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The Importance and Potential Value of a Regional Midsize Arthropod Collection

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The Importance and Potential Value of a Regional Midsize Arthropod Collection: An Example of IBULC

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Abstract: During the last three centuries, people involved in natural history sciences have produced thousands of natural history collections worldwide. Specimens have been used for scientific proof of various discoveries and for gaining new knowledge in many disciplines of science not only in the area of biodiversity but also in taxonomy, species biology and ecology, parasitology, evolution, organisms' responses to climate change, nature conservation and many other biological sub-disciplines. Despite never-ending financial struggles, the world's largest collections as well as many regional midsize collections contain billions of specimens. This provides an enormous database for present and future studies. This article presents a critical description of the material of the Institute of Biology, University of Latvia collection (IBULC) containing roughly 59,000 identified arthropod individuals of about 3,700 species, including twenty-eight primary types as a part of around ninety type specimens, to illustrate the importance of midsize regional natural history collections in detail.

Keywords: Arthropoda, Baltic Region, Collaboration, Collections, IBULC, Rare Species, Species Diversity, Type Material

Introduction

At present, billions of specimens with their documentation (associated data, e.g., where, when, and how the specimen was collected, etc.) are preserved as part of thousands of natural history collections worldwide (Evenhuis [2007] 2017; McLean et al. 2015; Suarez and Tsutsui 2004; Thomson 2005). Such a tremendous amount of material and immaterial (theoretical) knowledge captures endless potential for both present and future contribution. Collections are used commonly as a helpful tool in the fields of natural sciences, public health and food security, plant protection, criminalistics, education, economics, modern technologies and even beyond (Bakkes 2014; Colvin 2014; Gutiérrez and Pine 2017; Lee 2014; Lincoln and Sheals 1979; Natural Science Collections Alliance [NSCA] 2005; Ownes and Duin 2008; Pettitt 1991).

The world's largest and best known institutions hold the largest number of specimens and have the greatest impact on research and scientific publications worldwide: Natural History Museum in London, American Museum of Natural History in New York and Smithsonian National Museum of Nature History in Washington DC, Museum national d'histoire naturelle in Paris, Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung (formerly Museum für Naturkunde der Humboldt-Universität) in Berlin, Naturalis Biodiversity

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Center in Leiden, Oxford University Museum of Natural History and many more (Codella 2000; Thomson 2005; Wiedenmann, Dowling, and Barnes 2014). However, in addition to these, there are literally thousands of midsized regional and national collections at various institutions and museums scattered all over the world that deserve to be recognized (Walker 1999; Codella 2000; Ferreira, Prado, and Seripierri 2016; Franz and Yusseff Vanegas 2009; Gaidienė 1993; Singh 2007; Ullah and Ullah 2006; Walker et al. 1999). The development and use of midsized collections suffered a setback during the year 2000 mainly because of the financial crisis (Dalton 2003; Gropp 2003). Furthermore, there has been a backlog of curation in the Baltic States as well as in other countries, engagement in scientific projects and low loaning activities, which could have increased the scientific value of these collections (Kurina 2009; Wass and Ross 2002; Wiedenmann, Dowling, and Barnes 2014).

A relatively young collection deposited in the Institute of Biology, University of Latvia (IBULC), is an example of a midsized, regional collection that deserves to be recognized by the international scientific community and utilized in more scientific activities. IBULC has been promoted for further improvements, and there are plans to undertake digitization soon (Kagainis et al. 2018). In this article we use the IBULC as a case study to highlight the importance and potential of midsized collections.

The Material of IBULC

During 2017–2019, the IBULC collections were inventoried by the authors—the number of species and specimens was recounted and information on specimen labels reviewed. The acronym IBULC (Institute of Biology, University of Latvia collections) was devised in 2017 as a standard means of referring to the collections in 2017 and now appears in the official online list of the insect and spider collections of the world (http://hbs.bishopmuseum.org/codens, see also Evenhuis [2007] 2017). Collection material was divided into subcollections representing different orders of Arthropoda.

Since the IBULC consists predominantly of domestic samplings, the following paragraphs provide biogeographical descriptions of the collections' sites relative to specimen material.

Latvia is situated in the northwestern part of the Palaearctic biogeographical region (56°79 N, 024°24 E). The territory is dominated by the mixed-forest biome, incorporating habitats of both boreal and temperate (continental) biomes and their respective fauna, reflecting a significantly wide range of climatic conditions. The West–East gradient characterizes both the continental variation of Latvian climate and the distribution of precipitation (Kalniņa 1995; Ramans and Zelčs 1995). The western part also incorporates Central Europe species, whereas in the eastern part some taxa show characteristics even of steppe-biome species (Laiviņš and Melecis 2003; Mücher et al. 2009; Rutkis 1960). The territory of Latvia has been reported as a transitional area for a considerable number of European and Eurasian chorotypes (Spuris 1970).

The northern and southern parts of Latvia correspond more to a boreal and a temperate biome, respectively. Both boreal and temperate biomes exist across a relatively broad spectrum of natural and seminatural habitats described by the European Council Directive 92/43/EEC of May 21, 1992. More than half of Latvian territory is forested, including habitats of EU importance: Western taiga (9010), Fennoscandian deciduous swamp woods (9080), *Tilio-Acerion* forests of slopes, screes and ravines (9180), and others. The cover of natural meadows, for example, xeric and calcareous grasslands (6120), seminatural dry grasslands and scrubland facies on calcareous substrates (6210), and other types, is relatively low—approximately 0.3% of the total area of Latvia (Kabucis 2001). Raised bogs in Latvia are rather extensive, with an example of a very specific alkaline fens (7230) that originated after the receding of the Littorina Sea. These fens occur mostly in the Maritime Lowlands and preserve unique species' composition patterns (Auniņš 2010; European Commission 2013). A study of caddisflies by Spuris (1970) highlighted zoogeographical peculiarities of the Eastern Baltic fauna by uncovering high species diversity, transitions, and a unique mixture of West-Palearctic, boreal, and temperate faunas.

With regard to IBULC arthropod collections, the methodology, for example, sampling and preparation techniques, biogeographical details of domestic and foreign samples, and percentage classes of collecting area compared with the total area of Latvia, is summarized (Table A1). Since the 1940s adult insects of IBULC have been mostly pinned and kept air-dry (Hemiptera, Homoptera, Hymenoptera, Coleoptera, and part of Diptera), sorted by families, and stored in separate wooden drawers in the collection room at the institute (Karpa 2008; Karps 1978; Spuņģis 2002, 2003; Telnov 2004; Varzinska 1975; Velce and Danka 1970). Once a year, the specimen drawers are kept refrigerated (−18°C) for at least three days, filled with fresh naphthalene sponges. Families and specimens are arranged alphabetically in drawers (see similar practices in Dawson and Strang 1992; Upton 1991; Walker and Crosby 1988). Dissected genitalia of Diptera are stored in glycerol-filled microvials together with their corresponding specimens. Coleopteran genitalia, if dissected, are mostly mounted (glued) on mounting slides adjacent to their corresponding specimens. The Canada balsam method (Martin 1977; Upton 1993; Walker and Crosby 1988; Walker et al. 1999) is used to preserve the majority of Diptera—Nematocera specimens. Spiders and some Collembola are kept in ethanol vials, some of the collembolans in glycerol, and most specimens of mites and collembolans are prepared in hard media on microscopy slides (Lincoln and Sheals 1979; Rusek 1974).

The IBULC Oribatida subcollection is digitally databased. The available information of taxonomic importance includes specimen-specific data on leg./det. (collector/identifier), district, habitat, sex, reproductive mode, and even the body position of the mounted specimen (Bluhm, Scheu, and Maraun 2016; Evenhuis [2007] 2017; Lions 1967; Palmer and Norton 1990). Also, scientific names and specimen label data have been digitized for Diptera–Brachycera (Karpa 2001, 2008; see also Weon, Byun, and Lee 1996). Digitization of other subcollections is currently in progress.

More than 500,000 arthropods had been deposited unidentified and taxonomically unsorted at the beginning of the collection of the material for IBULC. These specimens had been preserved mostly in ethanol, others pinned or slide mounted. The majority have been sorted to order or family level, and partial data have been summarized on locality and habitat, code of sample, sampling date, and so forth for each sample (Animal Ethics Infolink 2010; Meester 1990). The digital version of IBULC's data summary has recently been prepared and is available online for potential collaborators (Jankevica 2017).

A summarized quantitative overview of IBULC is presented in Table A2. Exact data on species and the numbers of specimens from each arthropod family are summarized and accessible on the Internet (Jankevica 2017, also accessible through the webpage by Evenhuis [2007] 2017). Certain samples of these subcollections (orders: Collembola, Parasitiformes, nematoceran Diptera) are unique for the Baltic state region. Detailed data on type material presented by IBULC are provided in Table A3.

Discussion: Importance and Potentials of Midsize Regional Collections

Without the availability of a real specimen, there is the possibility of misidentification of an invertebrate species even by experienced scientists owing to the high morphological variability and traits that are undetectable in descriptions, drawings, photographs, or videos (Browne 2001; Codella 2000; Dincă et al. 2011; Pettitt 1991; Pittino 2006). A well-preserved specimen may offer traits that have not yet been discovered but may be valuable for future species clarification (Codella 2000; Enghoff and Seberg 2006; Harper, Maclean, and Goulson 2006; Mayr and Ashlock 1991; Wandeler, Hoeck, and Keller 2007). The identification and/or verification of arthropod species of IBULC has been performed by the institute's experienced specialists with the assistance of the world's leading taxonomists. Therefore, the value of the collection for future taxonomic studies is ensured by the fact that the material is reviewed and approved by experienced specialists from around the globe (Bakkes 2014; Ellis 2008; Kotrba et al. 2006; Pettitt 1991; Suarez and Tsutsui 2004).

Diptera and Hemiptera are currently among the richest orders in terms of diversity of species and are the largest subcollections of IBULC compared with other arthropod collections in Latvia (Karpa 2001). The most numerous specimens are the brachycerans represented by Sarcophagidae, consisting mainly of two species, *Sarcophaga carnaria* Linnaeus 1758 and *S. lehmanni* A. Mueller, 1922, collected from a variety of habitats in central and eastern Latvia from 1954 to 1980. Owing to the large variety of sampled districts over a relatively long period and the large number of individuals sampled, the material of hundreds of specimens for both species provides opportunities for comparative studies, including morphological and species variation. Distribution mapping, ecology, conservation, and even long-term global climate effects on a population could be analyzed using the *Sarcophaga* material (Alberch 1993; Codella 2000; Enghoff and Seberg 2006; Gunter and Brown 2004; Ownes and Duin 2008; Pettitt 1991; Pittino 2006; Sánchez-Cordero and Martinez-Meyer 2000; Weon, Byun, and Lee 1996). However, specimens represent mainly the distribution of brachyceran flies within the Baltic States (Karpa 2001, 2008) and do not provide examples of morphological variation worldwide (DERM AEC 2009).

Considerable information useful for studies on sustainable forestry and agriculture may also be obtained from collections. Understanding morphological differences of various phytophagous pest invertebrates, studying interaction patterns among pests and their host plants, and defining ecological and environmental conditions affecting pest populations are the important tasks of the collection visitors. Completing these tasks may provide low-cost information that is beneficial, for instance, for integrated pest management, providing saving on financial resources (Singh and Singh 2012; Ullah and Ullah 2006; Weon, Byun, and Lee 1996). Ownes and Duin (2008) provide clear examples of studies designed to predict future distribution and activity changes of insect pest species, some of which are explained and referenced further. Davies, Villablanca, and Roderick (1999) cites an example of how the analysis of collection material and mapping of the distribution of the pest, facilitated the development of successful management plans for a highly dangerous dipteran pest. The particular beetle species, the Australian fern weevil *Syagrius fulvitarsis* Pascoe, 1875, was recorded as having appeared in Hawaii, which was problematic to control because of the limited knowledge of its ecology in this region at that time. However, by using only Australian collection material and data on a specimen's type locality, Pamberton (1941) was able to locate and collect more specimens in Hawaii and investigate ecology and natural enemies in order to organize an effective pest control program.

Invertebrate specimen collections may also be useful for commercial purposes. For instance, by providing visual-concept designers with material that can be observed or digitized, scientific collections can be widely used by the commercial sector. In this way, animals can be photographed, scanned, or tomographed without spending considerable time and extra funds on field trips searching for a particular specimen of interest in natural environment or an endangered/already extinct species (Ownes and Duin 2008; Pettitt 1991).

Recently, a group of zoologists proposed that in exceptional circumstances the descriptions of some animal taxa could be published without preserved specimens. Many invertebrate taxa have diagnostic characteristics that deteriorate quickly after specimen preservation, and it was proposed that these taxa be described using digital images without the preservation of a type specimen (Garraffoni and Freitas 2017; Marshall and Evenhuis 2015). The International Commission on Zoological Nomenclature is not exact on how hard the concept of fixing the holotype really is (Donegan 2008; Dubois and Nemesio 2007) and how this concept must be used for all animal taxa (ICZN 1999). The concept of photography-based taxonomy is being widely discussed and numerous risks are consequently highlighted (e.g., Ceriaco, Gutiérrez, and Dubios 2016; Marshall and Evenhuis 2015; Minteer et al. 2014). Moreover, in the last three decades a part of the nonscientific community has been negatively minded about specimen collections as "wasted piles of dead organisms" with no practical use in future. This opinion most likely exists owing to the public's lack of understanding of the value of collections and preserved scientific specimens. The studies and benefits gained should be communicated to the public, informing them of successful outcomes (Pettitt 1991).

Historical Specimens

Not only the high financial value (Kotrba et al. 2006) but also the highly scientific (historical, cultural, etc.) importance of old specimens has been proved in many publications and discussed broadly in microevolution studies (Codella 2000; Holmes et al. 2016; Ownes and Duin 2008; Ullah and Ullah 2006; Wandeler et al. 2007) investigating habitat loss (Harper, Maclean, and Goulson 2006; Notton 2007; Pettitt 1991). Since a considerable part of IBULC arthropod specimens are kept dry, most of them have never been put through relaxation (Walker et al. 1999); molecular data can also be obtained from very old specimens without damaging their structure (Gilbert et al. 2007). In cases of extinct species, NSCA (2005) encouraged the use of historical specimens for relatively precise calculations of the extinction time of this species.

Pettitt (1991) gives an example of old specimens used successfully in research on historical changes of habitats and landscapes under anthropogenic pressure. Singh and Singh (2012) discuss the use of gene banks of such species for future possibility of species reintroduction. Sánchez-Cordero and Martinez-Meyer (2000) extrapolate data on geographical coordinates attached to historical specimens into a long timeline model of geographic changes. Finally, Kotrba et al. (2006) describe the increased monetary value of collections containing historically old specimens.

One of the first descriptions of a scientific arthropod specimen collection in Latvia was by Lindemann (1846), listing about fifteen different depositories (Lindemann 1846). The following article was published in Latvia in 1923 for the general public in German, Latvian, and Russian. This brochure described the zoological collection of the former “Riga Dom museum” (Anonymous 1923).

As in many institutions specializing in biodiversity research, a collection was naturally developed at the Institute of Biology, University of Latvia. Several specimens have been incorporated from the collection of Gimmerthal (1842) during the revisions, yet none of them have remained in IBULC. A small part of the arthropod collection represented by historical specimens was donated by H. Jacobson (Jacobson 1936; Spuris 1956), some of which are older than 120 years. The authors believe that these specimens are of considerable scientific importance to microevolution research and for the modeling of geographic changes (Holmes et al. 2016; Pettitt 1991; Sánchez-Cordero and Martinez-Meyer 2000), as well as for understanding changes in natural habitats and faunal composition.

However, the oldest specimens collected systematically date back to the 1940s and 1950s. During the second half of the twentieth century, numerous Latvian zoologists, including employees of the Institute of Biology, University of Latvia (during 1951–1993 named “Institute of Biology of the Academy of Sciences of the Latvian SSR”), have been contributing by collecting, identifying, and managing the IBULC (Cinovskis 1953; Grīnbergs 1946; Jacobson 1936; Karps 1978; Lapiņa 1988; Spuris 1970; Šternbergs 1974, 1980; Varzinska 1975; Velce and Danka 1970). Zandis Spuris (1923–1998) is considered the founder and the main IBULC contributor (Jankevica 2017; Kalniņš 2003).

The oldest specimen in IBULC is of *Eristalis alpina* (Panzer, 1798) (Diptera: Syrphidae), collected by Jacobson on July 19, 1895. Additionally, several dozen *Eristalis* specimens were collected from 1902 to 1931. The oldest permanent microscopic slides are of springtails, originating from 1943, and are of very good quality. A considerable part of IBULC specimens were sampled forty to fifty years ago. These historical arthropod specimens are useful in a wide range of studies, including genetic analysis (Bulat and Zakharov 1992; Harper, Maclean, and Goulson 2006; Kokina et al. 2015), population genetics and microevolution (Holmes et al. 2016; Wandeler et al. 2007), and for investigations using stable isotopes (Hardenbroek et al. 2012). Schimmelmann et al. (1986) described the study of archaeological chitin samples for environmental and climatic reconstruction research. Suarez and Tsutsui (2004) have pointed out, citing several important examples, how historical samplings can be of help in regard to public health. One example shows how effectively the probability of a malarial invasion was decreased in the human population after the *Anopheles maculipennis* Meigen, 1818 mosquito collection material that lay gathered for more than 100 years in museums and institutions was analyzed (Suarez and Tsutsui 2004).

Palaeontological inclusions of Collembola in Eocene Baltic amber containing well-preserved springtails are also deposited in the IBULC (Table A1). This material has great study potential, for instance for the estimation of ecological stressors and environmental conditions that occurred in the past millions of years (McKellar et al. 2011). Since the 1980s, as a part of ecological research, the stable isotope analysis has been developed and methodology adapted to analyze material from historical specimens. For instance, through loans to collaborative laboratories, the tissues of Collembola or even foreign particles attached to the specimen's body could be extracted and analyzed. As a result, paleoenvironmental, paleodietary, paleomigrational, and provenance reconstructions could be researched, analyzed, and published, thus improving knowledge related to species evolution (Hardenbroek et al. 2012; Holmes et al. 2016; Lyman 2010; McKellar et al. 2011; McLean et al. 2015; Schimmelmann et al. 1986).

Type Material

Use of the type material is often a top priority and an obligate element during the identification procedures for large taxonomical groups or "problematic" taxa (Enghoff and Seberg 2006; Lindemann 1846; Notton 2007; NSCA 2005; Singh 2007; Singh and Singh 2012; Walker et al. 1999). Gutiérrez and Pine (2017) pointed out that according to the International Code of Zoological Nomenclature (ICZN 1999), specimens of presumably new species must first be compared with types of closely related taxa of the same taxonomical group before publishing a new description (Ellis 2008; Kokina et al. 2015; Ownes and Duin 2008; Thomson 2005; Wiedenmann, Dowling, and Barnes 2014). In addition, Naumann et al. (1994) discussed the importance of secondary types (those that are not holo- or lectotypes).

The most type-rich group at IBULC currently is Cecidomyiidae (Diptera) (see Table A3). The collection is prepared according to Gagné and Jaschhof (2014) and consists of primary and secondary types of dozens of Cecidomyiidae species. Additionally, three paratypes of Chloropidae and Anthomyzidae, paratypes of springtails, and paratypes of two Mesostigmata mite species are stored in IBULC (Table A3). Type specimens of IBULC are ready to be loaned to potential collaborators.

Domestic Specimens—Presentations of Relative Biogeographical Uniqueness

Global distribution of animals and plants depends on various environmental and geo-historical factors, among which the present climate is of particular importance. In other words, regional collections are the clearest representations of organisms living in a particular region with its particular climate (Tuhkanen 1980). Biota in Latvia is geologically relatively young—rising after the last glaciation and existing for 10,000–14,000 years and biogeographically relatively specific (Kabucis 2001; Laiviņš and Melecis 2003; Spuris 1970), and thus a regional specimen collection would be of value for the study of relative biogeographical uniqueness (McLean et al. 2015; Roháček and Barber 2005). Owing to the relatively unique biogeographical properties of the region of Latvia (see Introduction) as well as the fluctuations of short-term climatic conditions (Kalniņa 1995), the IBULC can be used effectively as a reference point for the study of structural changes of fauna and distribution changes of species (Browne 2001; Colvin 2014; Mücher et al. 2009; NSCA 2005; Pettitt 1991).

The IBULC collections represent samplings of dipteran fauna from almost 50% of the entire territory of Latvia (Table A1; see also Karpa 2008). One specimen of *Polydaspis ruficornis*

(Macquart, 1835) (Chloropidae) was sampled recently in the Natura 2000 site (European Commission 2013) *7210 and is a unique record of this dipteran species for Latvia. Another example of the collections' value includes eighty-five species of Chloropidae (70% of the total fauna of Latvia according to Karpa [2008]), which were collected from biologically sensitive habitats of the Baltic Sea coast of Latvia (*1630, 2120 and *2130).

One of the brachyceran paratypes is of interest from a taxonomical and biogeographical point of view. *Stiphrosoma humerale* Roháček et Barber, 2005 (Diptera: Anthomyzidae) was described for the first time from Northern America, Eastern and Western Palaearctic in 2005 (Roháček and Barber 2005). Paratypes at IBULC were the only known Western Palaearctic record of *S. humerale* collected and determined in Latvia in 2004. Thus, these paratypes of the Baltic region show a wide and yet rare distribution pattern for this species (Roháček and Barber 2005).

National parks, reserves, and other protected nature areas in Latvia have served as sampling sites for uncommon or biogeographically unique species (Karpa 2008; Spuris 1998; Telnov 2004). A relatively old specimen of *Carabodes coriaceus* C. L. Koch, 1835 (Acari: Sarcoptiformes) at IBULC was collected in oak forest *9020 at the Moricsala Nature Reserve (Latvia) and has been remounted consequently (Kagainis 2012). The single specimen of *Eulohmannia ribagai* (Berlese 1910) was sampled in the winter of 2017. This species had not been sampled in the territory of Latvia since 1954. *E. ribagai* also has been reported as rare in Lithuania, and there are no reports from Estonia (Eglītis 1954; Eitminavičiūtė 2003).

Oribatid mite specimens of thirty-three relatively rare species were sampled at a calcareous fen in Natura 2000 site, *7210. Many poorly known and biogeographically unique collembolan species had been collected along the coastal habitats of the Baltic Sea (dunes 2120, *2130, 2320 and coastal meadows *1630 and *6270) from Estonia, Latvia, Lithuania, and Denmark (Juceviča 2001). Regional collections of specimens from natural, protected, and relatively undisturbed territories are small gold mines of rare and ecologically important species of arthropods (Ferreira, Prado, and Seripierri 2016; NSCA 2005; Singh and Singh 2012; Telnov 2004).

Foreign Specimens

A section of the IBULC contains specimens collected worldwide (Table A1). These specimens may be useful to foreign researchers working on their native species studying their distribution range (Kurina 2009; Ullah and Ullah 2006). In this respect the collection has significant value for international collaboration, which could promote a wide range of biodiversity studies through the loan exchange. The supplementary data attached to these specimens could also be analyzed, providing additional information during research on the distribution range or distribution change (Alberch 1993; Codella 2000; Enghoff and Seberg 2006; Gutiérrez and Pine 2017; Ownes and Duin 2008; Pettitt 1991; Pittino 2006; Sánchez-Cordero and Martinez-Meyer 2000; Weon, Byun, and Lee 1996). The authors also look forward to any future collaboration regarding specimen loan.

In an example cited by NSCA (2005), collection material was used to prove that an increase in radiation contamination of plants and animals of the Pacific Ocean had taken place post–nuclear weapons testing. Suarez and Tsutsui (2004) summarized numerous examples of how specimens gathered from various world natural history museums have helped to prevent or eliminate global catastrophic events; for example, pest-induced damage or so-called agricultural bioterrorism (Gewin 2003), damage inflicted by invasive species (Suarez, Holway, and Case 2001), degradation of habitats (Bouzat, Lewin, and Paige 1998; Westemeier et al. 1998), and parasite proliferations. The authors of these publications have also emphasized that many millions of US dollars have been saved by using preserved specimens of natural history for the study of preventative actions (Pettitt 1991; Suarez and Tsutsui 2004).

Other Collection Highlights

IBULC comprises heterogeneous collections in which many collaborators found attractive study objects. The following are just a few examples to illustrate this point. The oribatid mite species at the IBULC demonstrate disjunct distribution in the Baltic States or in Europe, for example, *Palaeacarus hystricinus* (Tragardh, 1932), *Adelphacarus sellnicki* (Grandjean, 1952), *Haplochthonius simplex* (Willmann, 1930), *Haplophthiracarus illinoisensis* (Ewing, 1909), *Zetorchestes flabrarius* Grandjean, 1951, *Autogneta parva* Forsslund, 1947, and *Acrogalumna longipluma* (Berlese, 1904) (Eitminavičiūtė 2003). Juvenile specimens representing various developmental stages of more than twenty species are also presented in the collection (Table A1). These sets of specimens could be useful in future interdisciplinary studies. In a study of the feeding preferences of bees, Colvin (2014) provides an example of research in which pollen collected from the legs of a bee specimen was analyzed in order to show changes in the type of plant communities preferred by bees. Specimens of about thirty Mesostigmata species phoretic on beetles from East Indonesia as well as Mesostigmata mites associated with tropical Diplopoda and Dictyoptera are among objects in the IBULC (Salmane and Telnov 2007; Salmane, personal communication, September 23, 2017; see also Tables A1 and A2). In this regard, the study of these specimens may lead to a new understanding of invertebrate species and their role in population variations and distribution of phoretic arthropods (Hunter and Rosario 1988).

Appropriately Maintained Specimens for Scientific Collaboration and Education

The condition of specimens is one of the top priorities for detailed observations and biological analysis (Codella 2000; Enghoff and Seberg 2006; Harper, Maclean, and Goulson 2006; Mayr and Ashlock 1991; Wandeler, Hoeck, and Keller 2007). The condition of specimens of IBULC varies greatly among various orders, but most deteriorated specimens are routinely removed or replaced. Because of insufficient conditions and lack of curation, the main part of the original Tenthredinidae (Hymenoptera) collection was lost, and only 76 species of 630 specimens were saved (Cinovskis 1953). A large part of the Hemiptera collection was also damaged as a result of poor management. Most specimens of Odonata are kept in envelopes (Table A1); the material is strongly damaged yet still useful for some research (Kalniņš 2018). It is critical to have some of the taxonomically important specimens of Coleoptera and Hemiptera digitized as soon as possible for the preservation of this material (Martin 1977; Story 1986; Walker and Crosby 1988; Walker et al. 1999).

For the brachyceran species, additional preparations of genitalia are important according to the most accepted taxonomic standards and determination keys (Bei-Bienko 1969, 1970; Grichanov 2006; ICZN 1999). Comparative and well-made preparations of genitalia may ease the identification procedure and raise the taxonomical value of the collection (Kotrba et al. 2006). In the case of Nematocera, nearly all specimens are mounted in the Canada balsam, and thus these specimens are stored permanently (Walker and Crosby 1988).

In view of the complexity of determining Oribatida mites, it is highly recommended that new specimens are compared with voucher specimens (Krantz and Walter 2009; Norton 1990; Subías [2004] 2011). The use of comparative materials has been strongly suggested by many authors (Al-Assiuty and Khalil 1995; André, Bolly, and Lebrun 1982; Banerjee and Sanyal 1991; Gutiérrez and Pine 2017; Julie and Ramani 2007; Krivolutsky 2004). Moreover, soil invertebrates, including Mesostigmata, Oribatida, and Collembola, proved to be effective biological indicators of environmental change, making their correct identification critical (Coleman and Crossley 1996; Cragg and Bardgett 2001; Karg 1961; Koehler 1999; Shimano 2011). Animals of these groups are small sized and hardly visible to the naked eye. The properly stored and databased microscopic slide collections are considered to be of a high value. There are various ways to preserve mites (Upton 1993); however, the drying out of the media used for slide preparations still remains a problem (Walker et al. 1999).

The IBULC Mesostigmata mite material collected during 1950–1970 was preserved mostly in modified Berlese media (Lapiņa 1988). A certain part of it was later remounted. The oldest Oribatida specimens collected in Latvia were recently remounted from historical microscopic slides and included in the IBULC (Kagainis 2012, see also Fain 1980; Mitchell and Cook 1952).

A part of Collembola specimens have been mounted between two coverslips (one rectangular, 24 × 32 mm, and one circular, 15 mm in diameter). This provides clear ventral and dorsal observations of the same individual. Moreover, the probability of correct identification is increased (Rusek 1974; Walker and Crosby 1988).

In general, midsized collections provide the basis for vast taxonomical, ecological, and regional faunistic research (McLean et al. 2015; Singh 2007; Singh and Singh 2012; Ullah and Ullah 2006; Wass and Ross 2002). The collections of IBULC have been used as a base for species lists and a wide range of faunistic and ecological studies. The IBULC value has been raised by numerous studies based on the collection material and owing to the host of depending scientific publications: insects (Escher et al. 2002; Karpa 2000, 2008; Melecis, Karpa, and Spuņģis 1998; Melecis et al. 2005; Spuņģis 2002, 2003; Telnov 2004; Vilks 2003), collembolans (Grīnbergs 1956, 1960; Juceviča and Melecis 2002), and arachnids (Cera 2008, 2009, 2013; Cera and Keišs 2016; Cera and Spuņģis 2008, 2010, 2011, 2013; Cera, Spuņģis, and Melecis 2010; Kagainis 2011; Kagainis and Eitminavičiūtė 2011; Kagainis and Spuņģis 2013; Kagainis, Spuņģis, and Melecis 2014; Kontschán and Salmane 2005; Lapiņa 1988; Relys and Spuņģis 2008; Salmane 1999, 2005a, 2005b, 2007, 2009; Salmane and Brūmelis 2010; Salmane and Petrova 2002; Salmane and Spuņģis 2008; Šternbergs 1984, 1985, 1998). Several doctoral theses were also completed on the basis of IBULC material (Karpa 1981; Melecis 1978; Salmane 2011; Varzinska 1975) and developed alongside with IBULC.

Suarez and Tsutsui (2004) mentioned that the scientific value of the collection can be estimated with reference to three broad variables: (1) loan activity and visitors, (2) curation and management, and (3) publicity and citing. The average loan activity (proportion of loaned specimens against all stored specimens per year) for a large, well-known, and actively used natural history collection is estimated to be around 0.0025 specimens. For the IBULC this estimate of loan activity is even higher—0.005 (Kagainis, personal communication, October 20, 2018); however, the total number of determined specimens waiting for curation is much lower—a little less than 60,000 specimens (Table A2). Numerous authors have underlined the importance of the curation process of successful specimen collections. However, proper curation and management of a collection is labor intensive and financially expensive, and these aspects should be perfected for most of the collections worldwide (Grove and Bashford 2013; Kotrba et al. 2006; Pavlinov 2016; Thomson 2005; Walker and Crosby 1988; Walker et al. 1999; Wass and Ross 2002). The IBULC holdings have been relatively rarely cited in scientific publications thus far. Active citing would help promote the content of these collections for potential collaboration (Faisal, Singh, and Yousuf 2014; McLean et al. 2015).

The IBULC holdings have been used regularly as reference material by various enthusiasts and students of master's and doctoral programs from various institutions in Latvia and other countries. Frequently, students and enthusiasts lack the personal finances or the necessary grant support for visiting foreign collections; thus, regional midsize collections, such as IBULC, are a highly useful resource, providing needed research materials. By working with these collections, people have been able to further their knowledge by supplementing traditional study materials such as scientific books and publications with observation of actual specimen. In addition, they help in demonstrating the importance of diversity and systematics of native species and fauna (Browne 2001; Codella 2000; Ferreira, Prado, and Seripierri 2016; MacFadden et al. 2007; NSCA 2003; Pettitt 1991; Singh and Singh 2012; Ullah and Ullah 2006; Wiedenmann, Dowling, and Barnes 2014).

Funding Support and Available Experts

Not all specimens at IBULC that were historically successfully curated and databased are still useful. As a result of long-term underpayment and the lack of full-time staff, some sections of IBULC holdings have been irreversibly damaged. Some of the specimens kept in alcohol vials (Table A1) have dried out for want of regular care. To avoid such a problem in future, better collection jars should be used and regular inspections made (Crawford 1992). Regarding the spider collection, the majority of which had been used in ecological and faunistic surveys more than twenty years ago (Šternbergs 1974, 1980, 1984, 1985, 1998), specimens must be kept at a constant (low) temperature (Cera, personal communication, December 7, 2017). Collection boxes containing pinned specimens should also be housed in rooms with controlled low temperature and humidity (Grove and Bashford 2013; Thomson 2005; Walker et al. 1999; World Spider Catalog 2017).

Unidentified Specimens as an Important Potential of the Collection

In addition to the identified material of IBULC, there are many subcollections or so-called systematically collected material still waiting to be determined (see Table 2 in Jankevica 2017). All specimens unidentified to species level that are well preserved and stored with necessary supplemental data may be of equal importance as, or even of more importance than, the determined specimens (Alberch 1993; Animal Ethics Infolink 2010; Codella 2000; Enghoff and Seberg 2006; Laubitz, Shih, and Sutherland 1983; Meester 1990; Ownes and Duin 2008; Pittino 2006; Sánchez-Cordero and Martinez-Meyer 2000; Weon, Byun, and Lee 1996). Material collected and stored yet unidentified and unclassified is a valuable source of scientific reference material in the future—a gold mine for voucher specimen sets (DERM AEC 2009; Dincă et al. 2011; Hennemann 2009; McLean et al. 2015; Pettitt 1991; Singh and Singh 2012). A considerable number of IBULC specimens are unsorted and unidentified. The identification may be achieved as a result of successful collaboration with taxonomic group experts (demand) and/or with a significant increase in funding. This is known to be a common concern globally for many zoological collections (Dalton 2003; Gropp 2003; NSCA 2003). At IBULC, for example, nematoceran specimens of Sciaridae, Mycetophiloidea, and Ceratopogonidae are unidentified, in part prepared on slides, but are slowly undergoing chemical degradation. Another problem is that a significant part of the properly maintained spider collection has been left without identification (2,499 specimens), for want of an expert for this particular taxonomic group (especially taxonomically complex genera of Linyphiidae and Tetragnathidae). Collaboration with other institutions and specialists is essential to resolve this situation.

The unidentified specimens may not only represent significant species diversity but also demonstrate important long-term change in the faunal patterns at the localities studied, for example, climate change connected ones. Parmesan et al. (1996) demonstrated the impact of significant climate change on the variation of suitable distribution areas of insects by comparing different mortality rates of southern and northern populations of Lepidoptera. Collection material can be used even in stable isotope research describing debris attached to the specimen in a manner that defines soil paleobiological conditions (McKellar et al. 2011). Pettitt (1991) mentioned the mammoth DNA that has been successfully extracted from a specimen of a museum collection, which opened the possibility to test whether the original mammoth species could be reintroduced. Many studies have provided good examples of how unidentified specimens can be incorporated into successful research (Colvin 2014; Hennemann 2009).

Specimen Digitization and Databasing

The IBULC collection of Oribatida is already linked to a digital database providing a wide range of data for each specimen on leg./det. information, district, habitat, sex, reproductive mode, and even the body position in which it has been mounted on the slide, which is of taxonomic importance (Palmer and Norton 1990; Bluhm, Scheu and Maraun 2016; Lions 1967). However, even though the greatest part of the determined arthropod specimens of IBULC is labeled, a digital database to species level of the majority of specimens still needs to be developed. Franz and Yussef Vanegas (2009) proposed a very good example of how a specimen collection was successfully curated. This collection received a three-year grant for serious advancement and new development, including moving to modernized facilities, revising taxonomic names, sequencing of genome, making high-definition visual scans, and digitizing the label data. As a result, the collection has been actively supporting a variety of scientific projects for a while now. Fisher and Mantle (2012) described noninvasive specimen scanning methodology, without even taking items out of collection drawers. Stork et al. (2019) have recently started a global-scale project to link digital data of specimen collections of natural history findings worldwide in a single Internet database. Digitized information of collections makes them more accessible to a wider scientific community and suitable for digital analysis for a broad range of future research (Colvin 2014; Enghoff and Seberg 2006; Gutiérrez and Pine 2017; McLean et al. 2015; NSCA 2005; Ownes and Duin 2008; Page et al. 2015; Sánchez-Cordero and Martinez-Meyer 2000; Singh and Singh 2012; Wiedenmann, Dowling, and Barnes 2014).

Singh (2007) enumerated the problems of nondigitized material of a type collection. Even though the material was proposed for loan, the researcher was never able to inspect the material in view of its unavailability. If types were digitized, as is already the practice for a part of collections worldwide (Faisal and Singh 2014; Fisher and Mantle 2012; Grove and Bashford 2013; Lee 2014; Wiedenmann et al. 2014), it would be easier to organize observation by many authors simultaneously (Faisal et al. 2014; Franz and Yusseff Vanegas 2009; McLean et al. 2015; NSCA 2005; Ownes and Duin 2008; Singh 2007; Thomson 2005). Sánchez-Cordero and Martinez-Meyer (2000) analyzed data profiles of ecological niches of seventeen rodent species that are agricultural pests in Mexico. Specimens were taken from collections and attached data were analyzed. Thus, successful prediction models were made, yet the authors expressed regret about not digitizing all data from labels, which would have been useful for future studies.

Specimens also can be used as objects for the development of biomechanical biomimic technologies. Fish specimens from a collection were thoroughly examined to propose an innovative design of yachts and their hydrodynamic effectiveness (NSCA 2005). Pettitt (1991) gives examples of shark skin specimens from nature history collections used in innovative macrosculpture design in order to increase aerodynamic properties of the surface coat of airplanes. An armadillo skeleton available from the natural history collections inspired a new design for an orthopedic chair. IBULC curators are open to any appropriate collaboration suggestions with regard to technologies and innovative research and are planning to promote the value and the availability of their museum holdings.

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APPENDIX

This section is devoted to describing the content of the material of IBULC collections.

Table 1: The Characteristic Data on the Specimen Collection of the Institute of Biology, University of Latvia (IBULC) consistng of Domestic (Latvian) and Foreign Material

1	2	3	4	5	6
			Domestic Collection		***Foreign Collection***
Order, Arranged Phylogenetically	*Sampling Techniques*	*Preparation Techniques*	*The Overall Cover Percentage Classes of Collecting Area Compared to the Total Area of Latvia*	*Mostly Represented and Most Unusual Habitats (EU Protected Habitats Are Coded)*	*Represented Countries*
Parasitiformes	bor, man	prep-mm	Dense	Associations with Aphyllophorales fungi (88) and with Coleoptera (36), Baltic Sea coastal habitats incl. 2120, *2130, 2320 (60), coastal meadows incl. *6120, 6210 (85), *7210 (28), various forests incl. *9010 and *9080 (94)	Germany, Hungary (76), Indonesia (30), Poland (17), United Kingdom
Sarcoptiformes	bor, man	prep-mm[J]♀♂	sparse	Associations with *Aesculus hippocastanum* (3), deciduous forests incl. *9020 (1) and 9160 (9), pine forest (49), spruce forest (2), 2180 (1), *7110 (1), *7210 (33), *9010 (35)	None
			dense	Boreal forests (83), 2180 and 7230 (146), 1220 (127), *1630 (149 by net and 185 by pit), 2120, *2130, *7110 (70), 7120, 7140, *7210 (103), *9010	None

1	2	3	4	5	6
			dense	Baltic Amber inclusions (22), lake shores and marine littoral habitats along the Baltic Sea coast incl. 2120, *2130, 2320, coastal meadows incl. *1630 and*6270, pine forest,	Denmark, Estonia, Georgia, Kyrgyzstan, Lithuania, Moldova, Norway, Sweden
Hemiptera	man, net, pit	pinned	very sparse	Mostly in grasslands, incl. *1630, *6120, *6270, 6510	None
Homoptera	man, net, pit	pinned	sparse	Mostly in associations with shrubs (3) incl. *Ribes* spp., *Prunus* spp., *Salix* spp. and *Betula* spp, on hydrophilic vascular plants near lakeshores (6), coastal habitats along the Baltic Sea coast incl. *1230 and *1630, meadows (2), pine forest and in raised bogs incl. *7110 and 7140	None
Hymenoptera	man, net, pit	pinned	very sparse	Mostly on plant flowers (38) incl. *Angelica* spp. (18), in gardens on plants (34) incl. on *Sium* spp. (11), on walls of buildings (5), in river banks (3), pine (4) and deciduous forests (3)	None

1	2	3	4	5	6
Diptera	bait, lab, light, man, net, pit, siev	pinned, prep-al, prep-gc, prep-mm	dense	Boreal forests incl. *9010, agricultural fields, nearly all types of grasslands, littoral habitats along the Baltic Sea coast incl. *1630, 2120 and *2130, *6270, wetlands incl. *7110, *7210, 7230	Estonia, Greece (>50), Japan (1), Lithuania (92), Poland (1), Russia, Switzerland (17), Ukraine (>50), Seychelles (2)
Other	light, man, net, pit, siev	pinned, flattened	very sparse	*1630, 2120, *2130, 2320, *7110, 7120, *7210, *9010	Georgia, Romania

Note: Habitat codes follow the standardized classification of Natura 2000 habitats (European Commission 2013), and the priority of "habitats in danger of disappearance" is abbreviated with an asterisk (*); a number of species represented in the IBULC are indicated in parentheses if available. bait, sampled using bait for attraction (sugar, meat, pheromone); bor, sampled using soil borer and extracted from the substrate using photothermal extraction; flattened, individuals kept air dry into paper envelopes flattened; lab, sampled from a culture in a laboratory; light, sampled using light traps; man, sampled manually; net, sampled with entomological sweep net; pit, sampled with pitfall traps; siev, sampled by sieving the substrate (mostly litter or soil); pinned, individuals pinned and kept air dry; pinned ♀♂, individuals of both male and female preparates indicated, pinned and kept air dry; prep-al, whole individuals kept in separate alcohol vials; prep-gc, genitalia of individuals prepared and kept in separate glycerol vials; prep-gl, genitalia of individuals mounted (glued) on the plastic card pinned together with the specimen; prep-mm, some body parts or whole individuals prepared in microscopic slide (two coverslip preparates indicated with superscript "2" symbol, indicated male/female individuals abbreviated with "♀♂" symbol, separated juvenile preparates indicated with superscript "J" symbol) by mounting into a semihard or hard fixation medium), very sparse, sampling covers less than 1% of the area of Latvia; sparse, sampling covers 1%–4% of the area of Latvia; dense, sampling covers 5%–20% of the area of Latvia; very dense, sampling covers 20%–50% of the area of Latvia; incl., including.

Table 2: Characteristics of Families, Species, and Identified Specimens among the Most Represented Orders in the IBULC

1	2	3	4	5
Classes	*Orders (Total Numbers)*	*The Most Species-Richest Families (Number of Species)*	*The Most Specimen-Richest Families (Number of Specimens)*	*The Most Species-Represented Families (According to the Checklist of Latvia)*
Arachnida	Parasitiformes (22 families, 310 species, 3,786 specimens)	Rhodacaridae (48), Aceoseiidae (47), Laelaptidae (43)	Rhodacaridae (762), Parasitidae (735), Laelaptidae (712)	Rhodacaridae (100%), Aceoseiidae (100%), Laelaptidae (93%)
	Sarcoptiformes (47 families, 136 species, 1,033 specimens)	Carabodidae (9), Camisiidae (8), Phthiracaridae (8)	Carabodidae (81), Suctobelbidae (64), Camisiidae (58)	Camisiidae (100%), Carabodidae (82%), Scheloribatidae (75%)
	Araneae (22 families, 348 species, 21,354 specimens)	Linyphiidae (144), Lycosidae (35), Gnaphosidae (26)	Lycosidae (8,850), Linyphiidae (4,462), Tetragnathidae (2,387)	Linyphiidae (89%), Gnaphosidae (81%), Salticidae (70%)
Entognatha	Collembola (17 families, 109 species, 1,157 specimens)	Isotomidae (31), Onychiuridae (14), Hypogastruridae (12)	Isotomidae (337), Entomobryidae (246), Sminthirididae (168)	Dicyrtomidae (100%), Katiannidae (71%), Onychiuridae (64%)
Insecta	Hemiptera (19 families, 280 species, 5,178 specimens)	Miridae (126), Lygaeidae (64), Pentatomidae (37)	Miridae (2,160), Lygaeidae (1,320), Pentatomidae (780)	Lygaeidae (64%), Pentatomidae (100%), Coreidae (100%)
	Hymenoptera (11 families, 91 species, 630 specimens)	Tenthredinidae (76)	Tenthredinidae (630)	Tenthredinidae (24%)
	Homoptera (3 families, 11 species, 318 specimens)	Aphrophoridae (8), Cicadellidae (2), Membracidae (1)	Aphrophoridae (100), Cicadellidae (14), Membracidae (6)	Aphrophoridae (100%), Membracidae (50%), Cicadellidae (1%)

1	2	3	4	5
Insecta	Coleoptera (38 families, 977 species, 9,857 specimens)	Chrysomelidae (221 species), Carabidae (185) Curculionidae (91)	Carabidae (2,510), Chrysomelidae (1,476), Elateridae (1,298)	Cantharidae (91%), Coccinellidae (69%), Chrysomelidae (67%)
	Diptera (51 families, 1,472 species, 15,704 specimens)	Cecidomyiidae (>550), Dolichopodidae (144), Chloropidae (122)	Cecidomyiidae (5,500), Chloropidae (1,922), Sarcophagidae (1,649)	Cecidomyiidae (100%), Chloropidae (100%), Sciomyzidae (94%)

Note: Precise numbers or percentages are indicated in parentheses.

Table 3: Type Specimens Stored in the Collection of the Institute of Biology, University of Latvia

1	2	3
Species	*Exact Labels as Published/On Slide or with Pinned Individual*	*Type Specimens and Remarks*
Order: Parasitoformes		
Family: Uropodidae		
Uropoda ocellata Kontschán et Salmane, 2008	Leg. I. Salmane; 06.06.2004, Latvia, Ogre mun., Ogre, garden, compost, on Histeridae sp. (Coleoptera), 2 F	Female, paratype
Family: Oplitidae		
Oplitis latvica Kontschán et Salmane, 2008	Leg. I. Salmane; 15.08.2003, Limbaži mun., N of Ķurmrags, coastal meadows, dry sandy soil, 2 F	Female, paratype
Order: Collembola		
Family: Isotomidae		
Archisotoma martae Fjellberg et Jucevica, 2000	Latvia. Ventspils. 27.VI.1998. In gravel at seashore. E. Pauliņa leg.	Paratypes, 4+4 specimens (on 2 slides)
Order: Diptera		
Family: Chloropidae		
Lipara baltica Karps, 1978	Leg. А. Карпс; Латв. ССР; Лимбажи; *Phragmites communis*/Paratypus; Lipara baltica; Karps	Male, paratype
Gaurax strobilum Karps, 1981	A. Karps; 4.4.79; Ogre, Egļu čiekuros/Paratypus; Gaurax strobilum; Karps	Female, paratype
Family: Anthomyzidae		
Stiphrosoma humerale Roháček et Barber, 2005	Leg. A. Karpa; 05.08.2004; Latvia, Melturu sils / PARATYPUS; Stiphrosoma humerale sp.n.; J.Rohácek & K.N. Barber det 2004	Male, paratype
Stiphrosoma humerale Roháček et Barber, 2005	Leg. A.Karpa; 22.07.2004; Latvia, Nīcgale/PARATYPUS; Stiphrosoma humerale sp.n.; J.Rohácek & K.N. Barber det 2004	Female, paratype
Family: Cecidomyiidae		
Acoenonia nana Meyer et Spuņģis, 1994	Germany K 545 Glyceria maxima swamp SW of Kiel, leg. H. MEYER, 26.3.83./Germany K545 Mashlands, leg. H.Meyer	Male, holotype
Acoenonia nana Meyer et Spuņģis, 1994	Germany K 545 Glyceria maxima swamp SW of Kiel, leg. H. MEYER, 26.3.83./Germany K545 Mashlands, leg. H.Meyer	2 males, 1 female, paratypes, each on separate slide
Allaretella germanica Meyer et Spuņģis, 1994	Germany G 196, leg. H. MEYER, Seadikes near Meldorf, adjacent to salt marshes, captured with yellow color trays, 16.8.-31.8.72./Germany G196 Marshlands leg. H.Meyer	Male, holotype
Allaretella germanica Meyer et Spuņģis, 1994	Germany G 193, leg. H. MEYER dto: 1.8.-16.8.72./Germany G196 Marshlands leg. H.Meyer	2 females, paratypes, on one slide
Asynapta northi Spuņģis, 2006	No. S1, Seychelles, North Island, 30.07-15.08.2005, marsh edge, Malaise trap, leg. O'Shea. / ibid.	Male, holotype
Asynapta northi Spuņģis, 2006	No. S2, S3, S4, S5, Seychelles, North Island, 30.07-15.08.2005, marsh edge, Malaise trap, leg. O'Shea. / ibid.	4 males, paratypes, on separate slides

1	2	3
Chastomera spinigera Spuņģis, 1985	№ 577-7, ЛатвССР, Кокнесе, 08.06.80, широколиственник снытевый, эксг. / ibid. V.Sp.	Male, holotype
Clinorhytis flavitarsis Kieffer, 1896	N 711-2a, Latvia, Saulkalne, 22 V 1986, in deciduous forest, collected by aspirator. / 711-2a, Latvia, Saulkalne, 22.05.1986. In deciduous forest, coll. by aspirator V.Sp.	Male, neotype
Diallactes obscuripes Spuņģis, 1985	№ 636-7б, ЛатвССР, Саулкалне, 18.05.83, в мелколиственном кисличнике, эксг. / ibid. V.Sp.	Male, holotype
Diallactes obscuripes Spuņģis, 1985	№ 636-1е, ЛатвССР, Саулкалне, 16.05.83, в мелколиственном кисличнике, эксг. / ibid. V.Sp.	Female, paratype
Dicerura complicata Spuņģis, 1987	№ 580-9е, ЛатвССР, Саулкалне, 25.08.80, в ольшаннике-кисличнике, эксг. / ibid. V.Sp.	Male, holotype
Dicerura mixta Spuņģis, 1987	№ 578-8х, ЛатвССР, Каугури, 16.07.80, в лиственнике снытевом, эксг. / ibid. V.Sp.	Male, holotype
Dicerura mixta Spuņģis, 1987	№ 697-7а, ЛатвССР, Каугури, 16.07.80, в лиственнике снытевом, эксг. / ibid. V.Sp.	Male, paratype
Dicerura separata Spuņģis, 1987	№ 636-8е, ЛатвССР, Дарзини, 19.05.83, в мелколиственном кисличнике, эксг. / ibid. V.Sp.	Male, holotype
Dicerura separata Spuņģis, 1987	№ 636-8е, ЛатвССР, Дарзини, 19.05.83, в мелколиственном кисличнике, эксг. / ibid. V.Sp.	Male, paratype
Dicerura separata Spuņģis, 1987	№ 387-2, ЛатвССР, Дарзини, 04.12.76, в опавших листьях. / ibid. V.Sp.	Larva, paratype
Dicerura unidentata Spuņģis, 1987	№ 546-1, ЛатвССР, Каугури, 30.03.79, в пазухах листьев лесного камыша. / ibid. V.Sp.	Two larvae, paratypes, on one slide
Groveriella baltica Spuņģis et Jaschhof, 2000	Series no. E77-1a, Estonia, Puurmani, 07.09.1987, in mixed spruce-birch forest, leg. SPUNGIS. / E77-1a, Пуурмани 7.9.87. Ел.-бер. Кисл. Э.	Male, holotype
Groveriella baltica Spuņģis et Jaschhof, 2000	Series no. E77-1a, Estonia, Puurmani, 07.09.1987, in mixed spruce-birch forest, leg. SPUNGIS. / E77-1a, Пуурмани 7.9.87. Ел.-бер. Кисл. Э.	Male, paratype
Groveriella baltica Spuņģis et Jaschhof, 2000	Series no. 582-5, Latvia, Milzkalne, 09.09.1980, in spruce forest, leg. SPUNGIS. / 582-5 Milzkalne 9.9.80. Egļu vēris E.	Male, paratype
Groveriella baltica Spuņģis et Jaschhof, 2000	Series no. 752-6, Latvia, Mazsalaca, 18.09.1990, in mixed forest, leg. SPUNGIS. / 752-6 Mazsalaca 18.9.90. Jaukts vēris. E. V.Sp.	Male, paratype
Heterogenella multifurcata Spuņģis et Jaschhof, 2000	Series no. E22-4j, Estonia, Kaansoo 18.07.1987, in poplar forest, leg. SPUNGIS. / E22-4j Каансоо 18.07.87. Осин. кисл. Э. V.Sp.	Male, paratype
Heterogenella multifurcata Spuņģis et Jaschhof, 2000	Series no. E27-1e, Estonia, Urge 19.07.1987, in poplar forest, leg. SPUNGIS. / E27-1e Урге 19.7.87. Осин. кисл. Кош. V.Sp.	Male, paratype

1	2	3
Isogynandromyia terricola Spuņģis, 1980	№ 543-1, ЛатвССР, Броцени, 29.11.78, вывелен из личинки в подстилке ельника-кисличника / ibid. ... 29 XI 78 … ельника-черничника	Male, designated as type
Manepidosis scepteri Spuņģis, 2006	Latvia, N500-5h, Bramberge 31.05.1981, deciduous forest, by aspirator, leg. V.Spungis. / 600-5h Bramberģe 31.5.81. Lapk. Gs. E. V.Sp.	Male, holotype
Manepidosis scepteri Spuņģis, 2006	Latvia, N578-10f, Koknese 03.08.1980, deciduous forest, by aspirator, leg. V.Spungis. / 578-10f Koknese 3.8.80. lapk. Gs. Eksh. V.Sp.	Male, paratype, on one slide
Monepidosis spatulata Spuņģis, 2006	Latvia, N600-5g, Bramberge 31.05.1981, deciduous forest, by aspirator, leg. V.Spungis. / 600-5g Bramberģe 31.5.81. Lapk.Gs. E. V.Sp.	Male, holotype
Monepidosis spatulata Spuņģis, 2006	Latvia, N600-5g, Bramberge 31.05.1981, deciduous forest, by aspirator, leg. V.Spungis. / 600-5g Bramberģe 31.5.81. Lapk.Gs. E. V.Sp.	Two females, paratypes, on one slide
Neoteraneuromyia lenticularis Spuņģis, 1987	№ 704-5c, ЛатвССР, Юмправа, 17.09.85, в ельнике-зеленомошнике, эксг. / ibid. V.Sp.	Male, holotype
Neoteraneuromyia lenticularis Spuņģis, 1987	№ 704-5c, ЛатвССР, Юмправа, 17.09.85, в ельнике-зеленомошнике, эксг. / ibid. V.Sp.	Male, paratype
Neoteraneuromyia moldavensis Spuņģis, 1987	№ 605-4г, МолдССР, Дурлешты, 03.10.81, в лиственном лесу, эксг. / ibid. V.Sp.	Male, holotype
Neurepidosis gracilis Spuņģis, 1987	№ 437-23д, ЛатвССР, Саласпилс, 09.08.77, на окне. / ibid. V.Sp.	Male, holotype
Neurepidosis minutus Spuņģis, 1987	№ 589-15, ЛатвССР, Дарзини, 14.04.81, выведен из личинок из подстилки смешанного ольшанника-сосняка. / ibid. V.Sp.	Male, holotype
Paratetraneuromyia vernalis Spuņģis, 1987	№ 633-1, ЛатвССР, Каугури, 09.04.83, лиственник снытевый, эксг. / ibid. V.Sp.	Male, holotype
Paratetraneuromyia vernalis Spuņģis, 1987	№ 633-1, ЛатвССР, Каугури, 09.04.83, лиственник снытевый, эксг. / ibid. V.Sp.	Female, paratype
Porricondyla acuta Spuņģis, 1981	№ 532-25н, ЛатвССР, Видрижи, 22.08.78, отловлен в лиственном лесу кошением / 532-25н, ЛатвССР, Видрижи, 22 VIII 78, в лиственном лесу.Кош. V.Sp.	Male, designated as type
Porricondyla globosa Spuņģis, 1981	№ 513-13а, ЛатвССР, Дарзини, 28.05.78, отловлен в сосняке-брусничнике кошением. / 513-13а, ЛатвССР, Дарзини, 28 V 78, в сосняке-брусничнике. Кош. V.Sp.	Male, designated as type
Porricondyla lutescens Spuņģis, 1981	№ 530-9ф, ЛатвССР, Лаутере, 11.08.78, отловлен в осиновом кисличнике кошением. / 530-9ф, ЛатвССР, Лаутере, 11 VIII 78, в осиновом кисличнике. Кош. V.Sp.	Male, designated as type
Porricondyla media Spuņģis, 1981	№ 559-10б, ЛатвССР, Броцени, 21.05.79, отловлены в березняке-кисличнике эксгаустером / 559-10б, ЛатвССР, Броцени, 21 V 79, березняке-кисличнике. Эксг. V.Sp.	Male, designated as type

1	2	3
Porricondyla modesta Spuņģis, 1981	№ 481-8, ЛатвССР, Кокнесе, 11.09.77, отловлен в березняке-кисличнике эксгаустером. / 481-8, ЛатвССР, Кокнесе, 11 IX 77. в березняке-кисличнике. Эксг. V.Sp.	Male, designated as type
Porricondyla photophila Spuņģis, 1981	№ 437-22в, ЛатвССР, Саласпилс, 09.08.77, отловлен в окне. / 437-22в, ЛатвССР, Саласпилс, 09 VIII 77.на окне. V.Sp.	Male, designated as type
Seychellepidosis spinosa Spuņģis, 2007	No. S108, Seychelles, Picard, Aldabra, 1974, Malaise trap, leg. R.Prys-Jones. / ibid.	Male, holotype
Seychellepidosis spinosa Spuņģis, 2007	No. S108, Seychelles, Picard, Aldabra, 1974, Malaise trap, leg. R.Prys-Jones. / ibid.	Female, paratype
Tetraneuromyia lamellata Spuņģis, 1987	№ 557-8а, ЛатвССР, Дарзини, 13.09.79, в сосняке-брусничнике, эксг. / № 567-8а, ЛатвССР, Дарзини, 13.09.79, в сосняке-брусничнике, эксг.	Male, holotype
Tetraneuromyia lamellata Spuņģis, 1987	№ 704-5д, ЛатвССР, Юмправа, 17.09.85, в ельнике-зеленомошнике, эксг. / ibid.	Female, paratype
Winnertzia discretella Spuņģis, 1992	N 429-8, Latvia, Brocēni, 26.V.1977, reared from the larvae extracted from the soil of a spruce forest. / 429-8, Latvia, Brocēni, 26.05.1977, larvae from spruce forest soil V.Sp.	Male, holotype, and female, paratype, on one slide
Winnertzia fusca Kieffer, 1913	N 685-3, Latvia, Saulkalne 11 V 1985, reared from larvae collected under decaying bark of a birch. / ibid.	Male, neotype
Winnertzia graduata Spuņģis, 1992	N 577-13a, Latvia, Dārziņi 18 VI 1980, collected in dry pine forest. / 577-13a, Latvia, Dārziņi 18.06.1980. In dry pine forest. Swept.	Male, holotype
Winnertzia padicola Spuņģis, 1992	N 633-2a, Latvia, Kauguri 9 IV 1983, reared from larvae collected from decaying trunk of a bird-cherry tree. / 633-2a, Latvia, Kauguri 9.04.1983. Larvae from decaying bird-cherry tree trunk. V.Sp.	Male, holotype
Winnertzia padicola Spuņģis, 1992	N 633-2a, Latvia, Kauguri 9 IV 1983, reared from larvae collected from decaying trunk of a bird-cherry tree. / 633-2a, Latvia, Kauguri 9.04.1983. Larvae from decaying bird-cherry tree trunk. V.Sp.	4 females, paratypes, on one slide
Winnertzia populicola Spuņģis, 1992	N 636-3a, Latvia, Saulkalne, 16 V 1983, reared from larvae collected from decaying trunk of poplar. / 636-3a, Latvia, Saulkalne, 16.05.1983. Larvae from decaying poplar trunk. V.Sp.	Male, holotype
Winnertzia populicola Spuņģis, 1992	N 636-3a, Latvia, Saulkalne, 16 V 1983, reared from larvae collected from decaying trunk of poplar. / 636-3a, Latvia, Saulkalne, 16.05.1983. Larvae from decaying poplar trunk. V.Sp.	3 females, paratypes, on one slide

1	2	3
Winnertzia pustulata Spuņģis, 1992	N 677-3, Latvia, Jumprava 28 IX 1984, reared from the larvae extracted from the soil of a humid spruce forest. / 677-3, Latvia, Jumprava 28.11.84. larvae in humid spruce forest soil. V.Sp.	Male, holotype
Winnertzia rotundata Spuņģis, 1992	N 720-7a, Latvia, Jumprava 28 XI 1986, reared from the larvae collected under the decaying bark of the pine. / 720-7a, Latvia, Jumprava .11.1986., larvae under decay. pine bark V.Sp.	Male, holotype,
Winnertzia rotundata Spuņģis, 1992	N 720-7a, Latvia, Jumprava 28 XI 1986, reared from the larvae collected under the decaying bark of the pine. / 720-7a, Latvia, Jumprava .11.1986., larvae under decaying pine bark V.Sp.	Female, paratype

Note: Different labels, if more than one in the same specimen, are separated by slash mark "/".
leg., legit (in Latin) or the person who took the specimen from nature; sp., species; mun., municipality; sp.n., species novum (in Latin) or the new species to the science; det., determinavit (in Latin) or the person who identified the specimen; ibid., ibidem (in Latin) or "the same"; Кисл., кисличник (in Russian) or tree stand; Осин., осиновом (in Russian) or the ash tree forest; Lapk.Gs., lapkoku gārša (in Latvian) or broad-leafed forest. Eksh., exhauster (in Latvian: ekshausters, in Russian: эксгаустер or эксг.); Кош., кошением (in Russian) or sweep netting; Ел.-бер., Ельник-березняк (in Russian) or the mixed forest represented by spruce and birch trees; Э. V. Sp., E. V. Sp. Additional Russian translations: Карпс, Karps; ЛатвССР, Latvian SSR; Лимбажи, Limbaži; Кокнесе, Koknese; Каугури, Kauguri; в лиственнике снытевом, in deciduous stand; Саулкалне, Saulkalne; в мелколиственном кисличнике, in deciduous forest with calcareous soils; в ольшаннике-кисличнике, in alder forest; Дарзини, Dārziņi; из личинок в пазухах листьев лесного камыша, collected from the leaf holsters of sedge leaves; в опавших листьях, in soil litter; Пуурмани, Puurmani; Каансоо, Kaansoo; Урге, Urge; Броцени, Brocēni; вывелен из личинки в подстилке ельника—кисличника, reared from the larvae collected from spruce forest soil; ельника-черничника, collected from spruce forest; Юмправа, Jumprava; в ельнике-зеленомошнике, in spruce forest; Дурлешты, Durlešti; в лиственном лесу, in deciduous forest; Саласпилс, Salaspils; на (в) окне, on window; выведен из личинок из подстилки смешанного ольшанника-сосняка, reared from the larvae collected from the soil litter in alder-pine forest; лиственник снытевый, in the deciduous forest; Видрижи, Vidriži; отловлен в, sampled from; в лиственном лесу, in deciduous forest; кошением, by sweep-netting; в сосняке-брусничнике кошением, in dry pine forest, by sweeping; Лаутере, Lautere, в осиновом кисличнике кошением, in ash forest by sweeping; в березняке-кисличнике, in birch forest.

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The International Journal of the Inclusive Museum addresses the key question: How can the institution of the museum become more inclusive? The journal brings together academics, curators, museum and public administrators, cultural policy makers, and research students to engage in discussions about the historic character and future shape of the museum.

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