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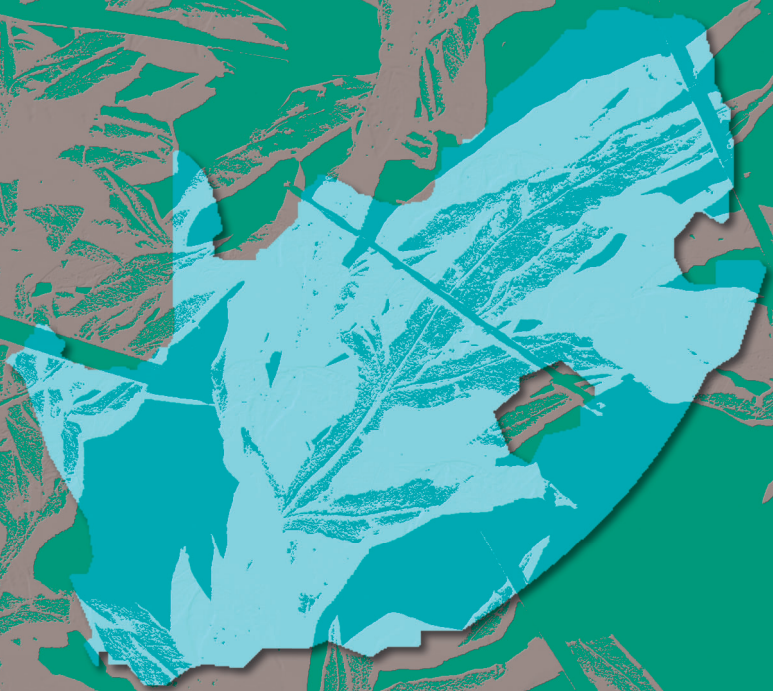

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ABSTRACT
The Eurasian species *Artemisia vulgaris* L. has been reported from the Eastern Cape Province (Stutterheim District) in South Africa since at least half a century. However, examination of relevant herbarium specimens has demonstrated that the South African plant material belongs to a morphologically similar East Asian species, *A. verlotiorum*. It is included in the South African Alien and Invasive Species Lists as a prohibited species absent in the country. However, judging from available data, in South Africa it has become a locally naturalised weed of cultivated land and apparently is difficult to eradicate. *A. verlotiorum* indeed is a pernicious weed in many regions of the world, appearing to be much more invasive than *A. vulgaris*, especially in warm-temperate and subtropical climates. Characteristics useful for distinguishing these two species are provided.

KEY WORDS
Alien species,
Artemisia,
invasive species,
South Africa.

RÉSUMÉ
Artemisia verlotiorum *Lamotte (Anthemideae, Asteraceae), espèce envahissante incluse dans la liste sud-africaine des plantes interdites, est déjà présente en Afrique du Sud.*
L'espèce eurasiatique *Artemisia vulgaris* L. a été signalée dans la province du Cap oriental (district de Stutterheim) en Afrique du Sud depuis au moins un demi-siècle. Or, l'examen de spécimens d'herbiers a démontré que le matériel sud-africain appartient à une espèce morphologiquement similaire d'Asie de l'Est, *A. verlotiorum*. Cette dernière espèce est incluse dans les listes des espèces exotiques et envahissantes d'Afrique du Sud en tant qu'espèce interdite absente du pays. Cependant, d'après les données disponibles, elle est bien présente en Afrique du Sud. En plus, elle est devenue une mauvaise herbe localement naturalisée des terres cultivées et est apparemment difficile à éradiquer. *A. verlotiorum* est en effet une mauvaise herbe pernicieuse dans de nombreuses régions du monde, semblant être beaucoup plus envahissante que *A. vulgaris*, en particulier dans les climats chauds-tempérés et subtropicaux. Des caractéristiques utiles pour distinguer ces deux espèces sont fournies.

MOTS CLÉS
Espèces exotiques,
Artemisia,
espèces envahissantes,
Afrique du Sud.

INTRODUCTION

Artemisia vulgaris L. is the nomenclatural type ("lectotype" in the sense of Art. 10.1, Note 1 of the ICN: Turland *et al.* 2018) of the genus *Artemisia* L. (Asteraceae), designated by Britton & Brown (1913) and confirmed by Green (in Hitchcock & Green 1929: 180); regarding the generic types initially designated under the *American Code* (Arthur *et al.* 1907), including those designated by Britton & Brown (1913), see McNeill *et al.* (2016a, 2016b) and Art. 10.6–10.7 of the ICN (Turland *et al.* 2018). In turn, Gabrielian & Chandjian (1986: 206) designated the Linnaean specimen LINN 988.41 as the lectotype of the name *A. vulgaris*.

Artemisia vulgaris is a common and widely distributed species in large parts of cold-temperate Eurasia (Tutin *et al.* 1976; Polyakov 1961, 1995; Ling *et al.* 2011; etc.). Elsewhere, especially (but not exclusively) in the northern hemisphere, for instance in North America (Shultz 2006), it is a commonly introduced and naturalised species. However, the name *A. vulgaris* has also been frequently misapplied to many other members of *Artemisia* section *Artemisia* (the group often referred to as "the *Artemisia vulgaris* complex"). Several weedy lookalikes of it, for instance, *A. verlotiorum* Lamotte (see Brenan 1950; Mosyakin *et al.* 2019, and references therein), *A. umbrosa* (Turcz. ex Besser) Turcz. ex Verlot (see Mosyakin *et al.* 2018), *A. princeps* Pamp. (see Verloove & Andeweg 2020), now occurring in Europe and in some other regions of the world but originally native to East Asia (Ling *et al.* 2011), have been overlooked for quite a long time. In the past decades, as a result of a better understanding of these species, particularly in Europe, all three species (as well as some other but yet rarer alien congeners) were increasingly recorded, especially the former; for the relevant recent publications, too numerous to be cited here, see Mosyakin *et al.* (2018, 2019), Verloove & Andeweg (2020), and references therein. Outside Eurasia, *A. verlotiorum* has reliably been reported from Australia and New Zealand (Bangerter 1978; Thompson 2007; etc.) and South America (Ariza Espinar 1997; etc.), but also from North America where it largely passed unnoticed as a result of confusion with *A. vulgaris*, and partly also with some of the native North American taxa of *Artemisia* sect. *Artemisia* (Mosyakin *et al.* 2019; Mosyakin *et al.* in prep.).

In the course of our study of *Artemisia* sect. *Artemisia* we came across herbarium specimens identified as *A. vulgaris* that were collected in the Stutterheim district in the Eastern Cape Province in South Africa. There, the species is a locally naturalised weed of cultivated fields and is reported as a species difficult to eradicate. However, based on the morphological characters seen in these specimens, as well as further data from herbarium labels and literature sources, it has become evident that these plants are not *A. vulgaris* but in fact belong to *A. verlotiorum*. The latter apparently has a much higher invasive potential as compared to that of *A. vulgaris*.

In this paper, morphological features characteristic for both species are briefly discussed and additional information on the distribution and ecology of *A. verlotiorum* in South Africa is also provided.

MATERIAL AND METHODS

Several of the world's largest online herbaria were consulted in search for herbarium specimens of *Artemisia vulgaris* and its relatives from South Africa: BM, BR, E, G, K, L, NY, P, PE, US, W (herbarium acronyms following Thiers 2020). In addition, other online resources, such as GBIF, JSTOR Global Plants, observation.org and iNaturalist.org were searched for observations of the species of interest in South Africa.

For an accurate identification, numerous relevant Floras (mainly covering the northern parts of Eurasia, including Japan and China), as well as other literature references, were consulted.

RESULTS AND DISCUSSION

Identity of the South African plant material

Although naturalised since at least half a century, weedy mugwort apparently has only rarely been collected in South Africa, i.e. only five specimens were detected during our search online, all from the same locality. It should be noted, however, that none of the South African herbaria has online resources (comm. G. Smith, March 2020). Since this species is known until now (at least to us) only from this particular area in South Africa and that the images of specimens examined are from the supposedly initial place of its introduction, we assume that they are representative for the populations found elsewhere in the area.

The South African collections show individuals with middle and upper cauline leaves pinnatisect with a long, undivided terminal leaf lobe with more or less parallel sides. Although collected late in the season (end of March, which corresponds with the meteorological autumn in the Southern Hemisphere), specimens are in the early stage of flowering, or not yet flowering at all. Specimens with underground parts clearly show well-developed rhizomes and stolons, a character pointing to *A. verlotiorum*. The herbarium label furthermore specifies that the species propagates from "roots" remaining after harrowing.

Artemisia vulgaris is erroneously said to be "annual or occasionally perennial" by some South African authors (e.g. Herman 2003; Bredenkamp 2019). In fact, both *A. vulgaris* and *A. verlotiorum* are evidently perennials; however, they differ in their underground parts, and these differences result in different spatial structure patterns of their populations and the differing modes of vegetative renewal and spread. *Artemisia verlotiorum* is a long-lived rhizomatous perennial forming large clonal colonies by vegetative propagation, sometimes combined with sexual reproduction and seed dispersal; although dispersal by means of fragments of underground parts (rhizomes and stolons) in soil and plant material seems to be the primary mode, at least in Europe. Due to its vegetative mobility, *A. verlotiorum* normally forms rather dense stands that, if viewed from above the ground, usually consist of individual almost unbranched stems, in contrast to a more "bushy" branching habit of *A. vulgaris*, in which several stems quite often appear from one point at the ground level.

Artemisia vulgaris usually has leaves that are pinnatisect to pinnatipartite (lower ones), with an apical segment usually shorter than that in *A. verlotiorum*; however, leaves in both species may be very variable. *A. vulgaris* flowers markedly earlier in the season (as compared to the late-flowering *A. verlotiorum*), in late spring or early summer, (although flowering may be extended almost through the whole summer, and second flowering in autumn is frequently observed) in the Northern Hemisphere, or, respectively, in late meteorological autumn or early meteorological winter in the Southern Hemisphere. It is a tufted perennial, usually without rhizomes or with comparatively short stolons. Finally, although a certain scent in *A. vulgaris* is discernable, it can be hardly considered an aromatic species. It is noteworthy that Bredenkamp (2019: 449) stated that the species occurring in South Africa and identified as *A. vulgaris* is an aromatic herb, which also suggests *A. verlotiorum*.

Ling *et al.* (2011) attached much weight to the presence or absence of white sessile glands on the upper leaf surface of *A. verlotiorum* and *A. vulgaris* respectively. This character is not observable in the digital images found online. However, we have noticed that these glands are frequently hardly discernable, early deciduous or merely absent in *A. verlotiorum*, at least in Western European populations (Verloove & Andeweg 2020).

Thus, the morphological details observed in the specimens collected in South Africa evidently point at *A. verlotiorum*, not at *A. vulgaris*. In Table 1 the main differences between these two species are concisely opposed.

Table 1. Overview of main diagnostic characters of *Artemisia verlotiorum* Lamotte and *A. vulgaris* L.

	Artemisia verlotiorum	***Artemisia vulgaris***
Cauline leaves	pinnatisect with a long, undivided terminal leaf lobe with more or less parallel sides	pinnatisect to pinnatipartite (lower ones), with a shorter apical segment
Flowering time	autumn	late spring or early summer (but often with second flowering in autumn)
Underground parts	always with well-developed rhizomes and stolons, forming dense colonies	nearly always non-rhizomatous, with several stems appearing from one point at the ground level
Scent	clearly aromatic	with a faint, non-aromatic scent

Digital images of the following herbarium specimens were examined, all originally from the National Herbarium, South African National Biodiversity Institute, Pretoria (PRE), with duplicates also available in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA:

1) Eastern Cape, Stutterheim Dist., Sandiles Grave, 29.III.1977, *R. Bowie* 2081 (US Catalog No. 3010298; barcode US01819493; image: http://n2t.net/ark:/65665/3280bccdf-4dfc-46b1-91ee-f23495532e89; GBIF record: https://www.gbif.org/occurrence/1456021459);

2) *idem* (US Catalog No. 2999681; barcode US01819492; image: http://n2t.net/ark:/65665/32ca085a5-9479-4cd6-a251-d53fe9cbfeb0; GBIG record: https://www.gbif.org/occurrence/1456031382) (Fig. 1);

3) *idem* (US Catalog No. 3000633; barcode US01819494; image: http://n2t.net/ark:/65665/3e01852bb-adca-474c-8125-7d7580329f06; GBIF record: https://www.gbif.org/occurrence/1456415979);

4) *idem* (US Catalog No. 2857226; barcode US01819495; image: http://n2t.net/ark:/65665/3e1bdebfb-5c95-4214-902f-98df1ac40767; GBIF record: https://www.gbif.org/occurrence/1456419578);

5) *idem* (PRE, barcode PRE0531218-0; JSTOR Global Plants record and image: https://plants.jstor.org/stable/10.5555/al.ap.specimen.pre0531218-0).

Weed in cultivated lands. First noticed 1964. Propagation from roots remaining after harrowing. Cannot be controlled by weedicide [herbicide].

Artemisia verlotiorum was first described based on alien and naturalised specimens collected in the second half of the 19th century in France (Lamotte 1877). As we know now, *A. verlotiorum* is a native of China, but that was not at all evident in the 19th and the first three decades of the 20th century. Even the taxonomic identity of the species was very problematic and several names properly belonging to other species (such as *A. umbrosa* auct., *A. selengensis* auct., etc.) were misapplied to it. The amazing scientific quest for establishing the real identity and origin of *A. verlotiorum*, initiated by the Italian botanist Renato Pampanini (1923, 1930, 1933; etc.) and continued by many researchers from various parts of the world, is, in our opinion, one of the most intriguing and fascinating "detective stories" in biogeography, invasive biology, and plant taxonomy of the 20th century. And that story continues, while *A. verlotiorum* is continuing to conquer new areas for its expanding secondary (synanthropic) range.

It should be mentioned that in the protologue (Lamotte 1877) and in many other publications the species epithet was given as "*verlotorum*". However, now that spelling is considered to be an orthographic error (an epithet published with an improper Latin termination) correctable to *verlotiorum* without change of the authorship or date of the name (Art. 32.2 of the ICN), and the case of that epithet (given for the Verlot brothers) is specially listed in Art. 60.8(b) of the ICN (Turland *et al.* 2018). Thus, the correct spelling of the epithet of that species is *verlotiorum*, not "*verlotorum*", but the erroneous original variant should be also considered, e.g., when searching for specific references in the Internet.

An early but still very informative and well-written overview by Brenan (1950) provides the history of early research of *A. verlotiorum* and its initial spread in Europe and beyond. Already in 1950, Brenan (1950: 209) noted that "There must be comparatively few species of plants discovered as recently as 1873 which have in so short a time given rise to so formidable a spate of literature as has *A. Verlotorum* – literature remarkable for its bulk, its controversial content, and its very wide dispersal. I have made the bibliography given at the end of this paper as complete as I could, but even so have little doubt that there are additional references that I

Fig. 1. — *Artemisia verlotiorum*, specimen no. US01819492 (US Catalog No. 2999681).

have missed". Since then the literature on *A. verlotiorum* (ranging from in-depth ecological studies and comprehensive reviews to brief new records and popular booklets on invasive species) much expanded and now counts many hundreds of sources, with many references freely and easily available online, so there is no need to repeat here the basic information on the species and its characters distinguishing it from similar *A. vulgaris* and some other species of *Artemisia* sect. *Artemisia*, which are also known now as aliens from regions far beyond their native ranges.

Distribution and status in South Africa

Plants named as *Artemisia vulgaris* have been known in South Africa reportedly since at least 1964. R. Bowie collected plant material in March 1977 at Sandile's Grave in the Stutterheim district in the Eastern Cape Province, at an altitude of up to 1000 m (Herman 2003; Bredenkamp 2019). He added that these plants were first noticed there in 1964. The species was found as a weed of cultivated land and apparently difficult to control. As a result of being rhizomatous and thus vegetatively mobile, the species reappeared time and again after harrowing. It was also reported as being resistant to weed killer.

According to contemporary databases on South African plants, this species is only known from the Cape Province where it is considered to be naturalised (SANBI 2020; see also Herman 2003). Its status as a naturalised weed of cultivated lands was confirmed in a recent Flora of the Eastern Cape Province (Bredenkamp 2019), although some other recent authors do not mention it (e.g. Goldblatt & Manning 2000; Manning & Goldblatt 2012).

Older literature sources, from South Africa as a whole (e.g. Harvey 1865 in Flora Capensis) as well as from the Cape Province in particular (e.g. Adamson & Salter 1950; Levyns 1966), apparently did not refer yet to '*A. vulgaris*'. The species is even lacking in some less old references such as Bond & Goldblatt (1984). From this we deduce that *A. verlotiorum* was probably introduced in South Africa in the 1960's and locally naturalised as a weed of cultivated fields in the Eastern Cape Province (and probably beyond?) where it is found up to *c.* 1000 m altitude.

Interestingly, the name *A. verlotiorum* was taken up in South African official national lists of prohibited invasive plant species (NEMBA 2004, 2014, 2016). However, this species was merely included in the list of prohibited species considered but not yet actually reported in South Africa. In the South African legislation, prohibited species are defined as alien species that are listed as prohibited under the National Environmental Management: Biodiversity Act (NEMBA) (Act no. 10 of 2004) – Alien and Invasive Species (AIS) Regulations. These species are assumed to be absent from the country and their new introductions are prohibited (NEMBA 2016).

It should be noted that Mosyakin *et al.* (2019: 3-4) gave the distribution pattern of *A. verlotiorum* as "native to East Asia (China), is currently known as an alien and/or invasive species naturalized in many regions of Europe, North and **South Africa** [emphasis added], western Asia, South America, Australia, and New Zealand […] It is also definitely present in North America (Mosyakin, unpublished data and an article in preparation), where its cryptic invasion was totally overlooked until recently […]". In this statement, the mention of South Africa was based on the listing of the species as a prohibited species (see above) and an occasional checking of the JSTOR Global Plants online record and image of a South African specimen PRE0531218-0 (see above); however, the authors at that time did not realise that the species has not been recorded yet from South Africa, at least "officially", and did not pay attention to the need of reporting the occurrence of that potentially dangerous invasive species in South Africa. That need to alert South African botanists, agriculturalists, conservationists, and government officials of the actual presence of *A. verlotiorum* in their country was realized by the first author of the present contribution (Filip Verloove), who initiated the present article.

Artemisia vulgaris and *A. verlotiorum* are not mentioned in the latest comprehensive overview monograph on biological invasions in South Africa (van Wilgen *et al.* 2020).

CONCLUDING REMARKS

Based on examination of online records and high-resolution digital images of herbarium specimens (PRE and US herbaria) collected in the Stutterheim district in the South African Eastern Cape Province, we conclude that the weedy species of *Artemisia* naturalised in that region is definitely not the Eurasian *A. vulgaris* but the East Asian and now widespread in many parts of the world species *A. verlotiorum*. Both species have also been confused in other parts of the world. However, the latter species is a strongly rhizomatous species and, probably as a result of this, is much more invasive. South African botanists, weed scientists, conservationists, and government officials should pay attention to the possible spread of that species in the Republic of South Africa. Special field surveys should be performed and any records or herbarium specimens of plants identified as "*A. vulgaris*" should be critically re-assessed because they may in fact refer to *A. verlotiorum*, an invasive species that seems to be much better adapted to Mediterranean-type ecosystems than *A. vulgaris*.

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