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Authors: Ballarin, Francesco, Salmaso, Roberta, and Latella, Leonardo

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## The arachnological collections of the Museo Civico di Storia Naturale of Verona (Italy): an overview

Francesco Ballarin, Roberta Salmaso & Leonardo Latella



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**Abstract.** The arachnological collections of the Museo Civico di Storia Naturale of Verona, Italy, contains roughly 20000 vials, including approximately 2000 species of Araneae and other Arachnida from all over the world. Within the collection, type material represents an important proportion with a count of more than 373 type series. All samples are distributed within four main collections: Brignoli, di Caporiacco, Museo Zangheri and 'Generale'. A further collection of 99% ethanol-preserved samples for molecular analysis is currently under preparation. A detailed list of all the arachnological type material stored in the museum is provided.

**Keywords:** Lodovico di Caporiacco, Natural History collections, Paolo Marcello Brignoli, Pietro Zangheri, spiders, type material

**Zusammenfassung. Die arachnologischen Sammlungen des Museo Civico di Storia Naturale Verona (Italien): ein Überblick.** Die arachnologischen Sammlungen des Museo Civico di Storia Naturale Verona umfassen rund 20000 Proben, darunter fast 2000 Arten Spinnen und andere Arachnida aus der ganzen Welt. Innerhalb der Sammlung hat das Typenmaterial mit mehr als 373 Serien einen wichtigen Anteil. Die Proben verteilen sich auf vier Hauptsammlungen: Brignoli, di Caporiacco, Museo Zangheri und 'Generale'. Eine weitere Sammlung mit Proben in 99% Ethanol für molekulare Analysen ist im Aufbau. Eine detaillierte Liste aller arachnologischen Typen des Museums wird präsentiert.

**Riassunto. Le collezioni arachnologiche del Museo Civico di Storia Naturale di Verona: una panoramica.** Vengono qui brevemente illustrate le collezioni aracnologiche conservate presso il Museo Civico di Storia Naturale di Verona (Italia). Il materiale preservato è composto da circa 20000 esemplari e 2000 specie di ragni e altri aracnidi provenienti da paesi di tutto il mondo. Tra questi sono inclusi 373 tipi. Tutti gli esemplari sono suddivisi in quattro collezioni principali: Brignoli, di Caporiacco, Museo Zangheri e 'Generale'. Una ulteriore collezione comprendente campioni conservati in etanolo puro per analisi molecolari è in corso di preparazione. Si allega una lista dettagliata di tutto il materiale tipico conservato presso il museo.

As a record of the present and past diversity of living organisms, natural history collections play a crucial role in the study of Nature (Drew 2011). Specimens housed in museums are commonly used by researchers as a data source in various study areas including taxonomy, biogeography, ecology and genetics. Among the preserved material stored in collections are types that represent unique, irreplaceable samples of high scientific relevance. One of the main functions of a natural history collection is to preserve the voucher specimens, particularly types, for the future. Such material should be freely accessible to researchers, as defining species and assessing intraspecific variation is a vital part of biology. Museums must also organise and share lists of the type material preserved in their collections (ICZN 2012: recommendation 72F). The role of museums and other scientific institutions in specimen preservation and data sharing is particularly important in modern times, due to the current crisis of biodiversity (Shaffer et al. 1998), of taxonomy (Agnarsson & Kuntner 2007) and of natural history museums, especially in Italy (Latella 2011, Andreone et al. 2014).

The Museo Civico di Storia Naturale of Verona (MSNVR, Italy) houses unique zoological collections of land and water invertebrates, including arachnids, crustaceans, insects, molluscs and tardigrades. The arachnological collections in particular represents an excellent resource, including thousands

of specimens and hundreds of species, mostly spiders, from all around the world. Type material represents an important fraction of the stored samples, considerably increasing the scientific value of the collections as a whole. Nevertheless, despite the undeniable taxonomic and systematic importance, the typology, composition and even existence of the MSNVR spider collections remain poorly-known among international arachnologists. Herein we summarise the features of these collections, providing a synthesis of the preserved material and a detailed list of the hosted types.

### Material and methods

Over the last 10 years, several attempts to revise the general state of the hosted arachnological collections have been carried out by the staff of the MSNVR and external collaborators. As a result of this effort, all information regarding preserved samples, previously existing only in paper archives, has gradually been digitised. We established a comprehensive database for each of the main collections. Data reported includes species names, number and sex of specimens, label data, jar code and any other potentially useful information related to each vial. In order to minimise error, data acquired from the paper archives were checked directly where possible, by inspecting the tubes in the collections. When data mismatching occurred, we consulted the bibliography relating to the incongruent samples. Type labels were revised, updating the names of taxa as reported in the World Spider Catalog (2020). A similar revision is currently in progress for all preserved species. Types of species currently under synonymy were excluded from the list of type material. The complete list of preserved specimens is still under review and temporarily available to the staff of the MSNVR only, thus not being freely accessible. Nevertheless, information concerning specific samples or species can be requested by researchers directly contacting the museum or the authors of this manuscript.

Francesco BALLARIN, Roberta SALMASO & Leonardo LATELLA, Department of Zoology, Museo Civico di Storia Naturale of Verona, Lungadige Porta Vittoria, 9, I-37129 Verona, Italy; E-mails: ballarin.francesco@gmail.com, roberta.salmaso@comune.verona.it, leonardo.latella@comune.verona.it  
Francesco BALLARIN, Systematic Zoology Laboratory, Department of Biological Sciences, Tokyo Metropolitan University 1-1 Minami-Osawa, Hachioji-shi, Tokyo, 192-0397, Japan; E-mail: ballarin.francesco@gmail.com

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## Results

### Collection summary

A total of more than 20000 vials and approximately 2000 species of spiders and other arachnids are currently preserved in the MSNVR. The list of type material is reported in the Supplementary Tab. 1. It includes 373 type series divided as follows: 143 holotypes/lectotypes/neotypes, 153 paratypes/paralectotypes, five allotypes/parallotype and 72 syntypes. These types represent 301 taxa: 296 Araneae belonging to 41 families, two Opiliones, two Schizomida and one Ricinulei.

Spiders (Arachnida: Araneae) also represent the vast majority of the housed samples (>90%), with more than 1800 species from approximately 70 countries around the world. Other orders of Arachnida included in the collections, but represented in much smaller numbers, are: Acari, Amblypygi, Opiliones, Pseudoscorpiones, Ricinulei, Schizomida, Scorpiones, Solifugae and Uropygi. All specimens are currently shared within four main collections: Brignoli, di Caporiacco, Museo Zangheri and 'Generale'. Three collections are composed of arachnological material studied during periods of scientific activity of their former owners; thus, they are named after their authors: the Italian arachnologists Paolo Marcello Brignoli, Lodovico di Caporiacco and the botanist and naturalist Pietro Zangheri. In contrast, the collection 'Generale' has a wider origin. It includes the specimens collected during local or international field campaigns and research projects set by the MSNVR over the years and studied by various Italian or foreign arachnologists. In addition to the main collections, a separate assortment of pure ethanol-preserved samples for molecular study is currently under construction.

### Collection Brignoli

The Brignoli collection (Fig. 1) includes the arachnological material preserved and studied by the famous Italian arachnologist Paolo Marcello Brignoli (Rome, 25. Apr. 1942 – L'Aquila, 8. Jul. 1986). As the chief director of the Institute of Zoology and later Botany, at the University of L'Aquila, Italy, Brignoli had a short but fruitful scientific career. Known by colleagues and friends for his brightness and his love for cigars, Brignoli consistently contributed to the study of arachnology, publishing more than 200 scientific articles in approximately 20 years of activity (Osella 1987). His works included taxonomy, evolutionary systematics and the biogeography of spiders from all over the world. On a minor scale, he studied the biogeography of other orders of arachnids. Such scientific effort led to the impressive results of the establishment of 25 new genera and the description of more than 370 species (Bologna 1986, Osella 1987, Vigna Taglianti 1986). Several types designated by Brignoli are currently preserved in the MSNVR. The Brignoli collection, together with his extensive arachnological library, was donated to the MSNVR by Brignoli's wife after he passed away in 1986. It consists of roughly 16000 specimens and 6700 vials preserved in 570 jars. They include approximately 1200 species and 226 type series. Most of the species belong to the order Araneae (~1100 species), followed by Opiliones (60 species), Schizomida (9 species), Amblypygi (7 species), Solifugae (5 species), Ricinulei (4 species) and Scorpiones (2 species). All samples preserved in the Brignoli collection were gathered by Brignoli himself and his collaborators during numerous field collections in Europe, Africa, South America and Indochina, or donated



Fig. 1: Part of the Brignoli collection

to him by more than 280 other collectors. As a consequence of such extensive collection effort, the geographical origin of the preserved material covers a wide geographical range, including over 60 different countries. It is currently a closed collection, as it is no longer being developed.

### Collection di Caporiacco

This collection includes a portion of the large amount of arachnological material studied by the Italian arachnologist and explorer Lodovico di Caporiacco (Udine, 22. Jan. 1900 – Parma, 18. Jul. 1951). Di Caporiacco started his career as an Assistant Professor at the University of Florence and later progressed to Professor of Zoology at the University of Parma, Italy. During his scientific career, di Caporiacco had the opportunity to study a wide range of arachnid species collected by him or other contemporary researchers. His field campaigns extended to Africa, Central Asia, Central and South America, as well as Italy and other Mediterranean regions (Colosi 1951, Monterosso 1953, Glerean 2011). Di Caporiacco's former arachnological collection is currently split among different Italian institutions. The material preserved in the MSNVR consists of arachnid specimens collected in Kenya in the years 1944–1946 by two Italian zoologists, Augusto Toschi and Ferruccio Meneghetti. The collected material was subsequently studied and published by di Caporiacco (1949). Donated to the MSNVR in 1979, the collection includes 342 species and 74 type series, most of which hail from the surroundings of Nairobi. Araneae are the most-represented order (324 species), but other arachnids are also included in the collections: Solifugae (six species), Opiliones (five species), Scorpiones (four species) and Pseudoscorpiones (three species). The collection is closed.

### Arachnological collection of the Museo Zangheri

The arachnological collection of the Museo Zangheri (Zangheri's Museum, Fig. 2) is part of the much larger selection of natural material forming the Zangheri Museum of Romagna, currently housed in the MSNVR. Pietro Zangheri (Forlì, 23. Jul. 1889 – Padua, 25. Feb. 1983) was a botanist and passionate naturalist. Zangheri was active in the first half of the 20<sup>th</sup> century in his hometown, Forlì, in the Romagna area (south-eastern part of the Emilia-Romagna, north-east Ita-



**Fig. 2:** Arachnological collection of the Museo Zangheri

ly). During his life, Zangheri collected and catalogued an impressive array of botanical, zoological and geological samples, numbering approximately 150000 in total, all from the Romagna surroundings. His collections include a total of 15374 taxa: 10623 animals, 3683 plants and 1068 fossils (Zangheri 1970). He collected, prepared and catalogued all his specimens and stored them in his private museum. Specimens that he could not identify were sent to other Italian or foreign specialists with whom Zangheri was in constant contact (Latella 2020). The noteworthy arachnologists Pietro Alicata, Jacques Denis, Eduard Reimoser, Eugène Louis Simon, Lodovico di Caporiacco and Paolo Tongiorgi were among Zangheri's contacts.

In 1968, Zangheri donated all of his collections to the MSNVR, thanks to his long-standing friendship with Sandro Ruffo, at that time the director of the Museum. As the only condition for the donation, Zangheri requested that all his material would always be kept together in a single collection, named the Museo Zangheri di Storia Naturale della Romagna (Zangheri's Natural History Museum of Romagna).

The arachnological section of the Museo Zangheri consists mainly of Araneae (397 species, including 2 types) and Acari (409 species), but other classes of arachnids are also included, such as Opiliones (39 species), Scorpiones (2 species) and Pseudoscorpiones (20 species). All specimens were collected in the Romagna area. As the collections mentioned before, the Museo Zangheri collection is also closed.

### Collection 'Generale'

The collection 'Generale' (= general) was originally formed by merging the preserved material from several minor arachnological collections donated to the MSNVR by Italian and foreign researchers like the Austrian arachnologist Erich Krietscher. Spider specimens collected and studied by the Museum's staff and collaborators are also included. A total of approximately 3500 samples are preserved in 136 jars, including 700 species and 80 type series. Most of the material is derived from field campaigns conducted by the MSNVR during the second half of the 20<sup>th</sup> century. Specimens were collected in different localities throughout Italy (for example, Tremiti and the Egadi Islands, the Northern Apennines, the mountains Aspromonte, Sibillini, Matese and Sila and

the regions of Veneto and Apulia) and other Mediterranean areas such as the Balkans, Iberian Peninsula, Greece and Turkey. Although less well-represented, specimens from Central, Southern and Eastern Asia are also included, comprising species studied more recently (Marusik & Ballarin 2011a, 2011b, Logunov et al. 2011, Ballarin et al. 2012, Marusik et al. 2014). A part of the preserved material consists of troglomorphic spiders collected in subterranean environments. Such samples were gathered during the numerous biospeleological research trips carried out in Italy, or in other Eurasian countries by the MSNVR and its collaborators (Latella 2005, Latella & Zorzin 2008, Ballarin et al. 2008, Ballarin 2020).

The collection 'Generale' is currently open, with new specimens frequently added as field collection and studies progress.

### Molecular collection

In addition to standard-preserved samples, a new assortment of arachnid specimens preserved in 99% ethanol for molecular analysis is currently under development at the MSNVR. Such material consists of freshly-collected spider, harvestman and pseudoscorpion samples, mainly derived from recent collections in Italy and, in smaller numbers, from other Eurasian countries. Specimens are permanently stored at -40°C. Approximately a quarter of the material has been identified to genus or species level, but most of the samples are currently organised by family or remain unsorted until they are identified. The main goal of this newly-established collection is to promote future molecular studies on the Italian arachnological fauna, hosting representative species of arachnids distributed in the Italian peninsula. Although still at its initial stage, the collection is expected to gradually increase in size as the studies set by the MSNVR on the Italian spider fauna proceed.

### Unstudied material and the future of the collections

Together with the studied material from the Brignoli, di Caporiacco and 'Generale' collections, a wide number of still unstudied specimens are currently being housed in the storage rooms of the MSNVR. Such material, preserved in 70% ethanol for morphological analysis, includes roughly 35000 specimens from more than 65 countries that Brignoli or other authors gathered over the years and did not have the opportunity to study in detail. A large part of the material is derived from collecting campaigns organised by the MSNVR from the 1960s to the 1980s in Greece, Mexico, Spain, Turkey, South America, Indochina and various regions of Italy (Calabria, Puglia, Sicily, Veneto, etc.). Together with a large number of Araneae, further unsorted specimens of other arachnid orders such as Acari, Amblypygi, Opiliones, Palpigradi, Pseudoscorpiones, Ricinulei, Schizomida, Scorpiones, Solifugae and Uropygi are also present. The undetermined material is currently under rearrangement by the staff of the MSNVR, who are sorting the samples by family in order to facilitate their study by local and international arachnologists.

### Conclusions

The MSNVR conducts a vital role in preserving and ensuring the availability of the numerous species hosted in its collections. The high number of preserved samples and types makes the arachnological collections of the MSNVR indispensable for taxonomic and systematic studies of spiders and, on a



smaller scale, of other arachnid orders. The wide geographical range covered by the preserved material further provides important information about the biogeography and historical distribution of numerous species of arachnids, particularly concerning the Italian and other Mediterranean araneofauna. In this context the di Caporiacco and the Museo Zangheri collections represent a special case, hosting a significant number of species collected from a small and well-defined area of study. The arachnofauna of Kenya is currently very poorly-studied and most of the Kenyan species described by di Caporiacco have not been subsequently collected or studied in recent times. Besides its taxonomic value, the di Caporiacco collection may provide unique historical information about the diversity and species richness of Kenyan arachnids to future researchers. The arachnological section of the Museo Zangheri, instead, represents a unicum within the Italian naturalistic panorama. Being formed by extensive collections systematically carried out for nearly 50 years within a limited area in the Emilia-Romagna region, such material allows us to have a comprehensive view of the Italian arachnofauna of a specific portion of Italy.

In addition to the already-determined and published specimens, the unstudied arachnological material preserved at the MSNVR, represents a further source of useful data and of potential new species for future taxonomic and biogeographic research. Finally, the progressive addition of fresh samples and the establishment of a molecular collection allows the arachnological collections of the MSNVR to keep pace with modern research concerning spiders and other arachnids and future genetic research in arachnology.

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### Electronic supplement

Supplement Tab. 1: List of the type specimens hosted in the arachnological collections of the MSNVR