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A glimpse of the tropics – spiders (Araneae) in the greenhouses of the Botanic Garden Berlin-Dahlem

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Abstract: In a survey of the spider fauna in greenhouses of the Botanic Garden Berlin-Dahlem, 30 spider species were recorded. Two species are new to Europe: *Theotima minutissima* (Petrunkevitch, 1929) and *Heteroonops spinimanus* (Simon, 1891). *T. minutissima* is the first member of the family Ochyroceratidae reported from Europe. *Oecobius navus* Blackwall, 1859 is new to Central Europe. *Triaeris stenaspis* Simon, 1891, is recorded from Germany for the first time. *Zodarion italicum* (Canestrini, 1868) is new to eastern Germany. Despite the discovery of some species previously unknown to Germany, the spider fauna in the Botanic Garden consisted mainly of well-known synanthropic species and common inhabitants of greenhouses. Several alien spiders recently found in greenhouses, garden centers and houses were not recorded in the Botanic Garden. The species composition of the exotic spider fauna in greenhouses seems to depend chiefly on the specific modes of acquisition of plants and plant substrate.

Keywords: Europe, Germany, introduced species, Ochyroceratidae, Oecobiidae, Oonopidae

The spider fauna of botanic gardens and greenhouses has attracted several researchers, starting with SIMON (1896) and followed by PICKARD-CAMBRIDGE (1906), VAN DER HAMMEN (1949a), HOLZAPFEL (1932) and others. BOETTGER (1929) was the first to investigate the invertebrate fauna of the greenhouses of the Botanic Garden in Berlin-Dahlem (Germany). His main interest focused on molluscs. Nevertheless, he caught several exotic spiders new to Germany. The next survey of the fauna in the Dahlem greenhouses was conducted by W. Eichler between 1936 and 1938 (EICHLER 1952). In the last days of World War II, the greenhouses were severely damaged.

Today, global trade and climate change facilitate the importation and invasion of exotic spiders to Europe (JÄGER 2005, KOBELT & NENTWIG 2008). The number of established alien species is expected to rise. Therefore, a new survey of the spider fauna in the greenhouses of the Botanic Garden Berlin-Dahlem was conducted to compare the results with the data of BOETTGER (1929) and EICHLER (1952). In 2008, spiders in the greenhouses were collected by hand (including beating of plants and litter sieving) as well as by pitfall traps. Sampling was done as the opportunity presented itself and did not follow a fixed regime.

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The examined greenhouses are divided into two groups:

1. Hothouses with minimum temperatures around 20 °C.
   Display greenhouses: House B (Begonias), House C (useful plants of the tropics), House D (orchids), House E (plants of the humid tropics), House F (tropical ferns), House G (Bromeliads). The main tropical greenhouse was not accessible due to ongoing reconstruction work.
   Service greenhouses: House 7, 9, 10 and 14.
2. Cooler greenhouses with minimum temperatures around 10-12 °C.
   Display greenhouses: House H (Old World succulents), House I (cacti and other American succulents), House K (plants from South Africa), House M (plants from Australia and New Zealand), House N (*Camellia* and *Azalea* species), House Pa (Mediterranean region, minimum temperatures 6-8 °C) and Pb (tree ferns).

If not otherwise indicated, all spiders were collected and identified by the author. Voucher specimens were deposited in the collection of the author and in one case in the Royal Museum for Central Africa, Tervuren (Belgium). The Botanic Garden Berlin-Dahlem lies in the Northeast of Germany (52°27'22"N 13°18'24"E, TK 3545; 50-60 m a.s.l.).

Results

In 2008, 30 spider species were collected in the Dahlem greenhouses (Tab. 1). Most of the species were either common spiders living in natural habitats in Berlin or typical synanthropic spiders known

Tab. 1: Spider species recorded in the greenhouses of the Botanic Garden Berlin-Dahlem in the years 1927-1928 (BOETTGER 1929), 1936-1938 (EICHLER 1952) and 2008.

Family / Species	1927-28	1936-38	2008
Scytodidae			
Scytodes sp.		•	
Ochyroceratidae			
Theotima minutissima (Petrunkevitch, 1929)			•
Pholcidae			
Pholcus opilionoides (Schrank, 1781)		•	
Pholcus phalangioides (Fuesslin, 1775)		•	•
Psilochorus simoni (Berland, 1911)			•
Smeringopus pallidus (Blackwall, 1858)	•		
Segestriidae			
Segestria bavarica C. L. Koch, 1843			•
Dysderidae			
Harpactea rubicunda (C. L. Koch, 1838)			•
Oonopidae			
Heteroonops spinimanus (Simon, 1891)			•
Triaeris stenaspis Simon, 1891			•
Mimetidae			
Ero aphana (Walckenaer, 1802)			•
Oecobiidae			
Oecobius navus Blackwall, 1859			•
Nesticidae			
Nesticus cellulanus (Clerck, 1757)	•		
Theridiidae			
Enoplognatha ovata (Clerck, 1757)			•
Keijia tincta (Walckenaer, 1802)		•	
Parasteatoda tepidariorum (C. L. Koch, 1841)	•	•	•
Steatoda grossa (C. L. Koch, 1838)	•		•
Linyphiidae			
Erigone atra Blackwall, 1833			•
Erigone dentipalpis (Wider, 1834)			•
Lepthyphantes leprosus (Ohlert, 1865)			•
Meioneta rurestris (C. L. Koch, 1836)			•
Tenuiphantes tenuis (Blackwall, 1852)			•
Tiso vagans (Blackwall, 1834)			•
Troxochrus scabriculus (Westring, 1851)			•
Araneidae			
Araneus diadematus Clerck, 1757	•	•	•
Zygiella x-notata (Clerck, 1757)	•	•	•
Agelenidae			
Tegenaria atrica C. L. Koch, 1843	•	•	•
Tegenaria domestica (Clerck, 1757)	•		
Textrix denticulata (Olivier, 1789)			•
Amaurobiidae			
Amaurobius ferox (Walckenaer, 1830)			•
Liocranidae			
Liocranum rupicola (Walckenaer, 1830)			•
Corinnidae			
Phrurolithus festivus (C. L. Koch, 1835)			•
Zodariidae			
Zodarion italicum (Canestrini, 1868)			•
Salticidae			
Hasarius adansoni (Audouin, 1826)	•	•	•
Marpissa muscosa (Clerck, 1757)	•	•	
Panysinus sp.		•	
Pseudeuophrys lanigera (Simon, 1871)			•
Salticus scenicus (Clerck, 1757)			•
Semnolius chrysotrichus Simon, 1902	•		
Sitticus pubescens (Fabricius, 1775)		•	

from cellars, apartments, etc. Some were characteristic inhabitants of greenhouses. The "greenhouse spider" *Parasteatoda tepidariorum* was ubiquitous in all greenhouses. Another very common spider was *Pholcus phalangioides*.

These and six further species were found in both types of greenhouses regardless of temperature (see Appendix, Tab. 2). The majority of the spider species were observed only in the cooler greenhouses. Most of the native spiders belonged to this group. Five species were confined to the hothouses. In the wild, these spiders live in subtropical or tropical climates and, in one case, in Mediterranean climate conditions.

Compared to the results of BOETTGER (1929) and EICHLER (1952), 10 species recorded previously were not found in the current study (Tab. 1). Only five species were found in all studies: *P. tepidariorum*, *Araneus diadematus*, *Zygiella x-notata*, *Tegenaria atrica*, and the jumping spider *Hasarius adansoni*.

Tegenaria domestica was caught only in the study of BOETTGER (1929). According to KOMPOSCH (2002), this funnel-web spider has been common in urban habitats in the 19th century, but is now rare. It could have been displaced by *T. atrica*. Another intriguing species is *Nesticus cellulanus*. In Berlin-Dahlem, it was found only in the 1920´s. HOLZAPFEL (1932) reported it to be a frequent inhabitant of hothouses in the Botanic Garden of Bern (Switzerland) at the same time. *P. phalangioides* is known to displace other spider species (KOMPOSCH 2002) and might be responsible for the decline of *N. cellulanus* in the greenhouses.

Two exotic spiders reported by BOETTGER (1929) are not included in the current checklist of Central European spiders (BLICK et al. 2004): the jumping spider *Semnolius chrysotrichus* and the pholcid *Smeringopus pallidus*. The spiders caught by C. R. Boettger were identified by E. Schenkel. Unfortunately, the collection of Schenkel in the Natural History Museum Basel contains no specimens of these spider species from Berlin with the exception of *H. adansoni* (A. Hänggi in litt.). The whereabouts of the material from the study of EICHLER (1952) are unclear.

The apparent absence of small spider species in the preceding studies of the fauna in the Dahlem greenhouses may have been due to low sampling effort. EICHLER (1952: 63) did not try to identify the small spiders, whose webs he often found on the underside of leaves with mealybugs. HOLZAPFEL (1932) apparently paid more attention to smaller spiders. She recorded several species belonging to the Linyphiidae and Dictynidae as well as an unidentified oonopid spider in Bern.

Five species recorded in the present study are particularly remarkable. Detailed information on these spiders is given below.

Theotima minutissima (Petrunkevitch, 1929)

Diagnosis: This is a very small six-eyed spider (< 1 mm). The carapace shows a pattern of dark and light brown streaks. Four eyes form a straight transverse row with the two remaining eyes behind them. The females have no externally chitinized epigyne. The genital opening does not extend laterally on the abdomen as is the case in many species of the family (JOCQUÉ & DIPPENAAR-SCHOEMAN 2007). Contrary to the Oonopidae, there is only a single inconspicuous tracheal spiracle, which is situated near the spinnerets. For descriptions and illustrations of general appearance and genital opening see SAARISTO (1998: 20, 21: f. 1-3) and DEELEMAN-REINHOLD (1995: 72, 75: f. 202). Identification should always be verified by a specialist.

Distribution: Tropical America, Asia, Pacific Islands (PLATNICK 2008). New to Europe.

Material: House 10, 23 May 2008, 6 ♀♀, leg. J. Esser, 30 May 2008, 15 ♀♀, 5 June 2008, 5 ♀♀, 25 June 2008, 50 ♀♀, det. R. Jocqué, coll. Royal Museum for Central Africa (in pars), 21 August 2008, 15 ♀♀, 3 September 2008, 26 ♀♀; House B, 5 November 2008, 1 ♀, 24 November 2008, 1 ♀; House C, 17 July 2008, 2 juv.

While the other members of the genus are confined to tropical and subtropical America or Africa, *T. minutissima* is a pantropical species (DEELEMAN-REINHOLD 1995). This is the first record of a member of the family Ochyroceratidae (midget ground weavers) in Europe and the first record of *T. minutissima* from a greenhouse.

Theotima minutissima builds irregular webs in the ground litter. It was placed in a guild of "nocturnal ground weavers" by HÖFER & BRESCOVIT (2001). HÖFER (1990, 1997) reported it as one of the dominant species in several inundation forests in Brazil, constituting up to 35% of the total catch in pitfall traps. The spiders ascended tree trunks to avoid inundation. The species was not present in a terra firma forest (HÖFER 1997). In a wet subtropical forest in Puerto Rico, *T. minutissima* reached a density of about 60 individuals m^2 of the litter

layer (EDWARDS & EDWARDS 2006). It showed a slight preference for wetter litter with more decayed material in the forest.

The females lay 4-6 eggs and carry them in their chelicerae until the spiderlings are fully developed. *T. minutissima* was shown to be parthenogenetic by EDWARDS et al. (2003). Parthenogenesis in this species might be connected with the occurrence of endosymbiontic bacteria (GOODACRE et al. 2006).

In Berlin-Dahlem, *T. minutissima* occurred in large numbers in a service greenhouse. Here it was restricted to a small area of approximately 2.5 m^2 of coarse-fibred peat moss in a greenhouse bench. A thorough search in the other greenhouses resulted in the capture of two juvenile spiders in House C and two adult females in House B. The reason for their abundance in the service greenhouse is unclear.

Triaeris stenaspis Simon, 1891

Diagnosis: This oonopid spider can be identified using the key in NENTWIG et al. (2003) and by the pictures in KORENKO et al. (2007: 7, f. 4-8). Characteristic features are the large dorsal scutum and the small ventral scutum on the abdomen.

Distribution: USA to Venezuela, West Indies, introduced to Europe (PLATNICK 2008). In Europe known from the Czech Republic, Finland, France, Great Britain, Ireland and Slovakia (VAN HELSDINGEN 2008). New to Germany.

Material: House 10, 30 May 2008, 5 ♀♀, 5 June 2008, 2 ♀♀, 25 June 2008, 10 ♀♀, 3 September 2008, 11 ♀♀, 1 juv; House 14, 21 August 2008, 3 ♀♀; House B, 5 August 2008, 5 ♀♀, 5 November 2008, 1 ♀, 24 November 2008, 2 ♀♀; House C, 11 July 2008, 9 ♀♀, 3 juv., 17 July 2008, 29 ♀♀, 21 August 2008, 20 ♀♀; House D, 12 June 2008, 1 ♀, 25 June 2008, 3 ♀♀, 11 July 2008, 4 ♀♀, 5 August 2008, 5 ♀♀, pitfall traps; House E, 5 August 2008, 2 ♀♀.

Triaeris stenaspis is a well-established element of the exotic spider fauna in European greenhouses. SIMON (1896) discovered it in the greenhouses of the Jardin de Plantes in Paris just a few years after he described the species from the Caribbean island of St. Vincent. In Europe, the species was found exclusively in greenhouses (KOPONEN 1997, KORENKO et al. 2007, LOCKET & MILLIDGE 1951). GEITER et al. (2002) listed *T. stenaspis* as an introduced species in Germany due to a misinterpretation of data given in EICHLER (1952).

Like many other goblin spiders, *T. stenaspis* appears to live on the ground in the litter-layer (EDWARDS & EDWARDS 2006, JOCQUÉ & DIPPENAAR-SCHOEMAN 2007). Oonopids build no webs; ground-dwelling species in rainforests are "litter stalkers" (HÖFER & BRESCOVIT 2001). KORENKO & PEKÁR (2008) reared *T. stenaspis* in the laboratory and studied the life history of the species. The spiders lived about six months. *T. stenaspis* proved to be parthenogenetic. The females laid two eggs at a time and on the average only 27 eggs in their lifetime.

The species was collected in several service greenhouses in Berlin-Dahlem, and in practically all display greenhouses with a minimum temperature of 20 °C. It was most common in substrates with a high percentage of peat moss. Very few individuals were caught in pitfall traps compared to the high numbers collected by hand.

Heteroonops spinimanus (Simon, 1891)

Diagnosis: The species resembles the European oonopid *Tapinesthis inermis* (Simon, 1882) in size as well as in the lack of scuta. Unlike *T. inermis*, the legs bear spines. *H. spinimanus* can be distinguished from other members of the family by the shape of the palpal patella and the conspicuous spines on the palpus (CHICKERING 1969: 175, f. 28-32, SAARISTO 2001: 352, fig. 170-174).

Distribution: USA to Panama, West Indies, St. Helena, Seychelles (PLATNICK 2008). New to Europe.

Material: House 14, 21 August 2008, 1 ♀; House C, 17 July 2008, 1 ♀; House D, 25 June 2008, 1 ♀, vid. R. Jocqué.

Heteroonops spinimanus is widespread in Central America and the southern United States (CHICKERING 1973). It has been introduced to St. Helena and the Seychelles. The male of *H. spinimanus* is unknown (CHICKERING 1973), and the species is believed to be parthenogenetic (SAARISTO 2001). This is apparently the first record of *H. spinimanus* from a greenhouse.

Information on the habitat preferences of *H. spinimanus* is scarce. It is a litter-dwelling spider, confined to humid tropical or subtropical climates. In a rain forest in Puerto Rico, the species reached a density of about 14 individuals m^2 in the litter layer (PFEIFFER 1996). COREY et al. (1998) caught a single individual in xeric pineland in Florida. In

Panama, CHICKERING (1973) found it to be more abundant in mountainous regions.

In the Dahlem greenhouses, *H. spinimanus* was very rare compared to *T. stenaspis*. Only three females were collected. Nevertheless, the catches in three different greenhouses point to an established population of this spider in the greenhouses.

Oecobius navus Blackwall, 1859

Diagnosis: Members of the family Oecobiidae are easily recognized by a large anal tubercle with a conspicuous fringe of setae (JOCQUÉ & DIPPENAAR-SCHOEMAN 2007). *O. navus* can be distinguished from other members of the genus by the epigyne or palpus (SANTOS & GONZAGA 2003: 241, f. 1-5, WUNDERLICH 1995: 605, f. 31-35). In the past, the species has been confused with *O. annulipes* Lucas, 1846. Older studies on *O. annulipes* refer in most cases to *O. navus* (SANTOS & GONZAGA 2003, VOSS et al. 2007).

Distribution: Cosmopolitan (PLATNICK 2008). In Europe recorded from Belgium, Estonia, France, Greece, Italy, Portugal, Latvia, Malta, Netherlands and Spain (VAN HELSDINGEN 2008). New to Central Europe.

Material: House 7, 17 March 2008, 1 ♀, leg. J. Esser, 23 May 2008, 1 ♀, 2 juv.; House 9, 5 June 2008, 1 ♀; House 10, 30 May 2008, 1 ♂.

Oecobius navus was described from specimens found in Madeira (BLACKWALL 1859). The Macaronesian islands harbor a remarkable diversity of species of the genus *Oecobius* (WUNDERLICH 1995). *O. navus* might have originated there. Today, this spider has been spread by man to many parts of the world including such remote and isolated places as St. Helena (ASHMOLE & ASHMOLE 2004) or Macquarie Island south of Australia (FORSTER 1962).

It has been introduced to the Netherlands in the 19th century (VAN DER HAMMEN 1949b, VAN HELSDINGEN 1999). Records in Belgium date back to 1985 (VAN KEER 2007). In Estonia it was recorded for the first time in 1974 (VILBASTE 1974) and occurred shortly afterwards in Latvia (STERNBERGS 1980). In recent years it was found in Finland, too (M. Huttunen in litt.).

In Central Europe, the family Oecobiidae was present until now with the record of a single male of *Oecobius maculatus* Simon, 1870. The specimen was found on a railroad embankment in the city area of Basel (Switzerland) and is believed to have been imported by train (HÄNGGI 2003, BRENNEISEN & HÄNGGI 2006).

The popular English name "urban wall spider" refers to the preferred site for the webs of *O. navus* in urban environments. In favorable climate, the spiders build their webs on the outside of buildings (SANTOS & GONZAGA 2003, VOSS et al. 2007), but have also been found under rocks in coastal areas (GLATZ 1967) or bush land and in caves. In northern Europe and Japan, they live in the interior of buildings (MIYASHITA 1992, VAN KEER 2007, VILBASTE 1974). VAN KEER (2007) doubted the ability of *O. navus* to live outside of buildings in Belgium. Contrary to this, STERNBERGS (1980) reported that the spider lives in crevices of tree bark in Latvia. It was found there even after a hard winter. According to GLATZ (1967) *O. navus* prefers ants as prey. This is supported by VOSS et al. (2007), who found ants and various dipterans as prey items with one ant species as the most common prey.

Oecobius navus was found in three service greenhouses of the Botanic Garden. Spiders built their webs on rough concrete walls and painted brick walls. The population didn't seem to be very large. Some individuals were noticed beside the ones collected. A female was observed for several months on the same spot.

Zodarion italicum (Canestrini, 1868)

Diagnosis: *Z. italicum* is readily identified using the key in NENTWIG et al. (2003). ROBERTS (1987: 172-173, f. 89, plate C) provides an illustration of the general appearance as well as figures of the male palpus and female epigyne.

Distribution: Europe (PLATNICK 2008, for a map see PEKÁR et al. 2005), Caucasus (MIKHAILOV 1997). New to eastern Germany.

Material: House I, 23 May 2008, 1 ♂, pitfall trap.

As with many other invertebrates, this Southern European spider is extending its range to the North and has been reported as an invasive species from several countries, including Austria (KOMPOSCH 2002), Switzerland (BLICK et al. 2006) and Belgium (VAN KEER et al. 2006). In Germany it has been caught mainly in the south-west (STAUDT 2008). The spider was often recorded in man-made habitats on railroad yards, airports and the like (MALTEN et al. 2005, PEKÁR et al. 2005, VAN KEER et al. 2006). It prefers open sites with sparse vegetation and sandy or gravelly soil. *Z. italicum*

has even been found to colonize green roofs in the city of Basel (BRENNEISEN & HÄNGGI 2006). In Berlin-Dahlem, one single specimen was caught in a display greenhouse with cactuses. Since *Z. italicum* does not require tropical or subtropical conditions, the spider probably immigrated from outside. No data on the spider fauna of the outdoor garden were available.

Zodarion-species feed exclusively on ants (PEKÁR et al. 2005). No other ant-hunting spiders were collected in the display greenhouses with the exception of a single specimen of *Phrurolithus festivus*. This ant-mimicking species is known to prey on ants (CUSHING 1997). The absence of other ant-hunting spiders is surprising considering the large number of ants in the greenhouses.

Conclusions

The survey of the spider fauna in the greenhouses of the Botanic Garden Berlin-Dahlem yielded a number of interesting records. On the other hand, several alien spiders recently found in European greenhouses were not recorded in the present study. A good example to this is *Uloborus plumipes* Lucas, 1846. In 1989, the species was recorded for the first time in Germany (KÜMHOF et al. 1992). Today it can be found in greenhouses, garden centers and flower shops all over the country. In Berlin, the species was caught in a butterfly house in 1995 (BROEN & RUDLOFF 1996) and is now ubiquitous. It is a conspicuous spider, and easily spotted due to its typical resting posture in the web. Nevertheless, I never encountered it in the Dahlem greenhouses. Unlike other institutions, the Botanic Garden does not normally buy plants from commercial suppliers. Plant material is collected during field trips or acquired through exchange with other botanic gardens. Thus, the species composition of the exotic spider fauna in greenhouses seems to depend chiefly on the specific modes for acquisition of plants and plant substrate.

A common feature of the ochyroceratid and oonopid spiders found in the Botanic garden is the parthenogenetic reproduction. Parthenogenesis seems to be advantageous for colonization. Introduction of a single female of the species is sufficient to establish a population. These tiny spiders showed a heterogeneous, patchy distribution in the greenhouses. When they occur in low numbers, they are hard to find. In Berlin Dahlem, they were probably not recent immigrants, but had been overlooked in other studies. Most likely they can be found in other German greenhouses as well, at least the most common species *T. stenaspis*.

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Appendix

Tab. 2: Catch numbers of spiders in the greenhouses of the Botanic Garden Berlin-Dahlem in 2008. Please note: Differences in numbers do not reflect actual differences in abundance (+ = observations; * = one or more juvenile spiders raised to maturity).

	Cooler greenhouses			Hothouses		
Species	male	female	juv.	male	female	juv.
Amaurobius ferox		3	1			
Araneus diadematus		1	+			
Enoplognatha ovata	1					
Erigone atra		1			3	
Erigone dentipalpis	1					
Ero aphana			1			
Harpactea rubicunda			1*			
Hasarius adansoni				4	2	11*
Heteroonops spinimanus					3	
Lepthyphantes leprosus		2				
Liocranum rupicola			3*			
Meioneta rurestris	1			2	3	
Oecobius navus				1	3	2
Parasteatoda tepidariorum	2	3		+	+	+
Pholcus phalangioides	+	+	+	1	3	
Phrurolithus festivus	1					
Pseudeuophrys lanigera	1	2	1			
Psilochorus simoni	3	7	4			1
Salticus scenicus		2				
Segestria bavarica		1				
Steatoda grossa	2	1	8		+	+
Tegenaria atrica		2	1		+	
Tenuiphantes tenuis	2	2				
Textrix denticulata	1	1			+	
Theotima minutissima					119	2
Tiso vagans	1					
Triaeris stenaspis					112	4
Troxochrus scabriculus		1				
Zodarion italicum	1					
Zygiella x-notata		1	2*			