

Section 1. Biology

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AN ANALYSIS OF A HALF-CENTURY SCIENTIFIC PAPERS ON LEONURUS L. GENUS IS STUDIED IN THE WORLD: A REVIEW OF PAPERS FROM THE SCOPUS DATABASE PUBLISHED IN ENGLISH FOR THE PERIOD OF 1968–2023

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Abstract

In this article the review of papers of the *Leonurus* L. genus in the Scopus database for a half century, that is, from 1968 to 2023 is analyzed. For 55 years, 183 articles were published by 160 authors from 36 countries on the genus *Leonurus* L. and its promising species. About the species belonging to the genus *Leonurus* L., very few articles were published between 1968–2002, and between 2003–2008, 2–5 articles were published per year. During the years 2009–2023, 163 articles were published about the *Leonurus* genus, and this figure was 89% of the publications published for 55 years worldwide. 157 articles were published in 144 scientific journals about representatives of this category. Moreover, top 10 journals that have published the most articles on *Leonurus* L. genus plant species for 55 years, analytical results on Top-cited articles on motherwort, information on 160 authors who have studied motherwort in various directions, analysis of publications by countries and their organizations explained. The results of the research shows that the Chinese state ranks are the first in terms of funding and publication of articles. It is followed by Russian Federation (27; 16.54%), United States (11; 6.75%), South Korea (9; 5.52%), Iran (7; 4.29%), Germany (6; 3.68%), Lithuania (6; 3.68%), United Kingdom (6; 3.68%), and Australia (5; 3.06%), which are the countries with the top publications in terms of number of articles.

Keywords: *Leonurus* L., motherwort, top journals, Scopus database, medical plants

Introduction

This family is one of the largest and most distinctive families of flowering plants, with about 220 genera and almost 4000 species

worldwide. The last taxonomic revision of the Lamiaceae family was published in 2004 (Harley & et al., 2004). One of the families rich in medicinal, aromatic and essential oil

plants in the flora of Uzbekistan is the family of mints (Labiatae Juss.; Lamiaceae Lindley), which consists of 3,500 species belonging to 200 genera worldwide. There are 464 species belonging to 53 genera in the flora of Central Asia. 41 genera and 206 species of plants belonging to this family grow in the flora of Uzbekistan (Arabova, 2019). According to a recent classification of flowering plants, the family is divided into 12 subfamilies (Li & Olmstead, 2017) and consists of 236 genera and 7203 species. Of those, 3675 species from 105 genera (more than 50% of the Lamiaceae family) belong to the subfamily Nepetoideae (Brahmi & et al., 2017). Plant species from the Lamiaceae The genus *Leonurus* L. (subfamily: Lamioideae) comprises 25 species (Huang & et al, 2015), and four of them are reported in Central Asia (Tulaganova, 1987). Representatives of Lamioideae are characterized by the presence of iridoid glycosides and a lower essential oil content (Erdtman, 1945). Motherwort (*Leonurus cardiaca* L.) is a plant species belonging to the order Lamiales, labia families – Labiatae. Folk names are: goose foot, lion’s tail, lion’s heart, wolf’s foot. Motherwort is a perennial, i.e., a perennial plant that grows to approx. 150 cm in height. Branched stems grow from a short horizontal rhizome, which are roughly hairy, four-angular, furrowed, red-purple in color, hollow inside. Serrated leaves with long petioles are located opposite. The top part of the leaf is dark green, while the underside is lighter, both sides are covered with hairs (Medical College, The University of Rzeszów, Rzeszów, Poland. 2021). Plants belonging to the genus *Leonurus*, also named motherwort, are traditionally used for anti-gynecological disorders in East Asia, and for sedatives in Europe. Chemical investigation of the genus *Leonurus* not only enriched the natural products library, but also enlarged the pharmacological application of this traditional herb (Zhang & et al., 2018). Leonurin increases the maturation of oocytes of large-horned cattle and the subsequent embryonic development for the reduction of oxidative stress and the increase of mitochondrial function. According to the results of scientific research conducted by Ara Tachjian and others (2010), Motherwort has a long history of use in both European and Asian tradition-

al medicine because of its purported sedative and antispasmodic properties. Traditionally, it has been used for “cardiac debility,” tachycardia, anxiety, insomnia, and amenorrhea. It is also used as a hypotensive and a diuretic. When administered intravenously, motherwort reduces platelets aggregation and fibrinogen levels. It potentiates antithrombotic and antiplatelet effects and increases the risk of bleeding. Taken with benzodiazepines, motherwort can have a synergistic sedative effect and may result in coma (Tachjian & et al., 2010).

Many types of the genus *Leonurus* L. (sem. Lamiaceae) have medicinal properties: in European medicine, the herb *Leonurus cardiaca* L. (cardiac pustyrnica) is used for nerve and heart pain, rastroystvax pishchevarenia, amenorrhoea, and also externally (Wojtyniak, & et al., 2012). In modern medicine, preparations of the herb pustyrnica are taken as a neuro – and cardioprotective agent, the action of which is provided by a rich composition of biologically active substances (Ritter & et al., 2010; Rastogi & et al, 2016). Analogous action on the cardiovascular system is noted for the plant of Chinese folk medicine *Leonurus japonicus* Houtt (Zhao, et al., 2011). The plant of Mongolian folk medicine – *Leonurus sibiricus* L. – is used in the treatment of type 2 diabetes (Schmidt & et al, 2013), on takje obladaet antibacterial activity (Ahmed & et al, 2006). As a traditional medicine, the aerial parts of *Leonurus japonicus* Houtt. (Lamiaceae), aka motherwort, have been extensively used to treat gynecological diseases. The current study was designed to investigate the longevity properties of the methanolic extract of *L. japonicus* (MLJ) using *Caenorhabditis elegans* model system (Yang & et al., 2016).

Herba Leonuri, also named Chinese Motherwort, has been extensively investigated as an effective agent on the uterus system. Our group has been studying the natural products of Herba Leonuri for several years, and during this period, many biological activities of the drug were recognized. Leonurine (4-guanidino-Nbutyl- syringate) is an alkaloid present in Herba Leonuri. Recently, growing evidence has highlighted the therapeutic potential of leonurine in multiple diseases, especially cardiovascular. In this review, we discuss the biological activ-

ities of leonurine, also latest improvements including this alkaloid (Zhao & et al., 2022). *Leonurus japonicus* Houtt. (Motherwort) is the fresh or dried aerial part of *Leonurus japonicus* Houtt. (Labiaceae), which is widely used in clinical practice and daily life, used to treat gynecological diseases. However, the differences between different parts, single index component in Pharmacopoeias and the less stability of active ingredients affect its clinical efficacy. This study aimed to find the multi-active compounds between different parts of Motherwort to ensure its clinical efficacy, which related to stability and had pharmacokinetic behavior. Firstly, HPLC-Q-TOF-MS/MS was used to analyze the components in vitro and in vivo, as well as multivariate statistical analysis and network pharmacology analysis was conducted to find the significant different components related to activity. Secondly, the content determination methods were established to study the stability of effective components during storage in order to establish the content limit for quality control of Motherwort. Thirdly, UFLC-MS/MS was used to analyze the pharmacokinetic behavior of active components in Motherwort. The results showed that a total of 131 chemical constituents were identified in vitro and 21 prototype absorption compounds and 72 metabolites were found in vivo. Meantime, multivariate statistical analysis and network pharmacology analysis was combined to find that leonurine, stachydrine and trigonelline were activity-related substance, which could be used

as active components related to pharmacodynamics in different parts. Then the stability variation trend and content limit of three alkaloids were found, which could be used for the quality control of Motherwort. Furthermore, the results showed that three alkaloids had pharmacokinetic behavior in vivo. 3 alkaloids were screened, which could be used as active components most closely related to pharmacodynamics among different parts. The stable stage, assay tolerance and pharmacokinetic characteristics were studied by the active substances, which could provide a basis for quality control and clinical medication of Motherwort (Zhao & et al., 2022).

Methods

In this article, we went to the selection of publications on world-wide known researches. The search collects academic literature in English and Russian languages retrieved from the Scopus database for the period of 1968–2023. 199 materials were downloaded from the Scopus database on 9.11.2023. 184 of them were in English, and the remaining 15 were in Russian. We have removed 2 identical articles (deduplication) and removed sources that are not related to our topic. That is, 15 English articles about the plant *Leonotis Leonurus*, *Leonurus* and *Leonotis* are completely different genera, *Leonurus* L series is the topic we are going to analyze. Also, 1 Russian source was removed (deduplication). As a result, we processed 183 publications.

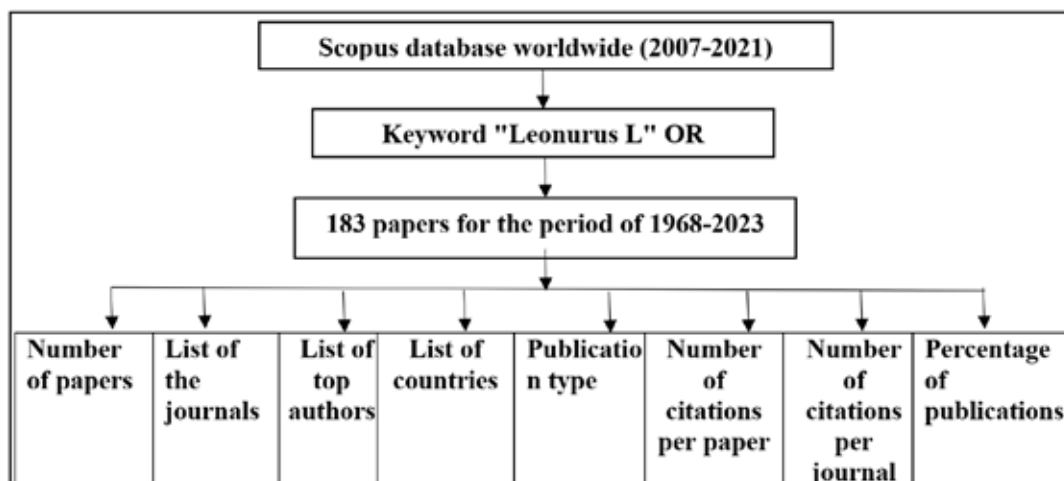
Table 1.

Nº	article	Conference paper	review
Doctype exclusions	14 English 13, Russian 1	1	1
Revised Doctype	157	19	6

In the next step, articles were categorized according to year of publication. A data base of all peer-reviewed papers was then created, including the year of publication, authors' names, countries, publication type, journal name, number of citations per paper, the number of citations per journal, the percentage of publications by the topic cluster name and subject area. The analysis was performed using CSV file, Microsoft Excel 2021,

RIS, VOS viewer. Figure 1 shows the flow of the selected methodology for the research. The reasons for our use of the methods mentioned above are related to Scopus, a well-known database that collects authoritative literature from around the world, especially on irrigation and drainage systems. English is a universal language, therefore, the literature in English is more standard and meaningful than literature in other languages.

Figure 1. Flowchart of the methodology



1. Results and discussion

1.1. Trends of publications on *Leonurus* genus

As a result of our research, 160 authors from 36 countries published 183 articles from 1968 to 2023. Between 1968 and 2002, 1 or 2 articles were published about species belonging to the genus *Leonurus*. By 2003, interest in this genus, rich in medicinal plants, began to increase, and 5 articles were published that year. During the period from 2004 to 2008, it was observed that the publication of articles decreased. Figure 2 shows the number of articles published between 2008 and 2023. When we analyze these years, 163 articles on the genus *Leonurus* were published during 16 years, which is 89% of the publications published during 55 years worldwide. 2008 was the year with the fewest articles published, 2 (163 articles taken as 100%,

1.09%), 9 (5.52%) in 2009, 8 (4.91%) in 2010, 5 (3.07%) in 2011, 6 (3.68%) in 2012, 5 (3.07%) in 2013, 10 (6.13%) in 2014, 9 (5, 52%), 11 (6.75%) in 2016, 8 (4.91%) articles by 2017, 11 (6.75%) in 2018, 12 (7.36%) in 2019, 14 (8.59%) in 2020, 17 (10.43%) in 2021, the publication of articles peaked in 2022 and reached 24 (14.72%), by 2023 the publication of articles decreased to 12 (7.36%) (Figure 2). During the years 1968–2023, 183 articles were published about the species of plants belonging to the genus *Leonurus*, of which 157 (85.79%) were articles published in journals as the results of scientific research, and 19 (10.38%) articles were reviews, (literature review) materials, 6 (3.28%) consist of conference materials, and the remaining 1 publication is covered as a Book Chapter (Figure 3). 7.65% of 183 articles are published in Russian.

Figure 2. Number of papers on *Leonurus* genus by the year of publication issues in the world

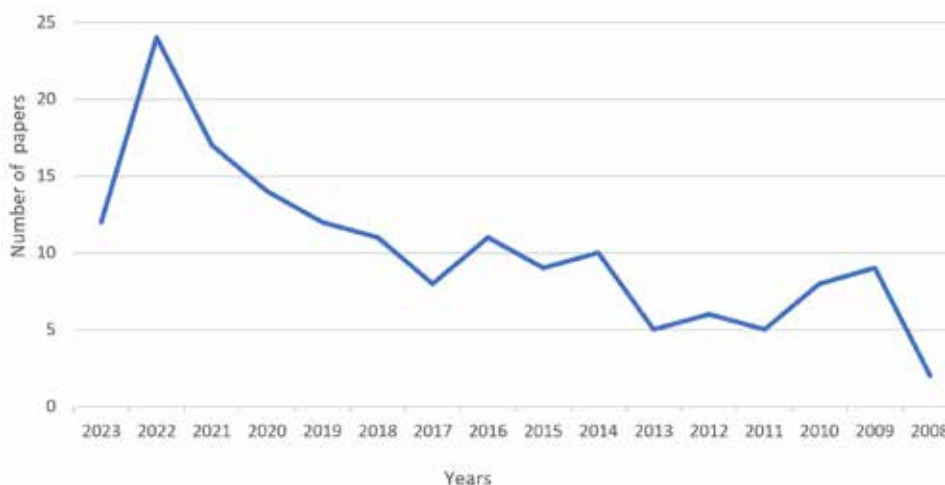
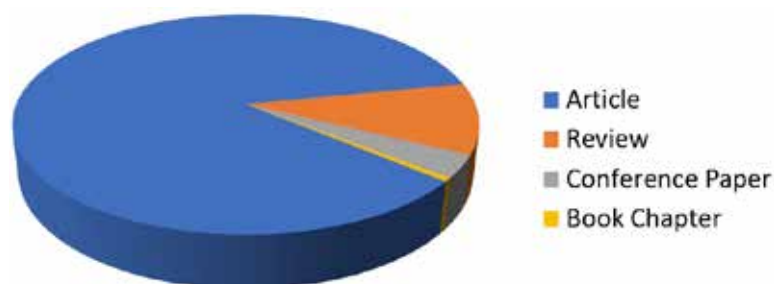


Figure 3. *Publication type on Leonurus genus issues in the world*

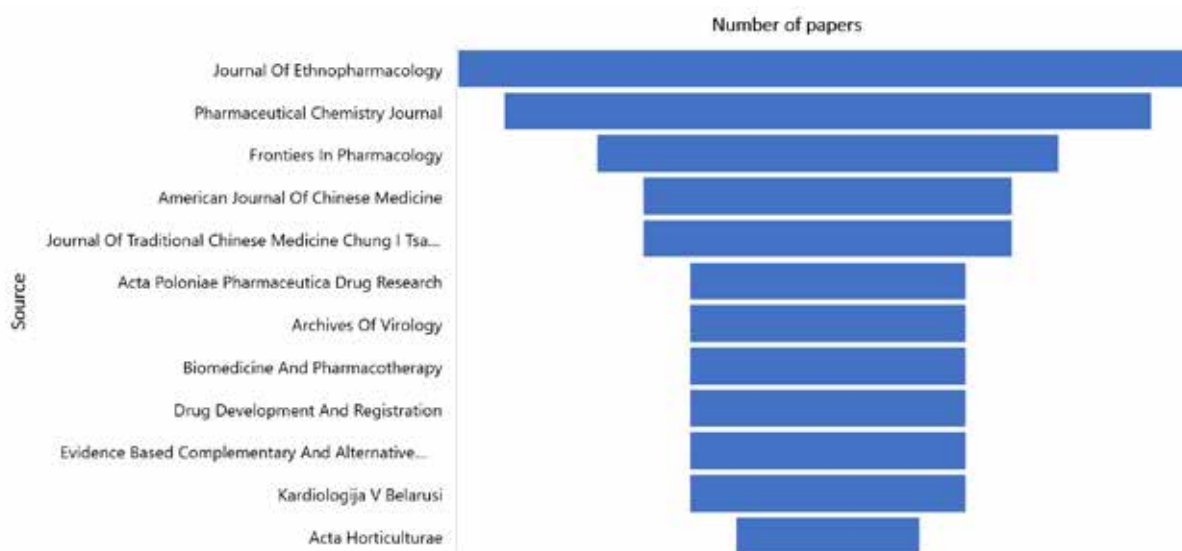


2. Journals on Leonurus genus

A wide range of journals in various parts of the world are used by scholars to publish their research. The communication patterns of the scholars specify that the total output was distributed across 144 journals published in 36 countries. Among them, 9

magazines published the results of scientific research in Russian. During these years, 157 (100%) articles were published in 144 journals, of which 15.29% of articles were published in 12 top journals (Figure 4) and remaining 84.71% of papers were published in other journals (Figure 4).

Figure 4. *Top journals on Leonurus genus by the year of publication issues in the world*



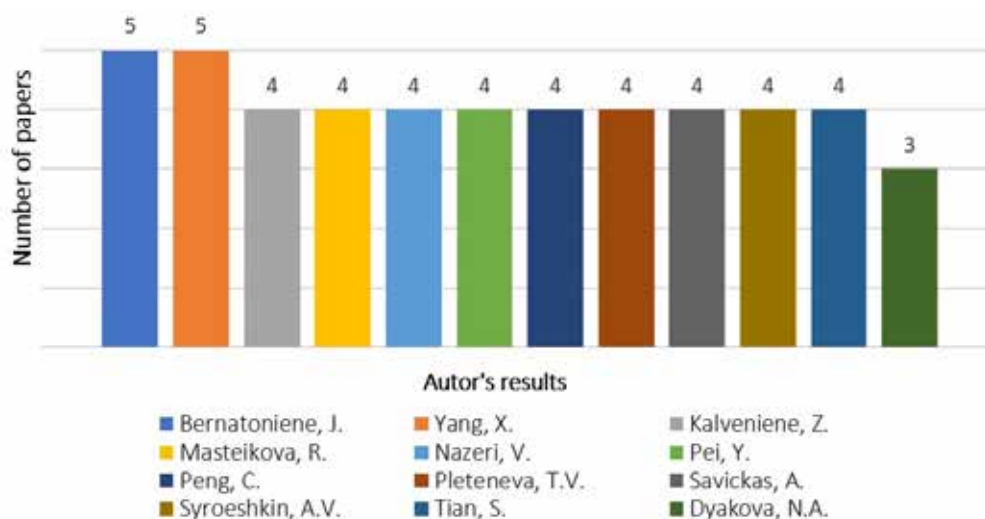
In some sense, among the top 12 journals that have published the most articles on *Leonurus* genus plant species during these 55 years, the Journal Of Ethnopharmacology takes pride of place with 8 articles, the Journal of Pharmaceutical Chemistry comes second with 7 articles, and the rest of the journals are: Frontiers In Pharmacology (5), American Journal Of Chinese Medicine (4), Journal Of Traditional Chinese Medicine Chung I Tsa Chih Ying Wen Pan sponsored by All China Association Of Traditional Chinese Medicine Academy Of Traditional Chinese Medicine (4), Acta Poloniae Pharmaceutica Drug Research (3), Archives Of Virology (3), Biomedicine And Pharmaco-

therapy (3), Drug Development And Registration (3), Evidence Based Complementary And Alternative Medicine (3), Kardiologija V Belarusi (3), Acta Horticulturae (2) (Figure 4). In addition, among these top magazines, there are 2 magazines that published articles in Russian, which accounted for 25% of the total publication (compared to 12 magazines).

3. Authors and their affiliated country

Our research revealed that 160 authors from 36 countries conducted research on *Leonurus* genus during 1968–2023. Figure 5 analyzes the results of scientific research of 12 authors who published the most articles.

Figure 5. Top authors on *Leonurus* genus by the year of publication issues in the world



Regarding top-cited articles on motherwort, the article by Ara Tachjian, Viqar Maria and Arshad Jahangir took the first place with 316 (compared to 9.11.2023) cytiruemia, Elizabeth A. Mazzio and Karam F.A. Soliman's In vitro screening for the tumoricidal properties of international medicinal herbs article is on the 2nd place with 130

cytiruemia, Xiaofei Shang, Hu Pan, Xuezhong Wang, Hua He, Maoxing Li's *Leonurus japonicus* Houtt: Ethnopharmacology, phytochemistry and pharmacology of an important traditional Chinese medicine is on the 3rd place with 106 cytiruemia is standing. Table 1 shows the top 10 articles and their authors.

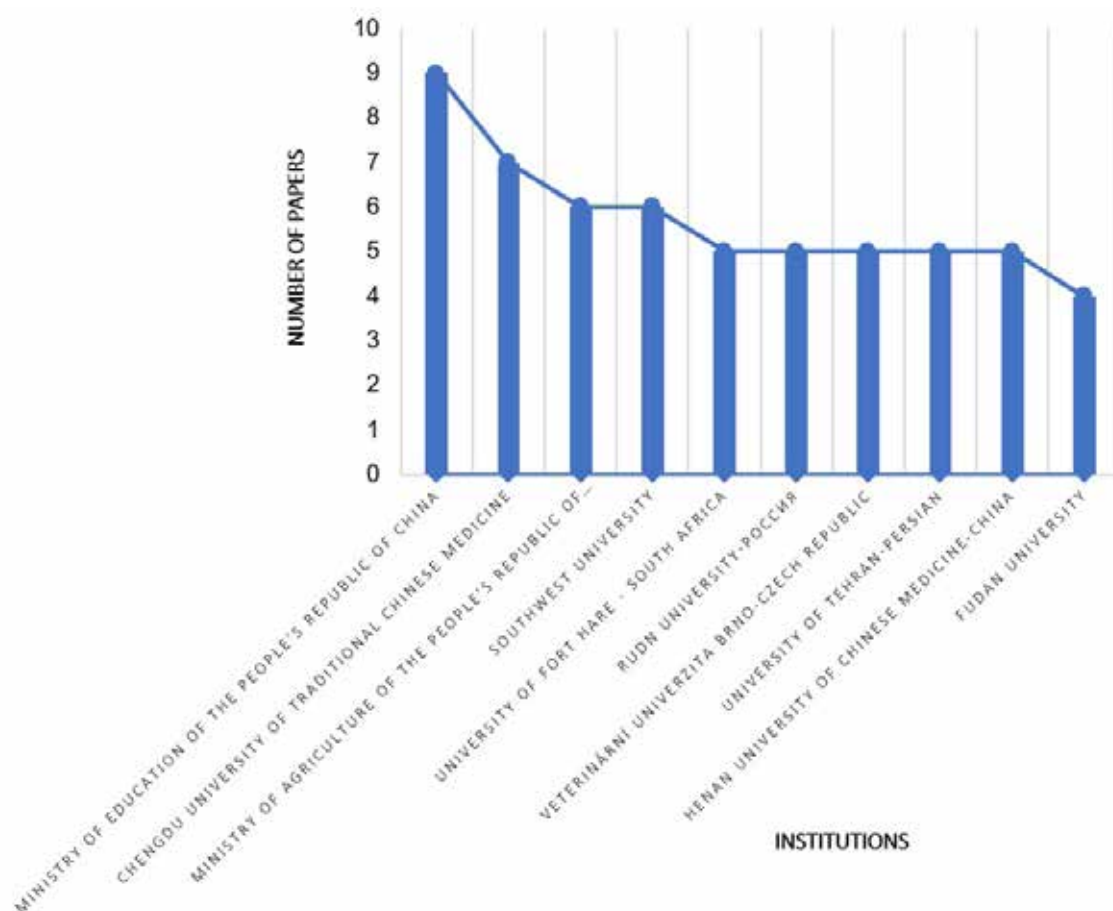
Table 1. List of the Top-cited articles on motherwort

N°	Title	Authors	Citations
1.	Use of Herbal Products and Potential Interactions in Patients With Cardiovascular Diseases	Tachjian A.; Maria V.; Jahangir A.	316
2.	In vitro screening for the tumoricidal properties of international medicinal herbs	Mazzio E. A.; Soliman K. F.A.	130
3.	<i>Leonurus japonicus</i> Houtt.: Ethnopharmacology, phytochemistry and pharmacology of an important traditional Chinese medicine	Shang X.; Pan H.; Wang X.; He H.; Li M.	106
4.	Mistletoe hepatitis	Harvey J.; Colin-Jones D.G.	85
5.	<i>Leonurine hydrochloride</i> inhibits osteoclastogenesis and prevents osteoporosis associated with estrogen deficiency by inhibiting the NF-κB and PI3K/Akt signaling pathways	Yuan F.-L.; Xu R.-S.; Jiang D.-L.; He X.-L.; Su Q.; Jin C.; Li X.	84
6.	<i>Leonurus cardiaca</i> L. (Motherwort): A review of its phytochemistry and pharmacology	Wojtyniak K.; Szymański M.; Matlawska I.	83
7.	The influence of herbal medicine on platelet function and coagulation: A narrative review	McEwen B.J.	74
8.	In vitro anti-HIV activity of five selected South African medicinal plant extracts	Klos M.; van de Venter M.; Milne P.J.; Traore H.N.; Meyer D.; Oosthuizen V.	66
9.	Enhanced resistance to fungal pathogens in transgenic <i>Populus tomentosa</i> Carr. by overexpression of an nsLTP-like antimicrobial protein gene from motherwort (<i>Leonurus japonicus</i>)	Jia Z.; Gou J.; Sun Y.; Yuan L.; Tang Q.; Yang X.; Pei Y.; Luo K.	60

The quality of papers published by researchers determines how institutions are ranked. One hundred and sixty different institutions worked in cooperation to publish 183 papers on *Leonurus* genus in the world in the period of 1968–2023. Our analysis of the top 10 institutions' publications on *Leonurus* genus allowed us to determine the

influential and productive institutions in this field. According to the results of our analysis, the country that has published the most articles about our research object is China, which ranks first with 20.22% of institutions that have published articles, followed by South Africa, the Czech Republic, and Russia (Figure 6).

Figure 6. List of top institutions on *Leonurus* genus issues in the world



4. Top funding sponsors on *Leonurus* genus

When we analyzed the publications of the 12 authors who have published the most articles about our subject for 55 years, J. Bernatoniene and X. Yang took the proud first place out of 12 by publishing 5 articles, and the next nine authors published 4 articles each are in second place: Z. Kalveniene, R. Masteikova, V. Nazeri, Y. Pei, C. Peng, T.V. Pleteneva, A. Savickas, A.V. Syroeshkin, S. Tian. The last 12 places were taken by N.A. who published 3 articles. Dyakova occupies this place, after her 14 other authors published 3 articles each. The next places are occupied by authors who have

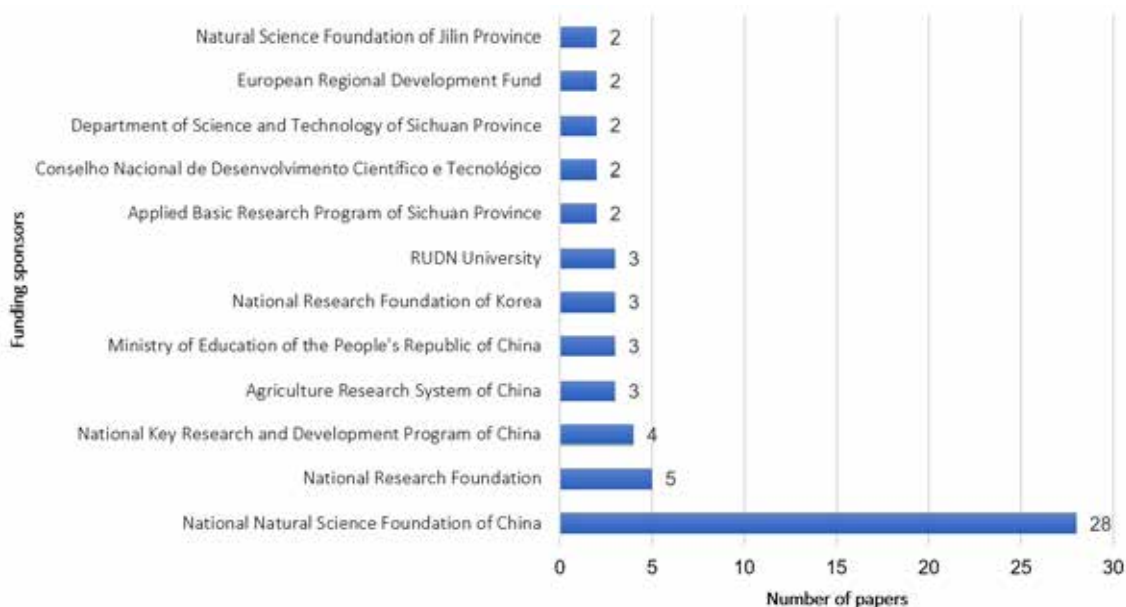
published 1–2 articles. The National Research Foundation of South Africa took the second place by sponsoring 5 articles, the National Key Research and Development Program of China took the third place by sponsoring 4 articles, the Agriculture Research System of China and the Ministry of Education of the People's Republic of China. Russia's RUDN University and Korea's National Research Foundation of Korea are in the third place, sponsoring 3 articles each. Applied Basic Research Program of Sichuan Province of China, Conselho Nacional de Desenvolvimento Científico e Tecnológico of Brazil, Department of Science and Technol-

ogy of Sichuan Province of China published 2 articles and took the fourth place (Figure 7).

When we analyzed the published articles by subject, it was found that articles were published in 22 areas. Top 6 most published articles in the field of knowledge. The major-

ity of articles were published in Pharmacology, Toxicology and Pharmaceutics, Medicine, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Chemistry, Environmental Science.

Figure 7. Top funding sponsors on *Leonurus* genus issues in the world

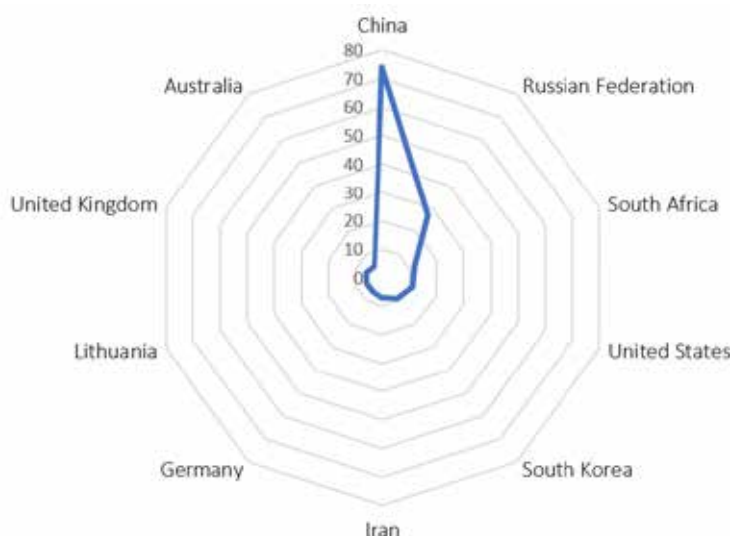


5. Top countries on *Leonurus* genus

Research on *Leonurus* genus was published in 36 countries around the world. Figure 8 lists 10 most prolific countries in the field of *Leonurus* genus research. Countries which published 183 research papers in last 55 years (1968–2023) have been considered as prolific countries. Figure 8 shows the top

10 countries that published the most 163 (100% of top 10 countries) articles, including China (74; 45.40%), Russian Federation (27; 16.54%), United States (11; 6.75%), South Korea (9; 5.52%), Iran (7; 4.29%), Germany (6; 3.68%), Lithuania (6; 3.68%), United Kingdom (6; 3.68%), and Australia (5; 3.06%) took the last place.

Figure 8. List of top countries on *Leonurus* genus matters around the world



Conclusion

It was found that 183 articles were published by 160 authors from 36 countries during the half-century of *Leonurus* genus, that is, from 1968 to 2023. Between 1968 and 2002, very few articles were published on species belonging to the genus *Leonurus*, and by 2003, an increase in the number of articles was observed. During the period from 2004 to 2008, the number of articles published decreased. During the years 2008–2023, 163 articles were published about the *Leonurus* genus, and this figure is 89% of the publications published during 55 years worldwide. In recent years, the increased interest in the species of the genus *Leonurus* shows that this genus has important medicinal species. 157 articles were published in 144 scientific journals. For 55 years, the Journal Of Ethnopharmacology, Pharmaceutical Chemistry Journal, and Frontiers In Pharmacology have been the top 3 publications on the plant species of the genus *Leonurus*. When we analyzed the top-cited articles on motherwort, the article by Ara Tachjian, Viqar Maria and Arshad Jahangir had 316 cytotoxic cases compared to November 9 and 327 cytotoxic cases compared to December 15. In addition, Elizabeth A Mazzi and Karam F A Soliman's article In

vitro screening for the tumoricidal properties of international medicinal herbs and Xiaofei Shang, Hu Pan, Xuezhi Wang, Hua He, Maxing Li *Leonurus japonicus* Houtt.: Ethnopharmacology, phytochemistry and pharmacology of an It was noted that they occupied 2–3 places with the article “Important traditional Chinese medicine”. 160 authors who studied dragonflies in various directions were identified. Research on *Leonurus* genus had been published in 36 countries around the world. Countries which published 183 research papers in last 55 years (1968–2023) have been considered as prolific countries. According to the results of the analysis, the Chinese state is in the first place in terms of funding sponsor, publication of articles. It is followed by Russian Federation (27; 16.54%), United States (11; 6.75%), South Korea (9; 5.52%), Iran (7; 4.29%), Germany (6; 3.68%), Lithuania (6; 3.68%), United Kingdom (6; 3.68%), and Australia (5; 3.06%) are the countries with top publications in terms of number of articles. A comprehensive analysis of 55 years of scientific articles published in the Scopus database shows that species of the genus *Leonurus* are important plants, and we believe that scientific research on them will increase in the next decade.

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