

# The natural history collections of Adam Mickiewicz University in Poznań (Poland): an outline of their history and content

Bogdan Jackowiak<sup>1,2\*</sup>, Jerzy Błoszyk<sup>3,4</sup>, Zbigniew Celka<sup>1</sup>, Szymon Konwerski<sup>4</sup>,  
Piotr Szkudlarz<sup>1</sup> & Justyna Wiland-Szymańska<sup>1</sup>

<sup>1</sup>Department of Systematic and Environmental Botany, Adam Mickiewicz University, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland; ORCID: BJ <https://orcid.org/0000-0003-1684-7380>; ZC <https://orcid.org/0000-0002-5344-8939>; PSz <https://orcid.org/0000-0002-4915-2721>; JW-Sz <https://orcid.org/0000-0002-1916-7201>

<sup>2</sup>Biodiversity Digitization Laboratory, Adam Mickiewicz University, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland

<sup>3</sup>Department of General Zoology, Adam Mickiewicz University, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland; ORCID: JB <https://orcid.org/0000-0002-3615-2263>

<sup>4</sup>Natural History Collections, Adam Mickiewicz University, Uniwersytetu Poznańskiego 6, 61-614 Poznań, Poland; ORCID: SzK <https://orcid.org/0000-0002-6438-8759>

\* corresponding author (e-mail: bogjack@amu.edu.pl)

**Abstract:** The origins of scientific nature collections in Wielkopolska (Western Poland) date back to the seventeenth century. Their development was repeatedly disrupted by major events, including two world wars fought in Poland in the twentieth century. The rescued historical collections as well as specimens of algae, plants, fungi and animals systematically collected after 1945 are now stored under optimal conditions at the Faculty of Biology of Adam Mickiewicz University in Poznań (FBAMU). The current collections include approximately 2.2 million pre-catalogued objects that document not only the biodiversity of Wielkopolska and Poland but also that of many regions of the world on all continents. Specimens included in the FBAMU are used extensively in taxonomic, biogeographic, phylogenetic, ecological and genetic studies. The collections also have significant educational value and help disseminate knowledge about biodiversity.

**Key words:** biodiversity collections, plant, fungi and animal collectors, Wielkopolska region, Central Europe

## 1. Introduction

Natural history collections are fundamentally important for the development of the natural sciences (Lane 1996). Specimens collected in the field, so-called nomenclatural types, are the basis for the description of most of the world's known species. From the time they are collected, they become the benchmarks against which samples collected in different parts of the world and for different scientific purposes are compared (JTCZ 1999; Turland *et al.* 2018).

The global stock of biological specimens are only approximately known. The lack of such knowledge results, *inter alia*, from the economic and organizational barriers faced by collections of biodiversity in many countries,

including those that are the most economically and scientifically developed. This lack of knowledge limits our ability to fully catalog such collections (Nelson & Ellis 2018).

The second half of the twentieth century also saw a mental barrier to the development of natural history collections. Even the scientific community began to believe that these natural collections are mainly of historical importance. Such a stereotype was perpetuated despite scientific facts showing that (i) knowledge of species diversity is still inadequate and, in some systematic groups, even insufficient and (ii) the importance of natural collections is increasing as the pace of anthropogenic threats to biodiversity increase. Meanwhile, it is known that often the only trace of species that have

become extinct in nature are specimens preserved in natural history collections (Allmon 1994; Shaffer *et al.* 1998; Paknia *et al.* 2015).

After a period of treating natural collections mainly as foundations for museums and evidence of scientific discoveries already made, the specimens and related descriptions regained significance at the turn of the twenty-first century (Nelson & Ellis 2018). This is mainly due to the progress of molecular analysis methods and the information technology revolution. Analyses of specimens using molecular techniques stimulate the development of many new research directions in biology, while the IT revolution started the process of digitizing specimens and developing the accompanying descriptions (Rivers *et al.* 2011; Nelson *et al.* 2012; Glon *et al.* 2017; Willis *et al.* 2017; Gallinat *et al.* 2018; Andrew *et al.* 2019; Hedrick *et al.* 2020). Through the websites of local and regional scientific institutions and portals of organizations that deal with data aggregation, natural collections are becoming increasingly accessible for research and education and able to contribute to biodiversity protection (Ballard *et al.* 2017; von Konrat *et al.* 2018; Butcher *et al.* 2019).

Nature collections located in Poland are also part of this process. This is evidenced by, *inter alia*, a recently published set of articles describing the content of twentieth-century scientific collections (Tykarski 2021 and the sources cited therein).

Adam Mickiewicz University in Poznań (AMU) has also joined this process, having begun in 2018 to digitize collections deposited at the Faculty of Biology. The purpose of this ongoing work is to provide an overview of the history and content of the collections that were digitized as part of the AMUNATCOLL project (Nowak *et al.* 2021, 2022; Jackowiak *et al.* 2022; Lawenda *et al.* 2022).

## 2. An outline of the history of the natural collection deposited at the AMU

The AMU was established in 1919, but the academic roots in this city date back to the sixteenth century. Currently, Poznań, next to Warsaw and Krakow, is one of the most important academic centers in Poland, and AMU is considered one of the leading universities in the country. A significant part of the history of natural sciences of the Wielkopolska region, Poland, Central Europe and other parts of the world is written based on the specimens and samples deposited at the Faculty of Biology. This history is particularly strongly influenced by events whose scope and extent go far beyond the borders of the region, such as the period of partitions (1793-1918) and the First (1914-1918) and Second (1939-1945) World Wars. During the period of partitions, the scientific life of Poles was very difficult, and

during World War II, scientific research was almost completely inhibited (Brzęk 1973).

The history of the natural collections currently deposited at the FBAMU can be divided into four periods: (1) before the founding of the Society of Friends of Sciences in Poznań in 1857 (later renamed the Poznań Society for the Advancement of Arts and Sciences; PSAAFS); (2) from the founding of the PSAAFS to the regaining of independence in 1918 and the establishment of the University of Poznań in 1919; (3) from the founding of the University in Poznań until the end of World War II in 1945; and (4) from the end of World War II to the present day. During this period, two events stood out: the first was related to the establishment of a museum unit at the FBAMU in the new university campus in Morasko (Natural History Collections) in 2004, and the second was the completion of the main stage of the digitization of the collections in 2021.

### Period 1

Scientific interests in the flora and fauna of the Wielkopolska region date back to the seventeenth century, but research involving natural collections matured in the mid-nineteenth century (e.g., Adamski 1828; Erzepki 1896). At that time, the first regional flora was published independently by German (Ritschl 1850) and Polish teachers (Szafarkiewicz 1871; Stecki & Pietkiewicz 1931a, 1931b). Initiatives to establish institutions collecting natural specimens appeared almost simultaneously in Polish and German circles.

### Period 2

A very important event was the establishment in 1857 of the PSAAFS, an institution that became the foundation for the future Polish university. The members of the Faculty of Life Sciences (Julian Zaborowski<sup>1</sup> and Felicjan Sypniewski<sup>2</sup>), from the beginning of its activity, appealed to the public to collect and send to the society collections of natural history from Polish lands, which in the future were to be deposited in the public regional museum. According to Brzęk (1973), in 1858, this collection included 3,000 specimens of fauna, which were sent mainly by landowners, foresters and hunters. Franciszek Chłapowski<sup>3</sup> has been carefully managing them for over 30 years. At the turn of the twentieth century, palaeontological and zoological collections increased very quickly. They came not only from regional collectors but also from trips abroad and exchanges with national museums (e.g., the Museum of the Physiographic Commission of the Academy of Learning in Krakow, the Dzieduszycki Museum in Lviv) and foreign museums (e.g., the Museum in Berlin). In 1909, the natural collections of the PSAAFS were made available to the public for the first time (Chłapowski 1909, 1913).

At that time, German naturalists focused more on flora and plant collections. At the end of the nineteenth century, they established a herbarium (in German: Das Herbarium der Provinz Posen), in which plant specimens collected in the region were to be deposited. The herbarium's history began around 1871 with a small collection located in the Royal Junior High School of St. Mary Magdalene (in German: Königliches Marien-Gymnasium). The herbarium was enriched with new collections, and in 1895, it was transferred to the Provincial Museum (in German: Provinzial Museum), which from 1902 was called the Emperor Frederick III Museum (in German: Kaiser Friedrich Museum). A little later, part of the collection was transferred to the Royal Academy in Poznań (in German: Königliche Akademie zu Posen), a Prussian school operating in the years 1903-1919 (Pfuhl 1894, 1897, 1903). After the death of long-time curator Friedrich Pfuhl<sup>4</sup> in 1913, the herbarium was stored in an inappropriate location and was largely destroyed during World War I (Szafranówna 1933a).

### Period 3

Poland regained independence in 1918, which created new conditions for the development of natural sciences and natural history collections in Poznań. The establishment of the university in 1919 and the further development of the PSAAFS meant that within twenty years, the capital of Wielkopolska became a major center for zoological and botanical research (Szafranówna 1933b; Krawiec 1936; Brzęk 1973; Dąbska 1973). Many eminent professors worked in Poznań, book collections were enhanced, and natural science journals in Polish appeared.

A great importance was also given to the natural history collections. At the Wielkopolska Museum at that time, a branch of natural sciences was separated, and in 1924 it received a new seat. Its independence was emphasized by the use of the name "Natural History Museum". From its foundation, the museum had the important task of consolidating the natural history collections widely scattered across many Polish and German institutions previously operating in Poznań (Gumowski 1925, 1929). Edward Lubicz-Niezabitowski<sup>5</sup>, who held the position of director of the museum until the outbreak of war in 1939, had special merit in this regard (Brzęk 1973). It is assumed that on the opening day of the museum, i.e., April 27, 1926, it housed approximately 40,000 collections items (Grabski 2000). The major tasks of the Natural History Museum included (i) collecting specimens of flora, fauna and geology; (ii) conducting scientific activities, (iii) conserving collections, (iv) taking care of permanent exhibitions, (v) organizing temporary exhibitions and (vi) engaging in educational activities. Among the

most valuable acquisitions was a gift of Brazilian fauna from Arkady Fiedler<sup>6</sup> in 1929. The museum was then enriched with a collection of several thousand insects. In 1930, a valuable collection of specimens of South African fauna was donated by Henryk Gordziałkowski<sup>7</sup>. Notable among the purchases was an extensive collection of microlepidoptera (small butterflies). In 1934, the museum established relationships with missionaries working on every continent to collect wildlife specimens from around the world. Thanks to all these activities, the size of the collections increased by almost 9 times in the interwar period (Grabski 2000). The Natural History Museum enjoyed great interest from the public. It was visited by approximately 4.5 thousand people annually, and in 1929, when the General National Exhibition was organized in Poznań, the museum was visited by over 29 thousand people (Grabski 2000).

During this period, the university also amassed natural history collections, as the zoological and botanical departments played an important role in the new university from the beginning. Jan Grochmalicki<sup>8</sup>, Head of the Zoology Department, gathered a library very carefully selected to match the department's research profile. In addition to many up-to-date journals, the library contained many valuable old Polish books on zoology. He also created a rich museum that included, among other things, an almost complete collection of the vertebrates of Poland. In the last years before World War II, the department had a rich library and a splendid museum of anatomical preparations, elaborately made mainly by Kajetan Boratyński<sup>9</sup> (Brzęk 1973).

Botanical collections at the university were organized by Józef Paczoski<sup>10</sup>, who headed the Department of Plant Systematics and Geography. Among other things, part of the herbarium after the Prussian Academy, which gathered the collections of many botanists active in the second half of the 19th century, was adopted (Szafranówna 1933a). In the early 1930s, the herbarium of vascular plants numbered approximately 40,000 sheets (Paczoski 1933; Krawiec 1936), as well as various bryophytes, lichens, and parasitic fungi compiled by Tadeusz Dominik<sup>11</sup>. In the Department of General Botany and Phytopathology, there was the herbarium of Józef Szafarkiewicz<sup>12</sup> (Stecki & Pietkiewicz 1931a, 1931b) and a collection of higher fungi compiled by Feliks Teodorowicz<sup>13</sup> (Krawiec 1936).

The outbreak of World War II interrupted the activities of both the Natural History Museum and the university and destroyed much of the natural history collections. By October 1939, the Germans had taken away part of the collections of the Natural History Museum, storing them in the building of the present National Museum in Poznań. The rest was dispersed (Grabski 2000). During the occupation, zoological institutions were part of the Zoological Institute of the

German University. The collections of the Department of Systematic Zoology and the Department of Comparative Anatomy and Biology of the University of Poznań, as well as many entomological private collections, were incorporated into the museum created there. At the end of the occupation, some of the zoological departments property was taken to Germany, and some was destroyed during the siege of Poznań in 1945. The university's zoological museum suffered its heaviest losses during the 1944 bombing (Rafalski 1973). Less well known at this time was the fate of the university's botanical collections.

#### Period 4

After the end of World War II, the scientific activities in Poznań resumed apace. In the Natural History Museum, the organization of the collections was headed until 1975 by Aleksander Wróblewski<sup>14</sup>, who contributed significantly to saving the collection of the PSAAFS, which had been severely damaged and scattered during the war (Kasprzak 1985). However, organizational changes at this institution meant that the zoological collections were gradually taken over by the university, which was increasingly active in this area.

In the early years, the focus was on rebuilding the apparatus, library, and natural history collections. In the botanical part, these works were directed by Adam Wodziczko<sup>15</sup>, while the protection of the herbarium was ensured by Tadeusz Dominik (Wojterski 1973). Crucial for the development of botany and botanical collections at the university was the restoration of the Department of Plant Systematics and Geography (in 1947), which for 20 years was headed by Zygmunt Czubiński<sup>16</sup>. On his initiative, many geobotanical monographs were written, mainly from the area of northwestern Poland (Pomerania and Wielkopolska). Czubiński's students and successors also conducted intensive floristic and phytosociological research in the mountainous regions of Poland (Bieszczady, Gorce, Góry Stołowe, Babia Góra, Tatry). Increasingly often, these scholars undertook research abroad, e.g., in Asia (Tian-Shan massif and the area of Lake Baikal), Africa (Guinea and Congo), the Oetzal Alps in Austria and Vranica Massif in the Balkans. Because this research was well documented, in the late 1970s, the herbarium collections of the University of Poznań were already very diverse and were among the richest in Poland (Mirek *et al.* 1997). In addition to our own collections, the herbarium housed materials obtained through exchange with various domestic and foreign centers. Herbarium publications published in separate fascicles for different groups of plants and fungi became the basis for this exchange: *Charothea Polonica*, *Lichenotheca Polonica*, *Bryotheca Polonica* and *Hepaticotheca Polonica*. The herbarium at that time numbered nearly 300,000 sheets, including 6,000 fungi,

25,000 lichens, 3,000 stoneworts, 80,000 mosses, 32,000 liverworts and over 150,000 vascular plants (Wojterski 1973). Descriptions of these collections are provided in subsequent editions of *Index Herbariorum* (2022). Floristic, phytogeographic, phytosociological and taxonomic research conducted by Poznań botanists continues today in Poland and in many regions of the world, enriching the botanical collections of the university, which now include over 500 thousand herbarium sheets.

Zoological research documented in natural collections is carried out in several streams: faunistic, zoogeographic, systematic and phylogenetic. After World War II, numerous faunal studies covered almost all major systematic groups (phyla and orders) represented in Poland, focusing especially on the northern and western parts of the country (Rafalski 1973). In later years, the scope was expanded to other countries and parts of the world.

Faunistic and systematic studies of zoologists from Poznań not only significantly enriched the knowledge of the fauna of Poland and many other regions of the world but also contributed to the knowledge of the animal world in general. By the early 1970s, the list of taxa new to science and described in the postwar period already included more than 100 species and subspecies. They represent a wide variety of animal groups, including Flagellata, Gregarionomorpha, Microsporidia, Turbellaria, Gastrotricha, Mollusca (Gastropoda), Oligochaeta, Tardigrada, Crustacea (Ostracoda), Arachnida (Pseudoscorpiones, Opiliones, Acari), Chilopoda, and Insecta (Ephemeroptera, Anoplura, Hemiptera, Diptera, Coleoptera) (Rafalski 1973).

Studies of previously poorly known groups, e.g., Isopoda, Chilopoda, Anoplura, Aphaniptera, Ephemeroptera, and especially Acari, were undertaken at the University of Poznań. The research on mites initiated by Jan Rafalski<sup>17</sup> aroused so much interest among his students and successors that at the end of the twentieth century, the name "Polish or Poznań School of Acarology" was widely recognized among zoologists. This was justified first by the results of systematic and zoogeographic studies and by the two decades of phylogenetic studies conducted there. The natural history collections at the Faculty of Biology contain over 1000 nomenclatural types for mite species described by Poznań acarologists.

The development of biological sciences at the University of Poznań, which has been named after the Polish poet Adam Mickiewicz since 1955, took place across several decades in difficult conditions. Natural specimens were collected and developed in the facilities of botanical and zoological departments. A breakthrough for the Faculty of Biology, established in 1984, came in 2003 when it moved into a new building with specially designed rooms for the natural science collections. In 2004, a museum-like unit called

“Natural History Collections” was established in the Faculty of Biology. Jerzy Błoszyk, who was in charge of this unit, led the consolidation and preservation of hitherto dispersed botanical, mycological, zoological and anthropological collections (Błoszyk & Konwerski 2017). Good facilities and the activity of the staff of this unit facilitated the acceptance of valuable collections from outside the University, from both institutions and private individuals. In 2016, given the need to make the collections accessible for research, education, and hands-on activities, a project to digitize them was developed and finally implemented in 2018-2021 (Jackowiak *et al.* 2022). Currently, digital data are available on our website (ANC 2022) and the Global Biodiversity Information Facility website (GBIF 2022).

### 3. The content of the natural science collection deposited at the FBAMU

An inventory conducted in 2016 showed that the natural history collections deposited at the Faculty of Biology of AMU include more than 2.2 million specimens, grouped within the botanical, mycological and zoological collections. Detailed quantitative data will be accessible after the completion of the digitization process, which is being carried out as part of the AMU-NATCOLL project (Jackowiak *et al.* 2022). Botanical and mycological collections are generally organized



**Fig. 1.** In the phycological collection (POZA), specimens of stoneworts collected since the 19th century are particularly valuable (Photo: Maciej Gąbka)

systematically, while animal specimens are consistently maintained in the collections in which they were obtained.

The following botanical and mycological collections have been indexed for many years in the *Index Herbariorum* (2022), in connection to the former organizational structure of the Faculty of Biology:

POZA (Fig. 1) – includes macro- and microalgae from around the world. It includes over 10,000 microscope slides and dried specimens. These include the specimens collected by Izabela Dąmbska<sup>18</sup> (approx. 3,800), which constitute the largest collection of stoneworts in Poland. Rabenhorst's collections from 1848-1877 are also noteworthy and are described more extensively in Burchardt *et al.* (1999).

POZW (Fig. 2) – an herbarium of liverworts from all over the world, mostly from Central Europe (approx. 10,200 bags). Most samples were collected in Poland, mainly by Jerzy Szwejkowski<sup>19</sup> (approx. 4,300).



**Fig. 2.** Examples from the liverwort collection (POZW) illustrating selected structures of *Calypogeia fissa*: A – sporophyte, B – gametophyte, C – oil bodies (leg., det., and photo: Katarzyna Buczkowska-Chmielewska)



**Fig. 3.** The POZ Herbarium contains specimens from the 18th century (A), Józef Paczoski's extensive collection from the Balkan countries (B), Ukraine and Poland, and a caropological collection (C)

POZ (Fig. 3) – includes vascular plants (approx. 190 thousand sheets) and lichens (approx. 30 thousand bags) collected mainly in Poland and other European countries. Especially valuable are the vascular plant collections of Friedrich Pfuhl (approx. 1,000 sheets), Heinrich Schenck (approx. 3,400 sheets), Józef Paczoski (approx. 12 thousand sheets, mainly from the Balkans and Poland), Feliks Krawiec<sup>20</sup> (approx. 7,200 sheets), and Waldemar Żukowski<sup>21</sup> (approx. 6,300 sheets). An important part of the POZ is the caropological collection of Karol Latowski<sup>22</sup>, consisting of over 2,000 samples. Nearly 2,700 bags of lichens are in the collection of Zygmunt Tobolewski<sup>23</sup>. The POZ herbarium contains approximately 240 nomenclatural types of various ranks.

POZG (Fig. 4) – includes vascular plants (approx. 160,000 sheets) primarily from the tropics, especially central Africa. The Poznań herbarium of tropical plants is one of the largest collections from this climatic-vegetation zone in Europe. It mainly comprises the collection of Stanisław Lisowski<sup>24</sup>, who conducted research in many African countries (Guinea, Congo,

Democratic Republic of Congo, Chad, Cameroon, Kenya, Uganda, Tanzania, Rwanda, Benin) and other regions of the world (Papua New Guinea, eastern Australia, Thailand and Indonesia – Java) between 1967 and 1999 (Kornaś & Ochyra 1994; Symoens *et al.* 2004). The collections of German botanists are also included in this herbarium: Heinrich Schenck's<sup>25</sup> collections from Brazil and Mexico (collected in the 1880s), including a collection of liana sections (Schenck 1893); Heinrich<sup>26</sup> and Erna<sup>27</sup> Walter's collections from East Africa and Namibia (from 1934-1938); and Carl Albert Purpus's<sup>28</sup> collection from Mexico (from 1907-1922). In the POZG herbarium, there are also Stanisław Lisowski's collections from extratropical areas (Kazakhstan, Greece, Bulgaria, Italy, France, Spain, Portugal). The POZG collection contains over 190 nomenclatural types of various ranks. Formally, it also includes mosses (approx. 90 thousand) from all over the world, mainly from Europe, and Poland in particular, but also from Africa.

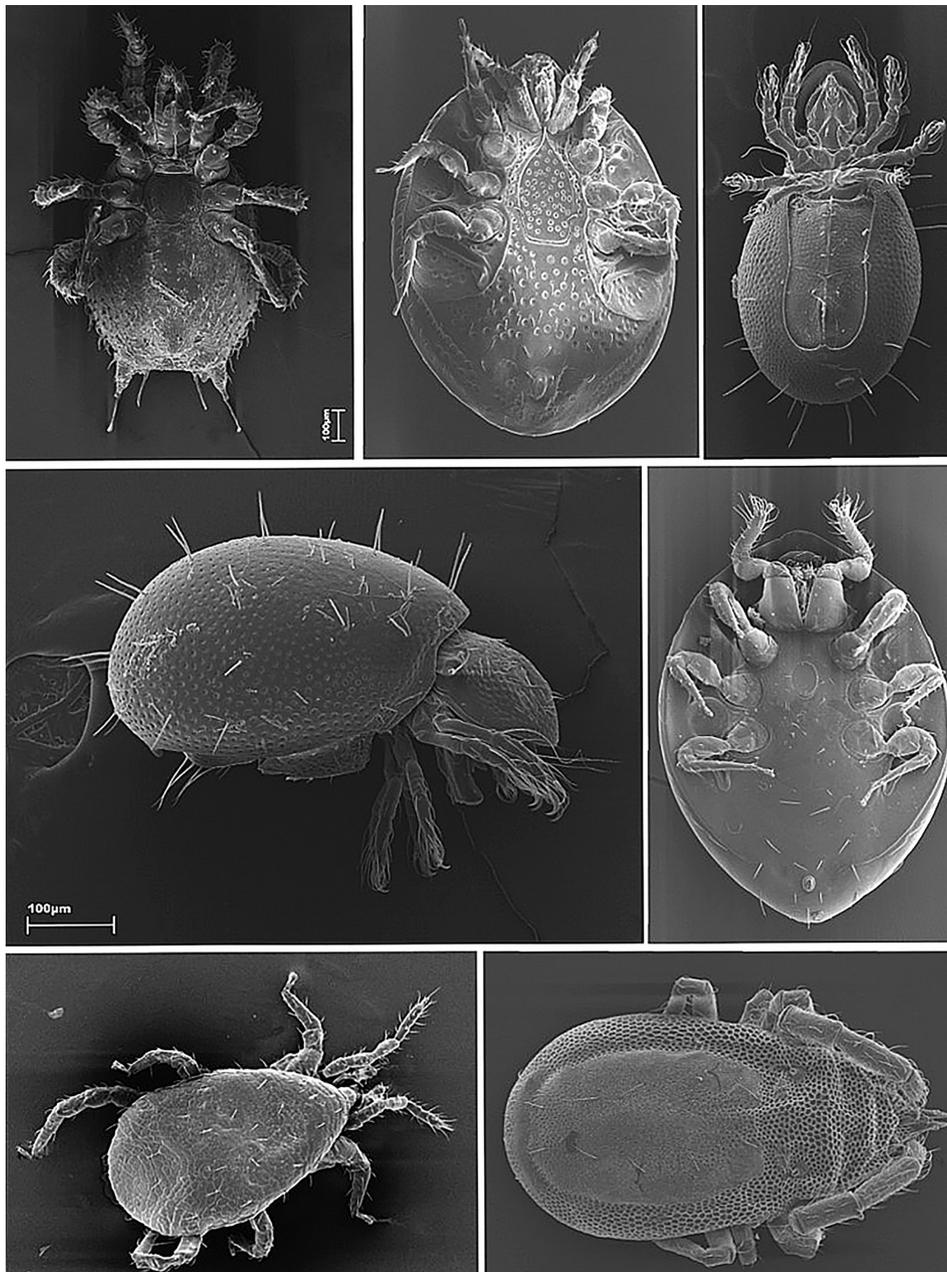
POZM (Fig. 5) – Mycological collection includes Fungi (Ascomycota, Basidiomycota, Chytridiomycetes, Mucoromycetes), Chromista (Peronospora)



Fig. 4. The POZG Herbarium primarily deposited S. Lisowski's collection of African plants, including numerous nomenclatural types



**Fig. 5.** An important part of the Natural History Collections are specimens and preparations of fungi (POZM) and lichens (Photo: Joanna Nita)



**Fig. 6.** The collection of mites (Acari) includes representatives of all orders. In addition to specimens stored mounted on microscope slides or in alcohol, we have a significant number of scanning electron microscope images (NHC archives)

and Protozoa (Myxomycetes, Protosteliomycetes). It comprises approximately 20,000 samples from central and southern Europe, Scandinavia, and North America. The most numerous are samples collected in Poland, especially in protected areas. The collections of Hanna Bujakiewicz<sup>29</sup> (approx. 5,400 samples) and Maria Lisiewska<sup>30</sup> (approx. 4,800 samples) represent a large share of this collection.

Zoological collections include over 1,700,000 specimens and samples cataloged until now. Approximately 85% of these are represented by Arthropoda, 12% by Mollusca, 2% by Chordata and 1% by other taxonomic groups. The most numerous arthropod specimens belong to Arachnida (46%) and Insecta (37%). Less abundant are collections of Chilopoda (approximately 2%), as well as Ostracoda, Malacostraca, Diplopoda, and Branchiopoda (less than 1%).

Specimens from Mesostigmata (30%) are the most numerous among arachnids, followed by Sarcoptiformes (9%) and Araneae (7%). The orders Opiliones, Pseudoscorpiones, and Trombidiformes are significantly less represented. Particularly noteworthy is the very large and diverse collection of specimens from the or-

der Mesostigmata (five suborders). Its core category is mites (Acari), forming one of the largest collections of these arachnids in the world (Fig. 6). The Mesostigmata collection was created within the framework of the so-called “Polish or Poznań School of Acarology”. Its most valuable part consists of over 900 nomenclatural types described by Poznań acarologists. Special positions among them are typical specimens of mites from the ptyctimous group (Oribatida), collected from all over the world by Wojciech Niedbała<sup>31</sup>.

At this point, it is important to mention the sample collection, which consists of litter and soil screenings from different environments, as well as unscreened samples from different types of microenvironments (merocenoses). These samples have been collected since 1941 by various researchers on all continents. The animals from which these samples were recovered were stored in alcohol. A number of publications, mainly acarological, have been produced on this basis, but they can still be studied for mites as well as for other animal groups.

Entomological collections include representatives of almost all orders. They are estimated to number



Fig. 7. One of the most numerous and richest in species groups of insects in our collections are beetles – Coleoptera (NHC archives)

several million dry- and wet-stored specimens, of which a significant number have not yet been catalogued or labeled. Dry-stored winged insects are most abundantly represented by Coleoptera (15%) (Fig. 7), Hymenoptera (12%) and Lepidoptera (5%). The majority of these are specimens from Poland and the western part of the Palearctic. The orders Siphonaptera (2%) and Odonata (1%) are also represented in the insect collection, along with the less numerous Ephemeroptera, Hemiptera, Diptera, and Orthoptera.

From the beetle collection, the following deserve special attention: Theodor Lackschewitz's<sup>32</sup> collection from the area of Riga 1895-1903 and that of Arkady Fiedler from his first trip to South America in 1929. Contemporary collections come from many points in Poland or from different regions of the country (Fig. 8), including naturally preserved ecosystems in the Augustów Primeval Forest, the Białowieża Primeval Forest and the Pisz Forest (collections of Jerzy Gutowski<sup>33</sup>) and the Świętokrzyskie Mountains (collections of Paweł Sienkiewicz<sup>34</sup>).



Fig. 8. The butterfly (Lepidoptera) collection is one of the largest in Poland (NHC archives)

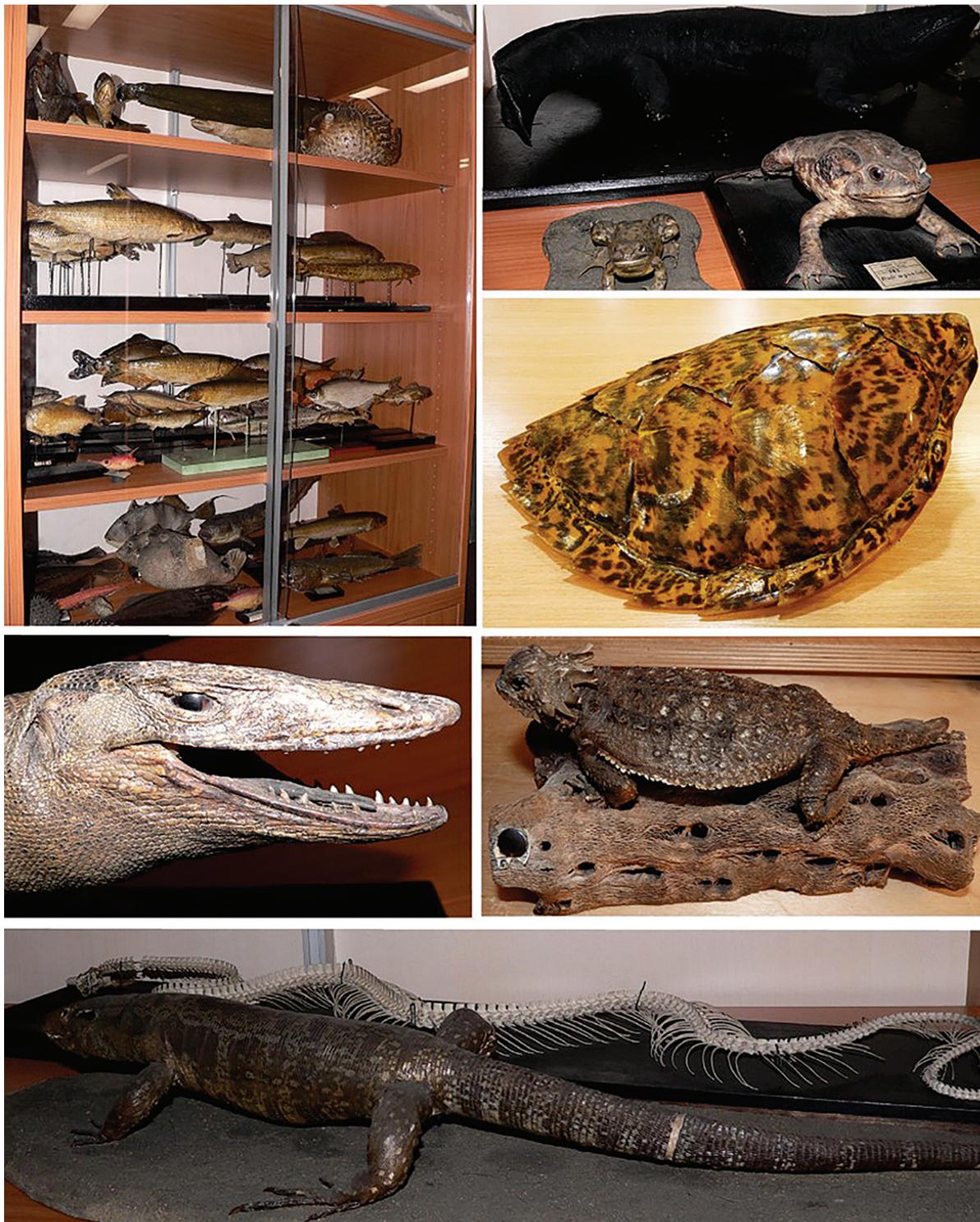
Butterfly specimens represented in the Natural History Collections include both diurnal butterflies and moths. Among the historical collections, we can distinguish first of all Burchard Schrenck's<sup>35</sup> collection from 1872-1885, Karol Pluciński's<sup>36</sup> collection from Poland gathered in 1900-1960 and the three-generation collection of Antoni, Anzelm, Marcelli and Rosław Lewandowski<sup>37</sup>, who gathered butterflies, mainly from Wielkopolska. Among the other insect groups, the following collections are particularly noteworthy:

Heteroptera by Andrzej Wróblewski, Ephemeroptera by Maria Keffermüller<sup>38</sup>, Hymenoptera by Józef Banaszak<sup>39</sup>, Siphonaptera from mole nests by Klara Bartkowska<sup>40</sup>.

The mollusc collection consists mainly of specimens belonging to Gastropoda (11.9%) (Fig. 9). Bivalvia specimens are few, while Scaphopoda and Cephalopoda are represented by only a single specimens each. Especially valuable are the collections of Jarosław Urbański<sup>41</sup>, including numerous specimens of Clausiliidae, and Jerzy



Fig. 9. The collection of molluscs (Mollusca) is very numerous and varied (NHC archives)



**Fig. 10.** The ichthyological and herpetological collections consist mainly of taxidermy specimens (NHC archives)

Kaczmarek's<sup>42</sup> collection from the Wielkopolska region. The collection of *Helix pomatia* Linnaeus, 1758 shells and data from field observations of this snail conducted since 1959 in several provinces in Poland is unique.

Also noteworthy are two Chilopoda collections, one from the mid-twentieth century (Jadwiga Kaczmarek's<sup>43</sup> collection) and one from the turn of the twenty-first century.

Among the Chordata, the Mammalia and Aves collections are equolous, while there are far fewer specimens representing Amphibia (Fig. 10). The Chordata collection consists of stuffed specimens, small mammal skins, and bird eggs (Figs. 11-12). The most noteworthy are Waław Skuratowicz's<sup>44</sup> collection of small mammals and Stefan Anioła's<sup>45</sup> oological collection.



**Fig. 11.** The osteological collection is also valuable – complete skeletons and bones of various vertebrates (NHC archives)

#### 4. Organization and functioning of the natural science collections in the Faculty of Biology

The collections gathered in the Faculty of Biology are distributed across seven air-conditioned rooms equipped with dust filters and fire and flood sensors (Konwerski & Błoszyk 2013; Błoszyk & Konwerski 2017). Most of the collection is housed in mobile storage shelving. Four rooms are used for botanical and

mycological collections, two are used for zoological collections, and one is used for osteological collections. The most sensitive scientific collections were housed in special rooms behind additional sealed doors. Research labs equipped with optical equipment and computers are assigned to all rooms with collections (Fig. 13).

These labs can be used by anyone interested in the collections, which reduces the risk of damage to specimens during transport and the possibility of them



**Fig. 12.** The ornithological collection consists mainly of taxidermy specimens as well as bird eggs and feathers (NHC archives)

being infected by harmful insects or fungi. In this way, off-site handling of specimens and samples is kept to a minimum. If necessary, specimens that have been out of storage for even a short time are frozen at  $-30^{\circ}\text{C}$  and kept in a thermoset before being returned to the collection. Type specimens may only be viewed and studied in the Natural History Collections area, where they are stored in mobile and fireproof safes. Herbarium specimens are available for loan to research institutions (Figs. 14-15).

A separate room in the Natural History Collections houses didactic collections, including a permanent “Exhibition of Tropical Plants”, which was an integral part of the POZG Herbarium. This exhibition was first organized in the Poznań Palm House by the employees of the Department of Geobotany of Adam Mickiewicz University in 1993 (Wiland 1996) and was described in detail in a book by Lisowski (1996). Both this collection and numerous didactic specimens



**Fig. 13.** Part of the Collegium Biologicum building where the collections are stored (A), the Natural History Collections' corridor decorated with cave paintings (B), laboratory rooms assigned to individual storage rooms (C) (NHC archives)

located in different parts of the Collegium Biologicum building are used in many academic and school classes, as well as during specialist trainings in the field of recognition and conservation of plants, fungi and animals (Fig. 16). They also provide basic material for regularly organized exhibitions, workshops and open lectures.

### 5. Conclusions

The natural specimens collected in the Poznań region from the seventeenth century onward have a complicated history strongly influenced by political events of international scope. This has resulted in the lack of a classical museum of natural history in Poznań, an institution present in many European cities

that fulfils a very important role in scientific and social life.

For 100 years, natural history collections have had a valuable place at the university, providing the basis for biodiversity science research. They document discoveries of taxa new to science, provide the basis for biogeographic and phylogenetic investigations, and provide material for genetic studies.

The museum-like unit, established in the FBAMU in 2004, has succeeded in preserving historical collections threatened by the reorganization of institutions in which they were previously held. Creating optimal conditions for the preservation of specimens and samples and conducting an initial inventory of the content formed the basis of the collections digitization process carried out as part of the AMUNATCOLL project.

**Footnotes\*:** Persons who have been of particular importance in the history of the nature collection and some of the collectors of specimens now deposited at the Faculty of Biology of Adam Mickiewicz University in Poznań

<sup>1</sup> Julian Zaborowski (1824-1858) – Polish patriot; editor of the journal “Nature and Industry” published in Poznań in the nineteenth century; served as vice-president of PSAAFS in 1858.

<sup>2</sup> Felician Odrowąż Sypniewski (1822-1877) – Polish naturalist, botanist, entomologist, malacologist, algologist and philosopher. Among other things, author of well-known studies and publications on diatoms.

<sup>3</sup> Franciszek Chłapowski (1846-1923) – medical doctor, professor at the University of Poznań. He headed two de-

partments of the PSAAFS (medical and natural sciences) and co-organized the Society's Natural History Museum. He published dozens of scientific papers on medicine, history of medicine, paleontology, history of natural sciences and history of philosophy. He left behind a rich archive and natural science collections.

<sup>4</sup> Friedrich (Fritz) Karl Adolph Pfuhl (1853-1913) – German teacher and botanist. He studied chemistry, botany, and ancient languages at the University of Berlin and received his doctorate in 1878 from the University of Giessen. Professor at the Royal Academy of Posen. He founded the journal of the Natural Science Association of the Province of Poznań and also the natural science collection of the Kaiser Friedrich Museum in Poznań.



**Fig. 14.** Herbaria (A), entomological collections (B), wet collections (C), anti-flood sensors (D), fireproof, mobile cabinet for type specimens (E), ornithological, ichthyological and herpetological collections (F) (NHC archives)

<sup>5</sup> Edward Feliks Lubicz-Niezabitowski (1875-1946) – zoologist and physician. He studied at the Jagiellonian University, where he received a doctorate in medicine. He collected a rich collection of preparations of specimens of planktonic fauna during numerous trips abroad. In 1921 he was appointed full professor of anatomy and histology of domestic animals at the Faculty of Agriculture and Forestry at the University of Poznań. In 1923 he became director of the Natural History Museum in Poznań.

<sup>6</sup> Arkady Adam Fiedler (1894-1985) – novelist, reporter, naturalist and traveler. In 1928 he went on his first trip to southern Brazil. From there he brought back rich zoological and botanical collections, which he selflessly donated to the Natural History Museum as well as other scientific institutions in Poznań.

<sup>7</sup> Henryk Gordziałkowski (1903-1973?) – graduated from the School of Tropical Medicine in Brussels. After earning his diploma (1927), he was hired by the Huileries du Congo Belges oil company. As a doctor, he traveled through little-recognized and hard-to-reach areas. In the Belgian Congo, he collected rich anthropological material, as well as zoological specimens.

<sup>8</sup> Jan Gabriel Grochmalicki (1883-1936) – zoologist. He studied natural sciences at Jan Kazimierz University in Lviv, where he received a doctorate of philosophy in zoology and habilitated in zoology and embryology. He was appointed a full professor of zoology at the University of Poznań, and in the years 1926-1928 he was the rector.

<sup>9</sup> Kajetan Ludwik Boratyński (1907-1980) – zoologist (entomologist), professor at the Polish University Abroad



**Fig. 15.** Equipment: heating chamber and freezers used to protect the collections from museum pests (A, B), locks and wire nets on all windows (C), large-format scanners for herbarium sheets (D) (NHC archives)



**Fig. 16.** The collected specimens are used in didactics. The photo shows temporary exhibitions for zoology classes (NHC archives)

in London, lecturer at the Imperial College of Science and Technology. He dealt with anatomical, faunal, morphological and taxonomic problems of maggots. He donated his collection to the Natural History Museum in London.

<sup>10</sup> Józef Konrad Paczoski (1864-1942) – botanist, researcher of flora and vegetation, creator of the theory of pantopism and the principles of phytosociology. He was a full professor of systematics and sociology of plants and an honorary doctor of the University of Poznań.

<sup>11</sup> Tadeusz Dominik (1909-1980) – phytopathologist and mycologist. He studied biology and forestry at the University of Poznań, where he also defended his doctoral thesis

in botany. He worked in the Department of Botany at the University of Poznań from 1947 to 1949. Later, among other things, he headed the Department of Plant Protection at the Agricultural Academy in Szczecin, working as an associate and full professor.

<sup>12</sup> Brunon Józef Szafarkiewicz (1821-1892) – Polish naturalist, teacher, social activist. Doctor of philosophy. In 1862-1867 and 1880-1886 he was chairman of the Natural Science Department of the PSAAFS. Secretary of the German Natural History Society (1857-1879). In the second half of the nineteenth century he was the most distinguished naturalist and social-positivist in the Prussian partition.

<sup>13</sup> Feliks Teodorowicz (1878-1944) – assistant in the Department of Botany and Phytopathology at the University of Poznań.

<sup>14</sup> Aleksander Wróblewski (1911-1985) – entomologist, heteropterologist. He studied biology and conducted research at the University of Poznań, where in 1963 he was awarded the title of professor. He was involved in faunistics, systematics and ecology of water insects.

<sup>15</sup> Adam Marcin Jakub Wodziczko (1887-1948) – botanist and conservation activist. He received his doctoral and postdoctoral degrees from the Jagiellonian University. In 1925 he was appointed associate professor at the Faculty of Mathematics and Natural Sciences at the University of Poznań. In 1936 he received the title of full professor of plant anatomy and physiology.

<sup>16</sup> Zygmunt Czubiński (1912-1967) – botanist, nature protection activist, professor at the Adam Mickiewicz University in Poznań. Member of the Polish Academy of Sciences, chairman of the Committee on National Parks and Nature Reserves of the State Council for Nature Protection.

<sup>17</sup> Jan Rafalski (1909-1995) – zoologist, higher education and doctorate graduated from the University of Poznań, where he worked all his life. His lifelong interests included Pseudoscorpiones, Opiliones, Acari. He was a true naturalist, enjoying most his regular collecting trips. He worked until his eighties.

<sup>18</sup> Izabela Dąmbska (1927-1984) – hydrobotanist and conservation activist. She studied biology and was a professor at the University of Poznań (Adam Mickiewicz University). She conducted hydrobotanical studies of Polish lakes, especially in national parks. She specialized in the taxonomy and ecology of algae, especially from the stonewort group.

<sup>19</sup> Jerzy Szweykowski (1925-2002) – botanist and geneticist, professor at the University of Poznań. Author of many publications on plant population genetics and taxonomy of bryophytes, especially liverworts.

<sup>20</sup> Feliks Krawiec (1906-1939) – graduated in biology and received a doctorate from the University of Poznań. Outstanding expert on lichens and vascular flora and bryophytes. He died in the first days of World War II in September 1939.

<sup>21</sup> Waldemar Żukowski (born 1935) – botanist dealing with floristics, taxonomy and geography of vascular plants. He graduated from the University of Poznań. At the same university he received a doctorate, a postdoctoral degree and the title of professor. He specializes in particular in the family Cyperaceae.

<sup>22</sup> Karol Latowski (1939-2017) – botanist working on floristics, taxonomy and geography of vascular plants. He graduated from the University of Poznań. At the same university he received a doctorate, a postdoctoral degree and the title of professor. He was a specialist in carpology, especially the Brassicaceae and Apiaceae families.

<sup>23</sup> Zygmunt Tobolewski (1927-1988) – lichenologist. He graduated from the University of Poznań. At the same university he received a doctoral degree, a postdoctoral degree and the title of professor. Among other things, he developed a key to the determination of Polish lichens.

<sup>24</sup> Stanisław Lisowski (1924-2002) – botanist, expert in vascular flora and bryophytes. He graduated from the University

of Poznań. At the same university he received a doctorate, a postdoctoral degree and the title of professor. Author of one of the largest herbaria of African plants.

<sup>25</sup> Johann Heinrich Rudolf Schenck (1860-1927) – German botanist and university professor. Schenck's research interest was in aquatic plants, where he mainly investigated the histological structure and living conditions. He also researched the morphology, histology and ecology of lianas. In 1886/1887 he undertook a research trip to Brazil.

<sup>26</sup> Heinrich Walter (1898-1989) – geobotanist and ecophysiological who came from Odessa. He stayed in Poznań briefly during World War II (in 1941). On numerous research trips, he got to know almost all vegetation zones of the earth from his own perspective and summarized his findings and experiences in many books.

<sup>27</sup> Erna Walter (1893-1992) – German botanist, primarily concerned with lichens and mosses. She received her doctorate from the University of Heidelberg in 1918. Wife and collaborator of Professor Walter.

<sup>28</sup> Carl Albert Purpus (1851-1941) – German collector of plants (Bryophytes, Spermatophytes) and fungi, which he collected in North America and Mexico, among other places.

<sup>29</sup> Anna Maria Bujakiewicz (born 1940) – mycologist; specialist in ecology and systematics of macrofungi. She graduated from the University of Poznań. At the same university she obtained her doctorate, habilitation and the title of professor.

<sup>30</sup> Maria Lisiewska (born 1934) – mycologist; specialist in ecology and systematics of macrofungi. She graduated from the University of Poznań. At the same university she obtained her doctorate, habilitation and the title of professor.

<sup>31</sup> Wojciech Niedbała (born 1943) – zoologist, working on animal systematics, acarology, soil zoology, ecosystem ecology, zoogeography. Outstanding expert on mites from the ptyctimous group (Acari, Oribatida). Graduated from the University of Poznań. At the same university he obtained his doctorate, habilitation and the title of professor.

<sup>32</sup> Paul Moritz Alexander Lackschewitz (1865-1936) – Latvian botanist (salicologist) and entomologist. Dr. med., honorary member of the Natural History Research Society in Riga.

<sup>33</sup> Jerzy Marian Gutowski (born 1954) – zoologist, entomologist, specializing in systematics and ecology of beetles. Graduated from the University of Life Sciences in Poznań. At the same university he obtained his doctorate, habilitation and the title of professor.

<sup>34</sup> Paweł Sienkiewicz (born 1974) – zoologist, entomologist, specializing in systematics, biogeography and beetles conservation. He graduated from the University of Life Sciences in Poznań. He obtained his doctorate and habilitation at the same university.

<sup>35</sup> Leopold von Schrenck (1826-1894) – came from a Baltic German family. He was a zoologist, geographer and ethnographer, and his son Burchard Schrenck (1865-1929) was a statistician. Their collection of butterflies came from, among other places, the area around Lviv.

<sup>36</sup> Karol Pluciński (1873-1966) – lepidopterologist, amateur entomologist, banker by profession; member of the Polish Entomological Society, owner of a large collection of butterflies of Poland.

<sup>37</sup> Lewandowski, Marcei, Roman (1910-1984) – banker, amateur entomologist; Anzelm (1908-1982) – chemistry professor, their father Antoni and Rosław (Marcei's son) are the authors of a butterfly collection of several generations.

<sup>38</sup> Maria Keffermüller (1924-2011) – zoologist, concerned with the systematics and ecology of mayflies (Ephemeroptera). Graduated from the University of Poznań. At the same university he obtained his doctoral and post-doctoral degrees and the title of professor.

<sup>39</sup> Józef Banaszak (born 1947) – zoologist, ecologist, bee expert. For many years he was a professor at Kazimierz Wielki University in Bydgoszcz.

<sup>40</sup> Klara Bartkowska (1939-2010) – zoologist, parasitologist and entomologist. She completed her studies in biology at Adam Mickiewicz University in Poznań. At the same university she obtained her doctoral and postdoctoral degrees. She conducted research on fleas (Siphonaptera).

<sup>41</sup> Jarosław Urbański (1909-1981) – professor, zoologist, outstanding expert on molluscs (Mollusca). He was also in-

involved in botany, nature conservation and nature photography. He graduated from the Faculty of Agriculture and Forestry at the University of Poznań. From 1946, he conducted scientific research at the same university.

<sup>42</sup> Jerzy Kaczmarek (1940-2022) – Catholic priest, nature lover and collector, specialist in entomology and malacology.

<sup>43</sup> Jadwiga Kaczmarek (1923-1991) – zoologist, associate professor, conducted research on Chilopoda at Adam Mickiewicz University in Poznań.

<sup>44</sup> Waław Skuratowicz (1915-1989) – zoologist, theriologist and parasitologist. He completed his biological studies at the University of Poznań. At the same university he obtained his doctoral degree and the title of professor, lectured and conducted scientific research.

<sup>45</sup> Stefan Anioła (1939-2014) – naturalist, collector, educator of many outstanding Polish ornithologists. He graduated in biology from the Adam Mickiewicz University in Poznań.

**Acknowledgments:** This work has been supported by the AMUNATCOLL project and has been partly funded by the European Union and Ministry of Digital Affairs from the European Regional Development Fund as part of the Digital Poland Operational Program under grant agreement number: POPC.02.03.01-00-0043/18. This paper expresses the opinions of the authors and not necessarily those of the European Commission and Ministry of Digital Affairs. The European Commission and Ministry of Digital Affairs are not liable for any use that may be made of the information contained in this paper.

The authors are grateful to Professor Katarzyna Buczkowska-Chmielewska, Professor Maciej Gąbka and M.Sc. Joanna Nita for providing photographs of the botanical collections.

### Author Contributions

Research concept and design: B. Jackowiak

Collection and/or assembly of data: B. Jackowiak, J. Błoszyk, Z. Celka, Sz. Konwerski, P. Szkudlarz, J. Wiland-Szymańska  
Data analysis and interpretation: B. Jackowiak, J. Błoszyk, Z. Celka, Sz. Konwerski, P. Szkudlarz, J. Wiland-Szymańska  
Writing the article: B. Jackowiak

Critical revision of the article: B. Jackowiak, J. Błoszyk, Z. Celka, Sz. Konwerski, P. Szkudlarz, J. Wiland-Szymańska  
Final approval of article: B. Jackowiak, J. Błoszyk, Z. Celka, Sz. Konwerski, P. Szkudlarz, J. Wiland-Szymańska

### References

- ADAMSKI W. 1828. Rośliny zbierane w różnych okolicach Wielkiego Księstwa Poznańskiego z przytoczeniem miejsc szczególnych gdzie rosną. *Gazeta Wielkiego Księstwa Poznańskiego* 40.
- ALLMON W. D. 1994. The Value of Natural History Collections. *Curator. The Museum Journal*. 37 (2): 83-89.
- ANC 2022. Available at: [amunatcoll.pl](http://amunatcoll.pl) (accessed 26 January 2022).
- ANDREW C., DIEZ J., JAMES T. Y. & KAUSERUD H. 2019. Fungarium specimens: a largely untapped source in global change biology and beyond. *Phil. Trans. R. Soc. B*. 374, 1763, 20170392.
- BALLARD H. L., ROBINSON L. D., YOUNG A. N., PAULY G. B., HIGGINS L. M., JOHNSON R. F. & TWEDDLE J. C. 2017. Contributions to conservation outcomes by natural history museum-led citizen science: Examining evidence and next steps. *Biol. Conserv.* 208: 87-97.
- BŁOSZYK J. & KONWERSKI S. 2017. Zbiory Przyrodnicze Wydziału Biologii UAM kontynuatorem 160-letnich tradycji muzealnictwa przyrodniczego w Wielkopolsce. *Ośrodek Kultury Leśnej w Gołuchowie*: 128-139.
- BRZEK G. 1973. Zoologia w Wielkopolsce (do r. 1945). In: G. LABUDA, W. JAKÓBCZYK & S. WEYMAN (eds.). *Nauka w Wielkopolsce. Studia i materiały*, pp. 605-637. Wyd. Poznańskie, Poznań.
- BURCHARDT L., TOMASZEWICZ G. H. & MATULA J. 1999. L. Rabenhorst's algae in Polish collections. *Polish Botanical Studies. Guidebook Series*. 21: 3-87.
- BUTCHER K. R., POWER M. J., LARSON M., ORR M. P., VELASQUEZ-FRANCO S., HUDSON M. A. & BAILEY V. J. 2019. Museum Leadership for Engaging, Equitable Education: The Transformative Potential of Digitized Collections for Authentic Learning Experiences. *Curator: The Museum Journal*. 64(2): 383-402.

- CHŁAPOWSKI F. 1909. Zbiory Przyrodnicze Towarzystwa Przyjaciół Nauk dla użytku zwiedzających je. Drukarnia Dziennika Poznańskiego, Poznań.
- CHŁAPOWSKI F. 1913. Zbiory Przyrodnicze Towarzystwa Przyjaciół Nauk dla użytku zwiedzających je. Wyd. II. Drukarnia „Praca”, Poznań.
- DĄBSKA I. 1973. Botanika (do r. 1939). In: G. LABUDA, W. JAKÓBCZYK & S. WEYMAN (eds.). *Nauka w Wielkopolsce. Studia i materiały*, pp. 656-664. Wyd. Poznańskie, Poznań.
- ERZEPKI B. 1896. Dra. Wojciecha Adamskiego materiały do flory W. Ks. Poznańskiego, pp. I-XI, 1-58. Drukarnia F. Chocieszyńskiego, Poznań.
- GALLINAT A. S., RUSSO L., MELAAE E. K., WILLIS C. G. & PRIMACK R. B. 2018. Herbarium specimens show patterns of fruiting phenology in native and invasive plant species across New England. *Am J Bot* 105(1) 1, 31-41.
- GBIF 2022. Available at: <https://www.gbif.org/publisher/5480dea7-2a71-409b-a832-cbc5f1b5a2e6> (accessed 26 January 2022).
- GLON H. E., HEUMANN, B. W., CARTER J. R., BARTEK J. M. & MONFILS A. K. 2017. The contribution of small collections to species distribution modelling: A case study from Fuireneae (Cyperaceae). *Ecol. Inform.* 42: 67-78.
- GRABSKI T. 2000. Oddział Przyrodniczy Muzeum Wielkopolskiego na Jeźyczach w okresie międzywojennym. *Kronika Miasta Poznania* 2: 236-242.
- GUMOWSKI M. 1925. Muzeum Wielkopolskie. Historia zbiorów. *Muzeum Wielkopolskie w Poznaniu Rocznik I*: 5-26.
- GUMOWSKI M. 1929. Rocznice muzealne. *Muzeum Wielkopolskie w Poznaniu Rocznik V*: 3-5.
- HEDRICK B. P., HEBERLING J. M., MEINEKE E. K., TURNER K. G., GRASSA C. J., PARK D. S., KENNEDY J., CLARKE J. A., COOK J. A., BLACKBURN D. C., EDWARDS S. V. & DAVIS C. C. 2020. Digitization and the Future of Natural History Collections. *BioScience*. 70(3): 243-251.
- JTCZ 1999. International code of zoological nomenclature. Fourth edition. London International Trust for zoological Nomenclature. 1-306.
- INDEX HERBARIORUM 2022. Available at: <http://sweetgum.nybg.org/science/ih/> (accessed 26 January 2022).
- JACKOWIAK B., BŁOSZYK J., DYLEWSKA M., NOWAK M. M., SZKUDLARZ P., LAWENDA M. & MEYER N. 2022. The Adam Mickiewicz University Nature Collections IT system (AMUNATCOLL): assumptions and implementation of the project. *Biodiv. Res. Conserv.* 65: 23-34.
- KASPRZAK K. 1985. Uwagi na temat raportu o stanie współczesnych zbiorów zoologicznych w Polsce. *Przegląd Zool.* 29(3): 375-379.
- KONWERSKI S. & BŁOSZYK J. 2013. Zbiory Przyrodnicze Wydziału Biologii Uniwersytetu im. Adama Mickiewicza w Poznaniu – struktura i funkcjonowanie. *Opuscula Musealia* 21: 137-144.
- KORNAŚ J. & OCHYRA R. 1994. Professor Stanisław Lisowski: Biographical sketch and list of publications. *Fragm. Flor. Geobot.* 39 (1): 7-23.
- KRAWIEC F. 1936. Ośrodek pracy naukowej nad roślinnością Wielkopolski. Wydawnictwo Okręgowego Komitetu Ochrony Przyrody na Wielkopolskę i Pomorze w Poznaniu 6: 81-84.
- LANE M.A. 1996. Roles of Natural History Collections. *Annals of the Missouri Botanical Garden*. 83: 536-545.
- LAWENDA M., WILAND-SZYMAŃSKA J., NOWAK M.M., JĘDRASIAK D. & JACKOWIAK B. 2022. The Adam Mickiewicz University Nature Collections IT system (AMUNATCOLL): metadata structure, database and operational procedures. *Biodiv. Res. Conserv.* 65: 35-48.
- LISOWSKI S. 1996. *Świat Roślinny Tropików*. 192 pp. Wyd. Sorus, Poznań.
- MIREK Z., MUSIAŁ L. & WÓJCICKI J. J. 1997. Polish herbaria. *Polish Botanical Studies, Guidebook Series* 18: 1-116.
- NELSON G. & ELLIS S. 2018. The history and impact of digitization and digital data mobilization on biodiversity research. *Phil. Trans. R. Soc. B*. 374, 20170391.
- NELSON G., PAUL D., RICCARDI G. & MAST A. 2012. Five task clusters that enable efficient and effective digitization of biological collections. *ZooKeys*. 209: 19-45.
- NOWAK M. M., LAWENDA M., WOLNIEWICZ P., URBANIAK M. & JACKOWIAK B. 2022. The Adam Mickiewicz University Nature Collections IT system (AMUNATCOLL): portal, mobile application and graphical interface. *Biodiv. Res. Conserv.* 65: 49-67.
- NOWAK M. M., SŁUPECKA K. & JACKOWIAK B. 2021. Geotagging of natural history collections for reuse in environmental research. *Ecol. Indicators* 131, 108131.
- PACZOSKI J. 1933. Zakład Botaniki Systematycznej Uniwersytetu Poznańskiego. Wydawnictwo Okręgowego Komitetu Ochrony Przyrody na Wielkopolskę i Pomorze w Poznaniu 4: 151-152.
- PAKNIA O., RAJAEI SH. H. & KOCH A. 2015. Lack of well-maintained natural history collections and taxonomists in megadiverse developing countries hampers global biodiversity exploration. *Organism Diversity & Evolution*. 15: 619-629.
- PFUHL F. 1894. Das Herbarium der Provinz Posen. *Zeitschrift der Botanischen Abteilung, Naturwissenschaftlicher Verein der Provinz Posen* 1(1): 62-63.
- PFUHL F. 1897. Das Herbarium der Provinz Posen. *Zeitschrift der Botanischen Abteilung, Naturwissenschaftlicher Verein der Provinz Posen* 4(1): 26-63.
- PFUHL F. 1903. Das Herbarium im Kaiser-Friedrich-Museum. *Zeitschrift der Naturwissenschaftlichen Abteilung (des Naturwissenschaftlichen Vereins), Deutsche Gesellschaft für Kunst und Wissenschaft in Posen* 4(1): 1-15.
- RAFALSKI J. 1973. Nauki zoologiczne (po r. 1945). In: G. LABUDA, W. JAKÓBCZYK & S. WEYMAN (eds.). *Nauka w Wielkopolsce. Studia i materiały*, pp. 638-655. Wyd. Poznańskie, Poznań.
- RITSCHL G. 1850. *Flora des Großherzogthums Posen, im Auftrage des naturhistorischen Vereins zu Posen*. 291 pp. Druck und Verlag von E. S. Mittler und Sohn. Berlin.
- RIVERS M. C., TAYLOR L., BRUMMITT N. A., MEAGHER T. R., ROBERTS D. L. & LUGHADHA E. N. 2011. How many herbarium specimens are needed to detect threatened species? *Biol. Conserv.* 144(10): 2541-2547.
- SCHENCK H. 1893. Beiträge zur Anatomie der Lianen. In: A. F. W. SCHIMPER (ed.). *Botanische Mitteilungen aus den Tropen. Part 2*: 1-271. Gustav Fischer Verlag, Jena.

- SHAFFER H. B., FISHER R. N. & DAVIDSON C. 1998. The role of natural history collections in documenting species declines. *Trends in Ecology and Evolution* 13 (1): 27-30.
- STECKI K. & PIETKIEWICZ J. 1931a. Józef Szafarkiewicz jako florysta i jego zielnik. *Przegląd Leśniczy* 1: 2-9.
- STECKI K. & PIETKIEWICZ J. 1931b. Józef Szafarkiewicz jako florysta i jego zielnik. *Przegląd Leśniczy* 2: 63-74.
- SYMOENS J.-J., WILAND-SZYMAŃSKA J. & LEJOLY J. 2004. Stanisław Lisowski. *Systematics and Geography of Plants* 74: 9-16.
- SZAFARKIEWICZ J. 1871. Rośliny jawnokwiatowe dziko rosnące w W. Ks. Poznańskim. In: *Historia Naturalna. Kurs II. Poznań*.
- SZAFRANÓWNA H. 1933a. Nieznany florysta Wielkopolski X. Biskup Cybichowski i jego zielnik. *Wydawnictwo Okręgowego Komitetu Ochrony Przyrody na Wielkopolskę i Pomorze w Poznaniu* 4: 109-113.
- SZAFRANÓWNA H. 1933b. Przyczynki do historii badań flory poznańskiej. *Biblioteka „Kroniki Miasta Poznania”*. 4: 1-43.
- TURLAND N. J., WIERSEMA J. H., BARRIE F. R., GREUTER W., HAWKSWORTH D. L., HERENDEEN P. S., KNAPP S., KUSBER W-H., LI D-Z., MARHOLD K., MAY T. W., MCNEILL J., MONRO A. M., PRADO J., PRICE M. J. & SMITH G. F. (eds.). 2018. *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. *Regnum Vegetabile* 159. Glashütten: Koeltz Botanical Books.
- TYKARSKI P. 2021. Zasoby danych przyrodniczych polskich instytucji naukowych – bogactwo, historia, znaczenie – wstęp. *Kosmos*. 70(2): 131-137.
- VON KONRAT M., CAMPBELL T., CARTER B., GREIF M., BRYSON M., LARRAIN J., TROUILLE L., COHEN S., GAUS E., QAZI A., RIBBENS E., LIVSHULTZ T., WALKER T. J., SUWA T., PETERSON T., RODRIGUEZ Y., VAUGHN C., YANG C., ABURAHMEH S., CARSTENSEN B., DE LANGE P., DELAVOI C., STRAUSS K., DRAG J., AGUERO B., SNYDER C., MARTINEC J. & SMITH A. 2018. Using citizen science to bridge taxonomic discovery with education and outreach. *Appl. Plant Sci.* 6, 2, e1023.
- WILLIS C. G., ELLWOOD E. R., PRIMACK R. B., DAVIS C. C., PEARSON K. D., GALLINAT A. S., YOST J. M., NELSON G., MAZER S. J., ROSSINGTON N. L., SPARKS T. H. & SOLTIS P. S. 2017. Old Plants, New Tricks: Phenological Research Using Herbarium Specimens. *Trends in Ecology & Evolution* 32(7): 531-546.
- WILAND J. 1996. *Dydaktyczna Wystawa Roślin Tropikalnych ze zbiorów Uniwersytetu im. Adama Mickiewicza w Palmiarni Poznańskiej*. (The didactic tropical plants exhibition from the collection of the Adam Mickiewicz University in the Poznań Palm House) (in Polish) *Biuletyn Ogrodów Botanicznych* 5: 79-84.
- WOJTERSKI T. 1973. *Botanika (po r. 1945)*. In: G. LABUDA, W. JAKÓBCZYK & S. WEYMAN (eds.). *Nauka w Wielkopolsce. Studia i materiały*, pp. 605-637. Wyd. Poznańskie, Poznań.

\* Footnotes are based on the following sources:

- Archive of the Faculty of Biology, Adam Mickiewicz University in Poznań.
- CZARNECKA B. 2013. *Wizerunek Konga Belgijskiego w piśmiennictwie polskim i irlandzkim*. 282 pp. Wydawnictwo Uniwersytetu Wrocławskiego. Wrocław.
- FELIKSIAK S. (ed.). 1987. *Słownik biologów polskich*. 618 pp. PWN Warszawa.
- MIREK Z., MUSIAŁ L. & WÓJCICKI J. J. (eds.). 1995. *Kto jest kim w botanice polskiej [Who is who in Polish botany]*. *Polish Botanical Studies* 14, 436 pp. Polish Academy of Sciences, W. Szafer Institute of Botany in Kraków.
- WDOWIAK L. 2009/2010. *Lekarze-folklorysty na ziemiach polskich w XIX i XX stuleciu*. *Medycyna nowożytna* 16(1-2): 85-108.

- <http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-fe62850f-97a7-4aba-a63d-38dd3ab9cbc9>
- [http://wiki.meteoritica.pl/index.php5/Morasko/Archiwum\\_Zygmunta\\_Pniewskiego](http://wiki.meteoritica.pl/index.php5/Morasko/Archiwum_Zygmunta_Pniewskiego)
- <http://www.tmmp.poznan.pl/cms/content/view/94/49/>
- <http://www1.up.poznan.pl/keos/pracownicy/>
- <https://de.wikipedia.org/wiki/>
- <https://mndi.museunacional.ufjf.br/aracnologia/pdfliteratura/>
- <https://pl.wikipedia.org/wiki/>
- <https://plus.gloswielkopolski.pl/100-powodow-do-dumy-100-ludzi-nauki-z-wielkopolski/ar/13755984>