Description of the egg sac of Paratrachelas maculatus, with notes on its establishment in urban regions of Germany and Austria (Araneae: Trachelidae)

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Description of the egg sac of *Paratrachelas maculatus,* with notes on its establishment in urban regions of Germany and Austria (Araneae: Trachelidae)

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Abstract. The as yet unknown egg sac and clutch of *Paratrachelas maculatus* (Thorell, 1875) is described together with new records of the species from Germany and Austria. The flat, lens-like egg sacs contained 5 to 7 eggs, each approximately 0.75 mm in diameter, and were camouflaged with substrate by the female. Based on known records and locations, the species is most probably established in urban regions of Central Europe.

Keywords: alien, Central Europe, distribution, natural history, reproduction

Zusammenfassung. **Beschreibung des Eikokons von *Paratrachelas maculatus* (Araneae: Trachelidae) mit Anmerkungen zur Etablierung der Art in urbanen Gebieten Deutschlands und Österreichs.** Der bisher unbekannte Eikokon und das Gelege von *Paratrachelas maculatus* (Thorell, 1875) werden zusammen mit neuen Nachweisen der Art aus Deutschland und Österreich beschrieben. Die flachen, linsenförmigen Eikokons enthielten 5 bis 7 Eier mit jeweils etwa 0,75 mm Durchmesser und wurde vom Weibchen mit Substrat getarnt. Basierend auf der bekannten Verbreitung und den Fundorten ist die Art sehr wahrscheinlich in urbanen Regionen Mitteleuropas etabliert.

Assisted by human activities, e.g., global trade and tourism, an increasing number of species are able to reach and colonize areas outside their native distribution. Many spider species are known to be successful alien colonizers (Kobelt & Nentwig 2008, Levi 1967, Nentwig 2015) and today a large number of non-native spider species have become established in Central Europe, several of them with Mediterranean origins (Blick et al. 2016). Their number is constantly rising (Bauer et al. 2016, Hänggi & Straub 2016, Huber et al. 2017) and although their impact to date seems limited (Nentwig 2015, Blick et al. 2016) a close monitoring of non-native species in general should be pursued (e.g., Toft 2018a). Also, non-native species often behave in unpredictable and surprising ways, and sometimes become invasive decades after their introduction (Aikio et al. 2010, Allendorf & Lundquist 2003, Wittenberg & Cock 2001). However, the biology and natural history of the majority of spider species is less known, even often for synanthropic species with possible medical relevance (e.g., Dolejš & Hanko 2018). Life history traits and especially ontogenetic development can significantly contribute to the understanding of mechanisms underlying an invasion (Sakai et al. 2001) or natural extension of their distribution (Krehenwinkel & Tautz 2013). Also, life history traits are frequently used in cladistic analyses (e.g., Polotow et al. 2015) or can corroborate a proposed classification (Bauer et al. 2018). Life history traits can also inform about the structure of communities beyond classical species diversity measures (e.g., Schirmel et al. 2012).

Paratrachelas maculatus (Thorell, 1875) was originally described from the Crimean Peninsula in Eastern Europe (Thorell 1875) and was first recorded from Austria and Germany in 2010 and 2011 respectively (Bauer & Grabolle 2012). Two additional records from more recent years were published in Bauer & Höfer (2017). Recently, new records of this species from Austria and Germany became known, including a gravid female that produced three egg sacs in captivity. Based on these results, the species has to be considered as established in Central Europe. The aim of this work is to present the, as yet unknown, egg sac and clutch of *P. maculatus* together with some new records from Germany and Austria.

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Material and methods

Specimens of *P. maculatus* were encountered by chance and collected in residential buildings. In one case, a female specimen was transferred to a small plastic tube (10×5 cm) with black sand as a substrate and a dry leaf for hiding. It was fed ad libitum with feeder crickets [*Acheta domestica* (Linnaeus, 1758)] of 2–4 mm length and kept at room temperature. Produced egg sacs were removed about a week after deposition. After the third egg sac the female stopped hunting for crickets and was subsequently transferred to 75% ethanol for conservation to avoid loss or damage to the specimen by feeder insects or dehydration following a possibly unnoticed natural death. All material is deposited in the arachnological collection of the State Museum of Natural History Karlsruhe (SMNK-ARA). The record map was created with SimpleMappr (Shorthouse 2010). Photographs of the eggs and egg sac were made with Software "Automontage" (Syncroscopy, Cambridge, UK) and a Leica DFC 495 Digital camera, connected to a Leica Z6 APO (Leica Microsystems, Wetzlar, Germany). Coordinates (WGS 84) are given in decimal degrees.

Results

Family Trachelidae

***Paratrachelas maculatus* (Thorell, 1875)** (Fig. 1)

Material examined. AUSTRIA: 1 ♀ (SMNK-ARA 15992), 29.X.2018, Vienna (48.1611°N, 16.3127°E), in a house, leg. E. Derschmidt, det. T. Bauer.

GERMANY: 1 ♀ + opened egg sac (SMNK-ARA 15997), 16.XI.2018, Baden-Württemberg, Stuttgart-Zuffenhausen, Marbacher Straße 5 (48.8307°N, 9.1757°E), in a bathroom, leg. & det. T. Bauer; 1 ♀ (SMNK-ARA 15021), 13.IX.2017, Baden-Württemberg, Stutensee-Blankenloch (49.0622°N, 8.4731°E), cellar of a house, leg. & det. S. Bayer.

Determination. Mikhailov (1987), Kovblyuk & Nadolny (2009), Bosselaers et al. (2009).

Fig. 1: *Paratrachelas maculatus* (Thorell, 1875) female from Vienna, Austria (both legs I missing)

Measurements. Prosoma length: 1.85 mm (♀ from Stuttgart), 1.95 mm (♀ from Vienna).

Remarks. The new records fit into the hitherto known distribution of *P. maculatus* in Germany and Austria (Fig. 2). All known records were made in regions near the Rhine or Neckar in more or less densely urbanized areas within a distance of 10 km from the rivers. *Paratrachelas maculatus* has to be considered as the second established trachelid species in Germany in the sense of Ludwig et al. (2006).

Description of egg sac and clutch

The female from the locality in Stuttgart was held in captivity for about 10 weeks. A few days after collecting it built a completely white, lens-like egg sac with a diameter of about 5 mm attached to a dry leaf at about 3 cm height (Fig. 3a). On 8.XII.2018, at night a second egg sac was built (Fig. 3b) that had a diameter of around 4.5 mm. A third egg sac of similar size was built about two weeks later. The underside was always completely attached to the leaf, but the whole egg sac could be removed by us with tweezers without any damage to the silk. The egg sacs consist of one layer of thin and firm, papery silk, with very little flocculent silk wrapping the therein hidden eggs. All egg sacs were encrusted with some substrate (black sand/soil) on the outside, which was probably collected and added by the female as a sort of camouflage. However, we never observed the construction of egg sacs. The first egg sac contained a clutch (diameter about 2.5 mm) of seven slightly polyhedral, orange eggs (diameter of single egg around 0.75 mm), which were stuck together (Fig. 4). The second and third egg sac contained a similar clutch consisting of six and resp. five eggs of approximately the same size. The female never guarded the egg sacs and hid most time of the day in a wrinkle of the dry leaf. All egg sacs were attached to the dry leaf at a certain height and never directly beneath the ground or on the substrate. After opening the egg sacs, the eggs were incubated at room temperature on moistened cotton wool, but no spiderlings hatched, possibly due to the very dry air in the room.

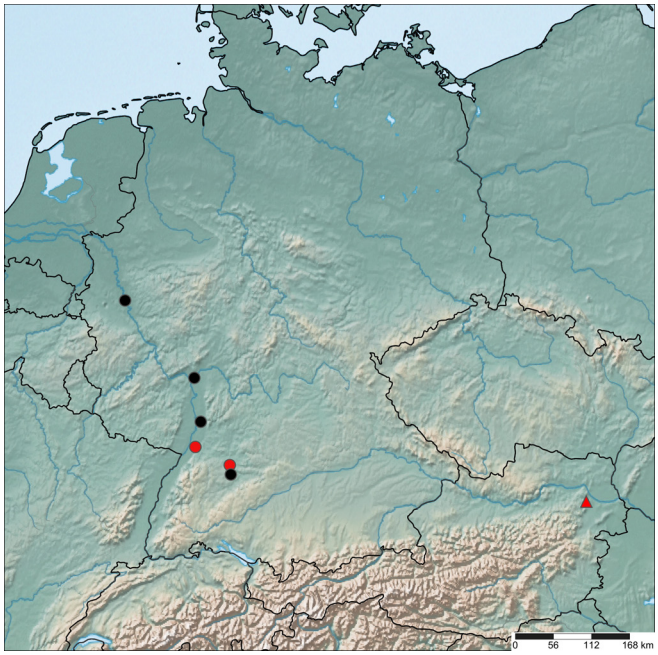
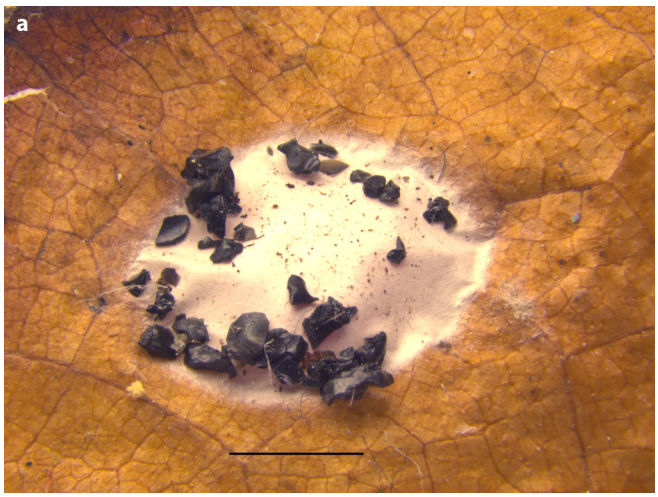


Fig. 2: Records of *Paratrachelas maculatus* in Germany and Austria (black circles = old records in the literature, red circles = new German records, red triangle = repeated record from Austria in 2010 and 2018 from the same location in Vienna)



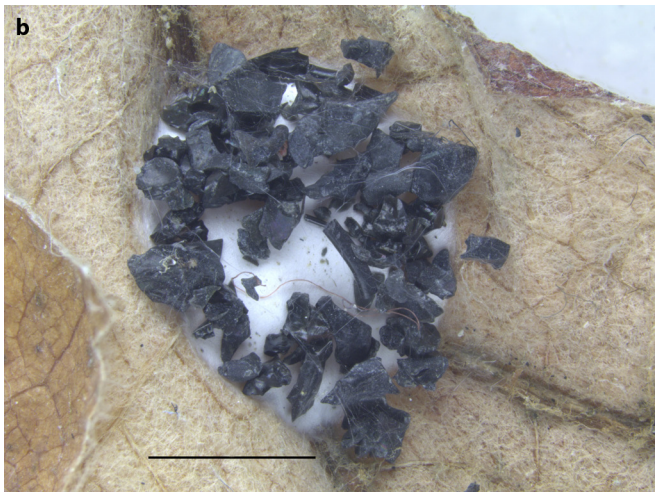


Fig. 3: Egg sacs of *Paratrachelas maculatus* (Thorell, 1875) from Stuttgart, Germany, black sand was attached by the female during deposition. **a.** First egg sac, built around 20.XI.2018; **b.** Second egg sac, built on 8.XII.2018. Scale = 2 mm

Discussion

Distribution

Further European records of this species are known from France, the Balearic Islands, Italy, Croatia, Ukraine, Slovenia, Hungary and Bulgaria (reviewed in Bauer & Grabolle 2012,

Fig. 4. *Paratrachelas maculatus* (Thorell, 1875), clutch of first egg sac built around 20.XI.2018. Scale = 1 mm

Nentwig et al. 2018). The record from Cologne is also, to date, the northernmost in its global distribution (Bauer & Grabolle 2012). The southernmost record of *P. maculatus* currently known is from Israel (Zonstein et al. 2015). In Germany, *Paratrachelas maculatus* shows a distribution pattern similar to the Mediterranean invaders *Zoropsis spinimana* (Dufour, 1820) and *Cheiracanthium mildei* L. Koch, 1864 (Arachnologische Gesellschaft 2018). The second record from Austria (Fig. 1) indicates a possible establishment in Vienna. In 2017 another specimen from Vienna was observed which could, based on its morphology, be identified as male of *P. maculatus* (https://forum.arages.de/index.php?topic=23427.0), but unfortunately it was not collected. All records were made in autumn, which coincides with the typical phenology of the species (Kovblyuk & Nadolny 2009). The recent records from Stutensee-Blankenloch and the north of Stuttgart are the fifth and sixth in Germany (Arachnologische Gesellschaft 2018), while the record from Vienna was collected at exactly the same locality as another female in 2010 (Bauer & Grabolle 2012). We interpret our data (including a gravid female) as indication that the specimens collected in Germany and Austria originate from established populations, but additional records are needed to prove a (presumed) wider distribution in Austria.

Notwithstanding the debate about whether European spider species should be seen as alien in other, formerly not colonized parts of Europe (Nentwig 2015, Nentwig et al. 2018), we decided to define *P. maculatus* as an alien species to Germany and Austria, similar to Mediterranean alien species included in the German checklist (Blick et al. 2016). In harvestmen (Opiliones), invading Mediterranean species are possibly responsible for the recent decline of several native species in urban areas of Central and Northern Europe (e.g., Toft 2018b). Therefore, the invasive potential of alien species from other parts of Europe should not be deemphasized by the usage of oversimplified definitions for alien spider taxa in Central and Northern Europe.

Paratrachelas maculatus is associated with buildings and urban areas in Germany and Austria (and also in Italy and Slovenia; Hansen 1996, Kuntner 1997), while in Eastern Europe, the possible original distribution area, *P. maculatus* is common in a wide range of non-synanthropic habitats, e.g., sub-montane and montane forest steppes and forest plantations (Kovblyuk & Nadolny 2009). The occurrence in forest plantations could also have led to an inadvertent distribution of egg sacs or specimens with tree trunks or other plant material (potted plants). Currently, a preference for synanthropic habitats can be observed in the majority of non-native species in Europe (Kobelt & Nentwig 2008). On the other hand, a natural spread from Eastern Europe along river valleys, possibly caused by climate change, seems unlikely at the moment. *P. maculatus* is currently not known from large areas of Southern and Eastern Europe (Nentwig et al. 2018), although it was found in individual countries like Italy (Hansen 1996). The species was also recorded in Vienna, Austria and Cologne, Germany in two subsequent years (Bauer & Grabolle 2012). Both cities are separated by a linear distance of 750 km, which argues for long-distance jump dispersal due to transportation with traffic (see also Vestbo et al. 2018). A natural distribution from a population based on a single introduction into Central Europe is therefore implausible. A fast spreading invader like *Mermessus trilobatus* (Emerton, 1882), probably introduced in the 1970s to south-western Germany and mostly inhabiting natural and semi-natural habitats, needed about 30 years to reach the northernmost areas of Germany (Arachnologische Gesellschaft 2018, Nentwig et al. 2018).

Egg sac and clutch

With only 5–7 (large) eggs (Fig. 3), the documented egg number of *P. maculatus* is low compared to other non-native spider species in Central Europe, often producing dozens of eggs per egg sac (e.g., Miyashita 1987, Skow & Jacob 2003, Uhl 1998, Vetter & Rust 2012). Few large eggs per clutch could be evidence for a low reproduction rate and population density. Even in comparison with other Trachelidae the egg number is low. *Trachelas volutus* Gertsch, 1935, for example, a species only around 2 mm larger than *P. maculatus* (Platnick & Shadab 1974), produced 47–66 eggs (on average 56) in captivity (Amalin et al. 2001). Although egg number per clutch is generally related to body size and body mass of spiders (larger and heavier spider species produce more eggs per clutch; see Marshall & Gittleman 1994), several substantially smaller linyphiids like *Oedothorax apicatus* (Blackwall, 1850) are known to be able to produce more eggs per clutch than we have observed in *P. maculatus* (Holm 1940). On the other hand, a low reproduction rate could possibly explain the rarity of records of *P. maculatus* despite a relatively large known distribution area in Germany (and Central Europe). Interestingly, Bosselaers et al. (2009) mentioned that *Paratrachelas ibericus* (Bosselaers, 2009) is guarding its egg sac inside a silken retreat, while the (camouflaged) egg sacs of *P. maculatus* were abandoned by the female. This could be an artefact of captivity, but the female was not disturbed several days before and after the egg depositions. The often observed polyhedral shape of (agglutinated) spider eggs was explained by Holm (1940) with a high degree of egg softness during oviposition, the subsequent drying of an oviposition liquid on the outside and the following agglutination of the eggs. The egg sac can be classified as type 4 sensu Austin (1985), consisting of very firm, thin and papery silk probably serving as a protection against scavenging predators like ants. Camouflaging an egg sac could be a reaction of a spider species to high parasitoid pressure. Species of *Agroeca* Westring, 1861 are known to ca-

mouflage their egg sacs, while their eggs often show a high rate of parasitoid-induced mortality (Finch 2005). Future research could therefore target the diversity of trachelid egg sacs and differences in egg numbers in relation to ecology, life history and parasitoids.

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