The 16th-19th Century *Soundtoll Registers Online:* Uncovering Traded Plant Diversity between the North and the Baltic Seas

W. De Groot[1], T. Van Andel[1,2], A. Kool[3], M. Hazenberg[4], K. Kjesrud[5], and I. Teixidor-Toneu[2,3]

[1] Wageningen University & Research, Wageningen, The Netherlands
[2] Naturalis Biodiversity Center, Leiden, The Netherlands
[3] Natural History Museum, University of Oslo, Oslo, Norway
[4] STRO participant (2015-2020), Groningen, The Netherlands
[5] Museum of Cultural History, University of Oslo, Oslo, Norway
*Corresponding author; e-mail: willemien.degroot30@gmail.com

Studies of European trade have largely focused on bulk commodities, ignoring minor products. The Danish Soundtoll Registers Online (STRO) document the North-Baltic Seas maritime trade from the 16th century to the 19th. They are an untapped resource to understand the trade of plant products. Here, we present an overview of plants recorded in the STRO from 1497–1857, based on thousands of handwritten vernacular plant name variations in Danish. We found 264 plant products corresponding to 140 botanical taxa. We confirm previous findings regarding bulk goods, such as wood, wine, and (sub)tropical spices, but also uncover trade of wild food plants and herbal medicines. Notably dodder (*Cuscuta* spp.) and purging cassia (*Cassia fistula* L.) were traded as frequently as currently well-known plant-based commodities such as tea (*Camellia sinensis* [L.] Kuntze) and rhubarb (*Rheum rhabarbarum* L.). This indicates their former importance. Through the botanically identified dataset we present here, the STRO reveal the diversity of historical plant trade. We discuss what this overview adds to the understanding of historic plant trade in Europe and outline suggestions for future research that can be addressed using these data.

Key Words: Historical archives, Biodiversity, Baltic maritime trade, Northern Europe

Introduction

From the 16th century to the 19th, most European commodity trade took place by sea. The Hanseatic League, established in the 12th century, played an important role in connecting cities through the sea. The League was a confederation that bound northern European towns together by common trading interests and made maritime trade easier for European merchants (Liggio 2007). The Hanseatic League's influence peaked in the 15th century (Liggio 2007), after which it gradually declined until its demise in the mid-1600s (Strayer and Munro 1942). However, the Northern European demand for grain, wood, iron, and animal furs remained, as did the demand in the Baltic cities for luxury goods like wine, sugar, tobacco, and (sub)tropical spices. The Baltic Maritime Trade continued first led by Dutch and later by English merchants (Strayer and Munro 1942).

Most ships transporting goods between the North and the Baltic seas passed through the *Øresund* (the Sound, in English), a strait separating Denmark from Sweden. In 1429, the Danish

Received: 22 November 2021; accepted: 5 April 2022; published online 3 May 2022

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12231-022-09550-x.

© 2022, by The New York Botanical Garden, Press, Bronx, NY 10458-5126 U.S.A.

King Eric VII imposed a toll for all ships that transited the Sound (Gøbel 2010). In three and a half centuries, trading vessels made 1.8 million passages through the Sound (STRO 2020). Strong currents, navigation difficulties along with tolls rendered alternative routes undesirable for most shipmasters (Gøbel 2010).

Vessels transiting the Sound registered at the customs house in *Helsingør*, Denmark. The date, name, and hometown of the shipmaster, port of departure, port of destination (only after 1660), tax levied, and nature and quantity of the commodities were recorded in Danish. More than 700 volumes with handwritten administration have been preserved for the years 1497, 1503, 1528, 1536–1548, 1557–1558, 1560, 1562–1569, and 1574–1857. These registers, preserved in the Danish National Archive in Copenhagen, are known as the Soundtoll Registers. Through a 10-year project (2009–2019), set up by the University of Groningen and Tresoar in cooperation with the Danish National Archives, the manuscripts have been digitalized and transcribed by volunteers into the Soundtoll Registers Online, or STRO (Gøbel 2010; STRO 2020) and are publicly accessible (www.soundtoll.nl).

The STRO records document trade patterns through the peak of the Hanseatic League and in its aftermath. They have been used to study the transportation of bulk commodities shipped through the Sound (e.g., Bizière 1972; Gøbel 2010; Unger 1959; Van Tielhof 2002; Veluwenkamp and Scheltjens 2018a). Among the trade goods in both directions were plant products, including fabrics, spices, wheat, rye, and timber (Gøbel 2010; Unger 1959).

Bulk export of grain from northeastern Europe to the Netherlands, called "The Mother of all Trades," drove the Dutch economy and Dutch maritime dominance in the 17th century (Van Tielhof 2002). A side effect of the flourishing trade with northeastern Europe was the need for more ships, which led to a substantial trade in timber between Norway and the Netherlands (Van Tielhof 2002). A substantial fleet and thriving grain trade facilitated importation of tropical spices to Europe from its overseas colonies, in particular by the Dutch East India Company, the hegemony of which persisted through the 19th century (de Zwart 2016).

STRO records can elucidate large-scale plant trade patterns, as well as trends in minor products. For example, the STRO were used to study export of madder (*Rubia tinctorium* L.) (Scheltjens 2015) and herbal medicines (Veluwenkamp and Scheltjens 2018b). While studies on specific plants have been conducted, a complete picture of the diversity of plants traded overseas in 16th-19th-century Europe is still lacking. Plant species that were important to past societies may currently be overlooked. This includes plants that were less often traded, or shipped in smaller quantities (e.g., wild food plants, herbal medicines) that may have nonetheless provided important resources. There may be a focus on the economical plant species most often traded, but a bias towards the plants that are still of importance at present is also possible. Since the understanding of history is dependent on how and what is studied in academic contexts, biases shroud essential parts of history that may add perspectives to our understanding of trade history, cultural encounters, and knowledge exchange regarding plant use.

Here we aim to retrieve the cryptic plant trade through the Sound, exploring passages from ships registered in *Helsingør* (Denmark) between the 16th and 19th centuries. A multidisciplinary approach, combining history, linguistics, botany, and ethnobotany, allowed us to assign scientific binomials to the vernacular names in the trade records. We recorded which plant products were traded and in what frequency. We further aim to highlight the potential of the STRO to study people-plant relations through time and provide a list of search words that can guide future research.

Methodology

Finding Danish Plant Names in the STRO

An overview of the plant-based products traded through the Sound throughout all years (1497–1857) was compiled in the following way. First, the List of Products (STRO 2016) was searched for plant-based commodities. This list contains the commodities often found by STRO volunteers with preliminary translations and is the result of years of work involving many volunteers, experts, and scientists. Nonetheless, the STRO databases available online are an interpretation of the original source, not a direct copy, and mistakes may have been made during the transcription

(Scheltjens and Veluwenkamp 2012; STRO 2016). Figure 1 shows an example of passages in the original registers describing traded plants.

To account for this variability in the data, we consulted the original online sources when in doubt about a transcription or translation of the word (STRO 2020). Some products identified as plants in the List of Products (STRO 2016) were excluded or identified as different species, when their transcriptions or translations were likely to be incorrect. For example, the word *gultræ* in the List of Products (STRO 2016) was previously identified as *Cotinus coggygria* Scop. (common smoke tree), whereas the words found actually read *guldtræt*: a gold thread used to decorate fabrics. This word was therefore excluded from the list. Next, plant products found in the STRO database but not recorded in the List of Products (STRO 2016) and spelling variations were added. We read lists with unstandardized commodity spellings (circa 100,000 terms from 1497–1633 and 186,000 terms from 1634–1857; STRO 2020) and recorded all plant products including unspecified plant products (e.g., unspecified wood, herbs, grains, nuts, etc.) and words referring to herbal drugs (e.g., *medikamenter, drogerier*). Spellings that could not be translated and of which no more than one variation was found were left out, as these were likely transcription mistakes.

Search terms were compiled to retrieve the number of passages for each found plant product. Commodity names are not standardized in the database; thus, in order to search for a certain type of commodity, all individual spellings and variations found in the STRO had to be included. The best search words for every plant product were selected; for some products one search term sufficed, but others required multiple terms. Search terms were added to the first, second, and third tabs of the Electronic Supplementary Material (ESM).

Species Identification

Identification of plant products to species or genus level was performed by consulting historical dictionaries of merchandise (e.g., Kauffman 1814; Nemnich 1799), pharmacopeias (Coxe 1814; Hooper 1817), the 18th century Norwegian *Flora Norvegica* (Jørgensen et al. 2016), and a book on traditional plant use in Norway in the 20th Century: *Planter og Tradisjon* (Høeg 1974). These historical Scandinavian sources use vernacular plant names similar to those found in the Danish STRO. Scientific names were crosschecked with the Plants of the World Online database (POWO 2019).

Categorization of Traded Plant Products

We determined the most likely use category and part used for each species. The plant part categories included wood (specified and unspecified species), tree, bark, stems, flowers, fruits, cereals, seeds, roots, and latex. Often the term describing the product included information on the plant part traded: *holt* or *træ* (wood), *trær* (trees), *bark* (bark), *bær* (berry), *nødder* (nuts), *gryn* (groats), *frø* (seed), *radix* (root), *gummi* (resin), and *krud(t)* (entire herbs).

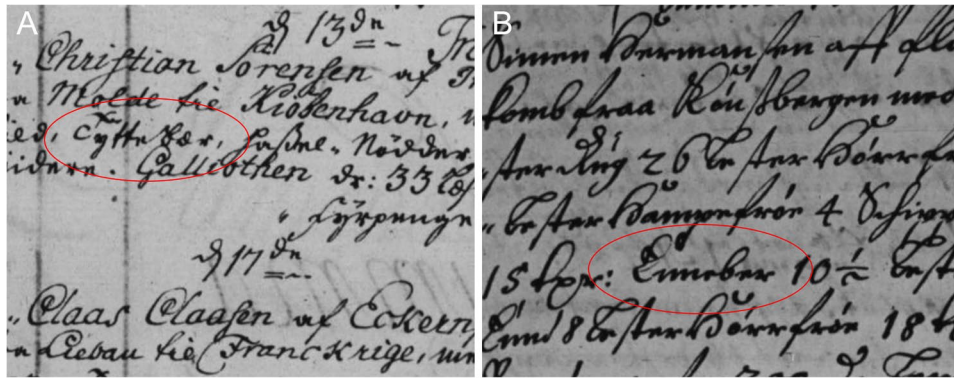

Fig. 1. Original Danish recordings from the digitalized Soundtoll Registers mentioning berries (circled words) that passed through the Sound. **A**: *tyltebær* (lingonberry, *Vaccinium vitis-idaea* L.), **B**: *enebær* (juniperberry, *Juniperus communis* L.).

To distinguish between the frequently traded cereals and other seeds and fruits, cereals were chosen as a separate category. Data on the historical use of the plant helped to infer the most likely part used. For example, historical sources mention that from rhubarb (*Rheum rhabarbarum* L.), the root was used medicinally (Foust 2014) and shipping fresh stems would be unlikely. Categories for potential historical use were food, fabric, timber, non-construction wood, firewood, medicinal, aromatic, incense, tobacco, wine, beer, other alcoholic beverages, colorants, coffee, tea, and other (e.g., ink production from oak galls, starch, canary feed). Climate zones from where plants were sourced were derived from distribution data in POWO (2019) and classified following Köppen with some modifications, namely: boreal, temperate, subtropical-temperate, tropical, subtropical, and cosmopolitan. Continent of origin of the plants were sourced from (POWO 2019) as well. The proportions of the climate zones and continental origins within the tropics or subtropics (Asia, Africa, America, Europe, Oceania, pantropical), were calculated relative to the number of species per climate zone and continent.

Calculations and Data Analysis

The frequency of shipment of specific plant products was calculated by counting the number of ships transporting this specific product through the Sound (Gøbel 2010). For practical reasons, the STRO data are split in two separate databases for the years 1497–1633 and the years 1634–1857, as the registrations were more complex in the first half and the approach to digitize them was different (SVO 2020). The two databases were queried with the previously compiled search terms, via the Advanced Search menu where multiple values could be combined (e.g., commodity, place of departure, place of destination, and years of trade).

The total of all passages recorded in the STRO before and after 1633 was obtained with the search terms for each plant-based commodity individually, and the sum from before and after 1633 was calculated. A summary of the methodology is provided in Fig. 2.

Results

The Diversity of Plant Products Traded Through the Sound

An abundance of plant products was traded through the Sound from 1497–1857: a total of 2,130,930 passages documented plant-based commodities between 1497 and 1857. We retrieved 207 plants or plant-based products from the List of Products (STRO 2016). Scanning the complete database with unstandardized

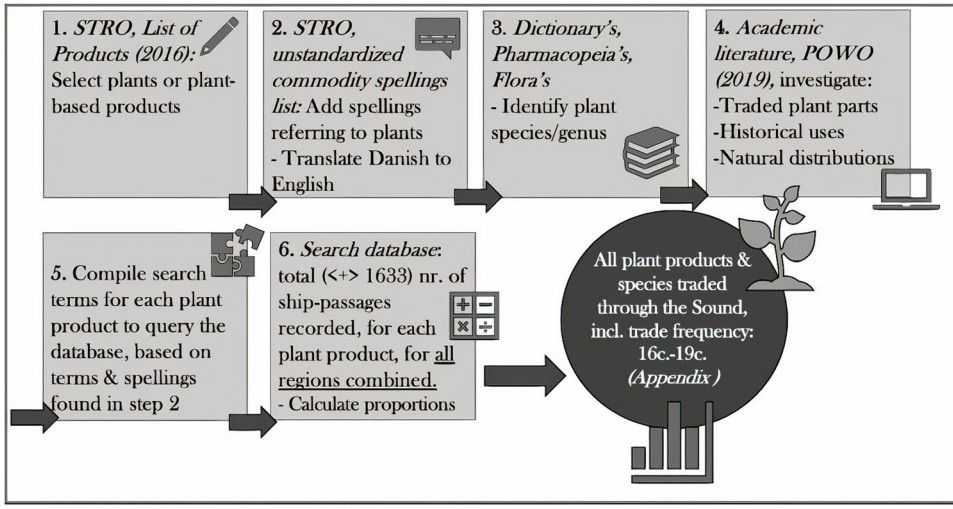

Fig. 2. Summary of methodology.

spellings allowed identifying 57 additional plant products (STRO 2016), resulting in a total of 264 items. A total of 140 taxa from 56 plant families were found, of which the majority (110 taxa) could be identified to species level (Fig. 3). The comprehensive list of all plant products including the documented Danish terms referring to the product, their verified botanical nomenclature, family, potential traded parts, potential historical use, climate zone, continental origin, search terms and number of passages and references to literature, is provided in the ESM.

Our study confirms the well-known plant products that dominated the trade: cereals, timber, fibers, beer, and wine, (sub)tropical spices, and colorants (Fig. 4). We additionally found lesser-known plant products including non-tropical aromatics, wild plants, and herbal medicines. We only present and discuss the above-mentioned products. Please see the ESM for a detailed overview of traded plants, plant products and the frequencies with which they were traded.

Cereals and Other Foods

Cereals were the most often traded plant products with ~34% of all passages (Fig. 4). Regarding food or drink items specifically, 87% (519,506 out of 595,120 passages) of the terms referred to cereals, while the remaining (13%, 75,614 out of 595,120 passages) translated to sugar (*sukker)*, syrup (*sirup*), or alcoholic beverages made from sugarcane (*Saccharum officinarum* L.), such as rum (~8,800 passages) and arrack (~3,700 passages*)*. Other frequently shipped (~4,000-31,000 passages) food items were peas (*Pisum sativum* L.), almonds (*Prunus dulcis* [MilL.] D. A. Webb), plums (*Prunus domestica* L.), figs (*Ficus carica* L.), and apples (*Malus* spp.). The most substantial trade was in cereals, with rye (*Secale cereale* L.*,* ~226,000 passages) as the main product, followed by wheat (*Triticum* spp., ~121,000), barley (*Hordeum vulgare* L., 48,000 passages), rice (*Oryza sativa* L.*,* >22.000 passages), and oats (*Avena sativa* L.*,* ~21,500 passages). Our findings also bring to light the trade of the tropical cereal millet (*Panicum miliaceum* L.*,* almost 6,000 passages).

Timber

Timber (*holt*, *bjælker*, *træ*, *spirer*) was most often recorded in the STRO, along with cereals and fibers. Approximately 95% (552,601 of 581,644 passages) of all the unstandardized terms referring to wood were identified as construction wood, of which the majority could not be identified to species level (Fig. 4). However, we found that at least 8% (47,112 of 581,644 passages) was pine wood (*Pinus* spp.*,* ~3% of total trade) and 3% (15,570 of 581,644 passages) was oak (*Quercus* spp.).

Fiber Plants

Regarding fiber plants specifically, words referring to hemp (*Cannabis sativa* L.) such as *hamp,* and likely *canefas,* and *seiljdug* (although modern versions of these words almost exclusively refer to cotton nowadays) were most often encountered in the STRO (59.5%, ~153,000 passages), followed by flax (*Linum usitatissimum* L., *hør,* 30.3%, ~78,000 passages), and cotton (*Gossypium* spp.*, cattun, bomuld, bomersi*, 10.2%, ~26,000 passages). Fabrics or plants used for fabrics were recorded on 12% of the ships (257,503 of 2,130,930 passages). The share of hemp in the total fabric trade through the Sound was estimated at 7% (153,266 of 2,130,930

Fig. 3. Number of plant products and taxa identified that were retrieved from the Soundtoll Registers Online (STRO 2016).

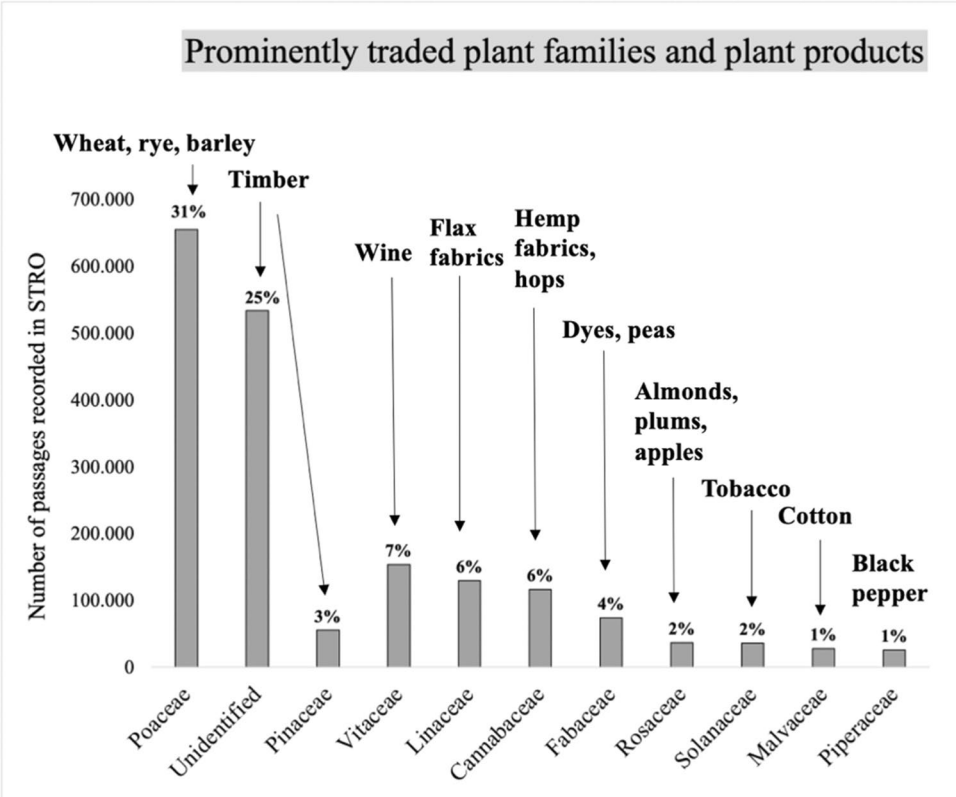

Fig. 4. Most frequently listed plant families in the STRO (1497–1857), and their most commonly traded plant products.

passages), of which the majority was unprocessed fiber (>70%).

Beer and Wine

Beer was frequently traded (~29,500 passages). Although we mainly found the term *øl* (>25,000 passages), we found that *mumme*, *joppenbeer*, *porter*, and *pryssing* were also documented, bringing the total of beer shipments to almost 30,000 passages. We additionally found a significant trade of beer ingredients, approximately 88,000: barley (~48,000 passages, already mentioned under cereals), often shipped from northeastern Europe (Unger 1959), malt (~28,000 passages, also counted as cereal), and hops (*Humulus lupulus* L., ~12,000 passages). Throughout all the years, it is estimated that 5.5% (116,897 of the 2,130,930 passages) of the ships recorded wine on board and we found a total of 48 different terms referring to wine (e.g., *fransk win*, *rhinskvin*, *viin*, *stadsvin*, *madeira*, see ESM). However, only 388 passages recorded grapes (*Vitis vinifera* L.) that could be used for winemaking.

Tropical and Subtropical Plant Trade

The climate zone origins of 133 species are shown in Fig. 5. At species level, most plant products (64%, 85 of 133 species) had a climate zone either in the tropical or subtropical regions (87 species), while there were fewer species from the temperate and temperate-arctic zones (19 species). We found 29 species that could grow in several climate zones (i.e., cosmopolitan).

Many of the (sub)tropical plant products recorded in the STRO were of Asian origin (Fig. 6) and consisted of sugarcane, although widely grown in the Americas as well (>60,000 passages), black pepper (*Piper nigrum* L., >25,000 passages), ginger (*Zingiber officinale* Roscoe, ~15,000 passages), lemons (*Citrus limon* [L.] Burm. fiL.), tea leaves (*Camellia sinensis* [L.] Kuntze), ~1,000 passages), succade (*Citrus medica* L.), cinnamon bark (*Cinnamomum* spp.), nutmeg/mace (*Myristica fragrans* Houtt.), cloves (*Syzygium aromaticum* [L.] Merr. & Perry), cardamom seeds (*Elettaria cardamomum* [L.] Maton), licorice root (*Glycyrrhiza glabra* L.), and curcuma rhizome (*Curcuma longa* L.). Some African species were also commonly traded, such as coffee beans (*Coffea* spp., Ethiopian, but also likely grown in Asia), Arabic gum (*Accacia* spp.), frankincense (*Boswellia* spp.), and sandalwood (*Santalum album* L.), as well as grains of paradise (*Aframomum melegueta* K. Schum.). Frequently traded Neotropical plants were tobacco (*Nicotiana tabacum* L.) and cacao (*Theobroma cacao* L.). Rubber is conveniently considered to represent the latex from the *Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg. because this is the most frequently traded species during that time. But it could possibly also include other latex-producing species like *Castilla elastica* Cerv., *Ficus elastica* Roxb. ex Hornem., or *Landolphia* spp. from West Africa. We also identified some Neotropical species that were traded less frequently (<100 passages), such as allspice (*Pimenta dioica* [L.] Merr.), cassava (*Manihot esculenta* Crantz), yams (*Dioscorea* spp.), camphor (*Cinnamomum camphora* [L.] J. Presl), and possibly the latex from *Danielia* spp., listed in the STRO as *gummi copal.*

Colorants

Twelve dye plants were identified, mostly from Fabaceae (73.8%, ~33,000 passages). Indigo was the dyestuff most often traded (~21,000 passages). This could be *Indigofera suffruticosa* Mill., as the term *anil* recorded in the STRO refers to this species (Buchanan 1999) but possibly also *Indigofera tinctoria* L. or other species were used to extract the dye. A purple dye from campeche wood (*Haematoxylum campechianum* L.) and the red dye "braziline" from Brazilian dyewood (*Paubrasilia echinata* [Lam.] Gagnon, H.C.Lima & G.P.Lewis)

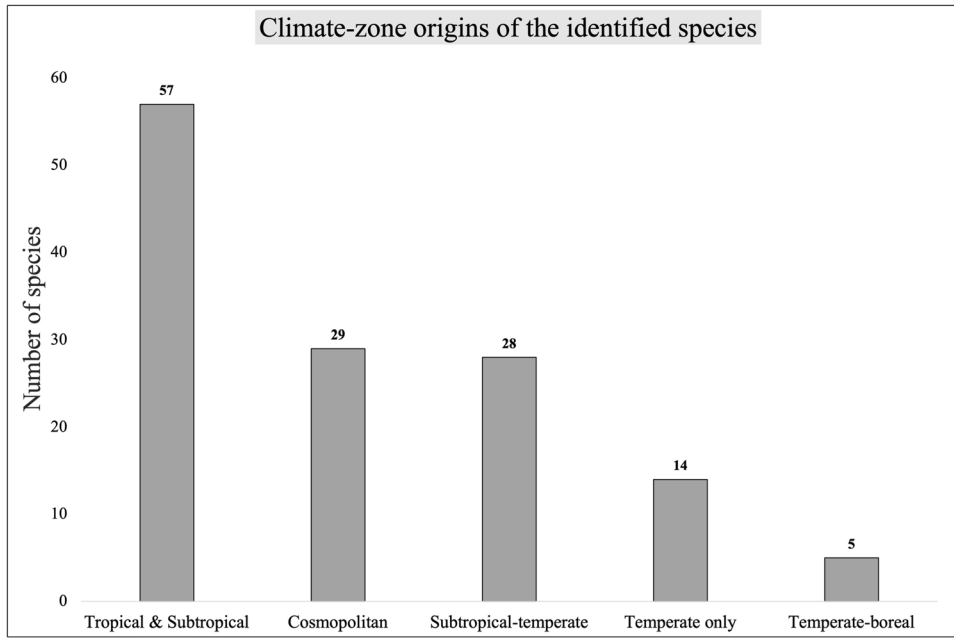

Fig. 5. Likely climate zone origins of 133 identified species that were traded through the Sound in 1497-1857, according to POWO (2019). Plant species for which fewer than 10 passages were recorded and those that remained unidentified, were excluded here.

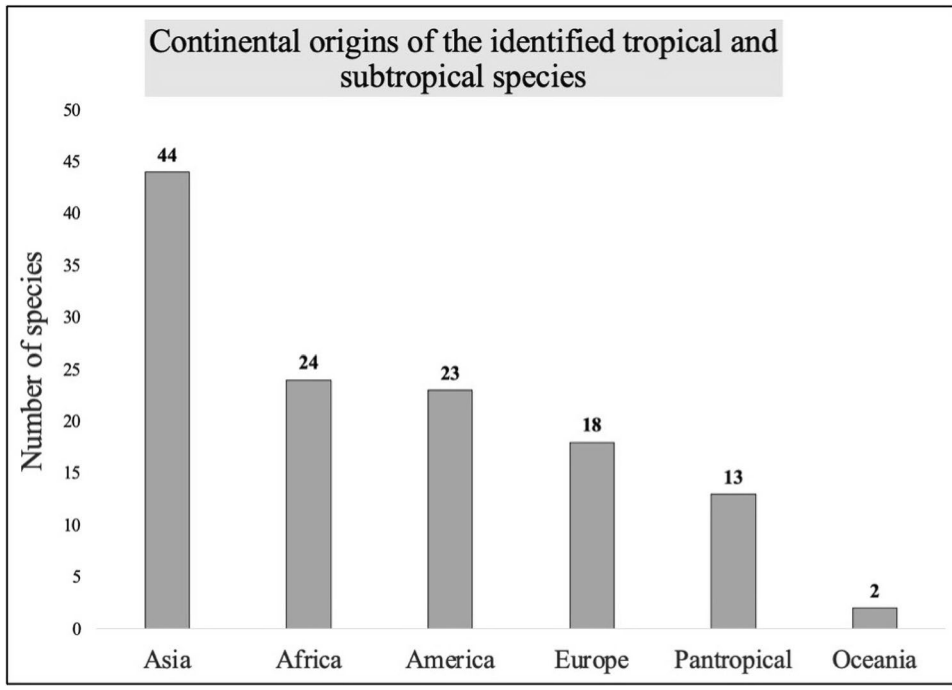

Fig. 6. Continental origins of 85 species traded through the Sound (1497–1857). Some species were accounted for more than once as they had multiple possible origins. Unidentified species and species with fewer than 10 passages were excluded. (Note that some species have their biological origin on one continent while having been predominantly cultivated in another continent during the period of the Soundtoll registration.)

were also often traded (>6,500 passages). From 1806 to 1840, the STRO moreover show a decrease in the trade of *brazilholt*, after which the trade appears to increase again.

Two Asian dyes were often listed in the STRO as well: sappan wood (*Biancaea sappan* [L.] Tod.) with ~1,385 passages and caliature wood (*Pterocarpus santalinus* L.f.) with ~350 passages. *St. Martinsholt*, a "brazil wood from Santa Marta" (Nemnich 1799) may refer to the species *Libidibia coriaria* (Jacq.) Schltdl. Schneider (1981) stated that the wood originates from northern Colombia and mentioned its export from Santa Marta. The red dye wood *nicaracuaholt* (279 passages) could be *Tara vesicaria (L.)* Molinari, Sánchez Och. & Mayta., but the identifications of these two woods remain tentative.

Other colorants included the red dye "annatto" from the seeds of *Bixa orellana* L. with ~1,660 passages and the yellow dyestuff "fustic" from the wood of *Maclura tinctoria* (L.) D. Don ex Steud. with ~130 passages, both from the Neotropics. Other dye products found were woad (*Isatis tinctoria* L., 11.5%, ~5,100 passages), of which the blue colorant "pastel" was obtained, and madder (10.5%, ~4,660 passages), its roots used as a red dye. Woad is a temperate plant, and madder grows in tropical, subtropical, to temperate Asia or Europe. One other dye plant growing in the temperate region and recorded in the STRO, was sawwort (*Serratula tinctoria*, 107 passages).

Herbal Medicines

We found an assortment of plants that may have been traded as medicinal plants. Most notably traded were *dodder* (*Cuscuta* spp., stems and seeds traded, 951 and 920 passages, respectively) and fruits, stems, or leaves of purging cassia (*Cassia fistula* L. ~1,400 passages). Additionally, the STRO often reported rhubarb root (1,050 passages) and manna ash (*Fraxinus ornus* L., 663 passages).

Almost 1,000 passages listed the term *pokholz,* referring to the Caribbean pockwood. Pockwood is among the densest woods in the world and used for construction, but is also a presumed remedy against syphilis, a sexually transmitted disease then known as "the pox," was derived from the resin of the heartwood from either *Guaiacum officinale* L., native to the north coast of South America and the Caribbean Islands (including the Virgin Islands) or *Guaiacum sanctum* L., from southern Florida and the Bahamas (Wallis 1946). *Pokholz* was traded most frequently through the Sound after 1800 and mainly exported from Saint Croix (32.6%) and Great Britain (22%). Hence, it is more likely that the plant recorded in the STRO represented *G. officinale*. Other historically used remedies against syphilis that were recorded in the STRO included China root (*Smilax china* L.; nine passages) and *sarsaparilla* (root of *Smilax* spp., ~600 passages).

Although traded less frequently (<65 passages), we found tropical medicinal plants like tamarind fruits (*Tamarindus indica* L.), resin from the gum benjamin tree (*Styrax benzoin* Dryand.), the Peruvian anti-malarial quinine bark (*Cinchona* spp.), and *Senna alexandrina* Mill. Rarely traded (<20 passages) herbal drugs from the temperate regions were figwort (*Scrophularia nodosa* L.) and possibly *rapontica.* Two 19th century pharmacopeias (Coxe 1814; Gray 1828) link *rhaponticum* to *Rheum rhaponticum* L. (false rhubarb), but the term could also refer to maral root (*Rhaponticum carthamoides* [Willd.] Iljin), so no sufficient evidence to identify *rapontica* to species level was found. One passage recording *radix acthea* was found, which may refer to black snake root (*Actaea racemosa* L.), but this also remains unverified.

Non-Tropical Aromatics

In addition to the frequently traded tropical and subtropical spices, aromatic or food plants from the Mediterranean were also traded, such as anise *(Pimpinella anisum* L. or *P. saxifraga* L., ~7,400 passages), a spice with a subtropical to temperate distribution also present in the traded anise wine (*anisvin*). Additionally, ~4,000 passages with terms referring either to cumin (*Cuminum cyminum* L.) or caraway (*Carum carvi* L.) were found, documenting *comin*, *komen*, and other spellings, as well as a total of ~1,000 passages with white mustard or its seeds (*Sinapis alba* L.). Furthermore, Mediterranean saffron (*Crocus sativus* L., ~3,800 passages) and laurel or bayberry (*Laurus nobilis* L., >1,600 passages) were frequently documented. Less frequently traded, but mentionable, are chicory (*Cichorium intybus* L., >300 passages), coriander (*Coriandrum sativum* L., ~100 passages), horseradish (*Armoracia rusticana* G.Gaertn., B.Mey. & Schreb., 15 passages), fennel or its seeds (*Foeniculum vulgare* MilL., 17 passages), and herbal spirits such as *gin* (~1,800 passages), *Riga balsem* (~60 passages), and *aquavit* (~20 passages).

Scandinavian Wild Plants

European wild berries were not often recorded (<100 passages), yet we found three species of wild berries native to the temperate-arctic regions passed through the Sound: cloudberry (*Rubus chamaemorus* L.), lingonberry (*Vaccinium vitis-idaea* L.), and cranberry (*Vaccinium oxycoccos* L.). We also noted the trade of two common European trees: berries (*bær*, >600 passages) and wood/branches (*stager*, ~100 passages) from juniper (*Juniperus communis* L.), and bark, wood, and sap from birch trees (*Betula* spp., almost 200 passages total).

Discussion

Although the terms in the STRO most often refer to plant products that represent well-known goods that still are economically important nowadays (i.e., rye and wheat, timber, hemp, flax, cotton, beer, and wine), we found a significant additional diversity of plant products that have not been found before. These species specifically represent the trade in non-agricultural, flavoring, and medicinal plants. Trade frequencies of bulk goods and the considerable share of tropical and subtropical plant trade, concur with results from previous studies (e.g., Bogucka 1973; Gøbel 2010; Malowist 1959; Unger 1959; Van Tielhof 2002). This indicates that counting the number of vessels that passed the Sound carrying a certain plant product can give an estimation of their trade popularity. Calculating volumes of traded plants certainly would have better represented the importance of the traded products, but this

was not feasible as weight units were inconsistent and not standardized during the period of the Soundtoll; many regions and even ports had their own measuring units to quantify the amounts traded (SVO 2020). Our inquiry of the trade provides new insights in hitherto overlooked diversity. The range in trade frequency per individual plant product allows for additional information on the relative importance of these species in 16th-19th-century Europe.

Although it is not possible to know whether all words for plant products were retrieved due to the almost countless spelling variations, we are confident that we recovered the vast majority of them. Standardizing commodity data from the STRO for this type of research was challenging as multiple recordings in Danish were found for the same item and sometimes words from different languages appeared. For example, the Polish term *tatarck/tatarch* referred to "calamus" (Zemanek et al. 2009) and meant the same as the Danish *kalmus* (*Acorus calamus* L.). Orthographic variants were potential sources of confusions. This was, for example, the case for the terms *commen* and *kommen*, which could either refer to caraway or cumin. Some terms were difficult to match to a genus or species with certainty (e.g., *rapontica, radix acthea*), leaving room for revision by other researchers, specifically botanists, historians, and linguists. We strived to compile search terms that were optimally sensitive (yielding as much results as possible) and specific (least confusion with other products) to query the STRO.

Cereals and Other Foods

With ~226,000 and ~121,000 passages, respectively, rye and wheat contributed most to the trade. The large share of rye in the trade displays proportionality to their historical importance, as rye traded from northeastern Europe especially ensured food security of northern and western Europeans who did not cultivate cereals on their lands anymore (Malowist 1959). Our study furthermore recognizes a substantial trade in rice (>22,000 passages), oats (21,500 passages), and millet (almost 6,000 passages). Apples, almonds, plums, peas, and figs were also significantly represented in the trade (~9,500 passages). Possibly, these numbers reflect common food items in 16th-19th-century Europe.

Timber

Previous STRO analyzes identified 111 citations of wood products (Gøbel 2010). Our study also illustrates a striking importance of trade in wood and timber products with it being the second most often traded commodity (581,644 passages). We find that 3% of the timber trade was made up of common oak (*Quercus robur* L.) and Scots pine or firs (*fyrre dehler*, *Pinus sylvestris* L., or *Abies* spp., respectively), which was also demonstrated in previous research (Gallagher 2016). We only found a few species-specific terms referring to *Fagus sylvatica* L. (European beech, *bøgetræ, bugeholt*) and *Fraxinus excelsior* L. (European ash, *asketræ*). However, the extent of trade in *F. sylvatica* and *F. excelsior* is supposedly larger than our study suggests, as other studies showed that specifically these species were traded from the Baltic region (Gallagher 2016). Possibly, the trade of beech and ash is buried in the large proportion of wood that could not be identified. The STRO thus provide limited information for identifying construction wood species and their relative importance in the trade.

Fiber Plants

We found that hemp (*C. sativa,* ~153,000 passages) and flax (*L. usitatissimum* ~78,000 passages) were shipped particularly often. This is confirmed by previous studies inquiring hemp and flax trade through the Sound (Bogucka 1973; Gøbel 2010). Our study points out that the majority (>70%) of *C. sativa* traded, was in unprocessed form, indicated by terms as *hamp* and *hennep*. Mostly, hemp and flax were shipped from eastern to western Europe (Gøbel 2010), so it is likely that shipment took place from areas that cultivated the plants to areas that specialized in the manufacturing process. Although less often traded than hemp or flax, we also observed a substantial trade in cotton (*Gossypium* spp., ~26,000 passages). However, species identification for some terms we found referring to fabrics remain tentative (e.g., *canefas, seiljdug*), due to the complex historical terminology for fabrics, or the combination of fiber species in production.

Beer and Wine

The large trade of both wine and beer through the Sound has already been well-explored (Unger 1959) and the wine trade has been described elaborately in previous research that used the Soundtoll Registers (Bizière 1972). We confirm the importance of wine and beer in the trade and specify that ~117,000 ships recorded wine on board (5.5%). Wine was traded significantly more often than grapes (388 passages) and brewed beer (30,000 passages), which was likely a mostly homemade product at the time (Nelson 2005). Moreover, the diversity of terms referring to wine is great (48 different terms), and they often referred to a specific area of origin (e.g., *Sicilianske vin*, *Græk vin*, *Malaga*, *Borgognevin*, *Ungarsk vin*, *Rhinskvin*). This also suggests that wine trade played a more significant role in the overseas trade than beer, and that winemaking and trade was solidly established in 16th-19th-century Europe. The large share of beer brewing ingredients (barley, malt, hops, ~88,000 passages), compared to the trade of beer itself (~30,000 passages), suggests that beer was often brewed on location. Although the trade of barley and malt was ~48,000 and ~28,000 passages, respectively, it is uncertain if all was used for beer brewing. The raw material or the form (fermented) malt could have been used for beer brewing but also as cattle feed (Van Tielhof 2002). Barley trade reserved for beer making might thus be a portion of the total amount traded.

Tropical and Subtropical Spices

First, our study found a large share (1,000-60,000 passages) in trade in well-known tropical species with economic importance (e.g., sugar, black pepper, ginger, tobacco, cacao, lemons, coffee beans, tea, and several other spices). Regarding species diversity, our study revealed tropical and subtropical plant species represented two-thirds of the traded plants (64%, 85 of 133 species). Asian plant species were particularly well represented, likely due to European colonization of large areas in Southeast Asia and the Indian subcontinent, which resulted in easy access to these products. Second, we show that in addition to food species, tropical non-food species such as Arabic gum, frankincense, sandalwood, and rubber were frequently traded (>1,000 passages), showing that there was a wide use of (sub)tropical species other than spices. Third, we found significant transport (<100 passages) of yams, cassava, allspice (Neotropical), and camphor. Occasionally we found ambiguous terms such as *gummi copal* that may refer to *Danielia* spp. (James 1747). These findings of less-frequently traded goods implies that certain species could have been overlooked previously in the STRO or were not yet identified.

Colorants

We identified 12 plant species that were frequently traded through the Sound as colorants, such as annatto (1,660 passages), woad (5,100 passages), and madder (4,660 passages). These findings suggest a particular relevance of colorants in the 16th-19th-century overseas trade in Europe. The STRO data specifically illustrated a considerable share (>33,000 passages, 73.8% of total) of (sub)tropical Fabaceae species in the trade of colorants. Specifically, Brazilian dyewood became valuable in 16th-century Europe (Dodge 2018). However, the STRO shows a decline in the 18th century of the trade. We hypothesize that excessive harvesting and exporting (>6,500 passages) of tropical dye woods such as the now endangered brazilwood (Varty 1998) could have caused declines in populations of popular species. Notably, some terms (*St. Martinsholt, nicaracuaholt*) could not accurately be matched to a species be identified, although they were often found in the STRO (>250 passages). This leaves room to further investigate the trade and trade dynamics of these products, which may have been affected by changes in availability as well as fashion.

Herbal Medicines

The STRO have revealed a substantial share in overseas medicinal plant trade in the 16th-19th century. Almost all medicinal plants shipped though the Sound were recorded in the 19th century pharmacopeias of Coxe (1814) and Gray (1828). The frequently traded dodder (almost 1,000 passages) and the pulp from the bruised pods of purging cassia (1,400 passages) were historical medicinal plants (Chabra et al. 2019; Duraipandiyan and Ignacimuthu 2007), prescribed as purgatives (Coxe 1814; Gray 1828). Rhubarb roots were also "cathartic salts" as referred to in historical pharmacopeias

(Coxe 1814; Gray 1828). Notably, dodder and purging cassia were traded as often as or even more frequently than tea and rhubarb (1,000 passages), which are commonly known plants in the present. We identified dodder as a species within the *Cuscuta* genus. Further literature investigations might specify which species was traded. A possibility is *Cuscuta europaea* L., listed as a replacement for the purgative *senna* (Jørgensen et al. 2016), which we also found in the STRO but in small trade frequencies. The mildly laxative *manna*, on the other hand, was much more frequently traded (>600 passages). Today, rhubarb stalks remain popular as a food, and the interest in rhubarb root as a medicine has increased again since 2005 (Kolodziejczyk-Czepas and Liudvytska 2020). Although we find a substantial historical trade in plants like dodder, purging cassia, or manna ash, they receive less attention. Less-frequently traded medicinal plants (e.g., tamarind, gum benjamin tree, quinine, figwort) and terms that supposedly refer to herbal remedies like *radix acthea* and *rhaponticum*, were uncovered in this study. The small number of passages for quinine is surprising since malaria was prevalent around the Baltic ports, although perhaps not very common (Zhao et al. 2016). The traditional and historical uses of plant medicines traded through the Sound may be interesting for future research.

During the time of the Soundtoll trade there was also a competitive market for medicinal plants that were used to treat syphilis (Flood and Shaw 1992). The disease, also known as "the pox," became prevalent in Europe in the end of the 15th century, but it took until the 1900s to discover an effective cure. Until that time, several remedies were believed to cure this sexually transmitted disease, amongst which is a dangerous mercury treatment (Flood and Shaw 1992). Our study found substantial frequencies of trade in anti-syphilis drugs like *Smilax* roots (*sarsaparilla*, ~600 passages) and the now-endangered pockwood (almost 1,000 passages) from *G, officinale* (Barstow 2019), which was used to treat syphilis. These were shipped from the Americas and eventually passed the Sound. We only found a few passages with China root (*Smilax china*), a globally demanded drug used in the 16th century to treat syphilis, before it was replaced in Europe by several different Caribbean *Smilax* species, commonly known as *sarsaparilla* (Winterbottom 2015). Our observations thus suggest an importance of herbal drugs against "the pox" during the 16th-19th-century period.

Non-Tropical Aromatics

We found a significant trade of non-agricultural, temperate plants with a variety of uses. For example, chicory (>300 passages) and fennel (17 passages) have qualities of being edible as well as aromatic species with medicinal qualities. Many traded plants were employed to flavor beverages, particularly alcohols. Often traded (>1,500 passages) were anise, added in anise wine (*anisvin*), and caraway used in *aquavit* production and to spice cabbage dishes. Several less-often recorded aromatics (<100 passages) might have been traded to flavor alcoholic spirits (e.g., coriander), and the medicinal *Acorus calamus* in the bitter drink *Riga balsem* or as condiments due to their pungent taste (white mustard, horseradish). Arguably, Mediterranean spices such as laurel/bayberry and saffron, were more often found on ships (>1,500 passages) because they could not be grown in the Northern European climate. These findings thus demonstrate an importance of trading flavoring plants in 16th-19th-century Europe.

Scandinavian Wild Plants

Our findings imply a relatively small share in trade of temperate plants, such as wild berries from Northern Europe in the trade through the Sound (<100 passages). Nonetheless, cloudberries, lingonberries, and cranberries may have had important medicinal uses as an antiscorbutic, due to their high vitamin C and benzoic acid content (Martinussen et al. 2018), in addition to their nice taste. The high benzoic acid content could keep the berries well-preserved on board (Chipley 1993), speculating that this, as well as their antiscorbutic qualities and nice taste, makes them excellent fruits to bring along on an overseas journey. Likewise, juniper berries have medicinal qualities, but they are more commonly known for flavoring *gin.* Birch sap was potable, but was also used against illnesses, including scurvy, intestinal worms, rash, and

hepatitis (Brøndegaard 1979). Birch bark might have been imported for tanning leather (Papp et al. 2014), as a wound-healing drug (Jørgensen et al. 2016), or used against rheumatism (Rastogi et al. 2015; Šarić-Kundalić et al. 2010). Our analysis suggests that the trade of these specific Nordic plants may have been particularly useful as preventive medicine on board of ships.

Conclusion

Our comprehensive overview of the plant species traded yielded 264 plant products and 140 taxa, which shows that a great diversity of species was traded. Our analysis confirmed earlier findings of bulk plant products traded through the Sound, such as cereals, timber, fabrics, wine, beer, and (sub)tropical spices. Furthermore, our study highlighted a significant trade of plant colorants and several herbal medicines (e.g., dodder, purging cassia, *sarsaparilla*, and pockwood) as well as non-tropical aromatic plants such as anise. These plant products have not yet been acknowledged accordingly in previous studies on historical plant trade through the Sound. Although traded less frequently, other plant products such as Scandinavian wild berries may still have provided important historical uses. The Soundtoll Registers are thus an invaluable and understudied resource to understand plant trade in Northern Europe from the 16th century to the 19th. The list with plant products and their trade frequency, identified species, and search terms (ESM) can be used as a starting point for further research. Follow-up studies using the STRO can make use of the compiled list of search terms to query the database; e.g., for ports of departure and destination for specific products or trade dynamics throughout time, and for further investigation on the volume of the trade.

Acknowledgements

We express great appreciation and gratitude to the STRO volunteers who spent years transcribing the Soundtoll registers into a digitalized, searchable database. Without their work, this research would not have been possible. We also thank Jan-Willem Veluwenkamp and Ubo Kooijenga, whom we could consult to ask questions about the STRO-project and database. This research was funded by the SAMKUL program of the Research Council of Norway (project number 283364).

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visithttp://creativecommons.org/licenses/by/4.0/.

Literature Cited

Barstow, M. 2019. Guaiacum officinale. The IUCN Red List of Threatened Species 2019: e.T33701A68085935. https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T33701A68085935.en. (18 July 2021).

Bizière, J. M. 1972. The Baltic wine trade 1563–1657. Scandinavian Economic History Review 20(2):121-132.

Bogucka, M. 1973. Amsterdam and the Baltic in the first half of the seventeenth century. The Economic History Review 26(3):433-447.

Brøndegaard, V. J. 1979. Folk og flora: dansk etnobotanik, vol. 3. Copenhagen: Rosenkilde og Bagger.

Buchanan, R. 1999. A weaver's garden: Growing plants for natural dyes and fibers. North Chelmsford: Courier Corporation.

Chabra, A., T. Monadi, M. Azadbakht, and S. I. Haerizadeh. 2019. Ethnopharmacology of Cuscuta epithymum: A comprehensive review on ethnobotany, phytochemistry, pharmacology and toxicity. Journal of ethnopharmacology 231:555-569.

Chipley, J. R. 1993. Sodium benzoate and benzoic acid. Antimicrobials in Foods 2:11-48.

Coxe, J. R. 1814. The American dispensatory, containing the operations of pharmacy: Together with the natural, chemical, pharmaceutical and medical history of the different substances employed in medicine; illustrated and explained, according to the principles of

modern chemistry: The arrangement simplified, and the whole adapted to the practice of medicine and pharmacy in the United States. Philadelphia: Thomas Dobson. https://collections.nlm.nih.gov/ext/mhl/2547020R/PDF/2547020R.pdf.

De Zwart, P. 2016. Globalization and the colonial origins of the great divergence: Intercontinental trade and living standards in the Dutch East India Company's commercial empire, c. 1600-1800. Leiden, Netherlands: Brill.

Dodge, C. J. 2018. A forgotten century of brazilwood: The brazilwood trade from the mid-sixteenth to mid-seventeenth century. e-Journal of Portuguese History 16(1):1-27.

Duraipandiyan, V. and S. Ignacimuthu. 2007. Antibacterial and antifungal activity of *Cassia fistula* L.: An ethnomedicinal plant. Journal of ethnopharmacology 112(3):590-594.

Flood, J. L. and D. J. Shaw. 1992. The price of the pox in 1527 Johannes Sinapius and the guaiac cure. Bibliothèque d'Humanisme et Renaissance, 54(3):691–707. https://www.jstor.org/stable/20679350. (July 2020).

Foust, C. M. 2014. Rhubarb: The wondrous drug, vol. 191. Princeton, New Jersey: Princeton University Press.

Gallagher, N. 2016. A methodology for estimating the volume of Baltic timber to Spain using the Sound Toll Registers: 1670–1806. International Journal of Maritime History 28(4):752-773.

Gøbel, E. 2010. The Sound toll registers online project, 1497–1857. International Journal of Maritime History 22(2):305-324.

Gray, S. F. 1828. A supplement to the pharmacopoeias. London: Printed for Thomas and George Underwood. https://archive.org/details/b28753379. (July 2020).

Høeg, O. A. 1974. Planter og tradisjon: Floraen i levende tale og tradisjon i Norge 1925-1973. Oslo, Bergen, Tromsø: Universitetsforlaget 1974.

Hooper, R. 1817. A new medical dictionary: Containing an explanation of the terms in anatomy, physiology ... and the various branches of natural philosophy connected with medicine (No. 41081). Philadelphia: E. & R. Parker, M. Carey, and B. Warner. https://archive.org/details/anewmedicaldict00quingoog. (July 2020).

James, R. 1747. Pharmacopoeia Universalis: Or, a new universal English dispensatory. containing. An account of all the natural and artificial implements and instruments of pharmacy, together with the processes and operations, whereby changes are induced in natural bodies for medicinal purposes. With a copious index to the whole, eds. I. J. Hodges and J. Wood. https://archive.org/details/pharmacopoeiaun00jamegoog.

Jørgensen, P. M., E. Weidemann, and E. Fremstad. 2016. Flora Norvegica av JE Gunnerus. På norsk og med kommentarer. NTNU University Museum, Gunneria 80:1–505.https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2427204?show=full&locale-attribute=en. (July 2020).

Kauffman, C. H. 1814. The dictionary of merchandize and nomenclature in all languages, for the use of counting houses, &c: Containing the history, places of growth, culture, use, and marks of excellency. London: T. Boosey. https://archive.org/details/b22032265. (July 2020).

Kolodziejczyk-Czepas, J. and O. Liudvytska. 2020. *Rheum rhaponticum* and *Rheum rhabarbarum*: A review of phytochemistry, biological activities and therapeutic potential. Phytochemistry Reviews 1-19.

Liggio, L. P. 2007. The Hanseatic League and freedom of trade. Journal of Private Enterprise 23(1):134–141

Malowist, M. 1959. The economic and social development of the Baltic countries from the fifteenth to the seventeenth centuries. The Economic History Review 12(2):177-189.

Martinussen, I., A. L. Hykkerud, and R. Nestby. 2018. Nordic wild berries-properties and potentials. ISHS Acta Horticulturae 1259: III International Symposium on Horticultural Crop Wild Relatives. Acta Hortic. 1259:31-34. https://doi.org/10.17660/ActaHortic.2019.1259.6.

Nelson, M. 2005. The barbarian's beverage: A history of beer in ancient Europe. London and New York: Routledge.

Nemnich, P. A. 1799. A universal European dictionary of merchandise, in the English, German, Dutch, Danish, Swedish, French, Italian, Spanish, Portuguese, Russian, Polish, and Latin languages. London: J. Johnson. https://archive.org/details/b28773329.

Papp, N., D. Czégényi, A. Hegedus, T. Morschhauser, C. L. Quave, K. Cianfaglione, and A. Pieroni. 2014. The uses of *Betula pendula* Roth among Hungarian Csángós and Székelys in Transylvania, Romania. Acta Societatis Botanicorum Poloniae 83(2):113–122.

POWO 2019. Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/ (6 August 2020).

Rastogi, S., M. M. Pandey, and A. K. S. Rawat. 2015. Medicinal plants of the genus *Betula*—Traditional uses and a phytochemical–pharmacological review. Journal of Ethnopharmacology 159:62-83.

Šarić-Kundalić, B., C. Dobeš, V. Klatte-Asselmeyer, and J. Saukel. 2010. Ethnobotanical study on medicinal use of wild and cultivated plants in middle, south and west Bosnia and Herzegovina. Journal of Ethnopharmacology 131(1), 33-55.

Scheltjens, W. 2015. French imports to the Baltic, 1670-1850. Revue de l'OFCE 4:137-173.

——— and J. W. Veluwenkamp. 2012. Sound Toll Registers Online: Introduction and first research examples. International Journal of Maritime History 24(1):301-330.

Schneider, J. 1981. Frankreich und die Unabhängigkeit Spanisch-Amerikas: zum französischen Handel mit den entstehenden Nationalstaaten (1810-1850). Stuttgart, Germany: Klett-Cotta [in Komm.].

Strayer, J. R. and D. C. Munro. 1942. The Middle Ages: 395-1500. New York: Appleton-Century Crofts, Inc.

STRO (Soundtoll Registers Online). 2016. List of Products Tresoar. http://soundtoll.nl/images/files/List%20of%20products.pdf (29 June 2020).

——— (Soundtoll Registers 2020. Tresoar. http://www.soundtoll.nl/index.php/en/welkom (29 June 2020).

SVO (Soundtoll Volunteers Online) 2020. Tresoar. http://soundtoll.nl/index.php/nl/passages (29 June 2020).

Unger, W. S. 1959. Trade through the Sound in the seventeenth and eighteenth centuries. The Economic History Review 12(2):206-221.

Van Tielhof, M. 2002. The 'mother of all trades': The Baltic grain trade in Amsterdam from the late 16th to the early 19th century, vol. 3. Leiden, Netherlands: Brill.

Varty, N. 1998. Caesalpinia echinata. The IUCN Red List of Threatened Species 1998: e.T33974A9818224. https://doi.org/10.2305/IUCN.UK.1998.RLTS.T33974A9818224.en (18 July 2021).

Veluwenkamp, J. W. and W. Scheltjens. 2018a. Early modern shipping and trade: Novel approaches using Sound Toll Registers Online. Leiden, Netherlands: Brill.

———. 2018b. Baltic drugs traffic, 1650–1850. Sound Toll Registers Online as a source for the import of exotic medicines in the Baltic Sea area. Social History of Medicine 31(1):140-176.

Wallis, T. E. 1946. Textbook of pharmacognosy. London: J. and A. Churchill, Ltd.

Winterbottom, A. E. 2015. Of the China root: A case study of the early modern circulation of materia medica. Social History of Medicine 28(1):22-44.

Zemanek, A., B. Zemanek, K. Harmata, J. Madeja, and P. Klepacki. 2009. Selected foreign plants in old Polish botanical literature, customs and art (*Acorus calamus*, *Aesculus hippocastanum*, *Cannabis sativa*, *Fagopyrum*, *Helianthus annuus*, *Iris*). In: Plants and culture: Seeds of the cultural heritage of Europe, eds., J.-P. Moel and A. M. Mercuri, 179-193. Bari, Italy: Edipuglia Publishing House.

Zhao, X., D. L. Smith, and A. J. Tatem. 2016. Exploring the spatiotemporal drivers of malaria elimination in Europe. Malaria Journal 15(1):1-13.