lithospermum arvense/Buglossoides arvensis* var. *coeruleascens* in Europe (Euro+Med Plantbase).

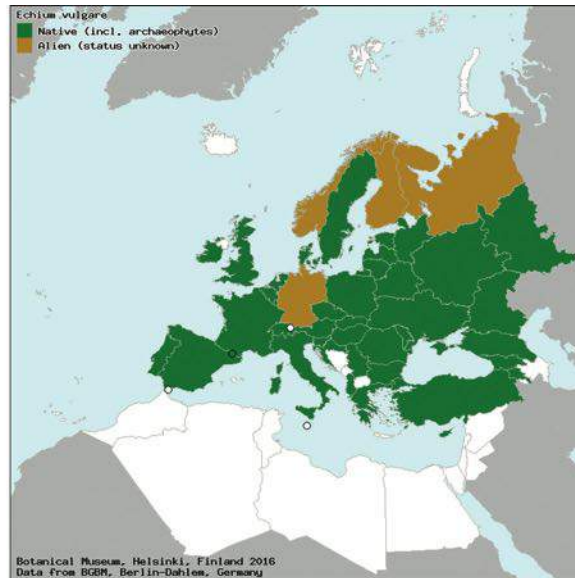


Fig. 9. *Echium vulgare* near Saratov, south-western Russia (Image: Wiki-user Le.Loup.Gris). Distribution of *Echium vulgare* in Europe (Euro+Med Plantbase).

Suecica, and witnessed by Marzell in 1936 in Krosno Odrzańskie in western Poland (Marzell 1951, 1342). In Missouri, the related *Lithospermum canescens* was called Indian-paint because the Native Americans used the root in this way (Marzell 1951, 1342). The German name *Schmink* for *Lithospermum arvense* indicates an association with cosmetics since 1590 (Svanberg 2000, 83). However, dyeing experiments with it have not yet been undertaken or remain undocumented. One Early Iron Age sample from Huldremose II, Denmark, showed a dyestuff the authors termed "Unknown 3", which looked similar to alkannin

(perhaps from alkanet, *Alkanna tinctoria*) or a lichen species called Scandinavian orchil (*Ochrolechia tartarea*). However, for historical reasons, and because of a probable parallel in Norway, the authors lean towards orchil (Vanden Berghe et al. 2009, 1913, 1918). The red pigment produced a deep red colour when it was extracted from 10 g of *Alkanna tinctoria* roots in a solution of 200 mL denatured alcohol (93%) in a bottle and left for three days. The extract was then put in a pot with alum-mordanted wool yarn and water until the yarn floated. The colour turned a "red cabbage violet". It was then heated and the

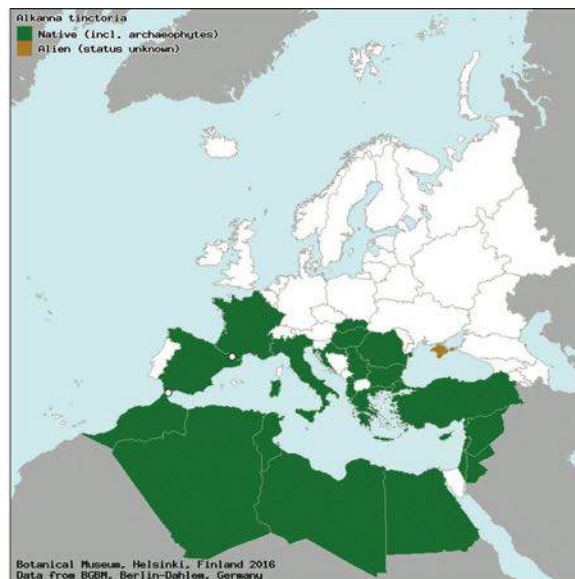


Fig. 10. *Alkanna tinctoria* in Torreilles, France (Image: Jean Tosti). Distribution of *Alkanna tinctoria* in Europe (Euro+Med Plantbase).

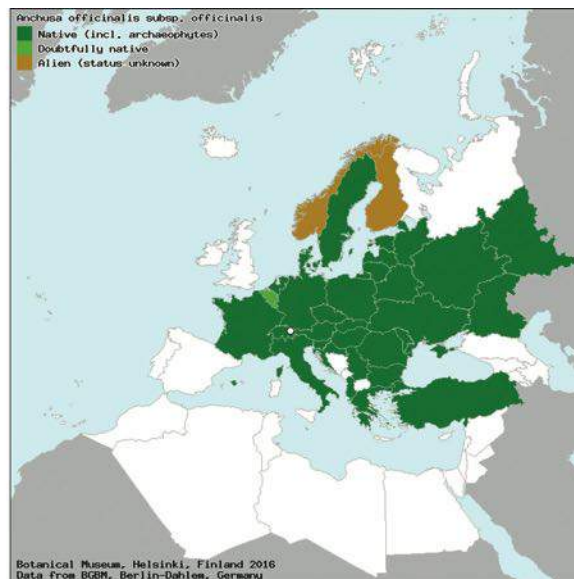


Fig. 11. *Anchusa officinalis* (Image: Kurt Stueber, www.biolib.de). Distribution of *Anchusa officinalis* (Euro+Med Plantbase).

colour changed to a deep violet or “eggplant colour” (fig. 13).

As denatured alcohol was not available in prehistory, another extraction method would be necessary. One method is extraction with fat or grease (Cardon 2007, 62) but this is probably not suitable for textile dyeing. According to Dominique Cardon (pers. comm. 24 November 2017), the extraction works well using mead, and Cardon has also had success with dyeing wool using the mead-extracted Boraginaceae pigment (from *Alkanna tinctoria* and *Onosma*. Cardon (2007, 62) also mentions the historical use of hydromel (low-alcohol mead, honey-water, or perhaps an English

translation error from the French *hydromel* referring to regular mead) for this extraction.

Mead has been found widely in prehistoric containers, at least since the Bell Beakers (Guerra-Doce 2003), and the word is very securely reconstructed to PIE as **médh-u-* ‘mead, honey’, attested in nine branches: Germanic, Greek, Celtic, Baltic, Slavic, Indic, Iranian, Tocharian, Anatolian (Hyllested 2003, 49; Kroonen 2013, 361; Nørtoft 2017, 95). One blue Boraginaceae species, *Echium vulgare*, also native to the Pontic-Caspian steppe (fig. 9), is a key component in bees’ honey production (Martín Arroyo et al. 2017). With these facts in mind, one might further speculate about

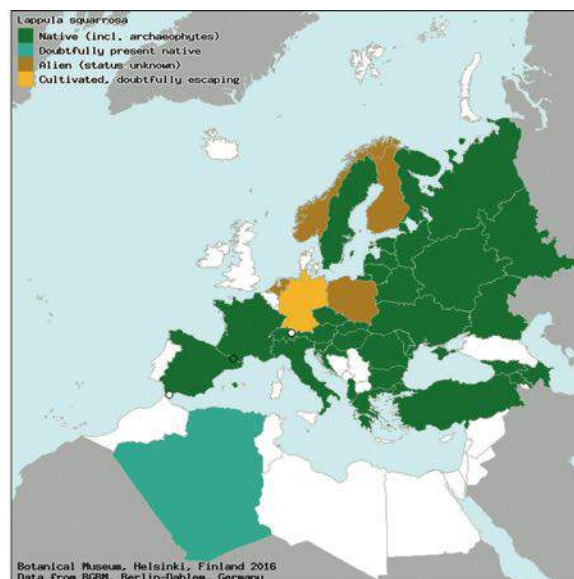


Fig. 12. *Lappula squarrosa* (Image: Matt Levin). Distribution of *Lappula squarrosa* (Euro+Med Plantbase).



a connection between PIE **méd^h-u-* ‘mead, honey’ and **mod^h-r-/*mǵ^h-ro-* ‘blue, blue (dye) plant(?)’. However, that would be another study, entirely.

The shikonin content of the blue-flowered *Echium vulgare* (and its derivatives) is very low. It is measured to 4.8 mg/kg (= 0.0048 mg/g (0.00048%)) of air-dried material in one study (Dresler et al. 2015, 700), but 0.284 mg/g (0.0284%) in another (Dresler et al. 2017, 692–93). Further studies would be welcome. *Lithospermum*

officinale’s shikonin content is measured as 0.079 mg/g (0.0079%, with 0.002 mg uncertainty) (Dresler, et al. 2017, 692–93). In comparison, *Alkanna tinctoria* yields 1.24 to 1.47% alkannin (Akgun et al. 2011), and *Lithospermum erythrorizon* c. 3% shikonin (Krivoshchekova et al. 1976, 652) (Table 2). However, the shikonin level of *Arnebia guttata*, still used as cosmetic by the wakhi-nomads of Afghanistan (see above), is measured at 0.078 mg/g (0.0078%), almost the same as *Lithospermum*



Fig. 13. The process of dyeing wool with *Alkanna tinctoria* by Jane Nøhr (with permission). a. Extracted dye solution from roots, b. Dye solution sample on cotton pad, c. Dye bath with wool, d. Fabric dyed with *Alkanna tinctoria*.



Fig. 14. *Lithospermum purpurocaeruleum*, a possible source of the maclurin-equivalent in HallTex 205.

officinale. Thus, the even higher shikonin measurement for *Echium vulgare* (up to 0.0284%) might also be enough to have been used as cosmetic in the steppes. One of the Bronze Age Hallstatt textiles (HallTex 205) that contained purpurin (= *Galium* or *Rubia peregrina*) also contained a maclurin-equivalent (Grömer 2013, 263) that the authors suggest could be from the root of purple gromwell (*Lithospermum purpurocaeruleum*) bearing purple or bright blue flowers depending on the season (fig. 14). However, maclurin is typically connected with yellowish dyes, so a red-blue association is less probable. Nevertheless, it could testify to a knowledge of using textile dye from some Boraginaceae roots in Bronze Age Hallstatt.

Other Boraginaceae also have characteristic blue flowers, such as *Lithospermum arvense* var. *coerulescens*, *Echium vulgare*, *Alkanna tinctoria*, *Anchusa officinalis*, and *Lappula squarrosa* (figs 8-12).

The blue flowers are also reflected in some Boraginaceae names (Table 3), such as Swedish *blå sminkrot* about *Lithospermum arvense* var. *coerulescens* and Danish *blåfrue* ("blue-lady"), Swedish *blåeld* ("blue-fire"), Finnish *sini-kunteri*, Russian *sinij cvet* (*sini(j)*-="blue") and English *blueweed*, all used about *Echium vulgare* (Marzell 1951, 192-193).

In the Slavic languages, the PIE root **mod^h-r-* 'blue' appears in several plant names, some of them Boraginaceae (highlighted in bold): Slovincian *modřińc* (*Delphinium consolida*, *Echium vulgare*), *modré krěpk'i* 'forget-me-not (*Myosotis palustris*, another blue Boraginaceae sp.)', *modri mlěč* 'chicory (*Cichorium intybus*)', Kashubian *Zwěczajny mòdrzińc* (*Echium vulgare*), Kashubian *mòdròk* 'blue cornflower (*Centaurea* sp.)',

Vernacular names of Boraginaceae mentioned in this article

Names relating to cosmetic properties of

(*Lithospermum arvense*, *Alkanna tinctoria*, *Onosma paniculata*)

Danish	sminkerod
Swedish	sminkrot
German	Schminkwurz (<i>Lithospermum arvense</i>); Bauernschminke (<i>L. arvense</i>); Schmink (<i>L.</i>

Names relating to "blood/red/pigment"

(*Potentilla* sp., and various Boraginaceae)

German	Blutkraut
German	Rothwurz
German	Färbekraut
Spanish	sanguinaria (<i>Lithospermum arvense</i>)
American English (Missouri)	indian-paint (<i>Lithospermum canescens</i>)

Names relating to 'blue' (in blue font) for Boraginaceae

(in bold) and other plants

Swedish	blå sminkrot (<i>L. arvense</i> var. coerulescens); blåeld
Danish	blåfrue (<i>L. arvense</i> var. coerulescens)
Finnish	sini-kunteri (<i>Echium vulgare</i>)
Russian	Sinij cvet (<i>Echium vulgare</i>)
English	Blueweed (<i>Echium vulgare</i>)
Slovincian	modřińc (<i>Delphinium consolida</i> , Echium vulgare)
Slovincian	modré krěpk'i 'forget-me-not (<i>Myosotis palustris</i>)
Slovincian	modri mlěč (<i>Cichorium intybus</i>)
Kashubian	Zwěczajny mòdrzińc (<i>Echium vulgare</i>)
Kashubian	mòdròk (<i>Centaurea</i> sp.)
Polish	modrzeniec , modrzyk (<i>Centaurea</i> sp.)
Old Polish	modrak , modrzyk (<i>Centaurea cyanus</i> , <i>Cichorium intybus</i>)
Bosnian	modrec , modrac (<i>Centaurea cyanus</i>)

Table 3. Common names of Boraginaceae related to blue.

Polish *modrzeniec*, *modrzyk* 'cornflower (*Centaurea*)', and Old Polish *modrak*, *modrzyk* 'blue cornflower (*Centaurea cyanus*)', chicory (*Cichorium intybus*)', Bosnian *modrec*, *modrac* 'blue cornflower (*Centaurea cyanus*)' (Trubačev 1992, 96-99, 102, 104).

It is important to remember, however, that the Slavic plant names in *modr-* could be secondarily derived, as they are still identifiable as 'blue' to Slavic speakers to some extent. Most of the Slavic non-Boraginaceae plants are also found in the PIE homeland (see below). Perhaps the Indo-European word **mod^h-r-* was



Fig. 15. Prehistoric finds of different Boraginaceae in this survey of archaeobotanical literature by period/culture.

originally a descriptive term for blue-flowered plants, such as *Echium vulgare* until the Corded Ware/Bell Beaker/Unetice period and later referred to the pigmented roots of blue Boraginaceae sp. (*Echium vulgare*, *Lithospermum purpureocaeruleum*). It may have only later been assigned to the red-dyeing roots of the Rubiaceae species in the prehistory of Germanic (fig. 7).

Boraginaceae in archaeobotany

The archaeobotanical record also merits study in order to assess what plants were present in the PIE homeland, and the target area of Indo-European peoples' migrations into Europe around 3000 BC. Archaeobotanical studies have often focused on domesticated crops, which makes looking for wild weeds in the literature difficult. In the case of steppe research, the excavations were often conducted without the benefit of flotation methods and other techniques for finding plant remains (Anthony 2007, 129). However, awareness of these methods is improving, and no doubt there will be more archaeobotanical data available in the future. Therefore, there is no current definitive evidence when comparing the linguistic and

archaeobotanical data, but there is a likely indication of the availability and intentional collection of wild Boraginaceae in prehistory.

Limited access to archaeobotanical databases in this study identified finds of *Lithospermum* sp. (*arvense*, *officinale*, and *purpureocaeruleum*), *Alkanna/Anchusa* sp., a few (but some plentyful) finds of *Echium* sp., one find of *Lappula* sp., and one of *Arnebia* sp. (fig. 15). Supplementary data, further literature and maps of dye plants are available at:

<http://prehistoricmap.com/Nortoft2017appendix.pdf>.

Although the prehistoric distribution of the plants (fig. 15) seems to be widespread today in most of Eurasia (figs 8-12), they mostly appear in archaeobotany around the Mediterranean. This may be the result of a sample bias because of a poor archaeobotanical tradition in Russia. *Lithospermum officinale* seeds are found in large, concentrated numbers in the Cucuteni culture (phase A2, 4400 to 4200 BC) of Copper Age Romania (Solcan et al. 2014). These seeds have also been found in several finds from the Catacomb culture (2300 to 2200 BC), where there were local descendants of the Indo-European-speaking Yamnaya herders of the steppe



region. The seeds are also found on an orange-dyed headdress of the same culture (Shishlina et al. 2005), and in the Crimean Neolithic period as early as 5836 to 5358 BC (Salavert et al. 2014, 4). They are also found with a cataplasm in the late Mierzanowice culture (1750 to 1600 BC) of Poland, which shows the plants' association with medicine (Baczyńska & Lityńska-Zajac 2005). However socially important this plant

may have been, its flowers are not blue, but white, and its dye concentration (shikonin content c. 0.0079%) is quite low compared to some other Boraginaceae that are known to dye wool. Therefore, the blue or purple colour on wool dyed with *Alkanna tinctoria* is unlikely to have been achieved with *Lithospermum officinale*, which makes it a poor candidate for an association with the original meaning of PIE **mod^h-r-* 'blue'.

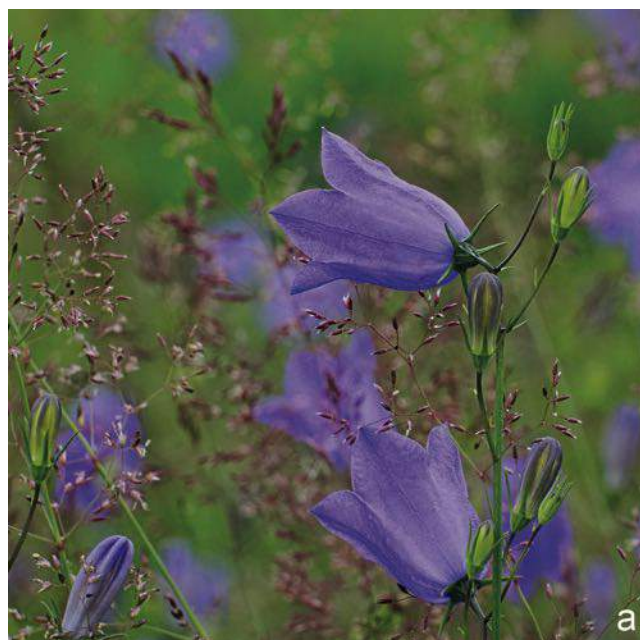


Fig. 16. Blue flowers found in the prehistoric steppe region. a. *Campanula rotundifolia* (Image: Andreas Eichler), b. *Centaurea cyanus* (and other flowers) (Image: Wiki-user Valen1988), c. *Cichorium intybus* (Image: Bruce Marlin), d. *Gentiana asclepiadea* (Image: Martin Kozák).



Nutlets of the blue-flowered *Lithospermum purpurocaeruleum* are found in abundance at two other Cututeni (Copper Age, phases A2-B: c. 4400 to 3350 BC) sites. They were found in two dwellings at Izvoare, Romania: 8,000 nutlets (half of them perforated) in one and 1,091 in the other. At Bodești, Romania, 75 nutlets were found. They were deposited in pots and goblets, demonstrating meticulous gathering and modification of these seeds, which the authors suggest had a social and ritual significance through a wide range of medical properties in this and many other Boraginaceae species (Solcan et al. 2014). There are no published studies on the shikonin/alkannin content of *Lithospermum purpurocaeruleum* known to date. Thus, the yellow-dyeing maclurin-equivalent (together with purpurin) in Bronze Age Hallstatt reported by Grömer et al. (2013, 263) is the only trace of its possible use as a textile dye. Perhaps this could be interpreted as a transition period using roots of both *Lithospermum* sp. and Rubiaceae for textile dyeing, and accordingly associating the plant names of *Lithospermum* and bedstraws.

Echium vulgare, with characteristic blue flowers, has been found in the Srubnaya-Albar phase (c. 1890 to 1650 BC) in the vegetation of Kammenyi Ambar, Trans Urals, Russia (Stobbe et al. 2016, 1694, 1699). Although this is the easternmost periphery of the proposed homeland area, the Srubnaya culture was mainly of Yamnaya descent, occupying largely the same area as their Yamnaya and Catacomb ancestors (Anthony et al. 2016, 13; Unterländer et al. 2017, 7). This plant has bright blue flowers, and despite its low concentration of shikonin (from 0.00048 to 0.0283% in different studies), it could provide enough red pigment for cosmetics or similar, despite its name still being attached to its prominent blue flowers.

It could also be a factor that some plant seeds are better preserved than others. *Lithospermum officinale* nutlets have very hard shells, which give its Latin name, meaning "stone seed" (Anderberg & Anderberg 2016, s.v. "Lithospermum officinale"). This might explain its predominance among Boraginaceae in the archaeobotanical record (fig. 15).

Alternatively, PIE **mod^h-r-* could have been used generally for blue flowers found in the prehistoric Pontic-Caspian steppes, such as *Campanula* sp., *Centaurea cyanus* in Bronze Age Samara (Popova 2016a, 340-346), and *Cichorium intybus*, and *Gentiana* sp., throughout the Holocene (fig. 16) (Kremenetski et al. 1997; Kremenetski et al. 1999; Popova 2016b, 95). However, their roots do not dye, making the term blue a purely descriptive one for the flowers. The name would thus only later be associated with blue-flowered Boraginaceae used as cosmetics, such as *Alkanna*

tinctoria, and, according to ethnography, *Lithospermum arvense*, known as German *Schminckwurz*.

Conclusion

This paper provides a brief account of the historical and prehistoric evidence for the use of different Rubiaceae (madder plants) in textiles, with a survey of the cognates of English *madder*, and a reconstruction of its Proto-Indo-European root and adjectival formation. However, this word has a relationship with red dye alone in the Germanic languages, and seems to go back to a Proto-Indo-European adjective meaning 'blue', which the madder plants are not. Therefore, another family of plants associated with red-pigmented roots and with characteristic blue flowers has been identified and investigated. The Boraginaceae family, some of which were used as textile dye (*Alkanna/Anchusa* sp.), and some with red root pigment and found in the PIE homeland (perhaps *Echium vulgare*) are suggested as a source for the Germanic word. The semantic shift may have happened in a phase of (European) late PIE or Pre-Proto-Germanic (c. 2500 to 500 BC), when Indo-European speakers migrated to Central Europe with blue-flowered Boraginaceae better suited for dyeing.

The following three-step model explains the missing link between a plant name derived from PIE **mod^h-r-* 'blue' and the red-associated English madder:

- 1) PIE **mod^h-r-* 'blue, blue flowers, or blue-flowered Boraginaceae with pigmented roots (*Echium vulgare*)'. This development occurs in the Pontic-Caspian steppes 4500 BC to 3000 BC before the Indo-Europeans migrate to Central Europe.
- 2) Pre-Proto-Germanic, Late PIE (perhaps also the Slavic branch?) **mod^h-r-* 'blue flowered Boraginaceae with (red?) pigmented roots' designating *Echium vulgare*, *Alkanna/Anchusa* sp. (strong dyestuff), *Lithospermum purpurocaeruleum*, *Lithospermum arvense* (blue variant). This development occurs after 3000 BC following migration of Indo-European peoples to Central Europe.
- 3) Proto-Germanic **madrōn-* 'red-dyeing plants, Rubiaceae'. This development occurs in Scandinavia from 500 BC.

If more archaeobotanical blue-flowered and pigmented Boraginaceae such as *Echium vulgare* or *Lithospermum purpurocaeruleum* are found in the homeland in the PIE period, there would be even stronger evidence for these plants being the original designation of PIE **mod^h-r-*.

This development could be comparable to that of *Chamomila* in Spain, whereby the name of the



“proto-typical” species in Spain is grouped by the appearance of the flowers and its use as herbal tea, but later also associated with other plants with either similar flowers or the same use as a herbal (Morales & Pardo-de-Santayana 2010, 298–299).

This solution rests on circumstantial evidence from various disciplines and other explanations may be feasible. Nevertheless, the linguistic difficulty of ‘blue’ > ‘red’ presented here suggests that the dyeing properties and archaeobotanical finds of Boraginaceae (and experimentation with dyeing methods) deserve more thorough exploration in the future, in addition to dye-stuff analyses on prehistoric dyed textile finds from the Pontic-Caspian steppes.

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