

Literature Research

Current Status and Research Trends of *Panax* Between 1900—2019: A Bibliometric Analysis*

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ABSTRACT **Objective:** To investigate the current status and further development of *Panax* genus and 6 important individual species including *P. notoginseng*, *P. quinquefolium*, *P. vietnamensis*, *P. japonicus*, *P. stipuleanatus* and *P. zingiberensis*. **Methods:** The bibliometric analysis was based on the Web of Science core database platform from Thomson Reuters. Totally, 7,574 records of scientific research of *Panax* species published from 1900—2019 were analyzed. The statistical and visualization analysis was performed by CiteSpace and HistCite software. **Results:** The academic research of *Panax* species increase promptly. Plant science is the main research field while research and experimental medicine and agricultural engineering will be the further development tendency. Particularly, the discrimination research of *P. notoginseng* will be the research tendency among *Panax* species, especially diversity research. In addition, *P. vietnamensis* deserves more attention in the genus *Panax*. **Conclusion:** This research provides a reference for further research of the genus and individual species.

KEYWORDS *Panax*, development tendency, bibliometric, Ginseng discrimination, cultivation engineering

There are many different species of genus *Panax*, which are widely-accepted in the world because of their obvious effects on humans as supplements, stimulants, and anti-fatigue herbs.⁽¹⁻³⁾ There are about 120 species in the world, including 10 species in East Asia and 2 species in East North America. Ginseng, named as king of herbs, is one of the most important medicinal plant in the Orient.⁽⁴⁻⁶⁾ To date, 6 herbs are included in China Pharmacopeia (2015 version), which come from 5 species comprised of *Ginseng Radix et Rhizoma* (original from *Panax ginseng*), *Notoginseng Radix et Rhizoma* (original from *P. notoginseng*), *Panacis Quinquefolii Radix* (original from *P. quinquefolium*), *Panacis Japonici Rhizoma* (original from *P. japonicus*), and *Panacis Majoris Rhizoma* (original from *P. japonicus* var. *major* and *P. japonicus* var. *bipinnatifidus*). Amongst, the latter 3 species (*P. japonicus*, *japonicus* var. *major* and *P. japonicus* var. *bipinnatifidus*) and *P. zingiberensis* are endangered species in the middle and low latitudes of China.⁽⁷⁾ Besides, *P. vietnamensis* and *P. stipuleanatus* also have similar pharmacological action and gene with *P. notoginseng*, which have potential research value.⁽⁶⁾ There is abundant literature on various subjects of the genus *Panax*, which mainly focus on *P. ginseng*,^(3,8) *P. notoginseng*,⁽⁹⁻¹¹⁾ and *P. quinquefolium*.^(12,13) However, there are few studies on other similar species of the

genus *Panax*, which may have potential cultivation or research perspective. For example, *P. vietnamensis* has more biomass than *P. notoginseng* in terms of the root and aerial part.^(10,11) It has been cultivated in the Yunnan Province of China on a large scale. Therefore, it is necessary to summarize current literature to make a prospect of the genus and its corresponding species with potential value.⁽¹⁴⁾

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Bibliometric is a scientific statistical method for investigating the present status and further research trends of the specific object over time.⁽¹⁵⁾ After collection of published articles or other forms of literature profiles, the importance of discipline and specific field can be evaluated quantitatively and qualitatively. According to analysis of published literature, we can focus on the longitudinal trend of a special chemical component,⁽¹⁶⁾ a special research topic of a species,⁽¹⁷⁾ the author structure of a target field,⁽¹⁸⁾ even the publication characteristics of a journal.⁽¹⁹⁾

The main purpose of this study was to explore the current status and future research trends of *Panax* from 1900—2019, using bibliometrics method based on the Web of Science (WoS) core dataset. Besides, we also focus on lateral research of 6 *Panax* species, including *P. notoginseng*, *P. quinquefolium*, *P. vietnamensis*, *P. japonicus*, *P. stipuleanatus*, and *P. zingiberensis*. Our previous published article regarding *P. ginseng* has displayed a comprehensive description of the global status of *P. ginseng* between 1959 and 2016.⁽²⁰⁾ The results aim to provide a research direction of the genus *Panax* and its main species.

METHODS

Data Collection and Search Strategy

WoS core database in Web of Science was selected as the bibliometric data source.⁽²¹⁾ *Panax* was used as the topic search term and the period was defined from 1900—2019. Six individual topic terms, including *Panax notoginseng*, *Panax quinquefolium*, *Panax stipuleanatus*, *Panax vietnamensis*, *Panax zingiberensis*, and *Panax japonicus*, were repeated to the search process the same as *Panax* for investigating the research status and further development of these *Panax* species, respectively. The title, author list, author affiliation, abstract, keywords, and cited references were collected.

Bibliometric Analysis

Additionally, co-words, co-occurrence analysis, and bibliographic coupling were conducted with CiteSpace. A bibliometric online analysis platform (<https://bibliometric.com/>) for co-authorship analysis was selected, which is a macroscopical cooperation investigation between different countries.

Evaluation Parameters

For a comprehensive evaluation of the statistical

and visualization results, total local citation score (TLCS) and total global citation score (TGCS) were regarded as 2 index parameters to evaluate the influence of authors.^(22,23) The impact of the journal was evaluated by impact factor (IF, in the 2019 year) and H-index (in the latest 5 years). Additionally, TLCS and TGCS are used as evaluation factors for cited reference analysis, and a high value indicated that the reference records among the same-field documents are classic.

Analytical Software

All the statistical analysis were performed using HistCite software (Version 12.3, 17, USA). Based on the statistical results, the results of author, language, country, institution (institution with subdivision), journal, document type, cited reference, yearly output, and the frequency of keywords were retrieved. The obtained results were visualized using Origin software (Version 2018, OriginLab Corporation, USA). The visualization of country distribution was finished by the results of HistCite combined with ArcGIS software (Version 10.0, Environmental Systems Research Institute, Inc. USA).

RESULTS

Document Type

Collection records of *Panax ginseng* C were comprised of article, review, meeting, abstract, proceedings paper, note, and the letter accounts for 97.6% in the whole collected dataset (Figure 1). The document types of other 4 *Panax* species, including *P. notoginseng*, *P. quinquefolium*, *P. vietnamensis* and *P. japonicus*, were similar to *Panax*, also has a high percentage of articles. All of the documents of *P. stipuleanatus* and *P. zingiberensis* were articles without other document types. Generally, there were 7,574, 1,753, 442, 49, 182, 20, 10 records (published date for records is Dec.25th, 2020) of *Panax*, *P. notoginseng*, *P. quinquefolium*, *P. vietnamensis*, *P. japonicus*, *P. stipuleanatus*, *P. zingiberensis*, respectively, for bibliometrics analysis below.

Document Language

Among this literature profile, 97.8% (7,407) of collected records of *Panax* with these language distributions in the world (Appendix 1A), which were published in English (Appendix 1B). The low percentage was comprised of Chinese, Japanese, Russian, German, Polish, Portuguese, French, Korean, Spanish, Hungarian, Italian, and Turkish (Appendix 1C).

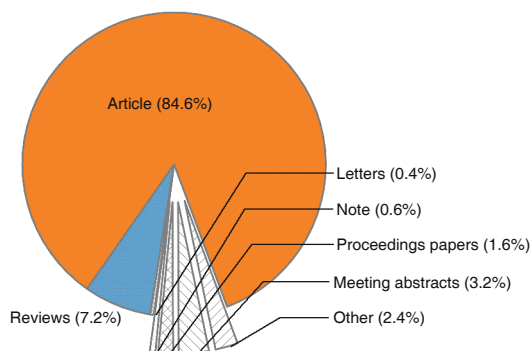


Figure 1. Document Types of Panax between 1900–2019

All records of *P. zingiberensis* were written in English so that these plots didn't include the species.

Top 10 Journals

The top 10 journals published in the scientific research of *Panax* are visualized in Appendix 2A including IF and H index. *Journal of Ginseng Research* published the most records (489) for the genus with the highest IF value in 2018, followed by *Journal of Ethnopharmacology*, *Planta Medica*, *Biological & Pharmaceutical Bulletin*, *Molecules*, *Phytotherapy Research*, *Journal of Agricultural and Food Chemistry*, *Chemical & Pharmaceutical Bulletin*, *Journal of Pharmaceutical and Biomedical Analysis*, and *Evidence-Based Complementary and Alternative Medicine*. *Journal of Ethnopharmacology* recorded a large proportion of literatures for *P. notoginseng* and *P. quinquefolium*,⁽¹³⁾ among which also have published literatures of *P. japonicus*.

Top 10 Authors

The top 10 authors contributed to the scientific research of *Panax* are displayed in Appendix 2B including TLCS and TGCS. The most contributed author is Deok-Chun Yang (Yang DC) from Kyung Hee University (current affiliation), who contributed 173 records in the WoS database, and total publications covered *P. ginseng*, *P. quinquefolium*, including the experiment design of their main chemical components. Kim Dong Hyun (Kim DH) from Korea University has the highest TLCS and TGCS values among the top 10 authors. The main contribution of the author is in the field of pharmacological activities extraction such as ginseng saponin.

Country Characteristics

Countries Contributed for Research of the Genus

In global, the total document production of

top 10 countries and annual output documents of these countries are shown in Figure 2. Among 7,574 documents responsible for the *Panax* research, China and South Korea are the main research countries, and the number of records indicates an increasing trend from 2002–2018. The total amount also shows the tendency from 1933–2018, with 576 records reaching peak in 2018. The first article was published in 1933.⁽¹³⁾ The article was written in German about pharmacology and pharmacy research. From 1981 to 2019, there were 1,753 records about scientific research of *P. notoginseng*, the first of which was about the isolation of chemical components.⁽²⁴⁾ The other researches on 5 species (*P. quinquefolium*, *P. vietnamensis*, *P. japonicus*, *P. stipuleanatus*, *P. zingiberensis*) were first published in 1979, 1991, 1977, 2000, and 1994, respectively. And the initial 5 published articles focused on content determination of ginsenosides,⁽²⁾ pharmacology,⁽²⁵⁾ new components,⁽²⁶⁾ phylogenetic analysis,⁽¹²⁾ and tumor.⁽²⁷⁾

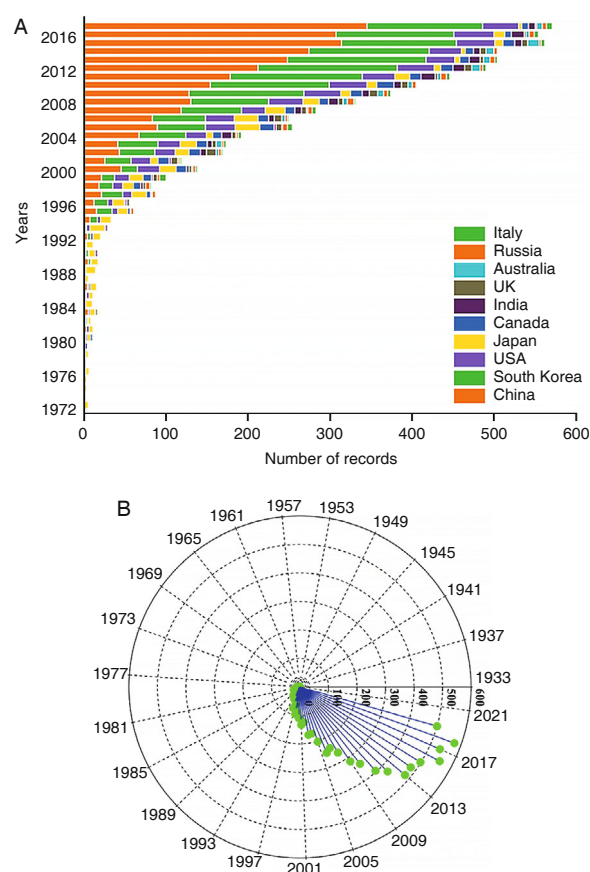


Figure 2. Yearly Output of Top 10 Countries (A) and All Countries (B) in Panax

There were 84 countries contributed to the scientific research of the genus (Appendix 1A).

Amongst, the top 5 countries with the greatest contribution are China (3,403 records), South Korea (2,119 records), the United States (787 records), Japan (549 records), and Canada (294 records). These countries cover almost 6 continents, especially Asian and North America. Fifty-two countries published articles related to *P. notoginseng*, among which the top 5 countries were China, the United States, South Korea, Japan, and Australia. Furthermore, China, the United States, Canada, South Korea, and Japan were the main research countries for *P. quinquefolium*. Eleven countries have participated in the research of *P. vietnamensis*, and Vietnam was the most output country, followed by Japan, China, South Korea, and France. Compared with the above species, there are few countries and records contributed to the research of *P. japonicus*, *P. stipuleanatus*, and *P. zingiberensis*. China still was the most contributed country for these 3 species.

But even countries have extensive co-operation in scientific field, there are only 32 articles in import or export trade field (Figure 3A). The highest cited article is *The World Ginseng Market and the Ginseng* (Korea) with 170 citations. Authors care more about ginseng itself than trade, even that the economic value of ginseng is very high (Figure 3B). The total literature production in the top 10 countries of 6 individual species of *Panax* indicated that China contributes the most to the research of *P. notoginseng*. *P. quinquefolium* is a world-popular species that the 10 countries jointly conduct relative research on the species each year. As for the other 4 species, there were few kinds of literature each year.

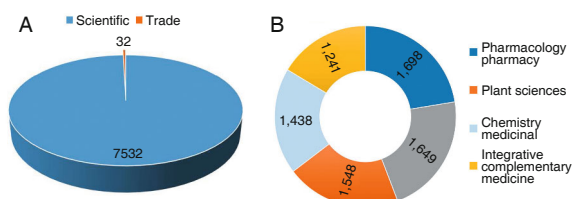


Figure 3. Trade (A) and Scientific Distribution (B) of *Panax* Research

Co-authorship Analysis

The main co-authorship was based on national units through bibliometric analysis. The cooperation relationship among different countries in the genus is visualized in Figure 4. The cooperation of different countries shows that these species of the genus seem to be a universally recognized research goal,

and different institutions from these countries equally contributed to the safety and world-wide application of herbal medicines. Amongst, there was high-frequency cooperation among China, South Korea, and the United States, especially between China and the United States. Certainly, there were other low-frequency teamwork among different countries, forming a sophisticated cooperation circle plot.

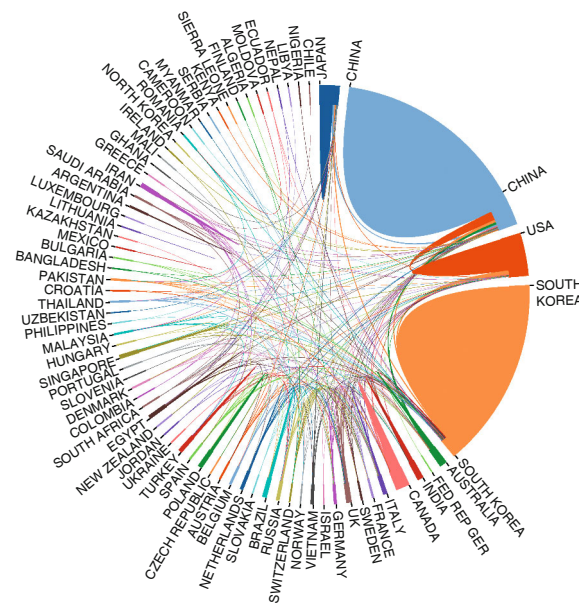


Figure 4. Cooperation Results of Different Countries in *Panax*

The cooperation results of the other 6 *Panax* species are similar to the results of ginseng, China, South Korea, and the United States are still the high-frequency cooperative units with the highest production in terms of *P. notoginseng*. There was less cooperation among different countries for *P. quinquefolium*, in which China only has academic cooperation with the United States, Japan, Australia, Canada, Ireland, Switzerland, while the Netherlands and Poland only cooperated with Hungary. For *P. vietnamensis*, the most productive teamwork contains Japan, South Korea, and France. China has academic consociation with Japan, the United States, South Korea, and Australia in the research fields of *P. japonicus*. As for *P. stipuleanatus*, there was cooperation among China, the United States, Japan, Canada, and South Korea. China, Japan, and Switzerland have contributed to the research of *P. zingiberensis*.

Supported Grants for Scientific Research of *Panax*

The type of support indicated that the local

government pays more attention to the deep development of these species of the genus. Top 20 supported grants are listed in Appendix 3, comprising of the grant title, original country, supported year, and frequency. In the top 20 supported grants, 6 countries (China, USA, Turkey, India, Russia, and South Korea) are responsible for the research of the ginseng varieties, of which China and USA account for a large proportion. Among them, the support for cultivation techniques of *Pinellia ternata* was used to support the research of *Panax*. In particular, the National Natural Science Foundation of China provided high-frequency support for the academic research of these species of the genus. Some provinces of China have also provided grant support for the research, such as Henan, Jilin, Macau, Yunnan, and Zhejiang provinces. Moreover, the United States Department of Health & Human Services National Institutes of Health is the main support institute that supported the research of the genus.

Co-occurrence Analysis

Co-occurrence reflects the structure and distribution of text data collected in the current knowledge field. In our study, the *Panax* genus and *P. notoginseng* were conducted the bibliometrics analysis because of the enormous publications. In addition, these 5 species are too sparse to select meaningful features for forming a timeline plot. The timeline of *Panax* showed these categories were divided into 8 clusters including chemistry, pharmacology, and cultivation (Appendix 4). The figure also shows that since 2000, the scientific research of ginseng began to transform into the food field, because the chemical category laid a foundation for its safe application in food. The timeline plot of *P. notoginseng* was similar to that of *Panax* especially the development tendency that the category of food science and technology is the current development domain of the species since 2010.

Burst Analysis of Category and Keywords

With the help of CiteSpace software, the burst analysis of classification was performed for investigation of status and development tendency of *Panax* from 1900–2019. The results indicated scientists began to pay attention to plant sciences in 1982, which lasted the longest time, followed by science and technology–other subjects and multidisciplinary sciences. Two research topics, research and experimental medicine and agricultural engineering, are novel categories that started in

2017 and continue to this day (Figure 5A). Keyword burst results show that Araliaceae (36.0559), culture (12.2352) and Vietnamese ginseng (11.8087) have the highest strength. Panaxytriol (104 years), callus (105 years) and plant tissue culture (17 years) have the longest duration time (Figure 5B). In addition, the keywords of these over 300 records are summarized in Appendix 5. The results indicated that ginseng and *P. notoginseng* were the main research varieties, and their research focused on activity determination.

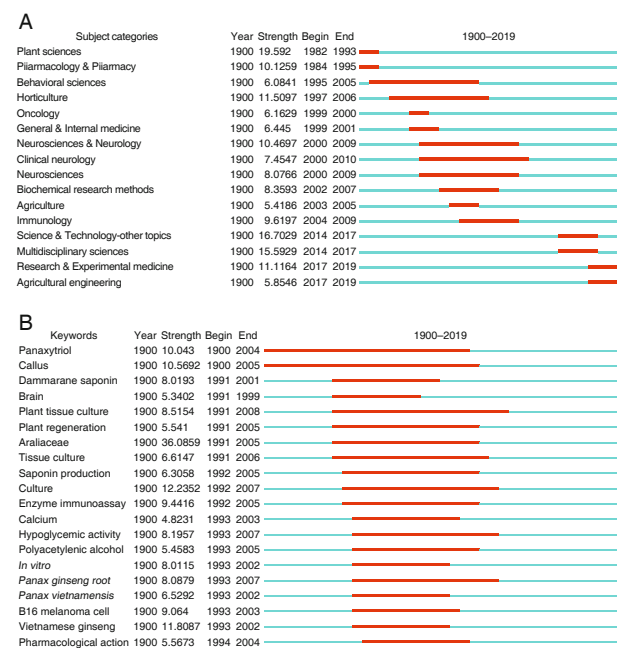


Figure 5. Burst Results of Category (A) and Keywords (B) in *Panax*

Since there were few literatures for individual *Panax* species except for *P. notoginseng*, the species was further used for burst analysis of category and keyword. The result of category burst shows two areas with significant differences, including pharmacology & pharmacy and biochemical research methods with the same intensity (6.7922 and 6.4033). The keyword burst result indicated that diversity, *Panax ginseng*, and suspension culture have the greatest significance. Dammarane saponin has the longest duration period while diversity is the new research trend of the species. The main keywords with records more than 100 are displayed in Appendix 6, whose characteristics are similar to that of *Panax*. Furthermore, the role and activity of species is still the state of the species.

Classical Articles for Scientific Research of *Panax*

High half-life value is the symbol of an article

whether it is classical literature or not. Herein, we list these classic publications in Appendix 7 including published year, publication title, article title, first author, corresponding author, digital object unique identifier (DOI), the IF and H-index of the journal, which half-life value is equal to 8. The results indicated that these articles mainly focused on the identification and pharmacological activities of two *Panax* species (*P. ginseng* and *P. quinquefolium*) and saponin.

DISCUSSION

China has obtained cooperation relationships with surrounding countries under the project of the Belt and Road Initiative proposed by Chinese president Jinping Xi. Up to now, 137 countries and 30 international organizations have signed relative documents with China for mutual development. Among these countries and international organizations, 55 countries have contributed to the scientific research of *Panax* species, accounting for more than 40% of the above cooperative countries (Appendix 8). In addition, these species of this genus are often used as tonics, and they are produced relatively in some supermarkets. Therefore, *Panax* species could be regarded as an appropriate choice for this project, which could lead to a rational and safe application of this nourishing Chinese herbal medicine. In addition, the relative yield of natural raw materials containing this genus would help residents increase their household income.

There are about 8 species of the genus *Panax*, which are mainly distributed in East Asia, Himalayan region, Indochina Peninsula and North America. Seven varieties have extensive natural and cultivated distribution areas in China, especially in Northeast China (Jilin, Liaoning and Heilongjiang provinces), and *Panax notoginseng* in Southwest China (Yunnan province and Guangxi Zhuang Autonomous Region). The results have shown that 2018 has the highest article yield, which indicated the research of these species would be a hot topic and focus on further academic development. Additionally, China has high-frequency cooperation with the United States and the two countries would conduct more frequent teamwork for the deep development of the scientific experiment of the genus. Among them, the research on the diversity of *P. notoginseng* is the focus of further research, which could be explained by the fact that *Panax notoginseng* is getting more attention. Therefore, some illegal small

retailers mix fake herbal material with a shape similar to the high interest rate of real materials. Furthermore, more and more publications pay attention to the identification of these species, so as to control the quality and ensure the legal status of manufacturers or consumers. Finally, diversity has become the current research topic, which is the results of keyword burst analysis.

In conclusion, a comprehensive investigation was conducted for learning about the present status of *Panax* research and predicting the further tendency of the scientific research of the genus. Besides, 6 *Panax* species (*P. notoginseng*, *P. quinquefolium*, *P. vietnamensis*, *P. japonicus*, *P. stipuleanatus* and *P. zingiberensis*) were individually analyzed with the same method of the genus investigation. Generally, the academic research of *Panax* species is still in the increasing stage. Plant sciences is the main research field, and research and experimental medicine and agricultural engineering are the further development trends. Finally, we emphasize that the discrimination research of *P. notoginseng* would be the research tendency among *Panax* species, especially diversity research. In addition, in the scientific research of this genus, more attention should be paid to the further study of *P. vietnamensis*.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Zeng TX drafted the original manuscript; Pei J and Zhao L contributed to supervision and investigation. Miao YJ performed data curation and formal analysis; Zheng Y and Gu SJ wrote and edited this paper; Huang LF contributed to review writing, editing and supervision.

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