

Chapter 53

STUTTGART: The Zoological Collections of the Stuttgart State Museum of Natural History

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Abstract Emerging from the sixteenth century “Cabinet of Arts and Natural Curiosities” of the Dukes of Württemberg, the Stuttgart State Museum of Natural History (SMNS) ranks among the oldest and most prominent natural history museums in Europe. With its collections, libraries, laboratories, and other research facilities, the museum comprises two building complexes both with extensive exhibition and storage areas. The permanent exhibitions at Museum Schloss Rosenstein and Museum am Löwentor are tightly interwoven in form and content. Today, the SMNS collections hold more than 12 million specimens and other natural objects as well as numerous associated data on taxonomy, genetics, ecology, and geography. Together these comprehensive records and archives of life on Earth and its history constitute a large-scale research infrastructure used by research scientists and the international community. Characteristic of the SMNS is the tight collaboration between its paleontologists and researchers working on extant fauna.

Keywords SMNS • Museum am Löwentor • Schloss Rosenstein • Naturkundemuseum • Willi Hennig • Württemberg

53.1 The Museum’s Infrastructure

The museum is carried by the Federal State of Baden-Württemberg. In 2014, its annual balance amounted to 8.3 million euro, of which government funding made up 7.0 million euro. The remaining budget was acquired by external funding and

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entrance fees to the exhibitions (Eder 2015). An independent scientific advisory council supports the SMNS in its strategies and policies. The museum is also backed up by the “Gesellschaft zur Förderung des Naturkundemuseums Stuttgart e.V.”, a society established in 1912 by friends of the museum to financially and ideationally support the mission of the SMNS, in particular the development of its collections.

As of 2015, the SMNS employs a permanent staff of 96 persons. These comprise scientific, technical, and administrative positions. Additionally, 49 persons including Ph.D. students and scientific and technical trainees are contracted on a temporary basis. More than 200 honorary assistants—some of them former staff but many of them dedicated laymen—commit parts of their spare time to work in the museum.

The staff is organized into four research departments (botany, entomology, paleontology, and zoology) and departments of administration, exhibitions, as well as education and public relations.

The museum’s staff, collections, and exhibitions are accommodated in two main complexes of buildings: the “Museum am Löwentor” (Fig. 53.1) and the “Museum Schloss Rosenstein” (Fig. 53.2). Two additional locations provide space for provisional outsourcing of various voluminous collections and only temporarily used equipment, e.g., for special exhibitions. These locations—all within walking distance—provide space of 24,000 m² in total.

The *Museum am Löwentor* (opened 1985, 15,800 m²) houses the permanent paleontological exhibition and provides room for temporary special exhibitions.



Fig. 53.1 Museum am Löwentor, exhibition hall (with permission from: SMNS; photo: R. Baumann)



Fig. 53.2 Museum Schloss Rosenstein (with permission from: SMNS; photo: U. Schmid)

Furthermore, most laboratories and equipment, seminar rooms, the main library, most offices, the museum administration, and the major part of the collections are located here (herbarium, insect collection, large parts of the paleontological collection, as well as the malacological, mammalogical, and osteological collections).

The *Museum Schloss Rosenstein* (built in the 1820's, part of the SMNS since 1954, 5000 m²) features the permanent exhibition of extant fauna and flora and also provides room for temporary exhibitions. Additionally, it houses the ornithological collection, laboratories for taxidermy, seminar rooms, and several offices.

The SMNS maintains numerous, well-equipped scientific laboratories to support research and exhibitions. Apart from labs specifically serving the needs of paleontological research (sieving, acid etching, hydrofluoric acid maceration, grinding, rock cutting, and sandblasting), the following labs and devices are available at the SMNS:

Molecular Laboratory (Fig. 53.3)

DNA/RNA extraction, amplification, and analysis are facilitated by state-of-the-art PCR equipment as well as modern robotics and a fragment analyzer. Biological tissues and extracted DNA are stored in ultralow temperature freezers (−80 °C).

Nitrogen Chamber For effective pest control, museum objects—especially new acquisitions—are treated in a large nitrogen chamber (12 m³) or are temporarily stored in ultralow temperature freezers.

Degreasing Facility A computer-controlled degreasing device (volume 150 l, closed circuit) allows for degreasing of bones.



Fig. 53.3 Molecular laboratory (with permission from: SMNS; photo: A. Staniczek)

Taxidermy Laboratories (Fig. 53.4)

Spacious and well-equipped taxidermy labs allow for high-quality preparation, restoration, and modeling (Fig. 53.5) of zoological objects. Besides traditional techniques, the lab also permits polyethylene glycol (PEG) treatment to obtain a lifelike appearance and preservation of animals. Over the past years, SMNS taxidermists have been awarded very prestigious prizes in European and world championships in their field (Fig. 53.6).

Histology Laboratory Serial thin sections are obtained with a Leica 1516 rotary microtome and subsequent staining.

Micro-CT Scanner (Fig. 53.7)

A Bruker Skyscan 1272 tomographic device generates 3D renderings of biological objects and is mainly used to investigate internal structures in a wide range of taxa.

Optical Laboratories Optical instruments at the SMNS include a digital microscope (Keyence VHX-500D) and a fully apochromatic zoom system (Leica Z16 APO A macroscope) to generate focus-stacked images. A scanning electron microscope (Zeiss Evo LS 15) allows the study of (type) material at different temperatures, humidity, and pressure without prior sputter coating (Fig. 53.7).

High-Resolution Scanners Specialized scanners deliver high-resolution images of insect boxes and herbarium sheets for efficient digitization of collections.



Fig. 53.4 Taxidermy laboratory (with permission from: SMNS; photo: A. Staniczek)



Fig. 53.5 Modeling an ancient dragonfly (with permission from: SMNS; photo: G. Bechly)

53.2 History

The history of the museum has been reviewed several times before (e.g., Lampert 1896; Rauther 1940; Schüz 1964; Adam 1991a, b; Fricke 1991; König 1991; Möhn 1991; Renner 1991; Ziegler 1991a, b; Warth and Ziegler 1991; Woog et al. 2003).

Fig. 53.6 Award-winning display of a white-faced saki (*Pithecia pithecia*) by SMNS taxidermist Jan Panniger, European Taxidermy Championship 2014 (with permission from: SMNS; photo: U. Stübler)



Much of the information given below—focusing on the zoological collections—is drawn from these contributions. For details on the museum’s paleontological, mineralogical, and botanical collections, we refer to these sources.

The oldest parts of the collection date back to the sixteenth century and were originally incorporated in the private “Cabinet of Arts and Natural Curiosities” of the Dukes of Württemberg (Fig. 53.8). Like many European aristocrats at that time, they had a strong interest in collecting art and natural curiosities. Natural objects comprised minerals, fossils, marine, and terrestrial animals. Up to now, the skull remains of a Pleistocene giant elk collected in 1600 count as the oldest preserved object of the museum collection.

From 1762 to 1791, Johann Friedrich Vischer (1726–1811) was responsible for the natural history collections amounting to 10,000 objects at the end of his career. He arranged its zoological part in systematic categories like mollusk shells, insects (including all other arthropods), fish, amphibians (also including reptiles), birds, and tetrapods.

In 1783, the private “Cabinet of Arts and Natural Curiosities” was made accessible to the scholars of the local “Hohe Carls-Schule”, a military academy and elite school for sons of distinguished families. Among them was Georges



Fig. 53.7 SEM and μ -CT laboratory (with permission from: SMNS; photo: A. Staniczek)

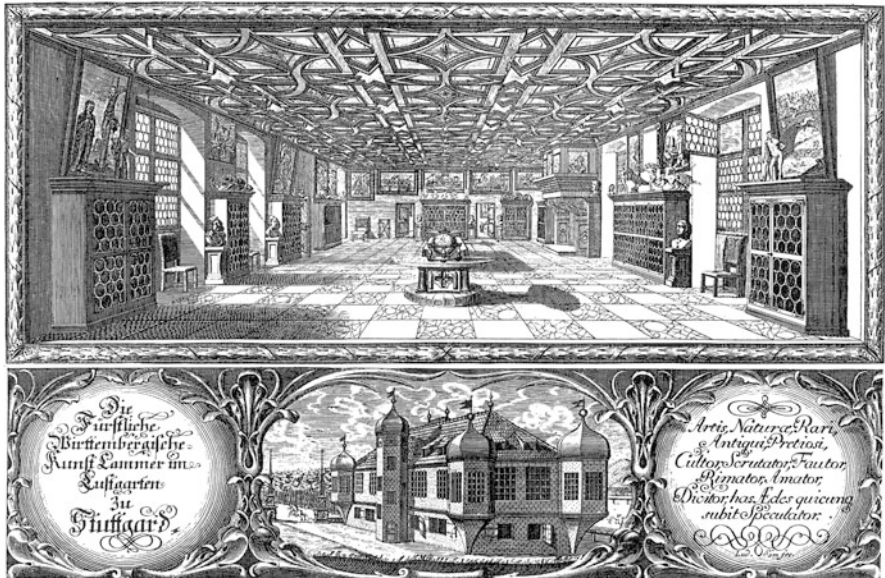


Fig. 53.8 The origins of the SMNS: The “Cabinet of Arts and Natural Curiosities” before 1746. Etching by Ludwig Som (Heimatmuseum der Stadt Ludwigsburg) (Photo: © with SMNS)

Cuvier (1769–1832), who studied in Stuttgart from 1784 to 1788. It was here that he received the stimulus for his groundbreaking studies on geology and paleontology.

The rapid growth of the collection soon made it necessary to separate natural objects from the remaining collectables. Through a decree in 1791, Carl Eugen, Duke of Württemberg, appointed four curators with respective responsibilities for art, minerals, plants, and the animal kingdom. This decree thus marked the starting point of what later would become the Stuttgart State Museum of Natural History. In 1792, Carl Friedrich Kielmeier (1765–1844) became the first curator of zoology. His successors developed the rapidly growing collections according to the swift increase of knowledge in systematic zoology. In the 1820's, the museum moved to a new, more spacious building within the city center of Stuttgart (Fig. 53.9). The volume and species diversity of arthropods in the collection then resulted in the appointment of lepidopterist Ernst Hofmann (1837–1892) as the first curator of entomology in 1869. He would later be known as the author of his magnum opus “Die Gross-Schmetterlinge Europas”.

During the nineteenth century, numerous explorers—many of them with Swabian roots—enlarged the zoological collections by donating or selling their collected specimens to the museum. The first significant contribution of material from overseas was made by Baron Carl von Ludwig (1784–1847), who traveled and worked in South Africa as a pharmacist and banker. In his spare time, he collected insects, plants, and vertebrates, which he regularly sent back to Stuttgart. Of considerable importance is his collection of smoky moths (*Zygaenidae*) from the Cape region. His South African collection was later complemented with two Cape lions donated by Stuttgart-born theologian Christian Barth (1799–1862). As only



Fig. 53.9 The historical museum building at Neckarstrasse around 1840 (Photo: © with SMNS)

seven specimens of this extinct lion form are preserved in the world's natural history museums, the two mounted skins in Stuttgart are a prominent part of the zoological collection.

The first major contribution to the insect collection was made by lawyer Karl von Roser (1787–1861), whose interest in natural history was sparked by lectures of Kiehmeyer, the museum's first curator of zoology. Aside from his career in administration—he eventually became the minister of foreign affairs in Württemberg—von Roser managed to assemble a large number of insects, both local fauna and material from overseas, today still forming the historical basis of the museum's entomological collection. Duke Paul Wilhelm von Württemberg (1797–1860) was a globe-trotter with a particular focus on North America. After his death, considerable parts of his collection were acquired by the museum, among these many bird skins and drawings. The butterfly collection of bird wings (*Ornithoptera*), donated in 1865 by King Carl and King Wilhelm II, both royals of Württemberg, most probably also had been collected by Duke Paul Wilhelm von Württemberg.

The South American fauna, especially Surinam, was extensively sampled by August Kappler (1815–1887). His material now constitutes a major part of the museum's collection of South American butterflies, birds, and mammals. German naturalist Baron Ferdinand von Mueller (1825–1896) immigrated to Australia where he soon became director of the Melbourne Zoological and Botanical Gardens. Apart from plants, he collected numerous insects and also 2269 vertebrates of 837 species that were all sent to Stuttgart. This material is still preserved to a large extent and includes birds of paradise, kangaroos, and also a skillfully prepared specimen of the extinct Tasmanian tiger. Theodor von Heuglin (1824–1876) extensively traveled East and Northeast Africa. The many animals and skins he brought back to Stuttgart now form a substantial portion of the SMNS zoological collections. A key role in the history of the museum was played by Ferdinand Krauss (1812–1890). Not only did he travel to Africa himself to collect animals, but later on he was also appointed as curator at the Stuttgart museum. It was his merit to sort and arrange the comprehensive material collected by him and other naturalists thereby making it available for scientific studies. One of the most important collections secured by the museum in this time was a donation by Dutch physician Pieter Bleeker (1819–1878). During his duty as a military doctor in the Dutch East Indies (now Indonesia), he was able to collect an enormous variety of fish and other animals. He published 432 articles on the ichthyofauna of the region—among these a high number of first species descriptions—and sent his collections to natural history museums worldwide. His repeated gifts to the Stuttgart museum now make up a considerable part of its fish collection. Carl Benjamin Klunzinger (1834–1914), a Swabian physician, worked on the marine fauna of the Red Sea. The many specimens he sent to Stuttgart now form a prominent part of the SMNS inventory.

In 1913, Erwin Lindner (1888–1988) joined the museum as a curator of Diptera and was head of the Department of Entomology until 1953. He would work and collect for more than 70 years for the museum as a distinguished expert on soldier flies (*Stratiomyidae*). As the editor of some 15,000 pages of the “Die Fliegen der

Paläarktischen Region”, he was known among entomologists all around the world. Important for the museum’s collections were not only his frequent field trips to the European Alps but also his excursions to the South American Gran Chaco (1925/1926). In addition to several journeys to Africa (1951/1952 East Africa, 1958/1959 South Africa and Tanzania), these expeditions considerably enlarged the Diptera collection.

A major incision in the museum’s history was its destruction during World War II. On the 21st of February 1944, allied bombs hit and destroyed the main museum building at Neckarstrasse. The adjacent collection buildings at Archivstrasse were hit on the 12th of September and also burned down. Although in the first years of war, the most valuable parts of the inventory had been transferred to numerous scattered locations in the countryside, considerable portions of the collections, catalogues, and libraries were lost. Previously outsourced collections were also affected, not only by destruction during the war but also due to postwar turmoil. Among the biggest losses were parts of the mollusk collection, the entire spider collection of Wilhelm Bösenberg (1841–1902) including 169 holotypes described by Strand, parts of the vertebrate collections, many invertebrate fossils, and also historically important mammoth tusks that had been excavated in 1815 under King Friedrich I. The geognostic collection of Oscar Fraas (1824–1897) was also destroyed.

After the war, the local government decided not to rebuild the museum at its previous location. Instead, it was decided to reerect “Schloss Rosenstein”, built in 1822–1829 by Giovanni Salucci for King Wilhelm I of Württemberg and destroyed during wartime. This manor palace was chosen to house the zoological exhibition and large parts of the scattered collections. The museum—in 1950 renamed “Staatliches Museum für Naturkunde Stuttgart”—moved into the rebuilt palace in 1954; the public exhibition was opened 2 years later.

However, as there was by far not enough space to accommodate the entire museum inventory at this new location, from 1962 on, the paleontological and entomological collections along with associated staff were temporarily quartered in an arsenal in Ludwigsburg near Stuttgart.

In 1963, the Department of Phylogenetic Research (“Abteilung für Stammesgeschichte”) was established for Willi Hennig (1913–1976), the founder of phylogenetic systematics. He worked at the SMNS outpost in Ludwigsburg until his untimely death in 1976. In 1998, this department was partly merged into the Department of Paleontology and into the Department of Entomology.

In 1969, Prof. Bernard Ziegler (1929–2013) was appointed as director of the SMNS. Owing to his persistent efforts, the 23-year interim at Ludwigsburg finally came to an end. In 1985, a new, modern building complex—the “Museum am Löwentor”—was opened in Stuttgart in immediate vicinity to “Schloss Rosenstein”. It gave room for a new paleontological exhibition, modern labs, offices, paleontological, mineralogical, entomological, malacological, and botanical collections, and all other parts of the museum previously outsourced to Ludwigsburg.

53.3 Collections

As in other big natural history museums, the collections represent a nucleus for systematic research. In total, the museum harbors more than 12 million items, many of them of great historical and scientific importance. Apart from fossils (4.1 million), minerals (40,000), fungi, and plants (one million), the museum staff curate zoological collections of about seven million objects. Among these, arthropods number up to more than 5.5 million specimens, mollusks to one million, and vertebrates to 500,000. Increasingly, the collection information is made available digitally and in online databases to serve the needs of scientists all over the world. To this date, all type series and specimens are searchable online through the museum's type database.

Apart from its classic collections of specimens and parts thereof, the museum has been building up libraries of DNA, either obtained from museum specimens or during fieldwork of museum staff.

53.3.1 *Arthropoda*

Today, the entomological collections include more than 5.5 million specimens from all over the world, thus forming the largest part of the museum's inventory. Its major part holds about 4.8 million dried insects stored in more than 22,000 insect drawers. Additionally, a considerable amount of insects and other arthropods, mainly Crustacea and Arachnida, are stored in ethanol. In recent years, specimens are increasingly preserved in 100 % ethanol and stored in deep freezers at $-80\text{ }^{\circ}\text{C}$ for genetic studies.

Coleoptera (Beetles) With about two million specimens of almost 60,000 species, the beetle collection is the largest insect collection at the SMNS (Fig. 53.10). Its major part was acquired during the last 70 years. Geographical emphasis lies on the Old World, notably Europe, southern Africa, Central Asia, the Himalayan region, and tropical Asia including New Guinea. Its systematic focus encompasses Carabidae, Silphidae, Leiodidae, Prostomidae, Tenebrionidae, Chrysomelidae, and Scarabaeidae. The collection holds about 5000 type series.

Local collections of numerous contributors (Böhme, Buck, Gladitsch, Köstlin, Ulbrich, von der Trappen) together form a faunistic reference collection on South German beetles.

The beetle collection also includes numerous special collections with a large amount of type material: the collection Puthz on the staphylinid genus *Stenus* contains 80 holotypes and numerous paratypes. The collections Daffner and Angelini on Leiodidae and the collection Heinz on Carabidae also hold a large amount of type series. Due to the work of Wolfgang Schawaller, a beetle curator at the SMNS from 1983 to 2015 and from 1995 to 2015 also the head of the Entomology Department, the outstanding collection of Tenebrionidae includes



Fig. 53.10 Beetle collection (with permission from: SMNS; photo: J. Reibnitz)

type series of 210 species of the genera *Laena* and *Platydema*. It also encompasses type material of other specialists on Tenebrionidae, namely, Ando, Bremer, Grimm, and Masumoto.

Lepidoptera (Moths and Butterflies) The global collection of butterflies (Figs. 53.11 and 53.12) numbers up to about one million specimens with geographical emphasis on the Neotropical and Ethiopian region including a collection of 40,000 specimens from Kenya. Of particular importance are the worldwide collections of Hoppe on Noctuidae (80,000 specimens) and of Reisinger on Pieridae (70,000 specimens). The special collection of Sesiidae includes about 450 species. Further taxonomic emphasis lies on Erebidae and Geometridae. The latter also include 30,000 specimens from Ecuador (collections Brehm and Hilt). The Lepidoptera collection holds about 400 type series—among these types of the recently described family Pseudobistonidae (Geometroidea).

Hymenoptera (Bees, Wasps, and Ants) The Hymenoptera collection accounts for 350,000 pinned specimens including about 200 type series. Its oldest stock dates back to the nineteenth century and is based on the historic collection of von Roser. Also of historic importance is a reference collection of Ichneumonidae by an eminent German hymenopterist Otto Schmiedeknecht. Furthermore, the collection Gauss features numerous species relevant for forest entomology.

The recent focus of collection especially lies on the Aculeata of the Neotropics and on Scoliidae, Ichneumonidae, and Chalcidoidea on a worldwide scale. Also worth mentioning is a collection of bee and wasp nests (Apidae, Vespidae) from the Neotropical region.



Fig. 53.11 Lepidoptera collection in compact shelving (with permission from: SMNS; photo: A. Staniczek)



Fig. 53.12 Compartmentalized insect boxes allow for variable storage (with permission from: SMNS; photo: J. Holstein)

As part of the project German Barcode of Life, about one million specimens of Hymenoptera: Parasitoidea were collected throughout Germany by malaise traps. From these samples, a molecular reference collection of presently 2500 species has been compiled.

Diptera (Flies and Midges) About 450,000 specimens of about 12,000 valid species form the Diptera collection including about 1150 type series. Two-thirds of the specimens are stored in dry condition, one-third in ethanol.

The oldest specimens were collected by Karl von Roser (1822–1861) in the first half of the nineteenth century. When Erwin Lindner became a curator of the SMNS early in the twentieth century, his emphasis was the enlargement of the collection serving as a scientific source for the edition of his monumental series “Die Fliegen der Paläarktischen Region”. Lindner collected many species himself but also motivated colleagues to donate or sell their material, e.g., Plaumann, Aharoni, Engel, Richter, and many others. Most of the flies and midges in the collection are from Europe, but Lindner’s expeditions in the 1930’s and 1950’s also yielded much material from South America and Africa.

The collection’s main focus lies on Stratiomyidae, Cecidomyiidae, Muscidae, Anthomyiidae, and Tachinidae, thus reflecting the main working areas of curators Erwin Lindner, Edwin Möhn, Willi Hennig, Benno Herting, and Hans-Peter Tschorsnig. Especially Tachinidae, which is of importance also in applied entomology, is studied in the SMNS since more than 50 years.

Other Insect Groups Of considerable importance is the Hemiptera collection comprising 160,000 specimens of cicadas (Auchenorrhyncha) and 80,000 species of true bugs (Heteroptera). Among these, there are 80 type series. The Orthoptera collection numbers up to 60,000 specimens including 50 types.

Recent efforts resulted in the buildup of an aquatic insect collection of about 150,000 specimens that are mainly stored in ethanol (Fig. 53.13). Emphasis is laid on a phylogenetic reference collection of Ephemeroptera on a global scale, including type series of 25 species. Its main geographic focus lies on Central Europe, the Caucasus, South Africa, and New Zealand. Additionally, a faunistic reference collection of German Ephemeroptera, Odonata, Plecoptera, and Trichoptera has been established.

Crustacea: Isopoda The entomological department also curates the worldwide largest collection of wood lice (Isopoda: Oniscidea). This is due to the ongoing work of Helmut Schmalzfuss, a curator at the SMNS between 1977 and 2007. Its geographical emphasis lies on the Eastern Mediterranean; its current stock was accumulated through numerous field trips to Greece and adjacent countries, rounded off with bycatches of numerous colleagues. It comprises about 83,000 specimens of 1462 species and includes type species of 350 species. The type collection also includes important type material by Italian isopodologists Ferrara and Taiti (University of Florence, Italy). The entire collection is completely determined, catalogued, and available online.



Fig. 53.13 Aquatic insects, wet collection (with permission from: SMNS; photo: A. Staniczek)

53.3.2 *Mollusca*

The mollusk collection at the SMNS (Fig. 53.14) comprises more than 130,000 lots (>1 million specimens). Exotic marine shells represent the oldest objects already listed in the catalogue of the physician Pasquay (Frankfurt a. M.) in 1777. The collection Clessin (German, Austrian, and Hungarian mollusks, bought in 1903), the collection Zwiesele (freshwater bivalves of southern Germany and Switzerland, bought in 1925), and the collection Geyer (mollusks of the state Württemberg, bought in 1932) are especially worth mentioning among the historical parts. During World War II, some parts of the collection were destroyed, but the main portion survived undamaged.

More recent additions among the marine mollusks include the collections of tropical cone shells (Conidae, mainly collections Röckel and Da Motta, about 20,000 lots), olives (Olividae, coll. Greifeneder, nearly 3000 lots), West African volutes (genus *Cymbium*, coll. Stürmer), and Mediterranean mollusks including a substantial part of wet specimens and with special consideration of the “Lessepsian” migration (coll. Enzenross)—all of which are of worldwide importance. Continental mollusks of special significance encompass collections of door snails of the Western Palearctic (Clausiliidae, coll. H. Nordsieck, about 10,000 lots), European island faunas (coll. Rähle, Beckmann), European slugs, and freshwater mollusks (coll. Meier-Brook).



Fig. 53.14 Malacological collection, *Comus* shells (with permission from: SMNS; photo: A. Staniczek)

53.3.3 *Vertebrata*

Based on the work of past collectors and curators, the global vertebrate collections at the SMNS include a large amount of historic material (collected prior to 1900).

Fishes The fish collection (Fig. 53.15) now comprises 25,000 lots (ca. 150,000 specimens) of fishes from all over the world. Its main focus lies on European freshwater fishes, Mediterranean marine fishes, Indo-Pacific marine fishes, and Central and South American freshwater fishes. The collection includes over 1000 type specimens of about 450 species, mainly described by Bleeker, Klunzinger, and Fricke. Of particular interest is a large collection of dragonets (Callionymidae).

Amphibians and Reptiles The herpetological collection housed at the SMNS contains some 22,000 specimens spanning over all major zoogeographical regions. It includes 118 type specimens of amphibians and reptiles. Parts of the collection including valuable type material and the catalogue were destroyed during the bombing raids in World War II. After the war, herpetology curators Heinz Wermuth and Andreas Schlüter reconstructed most of the prewar condition. Schlüter much enhanced the collection and extended the zoogeographical focus to the Neotropics (Peru, Brazil, and Guyana shield).

Birds The bird collection (Fig. 53.16) comprises about 134,000 specimens of more than 5400 species (50,000 skins, 20,000 mounts, 8000 feather sets, 50,000 eggs, and



Fig. 53.15 Historical types of the fish collection (with permission from: SMNS; photo: J. Bergener)



Fig. 53.16 Bird collection (with permission from: SMNS; photo: U. Schmid)

6000 partial or complete skeletons) from all over the world. It includes 119 type specimens. The first entry in the comprehensive, handwritten catalogue dates back to 1837, and owing to the continuous and immense interest of explorers and collectors in colorful avifauna, the bird collection and its development played a

major role in the course of the museum's history. Already in 1886, a total of 11,175 specimens of 4800 species were counted (Lampert 1896). This historical material is still well maintained; it was complemented by more recent additions including those of A. Fischer, K. Fischer, and Issel (Germany), Kipp (Europe), Hoy (Argentina), Gatter (Liberia), Nikolaus (Africa), and a substantial egg collection from Duve (Europe and Southern Africa).

Mammals The mammalogical repositories (Fig. 53.17) now hold more than 54,000 specimens of more than 1500 species, thus harboring one of the 25 largest mammalogical collections worldwide. Of special importance are the c. 240 type specimens including almost 80 primary types. The main focus of the collection lies on rodents, bats, and insectivores. Complementing the historical objects from Africa, former curator Fritz Dieterlen assembled a high number and diverse collection of Central African small mammals.

Osteology In the late twentieth century, osteologist Doris Mörike established a comparative collection of bird and mammal bones to assist quick determination of bone findings. Over the past years, this collection has proven its usefulness for answering numerous inquiries by the public, by the police needing assistance in identifying potential human remains, and by archeologists and paleontologists in order to assess fossil or subfossil discoveries.



Fig. 53.17 Mammalogical collection (with permission from: SMNS; photo: R. Baumann)

53.4 Collaborations and Research

As taxonomy and systematics on a global scale traditionally constitute core research areas of natural history museums, the SMNS is part of a multitude of collaborative research efforts. Preserving millions of biological specimens and associated information, it is also part of major institutional networks. Among these are CETAF (Consortium of European Taxonomic Facilities), GBIF (Global Biodiversity Information Facility), DNFS (Consortium “Deutsche Naturwissenschaftliche Forschungssammlungen”), Humboldt-Ring (Consortium of German Research Museums), and GFBio (German Federation for the Curation of Biological Data).

Major projects that the SMNS participates in include SYNTHESYS (Synthesis of Systematic Resources: an EC-funded project creating an integrated European infrastructure for natural history collections), GBOL (German Barcode of Life), and BiNHum (Biodiversity Network of the Humboldt-Ring).

SMNS collections can be partly accessed via data portals like GBIF, FishBase, and HerpNET. All type specimens and series are searchable in the type database on the museum’s website.

The SMNS annually hosts between 150 and 200 guest researchers from all over the world. On average, visiting scientists publish between 50 and 90 articles per year including data obtained in the SMNS collections.

Scientists of the SMNS regularly engage in teaching activities at universities. Since 2013, the museum maintains a formalized cooperation with the University of Hohenheim, Stuttgart. This cooperation involves teaching duties of SMNS staff at graduate and undergraduate level and supervision of Ph.D., M.Sc., and B.Sc. theses. As an advantage to the museum, junior scientists are attracted to collection-based systematic research, and museum staff get the opportunity to qualify for a professorship.

To introduce young researchers to working at a natural history museum, the SMNS provides the opportunity for 14 scientific trainees to learn about collection maintenance, exhibition design, and public outreach and to conduct their own research projects under the supervision of an experienced staff. Trainees are usually contracted for 2 years.

Two peer-reviewed scientific journals—“Palaeodiversity” and “Stuttgart State Museum Contributions to Natural History A (Biology)” —are published by the SMNS. One popular science journal—“Stuttgart State Museum Contributions to Natural History C (Popular Science)” —addresses a wider German readership. The SMNS also serves the scientific community by hosting and maintaining the international website on mayflies, *Ephemeroptera Galactica*.

Museum staff frequently visits international and national cooperation partners, conducts fieldwork, and regularly presents research results at scientific conferences. Museum scientists contribute about 100 peer-reviewed publications on a yearly basis—with the large majority listed on the Science Citation Index (SCI)—and about 40 articles to popular science journals.

One major strength of the SMNS is the tight collaboration between its paleontologists and researchers working on extant fauna. Joint investigations on the evolution of amphibians (Schoch et al. 2015) and the early diversification of winged insects (Sroka et al. 2015; Staniczek et al. 2014) are examples for this fruitful interdisciplinary approach. Insects preserved in amber also spark the interest and collaboration of both entomologists and paleontologists at the SMNS (Huang et al. 2016). Of considerable importance to understanding the evolution of extant fauna are conclusions drawn from studying the significant paleontological collections of the SMNS (Schoch and Sues 2015).

As in other natural history museums, taxonomy is a traditional domain of the SMNS. Projects center around the research collections and strive to fill the gaps of documentation and classification of the natural world. These meticulous efforts unite many scientists working at the SMNS irrespective of their group of interest. They result in taxonomic descriptions and revisions, monographs on selected groups or regions, species catalogues, faunistic checklists, or field guides. Prominent examples are the world catalogue of wood lice (Schmalfuss 2003) and the description of Oriental and Eastern Palearctic Tenebrionidae of the genus *Laena* (Schawaller 2015). Other systematic studies include the description of whole extinct radiations in tropical land snails documenting the devastating effects of human settlement on small Pacific islands (Richling and Bouchet 2013).

Following the tradition of Willi Hennig, who established phylogenetic methodology at the museum in the 1960's, current phylogenetic studies constitute another focus at the SMNS. Following an integrated approach, most of these studies are nowadays not only based on comparative morphology but are complemented by comprehensive molecular analyses. Examples of recent work include studies on the phylogeny of the order Ephemeroptera (Ogden et al. 2009) and the phylogeny of chalcid wasps (Heraty et al. 2013). The discovery of Pseudobistonidae, a new family of Macrolepidoptera, is another recent highlight of phylogenetic research at the SMNS (Rajaei et al. 2015).

In a number of research projects, biogeographical questions are asked. These studies apply multiple methods, looking at molecular, morphological, or bioacoustic characters, and span a wide range of taxa. For example, a series of projects aims at reconstructing evolutionary processes leading to the diversification and present distribution of tarsiers, small nocturnal primates of Southeast Asia (Merker et al. 2009). Other studies focus on the phylogeography of African elephants, Irrawaddy dolphins, or European beavers.

Ecological and conservation-related research is also an imminent part of the museum's scientific work. Overseas, the SMNS looks on blood parasitic infections, site fidelity, and habitat use of Malagasy rainforest birds (Jonsson et al. 2012). A regional focus lies on the ecology of introduced Amazon parrots (Martens et al. 2013) and the ecology and behavior of graylag geese in urban habitats in order to assess their potential relevance for spreading avian influenza (Schwarz et al. 2012). These projects as well as studies on the diversity and life history of parasitic fly and wasp groups—important for biological pest control—spark significant public interest.

Life history evolution is also the topic of a series of studies on caecilians: among the highly variable parental care strategies in amphibians, skin feeding in some Caecilian species has been shown to be a particularly interesting mode of parental care (Kupfer et al. 2006).

With its roots deep in the history of Baden-Württemberg, the SMNS also takes a leading role in documenting and monitoring regional fauna. A statewide survey of amphibians and reptiles is coordinated by the museum. Beetles, butterflies, and bees in particular are monitored by members of the associated Stuttgart Entomological Society (established 1869). The SMNS also organizes regular meetings of German coleopterologists, hymenopterologists, and malacologists.

53.5 Exhibitions, Education, and Public Outreach

Transfer of knowledge into society is one of the museum's key competencies that largely account for its public perception. On average, about 200,000 visitors come to see the exhibitions throughout the year. The permanent exhibitions at the Museum Schloss Rosenstein (Biology, Fig. 53.18) and the Museum am Löwentor (paleontology) are tightly interwoven in form and content. New research findings of SMNS curators are constantly incorporated into the permanent and temporary exhibitions.



Fig. 53.18 Permanent exhibition at the Museum Schloss Rosenstein (with permission from: SMNS; photo: U. Schmid)

Inventive temporary exhibitions on different scales are conceived, designed, and implemented by interdisciplinary teams under the scientific guidance of the museum's researchers. Temporary exhibitions on a smaller scale are displayed at the Museum am Löwentor and often feature special parts of collections that are usually hidden in the magazines. As a recent example, the special exhibition "Antlers" illustrated the evolution of deer and cranial appendages (Fig. 53.19). At the Museum Schloss Rosenstein, temporary exhibitions on a larger scale are shown that mainly deal with general themes of biology. Recent examples include exhibitions on "150 Years of Evolutionary Theory", "Sex—Motor of Evolution" (Fig. 53.20), "Climate Change: A Tightrope Walk", and "Forever Young: Masterpieces of Taxidermy".

All exhibitions are accompanied by various educational offers, notably optional guided tours to impart widened background knowledge on the theme on display. Temporary exhibitions are also deepened by a series of expert talks on the topic. Additionally, special museum events (museum night, open house presentation, summer fete) foster public interest.

On a regular basis, the museum educational service offers programs for different target groups—from primary school and grammar school pupils up to families and adults. Numerous special projects and workshops for preschools and schools are conducted. In the project "Bioforum", teenagers actively explore domestic fauna and flora under qualified guidance by museum staff. The SMNS educational service



Fig. 53.19 Temporary exhibition "Museum Special—Antlers" at the Museum am Löwentor in 2014 (with permission from: SMNS; photo: R. Baumann)



Fig. 53.20 Temporary exhibition “Sex—Motor of Evolution” at the Museum Schloss Rosenstein in 2012 (with permission from: SMNS; photo: A. Staniczek)

also organizes various training courses for teachers to optimize their educative efforts before they visit the museum with their classes.

Besides traditional education, the museum educational service also strikes new paths by offering new forms of knowledge transfer, such as the “science pub”, where people meet in a pub to listen to scientific talks in a relaxed atmosphere.

Finally, the SMNS is also present on the World Wide Web in many ways: the museum’s home page is the main entrance gate for a digital visit. The SMNS maintains its own Facebook site and also uses Twitter to spread news in the social media. In the museum’s science blog “Understanding Nature”, SMNS scientists write online about their latest discoveries and present their scientific results intelligible to all.

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