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ARTICLE

Review of the Megastigmidae in Belgium and the Netherlands (Hymenoptera: Chalcidoidea)

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Abstract

In this paper, we provide an overview of the seed chalcid wasps *Bootanomyia* spp. and *Megastigmus* spp. (Hymenoptera: Megastigmidae) in both Belgium and the Netherlands. Sixteen species, including six non-natives to Europe, are reported after checking over a thousand specimens. The European species *Megastigmus aculeatus* (SWEDERUS, 1795) and *M. suspectus* BORRIES, 1895 are reported for the first time in Belgium. The European species *Bootanomyia stigmatizans* (FABRICIUS, 1798), *Megastigmus rosae* BOUČEK, 1971 and *Megastigmus strobilobius* RATZBURG, 1848, and the Nearctic species *Megastigmus atedius* WALKER, 1851 and *Megastigmus lasiocarpae* CROSBY, 1913 (only the second report in Europe) are new for the Netherlands. Novel insights are offered on the ecology, morphology and phenology of *Megastigmus aculeatus*, *Megastigmus nigrovariegatus* and *Megastigmus rosae*.

Keywords | Seed wasps • Chalcid wasps • invasive species • Low Countries • biodiversity

Révision des Megastigmidae de Belgique et des Pays-Bas (Hymenoptera : Chalcidoidea)

Résumé

Dans cet article, nous proposons une vue d'ensemble sur les guêpes chalcidiennes parasites des semences des genres *Bootanomyia* spp. et *Megastigmus* spp. (Hymenoptera : Megastigmidae) de Belgique et des Pays-Bas. Seize espèces, dont six non-natives d'Europe, sont décrites après examen d'un millier de spécimens. Les espèces européennes *Megastigmus aculeatus* (SWEDERUS, 1795) et *Megastigmus suspectus* BORRIES, 1895 sont décrites pour la première fois en Belgique. Les espèces européennes *Bootanomyia stigmatizans* (FABRICIUS, 1798), *Megastigmus rosae* BOUČEK, 1971 et *Megastigmus strobilobius* RATZBURG, 1848, ainsi que les espèces néarctiques *Megastigmus atedius* WALKER, 1851 et *Megastigmus lasiocarpae* CROSBY, 1913 (deuxième mention pour l'Europe) sont nouvelles pour les Pays-Bas. De nouvelles perspectives sont proposées concernant l'écologie, la morphologie et la phénologie des espèces *Megastigmus aculeatus*, *Megastigmus nigrovariegatus* et *Megastigmus rosae*.

Mots-clefs | Guêpes parasites des semences • Chalcidiens • espèces invasives • Bénélux • biodiversité

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INTRODUCTION

Chalcid wasps (Chalcidoidea) are a huge superfamily of mostly small parasitoid wasps, consisting of fifty different families (BURKS *et al.*, 2022). The family Megastigmidae used to be a subfamily of Torymidae (GRISSELL, 1976; 1995). It was

only recently reinstated as a valid family (JANŠTA *et al.*, 2018) with more clearly defined subfamilies (BURKS *et al.*, 2022). Belonging to Megastigminae, important characteristics for the subfamily are the knobbed stigma, which is usually

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higher than wide, the rather yellowish body, which sometimes has metallic colours, the relatively short hind coxa, which is not more than two times the length of the mid coxa and the long ovipositor, which is often longer than the metasoma (BOUČEK, 1988, NIKOL'SKAYA & ZEROVA, 1988; GRISSELL, 1995, 1997; JANŠTA *et al.*, 2018). More remarkable is the ecology of most species. Within the Western Palearctic, two genera occur: *Bootanomyia* spp. and *Megastigmus* spp. The former genus mainly consists of larval parasitoids of various gall forming species of Cynipidae (Hymenoptera), while the latter genus is associated with seeds of shrubs and trees (for cases and examples see Results). Morphologically, *Bootanomyia* spp. can be distinguished from *Megastigmus* by the body which is at least partially iridescent, the medially excised or emarginated lower clypeal margin and the midlobe of the mesoscutum which has at least 4 longitudinal rows of setae (more details see DOĞANLAR, 2011).

The oldest specimens we report date back to the 19th century and were collected by (locally) well known entomologists such as the Belgian Jules TOSQUINET (1824–1902) (PAULY, 2001). Private collections would still be very important in the XXth century; examples are those of

Adolphe CRÈVECOEUR (1895–1959) in Belgium (figure 3) and Theo GIJSWIJT (1927–2015) in the Netherlands. Only at the end of the century more attention was paid to Megastigmidae by government agencies or universities. This is mainly because these wasps had attracted some attention as possible invasive 'pest' species (*i.e.*, MAILLIEUX *et al.*, 2008; PAULSON *et al.*, 2014), but also because many of the species can in fact be found on foreign trees in tree gardens or arboreta. In the history of both Belgium and the Netherlands, only the Dutch entomologist Johannes Th. OUDEMANS (1862–1934) can be seen as someone who has done systematic research on the subject spanning several decades (figure 1). OUDEMANS managed the estate 'Landgoed Schovenhorst' in the province of Gelderland (Putten) for many years. It can still be visited and has many non-native tree species in its arboretum (figure 2). In the 1930s, when OUDEMANS collected most of his specimens, he was already a renowned entomologist. Still, it is noteworthy that for three species (*M. pinus*, *M. specularis* and *M. suspectus*) our records from the Netherlands are mostly or even solely based on records from his arboretum. In recent years, most records come from isolated findings in Malaise trap projects, or from citizen science portals (see Results).



Figure 1. J. T. OUDEMANS in estate Landgoed Schovenhorst.

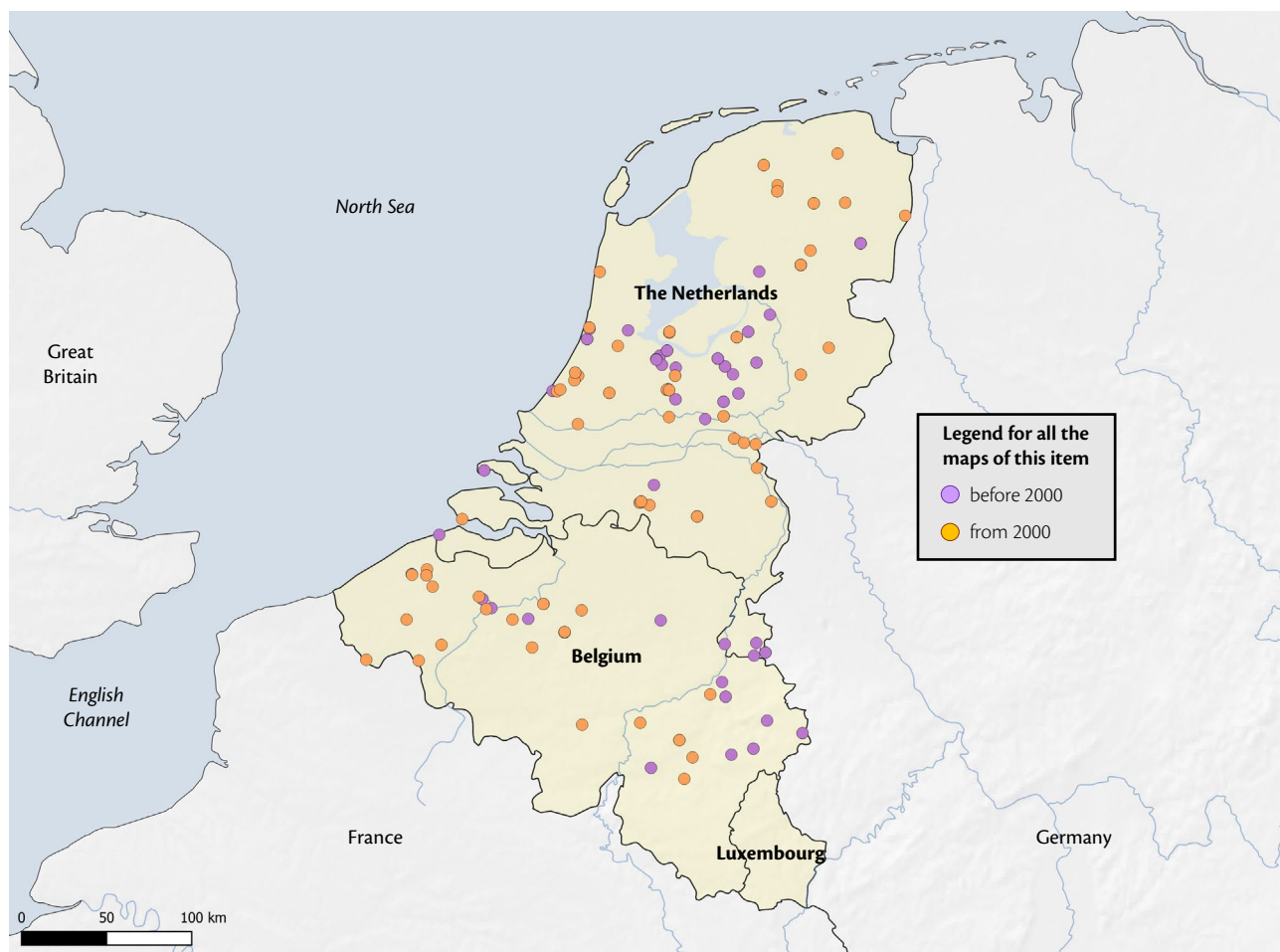


Figure 2. Arboretum of estate Landgoed Schovenhors in Putten.

MATERIAL AND METHODS

To gather our data, all available sources were used. First, we checked all published data in the literature. Secondly, we checked the historical collections of the national institutes: Royal Belgian Institute of Natural Sciences (RBINS) in Brussels and Naturalis (RMNH) in Leiden. Thirdly,

contemporary material was collected by the authors and other observers. Finally, we used open data from the citizen science portals *Waarnemingen.be* and *Waarneming.nl* (with the *ObsID* as unique identifier). These data were validated by the first author and were especially useful for some common



Map 1. Overview of the records in the used dataset 1858–2021.
Legend for this all the maps: purple / orange = before / from 2000. Map M. ISSERTES (QSIG).

species. In the complete dataset, 295 records of 1049 specimens were gathered across Belgium and the Netherlands (map 1). For the purposes of readability (duplicated data, very common species), we have integrated this material only partially in the results section. The first report and the four most recent ones are mentioned. When we did not include data, this was mentioned with '[...]'. Rearing data discussed in the remarks-section consists of validated data from the full dataset. This full dataset can be found linked to the article on the *ResearchGate*-page of the first author. References from the dataset are also integrated in the literature part of this article.

Repositories of collected material ("coll.") are abbreviated as

follows for institutes: RBINS (Royal Belgian Institute of Natural Sciences, Brussels), RMNH (Naturalis, Leiden); and for personal collections: ADK (Augustijn DE KETELAERE), AR (Alain ROQUES), FV (Fons VERHEYDE), HM (Hilco MEIJER), PH (Paul HOEKSTRA), PNL (Pierre-Nicolas LIBERT) and TP (Theo PEETERS).

Distribution maps were made with the open software QGIS 3.26.3 by Mehdi ISSERTES. Where possible, we used GPS-coordinates and included those in the dataset and results below. If those were not available, we used the county or city centre. Estimated coordinates are marked with orange in the dataset.

RESULTS

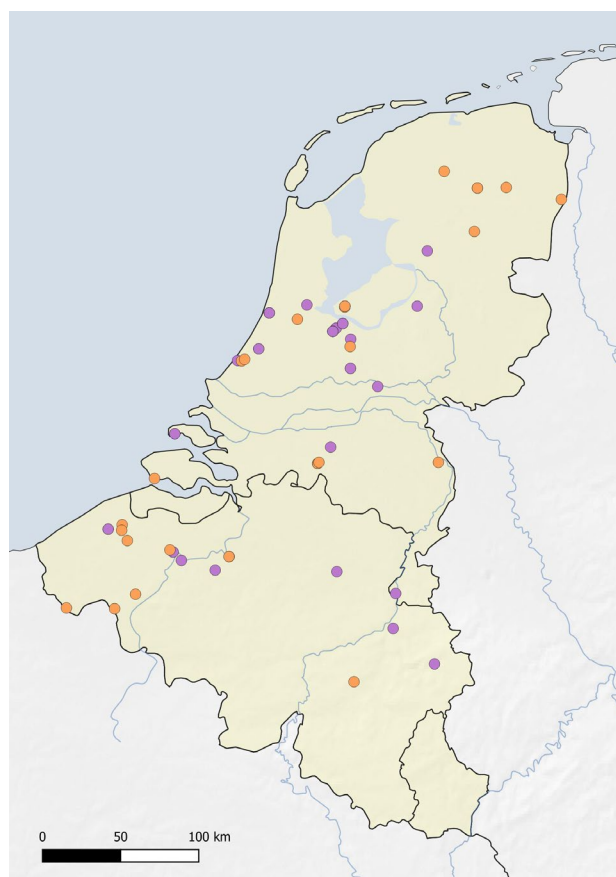
Bootanomyia GIRAULT, 1915

Bootanomyia dorsalis (FABRICIUS, 1798)

Material examined. BELGIUM (24 ♀♀, 2 ♂♂) • 1 ♀, Gent, 4.VI.1868, J. TOSQUINET *leg.*, coll. RBINS, reared ex '*C. foecundatrix*', F. VERHEYDE *det.* [...]; 1 ♀, Moeskroen, 50.735 – 3.214, 17 VIII 2020, C. GRUWIER *leg.*, ObsID: 198614888, light trap, F. VERHEYDE *det.*; 1 ♂, Buggenhout, 51.023 – 4.220, 23.V.2021, L. VERHELST *leg.*, ObsID: 214628498, F. VERHEYDE *det.*; 1 ♀, Buggenhout, 51.023 – 4.220, 2.VI.2021, L. VERHELST *leg.*, ObsID: 215718611, F. VERHEYDE *det.*; 1 ♀, Buggenhout, 51.023 – 4.220, 5.VI.2021, L. VERHELST *leg.*, ObsID: 216029633, F. VERHEYDE *det.*
THE NETHERLANDS (54 ♀♀, 30 ♂♂, 2 indet.) • (min.) 1 ♀ 1 ♂, Driebergen, VI.1858, G. A. SIX *leg.*, SIX 1859 [...]; 1 ♀ 1 ♂, Noordenveld, 53.012 – 6.401, 6.VI.2020, JAN HENK *leg.*, ObsID: 194239878 &

194239910, P. HOEKSTRA *det.*; 1 ♀ 10 ♂♂, Almere, 52.384 – 5.237, 9–14.III.2021 (galls collected 22.II.2021), P. HOEKSTRA *leg.*, coll. PH (ObsID: 208771913 & 208895376), reared indoors ex *Andricus coriarius*, P. HOEKSTRA *det.*; 1 ♀, Amstelveen, 52.314 – 4.820, 15.VI.2021, J. HEIJEN *leg.*, ObsID: 232435047, F. VERHEYDE *det.*; 1 ♀, Westerveld, 52.782 – 6.374, 21 VII 2021, J. HEIJEN *leg.*, ObsID: 232940190, reared ex ?, A. DE KETELAERE *det.*

Distribution (map 1). European. One of the most common species we report, with the oldest records (1858 and 1868) for the family. Widespread in both countries, especially where oaks are planted. As *Andricus* spp. are important hosts (see below) oaks planted at the borders of forests, or solitary trees, are often visited.



Map 2. Distribution of *Bootanomyia dorsalis*.
Map M. ISSERTS (QSIG).

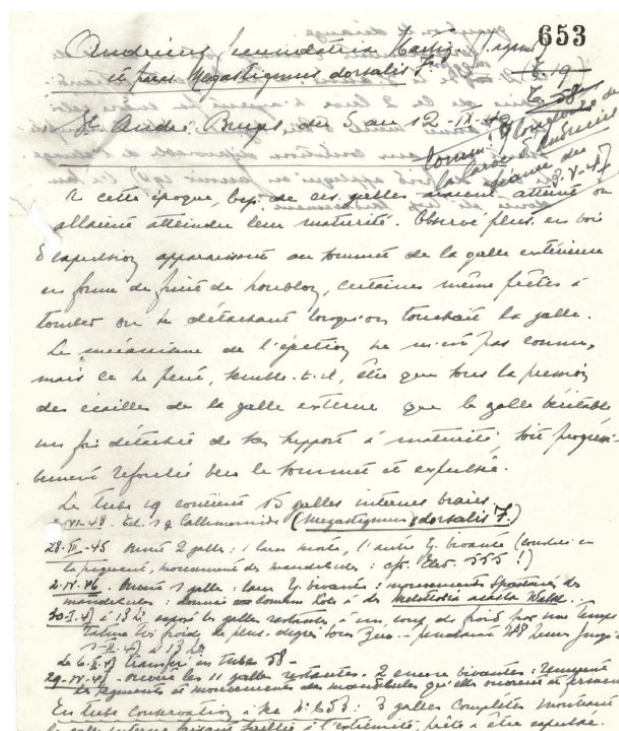


Figure 3. Notes of the Belgian entomologist CRÉVECOEUR, mentioning *B. dorsalis* (Sint-Andries, 1943). RBINS.

Remarks. The species (-complex; cf. *infra*) is well documented and has several rearing records, all hosts belonging to the family of Cynipidae associated with *Quercus* L. sp. Among the hosts reported are *Andricus aries* (GIRAUD, 1859) (1 ×), *Andricus coriarius* (HARTIG, 1843) (1 ×),

Andricus foecundatrix (HARTIG, 1840) (1 ×) and *Andricus grossulariae* GIRAUD, 1859 (1 ×). The main hosts are *Andricus kollari* (HARTIG, 1843) (8 ×) (figure 3) and *Biorhiza pallida* (OLIVIER, 1791) (4 ×). Finally, there is one uncertain report of *Cynips quercusfolii* LINNAEUS, 1758 as a host. Some reports mention specimens being reared just from an oak branch (*Quercus* L. sp.). It is important to note there are several cryptic lineages within the species-complex which may lead to taxonomic changes in the near future (NICHOLLS *et al.*, 2017).



Figure 4. a–b. Habitus (a) and frontal view (b) of *Bootanomyia dorsalis* (female). Coll. FV. Photo B. MINNEBO.

Bootanomyia stigmatizans (FABRICIUS, 1798)

Material examined. THE NETHERLANDS (1 ♂) • 1 ♂ Almere, 52.384 – 5.237, 9–11.III.2021 (galls collected 22.II.2021), P. HOEKSTRA *leg.*, coll. PH (ObsID: 208771912), reared indoors ex *Andricus coriarius*, P. HOEKSTRA *det.*

Distribution (map 3). European. Known from only one locality.

Remarks. One specimen was reared together with specimens of *B. dorsalis*. Being over 5 mm, this species has a distinctive size in comparison to the abovementioned species (ROQUES & SKRZYPCZYŃSKA, 2003).

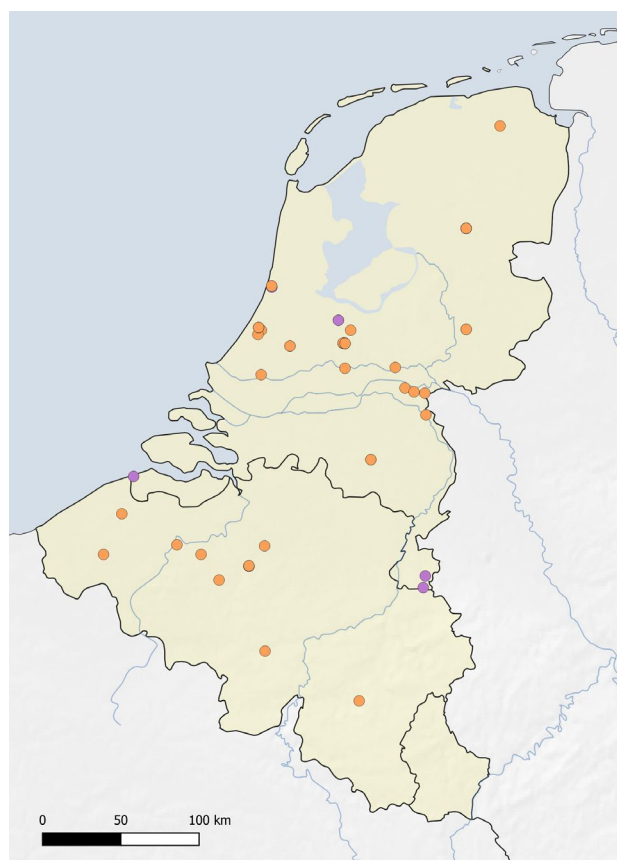
Megastigmus DALMAN, 1820

Megastigmus aculeatus (SWEDERUS, 1795)

Material examined. BELGIUM (20 ♀♀) • 1 ♀, Evere, 50.879 – 4.391, 16.VI.2008, B. HANSENS *leg.*, ObsID: 40099448, F. VERHEYDE & J. CORTENS



Map 3. Distribution of *Bootanomyia stigmatizans*.
Map M. ISSERTES (QSIG).



Map 4. Distribution of *Megastigmus aculeatus*.
Map M. ISSERTES (QSIG).

det. [...]; 1 ♀, Nassogne, 50.127 – 5.357, 13.VII.2021, M. VALDUEZA *leg.*, ObsID: 206973319, F. VERHEYDE *det.*; 1 ♀, Roeselare, 50.944 – 3.116,

13.VI.2021, M. VALDUEZA & F. VERHEYDE *leg.*, coll. FV, ObsID: 216923957, F. VERHEYDE *det.*; 4 ♀♀, Châtelet, 50.406 – 4.532, 20 VI 2021, E. LECLERCQ *leg.*, ObsID: 221612646, F. VERHEYDE *det.*; 1 ♀, Hever, 50.991 – 4.528, 20.VI.2021, R. SEGERS *leg.*, ObsID: 221612646, F. VERHEYDE *det.*
THE NETHERLANDS (93 ♀♀ 1 ♂) • 1 ♀, Bloemendaal – Kennemerduinen, 20.V.1967, M. J. GIJSWIJT *leg.*, coll. RMNH & GIJSWIJT, 2003, reared ex Rosaceae, T. GIJSWIJT *det.* [...]; 1 ♀, Rotterdam, 51.927 – 4.498, 24.VI.2021, M. SNIJDER *leg.*, ObsID: 218237964, F. VERHEYDE *det.*; 1 ♀, Land van Cuijk, 51.709 – 5.943, 26.VI.2021, P. SMEETS *leg.*, ObsID: 218266883, F. VERHEYDE *det.*; 1 ♀, Oegstgeest, 52.182 – 4.476, 16.VII.2021, B. DIJKSTRA *leg.*, ObsID: 234896036, F. VERHEYDE *det.*; 2 ♀♀, Oegstgeest, 52.712 – 6.296, 8 VIII 2021, J. ESSINK *leg.*, ObsID: 222424826, F. VERHEYDE *det.*

Distribution (map 4). European. The most commonly reported species from the family in recent years. The species was caught in three recent (2021–2022) MALAISE trap projects from different localities in Belgium and the Netherlands. It is associated with Rosaceae JUSS. (see below) and, as a consequence, it is perhaps more visible as these plants tend to be lower to the ground and planted in gardens, parks and urban environments. Before 1967, there are no records available, suggesting the species has succeeded in colonizing new areas in recent decades.

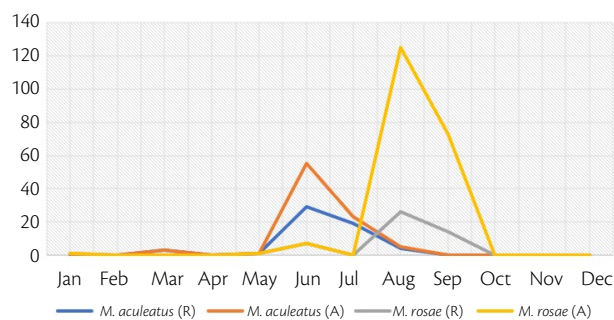


Figure 5. Diagram of phenology of *M. aculeatus* and *M. rosae*.
A: absolute numbers. R: per occurrence.

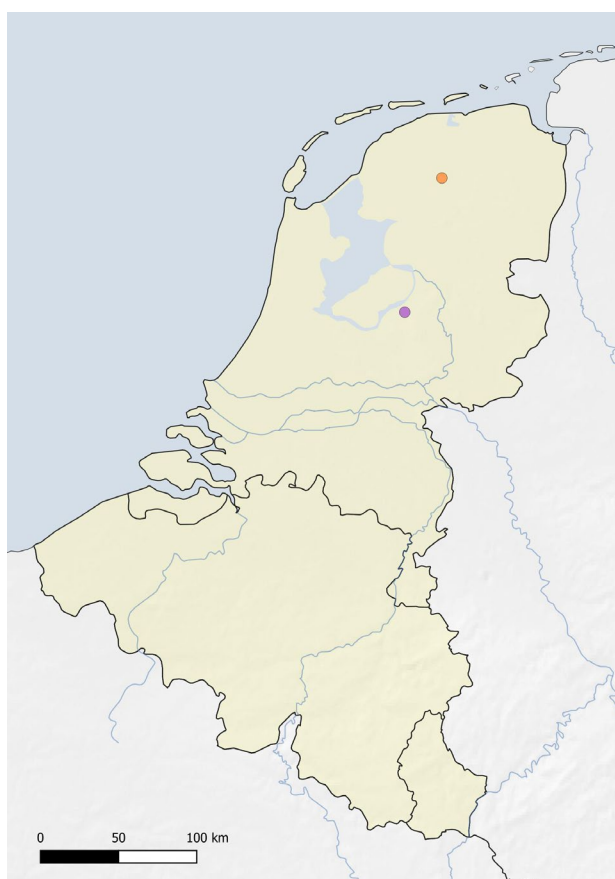
Remarks. As mentioned above, *M. aculeatus* but also *M. rosae* [see below; incl. *M. nigrovariegatus*] are species associated with Rosaceae. At least two cases of rearing are known from the Low Countries. Among the reported host plants are *Rosa rugosa* THUNB., but other unidentified Rosaceae were also used. In some gardens many specimens could be observed in detail throughout the year (e.g., pers. obs. of B. HANSSENS in Belgium and H. JANSEN in the Netherlands). Interestingly, in one garden in the Netherlands, both *M. aculeatus* and *M. rosae* were present and observed on a daily basis. We know there are clear differences in morphology (figures 6 vs. 8–10 for *M. rosae*), but these observations demonstrate that the phenology also differs. This is confirmed by all other data we have on both species. *M. aculeatus* clearly peaks in June, while *M. rosae* is only scarcely found at that moment of the year and peaks around August (figure 5). The obvious difference in phenology may explain how both species survive in more or less the same ecological niche. Males appear to be very rare for both species. Possibly, the species is partially thelytokous (see also our discussion on *M. rosae*).

Megastigmus atedius WALKER, 1851

Material examined. **THE NETHERLANDS** (1 ♀ + 1 ♀?) • 1 ♀?, Nunspeet – Veluwe, 23.III.1989, M. J. GIJSWIJT *leg.*, coll. RMNH, reared ex *Picea abies*, T. GIJSWIJT *det.* [...]; 1 ♀, Olterterp, 53.070 – 6.106,



Figure 6. Habitus of *Megastigmus aculeatus* (female). Coll. FV. Photo B. MINNEBO.



Map 5. Distribution of *Megastigmus atedius*.
Map M. ISSERTES (QSIG).

23.V.2021, H. MEIJER *leg.*, coll. HM, A. ROQUES, H. MEIJER & F. VERHEYDE *det.*

Distribution (map 5). Nearctic. The species is now confirmed and first reported for the Low Countries. It was found in the Netherlands by HM in the vicinity of conifers.

Remarks. This is one of the originally Nearctic species

imported to Europe and associated with several introduced conifers. It is already known from many neighboring countries including Denmark, France and Germany (ROQUES & SKRZYPCZYŃSKA, 2003). In the collection of RMNH, we found one uncertain specimen, reared from cones of *P. abies* (L.) H. KARST. The recent specimen collected in 2021 near foreign *Picea* spp. was carefully identified using the key of ROQUES & SKRZYPCZYŃSKA 2003.

Megastigmus bipunctatus (SWEDERUS, 1795)

Material examined. THE NETHERLANDS (1 ♀) • 1 ♀, Hattem, 28.VI.1993, B. VAN AARTSEN *leg.* (GIJSWIJT, 2003).

Distribution (map 6). European. Very rare and known from only one report in the Netherlands, dating from 1993 (GIJSWIJT, 2003). Host plants are *Juniperus* L. spp. The species can be expected near sandy heathlands where *J. communis* L. is more common. In Belgium, this will be mainly constricted to the province of Limburg in Flanders and the south-eastern parts of the country. In the Netherlands, the plant is slightly more widespread, starting from central Netherlands to the whole eastern part of the country. It is expected to be underreported.

Remarks. With the host plant known, it can only be confused with the extralimital and Mediterranean *M. amicum* BOUČEK, 1969; but there are clear morphological differences and its presence is more unlikely in our countries (ROQUES & SKRZYPCZYŃSKA, 2003).

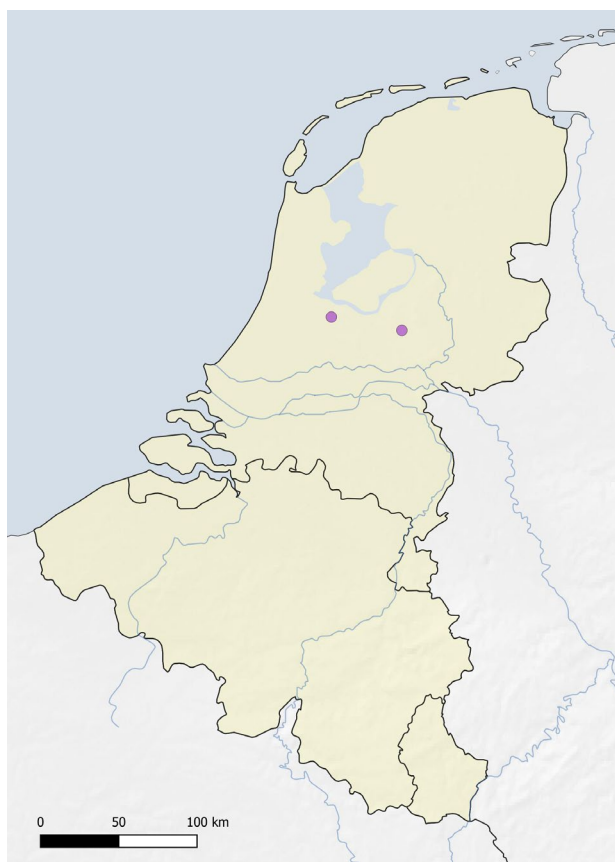
Megastigmus brevicaudis RATZBURG, 1852

Material examined. THE NETHERLANDS (2 ♀♀) • 1 ♀, 's Graveland, 7.VII.1962, M. J. GIJSWIJT *leg.*, coll. RMNH (GIJSWIJT, 2003); 1 ♀, Kootwijk, 27.V.1967, M. J. GIJSWIJT *leg.*, coll. RMNH (GIJSWIJT, 2003).

Distribution (map 7). European. Just as the abovementioned *M. bipunctatus* it is very rare, and only



Map 6. Distribution of *Megastigmus bipunctatus*.
Map M. ISSERTES (QSIG).



Map 7. Distribution of *Megastigmus brevicaudis*.
Map M. ISSERTES (QSIG).

known from two older reports in the sixties from the Netherlands (GIJSWIJT, 2003).

Remarks. In contrast to *M. bipunctatus*, the hosts plants are more abundant: *Amelanchier* MEDIK. and *Sorbus* L. spp. It is the only species associated with these plants in the West Palearctic (ROQUES & SKRZYPCZYŃSKA, 2003). With *S. aucuparia* L. as a plausible host plant this species appears to be genuinely rare; otherwise, it may have turned up in non-selective insect traps such as Malaise or pan traps.

Megastigmus lasiocarpae CROSBY, 1913

Material examined. THE NETHERLANDS (1 ♀) • 1 ♀, Olterterp, 53.070 – 6.106, 30.IV.2022, H. MEIJER *leg.*, coll. HM, H. MEIJER, F. VERHEYDE & A. ROQUES *det.*

Distribution (map 8). Nearctic. This is only the second finding of this species (figure 7) in Europe and therefore extremely rare. It was reported in Finland in 1969 (ANILLA, 1970).



Map 8. Distribution of *Megastigmus lasiocarpae*.
Map M. ISSERTES (QSIG).

Remarks. It is associated with Nearctic *Abies* MILL. spp. (ROQUES & SKRZYPCZYŃSKA, 2003).

Megastigmus milleri MILLIRON, 1949

Material examined. BELGIUM (1 ♀) • 1 ♀, Gesves, 2006, reared ex *Abies grandis* (ROZENBERG *et al.*, 2006; GBIF). THE NETHERLANDS (8 ♀♀, 7 ♂♂) • 8 ♀♀, 7 ♂♂, Sleenerzand, IV–V.1990, P. GRIJPMAN *leg.*, coll. RMNH, reared ex *Abies grandis*, GIJSWIJT, 2003.

Distribution (map 9). Nearctic. Known from only one locality in Namur (Belgium) and from one in Drenthe (the Netherlands), presumably on foreign conifers.

Remarks. Another Nearctic species. All specimens have been reported on the exotic *Abies grandis* (DOUGLAS ex D.

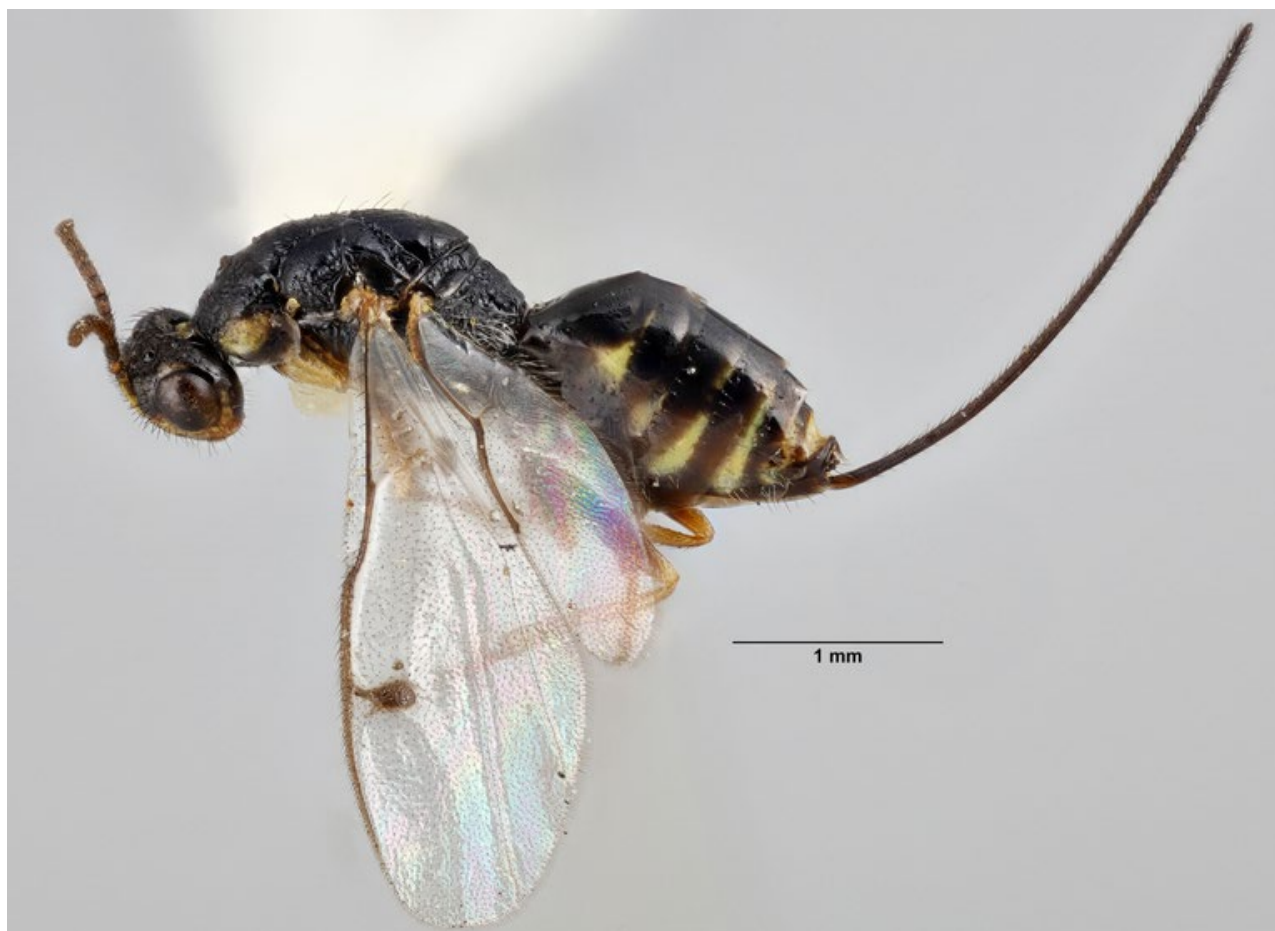


Figure 7. Habitus of *Megastigmus lasiocarpae* (female). Photo A. ROQUES.



Map 9. Distribution of *Megastigmus milleri*.
Map M. ISSERTES (QSIG).

DON) LINDL. It can thus be expected on similar conifers, more specifically firs (*Abies* spp.).

***Megastigmus pictus* (FÖRSTER, 1841)**

Material examined. THE NETHERLANDS (18 ♀♀, 2 ♂♂) • 18 ♀♀, 1 ♂, Vaals, III–IV.1986, P. GRIJPMAN *leg.*, coll. RMNH, reared ex *L. decidua* and *L. leptolepis* (syn. *kaempferi*) (GRIJPMAN & VAN DE WEERD, 1991; GIJSWIJT, 2003); 1 ♂, Vaals (seed orchard), 14.VII.1990, P. GRIJPMAN *leg.*, coll. AR, reared ex *L. leptolepis*, ROQUES & SKRZYPCZYŃSKA, 2003.

Distribution (map 10). European, but more specifically Eurasian. Only reported from one locality in the Netherlands (see also GRIJPMAN & VAN DE WEERD, 1991), but several specimens are preserved.

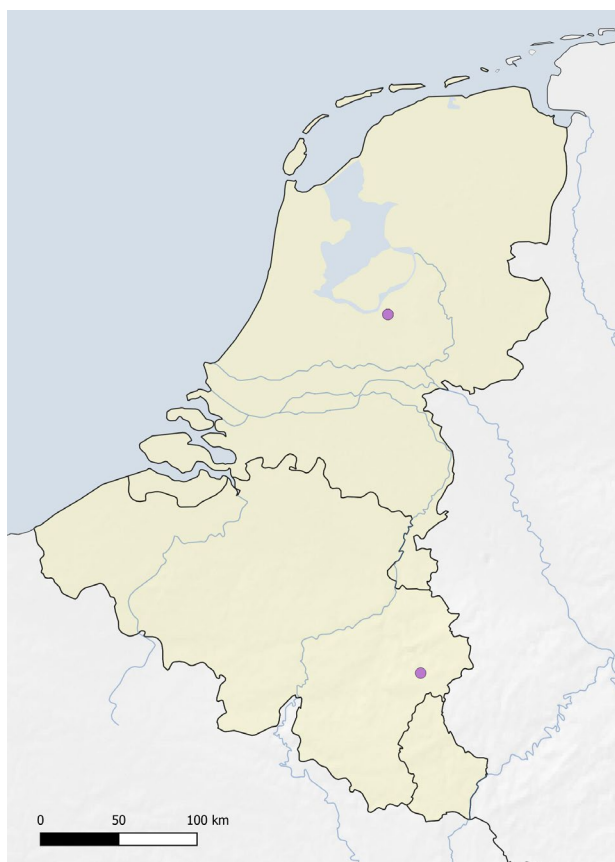
Remarks. Associated with conifers, and more specifically *Larix* spp. (ROQUES & SKRZYPCZYŃSKA, 2003). Larches are non-native species but commonly planted throughout Belgium and the Netherlands (especially *Larix kaempferi* (LAMB.) CARRIÈRE or hybrids with *Larix decidua* MILL.). Higher densities are reached on sandy soil near heathlands. This would suggest *M. pictus* is introduced but underreported, or other unknown (environmental) factors are important for stable populations (for example a closer association with a host tree species, i.e. *L. decidua*).

***Megastigmus pinus* PARFITT, 1857**

Material examined. BELGIUM (8 ♀♀, 9 ♂♂) • 8 ♀♀, 9 ♂♂, Vielsalm, 1993, F. TOMBYUSES *leg.*, coll. AR, reared ex *Abies procera* (ROQUES & SKRZYPCZYŃSKA, 2003). THE NETHERLANDS (46 ♀♀, 37 ♂♂) • 4 ♀♀,



Map 10. Distribution of *Megastigmus pictus*.
Map M. ISSERTES (QSIG).



Map 11. Distribution of *Megastigmus pinus*.
Map M. ISSERTES (QSIG).

Putten – Schovenhorst (Arboretum), V.1930, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Abies grandis* (OUDEMANS, 1933); 1 ♀, 1 ♂, Putten – Schovenhorst (Arboretum), 12–13.V.1931, J. Th. OUDEMANS *leg.*, coll.

RMNH, reared ex *Abies grandis* (OUDEMANS, 1933); 5 ♀♀, Putten – Schovenhorst (Arboretum), V.1932, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Abies grandis* (OUDEMANS, 1933); 8 ♀♀, 12 ♂♂, Putten – Schovenhorst (Arboretum), 10–20.IV.1936, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Abies magnifica*; 28 ♀♀, 24 ♂♂, Putten – Schovenhorst (Arboretum), 1936, WUR *leg.*, coll. RMNH, reared ex *Abies concolor*, *A. grandis* and *A. lowiana*.

Distribution (map 11). Another Nearctic species. Many specimens are available, but the species is known from only one locality in both countries.

Remarks. The species has been reared from many *Abies* spp., most of them by the Dutch entomologist OUDEMANS in the 1930s (figure 1). Among the cases reported are exotic *Abies* spp. such as *A. concolor* (GORDON & GLEND.) LINDL. Ex Hildebr. (2 ×), *A. grandis* (DOUGLAS ex D. DON) LINDL. (4 ×), *A. magnifica* A. MURRAY bis (1 ×) and *A. procera* REHDER (1 ×).

Megastigmus rafni HOFFMEYER, 1929

Material examined. BELGIUM (1) • Min. 1 ex., locality unknown, Belgium Forestry Office (AR) *leg.*, reared ex *Abies concolor* (ROQUES & SKRZYPCZYŃSKA, 2003). THE NETHERLANDS (10 ♀♀, 21 ♂♂) • 4 ♂♂, Ede, XI-XII.1970, W. C. NIJVELDT *leg.*, coll. RMNH, reared ex *Picea abies* (discussion see below) (GIJSWIJT, 2003); 7 ♀♀, 10 ♂♂, Sleenerzand, V.1989, P. GRIJPMAN *leg.*, coll. AR, reared ex *Abies grandis* (ROQUES & SKRZYPCZYŃSKA, 2003); 3 ♀♀, 7 ♂♂, Sleenerzand, V-VI.1990, P. GRIJPMAN *leg.*, coll. RMNH, reared ex *Abies grandis* (GIJSWIJT, 2003).

Distribution (map 12). Another species of Nearctic origin. Known from only few localities in both countries.

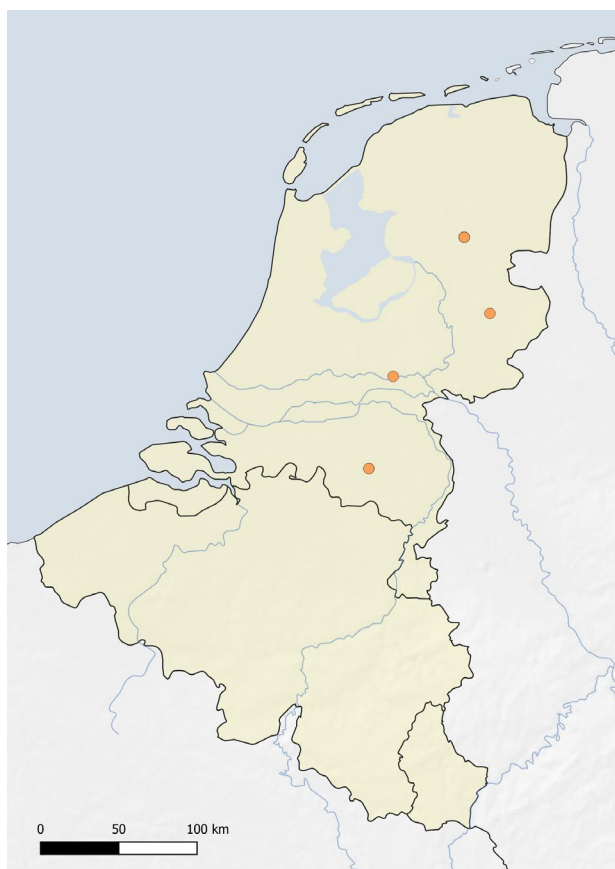


Map 12. Distribution of *Megastigmus rafni*.
Map M. ISSERTES (QSIG).

Remarks. Supposedly rare species, associated with both European and exotic *Abies* spp. (ROQUES & SKRZYPCZYŃSKA,



Figure 8. Habitus of *Megastigmus rosae* (female). Coll. FV. Photo B. MINNEBO.



Map 13. Distribution of *Megastigmus rosae*.
Map M. ISSERTES (QSIG).

2003). There is one report from cones of *Picea abies*. This rearing record is probably erroneous, analyzing the known rearing data of this species, which suggests it is strictly associated with *Abies* spp. Concerning the distribution, similarly to *M. pictus*, we may question whether or not the species is overlooked.

Megastigmus rosae BOUČEK, 1971

Material examined. THE NETHERLANDS (207 ♀♀) • 1 ♀, Eindhoven, 51.465 – 5.461, 26.VI.2014, M. GUÉGAN *leg.*, ObsID: 85817399, F. VERHEYDE *det.* [...]; 1 ♀, Berghuizen, 52.712 – 6.296, 12.VI.2020, A. KRUIHOF & J. ESSINK *leg.*, coll. FV, ObsID: 214797177, A. ROQUES & S. ULENBERG *det.*; 11 ♀♀, Berghuizen, 52.712 – 6.296, 31.VIII.2021, J. ESSINK *leg.*, ObsID: 224438495, F. VERHEYDE *det.*; 1 ♀, Rijssen-Holten, 52.305 – 6.522, 9.I.2022, G. VAN DE MAAT *leg.*, ObsID: 232796959, F. VERHEYDE *det.*

Distribution (map 13). European. Unreported in Belgium, but the Dutch findings suggest the habitat does not seem to be specific. In the Netherlands the species is mainly reported in the eastern half of the country, but this could be a coincidence as there are only four known localities. It is known from neighboring countries such as France, Germany and Denmark (ROQUES & SKRZYPczyńska, 2003 and unpublished data).

Remarks. This is one of the most difficult species to identify (figures 8–10). It can be confused with the Nearctic *M. nigrovariegatus* ASHMEAD, 1890, which is highly variable in color and similar to *M. rosae*. Therefore, a specimen was sent

to both SU and AR to confirm identification. There are some structural characters which can be used to separate our specimens from that of the abovementioned *M. nigrovariegatus*: (a) the scutellum is mostly striate and not largely reticulate; (b) the frenal area is quite smooth and not with longitudinal carinae; (c) the upper part of the stigmal vein is longer than the uncus (same length in *M. nigrovariegatus*); (d) usually the infusate area around the stigma is larger in *M. nigrovariegatus*, although variable.

In the Netherlands, confirmed rearings have mainly been associated with *Rosa rugosa* THUNB. and incidentally with *Rosa 'Hollandica'* PERS. ex STEUD. Only one uncertain male was found in August 2020, but in 2022 AK and JE succeeded in rearing males (this data was not included in the dataset) (figure 10). The ratio of males-females reared in comparison to those that could be found in the garden was 1:3 *versus* 1:20. Females appeared to be more flexible in flying behavior and were often seen ovipositing.



Figure 9. Stigma (front wing) of *Megastigmus rosae* (female). Coll. FV. Photo B. MINNEBO.



Figure 10. Habitus of *Megastigmus rosae* (male). Photo A. KRUIHOF.

Two generations of *M. rosae* fly in the Netherlands: an early generation in May and June, and a later one in August. The abundance of the early generation is low, and probably represents individuals emerging from infected seeds of the previous year. Larval diapause is common in *Megastigmus* spp. The early generation oviposits in young rose hips in June, followed by a period in July when individuals are absent. The late generation emerges in August, during which time mating and oviposition can be observed. In spite of most rosehips being mature at this time, oviposition predominantly occurs in the less common younger rosehips. Males have not been observed in the early generation,

although we should stress that the abundance of the generation is low and therefore easier for males simply to have been missed during sampling. As there are no observations of males (and logically, mating) early in the year, we cannot exclude adult diapause at this stage. In the case of free living or adult diapause, females would only be fertilized in August and September and hibernate the following months to emerge again in May and June. One adult individual was indeed found indoors in January, suggesting adult or free-living diapause, but it could also have been triggered by the artificial conditions inside. More research is needed to say anything definitive on the ecology of the species.

Megastigmus specularis WALLEY, 1932

Material examined. THE NETHERLANDS (11 ♀♀, 3 ♂♂) • 2 ♂♂, 1 ♂, Putten – Schovenhorst (Arboretum), V.1930, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Abies cilicica* (GIJSWIJT 2003); 3 ♀♀, 2 ♂♂, Putten – Schovenhorst (Arboretum), IV-V.1931, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Abies* sp. (GIJSWIJT, 2003); 1 ♀, Burgum, 53.197 – 5.997, 1.VI.2016, R. VAN DER ROL *leg.*, oviposition on *Abies koreana*, ObsID: 119426536, F. VERHEYDE & A. ROQUES *det.*; 5 ♀♀, Burgum, 53.197 – 5.997, 5.VI.2017, R. VAN DER ROL *leg.*, oviposition on *Abies koreana*, ObsID: 139649591, F. VERHEYDE & A. ROQUES *det.*

Distribution (map 14). Another Nearctic species imported to Europe and associated with introduced firs. Rare, but known from neighboring countries such as Denmark and France (ROQUES & SKRZYPCZYŃSKA, 2003).

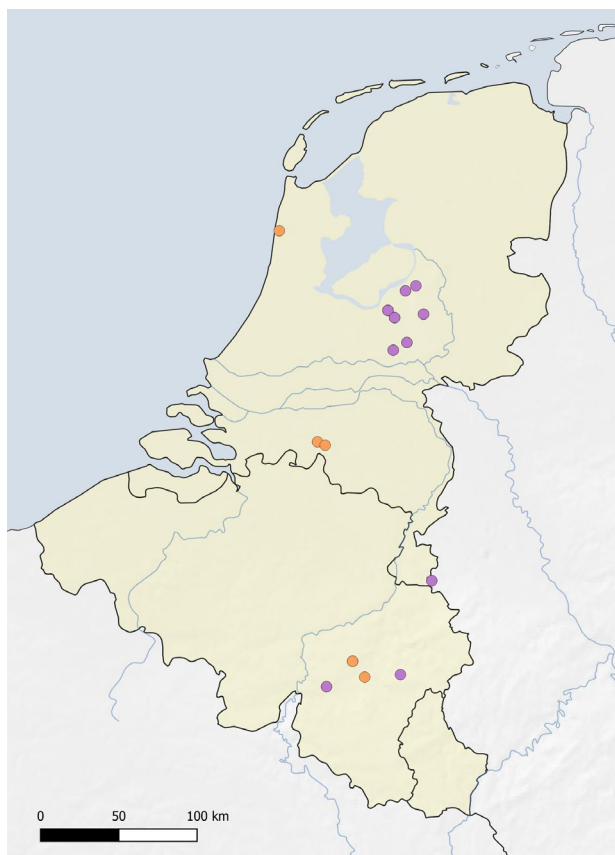


Map 14. Distribution of *Megastigmus specularis*. Map M. ISSERTES (QSIG).

Remarks. Until recently this species was only known from one locality in the Netherlands in the 1930s, where it was



Figure 11. Habitus of *Megastigmus specularis* (female) on *Abies koreana*. Photo R. VAN DER ROL.



Map 15. Distribution of *Megastigmus spermotrophus*.
Map M. ISSERTES (QSIG).

reared from *Abies cilicica* (ANTOINE & KOTSCHY) CARRIÈRE; so, this is clearly one of the more seldomly reported imported species. In 2016 it was rediscovered in a garden in the province of Friesland. One year later several individuals were seen ovipositing on cones of *Abies koreana* E. H. WILSON (figure 11).

Megastigmus spermotrophus WACHTL, 1893

Material examined. BELGIUM (8 ♀♀, 7 ♂♂ + 3 min. ex.) • 1 ex, Baraque de Fraiture, 1937, J. FOUARGE *leg.*, reared ex *Pseudotsuga menziesii* (VAN DEN BRUEL, 1937); 6 ♀♀, 5 ♂♂, Fenffe, V.1993, F. TOMBUYES *leg.*, coll. AR, reared ex *Pseudotsuga menziesii* (ROQUES & SKRZYPCZYŃSKA, 2003); Min. 2 ex., 2003–2004, reared ex *Pseudotsuga menziesii* (MAILLEUX *et al.*, 2008); 1 ♂, Somal, 50.327 – 5.317, 30.III.2018, P.-N. LIBERT *leg.*, reared ex *Pseudotsuga* sp. (LIBERT *et al.*, 2020); 1 ♂, Hotton, 50.238 – 5.423, 24.V.2020, M. VALDUEZA *leg.*, ObsID: 191822316, F. VERHEYDE *det.* THE NETHERLANDS (42 ♀♀, 29 ♂♂) • 9 ♀♀, 3 ♂♂, Apeldoorn - 't Loo, 1925, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Pseudotsuga menziesii* (OUDEMANS, 1931) [...]; 1 ♀, 't Harde, 29.V.1992, B. VAN AARTSEN *leg.*, coll. RMNH, T. GIJSWIJT *det.*; 1 ♀, Bergen, 52.678 – 4.674, 1.V.2019, T. DE GRAAF *leg.*, ObsID: 171436243, T. DE GRAAF & P. HOEKSTRA *det.*; 1 ♀, Tilburg – De Kaaistoep, 51.540 – 5.009, 1.VI.2019, H. SPIJKERS & P. VAN WIELINK *leg.*, coll. TP, light trap, P. HOEKSTRA *det.*; 1 ♀, Goirle, 51.522 – 5.076, 3.VI.2021, T. KRUIZE *leg.*, coll. FV, ObsID: 215798723, F. VERHEYDE *det.*

Distribution (map 15). Although of Nearctic origin, one of the more common species specifically bound to *Pseudotsuga menziesii* (MIRB.) FRANCO (ROQUES & SKRZYPCZYŃSKA, 2003).

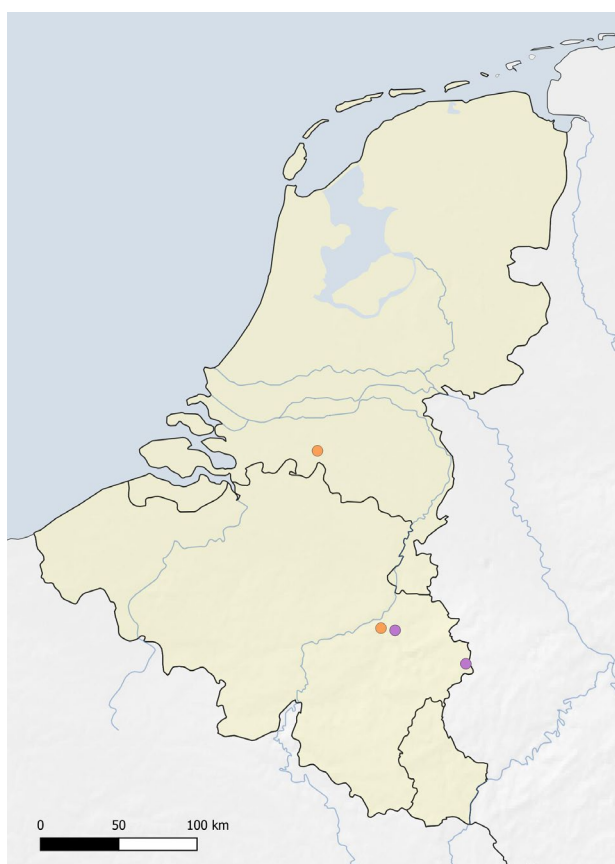
Remarks. Other Hymenoptera species such as the sawfly *Urocerus augur* (KLUG, 1803) have been associated with the same tree species (see observations on *Waarnemingen.be* and *Waarneming.nl*), and the number of sightings has been increasing in recent years. There are also some recent findings in both countries. Presumably the species (figure 12) is not uncommon and still spreading.

Megastigmus strobilobius RATZBURG, 1848

Material examined. BELGIUM (7 ♀♀, 4 ♂♂) • 7 ♀♀, 4 ♂♂, Gilbuschheck & Côte des Forges, 1993, Belgium Forestry Office *leg.*, coll. AR, reared ex *Picea abies* (ROQUES & SKRZYPCZYŃSKA, 2003). THE NETHERLANDS (3 ♀♀) • 2 ♀♀, Brunsum – Treebeek, 50.562 – 5.566, 24.VI–1.VII. 2019, G. LOMMEN *leg.*, coll. RMNH, light trap, S. ULENBERG *det.*; 1 ♀, Tilburg – De Kaaistoep, 51.540 – 5.009, 13.VI.2020, P. VAN



Figure 12. Habitus of *Megastigmus spermotrophus* (female). Coll. FV. Photo B. MINNEBO.



Map 16. Distribution of *Megastigmus strobilobius*.
Map M. ISSERTES (QSIG).

WIELINK *leg.*, coll. TP, light trap, P. HOEKSTRA *det.*

Distribution (map 16). European, associated with several

conifers, especially spruces (ROQUES & SKRZYPCZYŃSKA, 2003).

Remarks. This species was reported once in the Netherlands in several publications (SCHOEVERS, 1924; OUDEMANS, 1931; GIJSWIJT, 1969). However, the species presence was rejected at the beginning of the 21st century after checking all available material (GIJSWIJT, 2003). Therefore, our publication confirms or reaffirms the presence of the species.

Megastigmus suspectus BORRIES, 1895

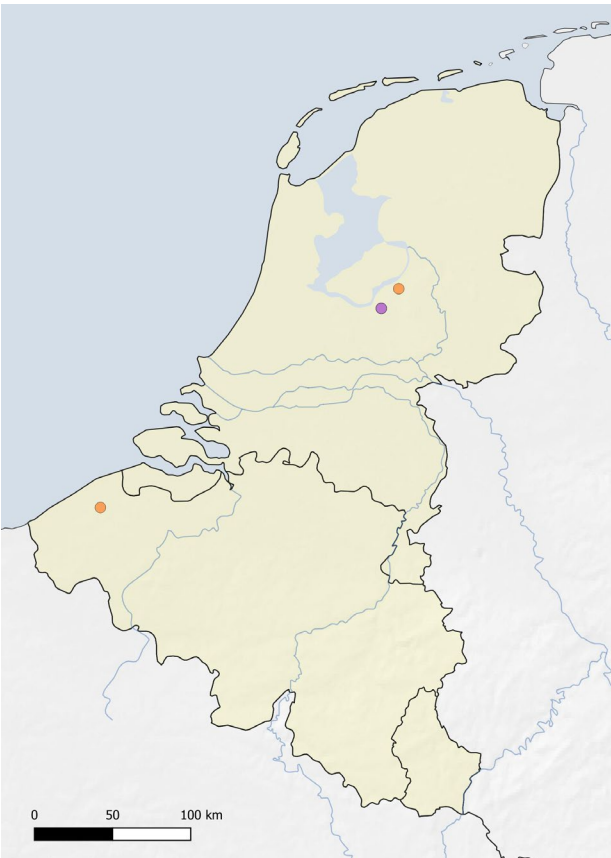
Material examined. BELGIUM (1 ♀) • 1 ♀, Sint-Andries – Beisbroek, 51.171 – 3.160, 27.VI.2016, W. DEKONINCK *et al. leg.*, coll. RBINS, yellow pan trap, F. VERHEYDE *det.* THE NETHERLANDS (273 ♀♀, 17 ♂♂) • 1 ♀, Putten – Schovenhorst (Arboretum), 16.V.1910, J. Th. OUDEMANS *leg.*, coll. RMNH, GIJSWIJT 2003; 53 ♀♀, 1 ♂, Putten – Schovenhorst (Arboretum), IV.1930, J. Th. OUDEMANS *leg.*, coll. RMNH, reared ex *Abies cilicica* [...]; 1 ♂, Nunspeet, 9.IV.2003, T. SIMON THOMAS *leg.*, coll. RMNH, reared ex *Abies* sp.

Distribution (map 17). European, but a species originating from southeastern Europe and Asia Minor. In the Netherlands, two older reports are known from 1910 and 1931 (GIJSWIJT, 2003) and one recent report from 2003. In Belgium, it was caught with a yellow pan trap in heathland. The species is associated with *Cedrus* MILL. spp. and *Abies* MILL. spp.

Remarks. The older findings in the Netherlands, reviewed by GIJSWIJT (2003), are coherent with its presence reported throughout France (ROQUES & SKRZYPCZYŃSKA, 2003). This species (figures 13–14) has been reared several times. Four *Abies* spp. were reported as a host plant at least once: *Abies cephalonica* LOUDON, *A. cilicica* (ANTOINE & KOTSCHY) CARRIÈRE, *A. firma* SIEBOLD & ZUCC. and *A. nordmanniana* (STEVEN) SPACH.



Figure 13. Habitus of *Megastigmus suspectus* (female). Coll. RBINS. Photo B. MINNEBO.



Map 17. Distribution of *Megastigmus suspectus*.
Map M. ISSERTES (QSIG).



Figure 14. Frontal view of *M. suspectus* (female). Coll. RBINS.
Photo B. MINNEBO.

DISCUSSION

This study cataloged sixteen species, of which only seven were reported in Belgium, accounting for less than half of the total. Notably, no species were identified in Belgium that had not been previously reported in the Netherlands. We suspect there is no actual reason why species occurring in the Netherlands cannot be expected to occur in Belgium. With 92 specimens examined from Belgium, we reach only 8 to 9 % of the total amount of specimens studied. This highlights a substantial observation bias, indicating the need for broader sampling to obtain a more comprehensive understanding of the species distribution.

Four European species are somewhat higher on the list of species to be expected in Belgium: *Bootanomyia stigmatizans* (associated with *Quercus* sp.); *Megastigmus bipunctatus* (associated with *Juniperus* spp.), *M. brevicaudis* (associated with *Amelanchier* and *Sorbus* sp.) and *M. rosae* (associated with *Rosa* spp.). The remaining species are predominantly non-native, often originating from the Nearctic region and associated with conifers. These species tend to inhabit larger coniferous forest patches, gardens, or arboreta, making their presence dependent on finding the right host tree at the appropriate time.

The identification of sixteen species in our study brings us to the brink of the full spectrum of native and introduced species in Western Europe, as outlined by ROQUES & SKRZYPCZYŃSKA (2003). Some of the remaining species are confined to host plants of the Mediterranean basin, facing challenges in adapting to more northern climates, thereby reducing the likelihood of their presence in our study area. Two species perhaps have a chance. *M. nigrovariegatus* is a non-native species we discussed in our paper in relation to *M. aculeatus* and *M. rosae*. It is also associated with *Rosa* spp. and occurs in France. A second plausible candidate is *M. pinsapinis* HOFFMEYER, 1931. This species originates from North Africa and/or Spain, but has been discovered up to north-central France. It is associated with *Abies* and *Cedrus* spp. (ROQUES & SKRZYPCZYŃSKA, 2003).

Yet, as emphasized throughout our study, Megastigmidae demonstrate a high sensitivity to introductions, creating a dynamic where 'unusual' species from diverse regions can be anticipated through importation. This underscores the need for continued vigilance and monitoring in understanding the intricate dynamics of Megastigmidae populations in different ecological contexts.

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The incentive to write this paper was based upon the interesting and still ongoing observations of Arp KRUITHOF and Jeanette ESSINK on *Megastigmus rosae* in the Netherlands. They are very much thanked for communicating those observations and for being open to dialogue. Bart MINNEBO further improved this paper enormously with his detailed photographs. Wouter DEKONINCK and Frederique BAKKER are thanked for their help in accessing the collections (including scanning archives/documents) of RBINS (Belgium, Brussels) and Naturalis (Leiden, the Netherlands). Els VAN GINKEL is thanked for providing us visual sources of OUDEMANS and Landgoed Schovenhorst. Koorosh MCCORMACK and Jean-Yves RASPLUS are sincerely thanked for reviewing this paper and thereby giving us valuable feedback. We wish to also thank all observers who contributed to the dataset used in the paper. Finally, Mehdi ISSERTES is thanked for making the layout and redrawing the maps in this item.

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