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Chapter

Prologue: Scientific and Societal Importance of Mites and Acarology From the Viewpoint of International Publication

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1. Introduction

Mites are arthropods typically (and mostly) with a size of 0.08–1 mm; however, exceptionally they might have individuals even with a size of 3 cm among the ticks (Ixodida) when full of blood. Nowadays, they are rather considered to be a morphological or life-form group than an evolutional zoosystematic concept. By comparing the body size, the size range of terrestrial soil mesofauna is 0.1–2 mm and the size range of insects is 0.2–300 mm, whereas in water ecosystems, microplankton has a range of 0.02–0.2 mm and mesoplankton has a range of 0.2–20 mm.

It is doubtless that all of them belong to the class Arachnida of the subphylum Chelicerata; however, the monophyletic origin of the subclass Acari is in question. Probably their groups Anactinotrichida (Parasitiformes) and Actinotrichida (=Acariformes) have to be considered as separate subclasses. Chelicerates were the first multicellular animals on land (in the Silurian), and their sea life-forms are known from the Cambrian Period on; however, their ancestors might have been present in the Ediacaran fauna as well, although their relationship with the Trilobites is not sufficiently explained. Back to the mites, Actinotrichida is known from the Devonian period. Several of their fossils cannot be distinguished morphologically from recent genera. Their relationship with the subclass Solifugae has been suggested. However, their group Anactinotrichida is known only from the Cretaceous Period on; it is not impossible that they form a monophyletic group with the subclass Ricinulei (which do not belong to the mites); however, their relationship with the group Pseudoscorpiones has also been suggested. They are mostly oviparous; however, viviparism also occurs, and even mature offspring may be born (e.g. Pyemotidae). Postembryonal development of the arachnids is usually epimorphosis; however, hemi-metamorphosis can be observed among the mites (with separate larval form and various nymphal forms; even the number of legs can vary from two to three pairs); this phenomenon also shows similarity with the subclass Ricinulei. Sometimes the postembryonal development is very complex, that of the male and the female can be different, which allows them to have different ecological functions. The phylogeny of Chelicerates is summarised by [1].

2. The scientific importance of mites

Mites form the most prevalent and diverse group of the subphylum Chelicerata. They are basically and mostly terrestrial animals; however, they also have freshwater and sea species secondarily. Multicellular animals which returned from the land to permanent sea life for the first time in the history of the Earth (in the Permian) belong here (Trombidiformes: Halacaridae). As for feeding, they have herbivorous, fungivorous, deposit feeder, predator and parasite species as well, which is a unique (and evolutionary secondary) feature among the mostly predator arachnids. Although their active motion is not efficient due to their small body, anemochorous, hydrochorous, biochorous and anthropocorous methods of dispersal are also known; thus, many of their species are cosmopolitans. Many of their ancient species live in tropical rain forests, moss forests and bogs, whereas in the temperate and arctic zones as well as in the (even tropical) mountains, their younger, derived forms are frequent. In South America, in the higher regions of the Pacific Mountain Range, Holarctic fauna can extend as far as South Chile, whereas at a lower height above sea level, the neotropical fauna becomes dominant in the southern part of Central America. At the same time, in the mountains of Papua New Guinea, in high elevations, their Antarctic species are present [2]. They are abundant in all biogeographical regions and all biomes, from the tundra through semi-deserts to the rain forests, from the Antarctica to the Arctic. They are extremely resistant to both physical and chemical impacts. Several of their species can tolerate dehydration well and others are able to live in sea water permanently (deep in the zone of eternal darkness), whereas others can tolerate the total freezing of the substrate surrounding them. The permanent darkness and the low oxygen level do not cause problems either. In most of their species resistance had developed to the special acaricides as well [3–5]. In case of a record-breaking mass extinction due to the destruction of the environment by mankind, they will have representatives among the survivors, since many of their groups had survived the most devastating Permian-Triassic extinction to date almost without any change.

The number of their taxa is very uncertain, the number of their species described so far exceeds 80,000, the number of their genera exceeds 3000 and that of their families exceeds 800. However, these numbers do not mean much. On the one hand, based on the pace of the species descriptions, the majority of species living on the Earth (even 90–95%) is still unknown for the science; on the other hand, their morphologically described species may prove to be several different species based on molecular studies. At the same time, it is doubtless that the majority of species was described by museologists who had the interest in increasing the number of species names in favour of their scientific career; thus it cannot be precluded that up to three-fourths of the described species has to be synonymised in the future. Their sometimes surprisingly significant sexual dimorphism may also play a role in this. Finally, uncertainty is increased by the fact that permanently parthenogenetic, asexual populations also occur among the mites. In this case, the definition of species itself becomes uninterpretable, since even each of their individuals can be considered as a separate species due to the existing gene flow barrier and the individual genetic differences which can certainly be easily demonstrated. However, it is doubtless that we face huge morphological, ecological and molecular diversity.

The research of mites is of great importance due to their quantity and role in the cycle of materials, since there can be tens of thousands of individuals belonging to up to 300–400 species in a handful of tropical soil, moss, bark, hanging soil, bromeliad funnel or tussock. There is no flat, city park, agricultural area, rubbish heap, tumbledown building or any other habitats where they are not abundant. They can be determined in the decomposition in the soils and especially in the inimitably waste-free cycle of materials in the floodplain tropical forests.

3. The social importance of mites

The role of mites (especially that of oribatid mites but also that of prostigmatic, mesostigmatic and astigmatic mites) in the cycle of materials in soils is not fully explained yet; however, their importance in agriculture and forestry is obvious (especially in the tropics). Without them, the release of plant nutrients from corpuscular organic materials would be much slower, and efficient agricultural production would be impossible in many cases. However, some phytophagous groups (e.g. Tetranychoidea, Tarsonemidae, Eriophyidae and Penthaleidae) can be significant pests in horticulture, agriculture and forestry. Research on the biological pest control of *Tetranychus urticae* is of special importance [6, 7]. Besides, they can be parasites and disease vectors (e.g. Varroa spp.) of bee species which have a significant role in pollination. On the contrary, other, mostly predator, mite groups contribute to biological pest management and ecological farming (Phytoseiidae).

The minority of mites is of public health or animal health importance as parasites (e.g. Sarcoptidae, Psoroptidae, Knemidokoptidae, Demodicidae, Cheyletidae), as vectors of pathogens (e.g. Ixodidae, Argasidae, Dermanyssidae) or due to the allergenic impact of their faeces (e.g. Pyroglyphidae). Forensic acarology is also an interesting field of application, where they can be used as bioindicators. As indicators, they are very promising in environmental and nature protection as well [8–15].

4. Volume and composition of the acarological literature according to the data in the large publication databases

Top quality but minor part of scientific papers is published in English-language journals with impact factor (these articles are available in the Web of Science Core Collection database dating back to 1975). Collecting the older scientific literature is more difficult; however, the Zoological Records database, which is part of the wider collection range of the Web of Science, is helpful in this case. A less selected but still internationally noted part of the scientific journals can be found in the Scopus database. However, these are still a fraction of the large amount of articles which were and are virtually published. Google Scholar provides a small insight into this, and it collects all scientific articles available on the Internet; however, its scientific criteria are much weaker. There are a large number of scientific journals available only in print and in national languages all over the world which are published by scientific research institutes, universities and museums but are not included in the above-mentioned large databases; the quality of their review and the level of their editorial board is often uncertain.

In order to be able to get a picture of the volume of the acarological research, an analysis was made on the results of the available important databases and information sources using some appropriate keywords (**Table 1**). We chose the Latin "Acari" and the English "mites" words as keywords, and the Hungarian "atkák" word was

Keyword	WoS Core Collection	Scopus	WoS all databases	Google Scholar	MATARKA	Google internet
"Acari"	19,805	26,903	50,975	275,000	572	5,030,000
"Mites"	36,605	43,186	49,128	650,000	144	30,300,000
"Atkák"	0	2	16	257	90	86,200

Table 1.
Number of results obtained with keywords related to acarology in different databases (status: 22 September 2018).

added as well in order to obtain some information also on the articles published in minor languages. Accordingly, besides the international databases, the national database of journals published in Hungary (MATARKA) was added as well. The number of the Hungarian results may help with estimating the potential volume of other hidden publications as a special indicator, considering that among the 243 countries (195 independent states) of the world, Hungary ranks 92nd regarding the size of the population, and it amounts to 0.13% of the world's population.

Finally, the table was completed with the number of results from the Google browser, since these data and proportions help with evaluating the obtained results.

The number of results in the scientific databases shows that the number of scientific articles amounts to 0.1–5% of the general frequency on the Internet; this is similar in the case of the Latin, English and Hungarian words. Furthermore, it can be stated that the number of top quality articles (WoS CC) amounts to only 5–7% of all scientific results on the Internet (Google Scholar).

The explosive increase in the intensity of scientific research is well characterised by the temporal distribution of the number of results regarding English and Latin keywords (**Table 2**).

On the graphs it can be seen that the increase in the research intensity is exponential, and the fall back in the last years is an artefact, which can be explained by the time needed for data to be included in the databases. At the same time, in the case of the Latin term, a real stagnating period can be recognised in the twenty-first century, which is not shown by the English keyword. This certainly refers to a break in the traditional taxonomic, faunistic and museological approaches compared to other (e.g. molecular and quantitative ecological or applied) studies.

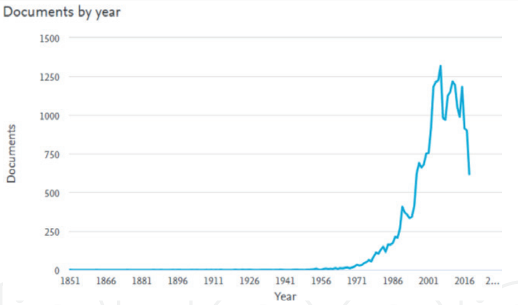
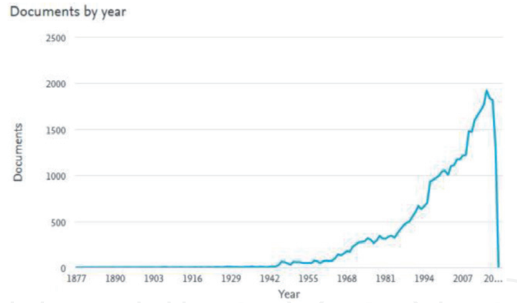
Acari Scopus: 26,903 docs (September 22, 2018)	Mites Scopus: 43,186 docs (September 22, 2018)
	

Table 2.
Temporal distribution of Scopus results between 1851 and 2018.

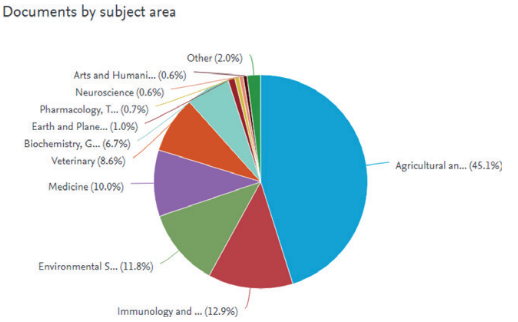
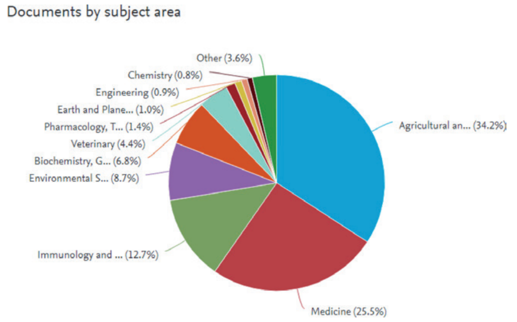
Acari Scopus: 26,903 docs (September 22, 2018)	Mites Scopus: 43,186 docs (September 22, 2018)
	

Table 3.
Distribution of Scopus results based on subject area between 1851 and 2018.

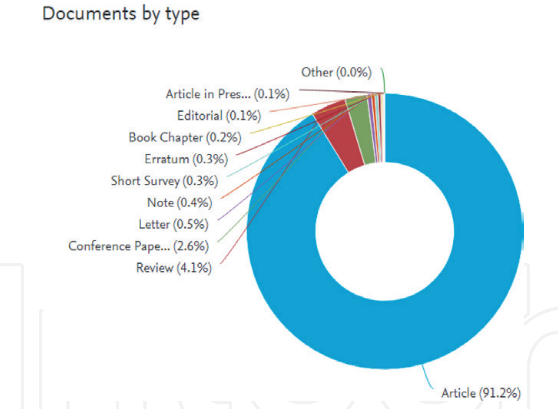
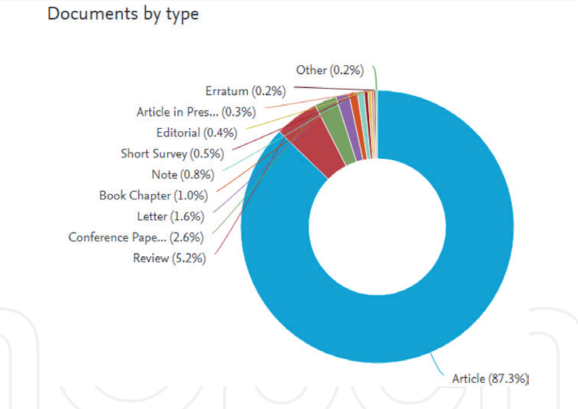
Acari Scopus: 26,903 docs (September 22, 2018)	Mites Scopus: 43,186 docs (September 22, 2018)
	

Table 4.
Distribution of Scopus results based on type between 1851 and 2018.

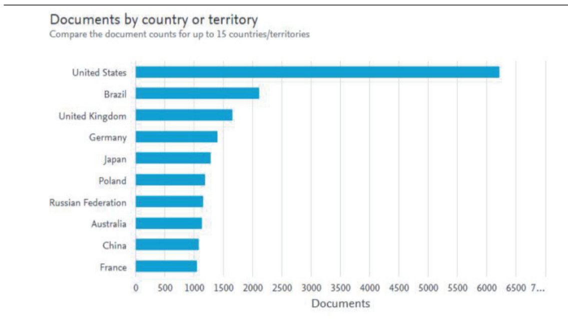
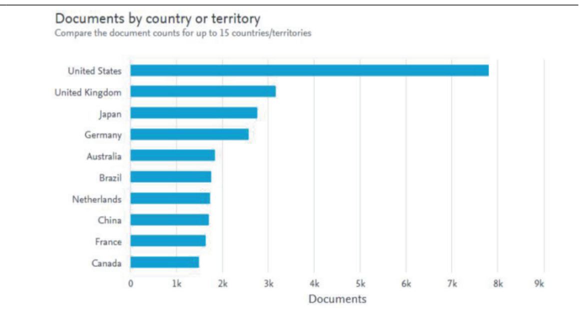
Acari Scopus: 26,903 docs (September 22, 2018)	Mites Scopus: 43,186 docs (September 22, 2018)
	

Table 5.
Distribution of Scopus results based on countries between 1851 and 2018.

Studying the distribution of the articles based on the subject area (**Table 3**), one can see that more than three-fourths of them belongs to applied fields of research (agricultural science, human health, environmental protection).

Studying the distribution of publications based on the type (**Table 4**), the high dominance of primary articles is clear, which refers to the low synthesis level of the subject area. This can have serious disadvantages regarding the application of new knowledge and the knowledge transfer.

Based on the geographical distribution by country (**Table 5**), the results show the dominance of the United States in this subject area so far. The contribution of Brazil, the United Kingdom, Germany and Japan seems to be significant as well.

5. Acarological research among elite publications considered to be an outstanding scientific breakthrough

It is worth studying in which extent acarological research contributed to outstanding scientific breakthroughs in the last four decades (from 1975 to February 2019). This study was based on the articles of the journals *Nature* and *Science*, two absolutely elite organs of scientific research, using the keywords "Acari" and "mites". A considerable article was published in *Nature* in 2013, whereas in *Science* in 2019 for the last time. The results can be seen in **Table 6**. The results obtained with the overview of the previous publications of greater volume are nuanced by 25% of the publications which were results using the keyword; however, by overviewing 55 articles, it can be stated that those do not have real acarological relevance.

	Nature	Science
Allergy and health	5	5
Agriculture and plant-Acari interactions	6	8
Ecology and evolutionary biology	8	9
Mentions without real acarological relevance	6	8
Total	25	30

Table 6.
Articles related to acarology in Nature and Science.

Furthermore, it can be stated that 42% of the elite publications with real acarological relevance have solely basic research (ecological and evolutionary biological) motivation, and 34% of them have agricultural science and 24% human health motivation. Among the articles published in *Nature*, the publication by [16] on the genome of *Tetranychus* urticae was cited on an outstanding number of times.

Another approach to elite publications is studying the most cited acarological articles in the WoS Core Collection database. Among the 60 most cited articles, 32 are related to allergy or human health, 19 are related to agriculture (11 to pest management and 8 to apiary), 5 are related to ecological basic research and 4 of them are without real acarological relevance. Concerning acarology, the following publications had an especially outstanding citation impact: [17] on the biology of *Varroa destructor*, [18] on the global patterns of soil communities, [16] on the genome of *Tetranychus urticae*, [19] on *Rhipicephalus sanguineus* related to veterinary parasitology as well as [20] on the European distribution of *Ixodes ricinus*.

6. Forefront of acarological research

The repository of the top quality and internationally recognised publications is the WoS Core Collection database. In WoS Core Collection, there are 2763 results (published between 1 January 2018 and 15 February 2019) with the keyword "Acari" or "mites" in their topic. Among these, 64% are related to human health, 35% have classical zoological approach, only 4% have ecological approach, also 4% have agricultural approach and only 5% have multidisciplinary approach (articles may belong to several categories; thus, these percentages cannot be added up).

This proportion is striking, since it shows that a significant part of the research on such an important group is not related to ecological, sustainability, agricultural and multidisciplinary research connected with the global ecological crisis of our time and the sixth mass extinction in the geological present, but to the diseases of a single species (human). What is more, it is not related to diseases considered to be the main causes of death, but mostly to allergy, whose main agents are not mites.

Among 2763 publications, 2682 were written in English, the second most important language is Spanish with 20 articles, then German comes with 16 articles and more than one article was written in Turkish, Japanese, Portuguese, Russian, French, Polish and Korean. (The above-mentioned Hungarian language is represented by one article.) This is natural, since the international language of science is basically English, and this database contains only articles of elite journals with impact factor conforming to the highest scientific criteria.

However, the ranking of research by countries is much more important than by languages, where behind the United States, China comes in second, preceding

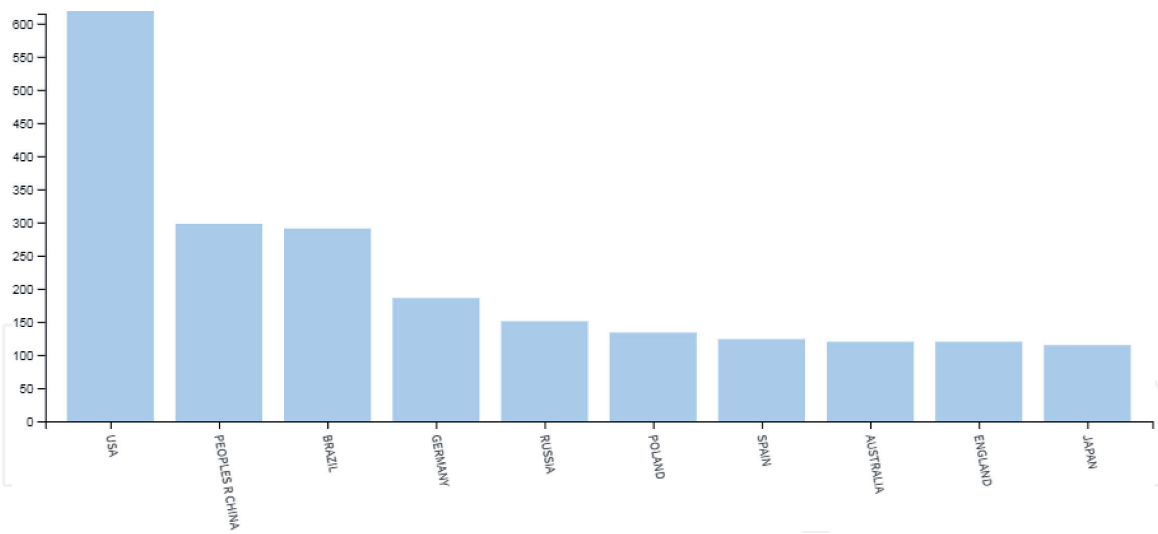


Figure 1.
Frequency distribution of acarological papers based on countries (WoS Core Collection).

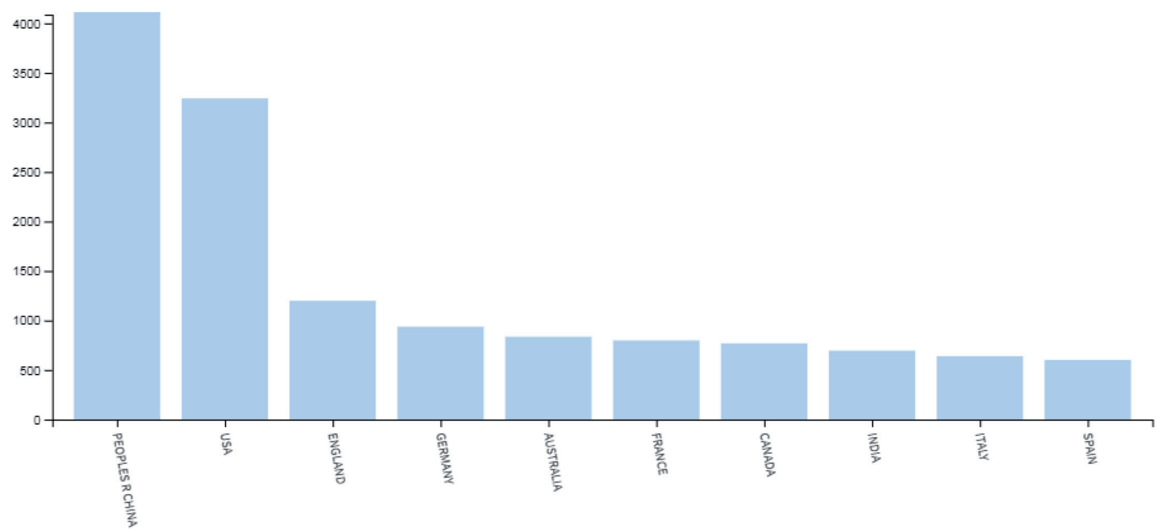


Figure 2.
Frequency distribution of environmental papers based on countries (WoS Core Collection).

Brazil and significantly outpacing the United Kingdom, which rank well before it in the summary relating to all time (**Figure 1**). The rise in Chinese scientific research is rather spectacular in other subject areas as well; this must set an example for all countries of the world.

If we do not search for mites but for the keyword combination “global problems or ecology or environment” in the same database for the same period, among the found 15,431 sources, the majority is published by Chinese authors (**Figure 2**). It would be worth studying the Chinese research funding and educational system; however, this is not the subject of this book.

The studied 2763 acarological publications were cited by other works 1794 times (1084 without self-citation) until the deadline of this study (16 February 2019), the h-index equals to 10 and the average number of citations is 0.65. There are 13 publications which are already cited more than 10 times. Among them, five are related to allergology and four to agricultural plant protection. None of the 10 articles was published in a specifically acarological journal; however, it is gladsome that two reviews can be found among them, which can improve the low synthesis level of the subject area.

7. Future perspectives, main directions and tasks of acarological research

In the front-rank scientific research, the main future research directions and tasks cannot be determined, and the real perspectives cannot be overviewed either, since these are results of the individual creativity of researchers and are inherently unpredictable. According to an article published in *Nature* by [21], the scientists of the University of Chicago, the larger a research team is, the less likely they will have really creative and innovative results. The outstanding intellectual work is basically individual, which can be efficiently fostered by some colleagues at most. However, larger teams and aligned research can have an important role in the accomplishment of existing ideas, setting up large databases and supporting future brilliant research. Concerning these, the following main tasks can be highlighted:

1. Taxonomical and biogeographical exploration of mite biodiversity

2. Quantitative coenological exploration of communities in intact ecosystems concerning mites as well

3. Preciser exploration of production biological roles of mites, especially in flood-plain tropical forests and other natural and seminatural habitats

4. Exploration of phylogenetic relationships of mites up to the level of the known genera

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