First sightings of the southern small white *Pieris mannii* (Lepidoptera: Pieridae) in the Low Countries

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Abstract. The first records of southern small white *Pieris mannii* (Mayer, 1851) for the Netherlands and Belgium in 2015, 2016 and 2017 are reviewed. An overview of the range expansion is given and the possible ecological triggers of this expansion are discussed. The possibility of historical presence of the species in Belgium is examined as well as the future of the species in the Low Countries.

Samenvatting. De eerste waarnemingen van het scheefbloemwitje *Pieris mannii* (Mayer, 1851) voor Nederland en België in 2015, 2016 en 2017 worden besproken. Er wordt ingegaan op de recente sterke areaaluitbreiding van de soort en de ecologische oorzaken ervan. Het mogelijk historisch voorkomen in België wordt nagegaan alsook de potentiële toekomst van de soort in de Lage Landen.

Résumé. Les premières mentions de la piéride de l'ibéride *Pieris mannii* (Mayer, 1851) pour Les Pays-Bas et la Belgique en 2015, 2016 et 2017 sont discutées. Un abrégé de l'expansion de la distribution de l'espèce est donné et les causes écologiques potentielles sont commentées. La possibilité de la présence historique de l'espèce est examinée ainsi que le futur de l'espèce aux Pays-Bas et en Belgique.

Key words. *Pieris mannii* – dispersion – range expansion – climate – Belgium – The Netherlands.

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Introduction

On 27.ix.2015 the author discovered a female of the southern small white, *Pieris mannii* (Mayer, 1851) on the Sint-Pietersberg near Maastricht (Limburg, the Netherlands). This was the first report of this species for the Netherlands. After this sighting was communicated, many Dutch observers re-examined their recent pictures of *Pieris* species and at least one earlier record became known. On 22.vii.2015 Marlie Huskens photographed a female *P. mannii* in her garden at Posterholt (Limburg, the Netherlands) (Van Swaay *et al*. 2016). It was not until the summer of 2016 that another specimen was recorded in the Low Countries. On 13.vii.2016, Jacky Poncin photographed a *Pieris* species in his garden in Wardin (Luxemburg, Belgium), which he initially identified as a large white, *Pieris brassicae* (Linnaeus, 1758). After uploading the pictures to the online nature observation platform, waarnemingen.be, Bram Omon was the first to note that this record, in fact, constituted the first Belgian record of *P. mannii*.

From September 2016 onwards, the autumnal generation of *P. mannii* appeared to be locally common at several locations in Dutch Limburg. Intensive monitoring of potential locations in the region by, among others, Paul Vossen revealed the species to be widespread in the whole south of Dutch Limburg. After the first Dutch sightings in September 2016 the author searched along the Belgian side of the border and on 17.ix.2016 multiple individuals of *P. mannii* could be caught and photographed in Teuven (Limburg, Belgium) (Fig. 1). Further research showed the species to be present at several other locations in the Voeren region (Limburg, Belgium) and nearby locations in the province of Liège (Belgium). Invariably, all sightings were made in gardens. On both sides of the Dutch-Belgian border in Limburg immature stages were found (Figs 2–3), each time on the widespread ornamental plant *Iberis sempervirens* L. An overview of the different Dutch and Belgian sightings is given in Fig. 4. The difference in amount of datapoints between the Netherlands and Belgium is largely caused by the difference in observer coverage between both regions.

Fig. 1. *P. mannii alpigena*, Teuven (Limburg, Belgium), 17.ix.2016, ♀.

Geographical distribution in evolution

Until early this century *P. mannii* was considered to be mainly a Mediterranean species. A large amount of subspecies and forms have been described of which Ziegler & Eitschberger (1999) in their monograph on the species withhold nine subspecies. The taxonomic relationships between these subspecies are still partly unclear and the amount of clearly distinguishable subspecies may even be lower (Meineke 2015). The species is distributed from the eastern Pyrenees over southeastern France and the southern Alpine flanks, the Italian Peninsula and the Balkan further to eastern Turkey (Ziegler & Eitschberger 1999). More to the west the species is local on the Iberian Peninsula to southern Spain (García-Barros *et al*. 2004; García-Barros *et al.* 2013). In Morocco it is probably extinct (Tarrier 1995). More to the north a few small populations existed near the Slovakian-Hungarian border and in western France. The former,

however, have probably gone extinct (Ziegler & Eitschberger 1999) while the latter have been considered extinct for a long time (Lafranchis *et al*. 2015, Hensle *et al*. 2016). An overview of the different subspecies is given in Table 1.

Fig. 2. Egg of *P. mannii alpigena* on *Iberis sempervirens*, Sint-Martens-Voeren (Limburg, Belgium), 18.ix.2016. The black head capsule of the larva can already be seen.

From 2005, and especially from 2008 on, *P. mannii* has been found north of the Alps in Switzerland by several observers (Ziegler 2009). Until then the species was only known from some small populations on calcareous and rocky south oriented slopes in the Rhône valley in Wallis, Switzerland (Lepidopterologen-Arbeitsgruppe 1987). Remarkably, the new locations did not match the natural habitat in Wallis. The new habitat seemed to consist mainly of rockeries and other types of inclining gardens in villages and small cities where the potential larval food plant *Iberis sempervirens* is present.

Fig. 3. 1st instar caterpillar of *P. mannii alpigena* on *Iberis sempervirens*, Teuven (Limburg, Belgium), 17.ix.2016. The black head capsule of the first two instars is a diagnostic feature when compared to *P. rapae*.

The 2008 invasion north of the Alps appeared to be more than a one-off event and in the following years the species expanded its range further north mainly following the Rhine valley and from there spreading west- and eastwards. Currently the species is known from north-eastern France and a large part of the southern half of Germany (Hensle & Seizmair 2016, Pähler 2016, Wiemers 2016). An overview of the first records per region in north-western Europe is given in Table 2.

Table 1: Overview of the geographical distribution of the different subspecies of *Pieris mannii* according to Ziegler & Eitschberger. Subspecies suspected to be extinct are marked with (†) (Ziegler & Eitschberger 1999).

Subspecies	Distribution
mannii (Mayer, 1851)	Balkan from Slovenia tot S Greece
haroldi Wyatt, 1952 (†)	Morocco, Atlas
roberti Eitschberger & Steiniger, 1973	SE and C Spain
alpigena Verity, 1911	Catalonia to the southern Alpine slopes, recently expanded its range northwards
andegava Delahaye, 1910	W France SE of Paris, recently discovered in NE France and GD Luxemburg
rossii Stefanelli, 1900	Italian peninsula
todaroana Pincitore-Marott, 1879	Sicily
reskovitsi Gozmany, 1968 (†)	Hungary & Slovakia, Bükk mountains
hethaea Pfeiffer, 1931	Turkey

Potential drivers of the range expansion

The phenomena of dispersion and migration have been well studied in the genus *Pieris* and some species have become model species in this kind of research (e.g. Gilbert 2005, Spieth *et al.* 2012). *P. mannii*, however, was long known as a local species and is described as "Standorttreu" in the older Swiss ecological literature (Lepidopterologen-Arbeitsgruppe 1987). Some examples, however, show that the potential for dispersion is present in the species. There are some older records (1960, 1994) of solitary *P. mannii* north of the known distribution in eastern France, however without follow-up records or indications of a long-term establishment (Essayan *et al.* 2012). On a longer time scale Ziegler (2009) points to the populations in Wallis. During the last ice ages these locations were covered with glaciers and therefore, without a potential for dispersion *P. mannii* would not have been able to reach them.

The same author examined if there was a possibility of accidental import in the north of Switzerland. This seemed highly unlikely as the larval food plants that were found to carry eggs of the species were cultivated locally (Ziegler 2009).

Therefore, climate change is often denoted as the main cause for this sudden range expansion. Longer and

more frequent periods of drought and heat in the Mediterranean area in the years preceding the start of the range expansion could have created moments when not enough larval food plants of good quality were present. This could have been a trigger for females of *P. mannii* to start dispersing (Ziegler 2009, Kratochwill 2011). This seems a valuable hypothesis for a single or repeated influx of migrants from the south but seems an insufficient explanation for the success of a strong northerly range expansion.

In addition it seems that the climate niche of *P. mannii* should include northwestern Europe only in a much later stage of climate change (Settele *et al*. 2008). The advanced stage of *P. mannii* on its predicted climate niche can possibly be explained by the broad grid that is used in large scale models like the Climatic Risk Atlas of Settele *et al*. (2008), whereas climatological factors for larval development are mainly important on a microscale (García-Barros *et al*. 2009). The recent observations mainly point to populations in gardens in villages and towns, a (semi-)urban environment. Here, microclimatic conditions such as temperature and humidity can be locally very different from the surrounding area. This is known as the urban heat island effect (New 2015). The effect is noticeable not only in larger urbanized areas but can play a role in moderately urbanized areas as well (Kaiser *et al*. 2016). As a result, effects of climate change can be more pronounced in such urbanized areas (Youngsteadt *et al*. 2015). Modelling of a distribution on a large scale could therefore miss the effect of changes in the climate niche of a species on a small scale. A thorough study comparing the larval habitats of *P. mannii* in the newly conquered areas to the larval habitat in the original distribution area has not been done yet. In addition, the possibility of an observer effect needs to be considered (Romo *et al*. 2006). While butterfly enthusiasts specifically search for the species in urban areas in the north, in the south the species could mainly be searched for in the more interesting natural habitats. This could create a bias in the data on habitat preference.

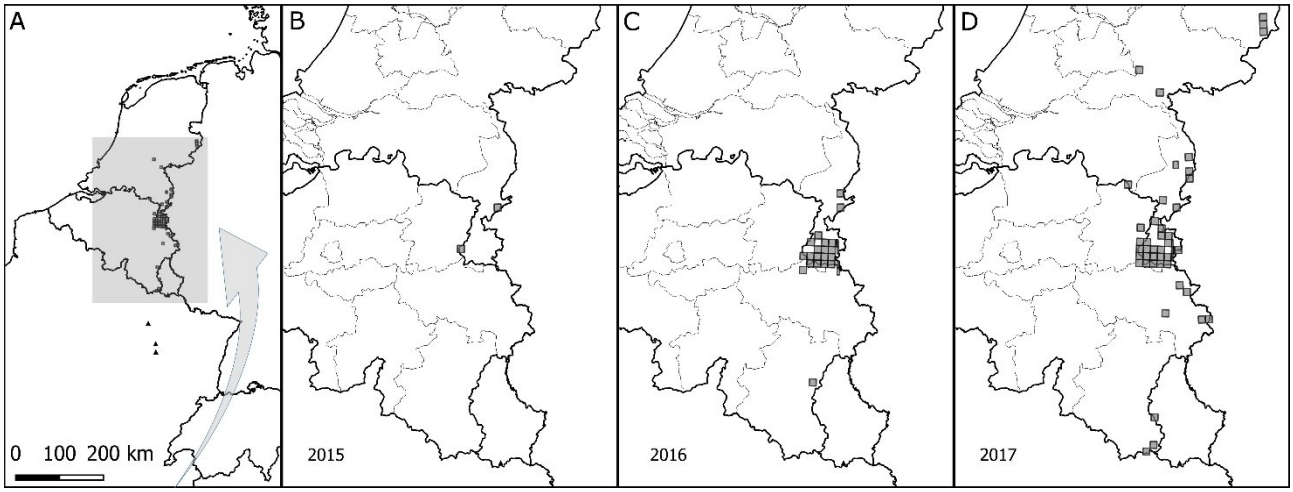

Fig. 4. Distribution (grid of 5 km UTM squares) of *P. mannii alpigena* in the Low Countries: Belgium & The Netherlands; **A**.– 5 km squares with all recent observations of *P. mannii alpigena* in the Low Countries, showing the position of the Low Countries in Northwestern Europe. The large grey rectangle shows the area of the details shown in parts B; C and D of the figure. The large grey arrow shows the main direction of the range expansion event. The small triangles show the position of the recently discovered populations of *P. mannii andegava* in northeastern France and the Grand Duchy of Luxembourg; **B**.– 5 km squares with observations of *P. mannii* in the Low Countries in 2015; **C**.– 5 km squares with observations of *P. mannii* in the Low Countries in 2016; **D**.– 5 km squares with observations of *P. mannii* in the Low Countries in 2017.

Small genetic changes can play a role as well in the sudden range expansion (Schulze 2016), especially the so-called spatial sorting. In spatial sorting a selection can arise in a species with an expanding range through space, at the dispersion front, rather than the well-known selection through time (Shine *et al*. 2011). A selection for the best disperser can in this way cause a cumulative effect and an acceleration of the observed range expansion. Such genetic changes have been described in other range expanding butterfly species (Mittika & Hanski 2010, Buckley *et al*. 2012). In a species like *P. mannii* with up to five generations per year, even in the north of the distribution (Schurian *et al*. 2016), such a selection can manifest itself rapidly and cause a swift range expansion. In Arthropods this can have an impact on several physical and behavioral conditions like speed of larval development, immunity and development of flight muscles (e.g. Therry *et al*. 2014). The presence of spatial sorting in the northern populations of *P. mannii* could thus be tested under laboratory conditions. In field conditions, however, it would be impossible to differentiate evolutionary effects from phenotypic plasticity of the species. Further research will have to show which of these effects have had an influence on the range expansion of *P. mannii* and to what extent.

Historical presence of *Pieris mannii* close to the Belgian border

The described range expansion of *P. mannii* finds its origin in the distribution of the western Mediterranean subspecies *P. mannii alpigena* Verity, 1911 (Table 1). However, recent discoveries have shown that the subspecies *P. mannii andegava* Delahaye, 1910, originally described from western France, is present as well in the valley of the river Meuse in north-eastern France and in

the extreme south of the Grand Duchy of Luxembourg (GDL), less than 20 km from the Belgian border (Fig. 5). In the GDL, the species has probably been present since at least the early 1970's (Goedert 2014, Schmidt-Koel 2014, Hensle *et al*. 2016). It seems likely that the species has always been overlooked because of the strong resemblance of the subspecies *andegava* to the abundant *Pieris rapae* (Linnaeus, 1758). The larval food plant at this location is *Iberis amara* L. This plant used to be widespread in the Belgian Gaume region and several river valleys in Wallonia before 1930. Later the number of locations declined strongly, mainly due to agricultural intensification, and nowadays the plant can only be found in one location in the valley of the Ourthe (Saintenoy-Simon 2006). Here, the population of the plant has recovered thanks to recent habitat restoration. The author looked for the presence of *P. mannii* at this location in the early autumn of 2015 but found only immature and adult stages of *P. rapae*. The wide distribution of the larval food plant before 1930, corresponding to the distribution in the south of the GDL may indicate that *P. mannii andegava* has been overlooked in Belgium as well. At this moment, however, there is no evidence of the (historical) presence of this subspecies in Belgium. It is advisable to check old collections for the presence of *P. mannii andegava*, as this may not have been done extensively yet.

Table 2: Overview of the first sightings per region in north-western Europe.

Year	Country	Region	Source
2001	France	Ain (Rhône-Alpes)	Bordon J. & Vernier R. 2003
2002	France	Jura (Franche-Comté)	Essayan *et al*. 2012
2005	Switzerland	Genf	Ziegler 2009
2006	Switzerland	Waadt	Ziegler 2009
2008	Switzerland	Bern	Ziegler 2009
		Luzern	Ziegler 2009
		Solothurn	Ziegler 2009
		Neuenburg	Ziegler 2009
		Basel	Ziegler 2009
		Freiburg	Ziegler 2009
		Jura	Ziegler 2009
		Aargau	Ziegler 2009
		Zurich	Ziegler 2009
	Germany	Freiburg (Badem-Württemberg)	Herrman 2008
2009	France	Haut-Rhin (Alsace)	Feldtrauer & Feldtrauer 2009
	Germany	Karlsruhe (Badem-Württemberg)	Herrman 2010
		Sigmaringen (Badem-Württemberg)	Herrman 2010
2010	Germany	Schwaben (Bayern)	Kratochwill 2011
	Austria	Voralberg	Kratochwill 2011
	France	Haut-Saône (Franche-Comté)	Essayan *et al*. 2012
2011	France	Côte d'Or (Bourgogne)	Essayan *et al*. 2012
		Bas-Rhin (Alsace)	Ochse & Schwab 2012
	Germany	Rheinland-Pfalz	Ochse & Schwab 2012
2012	Germany	Mittelfranken (Bayern)	Kostler 2012
		Nordwürttemberg (Badem-Württemberg)	Ekkehard 2013
		Giessen (Hessen)	Schurian & Siegel 2016
	France	Meurthe-et-Moselle (Lorraine)	Schmidt-Koel 2014
2013	Germany	Saarland	Schmidt-Koel 2013
2014	France	Moselle (Lorraine)	Schmidt-Koel 2014
	Germany	Niedersachsen	Meineke 2015
2015	Germany	Kassel (Hessen)	Schurian & Siege, 2016
		Westfalen (Nordrhein-Westfalen)	Schulze 2016
	Netherlands	Limburg	Van Swaay *et al*. 2016
2016	Germany	Sachsen-Anhalt	Wiemers 2016
	Belgium	Limburg	Vantieghem 2018
		Luik	Vantieghem 2018
		Luxemburg	Vantieghem 2018
2017	The Netherlands	Gelderland, Overijssel	Vantieghem 2018

Meanwhile it seems that the expanding range of *P. mannii alpigena* has reached the locations of the small colonies of *P. mannii andegava* (Hensle *et al*. 2016). Most probably this will lead to mingling of both populations. Genetic mixing can in this way decrease the phenotypic distinctiveness of the local *P. mannii* and increased parasitoid pressure following the range expansion can give raise to higher mortality (Layberry *et al*. 2014).

Future in the Low Countries

In recently colonised areas there seems to be a pattern in which the first observations of *P. mannii* are of one or a few solitary individuals in late summer or early autumn while the next summer the species seems already present all over the region. *P. mannii* is therefore likely to become a permanent member of the Dutch and the Belgian butterfly fauna. Long-term settlement seems evident all along the eastern borders of Belgium and the Netherlands, from the Gaume region in the south to Overijssel in the north. Several butterfly species that recently have expanded their range, such as *Brenthis daphne* (Bergsträsser, 1780) and *Cupido argiades* (Pallas, 1771), seem to have difficulties to protrude further to the west (Cuvelier *et al.* 2011; Vliegenthart 2016) and, apart from the eastern border zones, never reach large parts of Flanders or the Netherlands.

Fig. 5. *P. mannii andegava*, Pagny-la-Blanche-Côte (Meuse, France), 30.vi.2016, ♀.

The sandy regions in the eastern part of Flanders and the south of the Netherlands and the contiguous agricultural areas in parts of Flanders and the Netherlands may still form a barrier to further dispersion to the west while the higher and cooler forests of the Ardennes prevent a penetration from the south. Influence of the humid Atlantic climate may play a role as well. It could well be however that *P. mannii* is the first species to break this pattern, as has been shown by the sightings of single wandering individuals at great distance of suitable habitat.

At this point reproduction in Belgium and the Netherlands has only been noted on the garden plant *Iberis sempervirens*. In Germany however, research has shown that to a lesser extent the ruderal plant *Diplotaxis tenuifolia* (L.) DC. is used for reproduction which allows the species to reproduce outside gardens (Schurian *et al*. 2016). Further research will have to show if this is the case in the Low Countries as well.

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