Plant exchange networks in the 19th century – 200 years of citizen science

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Plant exchange networks in the 19th century have been investigated in a large-scale study, firstly by identifying as many plant exchange organizations (PEOs) as possible and secondly by searching for exchange partners in a 19th century private herbarium from Southwest Germany, and by analysing exchange activities related to the rare central European endemic *Saxifraga rosacea* subsp. *sponhemica* (C.C.Gmel) D.A.Webb. In this paper a first overview on selected results is given: 101 PEOs – founded from 1819 to 1947 – with a total of 3000 to 5000 members have been found; they distributed 15 to 20 million specimens; 111 collectors have been identified in the exemplary private herbarium, from which specimens have been found in 27 herbaria; *S. rosacea* subsp. *sponhemica* has been collected by 242 individuals, 233 exchange partners received duplicates distributed by 12 PEOs.

Keywords
Database, Herbaria, Networks, Plant exchange, *Saxifraga sponhemica*, 19th Century

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Herbarium specimens are not only documents of biodiversity, but also historical sources, collected by various people, from a day labourer to a judge at a High Court. They are made to be preserved for a long time, in contrast to daily correspondences, which are archived only if the sender or recipient was an important historical person, e.g., Linnaeus. Therefore, herbaria reveal social networks hardly visible in correspondences.

During decades of work in herbaria we became aware of stamps, printed labels, hand written annotations and cryptic abbreviations (Schröder 2019) indicating that a specimen has passed through several hands until it arrived at the institutional herbarium where it is hosted today. Exchange of herbarium specimens between individuals is well investigated (Groom et al. 2014), but increasingly we gained the impression, that there existed a well-organized plant exchange network driven by clubs, societies etc. as well. We could find few studies only, dealing with a very limited number of organizations (Foster 1979; Robin 2004, 2006; Bange 2012; Groom et al. 2014), but we identified several organizations, regularly mentioned on labels but not listed in the current literature. We therefore established a study focusing on exchange activities managed by organizations dedicated to the exchange of dried plants (herbarium specimens).

As a first step we intended to discover where and how many organizations dedicated to the exchange of plants sensu latissimo (incl. Cryptogams, Algae, etc.) were established during the years 1819 to 1947. Then we looked for two appropriate examples, one concerning an individual person, actively collecting and exchanging specimens, and one concerning a plant species intensively collected and exchanged during the period of time we are focusing on (19th century). Here we present a

first brief overview on selected results. A monograph with all results in detail is planned for late 2023.

Material and methods

Definition of „plant exchange organization" (PEO)

Several types of organizations have been established in the past to facilitate exchange of herbarium specimens. One type was a kind of stock corporation, issuing shares to finance expeditions. Shareholders received a pre-defined number of specimens for each share after fortunate return of the collectors (e.g., „Unio Itineraria", Wörz 2016). A different type was the classical botanical society, holding meetings, organizing excursions, publishing a journal, and exchanging more or less small numbers of specimens on the sideline, usually at meetings. However, there have been a lot of organizations primarily or more often exclusively dedicated to plant exchange. In our project we define a real plant exchange organization (PEO) by three properties:

- exchanges solely of plants for plants (i.e., not plant for butterfly etc.)
- „pro mutua commutatione" = mutual exchange
- no commercial or financial interest (i.e., not for money)

Principally, there are two corpora of sources which have to be examined when searching for PEOs: herbaria and literature.

Fig. 1. Stamps of the Association (Société) Pyrénéenne pour l'échange des plantes (CHE015821) and the Watson Botanical Exchange Club (BIRM 025119).

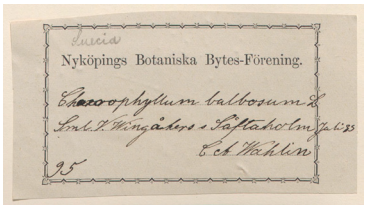

Fig. 2. Printed label of the Nyköpings Botaniska Bytes-Förening (CHE005000).

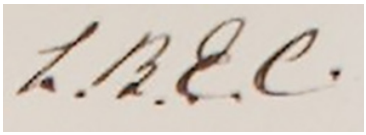

Fig. 3. Hand written abbreviation „L.B.E.C." on a specimen exchanged by the London Botanical Exchange Club (BIRM 009596).

Herbaria: Most PEOs marked specimens when preparing them for exchange, either with stamps (Fig. 1), printed labels (Fig. 2), or sometimes with hand written abbreviations (Fig. 3), but there are cases without any indication of the PEO, like Opiz' Anstalt in Prague. Not all databases store information about PEOs involved in the exchange of a specific specimen, but there are a few very helpful exceptions like Herbaria@home (Botanical Society of Britain & Ireland, herbariaunited.org), where clubs and societies are recorded as „collectors", „com" and „ex herb". The database of the Muséum national d'histoire naturelle at Paris allows search for collections, unfortunately not in the search form, but in an URL like „https://science.mnhn.fr/all/list?originalCollection=societe". Others store information on the provenance of a specimen in non-searchable fields like „annotations" (e.g., jacq.org).

We found the first records of PEOs by chance during our daily herbarium work when we noticed several stamps on the labels. For this study we used all available methods to systematically search digital repositories for relevant strings like „exchange club", „Tauschverein", „échange" etc.

Literature: Within the last two decades large amounts of literature have been digitized and made available. The most important repository for bioscience is The Biodiversity Heritage Library (biodiversitylibrary.org). Several national or state libraries run similar projects, without restriction to bio-

science, like the Bayerische Staatsbibliothek of Munich (bsb-muenchen.de), the Bibliothèque nationale de France (gallica.bnf.fr) or the Norwegian Nasjonalbiblioteket (nb.no). They provide not only digitized books, but newspapers, magazines and journals as well. We carried out full text searches in these repositories as well as in GoogleBooks (books.google.com).

In a second step we made two approaches to analyse and depict exchange activities: Firstly, we used an average size private herbarium of the 19th century and secondly, we analysed a rare Central European species, just described at the beginning of the 19th century.

The Bochkoltz-Herbarium: missing for 140 years and re-discovered

Wilhelm Christoph Bochkoltz (1810–1877) belonged to a bourgeois family in Trier (Southwest Germany). He studied Chemical Engineering in Metz and Paris. As a Civil engineer he was director of steel works, retired 1858, and after that – he was unmarried –, dedicated himself to nothing else but botany. Bochkoltz was one of the most important collectors of *Saxifraga rosacea* subsp. *sponhemica* (see below). His private herbarium was missing for 140 years, and we re-discovered it by accident in the herbarium of Heidelberg University (HEID) in late 2016. It comprised ca. 10 000 specimens, about half of them collected by himself, the other half acquired by exchange. He contributed to several series of exsiccata. In 2017 to 2018 a sample of 723 Bochkoltz specimens in HEID has been checked for collectors, revisors, exchange partners etc. in the so called „Old Herbarium" (pre-World War II-collections): all Cryptogams and Gymnosperms, two cabinets in the Angiosperm collection completely, and some further families due to our personal scientific interest, e.g., Saxifragaceae. Additionally, digital repositories have been searched for Bochkoltz-specimens.

Saxifraga rosacea subsp. *sponhemica* (C.C.Gmel.) D.A.Webb — a rare Central-European endemic

In the year of 1787 Carl Christian Gmelin (1762–1837) discovered an undescribed Saxifrage (Fig. 4) in Southwest Germany (Schröder 2023). In 1806, he published this novelty under the name *Saxifraga sponhemica* (Gmelin 1806: 224). Most modern floras accept the name *Saxifraga rosacea* subsp. *sponhemica* (C.C.Gmel.) D.A.Webb (Schröder 2023). This cespitose *Saxifrage* is a rare Central-European endemic with a very limited distribution and a disjunct areal (Decanter et al. 2020). As a glacial relict it grows on scree slopes facing from Northwest to Northeast, ideally above streams or small rivers. It does not tolerate full sun, but it is threatened by too much shadow as well. Some populations are currently endangered by shrubs, trees, and especially blackberries, benefitting strongly from atmospheric nitrogen impact.

Fig. 4. *Saxifraga rosacea* subsp. *sponhemica* in the valley of river Nahe (South-West Germany), CNS 2020/102, 2020-05-27.

Plant hunters from all Europe began to search for new localities of this desirable rarity and collected a large number of specimens, which were intensively exchanged by individuals as well as exchange clubs. Nowadays, specimens are found in many herbaria. As *S. rosacea* subsp. *sponhemica* was published shortly before the first plant exchange club was founded, and thanks to its rarity, it seems to be a good taxon to study exchange activities: the expected number of specimens is limited and it was immediately a focus of exchange clubs.

It has been collected, published, or stored under several names, like *S. affinis* D.Don, *S. aggregata* Lej., *S. c(a)espitosa* L. et subspp., *S. condensata* C.C.Gmel., *S. confusa* Lej., *S. decipiens* Ehrh. et subspp., *S. drucei* E.S.Marshall, *S. gmelinii* Host, *S. hartii* D.A.Webb, *S. hibernica* Haw., *S. hirta* Sm., *S. hypnoides* L. et subspp., *S. incurvifoli*a D.Don, *S. multifida* Rosbach, *S. palmata* Sm., *S. rosacea* Moench, S. *sponhemica* C.C.Gmel., *S. sternbergii* Willd. All these names have to be checked searching for specimens and references of *S. rosacea* subsp. *sponhemica.*

Within the years 2019 to 2022, 44 herbaria have been checked for specimens of *S. rosacea* subsp. *sponhemica*, 13 of them on site (B, BNL, HAL, HEID, JE, M, MSTR, NHV, SAAR, STU, W, WU & Herb. C.N.Schröder; acronyms according to Thiers 2022), the others digitally (naturalis.nl, jacq.org, gbif.org, mnhn.fr, recolnat.org, etc.) using the species search with the search string *„sponhemica"*. Fortunately, only one species with this epithet has been published. Beyond that we searched for specimens cited in publications and references, using the digital libraries listed above.

Technical Notes

The backbone of the project are two relational databases (MySQL) with PHP-scripts as frontend, one for *Saxifraga rosacea* subsp. *sponhemica* and one for the herbarium Bochkoltz. The first is composed of three main modules: specimens, persons & institutions, and bibliography. The Bochkoltz database has a highly normalized design to store collecting events and specimens coming from these events. A module for Bochkoltz-localities has been implemented but not yet filled with data. For collectors a relation to the persons module of the *Saxifraga rosacea* subsp. *sponhemica* database is implemented but not yet completely assigned for all datasets. The databases are hosted by a commercial service provider.

Two WikiProjects proposed a new Wikidata property „CNS-flora ID" (P10219). This was accepted by the community and implemented in December 2021. Subsequently we created Wikidata elements for all individuals and organizations in the database if not yet existing.

Results and Discussion

Plant Exchange Organisations (PEOs)

To our surprise we could identify no less than 101 PEOs (Fig. 5, Table 1 and 2), represented by digital specimens, exchange catalogues or cited in literature.

The first one was founded in the year 1819 (the letter of invitation was sent in 1818) by Philipp Maximilian Opiz (1787–1858) in Prague, the „Pflanzen-Saamen- und Insekten-Tausch-Anstalt" (Opiz 1818) with 36 founding members from Central Europe. In the last year of activity, this organization had 856 members worldwide (Opiz 1858). It was likely the largest organization, the smallest one we found was the Société d'échanges à Vierzon with eleven members and 233 numbers in the catalogue 1904 (Anonymous 1905: 17). Taking into account that some collectors were members in more than one PEO, we estimate the total number of collectors organized in PEOs with between 3000 and 5000. The largest PEOs distributed in total nearly two million specimens each, the smaller a few thousands only (Table 1).

With the Société d'Échange des Micromycètes in 1947, the last PEO was established, and around 2015 the last surviving organization, the Société pour l'Échange des Plantes Vasculaires de l'Europe et du Bassin Méditerranéen, established 1911 as Société Française pour l'échange des plantes vasculaires at Versailles, terminated with their dissolution two centuries of intensive plant exchange.

PEOs distributed a total of about 15 to 20 million specimens. Their members accumulated personal herbaria containing between some thousands and up to three million (Herbarium Roland Napoléon Bonaparte; cf. Anonymous 2022) specimens, exceeding all institutional herbaria of their time. Only a few members were professional academic botanists, most members had completely different professions: pharmacists, catholic priests, protestant pastors, teachers, entrepreneurs, judges, civil servants, day labourers, etc. – citizens of all kinds.

Table 1. Examples for the number of specimens exchanged by PEOs.

PEO	duration of activity	total of specimens exchanged
Wiener Botanischer Tauschverein	1845–1914	1'800'000
Pflanzen-, Samen- und Insekten-Tausch-Anstalt (Prague)	1819–1857	1'700'000
Den botaniske Forening i København	1848–1905	750'000
Botanischer Verein von Elsass-Lothringen	1880–1887	150'000
Malmö botaniska förening	1868–1871	3'000

Table 2. 101 plant exchange organizations, with year of founding, and place, if not part of the name.

1819	Pflanzen-Tausch-Anstalt in Prag (CZ)
1825	Apotheker-Verein in Norddeutschland, Botanische Tauschanstalt, Herford (DE); Süddeutsche Pflanzen-Tauschanstalt, Tübingen (DE)
1830	Botaniska Bytes-Sällskapet, Uppsala (SE)
1832	Botanischer Tauschverein, Erfurt (DE)
1836	Botanical Society of London (GB); Botanical Society of Scotland, Edinburgh (GB)
1840	Botaniske Forening i København (DK)
1842	Comptoir d'échanges botaniques, Strasbourg (FR)
1843	Stuttgarter botanische Tauschanstalt, Stuttgart (DE)
1844	Den botaniske Forening i København (DK); Skandinavisk-botaniske Bytteforening, Danske Afdeling, København (DK); Società di cambio di piante secche, Pisa (IT)
1845	Botanischer Tauschverein in Arnstadt (DE); Botanischer Tauschverein in Wien (AT); Botaniska Sällskapet i Götheborg (SE); Leipziger botanischer Tauschverein (DE)
1852	Upsala Botaniska Bytesförening (SE); Wiener Tausch-Herbarium (AT)
1854	Foreign Exchange Club, London (GB)
1856	Tausch-Verkehr mit mikroskopischen Präparaten, Gießen (DE)
1857	Botanical Exchange Club of the Thirsk Natural History Society (GB); Kryptogamen-Tauschverein, Gießen (DE)
1858	Botanischer Tauschverein [L. Fuckel], Nassau an der Lahn (DE); Botanischer Tauschverein ‹Trilobiten›, Praha (CZ); Lunds Botaniska Förening (SE)
1859	Botaniska Bytesföreningen i Strängnäs (SE); Stockholms Lycei Botaniska Bytesförenig (SE)
1862	Schlesischer Botanischer Tauschverein, Wroclaw (PL)
1863	Norrköpings botaniska bytesförening (SE); Société d'échanges Vogéso-rhénane, Mulhouse (FR)
1865	Jönköpings botaniska förening (SE); Kristianstads botaniska förening (SE)
1867	Botaniska föreningen i Carlskrona (SE); Kalmar botaniska förening (SE); Sällskapet Linnæas botaniska bytesförening, Karlstad (SE)
1868	Berliner Botanischer Tauschverein (DE); Botaniska Bytesföreningen ‹Rosa›, Visby (SE); Malmö botaniska förening (SE)
1869	Falun Botaniska Bytesförening (SE); Helsingfors botaniska bytesförening, Helsinki (FI)
1870	Schweizerischer Botanischer Tauschverein, Zürich (CH); Société Helvétique pour l'échange des plantes, Neuchâtel (CH); Tauschverein für Deutschlands Pflanzen, Königsberg (PU)
1872	Christiania botaniske Bytteforening, Oslo (NO); Nyköpings Botaniska Bytes-Förening (SE); Sociedad Botánica Barcelonesa (ES)
1873	Association rubologique, Lille (FR); Société dauphinoise pour l'Échange des plantes, Grenoble (FR)
1875	Société d'échange pour l'avancement des sciences naturelles, Cannes (FR)
1876	Növény-csereegylet Budapesten (HU)
1878	Deutscher Botanischer Tauschverein, Annen in Westfalen (DE); Société botanique rochelaise pour l'échange des plantes françaises, La Rochelle (FR)
1879	Comptoir parisien d'échange de plantes, Paris (FR); Internationaler botanischer Tauschverein, Berlin (DE); Nya Elementarskolans Botaniska Bytesförening, Stockholm (SE); Rheinischer Tauschverein, Wiesbaden-Biebrich (DE)
1880	Botanischer Verein von Elsass-Lothringen, Wasselonne (FR)

1882	International Botanical Exchange Club ‹Linnæa›, Lund (SE)
1883	Botanischer Tauschverein für Baden, Freiburg im Breisgau (DE); Botanischer Tauschverein in Sondershausen (DE); Europäischer Botanischer Tauschverein, München (DE)
1884	Botaniska Bytesförbundet Falun (SE); Malmö Botaniska Bytesförening (SE); Watson Botanical Exchange Club, York (GB)
1887	Linköpings Botaniska Bytesförening (SE); Thüringischer Botanischer Tauschverein, Schulpforte (DE); Västerviks botaniska bytesförening (SE)
1888	Botanical Exchange Club, Washington, D.C. (US); Bytesföreningen Flora, Uppsala (SE)
1890	Association Pyrénéenne pour l'échange des plantes, Foix (FR); Società Italiana per scambio di piante, Palermo (IT)
1891	Société pour l'Étude de la Flore Franco-helvétique, Paris (FR)
1892	Bryologischer Tauschverein, Annen in Westfalen (DE)
1893	Botaniska Bytesföreningen VIOLA, Kalmar (SE); Exchange Club of the Botanical Seminar of the University of Nebraska, Lincoln (US); Sandberg's Botanical Exchange Bureau, Minneapolis (US); Société du Sud-Est pour l'échange des plantes, Crémieu (FR)
1894	Stockholms Botaniska Bytes-Förening ‹Floras Vänner› (SE)
1895	Norsk botanisk Bytteforening, Sandefjord (NO)
1896	The Moss Exchange Club, Saintfield (GB)
1897	Botanische Tauschanstalt am Jurjew'schen Botanischen Garten, Tartu (EE); Glumaceen-Tauschverein, Annen in Westfalen (DE); Wiener Kryptogamen-Tauschanstalt (AT)
1898	Prager Botanische Tauschanstalt (CZ)
1899	Tauschvermittlung für Herbarpflanzen, Berlin (DE)
1901	Société cénomane d'exsiccata, Le Mans (FR?)
1903	Nürnberger Botanischer Tauschverein (DE)
1904	Österviks botaniska bytesförening (SE); Société d'échanges à Vierzon (FR)
1905	Canadian Botanical Exchange Bureau, St. Thomas (CA); Stettiner Vermittlungsanstalt für Herbarpflanzen, Szczecin (PL)
1906	Botanisk bytesförening vid Göteborgs latinläroverk (SE)
1907	Internationale Botanische Tauschanstalt zu Weimar (DE)
1911	Société Française pour l'échange des plantes vasculaires, Versailles (FR)
1913	Upsala Nya Botaniska Bytesförening (SE)
1914	American Botanical Exchange Bureau, Houston (US)
1920	Botanisk Bytteforening i København (DK)
1937	Société d'échanges Pteridophyta exsiccata, Paris (FR)
1947	Société d'Échange des Micromycètes, (FR); Société d'Échange des Muscinées, Saint-Étienne (FR)

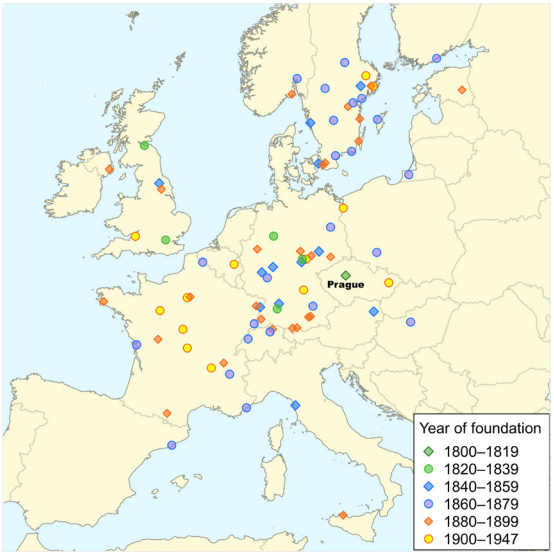

Fig. 5. PEOs by year of foundation. Not on the Map:
Botanical Exchange Club, Washington, D.C. (US, 1888);
Exchange Club of the Botanical Seminar of the University of Nebraska, Lincoln (US, 1893);
Sandberg's Botanical Exchange Bureau, Minneapolis (US, 1893);
Canadian Botanical Exchange Bureau, St. Thomas (CN, 1905);
American Botanical Exchange Bureau, Houston (US, 1914).

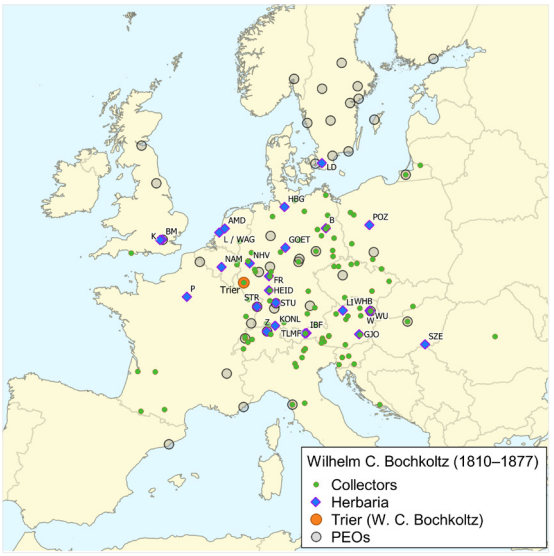

Fig. 6. Domiciles of collectors in herb. W. C. Bochkoltz and herbaria with specimens leg. Bochkoltz; not on the map: Herbarium US. PEOs only existing within the lifetime of Bochkoltz.

Wilhelm Christoph Bochkoltz

As a member of the Wiener Botanischer Tauschverein (WBT) Bochkoltz sent more than 1500 specimens to be distributed by the WBT. We identified, besides those in HEID, 79 Bochkoltz specimens in 27 herbaria: AMD, B, BM, FR, GJO, GOET, HBG, IBF, K, KONL, L, LD, LI, NAM, NHV, P, POZ, STR, STU, SZE, TLMF, US, W, WAG, WHB, Z (Fig. 6). We estimate, that he received an equivalent number of specimens from the WBT, which represent about one third of the specimens in his herbarium not collected by himself. Our sample revealed 111 collectors in his herbarium (Fig. 6), e.g., the young student Adolf Engler (1844–1930, author of „Die natürlichen Pflanzenfamilien" together with Karl Anton Eugen Prantl, 1887–1999 and „Das Pflanzenreich" 1900–1937), Carl Baenitz (1837–1913, editor of Herbarium Europaeum), and Anton Joseph Kerner (1831–1898, editor of Flora exsiccata Austro-Hungarica). His most important personal contact was Rupert Huter (1834–1919) who exchanged and sold large quantities of specimens from Tyrol, Dalmatia etc. (Fink et al. 2017), collected by himself and received from others. Bochkoltz had hundreds of specimens from Huter in his herbarium.

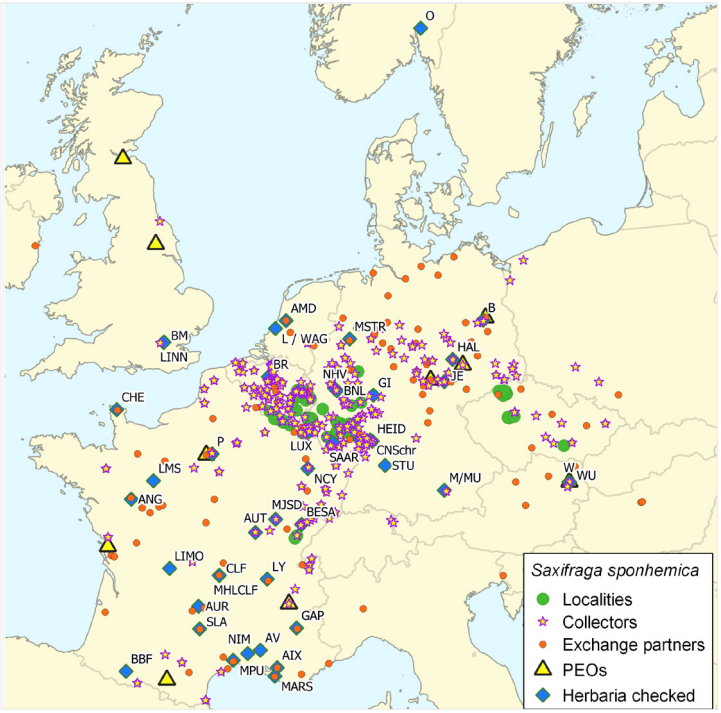

Fig. 7. *Saxifraga rosacea* subsp. *sponhemica* and exchange activities.
Shape files for this and maps in Fig. 5 and 6: Natural Earth. Free vector and raster map data@naturalearthdata.com. All maps: CNS using QGIS 3.4.

Saxifraga rosacea subsp. *sponhemica*

Specimens: We found 917 specimens (all Figs. as of 2022-11-30) of the *S. rosacea/sponhemica*-aggregate, 427 digitally and 490 on site. We determined that 649 (70.8.%) of them belong to *S. rosacea* subsp. *sponhemica,* 177 (19.3.%) of these originally had been determined as different taxa, mainly *S. c(a)espitosa* or *S. decipiens.* Conversely, 104 (11.3 %) specimens originally collected as *S. rosacea* subsp. *sponhemica* have been proven to belong to other taxa of cespitose Saxifrages. These specimens were collected for the most part at sites outside the distribution of *S. rosacea* subsp. *sponhemica.* We consider this is a consequence of the desire to find a new locality of this rarity, to increase the value of the own herbarium, and of the specimens sent to a PEO.

We could show that collecting and exchange activity started and increased about four decades later than publication activity (398 references published between 1806 and 2020 are recorded in the database). That is not surprising as the description of the new species had to be publicized before collectors could recognize it in the wild. Therefore, the peak of collecting was reached in the middle of the 19th century, declined

at the turn of the 20th century, and completely collapsed during World War II, with one exception: Belgian botanists stayed very busy collecting *S. rosacea* subsp. *sponhemica* until the 1970s!

Within our dataset we identified 12 PEOs who exchanged specimens of *S. rosacea* subsp. *sponhemica,* four each in France and Germany – which is not surprising as most of the localities are situated in Germany, France, Belgium and Luxemburg (Fig. 7) –, and two each in Austria and Great Britain.

Collectors: Most collectors of *Saxifraga rosacea* subsp. *sponhemica* (242 individuals have been identified) lived near the initially discovered populations, but some enthusiasts travelled long distances to collect this rarity (Fig. 7). Exchange partners (233 individuals) who received specimens from PEOs or individuals usually lived more or less far away from the localities. Some recipients and collectors lived near institutional herbaria, and some of them may have bequeathed their collection to such a herbarium.

Conclusion

With thousands of active members, the 101 PEOs were a significant social and cultural phenomenon. With their tireless curiosity and relentless passion these early „citizen scientists" founded and accumulated the basis of institutional herbaria and digital repositories of the biodiversity data age, a treasure of inestimable value for research on future topics like biodiversity loss and climate change.

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Credits: Fig.1, CHE015821 & Fig. 2: RECOLNAT (ANR-11-INBS- 0004) – picturae – 2016, CC BY 4.0; Fig. 1, BIRM 025119 & Fig. 3: University of Birmingham Herbarium, Winterbourne House and Garden, with kind permission; Figs 4–7: CNS.

URL for further data (most pages currently in German only), specimens, references, biographies, stamps etc.: https://cns-flora.de/plantexchange/

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