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Witnesses to industrial history: the recent return of wool alien plants on the banks of the River Meuse (the Netherlands, Belgium)

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Abstract – After the drastic redevelopment of the banks of the River Meuse in recent years, on both the Dutch and Belgian sides of the river, numerous exceptional exotic plants unexpectedly appeared. Although their precise introduction vector is difficult to determine with certainty, most of these species have most likely germinated from the old, long-buried seed bank that was uncovered by the works. The seeds were introduced many decades ago (at least 50 but perhaps more like 100 years ago, or even longer) via the wool processing industry, about 50 km further upstream, along the River Vesdre in Belgium. Here, we present a commented and illustrated overview of the 59 taxa observed in recent years. They belong to a very limited number of families that are known to have hard, long-lived seeds (mainly Fabaceae and Malvaceae, which together represent 48 taxa). Most taxa are native to the Mediterranean area, but are often widely naturalized elsewhere in the world, including in wool farming areas, while some are endemic to Australia, South Africa, or South America. The following species had not been recorded before in the Netherlands: *Cullen cinereum*, *Dichondra micrantha*, *Erodium carolinianum*, *Lotus ornithopodioides*, *Malva olbia*, *Malvastrum americanum*, *Sida acuta*, *S. rohlenae*, *S. sivarajanii*, *Sphaeralcea purpurata*, *Tarasa tenella*, *Trifolium hirtum*, *T. spumosum*, and *T. squarrosum*. *Nicotiana glauca* was reported for the first time in Belgium. The most remarkable species are depicted. Perhaps these records are of limited relevance for the Dutch and Belgian flora, because – as in the past – probably none of these wool aliens will be able to establish permanently (although this cannot be ruled out entirely, given the changing climate). Our findings highlight the exceptional longevity of seeds of certain plant families.

Samenvatting – Planten reizen op verschillende manieren de wereld rond, hetzij op eigen kracht of onder invloed van menselijke activiteiten. Door de mondialisering zijn zelfs de verste uithoeken van de wereld nu met elkaar verbonden, waardoor planten zich met hulp van de mens ongebreideld kunnen verspreiden. Momenteel is de sierteelt misschien wel de belangrijkste vector voor de introductie en verspreiding van uitheemse planten, vooral door de doelbewuste invoer van soorten (de eigenlijke sierplanten, die steeds vaker ontsnappen, inburgeren of zelfs invasief worden), maar ook voor de ermee geassocieerde, onbedoeld geïntroduceerde onkruiden. Andere belangrijke hedendaagse introductievectoren voor de onbewuste invoer van planten zijn granen (leidend tot zg. ‘graanadventieven’) en vogel- en oliezaden (leidend tot zg. ‘zaadcontaminanten’). Soms gaat het echter om minder voor de hand liggende vectoren, zoals toeristen en hun uitrusting (leidend tot zogenoemde ‘campingadventieven’). In het verleden was nog een andere vector verantwoordelijk voor de invoer van plantenzaden, namelijk het transport van wol en dierenhuiden. Tijdens het grazen hechtten zich talloze zaden en vruchten aan de vacht van de dieren. De geïmporteerde huiden – vaak afkomstig van het zuidelijk halfrond, vooral Australië, Zuid-Afrika en Zuid-Amerika – werden pas op de plaats van bestemming gereinigd. Exotische zaden werden vervolgens met het afvalwater geloosd en ontkiemden onder gunstige omstandigheden, wanneer de oevers aan het einde van de zomer opdroogden, stroomafwaarts van de wolwasserijen. Bij niet-riviergebonden wolfabrieken werd het wolafval, inclusief de zaden, vlak bij de fabriek gedumpt. Hierdoor werden ook in de omgeving van wolfabrieken vaak zeer bijzondere, exotische planten aangetroffen, de zogenaamde woladventieven. België – en in het bijzonder de vallei van de Vesder bij Verviers – stond lang bekend om zijn textielindustrie. Het is dan ook niet verwonderlijk dat er vanaf het einde van de 19e tot de tweede helft van de 20e eeuw (tot begin jaren zeventig) talloze woladventieven werden aangetroffen aan de oevers van deze rivier. In totaal werden enkele honderden soorten gedocumenteerd, waarvan de meeste afkomstig waren van het zuidelijk halfrond. Ook in Nederland werden woladventieven opgemerkt, zij het pas enkele decennia later. Vooral A.W. Kloos jr. schreef hier meerdere artikelen over. Deze hadden vooral betrekking op uitheemse planten die gevonden werden op stortplaatsen in de buurt van huiden- en pelsfabrieken. In de tweede helft van de 20e eeuw werden ook op de droogvallende oevers van de Maas geregeld uitheemse planten aangetroffen die in verband gebracht werden met de wolverwerkende industrie stroomopwaarts in België, langs de Vesder, een zijrivier van de Maas. Omdat afvalwater niet meer onbehandeld geloosd mag worden en er geen afval meer gestort wordt (en meer in het algemeen de wolverwerkende industrie achteruitging), worden de exotische planten die bij deze industrie horen al zeker een halve eeuw niet meer waargenomen. Overigens

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ontwikkelden de meeste soorten zich in Nederland en België moeilijk, omdat ze uit warme en droge streken (vaak halfwoestijnen) kwamen. De meesten bereikten niet eens het reproductieve stadium. Er was kennelijk een te groot verschil tussen het klimaat van herkomst en het West-Europese klimaat. Van de vele honderden indertijd aangevoerde woladventieven heeft waarschijnlijk slechts één soort zich uiteindelijk permanent gevestigd in de Lage Landen, de Zuid-Afrikaanse *Senecio inaequidens*.

In 2008 zijn echter grootschalige werken gestart langs de Maas, vooral in Limburg, aan de Nederlandse zijde van de rivier. Het project kende verschillende doelstellingen waar gelijktijdig aan werd gewerkt: rivierbescherming, natuurontwikkeling en zand- en grindwinning. Het totale gebied beslaat een traject van ongeveer 43 kilometer, tussen Maastricht en Echt-Susteren. De werken startten in Itteren (Maastricht) en momenteel zijn de meeste locaties gerealiseerd (Borgharen, Itteren, Visserweert/Illikhoven en Geulle aan de Maas). Als gevolg hiervan is het landschap ingrijpend veranderd: de rivierbedding is aanzienlijk breder geworden, waardoor voormalige akkers en weilanden werden omgezet in grind- en zandrijke oevers. Zoals verwacht werden de nieuw ontstane oevers al snel gekoloniseerd door talrijke interessante plantensoorten, zowel inheemse als geïntroduceerde. Soortgelijke maar veel minder ingrijpende werken vonden ook elders plaats, zowel aan de Belgische als Nederlandse kant van de rivier. Als een gevolg van deze grootschalige werken ontkiemden zaden uit de oude zaadbank. Omdat deze vondsten getuigen van het rijke industriële verleden van de riviervallei van de Vesder verder stroomopwaarts, leek het ons interessant om de recente vondsten te documenteren, nu de werken zo goed als voltooid zijn. Op zichzelf zijn ze van weinig belang voor de Nederlandse en Belgische flora, omdat – net als de woladventieven in het verleden – waarschijnlijk geen enkele soort zich permanent zal kunnen vestigen (hoewel dit gezien het veranderende, opwarmende klimaat ook niet geheel kan worden uitgesloten). Onze vondsten onderstrepen echter de uitzonderlijk lange kiemkracht die zaden van bepaalde plantenfamilies kunnen behouden. Dit artikel presenteert de meest bijzondere vondsten van de afgelopen vijftien jaar, zowel uit België als Nederland, met uitzondering van de talrijke exotische *Juncus*-soorten, waaraan een apart artikel zal worden gewijd. Uiteindelijk werden 59 taxa waargenomen die wellicht met de voormalige wolindustrie in verband kunnen worden gebracht. Ze behoren tot een zeer beperkt aantal families waarvan bekend is dat ze harde, langlevende zaden hebben (voornamelijk Fabaceae en Malvaceae, die samen 48 taxa vertegenwoordigen). Er werden slechts enkele taxa gevonden van zes andere families [in volgorde van belangrijkheid: Geraniaceae (5), Plantaginaceae (2), Boraginaceae (1), Convolvulaceae (1), Lamiaceae (1) en Solanaceae (1)]. Opvallend was voorts de grote diversiteit aan klaversoorten (*Trifolium*) (15 taxa), waaronder enkele soorten die nog niet eerder in Nederland waren waargenomen. De meeste woladventieven komen oorspronkelijk uit het Middellandse Zeegebied (maar zijn elders in de wereld vaak op grote schaal ingeburgerd, ook in de herkomstgebieden van de schapenwol), terwijl sommige endemisch zijn in Australië (bijvoorbeeld *Cullen cinereum*, *Erodium carolinianum* en *Sida rohlenae*), Zuid-Afrika (*Monsonia brevirostrata*) of Zuid-Amerika (*Sphaeralcea purpurata* en *Tarasa tenella*). De volgende soorten waren in Nederland nog niet eerder waargenomen: *Cullen cinereum*, *Dichondra micrantha*, *Erodium carolinianum*, *Lotus ornithopodioides*, *Malva olbia*, *Malvastrum americanum*, *Sida acuta*, *S. rohlenae*, *S. sivarajanii*, *Sphaeralcea purpurata*, *Tarasa tenella*, *Trifolium hirtum*, *T. spumosum* en *T. squarrosum*. *Nicotiana glauca* wordt voor het eerst gemeld voor België. De meest opmerkelijke soorten worden ook afgebeeld.

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INTRODUCTION

Plants travel around the world in various ways, either under their own means (e.g., by being adapted for wind dispersal) or under the influence of human activities. Due to globalization, even the farthest corners of the world are now connected, allowing plants to spread almost without restrictions with the help of humans. This so-called allochory has therefore become much more important than the spread by a species' own efforts (autochory). At present, the horticultural trade is perhaps the most important vector for the introduction and dispersal of non-native plants, primarily for the deliberate introduction of species (the actual ornamental plants, which are increasingly escaping and becoming naturalized) (e.g., Beaury et al. 2021, van Kleunen et al. 2018), but also for the unintentionally introduced weeds associated with them (Hoste & Verloove 2010). Other important contemporary vectors for the unintentional introduction of plants are cereals (e.g., Ikeda et al. 2022) or also seed contaminants (Lehan et al. 2013). Sometimes, however, less obvious vectors are involved, such as tourists and their equipment (Verloove et al. 2020).

In the past, yet another vector was responsible for the massive importation of plant seeds, namely wool and animal skins (furs, hides, etc.). During grazing, numerous seeds and fruits got stuck to the animal fur. The imported wool and skins – often from the southern hemisphere, mainly Australia, South Africa and South America – were usually cleaned at their destination. Exotic seeds were then discharged with the waste water and, under favorable conditions, when the river banks dried up at the end of the summer, germinated downstream of the wool washing facilities. At wool mills that were not located along rivers, the wool waste, including the seeds, was dumped near the mills. As a result, very exceptional exotic plants (the so-called wool aliens) were often also found in the vicinity of wool factories. Belgium – and in particular the Vesdre Valley near Verviers – has long been famous for its textile industry. It is therefore not surprising that from the end of the 19th to the second half of the 20th century (until the early 1970s) numerous wool aliens were found on the banks of the River Vesdre, a tributary of the River Meuse. In total, several hundred species were found, most of them from the southern hemisphere (see, e.g., Fabri & Lambinon 1991, Lambinon et al. 1959, van Ooststroom & Reichgelt 1961a; Visé 1942, 1958). Wool aliens were also noticed in the Netherlands, albeit a few decades later. Numerous records of wool aliens from the first half of the 20th century were published by, among others, A.W. Kloos jr. These mostly referred to alien plants found on dumps near hide and fur factories (e.g., Kloos 1939). In the second half of the 20th century several inventories were made by S.J. van Ooststroom & Th.J. Reichgelt on the exposed banks of the River Meuse (e.g., van Ooststroom & Mennema 1972; van Ooststroom & Reichgelt 1958b, 1959, 1960, 1962a, 1968). The alien plants found during these inventories were associated with the wool processing industry further upstream in Belgium, along the River Vesdre. As in Belgium, exotic plants were regularly found there until the early 1970s. Because, as a rule, industrial waste water is no longer discharged untreated and waste is no longer dumped – and more generally the wool processing industry significantly declined –, the exotic plants associated with this industry have not been observed for at least half a century (except, but only very occasionally, after disturbance of the seed bank).

It should also be noted that because most of the introduced plants came from warm and arid regions (often semi-deserts), in Belgium and the Netherlands they at best flowered or occasionally set fruit and then died; most did not even reach the reproductive stage. Apparently, the difference between the climate of origin and the western European climate was too big: of the many hundreds of wool aliens recorded, probably only one species ultimately established permanently, i.e., the South African *Senecio inaequidens* DC. (Ernst 1998, Lebeau et al. 1978).

In 2008, however, massive infrastructural works started alongside the River Meuse in the Province of Limburg, on the Dutch side of the river. The project had various objectives which were all worked on simultaneously: river protection, nature development, and the extraction of sand and gravel. The total area covered a stretch of about 43 kilometers, between Maastricht and Echt-Susteren. The works started in Itteren (Maastricht) and at present the works at the locations Borgharen, Itteren, Visserweert / Illikhoven, and Geulle aan de Maas are accomplished. As a result, the landscape has changed dramatically: the riverbed has been considerably widened, turning former agricultural fields and meadows to gravelly and sandy riparian habitats. As expected, the pristine banks were soon colonized by numerous interesting plant species, native as well as introduced ones. Occasionally, similar but much less drastic works were also carried out at other locations on the Dutch as well as on the Belgian side of the river.

In the past few decades, prior to infrastructural works, adventive plants that could be associated with the former wool industry already appeared every now and then along the River Meuse, usually after disturbance of the gravel banks (e.g., after floods or local excavations). However, these observations were rather anecdotal: they usually concerned only a few, fairly common species and a small number of individuals. Evidently, since new wool aliens are no longer introduced due to the fact that wool waste water is no longer discharged untreated, these wool aliens must have originated from seeds that were present in the long-lived seed bank.

As a result of the more recent and very drastic massive infrastructural works, seeds from this wool alien seed bank also got the opportunity to germinate, resulting in new finds of wool aliens, but this time on a much larger scale. Because these finds testify to the rich industrial past of the Vesdre Valley further upstream, we found it interesting to document the recent records. In themselves the finds have little importance for the Dutch and Belgian flora, since – as in the past – probably none of these wool aliens may be able to establish persistent populations, although this cannot be completely ruled out, given the changing, warming climate. The records also underline the exceptionally long germination capacity that seeds from particular plant families can retain. This paper presents the most extraordinary finds of the past c. 15 years, both from Belgium and the Netherlands, with the exception of the numerous exotic species of *Juncus* which are discussed in a separate article. In the Vesdre Valley itself, in Belgium, wool aliens also recently reappeared, not after major works, but after the devastating floods of 2021. These records will also be separately discussed (Verloove et al., submitted).

MATERIALS AND METHODS

Our fieldwork was of course primarily carried out in the areas that had been subjected to the recent infrastructural works. These were all located in the Netherlands, from Maastricht further downstream: Bosscherveld, Borgharen, Itteren, Meers, Geulle aan de Maas / Voulwames, Maasband, Urmond, Nattenhoven, Grevenbicht, Koeweide / Trierveld, and Visserweert. Not all locations were investigated equally intensively: at some locations (e.g., in Urmond) the works were limited or very local, which meant that the chance of finding interesting species was small. The main locations surveyed for this study were the following[1] (Fig. 1):

1. — Maastricht (Kleine Weerd). Some interesting species were discovered at this site, although no large-scale works have taken place recently. It is not entirely certain that these species can indeed be linked to the former wool industry. In addition to the species mentioned here, other alien species were also found in this locality, also with an uncertain introduction vector. One such species is *Chaiturus marrubiastrum* (L.) Ehrh. ex Rchb. (syn.: *Leonurus marrubiastrum* L.), found in 2017, a species not previously recorded in the Benelux countries that was recently also observed elsewhere along the River Meuse (Meers, in 2019).
2. — Maastricht (Bosscherveld). The newly constructed plain was visited from 2020 to late 2024. Together with the next location it was by far the most species-rich. The plain has a multitude of suitable habitats for wool aliens, both on sand and gravel and dry as well as moist.
3. — Grevenbicht (nature reserve Elba). This location used to be a gravel pit where wool aliens were regularly found in the past (see the van Ooststroom & Reichgelt references). In particular in 2019 and 2020 numerous exotic species were found there.

One additional site, the Eijsderbeemden, needs to be mentioned specifically. This area is located south of Maastricht and therefore falls outside the area where major works took place. However, after the floods in the Vesdre Valley in 2021, this area was the first along the River Meuse where sand and debris was deposited from the Vesdre River further upstream. As a result, several species likely associated with the former wool processing industry were observed shortly after the floods.

Several restoration projects and nature development works have also been carried out on the Belgian side of the River Meuse in the past two decades, in particular in Negenoord, Hochterbampd, Mazenhoven, Maasweerd (including Bichterweerd), and Koningssteen. These sites are all located in the Belgian Province of Limburg and occasionally yielded finds of adventive plants that may be associated with the former wool processing industry (e.g., *Medicago polymorpha* L. and *Melilotus indicus* (L.) All.), but no truly spectacular finds were made. One locality, however, was of particular interest:

Boorsem (Maasmechelen), between the village and the E314 motorway. Local excavation work was carried out at this location in 2011, which resulted in gravel piles next to the river. In 2011 and 2012 a few interesting and unusual wool aliens germinated here.

All authors have visited these and other localities on numerous occasions in the past 15 years, or longer. All records were registered on the local platforms for biodiversity citizen science: waarneming.nl for Dutch records and waarnemingen.be for Belgian records. These data were subsequently uploaded into GBIF, the Global Biodiversity Information Facility.

Determining which species can be associated with the former wool industry was not always easy and was in several cases only an ‘educated guess’. It must be taken into account that, apart from the wool industry, the River Meuse is an important supply route for diaspores and, therefore, exotic species that have nothing to do with this industry regularly appear as well. In order to estimate this more or less accurately, various factors were taken into account: (i) whether or not the seeds of the species are long-lived, (ii) existence of previous historical

[1] Curiously, the exotic rushes, which will be covered in a separate article, were mainly found at other locations along the River Meuse.

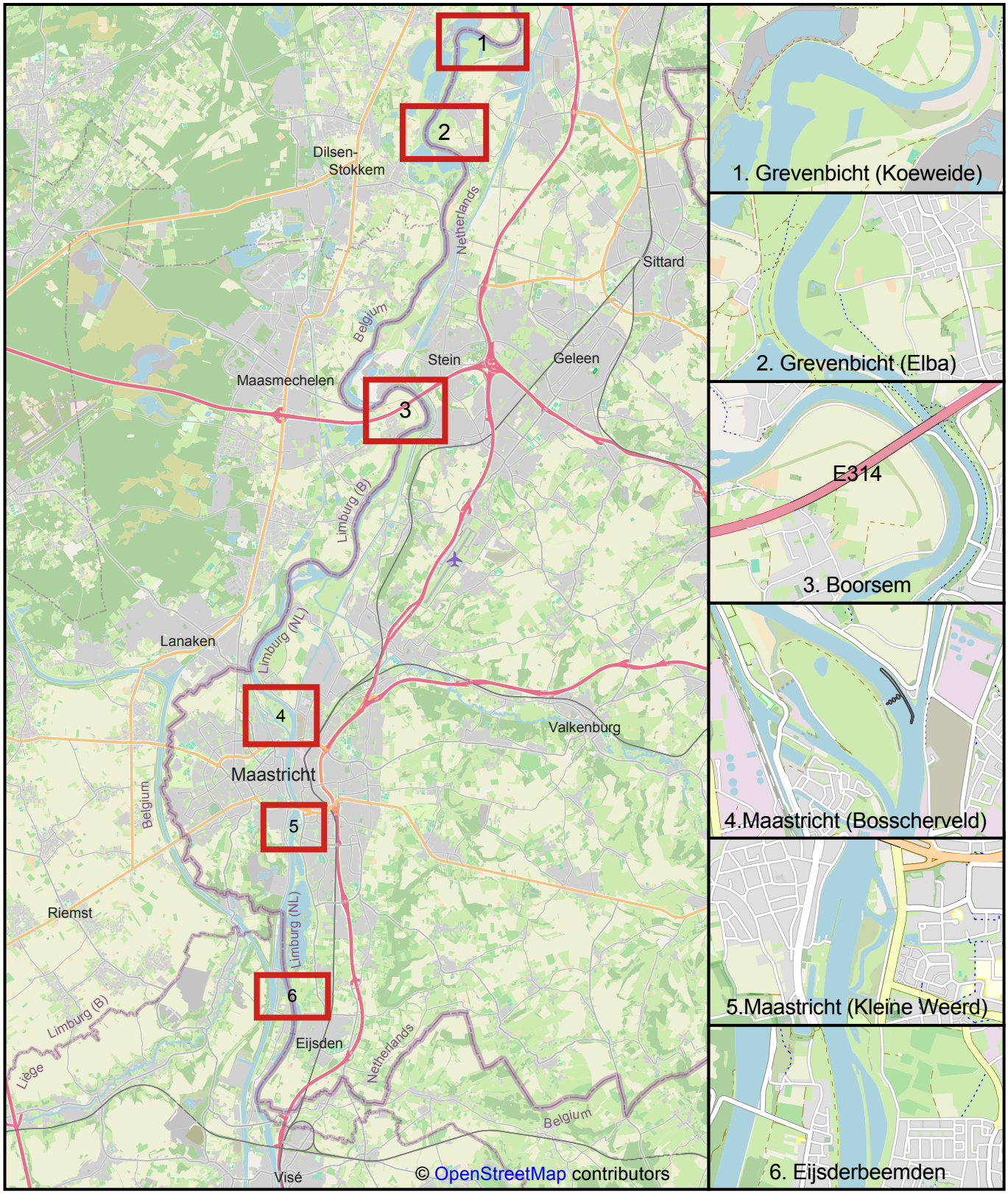

Fig. 1. The main locations along the River Meuse surveyed for this study in both Provinces of Limburg in Belgium and the Netherlands. From north to south: 1. Grevenbicht (Koeweide), 2. Grevenbicht (nature reserve Elba), 3. Boorsem (between the village and the E314), 4. Maastricht (Bosscherveld), 5. Maastricht (Kleine Weerd), and 6. Eijsderbeemden. See the text for details. Source background map: www.openstreetmap.org.

records as wool alien (in the Vesdre and / or Meuse Valleys or elsewhere in the world), and (iii) presence of the species in pastures (or similar habitats for grazing sheep) in the main areas of origin of the wool.

Species identification

Numerous Floras and other literature sources, mostly from the suspected areas of origin, were consulted to accurately identify the observed plants. Most plants were collected in situ at the flowering and / or fruiting stage. However, in case it

Fig. 2. *Dichondra micrantha* Urb. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 2 September 2020.

could reasonably be assumed that the flowering and / or fruiting stage would not be reached (especially towards the end of the season), vegetative plants were excavated and further grown ex situ, partly also indoors, for identification.

Herbarium vouchers

Numerous herbarium specimens were collected during our field work. These were deposited in the herbaria L (the herbarium of Naturalis Biodiversity Center, Leiden, the Netherlands) and / or BR (Meise Botanic Garden, Belgium). Because most collections are quite recent, not all of them have yet been digitized and therefore not all are yet available online. Soon, the specimens will be available for consultation on the respective platforms: Naturalis Bioportal (L) and Botanical Collections (BR). Both platforms have English and Dutch versions; the platform of Meise Botanic Garden has also a French and German version.

Previous records in the Netherlands and Belgium

To determine whether a species had previously been found in Belgium and / or the Netherlands, several sources were consulted. For the Netherlands, Naturalis Bioportal was searched for herbarium specimens and the website natuurtijdschriften.nl was consulted for relevant literature. For Belgium, the main reference was the 'Catalogue of neophytes in Belgium (1800 – 2005)' (Verloove 2006).

RESULTS

The species are discussed alphabetically within family.

BORAGINACEAE

Heliotropium europaeum L.

This weed from the Mediterranean area is widely naturalized elsewhere in the world, including in parts of southern Africa and Australia. In the past it was regularly associated with wool importation, in the British Isles (Clement & Foster 1994) as well as in Belgium (Verloove 2006). The species was apparently not found as a wool alien in the Netherlands (van Ooststroom & Reichgelt 1961b).

Heliotropium is a taxonomically complex genus and the identity of the wool alien plant material was sometimes questioned (Probst 1949). Given the origin of the wool, the presence of Australian species could not be excluded. However, our material belongs to *H. europaeum*, as clearly none of the Australian species qualify (Craven 1996).

Two flowering and fruiting individuals were found on gravel piles in Boorsem in September 2011. The species has recently also been reported from the banks of the River Vesdre in Belgium in 2022 and 2023 (Verloove et al., submitted) and, also in the Belgian Province of Limburg, on the banks of the Berwijn Rivulet, a tributary of the River Meuse, along with *Trigonella caelesyriaca* Boiss. in 2022.

Fig. 3. *Astragalus hamosus* L. in Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Rutger Barendse, 10 October 2021.

CONVOLVULACEAE

***Dichondra micrantha* Urb.** — Fig. 2.

This species is native from Texas to Mexico and the Caribbean; it is widely naturalized in the warm-temperate and subtropical areas of the world, including South Africa, South America and Australia. As a wool alien, it was formerly recorded in the British Isles and Swedish claims of *Dichondra repens* J.R.Forst. & G.Forst. (Probst 1949) probably also belong here, for both species were confused for quite a long time (e.g., Lawalrée 1970).

Two non-flowering individuals of *Dichondra micrantha* were discovered on the banks of the River Meuse in Grevenbicht (Elba) in July 2020. In 2021, one of these plants produced fruits and these were typical of *D. micrantha* (with capsules clearly exceeding the sepals). In 2022, the species had apparently disappeared. The species was not associated with wool imports in the Netherlands or Belgium in the past, but it also was found on the banks of the River Vesdre after the recent floods (Verloove et al., submitted).

Interestingly, in the past years, *Dichondra micrantha* was also found in two other localities in the Netherlands, in Ospel (Province of Limburg) and Tilburg (Province of Brabant)(waarneming.nl). It occurred in regularly mowed lawns, a habitat in which the species is more commonly found, especially further south in Europe.

FABACEAE

Astragalus hamosus L. — Fig. 3.

The native range of this species extends from the Mediterranean area to Pakistan. It is naturalized in parts of Australia. Probst (1949) reported this species from near wool mills in Marseille in France, but in general the species is more likely to be imported with cereals or tan bark, while the introduction vector is sometimes also unclear (Clement & Foster 1994, Verloove 2006).

Astragalus hamosus was recorded on a demolition site in Ghent (Belgium) in the 1990s, along with other alien plants (Verloove & Heyneman 2012). Since textile factories were located on this site in the past, these aliens can at least partly be considered wool aliens. The observation of the Australian *Erodium crinitum* Carolin at the same location also points to this.

In September 2021, a fruiting individual of *Astragalus hamosus* was recorded in Maastricht (Bosscherveld). In the Netherlands, the species was reported a few times in the first half of the 20th century and always being associated with cereals (e.g., Kloos 1927).

Fig. 4. *Cullen cinereum* (Lindl.) J.W.Grimes in Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Rutger Barendse, 10 October 2021.

***Coronilla scorpioides* (L.) W.D.J.Koch**

The native range of *Coronilla scorpioides* covers the Mediterranean area and extends to Iran and Eritrea. In the past it was regularly recorded as a wool alien (Clement & Foster 1994, Probst 1949), also in Belgium (Verloove 2006). Interestingly, *C. scorpioides* was previously recorded in 1961 from Grevenbicht on the banks of the River Meuse (van Ooststroom & Reichgelt 1962a).

In October 2021, a single individual with flower buds was recorded in Maastricht (Bosscherveld). Elsewhere in the Netherlands, the species has recently also been recorded as a weed in plant containers originating from the Mediterranean area. The species has regularly been found in the Netherlands in the past, often on landfills.

***Cullen cinereum* (Lindl.) J.W.Grimes** — Fig. 4.

[syn.: *Psoralea cinerea* Lindl.]

Cullen cinereum is widespread and occurs throughout Australia (Grimes 1997). The species was formerly recorded as a wool alien in the British Isles and Central Europe (e.g., Clement & Foster 1994, Probst 1949) and also in Belgium (Lawalrée 1950) but apparently not yet in the Netherlands.

In October 2021, a single individual with flower buds was recorded in Maastricht (Bosscherveld). In Belgium, the species was among the most common and typical wool aliens on the banks of the River Vesdre after the 2021 floods (Verloove et al., submitted).

***Lotus ornithopodioides* L.** — Fig. 5.

This species is (predominantly) native to the Mediterranean. As far as we could tell, it had not previously been associated with wool imports (a record from the Port Juvénal in Montpellier, France, is questionably linked to the wool industry; Probst 1949). In the British Isles, records of *Lotus ornithopodioides* have been associated with esparto [fibers from the West-Mediterranean perennial grass *Macrochloa* (*Stipa*) *tenacissima* Kunth] and ballast (Clement & Foster 1994).

A single flowering individual was observed in April 2020 in Grevenbicht (Elba), which was apparently the first time that this species was recorded in the Netherlands.

Lotus ornithopodioides superficially resembles *L. hispidus* Desf. ex DC., an alien that has recently appeared in a few places in the Netherlands, including as a weed in Mediterranean plant containers. It differs from *L. hispidus* by its calyx with markedly unequal teeth.

Fig. 5. *Lotus ornithopodioides* L. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 12 April 2020.

***Medicago laciniata* (L.) Mill.**, ***M. polymorpha* L.**, and ***M. praecox* DC.**

These three species have their main native range in the Mediterranean region (however, the first one naturally occurs only in the African and Asian parts of it). They have naturalized and become weedy in many warm-temperate regions across the world. *Medicago polymorpha*, for instance, was quite common in raw wool imported from Argentina and Australia (Visé 1942). Species of *Medicago* L. were among the most common impurities in raw wool (Kloos 1939), since their (usually) spiny pods easily adhere to sheep wool.

Medicago polymorpha is by far the most abundant of these three species. It regularly occurs on the banks of the River Meuse, even after minor disturbances of the riverbed, and is more or less naturalized in the river valley (Pinckaers 1985). In recent decades, including before the major works, the species has been more or less permanently present in the valley on both the Dutch and Belgian sides of the river.

Medicago laciniata is much rarer but is still regularly recorded. Two morphological variants have been recorded, i.e., plants with deeply laciniate stipules (var. *laciniata*) and plants with shallowly toothed stipules (var. *brachyacantha* Boiss.). Both were formerly recorded as wool aliens in Belgium and the Netherlands, the latter as *M. aschersoniana* Urb. (van Ooststroom & Reichgelt 1957, 1958a). On the Dutch side of the river, *M. laciniata* was regularly recorded since 2018 and in substantial numbers of indiviuals. A few dozen individuals were seen in Grevenbicht (Elba) in 2019 and 2020 and in Maastricht (Bosscherveld) in 2021. A single specimen was observed in Borgharen in 2018. On the Belgian side of the river, the species was only seen in Boorsem in 2011.

Medicago praecox was found in much smaller numbers and only on the Dutch side of the river: in Grevenbicht (Elba) in 2020 and 2021 (a few plants only), in Maastricht (Bosscherveld) in 2021, 2022, 2023 and 2024 (about a dozen individuals), and in Eijsden (2021).

Two native species were also frequently observed on the banks of the River Meuse, *Medicago minima* (L.) Bartal. and *M. arabica* (L.) Huds. Both were rather common and there is little doubt that these plants were at least partly introduced from abroad. Pods of *M. arabica* were quite common in wool from North Africa according to Visé (1942).

All these species were already reported from the banks of the River Meuse by van Ooststroom & Reichgelt (1958b, 1959, 1960, 1962a, 1968).

***Melilotus indicus* (L.) All.**

[syn.: *Trigonella smallii* Coulot & Rabaute]

The native range of this species extends from the Mediterranean area to Central Asia and the Indian Subcontinent. It is a rather frequent alien that is introduced through multiple vectors, including wool and cereals (Clement & Foster 1994, Probst 1949). It was already recorded in the past from the banks of the River Meuse by van Ooststroom & Reichgelt (1958b) and was among the rather common wool aliens in the Vesdre Valley in Belgium as well (Visé 1958).

Melilotus indicus is one of the species that already regularly appeared on the banks of the River Meuse before the recent massive works and to such an extent that it is sometimes considered to be more or less naturalized there (Verloove & Van Rossum 2023). It should be noted that the species sometimes also grows on gravel beaches far into the upper reaches of tributaries such as the River Gulp, which indicates that the species also ends up in the Meuse Valley via other supply sources than wool. In the last five or six years the species has been observed in large numbers and in many places, on both sides of the river.

***Ornithopus sativus* Brot.**

This species is native to the western Mediterranean region but widely naturalized elsewhere, including in some major sheep farming areas such as Australia, South Africa and parts of South America. The species could just as well have ended up on the banks of the River Meuse in some other way, as it is sometimes sown, also in the Meuse Valley. However, other than our own find, no observations seem to be known from the river bank itself. Moreover, the species has been found in the past as a wool alien, at least in Germany (Probst 1949).

In May 2020, a flowering individual was found in Grevenbicht (Elba).

***Sesbania herbacea* (Mill.) McVaugh**

[syn.: *S. exaltata* (Raf.) Rydb.]

Seedlings of *Sesbania* Adans. are very rarely recorded on the banks of the River Meuse and these have always been referred to as *S. herbacea*, a rather characteristic oilseed alien from North and Central America and the northern half of South America (Verloove & Vandenberghe 1994). The occasional occurrence of, for example, *Ipomoea lacunosa* L. along the River Meuse, another oilseed alien, seems to indicate that exotic species are indeed also introduced through this introduction vector.

Sesbania species have also been recorded as wool aliens, but these usually originate from other areas. Indeed, almost no wool was imported from the areas where *S. herbacea* naturally occurs, with the exception of parts of Bolivia and Brazil. The predominantly Australian *Sesbania cannabina* (Retz.) Poir. was recorded from the River Vesdre in the past and this species recently re-occurred there after the floods of 2021 (Verloove et al., submitted). Clement & Foster (1994) reported two additional species as wool aliens from the British Isles, the Australian *S. benthamiana* Domin and the palaetropical *S. bispinosa* (Jacq.) W.Wight. Probst (1949) reported *S. sesban* (L.) Merr., also a palaetropical species, from several localities in Central-Europe. However, given the taxonomic complexity of *Sesbania*, these identifications might require critical revision (Gross 2010).

In the autumn of 2021, a single young plant of *Sesbania* with flower buds was observed in Maastricht (Bosscherveld). Despite the young stage of the plant, it could be identified as *S. herbacea* because of the absence of appendages between the calyx teeth and the glabrous leaflets.

The discovery of this species shows that the River Meuse functions as an important introduction and dispersal route for non-native plants with potentially multiple introduction vectors. Theoretically, the species may have been imported with wool from northern South America in the past, but it was more likely imported more recently via another vector, perhaps with bird seed or oilseeds.

***Trifolium angustifolium* L.** — Fig. 6.

The native range of this species extends from the Mediterranean area to Iran. It is naturalized elsewhere in the warm-temperate

Fig. 6. *Trifolium angustifolium* L. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 9 May 2020.

regions of the world, including in large parts of Australia and South Africa. The species used to be a very characteristic wool alien (Clement & Foster 1994, Probst 1949). Wool was also the main introduction vector of this species in Belgium (Verloove 2006).

Trifolium angustifolium has repeatedly been collected in the Netherlands in the past. Almost all records came from clover fields fertilized with sumac or from nearby wool mills in Dordrecht, Helmond, and Tilburg (Kloos 1940, van Ooststroom & Reichgelt 1955). It is surprising that the species had not previously been seen along the Meuse.

A single plant of *Trifolium angustifolium* was first recorded in September 2012 in Boorsem. A few years later, in October 2019, a single plant was found in Grevenbicht (Elba) and another individual was found there again in 2020. In 2021, 2022, and 2023, several dozen individuals were seen in Grevenbicht (Elba), which were apparently offspring of the plants found in the previous years. In 2022 and 2023 a few plants were also observed in Maastricht (Bosscherveld).

Trifolium angustifolium was among the most common and typical wool aliens on the banks of the River Vesdre after the 2021 floods (Verloove et al., submitted).

***Trifolium cernuum* Brot.** — Fig. 7.

This species occurs naturally in southwestern Europe and northwestern Africa. It has naturalized in sheep farming areas such as Australia, South Africa, and India. It used to be a wool alien in the British Isles (Clement & Foster 1994). Before its discovery on the banks of the River Vesdre in 2022 (Verloove et al., submitted), it was not known from Belgium (Verloove 2006). Interestingly, *T. cernuum* was observed only once before in the Netherlands, near a wool mill in Tilburg (van Ooststroom & Reichgelt 1958c).

In 2020 and 2021 several flowering and fruiting individuals were recorded in Grevenbicht (Elba). In 2021, two individuals were also found in Maastricht (Bosscherveld).

***Trifolium glomeratum* L.** — Fig. 8.

The native range of this species extends from western Europe and the Mediterranean to Iran. It has often been recorded as a wool alien in Europe (Probst 1949). Many of the specimens preserved in the herbarium of Naturalis (L) were collected near wool mills or on the banks of the River Meuse (Kloos 1939, van Ooststroom & Reichgelt 1959, 1962a). Wool was the main introduction vector in Belgium as well (Verloove 2006).

Trifolium glomeratum was repeatedly observed on the banks of the River Meuse in the past years, at first in Meers in June 2018 (Gijs Kurstjens on waarneming.nl). In October 2019 and subsequently also in 2020, 2021, and 2022, several dozen flowering and fruiting plants were recorded in Grevenbicht (Elba). In the autumn of 2021, several dozen individuals were also seen in Maastricht (Bosscherveld) and Eijsden.

***Trifolium hirtum* All.** — Fig. 9.

The native range of this species extends from the Mediterranean area to Iran. It is naturalized elsewhere in the warm-temperate regions of the world, including in large parts of Australia. The species used to be a rather characteristic wool alien (Clement & Foster 1994). On the banks of the River Vesdre in Belgium, it was observed until 1971 (Verloove 2006), several years after the abandonment of the local textile industry.

In 2020, a single flowering individual was recorded in Grevenbicht (Elba). Several individuals were observed in Maastricht (Bosscherveld) in 2021 and 2022. The species had not been recorded before in the Netherlands.

***Trifolium incarnatum* L. subsp. *molinerii* (Hornem.) Ces.**

This taxon is probably of little taxonomic value, it merely is the wild progenitor of the widely cultivated subspecies (*T. incarnatum* subsp. *incarnatum*). Both taxa differ only in the color of the corollas, being whitish pink and dark red, respectively. Subsp. *incarnatum* is commonly sown in the Netherlands and Belgium and frequently occurs as an escape, also on the banks of the River Meuse, so that it is uncertain whether (some of) these finds can be linked to the wool industry. Subsp. *molinerii*, on the other hand, is a very rare alien.

Together with *Trifolium squarrosum* and *T. stellatum*, several individuals of subsp. *molinerii* were recorded in Maastricht (Kleine Weerd) in 2023 and 2024. Curiously, this taxon also recently reappeared along the River Vesdre in Belgium, in 2022 and, in particular, 2023. It was seen at multiple locations and in significant numbers (Verloove et al., submitted).

***Trifolium lappaceum* L.** — Fig. 10.

The native range of this species extends from the Mediterranean area to Central Asia and the Arabian Peninsula. It is locally naturalized elsewhere, including in parts of Australia. As an adventive, *Trifolium lappaceum* has been associated with cereals and wool (Clement & Foster 1994, Probst 1949, Verloove 2006). There are about 15 sheets in the herbarium of Naturalis (L), most of them are rather old. In the past, the species was apparently best known from sumac-fertilized clover fields near Apeldoorn. Interestingly, the species was already found on the banks of the River Meuse as early as the 1960s (van Ooststroom & Reichgelt 1962a).

In October 2019, a single flowering individual was recorded in Grevenbicht (Elba).

***Trifolium resupinatum* L.**

The native range of this species extends from the Mediterranean area to Nepal. It is a rather frequent alien that is introduced through multiple vectors, including wool (Clement & Foster 1994, Kloos 1939, Probst 1949, Verloove 2006).

Trifolium resupinatum is one of the species that already regularly appeared on the banks of the River Meuse before the recent massive works. It was already recorded in the 1950s (van Ooststroom & Reichgelt 1958b). In the past 15 years it was observed on the Belgian side of the river in Lanaken (Hochter Bampd) in 2010 and in Rotem (Bichterweerd) between 2011 and 2013. On the Dutch side of the river, the species was observed in Grevenbicht (Elba) and in Maastricht (Bosscherveld) between 2020 and 2023.

***Trifolium scabrum* L.**

This species is native to large parts of western and southern Europe, the Mediterranean area and its range extends eastwards to Iran. It is also native to Belgium and the Netherlands, but as such absent from the study area. Interestingly, *Trifolium scabrum* was found in the past near wool mills in Helmond and Tilburg (Kloos 1940, 1941).

Fig. 7. *Trifolium cernuum* Brot. in Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Filip Verloove, 10 October 2021.

Fig. 8. *Trifolium glomeratum* L. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 12 May 2021.

A single individual of this species was found in Maastricht (Bosscherveld) in 2021.

***Trifolium spumosum* L.** — Fig. 11.

The native range of this species extends from the Mediterranean area to Iran. Records as an alien are usually associated with cereals (Verloove 2006), less often with tan-bark and grass seeds (Clement & Foster 1994).

A single individual was observed in Maastricht (Bosscherveld) in October 2021. The species had not been recorded before in the Netherlands.

***Trifolium squarrosum* L.**

This species is native to the Mediterranean area and further extends to Mauritania in Africa. It is a rare alien, often with an unclear introduction vector. In Genk (Belgium), it was found on levelled soil – with dredging sludge from the River Scheldt – in 2019, along with other exceptional alien plants that could be associated with cereals, oilseeds, and possibly wool.

Two individuals of *Trifolium squarrosum* were found in Maastricht (Kleine Weerd) in June 2023, along with *T. incarnatum* subsp. *molinerii* and *T. stellatum*. The species has also recently been found sown and as a stowaway in a Mediterranean plant container, but our plants are probably the first found in the wild in the Netherlands.

***Trifolium stellatum* L.** — Fig. 12.

The native range of this species extends from the Mediterranean area to Iran. In the past, it was recorded as a wool alien in Switzerland (Probst 1949) and British records are also possibly related to wool imports (Clement & Foster 1994). The single Belgian record originates from the Vesdre Valley (Verloove 2006) and most likely also represents a wool alien.

Nearly 100 individuals of *Trifolium stellatum* were discovered in Maastricht (Kleine Weerd) in June 2023 and again in April 2024. The species had only been found for the first time in the Netherlands at a campsite in Petten (Province of Noord-Holland) in 2022 (waarneming.nl).

***Trifolium striatum* L.**

This is a native species in Belgium and the Netherlands, but it does not occur naturally on the banks of the River Meuse

in both Provinces of Limburg (although it is present on the nearby limestone slopes). *Trifolium striatum* was a frequent wool alien in the past (e.g., Probst 1949), also along the River Vesdre in Belgium (Visé 1958). The plants found along the River Meuse are not of native origin, which is also evident from the observed morphological deviation from native plants, in particular regarding the length of the calyx teeth. The same deviation was also seen on the banks of the River Vesdre in Belgium in 2022 and 2023.

Between 2019 and 2024, *Trifolium striatum* was repeatedly recorded in Grevenbicht (Elba) and Maastricht (Bosscherveld).

***Trifolium subterraneum* L.**

Like the previous species, *Trifolium subterraneum* is native to the Netherlands and Belgium, but it does not occur naturally in the study area. Recent records along the River Meuse can therefore likely be associated with the abandoned wool processing industry further upstream. The species was often found as a wool alien in the past (e.g., Probst 1949), also along the River Vesdre in Belgium (Visé 1958). According to herbarium material preserved in Naturalis in Leiden (L), Kloos recorded it several times near a wool mill in Tilburg from the 1930s to the 1950s.

In 2022, 2023, and 2024, several individuals were observed in Maastricht (Bosscherveld).

***Trifolium suffocatum* L.** — Fig. 13.

This species is native to southwestern Europe and the Mediterranean area. It was only very recently discovered in the Netherlands and Belgium, where it is locally naturalized in campsites (Verloove et al. 2020). Probst (1949) reported this species as a wool alien from Germany. In the British Isles, where it is native, it was also a very rare alien of wool shoddy (Pearman 2020).

About a dozen individuals were seen in Grevenbicht (Elba) in 2020 and 2021. A number of plants were also observed in Maastricht (Bosscherveld) in 2021, but only a single plant was found there in 2023. A single individual was found in Eijsden in 2021.

***Trifolium tomentosum* L.** — Fig. 14.

The native range of this species extends from the Mediterranean area to Iran and northeastern Africa. It is naturalized in, among others, Australia and South Africa. It is a rather characteristic wool alien that was previously also found as such in Belgium and the Netherlands. Van Ooststroom & Reichgelt (1958b, 1962a) and van Ooststroom & Mennema (1972) repeatedly found the species on the banks of the River Meuse and the species was formerly also found near wool mills, for instance in Tilburg (Kloos 1952).

In the past years, *Trifolium tomentosum* was regularly observed, mostly in Grevenbicht (Elba) and Maastricht (Bosscherveld) where a few dozen individuals were found between 2019 and 2023. In addition, the species was also occasionally seen elsewhere (Itteren, Oost-Maarland). Outside the study period, but nevertheless relatively recently, the species was also seen

Fig. 9. *Trifolium hirtum* All. in Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 13 May 2022.

Fig. 10. *Trifolium lappaceum* L. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 27 October 2019.

Fig. 11. *Trifolium spumosum* L. from Maastricht (Bosscherveld), Province of Limburg, the Netherlands, grown to maturity ex situ. Photo: Sipke Gonggrijp, 31 October 2021.

Fig. 12. *Trifolium stellatum* L. in Maastricht (Kleine Weerd), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 13 June October 2023.

in Boorsem on the Belgian side of the river in 1995 (obs. L. Andriessen & C. Nagels).

***Trigonella caelesyriaca* Boiss.** — Fig. 15.

This is a West Asian species with a native range from the East Mediterranean area to Iraq. It was observed as a wool alien in the British Isles (Clement & Foster 1994) and also in Belgium between 1954 and 1971 (Verloove 2006). At the end of the 1950s the species was found a few times along the River Meuse near Itteren (van Ooststroom & Reichgelt 1958c).

In 2011, a single flowering and fruiting individual was found on the gravel bank of the river in Boorsem. Similar vegetative plants, which may also belong to this species, were also observed in Maastricht (Bosscherveld) in 2021. The species has also recently reappeared along the River Vesdre in Belgium after the floods of 2021 (Verloove et al., submitted). Interestingly, also in the catchment basin of the River Meuse, two individuals were recorded in 2022 along the Berwijn Rivulet in Moelingen (Belgium), along with *Heliotropium europaeum*. The plants of the latter species also turned up after floods in the previous year.

Trigonella caelesyriaca has umbelliform inflorescences on long peduncles, deflexed fruiting pedicels and long, straight fruits that are longitudinally veined.

***Vicia bithynica* (L.) L.**

The native range of this species is from western Europe and the Mediterranean area to the Caucasus, Pakistan, and the Himalayas. The species has been found occasionally as an adventive plant in the Netherlands and Belgium for many years, especially as a cereal alien. Recently, it is also sometimes found in newly sown roadsides and plots.

A single individual was recorded in Grevenbicht (Elba) in April 2020. As far as we could tell, the species has not previously been associated with wool, so we are not entirely sure whether the find here can be considered a wool alien.

GERANIACEAE

***Erodium carolinianum* Aldasoro, Aedo, C.Navarro & L.Sáez** — Fig. 16.

[syn.: *E. cygnorum* Nees subsp. *glandulosum* Carolin]

This is an Australian endemic species (Alarcón et al. 2003, Carolin 1958). Although *Erodium carolinianum* is often reduced to subspecies rank under *E. cygnorum*, it is in fact readily separated from it (also from *E. crinitum*), based on its sepals with glandular hairs (which are missing from the sepals of the other two species).

Out of these three closely related species, *Erodium carolinianum* is by far the rarest as a wool alien: in Belgium, it was recorded only once in the past (in 1922; Verloove 2006) and

Fig. 13. *Trifolium suffocatum* L. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 12 May 2021.

it was probably not recorded before in the Netherlands. Some British records of *E. cygnorum* probably concern this species (Clement & Foster 1994).

In September 2021, a single flowering and fruiting individual was recorded in Maastricht (Bosscherveld). The species was recently also observed on the banks of the River Vesdre after the 2021 floods (Verloove et al., submitted).

***Erodium crinitum* Carolin** — Fig. 17.

This is an Australian endemic species (Alarcón et al. 2003, Carolin 1958). With its long-awned fruits, *Erodium crinitum* was particularly adapted to attach to wool and thus was among the most typical Australian wool aliens. It was frequently recorded as such in many parts of Europe (e.g., Bruggeman 1964, Clement & Foster 1994, Laine 1995, Lawalrée 1959, 1964, Probst 1949, van Ooststroom & Reichgelt 1963, Verloove 2006). The species has been recorded in livestock yards in New South Wales in Australia (Gray & Michael 1986).

In the past years, *Erodium crinitum* has repeatedly been observed on the banks of the River Meuse, at first in Grevenbicht (Elba) in 2019 when scattered non-flowering individuals were seen. In April 2020, at least nine individuals were found in the same locality, most of them flowering and even fruiting, despite the early season. In September and November of the same year, two additional individuals of *E. crinitum* were observed in Maastricht (Bosscherveld). In this locality, two non-flowering plants were seen in 2021. The species was apparently last seen in the Netherlands, also on the banks of the River Meuse, between 1955 and 1964. Previously, it had also been observed repeatedly between 1940 and 1954 near a wool and hide mill in Tilburg (Bruggeman 1964). After the floods of 2021, *E. crinitum* was among the most common wool aliens on the banks of the River Vesdre in Belgium as well (Verloove et al., submitted).

***Erodium stephanianum* Willd.**

This species is native to most of Asia, an area from where raw wool was much less frequently imported. Yet, the species is a well-known wool alien, for instance in Germany (Probst 1949), the British Isles (Lousley 1961), or the United States (Angelo & Boufford 2014). In Belgium, *Erodium stephanianum* was only known as a grain alien (Verloove 2006, Verloove & Vandenberghe 1998) before its recent rediscovery on the banks of the Vesdre in 2022 (Verloove et al., submitted).

In October 2021, a single non-flowering individual was observed in Maastricht (Bosscherveld). It was grown to maturity ex situ. *Erodium stephanianum* had previously been recorded in the Netherlands, including as a wool alien (Bruggeman 1964, van Ooststroom & Mennema 1972).

Fig. 14. *Trifolium tomentosum* L. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 12 May 2021.

***Geranium divaricatum* Ehrh.**

This species is native to large parts of Eurasia, except the western- and easternmost parts. It is quite often observed as an adventive, both inside and outside its natural range. In the Netherlands and Belgium, the species has mainly been observed near flour mills; observations as a wool alien seem to be missing, also from elsewhere in Europe, which means that it is not entirely certain that our find can be qualified as such.

In 2011, a single flowering individual of *Geranium divaricatum* was recorded in Boorsem.

***Monsonia brevirostrata* R.Knuth** — Fig. 18.

This species has a limited distribution in South Africa (Free State, KwaZulu-Natal, and the Northern Provinces) and Lesotho (Venter 1979). Nonetheless, it is a fairly typical wool alien that has been recorded in the past in various European countries, for instance in the British Isles (Lousley 1961), but also in Belgium (Lawalrée 1950, 1959, 1964, 1980) and the Netherlands (Kloos 1952). A plant of '*Erodium malacoides*' from wool waste, depicted by Kloos (1939), in fact belongs to *Monsonia brevirostrata*, which may represents the first Dutch record of this species.

A single young specimen of *Monsonia brevirostrata*, with flower buds, was observed in Maastricht (Bosscherveld) in September 2021. The species was also recorded again along the River Vesdre after the recent floods (Verloove et al., submitted).

LAMIACEAE

***Dracocephalum parviflorum* Nutt.**

This species naturally occurs in North America and is probably nowhere else in the world genuinely naturalized. *Dracocephalum parviflorum* is a rather regular but ephemeral adventive in Europe, including in Belgium and the Netherlands. It is usually associated with cereals but has also been recorded as a wool alien in the past, in the British Isles as well as in Belgium (Clement & Foster 1994, Verloove 2006). This is rather unexpected since hardly any wool was imported from North America.

In June 2016, a flowering individual was observed in Stokkem on the Belgian side of the river. In October 2019, a few rosettes were observed in Grevenbicht (Elba). In the same locality a rosette was also found in April 2020. One plant was grown ex situ to maturity to confirm its identity. *Dracocephalum parviflorum* is known for its very hard, long-lasting seeds (Clement 1977, Verloove & Heyneman 2012). In the Netherlands, the species

Fig. 15. *Trigonella caelesyriaca* Boiss. in Boorsem, Province of Limburg, Belgium. Photo: Ward Vercruysse, 9 September 2011.

Fig. 16. *Erodium carolinianum* Aldasoro, Aedo, C.Navarro & L.Sáez in Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 13 September 2021.

was regularly found in the past, almost always associated with imported cereals and animal feed.

MALVACEAE

***Abutilon theophrasti* Medik.**

This species, with a native range from Central Asia to China, is widely naturalized in, among others, Europe, North America, and Australia. It is known as a wool alien in, e.g., the British Isles and Central Europe (Clement & Foster 1994, Probst 1949). However, in Belgium, the species had only been associated with cereals and oilseeds (Verloove 2006) and never with wool waste. In the Netherlands, on the contrary, *Abutilon theophrasti* has been recorded more frequently, including on the banks of the River Meuse, presumably as a wool alien (van Ooststroom & Reichgelt 1962a, 1968).

Abutilon theophrasti is naturalized in beet fields in the Netherlands, also in the Meuse Valley. The species has occasionally been recorded on the exposed river banks as well. It has also reappeared on the recently excavated banks and these records may be more likely related to the former wool processing industry upstream. In September 2020, a few plants of *A. theophrasti* were recorded in Maastricht (Bosscherveld), including flowering and fruiting individuals. In 2011, the species was also observed on gravel piles in Boorsem and, still in Belgium, the species also re-appeared on the banks of the River Vesdre after the recent floods, along with several other, mainly Australian species from this genus (Verloove et al., submitted).

***Anoda cristata* (L.) Schltdl.**

This species from South and Central America and the southern United States is naturalized in parts of Asia and Australia; it could thus have been introduced with wool from its native range in South America, or from its secondary range in Australia. Interestingly, in the past, *Anoda cristata* had not been recorded before in Belgium or the Netherlands as a wool alien, but it had invariably been associated with cereals (Verloove 2006). Elsewhere in Europe, however, for example in the British Isles, Germany and Sweden, the species has been recorded in the past as a wool alien (Clement & Foster 1994, Probst 1949).

In October 2021, two non-flowering individuals were seen in Maastricht (Bosscherveld). The species also appeared on the banks of the River Vesdre after the recent floods (Verloove et al., submitted).

***Hibiscus trionum* L.**

Hibiscus trionum used to be a rather characteristic wool alien in Europe, but in Belgium and the Netherlands it was only rarely observed as such (e.g., Kloos 1939, Visé 1942, 1958). In both countries, the species is usually associated with cereals and oilseeds (Jansen & Muller 1963).

Fig. 17. *Erodium crinitum* Carolin Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Filip Verloove, 15 September 2020.

In 2019, scattered flowering and fruiting plants were observed in Grevenbicht (Elba). In 2020, an additional individual was seen in Maastricht (Bosscherweg) (Jan Klinckenberg on waarneming.nl).

Craven et al. (2011) threw new light on the identity of members of the *Hibiscus trionum* complex in Australasia. For instance, *H. verdcourtii* Craven was newly described as an Australian endemic species; it is common and widespread across northern Australia and is extending its range southwards in eastern Australia. A second species, *H. tridactylites* Lindl., was brought to the attention again; like the preceding species, it is common and widespread, especially in eastern and southern Australia (it has probably been dispersed over a wider area from its native range in Australia as a result of movement of agricultural machinery and livestock). Both species were recently found on the banks of the River Vesdre (Verloove et al., submitted) and therefore appear to occur as a contaminant in Australian wool. However, the plants recently observed along the River Meuse all seem to pertain to *H. trionum* s.str. The latter species itself is also morphologically very variable, especially when it comes to leaf shape. Kloos (1939) had already noticed (and illustrated) this variation.

***Malope trifida* Cav.** — Fig. 19.

This western Mediterranean species was in the past only exceptionally reported as a wool alien from Switzerland (Probst 1949) and the British Isles (Ryves 1976–1977). In Belgium and the Netherlands, it is a rare casual garden escape.

In October 2020, a single flowering individual was observed in Grevenbicht (Elba), possibly as a wool alien.

***Malva multiflora* (Cav.) Soldano, Banfi & Galasso**

[syn.: *Malva pseudolavatera* Webb & Berthel.
Lavatera cretica L.]

This Mediterranean species is recently increasing in western Europe and seems to be in the process of local naturalization. It is not always clear via which vectors the species has been introduced, but the introduction has mostly been associated with cereals (Kloos 1932, Verloove 2006). At least in Central Europe, however, the species was also introduced with wool (Probst 1949).

A single flowering and fruiting specimen was observed in Maastricht (Bosscherveld) in 2022, possibly as a wool alien.

Fig. 18. *Monsonia brevirostrata* R.Knuth in Maastricht (Bosscherveld), Province of Limburg, the Netherlands. Photo: Rutger Barendse, 10 October 2021.

***Malva olbia* (L.) Alef.** —

[syn.: *Lavatera olbia* L.]

This western Mediterranean species, occurring both in Europe and North Africa, apparently has not been associated before with wool importation.

A single non-flowering individual that was discovered in 2020 in Grevenbicht (Elba) was grown to maturity ex situ. As the species is also grown as an ornamental, it is not entirely certain that it is a wool alien.

***Malva parviflora* L.**

This species is a common weed in the Mediterranean area, extending eastwards to Pakistan and southwards to the Sahara. The species is imported through various sources, including grain and wool (Verloove 2006). It had previously been recorded from the banks of the River Meuse (van Ooststroom & Reichgelt 1962a).

Several flowering and fruit-bearing individuals were recorded in Grevenbicht (Elba) in the autumn of 2019 and in 2020. In 2021, it was furthermore observed in Maastricht (Bosscherveld). In 2011, *Malva parviflora* was already observed on gravel piles in Boorsem.

***Malva punctata* (All.) Alef.** — Fig. 20.

[syn.: *Lavatera punctata* All.]

The native range of this species extends from the Mediterranean to Turkmenistan. It is a very rare alien in the Netherlands, where the species was collected more than a century ago in a clover field in Apeldoorn, and Belgium. The few Belgian records are mostly recent and of uncertain origin. In the British Isles, *Malva punctata* was formerly reported as an exceptional wool alien.

In the summer of 2020, two individuals were observed in Grevenbicht (Elba).

***Malva pusilla* Sm.**

This species is native to large parts of Eurasia, but is an alien in the Netherlands and Belgium. It is a frequent adventive and is introduced through multiple vectors, including cereals and wool (Clement & Foster 1994, Probst 1949, Verloove 2006). Of the almost 200 Dutch collections kept in the herbarium of Naturalis (L), none, however, seems to be unambiguously linked to wool importation (most collections are from nearby mills, manure piles, etc.).

In 2011, *Malva pusilla* was observed on gravel piles in Boorsem and in 2019 and 2020 in Grevenbicht (Elba).

Fig. 19. *Malope trifida* Cav. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 16 October 2020.

Fig. 20. *Malva punctata* (All.) Alef. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 3 July 2020.

***Malva setigera* K.F.Schimp. & Spenn.**

[syn.: *Althaea hirsuta* L.]

As a native of Central Europe, the Mediterranean and West Asia, this species is a fairly frequent alien that is usually introduced with cereals, sometimes also with wool (Probst 1949).

From time to time, *Malva setigera* has been observed on the gravel banks of the River Meuse on both sides of the river. On the Belgian side, two individuals were seen in Dilsen-Stokkem (Negenoord-Kerkeweerd) in June 2010. On the Dutch side of the river, a few plants were observed in Grevenbicht (Elba) in 2020 and 2021, in Maastricht (Bosscherveld) in 2021 and 2022, and in Grevenbicht (Koeweide) in 2024.

***Malva trimestris* (L.) Salisb.**

[syn.: *Lavatera trimestris* L.]

This Mediterranean species is frequently grown as an ornamental and often escapes from cultivation. In addition, it is sometimes accidentally introduced as a weed. As such, it has been associated with wool imports in the British Isles (Clement & Foster 1994).

In the past two decades, *M. trimestris* has occasionally been observed on the banks of the River Meuse, although the exact introduction vector is not always clear. Records are available from Maastricht (Kleine Weerd, 2016), Grevenbicht (Elba, 2020), and Itteren (2022), all on the Dutch side of the river.

***Malva verticillata* L.**

This species is primarily distributed in Asia, but frequently occurs as an alien elsewhere in the world. It is usually associated with cereals, but also with wool (Clement & Foster 1994). Previous Dutch and Belgian records, however, were from various sources, mostly cereals and oilseeds, but not from wool (Verloove 2006).

Malva verticillata was seen in Grevenbicht (Elba) in 2019, possibly as a wool alien.

***Malvastrum americanum* (L.) Torr.** — Fig. 21.

Malvastrum americanum (var. *americanum*) originates from the southern United States, Central America, and South America. It is commonly naturalized in most of Australia, where the wool alien plant material might have come from.

The mericarps of this species, contrary to those of *Malvastrum coromandelianum*, are unornamented. Nevertheless, the species

Fig. 21. *Malvastrum americanum* (L.) Torr. in Boorsem, Province of Limburg, Belgium. Photo: Rutger Barendse, 14 October 2011.

Fig. 22. *Malvastrum coromandelianum* (L.) Garcke from Grevenbicht (Elba), Province of Limburg, the Netherlands, grown to maturity ex situ. Photo: Sipke Gonggrijp, 9 November 2019.

has been found in livestock yards in New South Wales in Australia (Gray & Michael 1986) and it was frequently recorded as a wool alien in Europe in the past (usually as *M. spicatum* A.Gray, a heterotypic synonym), for instance in the British Isles (Lousley 1961), France, Germany, and Switzerland (Bonte 1937, Issler 1934, Probst 1949). From Belgium, it was never recorded in the past (Visé 1942, 1958), but Verloove (1998) identified an unidentified Malvaceae specimen, that was collected as a wool alien in the Vesdre Valley in Goë (Province of Liège) in 1892, as *M. americanum*. More recently, in 2005, the species was also seen in a vegetable garden in Slins (near Liège), possibly from discarded birdseed waste.

In 2011, *Malvastrum americanum* was observed on gravel piles next to the River Meuse in Boorsem. In the autumn of 2019, several individuals were recorded on the exposed sandy river bank in Grevenbicht (Elba), some of them reaching the flowering stage. A few seedlings were seen in the same locality in 2020. The species had not been recorded before in the Netherlands.

***Malvastrum coromandelianum* (L.) Garcke** — Fig. 22.

Malvastrum coromandelianum has a similar native distribution as *M. americanum*, but, in addition to Australia, it is also naturalized in Africa and Asia. Although it has mericarps that are ornamented with spiny cusps, it is much less frequently observed as a wool alien, perhaps only in the British Isles (Lousley 1961) and the United States (Angelo & Boufford 2013). It was only relatively recently recorded for the first time from Belgium (Verloove 1998) and most records are associated with bird seeds or soybeans. In the Netherlands, it has occasionally been recorded in the past, but it was never associated with wool waste (e.g., Mennema & van Ooststroom 1975). The species has also recently been found as a weed in lily fields (Reijerse & Verrijdt 2010).

In October 2019, a single flowering individual was observed in Grevenbicht (Elba), most likely as a wool alien.

***Sida acuta* Burm.f.** — Fig. 23.

This species is widely distributed throughout the (sub-)tropics, including Australia (except the westernmost parts), South America, and large parts of Africa. As far as we know, it has not previously been associated with wool importation, nor has it been reported before as an adventive in Europe.

Sida acuta belongs to the well-defined section *Distichifoliae* (Monteiro) Krapovickas: its leaves are distichously arranged and the stipules are dimorphic (one linear, the other much wider). It is part of a complex group of several, closely related species (Krapovickas 2003).

A young plant that was found in Maastricht (Bosscherveld) in October 2021 was raised to maturity ex situ. The glabrous plant ultimately turned out to have fruits with 5–6 mericarps, typical characters of *Sida acuta* s.str. Identical plants were recently also observed on the banks of the River Vesdre in Belgium in 2022 (Verloove et al., submitted).

Fig. 23. *Sida acuta* Burm.f. from Maastricht (Bosscherveld), Province of Limburg, the Netherlands, grown to maturity ex situ. Photo: Sipke Gonggrijp, 8 January 2022.

***Sida cordifolia* L.**

This is a common weed throughout the (sub-)tropics, including South America and South Africa. It is less widespread in Australia, where it is mostly found in Queensland, Northern Territories, and Western Australia (Barker 1998). Despite being weedy, it was only exceptionally associated with imported wool in the past, for instance in the British Isles (Lousley 1961, Ryves 1976–1977). The mericarps have retrorsely barbed apical spines, so that they doubtlessly easily adhere to grazing sheep. However, until recently, when the species was found on the banks of the River Vesdre after the floods (Verloove et al., submitted), it had not been reported from Belgium. In 2006, the species was found for the first time in the Netherlands in a lily field (Reijerse & Verrijdt 2010).

Sida cordifolia is easily recognized by the broadly ovate leaves, the apically crowded flowers and 10–12 mericarps per fruit with retrorsely barbed spines.

A seedling was observed in Maastricht (Bosscherveld) in October 2021. Fruitless attempts were made to cultivate the plant ex situ.

***Sida rohlenae* Domin**

This is an endemic Australian species that, to our knowledge, has only once been recorded before outside of Australia: it was collected in 1957 on waste ground around the Wellman Wool Combing Mill, north of Johnsonville in South Carolina, United States (*H.E. Ahles 38155* in NCU; initially identified as *S. lindheimeri* Engelm. & Gray, corrected in 1999 by S.J. Siedo). This was one of the very few localities from where wool aliens have been documented in North America (e.g., Nesom 2004). *Sida rohlenae* – at least var. *rohlenae* – is characterized by mericarps with retrorsely barbed apical spines that easily adhere to grazing sheep (Barker 1998, Fryxell 1987). It has a velvety, appressed indumentum as a result of which the plant is often greyish-white in appearance.

Sida rohlenae occurs in the wool farming areas of Queensland and the area where the type came from (Jericho) was an early exporter of wool (comm. R. Barker, 2022). After the floods of 2021, this species was regularly observed in multiple localities in the Vesdre Valley in Belgium (Verloove et al., submitted). In 2019 and 2021, scattered young plants were recorded alongside the River Meuse as well, in Grevenbicht (Elba) and Maastricht (Bosscherveld). In the latter locality, another young individual was observed in September 2024.

***Sida sivarajanii* Tambde, Sardesai & A.K.Pandey** — Fig. 24 & 25.

This species was recently described from the Aurangabad District in Maharashtra, India (Tambde et al. 2020), and was subsequently also recorded from other regions in this state and the adjacent state of Telangana (Deshmukh Umakant et al. 2020, Swamy & Rasingam 2021). It is considered to be endemic to India.

Based on most morphological characters, *Sida sivarajanii*

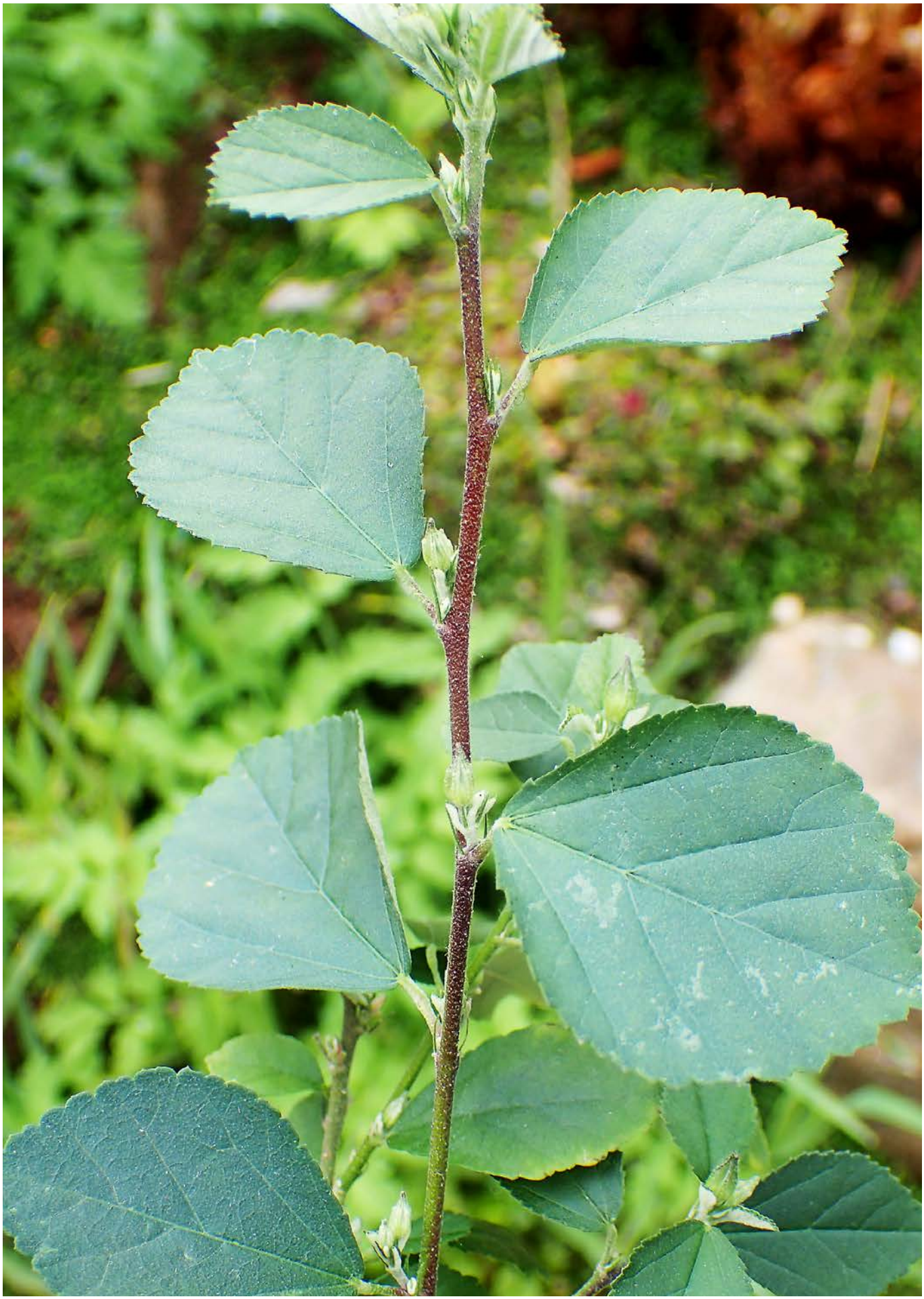

Fig. 24. Typical leaves of *Sida sivarajanii* Tambde, Sardesai & A.K.Pandey from Maastricht (Bosscherveld), Province of Limburg, the Netherlands, grown to maturity ex situ. Photo: Sipke Gonggrijp, 22 April 2023.

Fig. 25. The plant of *Sida sivarajanii* Tambde, Sardesai & A.K.Pandey from Maastricht (Bosscherveld), Province of Limburg, the Netherlands, grown to maturity ex situ. Photo: Sipke Gonggrijp, 22 April 2023.

obviously belongs to the *S. rhombifolia* complex. It is most reminiscent of segregates such as *S. alnifolia* L., *S. retusa* L. and *S. rhomboidea* Roxb., especially on behalf of its almost orbicular juvenile leaves with a broadly obtuse apex. However, *S. sivarajanii* clearly differs from *S. rhombifolia* and its relatives in mericarp (and style) number: 5 versus 7–12, a diagnostic feature which was previously not recorded for sect. *Sidae* (Fryxell 1985). Other noteworthy characters, not encountered in other members of the complex, are the stellate hairy, conical ovaries and the dehiscent mericarps. ITS sequence data confirmed the distinctness of *S. sivarajanii*, as sister to *S. alnifolia* (Tambde et al. 2020).

In October 2021, a single seedling was recorded in Maastricht (Bosscherveld). It was raised to maturity ex situ; flower and fruit characters were exactly in line with those described by Tambde et al. (2020) for *Sida sivarajanii*. Plants observed on the banks of the River Vesdre in Belgium in 2022 also turned out to belong to this species: genetically they turned out to be identical to the recently described plants from India (Verloove et al., submitted).

Although most wool was imported from Australia, South Africa, and South America, Visé (1942) also mentioned India as one of the areas of origin of the imported wool in the Vesdre Valley. This was also confirmed by Mr. Mathieu Schmetz, a retired worker from the local wool industry. For example, precious products such as angora were occasionally imported from the Himalayas (pers. comm. Mr. Mathieu Schmetz, May 2023).

***Sida spinosa* L.**

As a pantropical weed, this species occurs throughout many parts of South America and South Africa. In Australia it is limited to northern Australia (Barker 1998). As a wool alien, it has been reported (rarely) from Germany (Probst 1949), the British Isles (Ryves 1976–1977), and the United States (Angelo & Boufford 2013). In Belgium, it was first recorded in 1976, and therefore never as a wool alien. All Belgian records are associated with fodder, cereals, and soybeans (e.g., Sotiaux et al. 1981). The same applies to the Netherlands, where the species has been known since 1980 and is additionally also occasionally found as a weed in lily fields (Reijerse & Verrijdt 2010).

A few plants of *Sida spinosa* were found in Grevenbicht (Elba) in 2019.

***Sphaeralcea purpurata* (Lindl.) Krapov.** — Fig. 26, 27 & 28.

[syn.: *Malvastrum campanulatum* (Paxton) G.Nicholson]

This species naturally occurs in lowlands in a relatively small area in South America that covers parts of Central and southern Chile (Marticorena 2005) and Argentina (Provinces of Buenos Aires and Río Negro; Krapovickas 1949). It is not particularly common in its native range: it is ‘vulnerable’ in Buenos Aires (Delucchi 2006). It was once recorded, as a casual alien (probably

Fig. 26. Habit of *Sphaeralcea purpurata* (Lindl.) Krapov. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 12 May 2021.

Fig. 27. Flower buds of *Sphaeralcea purpurata* (Lindl.) Krapov. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 12 May 2021.

an escape from cultivation), in the British Isles (Clement & Foster 1994; as *Malvastrum campanulatum*). Up to now, the species apparently has not been recorded elsewhere outside of its native distribution range (GBIF).

A flowering individual of *Sphaeralcea purpurata* was discovered in May 2021 in Grevenbicht (Elba). Interestingly, in 2022, the species was also found on the banks of the River Vesdre in Goffontaine (Province of Liège) in Belgium (Verloove et al., submitted).

The systematic position and generic classification of *Sphaeralcea purpurata* has long been unclear. On behalf of its procumbent stems and palmately divided leaves, it is more reminiscent of certain species of *Tarasa* Phil., in particular *T. tenella*, another South American species that was recorded in the same locality in 2019 (see below). It differs from that species, however, by its much larger, pedicelled flowers and by the two-parted mericarps with a small, smooth and dehiscent apical portion and a reticulate and indehiscent distal portion.

***Tarasa tenella* (Cav.) Krapov.** — Fig. 29 & 30.

[syn.: *Malvastrum multicaule* Britton]

This species is native to South America where it naturally occurs in the Andes in Argentina, Bolivia, Chile, and Peru. Single plants of this species were formerly recorded from wool waste in Blackmoor and Maulden in the British Isles (Ryves 1976–1977, as *Malvastrum multicaule*). Otherwise, and except for our find, the species may never have been found outside its native range (GBIF).

In October 2019, a single individual with flower buds was found in Grevenbicht (Elba). It was raised to maturity ex situ, which allowed for accurate identification.

Fig. 28. Flowers of *Sphaeralcea purpurata* (Lindl.) Krapov. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Rien Ondersteyn, 12 May 2021.

PLANTAGINACEAE

***Plantago afra* L.** and ***P. indica* L.**

[syn. of *Plantago indica* L.: *Plantago arenaria* Waldst. & Kit.]

Plantago afra naturally occurs in the Mediterranean area, extending eastwards to Pakistan, and from the Arabian Peninsula Sahara to Tanzania. Alien records are usually associated with cereals (Kimstra-Sinnema 1965), but the species was formerly also found on the banks of the River Meuse in the Netherlands where it might have been introduced through the wool processing industry in Belgium further upstream (van Ooststroom & Reichgelt 1958b). Single individuals of *P. afra* were observed in 2020 and 2021 in Maastricht (Bosscherveld). The species also reappeared in 2023 along the River Vesdre in Belgium (Verloove et al., submitted). Surprisingly, elsewhere in Europe *P. afra* seems not to have been recorded as a wool alien (Clement & Foster 1994, Probst 1949).

More numerous plants of the similar *Plantago indica*, a Eurasian and Mediterranean weed, were observed in Maastricht (Bosscherveld) in 2020 and 2021. In the past, this species was regularly recorded as a wool alien, for instance in the British Isles (Clement & Foster 1994), but also in Belgium (Verloove 2006) and the Netherlands, including on the banks of the River Meuse (van Ooststroom & Reichgelt 1958b). According to Pinckaers (1985), *P. indica* is considered naturalized in the Meuse Valley.

SOLANACEAE

***Nicotiana glauca* Graham** — Fig. 31.

The native range of this species extends from Bolivia to Brazil and southern South America. It is widely naturalized and often quite invasive in other warm-temperate and subtropical regions across the world, including in South Africa and Australia. As a wool alien, *Nicotiana glauca* has been observed repeatedly in the past in the British Isles (Clement & Foster 1994), Germany, France, and Switzerland (Probst 1949).

In September 2011 a single non-flowering individual was observed on gravel piles in Boorsem.

This species has large, glaucous and glabrous leaves, which allows its identification, even in the absence of flowers or fruits.

DISCUSSION

After major changes in the landscape, respectively, the redevelopment of the valley and a devastating flood, numerous exotic plants that were once introduced as contaminants in wool recently germinated from the long-lived seed bank along both the Rivers Meuse and Vesdre. Details from the Vesdre Valley are discussed elsewhere (Verloove et al., submitted). Although the introduction pathways are identical in both cases, there are striking differences in the species composition, both in terms of the geographical origin of the species encountered and their taxonomic pattern. Evidently, approximately the same plant families were found in both river valleys, i.e., exclusively

Fig. 29. Basal leaves of *Tarasa tenella* (Cav.) Krapov. in Grevenbicht (Elba), Province of Limburg, the Netherlands. Photo: Sipke Gonggrijp, 18 October 2019.

Fig. 30. A flower of *Tarasa tenella* (Cav.) Krapov. from Grevenbicht (Elba), Province of Limburg, the Netherlands, grown to maturity ex situ. Photo: Sipke Gonggrijp, 20 October 2019.

taxa from (the relatively few) families that are known to have very hard and long-persisting seeds. However, while along the River Vesdre an astonishing majority of the observed taxa belonged to the Malvaceae, this predominance was much less pronounced along the River Meuse, where the Fabaceae accounted for most of the taxa (27), followed by the Malvaceae (21 taxa). Only a few taxa were recorded from six other families: Geraniaceae (5 taxa), Plantaginaceae (2), Boraginaceae (1), Convolvulaceae (1), Lamiaceae (1), and Solanaceae (1). The great diversity of *Trifolium* (clover) species (15 taxa) was remarkable and includes several species that had never been observed before in the Netherlands. Regarding the geographic origin, the clear over-representation of species native to Australia, the main source of the imported wool, as observed along the River Vesdre, was not seen along the River Meuse, where relatively few Australian species were found, with the exception of *Juncus* species. Alien *Juncus* species were surprisingly better represented along the River Meuse than along the River Vesdre.

From our list, only a few species were undoubtedly imported from Australia, because they are endemic there and are not established anywhere else in the world (e.g., *Cullen cinereum*, *Erodium carolinianum* and *Sida rohlenae*). It should be noted, however, that many of the recorded species that are native to the Mediterranean area have also become naturalized, and are often even invasive, in other parts of the world with a similar climate, such as South Africa and (parts of) South America and Australia. Such species could therefore just as well have been imported from there with wool, even though they do not occur there naturally. This is also evident from a list of weed species found on livestock farms in New South Wales, Australia (Gray & Michael 1986): a large proportion of the Mediterranean species we found on the banks of the River Meuse were also found there. The small number of species from South Africa, the second most important source of the wool, along the River Meuse is also remarkable: only a single species (*Monsonia brevirostrata*) was without doubt introduced from there, whereas South African taxa accounted for the second most species-rich group along the River Vesdre. These differences between the two river valleys are noticeable, because the species actually germinated from the same seedbank, albeit that the sites along the River Meuse are located approximately 50 km downstream from those along the River Vesdre.

The wool aliens observed along the River Meuse in the 1950–1970s also came from all parts of the world, including Australia and South Africa, but then, just like now, species from these regions did not dominate. It is striking that also in the past there was no close resemblance in floristic composition between the wool alien floras of the Rivers Meuse and Vesdre,

Fig. 31. The plant of *Nicotiana glauca* Graham in Boorsem, Province of Limburg, Belgium. Photo: Photo: Filip Verloove, 9 October 2011.

even though all species originated from the same sources. Van Ooststroom & Reichgelt (1958c, 1961c, 1962b, 1968) and van Ooststroom & Mennema (1972) regularly found species on the banks of the River Meuse that had never been observed along the River Vesdre, nor elsewhere in Belgium (e.g., *Chenopodium nitrariaceum* (F. Muell.) F.Muell. ex Benth., *Cyperus dactyliformis* Boeckeler, *Didesmus bipinnatus* (Desf.) DC., *Eremopyrum triticeum* (Gaertn.) Nevski, *Monsonia biflora* DC., *Oncosiphon intermedius* (Hutch.) Källersjö, etc.; nomenclature updated by the authors), although this can partly be explained by the fact that when their fieldwork was mainly done the attention for wool aliens in the Vesdre Valley was possibly already decreasing. However, also in recent years we have observed species on the banks of the River Meuse that have never been found in Belgium, not even after the recent floods in the Vesdre Valley (e.g., *Tarasa tenella*).

The discovery of the Indian endemic *Sida sivarajanii* is very remarkable, also because the species was only recently described as a new species – and was therefore unknown to science when it was imported with wool long ago. This species was found along both the Rivers Meuse and Vesdre and must have been imported from India, an area from which wool was indeed introduced in the past (Visé 1942).

Although the Meuse Valley was excavated over a distance of several dozen kilometers, large concentrations of wool aliens were only found at a (very) limited number of locations. Curiously, the numerous adventive rushes (*Juncus* species) were found at different locations than the remaining aliens, almost without overlap. Only a few exotic rushes were observed in the Bosscherveld. Most rushes evidently have different ecological needs, but this can only be a partial explanation, as exotic rushes were also found in places that would perfectly suit other wool aliens (and vice versa). The underlying reason remains unclear.

As could be expected many taxa in our list are susceptible to zoochory. They either have needle-like fruits (e.g., *Erodium* or *Monsonia*), fruits or mericarps bearing spines, often barbed or with hooked apices (e.g., *Medicago* or *Sida*), bristly or spiny fruiting heads (e.g., *Trifolium*) or mucilaginous seeds (*Juncus*). In some cases, however, it is much less clear why exactly these species were introduced as contaminants in raw wool. Hayward & Druce (1919) suggested that species without 'armature' relied upon the easily dehiscent fruit and the smallness and abundance of their seeds which readily adhere to the greasy wool. An additional, less obvious but undoubtedly important explanation was provided by Stace & Crawley (2015). Seeds from pasture plants grazed by the sheep also ended up in the raw wool via the dried dung, which stuck to it. This explains why epizoochory played only a partial role; seeds from species that were favored by the sheep but that had no special adaptations for dispersal were also introduced as contaminants, provided that they remained undigested after grazing.

There is little doubt about the fate of the recently germinated exotic plants: although due to global warming climatic conditions are now more favorable than when the species were introduced with wool 50–150 years ago, it is unlikely that some of these wool aliens will naturalize along the Rivers Meuse and Vesdre. Even species from warm-temperate regions (e.g., the Mediterranean) appear to persist only for a short time at most. Some clovers and other legumes appear to be able to survive for a few years, but will undoubtedly disappear again soon. At best, their seeds will someday germinate again, when conditions are favorable. Only some perennial *Juncus* species, mostly from Australia and New Zealand, have survived for almost ten years by now (Verloove et al., submitted).

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