

## **Earthworm (Clitellata: Megadrili) taxonomy in the last 200 years: A homage to András Zicsi (1928–2015)**

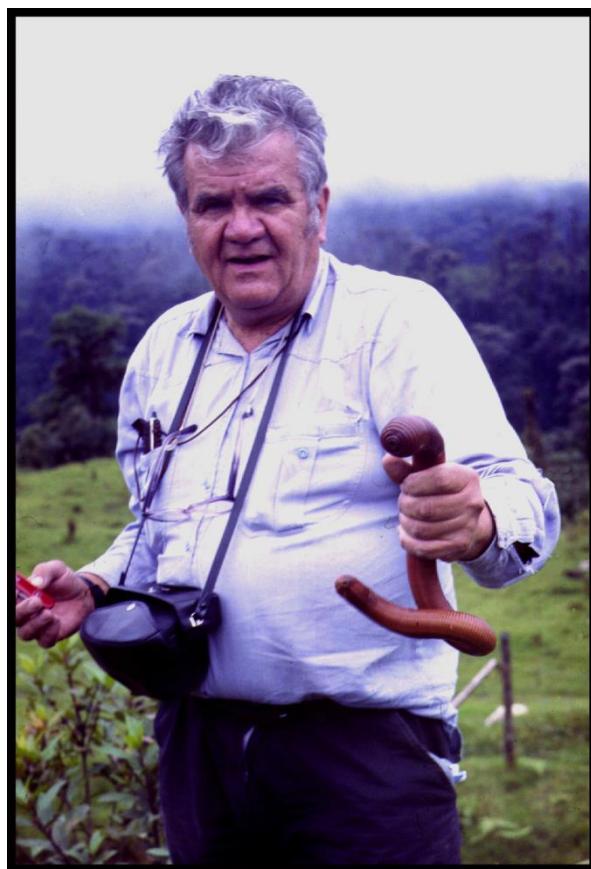
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**Abstract.** Prof. Dr. András Zicsi, the renowned soil biologist and earthworm taxonomist passed away on 22 July, 2015 at the age of 87. To honour his enormous contribution in exploring earthworm biodiversity all over the world, we provide a brief, albeit subjective overview of the history of earthworm taxonomy in the last two century.



To date, approximately 6200 earthworm species have been described (Csuzdi 2012), the first being *Lumbricus terrestris* by Carolus Linnaeus in 1758. Rate of species description in the subsequent decades was slow; only around 30 species were added, most of them by Savigny (1826). Not surprisingly, all of these belong to the Holarctic family, Lumbricidae. The first non-European species, *Glossoscolex giganteus* Leuckart, was described in 1835 from Brazil, South America, but up to the 1850s earthworm research still focused on the European fauna.

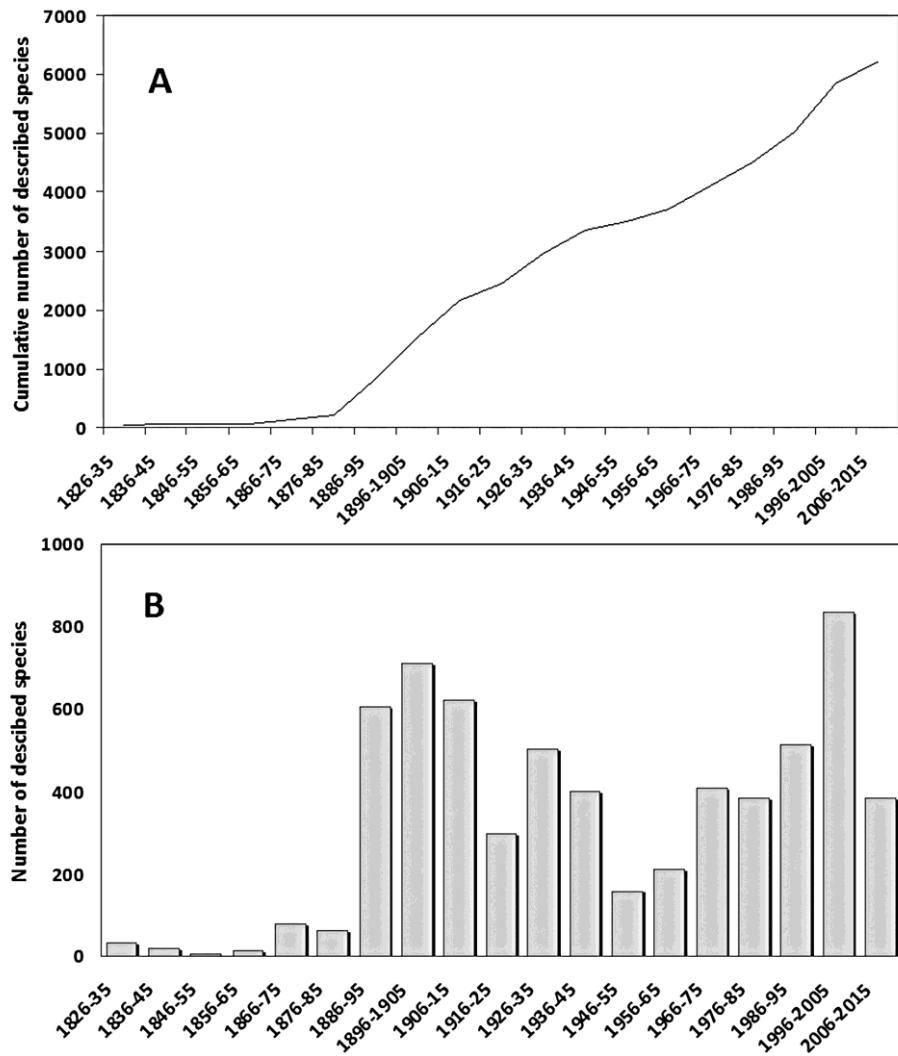
While in the first century of earthworm taxonomy (1758–1865) only *ca.* 70 new species descriptions were published, the situation markedly improved by the 1860s when a new generation of zoologists began exploring this important soil animal group. Research by Johan Gustaf Hjalmar Kinberg (1820–1908), Edmond Perrier (1844–1921), Gustav Eisen (1847–1940), Rutgerus Horst (1849–1930), László Örley (1856–1887), Daniel Rosa (1857–1944) and Frank Evers Beddard (1858–1925) dramatically improved our knowledge of both earthworm diversity and their geographical distribution (Fig. 1). Other distinguished zoologists, Johann Wilhelm Michaelsen (1860–1937), Sir Walter Baldwin Spencer (1860–1929), Sir William Blaxland Benham (1860–1950) and Luigi Cognetti De Martiis (1878–1931) joined this group, making fundamental contributions to earthworm taxonomy.

Between 1886–1905 approximately 1300 earthworm species, about 25% of total known species richness (Csuzdi 2012), were described from all over the world (Fig. 1). Additionally, this era produced the first modern earthworm monographs (e.g. Örley 1885, Benham 1886, Beddard 1895, Rosa 1893, 1895). Among these, Michaelsen's famous synthesis (1900) represents a milestone in modern earthworm taxonomy and systematics. Michaelsen's other main contribution was the first global biogeographical synthesis of the earthworm fauna, including the first comprehensive summary of invasive peregrine species (Michaelsen 1903). We can right-

fully call the turn of the nineteenth century “the golden age” of earthworm taxonomy.

This fruitful period of megadrilology ended abruptly with the outbreak of World War I. Between 1915–1918 only 147 species were described, mainly by Michaelsen and John Stephenson (1871–1933). Recovery from the wartime era was quite slow; still, two prominent books were published in this period: The Fauna of British India (Stephenson 1923) and The Oligochaeta (Stephenson 1930). During this time a new generation of scientists, Gordon Enoch Gates (1897–1987), Lev Černosvitov (1902–1945) and Grace Evelyn Pickford (1902–1986) joined Michaelsen and Stephenson. By the mid-1930s productivity almost reached the peak of the turn of the century (Fig. 1). This upward trend was again interrupted by the deaths of Stephenson (1933) and Michaelsen (1937), and World War II. Between 1940–45 only 120 earthworm species were described, mainly by Gates (e.g. 1940, 1945) and Černosvitov (1940, 1942). Additionally, Victr Pop (1903–1976) published his high-impact synthesis, which profoundly influenced the 20<sup>th</sup> century Lumbricidae systematics (Pop 1941). The war and deaths of iconic persons like Černositov, Stephenson, and Michaelsen took a major toll on megadrilology.

With only 159 new earthworm species descriptions, the decade of 1946–1955 represented a low point in earthworm taxonomy. After World War II, Pop continued working on the Romanian earthworm fauna (Pop 1949), and his son, Victor V. Pop (1936–) followed his footsteps decades later. Fortunately, a new generation of earthworm taxonomists, including Kenneth Ernest Lee (1927–2007), Pietro Omodeo (1919–) and Barrie Gillean Molyneux Jamieson (1934–) revived the field, bringing it out of its dormant state. The recovery continued in the mid-1960s when, along with Danuta Jadwiga Plisko (1927–), Reginald William Sims (1926–2012), Marcel Bouché and Gilberto Righi (1937–1999), András Zicsi started working on earthworms.

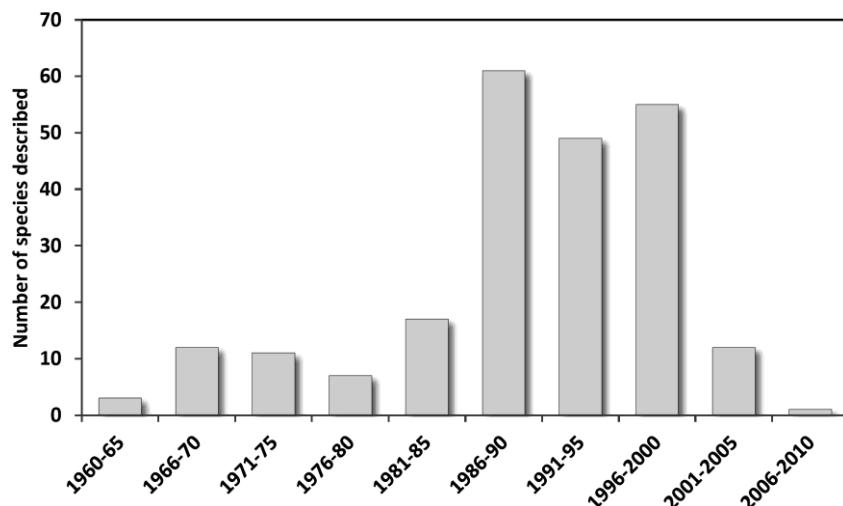


**Figure 1.** Rate of description of new species. A: Cumulative number of new species between 1826 and present. Intervals are decades. B: Number of earthworm species described after Savigny (1826). Intervals are decades.

In his early career Dr. Zicsi's research focused on agroecosystems, specifically on the role of the earthworms in organic matter decomposition. (Zicsi 1955, 1958ab). However, early on he realized that correct species identification is essential to properly interpret ecological data. He continued conducting field observations and experiments in earthworm ecology; at the same time, he wanted gain deeper taxonomical insight into this keystone soil invertebrate group. His collaboration with Victor Pop, whom he visited several times in Cluj (Romania), was crucial in

his professional development, as an earthworm taxonomist.

Between 1960s and mid-1980s Dr. Zicsi's taxonomic work focused on the Holarctic family Lumbricidae. In this group, he described over 60 species new to science; most of them remained valid up today (Csuzdi 2012). In a thorough revision of the Lumbricidae species, described up to 1971, he reported that out of the 561 Lumbricidae species names almost half, 271 fell into synonymy. Moreover, authors who pub-



**Figure 2.** Number of earthworm species described by A. Zicsi between 1960–2010.

lished only one or two papers in the field of earthworm taxonomy, almost always produced synonymous names (Zicsi 1974, 1982).

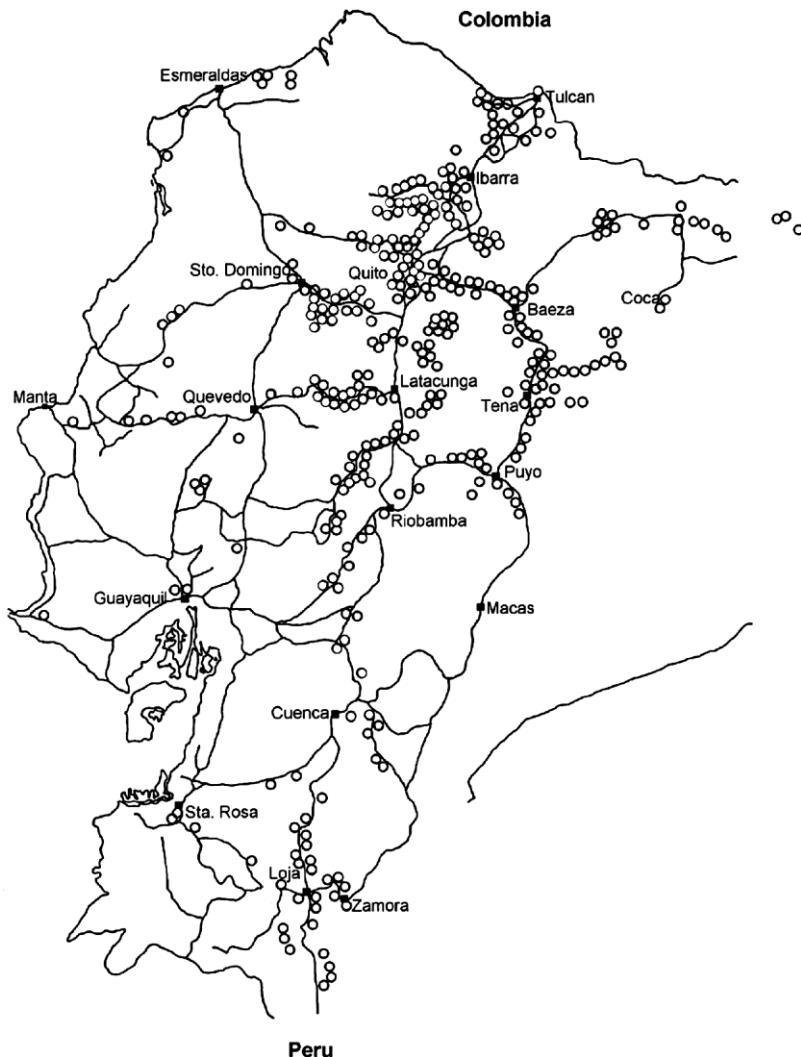
In the mid-1960s Dr. Zicsi had the opportunity to join to several collecting expeditions led by the late János Balogh, an expert in oribatid mites. These expeditions, supported by UNESCO, resulted in a huge earthworm material (3000 specimens representing 120 species) from Africa (Balogh *et al.* 1965) and South America (Andrássy *et al.* 1967, Balogh *et al.* 1969). However, this invaluable collection remained unprocessed until the middle 1980's when the present first author (Csaba Csuzdi) joined Prof. Zicsi's laboratory (Fig. 2). First, the African material was processed, which resulted in description of 20 species new to science belonging to the families Benhamiidae and Eudrilidae (Zicsi & Csuzdi 1986a,b, Csuzdi & Zicsi 1989).

Also in the late 1980s, a new opportunity emerged to continue the global exploration of earthworm diversity and distribution. In collaboration with the Pontificia Universidad Católica del Ecuador, Quito, and with financial support from the Hungarian Academy of Sciences, six collecting trips to Ecuador and Colombia were organized, resulting in an ex-

tremely rich earthworm and other soil invertebrate material (Zicsi & Csuzdi 2008). Prior to these expeditions only 39 earthworm species, described mainly by Cognetti (1904, 1905, 1906), were known from Ecuador. Dr. Zicsi examined over 10,000 specimens, described 68 species new to science, and added 32 new records, bringing up the number of earthworms recorded from Ecuador to 139 (Zicsi 2007). Dr. Zicsi published this and previously collected material from South America, in 43 papers, under a series title "Regenwürmer aus Südamerika" (see full list of publications). This extensive research made Ecuador the best explored country in South America regarding its earthworm fauna (Fig. 3). To this day, no new species has been added to the list.

Between 1986–1993, Dr. Zicsi travelled to Tanzania (1987, 1989) and carried out field collections with his friend the renown bryologist Tamás Pócs, then a professor at the University of Dar es Salaam. In South Africa (1990, 1991) he collected together with Danuta Plisko (Natal Museum, Pietermaritzburg).

In the late 1990s Dr. Zicsi's beloved wife was diagnosed with Alzheimer's disease. While caring for her, Dr. Zicsi's scientific activity gradually diminished, and in his final years he withdrew from public life.



**Figure 3.** Sampling localities in Ecuador between 1986–1993. Localities less than 10 km apart are represented in the same circle.

Dr. Zicsi had a tremendous impact on the earthworm taxonomy of the 20<sup>th</sup> century. Here we highlight two examples of his lasting legacy: the number of his taxonomy publications (137), and the establishment of one of the largest earthworm collections in the world. The “Zicsi” collection, currently deposited in the Hungarian Natural History Museum, Budapest, consists of over 100,000 specimens representing more than 800 earthworm species. A total of 228 of these have been described by Dr. Zicsi and his co-authors (Csuzdi 2012). In an era of diminishing interest and funding for “traditional” zoology research, including utilizing museum collec-

tions, he recognized the need to train and mentor a young scientist who will continue curating this invaluable collection. Today this is the task of the present first author.

Professor Zicsi’s death is a great loss for the international earthworm taxonomist community, but efforts to explore and understand earthworm biodiversity continue. At the end of 20<sup>th</sup> century megadrilology is again an active field, mainly through the works of Robert J. Blakemore, Samuel W. James, Huei-Ping Shen, Jiang-Ping Qiu, Dario Diaz Cosin (and his students), and others (Fig. 1). New methodologies (e.g. bar-

coding, molecular-taxonomy) are integrated with traditional approaches (Aspe *et al.* 2016, Blakemore et al. 2010, Csuzdi et al. 2016), providing new insights the taxonomy and systematics of earthworms. Still, many regions on the Earth remain to be explored. These areas, especially the tropics, might harbour hundreds of undescribed taxa, some in the danger of extinction even before being described. Our hope is that again a young generation of earthworm taxonomists will emerge, who will continue the work of their predecessors, such as Dr. András Zicsi. The efforts of these scientists have to be recognised, valued, and properly funded. They will continue exploring global diversity while also resolving taxonomical issues of this ecologically keystone group.

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**Appendix 1.** Complete list of publications of András Zicsi  
[http://opuscula.elte.hu/PDF/Tomus47\\_1/Zicsi\\_complete.pdf](http://opuscula.elte.hu/PDF/Tomus47_1/Zicsi_complete.pdf)