Worldwide trends on Cistanche species in 1968–2016

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Abstract

Cistanche provides benefits not only to desert control but also to the economy because this plant exhibits a high medicinal value and grows under drought conditions. This study aimed to comprehensively analyse *Cistanche* species by using a visual method based on data from Web of Science (WoS). Bibliometrics and network analysis were employed to investigate various items, including countries, institutions, and frequently cited articles and keywords from 272 articles about *Cistanche* in 1968–2016. Results showed an increase in the number of *Cistanche*-related published documents, and China is the leading country with 175 documents. Japan also presented an outstanding achievement (34 documents) and ranked second. Close cooperation existed between China and Japan. Pharmacology and pharmacy were the most popular subjects, followed by chemistry and plant sciences. The most frequently cited article was related to the pharmacology of *Cistanche tubulosa.* Our keyword analysis revealed that scholars prone to research the pharmacology of phenylethanoid glycosides in *C. deserticola* and *C. tubulosa.* This study explored the differences between *C. deserticola* and *C. tubulosa*, including their morphological characteristics, host plants and pharmacological effects. Overall, our results provided valuable information for further research on *Cistanche*.

Keywords: *Cistanche,* bibliometrics, research trend, cooperation

1. Introduction

Cistanche (Orobanchaceae) is a genus comprising desert plants, including *C. deserticola* Y. C. Ma*, C. tubulosa* (Schenk) Wight*, C. sinensis* Beck and *C. salsa* (C. A. Mey) Beck [1]. Among these species, *C. deserticola* and *C. tubulosa* are frequently used as medicinal plants and have been recorded in the *Pharmacopoeia of the People's Republic of China* (Chinese Pharmacopeia), 2015 edition [2]. Herbal *Cistanche*, commonly known as 'desert ginseng', is regarded as a top-grade traditional Chinese medicine because of its great medicinal values, such as antioxidant, antitumour, anti-inflammatory, antiviral and antibacterial effects [3-7]. *C. tubulosa* is used to treat body weakness and lumbago in Japan [8-12]. *Cistanche* is mainly distributed in deserts, particularly in Xinjiang and Inner Mongolia provinces [13]. Its cultivation is beneficial not only to desert control but also to economy. The resources of *C. deserticola* have decreased remarkably, and it has been recorded in the 'Convention on International Trade in Endangered Species of Wild Fauna and Flora' (CITES) [14] as an endangered plant. The alternative, *C. tubulosa*, is recorded

in the Chinese Pharmacopoeia in 2005 [15]. However, *C. deserticola* significantly differs from *C. tubulosa* in terms of host, origin, chemical composition, pharmacology, heredity and internal structure of tissues [16]. A previous research investigated the differences in the plant origins of *Cistanche* in terms of chemical components and contents and found different pharmacological activities, such as hypoxia tolerance and anti-fatigue, among *C. deserticola, C. tubulosa* and *C. salsa* [17]. Tu et al. [17] found that the kidney strengthening effect of *C. tubulosa* is lower than that of *C. deserticola*.

Cistanche has been extensively investigated because of its decreasing resources. However, studies have yet to examine the global research trend of *Cistanche*. Bibliometrics can be used to analyse the trend of a certain academic domain, explore a research hotspot and provide a valuable guide for future research [18-24]. In the current study, bibliometrics and network analysis were employed to explore the general research trend and hotspot of *Cistanche* species in 1968–2016.

2. Data and Methods

2.1 Data

We generally analysed research outputs in 1968–2016 in the Web of Science (WOS) database based on 272 articles. Each paper included countries, institutions, journals, authors and keywords.

2.2 Methods

Bibliometric analysis is defined as the application of statistical methods to communication media. It provides a useful instrument to transfer data from a micro aspect to a macro aspect. Bibliometric analysis includes citation and content analysis, such as author, keywords, sources, cited references, article quantity, journal and institution. Current topics and research trends of a certain study field can be identified on the basis of various parameters, including frequency of keywords and article quantity.

CiteSpace, invented by Dr. Chaomei Chen, is the most advanced visualisation instrument that can reveal the importance and influence of an item by using specific cooperation or other distributions [21]. In our research, network analysis was used to identify the collaboration among different countries, research institutions or authors by using CiteSpace.

3. Results

3.1 Quantity of publications and growth trend

Among the 272 publications, *C. deserticola* and *C. tubulosa* accounted for 58% (158 articles) and 29% (80 articles) of the commonly used medicinal plants, respectively. Fig. 1a shows the general study trend of *Cistanche* species, including the numbers of articles (NO) each year, total citations (TC) of articles and average citations (ATC) per article in 1968–2016. The NO of *Cistanche* species gradually increased in the first 37 years and then quickly increased in 2005. The papers published in the last 12 years accounted for 91.1% of the total published papers. The NO of *Cistanche* species peaked in 2016, whereas the TC and ATC were low. This low result was caused by the poor management and over-excavation of the wild resources of *C. deserticola*. The number of resources decreased sharply, resulting in shortage. Given the high market demand of *C. deserticola*, a substitute was urgently needed. Therefore, *C. tubulosa* was included in the Chinese

Pharmacopoeia in 2005 after a series of research. As a result, a wave of increasing trend has been observed since 1995 (Fig. 1b).

C. deserticola has been extensively investigated, although the volume of published articles slightly reduced in 2016. In contrast to studies on *C. deserticola,* studies on *C. tubulosa* have increased sharply since 2005 (Fig. 1b). The article published by an Indian scholar in 1832 was the first documentation of *C. tubulosa*, whereas the first published documentation of *C. deserticola* was in 1995.

3.2 Country contribution statistics

A total of 38 countries contributed to research on herbal *Cistanche* in 1968–2016. The publication volume of one country could reflect the attention and academic ability of a particular country in specific research fields. Fig. 2b shows the top 10 most productive countries and ATC per country. Among the top 10 countries, China was the most productive (175 papers) with a low ATC, followed by Japan (34 papers), Canada (7 papers) and the USA (7 papers). This result indicated that Chinese scholars should increase their effort to improve their article quality. Austria had the highest ATC with only 5 articles. Japan, the USA and South Korea had high ATC.

The collaborative relationships between countries are shown in Fig. 2a. China and Japan presented the closest cooperation. Moreover, the USA, Canada, South Korea, the UK and Croatia cooperated with China. Some countries relatively coordinated with one another. Austria collaborated with the USA and Switzerland. Algeria, Russia and Italy respectively worked together with the UK, the Netherlands and Argentina. The rest of the countries studied alone and did not have international cooperation. Notably, the number of countries with international collaboration was more than that of single countries in the top 10 productive countries (Figs. 2a and 2b). Burst detection is a useful technique that shows abrupt changes in certain information within a given period. Fig. 2c illustrates the burst detection of Japan in 2006–2010, indicating that Japan did a substantial research on *Panax ginseng* during these years.

3.3 Institution statistics

The result of the institution analysis revealed that 266 institutions were involved in studies on *Cistanche* species. Fig. 3b lists the performances of the top 10 productive institutions. Peking University was the most productive institution. Most of the institutions in the top 10 were from China, with Kindai University and Kyoto Pharmaceutical University (ranked fifth and sixth, respectively) coming from Japan. All of the Japanese institutions and most of the Chinese institutions in the top 10 were universities. Hence, universities were an important group in the research of *Cistanche* species.

Fig. 3a provides visualisation-related information about the cooperation among different institutions. Institutions were grouped into two clusters: the Chinese Academy of Sciences was as the centre of one cluster (cluster 1), and Peking University was the centre of the other cluster (cluster 2). International cooperation was present, including a collaboration between Kyoto Pharmaceutical University and the Chinese Academy of Sciences, in cluster 2. Peking University cooperated with domestic institutions. Thus, its cooperation and communication with other countries should be improved. Fig. 3c shows four institutions with burst detection, including the Chinese Academy of Sciences (1996–2005),

Kindai University (2006–2007), Kyoto Pharmaceutical University (2006–2008) and China Agricultural University (2011–2012).

3.4 Journal statistics

A total of 149 journals have published articles related to *Cistanche* species, and these journals are from various disciplines. Table 1 shows the top 15 productive journals, which account for 35.7% of the total documents. Most of the journals are from the Netherlands. *Chemical and Pharmaceutical Bulletin* is the most productive journal with 16 articles and 441 TC. Thus, it is an important journal about studies on *Cistanche* species.

The journal with the highest impact factor of 18.392 is *Gastroenterology* from the USA (Table S1). Only one article entitled, 'Effects of the polysaccharide of deserdiving *Cistanche* on mitochondria in the hepatocytes of aging rats', by Chinese authors published in this journal in 2006 studied the pharmacological effects of herbal *Cistanche* but not TC. Moreover, the articles of these top 10 journal are related to many academic disciplines.

3.5 Author statistics

A total of 881 authors contributed to studies on *Cistanche* species. Fig. 4b lists the performances of the top 10 productive authors and TC. Of these authors, 6 were from Japan and 4 were from China. P. F. Tu ranked first with 33 articles, and H. Matsuda, O. Muraoka and S. Nakamura ranked fifth, eighth and ninth, respectively. Among the top 10 productive authors, Yoshikawa (Japanese) had the most number of citations, followed by P. F. Tu (China), H. Matsuda (Japanese), T. Morikawa (Japanese) and S. Kadota (Japanese). Among the top 10 highest number of citations, most of the authors were from Japan, and only one was from China (Table 2). Fig. 4a represents the cooperation relationship between the authors. The authors were grouped into three clusters. M. Yoshikawa was the centre of the first cluster, P. F. Tu was the centre of the second cluster, and R. Xu was the centre of the third cluster. International cooperation existed only between the authors of the first cluster. Of the top 10, the Japanese authors had the most international cooperation. P. F. Tu's research team lacked cooperation with other countries. Fig. 4c shows the four authors with burst detection, namely, H. Matsuda (2006–2008), S. Nakamura (2006–2008), M. Yoshikawa (2006–2008) and Y. M. Guo (2011–2012). Most of the bursts occurred from 2007 to 2008.

3.6 Article citation statistics

Citation frequency usually reflects the academic value of an article. Table 4 lists the top 10 frequently cited articles, and the most frequently cited article was published by Q. B. Xiong (Japanese) in 1996. The article described the antioxidant effects of *C. deserticola* and was published in *Biological and Pharmaceutical Bulletin*. Interestingly, three articles written by Q. B. Xiong were in the top 10. Q. B. Xiong only wrote three articles about the *Cistanche* species (Table 2). Most of top 10 articles were from Japan and China. Therefore, the authors from Japan and China more strongly influenced the academic value of *Cistanche* species than the authors from the other countries. Of the top 10 most frequently cited

articles, 5 were on pharmacology, 4 were on chemistry and 1 was on biochemistry. The first article related to *Cistanche* and written by an Indian scholar and published in 1968 described the morphological characteristics of *C. tubulosa*. The possible reason for this early publication was that Indians particularly love to eat curry, and *Cistanche* is one of the ingredients of curry. However, only a few articles described *Cistanche* in India in 1968–2016.

3.7 Subject category statistics

All of the articles of *Cistanche* involved various categories (Fig. 5). The most common categories are pharmacology and pharmacy, followed by chemistry, plant sciences, biochemistry and molecular biology. Although biochemistry and molecular biology ranked fifth, the subject analysis showed a thick purple circle, indicating a high degree of centre and representing the potential of a scientific contribution.

3.8 Keyword statistics

Research topics were analysed on the basis of keyword frequency. The keywords *C. deserticola*, *C. tubulosa* and phenylethanoid glycoside are the top three in frequency (Fig. 6a). Thus, research has focused on *C.* deserticola and *C. tubulosa.* Moreover, the main research directions are chemistry and pharmacology. Notably, articles about 'Alzheimer' and '*Cistanche*' were published in 2013, 2014 and 2015. This observation indicated that *Cistanche* plays an important role in the treatment of Alzheimer's disease. Fig. 6b shows the two keywords with burst detection, namely, *C. deserticola* (1997–2005) and phenylethanoid glycoside (2003–2005). *C. deserticola* and *C. tubulosa* are the same kind of medicine in the Chinese Pharmacopoeia. However, both species differ (Tables 4 and 5) in terms of their morphology, host plants and pharmacological effects.

4. Discussion

In the current study, the general research trend and topics about *Cistanche* species were explored. This study provided valuable information for future research ideas and directions regarding *Cistanche*. As a valuable Chinese herbal medicine, *Cistanche* grows in deserts and withstands harsh environments. Hence, its scientific cultivation is beneficial not only to desert control but also to economy. Thus, to mitigate the condition of market demand exceeding the supply, *Cistanche* species should be further explored. *Cistanche* has gained considerable concern because of a decrease in resources. However, the development trends related to *Cistanche* are poorly understood. As such, the research trend should be comprehensively analysed. We applied bibliometrics to examine the articles describing *Cistanche* from WoS in 1968–2016. The results were summarized as follows：

(1) General trend

A total of 272 documents on *Cistanche* species were searched from WoS in 1968–2016. The number of articles could be divided into two stages. The NO gradually increased in the first 37 years (1968–2005). NO sharply increased (228 documents) in 2005–2016 and

peaked in 2016. The rapid growth stage occurred when *C. tubulosa* was recorded in the Chinese Pharmacopoeia in 2005 as an alternative to *C. deserticola.* The NO on *C. tubulosa* have remarkably increased since 2005. However, the TC was low in 2016. This result suggested that the quality of documents should be improved with the increase in the number of studies.

(2) Country and cooperation analysis

The analysis results showed that the most active country in the research of *Cistanche* is China (175 documents), followed by Japan (34 documents) and Canada (7 documents), because *Cistanche* is mainly distributed in China and recorded in the Chinese Pharmacopoeia. *C. tubulosa* is also an edible herb in Japan. The top four countries with the most number of citations are Austria, South Korea, the USA and Japan. The ATC per article in China is low. Hence, the quality of the articles in China should be improved. Moreover, universities are some of the most important groups in the research of *Cistanche* species. Among the 38 countries, China closely collaborated with Japan and Canada (Figs. 2, 3 and 4), including institutional cooperation (such as Kyoto Pharmaceutical University, Chinese Academy of Sciences, Kindai University and Shenyang Pharmaceutical University) and author's cooperation (such as Makamuras and H. H. Xie). Productive countries experienced remarkable international cooperation.

(3) Research topics

According to keyword and subject analyses, scholars were prompted to explore the pharmacological, pharmaceutical, chemical and biological characteristics of *Cistanche.* The most frequently cited article described the antioxidant effects of phenylethanoids from *C. deserticola*, and this article was written by a Japanese scholar (Q. B. Xiong) and published in 1996. The content of the most cited articles has been paid more and more attentionover time. And the content of the top 10 most frequently cited articles is related to pharmacology. A previous study reported that the antioxidant activity of herbal *Cistanche* is closely related to thes most of its neuropharmacological effects. Among the pharmacological research, many scholars focused on the neuroprotective effects of herbal *Cistanche*. Notably, herbal *Cistanche* potentially plays an important role in the research and development of new drugs against nervous system diseases (Fig. 6). The keyword analysis revealed that researchers showed considerable interest in phenylethanoid glycosides, *C. deserticola* and *C. tubulosa.* These results indicated that current topics are mainly associated with the pharmacological characteristics of phenylethanoid glycosides of *C. deserticola* and *C. tubulosa.*

However, *C. deserticola* and *C. tubulosa* exhibit numerous differences (Tables 6 and 7), including their morphological characteristics, host plants and pharmacological effects. Therefore, *C. deserticola* and *C. tubulosa* should be separated in the Chinese Pharmacopoeia.

5. Conclusion

We analysed 272 articles of *Cistanche* from WoS by using bibliometrics. The total number of articles increases yearly, and studies have focused on the pharmacology of *C. deserticola* and *C. tubulosa* according to the frequency of keywords. This study helped

elucidate the research trend and topics related to *Cistanche* species and provided a valuable basis for future research.

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Table1. The top 15 productive Journals

	Journal	NO	IF	TC	COUNTRY
1	CHEMICAL & PHARMACEUTICAL BULLETIN	16	1.133	441	JAPAN
2	SPECTROSCOPY AND SPECTRAL ANALYSIS	12	0.344	26	CHINA
3	BIOLOGICAL & PHARMACEUTICAL BULLETIN	9	1.682	351	JAPAN
4	JOURNAL OF ETHNOPHARMACOLOGY	8	2.980	131	IRELAND
5	PLANTA MEDICA	7	2.342	220	GERMANY
6	PHYTOTHERAPY RESEARCH	6	3.092	61	ENGLAND
7	FITOTERAPIA	5	2.698	79	NETHERLANDS
8	JOURNAL OF BIOTECHNOLOGY	5	2.599	56	NETHERLANDS
9	JOURNAL OF CHROMATOGRAPHY A	5	3.981	182	NETHERLANDS
10	JOURNAL OF CHROMATOGRAPHY B-ANALYTICAL TECHNOLOGIES IN THE BIOMEDICAL AND LIFE SCIENCES	5	2.603	109	NETHERLANDS
11	MOLECULES	5	2.861	40	SWITZERLAND
12	PHARMACEUTICAL BIOLOGY	4	1.916	44	NETHERLANDS
13	PLOS ONE	4	2.806	53	UNITED STATES
14	ACTA PHARMACOLOGICA SINICA	3	3.223	14	CHINA
15	BIOCHEMICAL ENGINEERING JOURNAL	3	2.892	11	NETHERLANDS

Table 2.The top 10 frequently cited authors

	Author	TC	NO
1	Yoshikawa M	496	21
2	Tu PF	490	33
3	Matsuda H	420	15
4	Morikawa T	413	17
5	Kadota S	401	4
6	Namba T	401	4
7	Nakamura S	339	12
8	Xiong QB	327	3
9	Muraoka O	291	13
10	Hase K	254	3

Table 3. The top 10 frequently cited articles.

	Title	Author	Journal	Citation
1	Antioxidative effects of phenylethanoids from Cistanche deserticola	Xiong QB, Kadota S, Tani T, Namba T	BIOLOGICAL & PHARMACEUTICAL BULLETIN	147
2	Hepatoprotective activity of phenylethanoids from Cistanche deserticola	Xiong QB, Hase K, Tezuka Y, Tani T, Namba T, et al.	PLANTA MEDICA.	100
3	NEW PHENYLETHANOID GLYCOSIDES FROM CISTANCHE-TUBULOSA (SCHRENK) HOOK-F-I	KOBAYASHI H, OGUCHI H, TAKIZAWA N, MIYASE T, UENO A, et al.	CHEMICAL & PHARMACEUTICAL BULLETIN	87
4	Protective effect of acteoside on carbon tetrachloride-induced hepatotoxicity	Lee KJ, Woo ER, Choi CY, Shin DW, Lee DG, et al.	LIFE SCIENCES	82
5	Acteoside inhibits apoptosis in D-galactosamine and lipopolysaccharide-induced liver injury	Xiong QB, Hase K, Tezuka Y, Namba T, Kadota S	LIFE SCIENCES	80
6	Inhibition of nitric oxide by phenylethanoids in activated macrophages	Xiong Q, Tezuka Y, Kaneko T, Li H, Tran LQ, et al.	EUROPEAN JOURNAL OF PHARMACOLOGY	74
7	Phylogeny of holoparasitic Orobanche (Orobanchaceae) inferred from nuclear ITS sequences	Schneeweiss GM, Colwell A, Park JM, Jang CG, Stuessy TF	MOLECULAR PHYLOGENETICS AND EVOLUTION	67
8	Isolation and purification of acteoside and isoacteoside from Plantago psyllium L. by high-speed counter-current	Li L, Tsao R, Liu ZQ, Liu SY, Yang R, et al.	JOURNAL OF CHROMATOGRAPHY A	65

	chromatography			
9	Analysis of chemical constituents in Cistanche species	Jiang Y, Tu PF	JOURNAL OF CHROMATOGRAPHY A	56
10	Isolation and purification of phenylethanoid glycosides from Cistanche deserticola by high-speed counter-current chromatography	Li L, Tsao R, Yang R, Liu C, Young JC, et al.	FOOD CHEMISTRY	51

Table 4. Comparison of *C.deserticola* and *C. tubulosa* including distribution and resources,etc.

		Cistanche deserticola Y.C.Ma	*Cistanche tubulosa (Schenk) Wight*	references
Collection situation of Pharmacopoeia		1. Recorded in the Chinese Pharmacopeia in1990. 2. Regarded as top grade medicine and first reference in Shen Nong's Herbal.	Recorded in the Chinese Pharmacopeia in 2005(due to Cistanche deserticola's resources is extremely scarce)	[15, 25, 26]
Resources		1.Resource scarcity and listed as endangered plant in China 2.*C.deserticola* recorded in 《 Convention on International Trade in Endangered Species of Wild Fauna and Flora》 Ⅱ (CITES) in April 2000.	Resource scarcity and listed as endangered plant in China	[27-29]
Distribution		Mainly distributed in Inner Mongolia Alxa League, northern Xinjiang, Qinghai, Gansu and other places	Distributed in the surrounding counties of the taklamakan desert(South of tianshan mountain in xinjiang)	[27, 30, 31]
Cold resistance		Cold tolerance is higher because of the high sugar content	Cold resistance is low, firewood is large and frozen death in winter may also be due to low sugar content	[30, 31]
Host plant		*Haloxylon ammodendron (C. A. Mey.) Bunge and Haloxylon Persicum Bunge ex Boiss. Et Buhse*	*Tamarix Linn plants*	[30, 31]
Organizational structure	*stem*	1. Vascular bundle: arranged in a wavy curved ring. 2. Vessel: few pitted vessel and reticulate vessel. 3. Starch granule: few complex grain. 4. Epidermis: without pres. 5. Bast Fiber: None. 6. Pith: pith cells larger, pith line is obvious.	1. Vascular bundle: Irregular dispersion. 2.Vessel:have lot spiral vessels，ladder vessel 3. Starch granule: a lot of complex grain. 4. Epidermis: without pres. 5. Bast Fiber: few. 6. Pith: none.	[28, 30, 31]
	leaf	1. Vascular bundle: have Few lateral. 2. Epidermis: without pres, epidermal is completely keratinization.	1.Vascular bundle: have lateral lateral 2. Epidermis: without pres, epidermal is not completely keratinization.	
	flower	1.Ovary:① Have amphicribral vascular bundle, quantity of bundle is abundant.② Its change is not obvious at at the time of flowering and not flowering 2.Style:① Have amphicribral vascular bundle.② Its change is not obvious at the time of flowering and not flowering 3. Stigma: Epidermis cell Presents the papillary, short or long branch hairs.	1. Ovary: ① Have unclosed collateral bundle, quantity of bundle is abundant little. ② Its change is obvious at the time of flowering and not flowering 2.Style:① Have amphivasal vascular bundle② Its change is obvious at at the time of flowering and not flowering	

			3. Stigma: Epidermis cell presents the papillar.	

Table 5. Comparison of *C.deserticola* and *C. tubulosa* including Chemical composition and pharmacological, etc.

Chemical composition	Suger content		*C. deserticola* > *C. tubulosa*	*[4, 28, 30, 32-34]*
	Phenyleth-yl alcohol glycosides	Total content	*C. deserticola C. tubulosa*	
		Quantily of Type	*C.deserticola* >*C.tubulosa*	
	Phenylethanoidglycosides/ iridoid glycosides		*C. deserticola*：Phenylethanoid glycosides ≈ iridoid glycosides *C.tubulosa*：Phenylethanoid glycosides > iridoid glycosides	
	Allantoin		*C.deserticola* > *C.tubulosa*	
	Betaine		*C.deserticola* ≥ *C.tubulosa*	
	Galactitol		*C.deserticola* > *C.tubulosa*	
Trace elements	Fe,Cu,Al		*C.deserticola* < *C.tubulosa*	
	Mn,K,Ca,Mg,Na		*C.deserticola* > *C.tubulosa*	
Pharmacological effects	The function: Activate human peripheral blood lymphocytes to Kill human leukemia K 562 cells		*C.deserticola* < *C.tubulosa*	
	Improve immunity, anti-aging effect		*C.deserticola* > *C.tubulosa*	
	Liver anti-tumor effect		*C.deserticola* > *C.tubulosa*	
	Runchang purge effect		*C.deserticola* > *C.tubulosa*	
	Nhibition of LPO production in rabbit blood and mouse liver		*C.deserticola* < *C.tubulosa*	
Genetic diversity	*C. deserticola* > *C.tubulosa*			

Table s1(附表)

	Journal	IF	NO	TC	COUNTRY
1	GASTROENTEROLOGY	18.392	1	0	UNITED STATES
2	ORGANIC LETTERS	6.579	1	1	UNITED STATES
3	FREE RADICAL BIOLOGY AND MEDICINE	5.606	0	0	UNITED STATES
4	FOOD CHEMISTRY	4.5289	2	71	ENGLAND
5	MOLECULAR PHYLOGENETICS AND EVOLUTION	4.419	2	106	UNITED STATES
6	TALANTA	4.162	1	37	ENGLAND
7	OBESITY SURGERY	3.947	2	0	CANADA
8	JOURNAL OF CHROMATOGRAPHY A	3.981	5	182	NETHERLANDS
9	EUROPEAN JOURNAL OF PHARMACEUTICAL SCIENCES	3.756	1	1	NETHERLANDS
10	INTERNATIONAL JOURNAL OF BIOLOGICAL MACROMOLECULES	3.671	3	19	NETHERLANDS

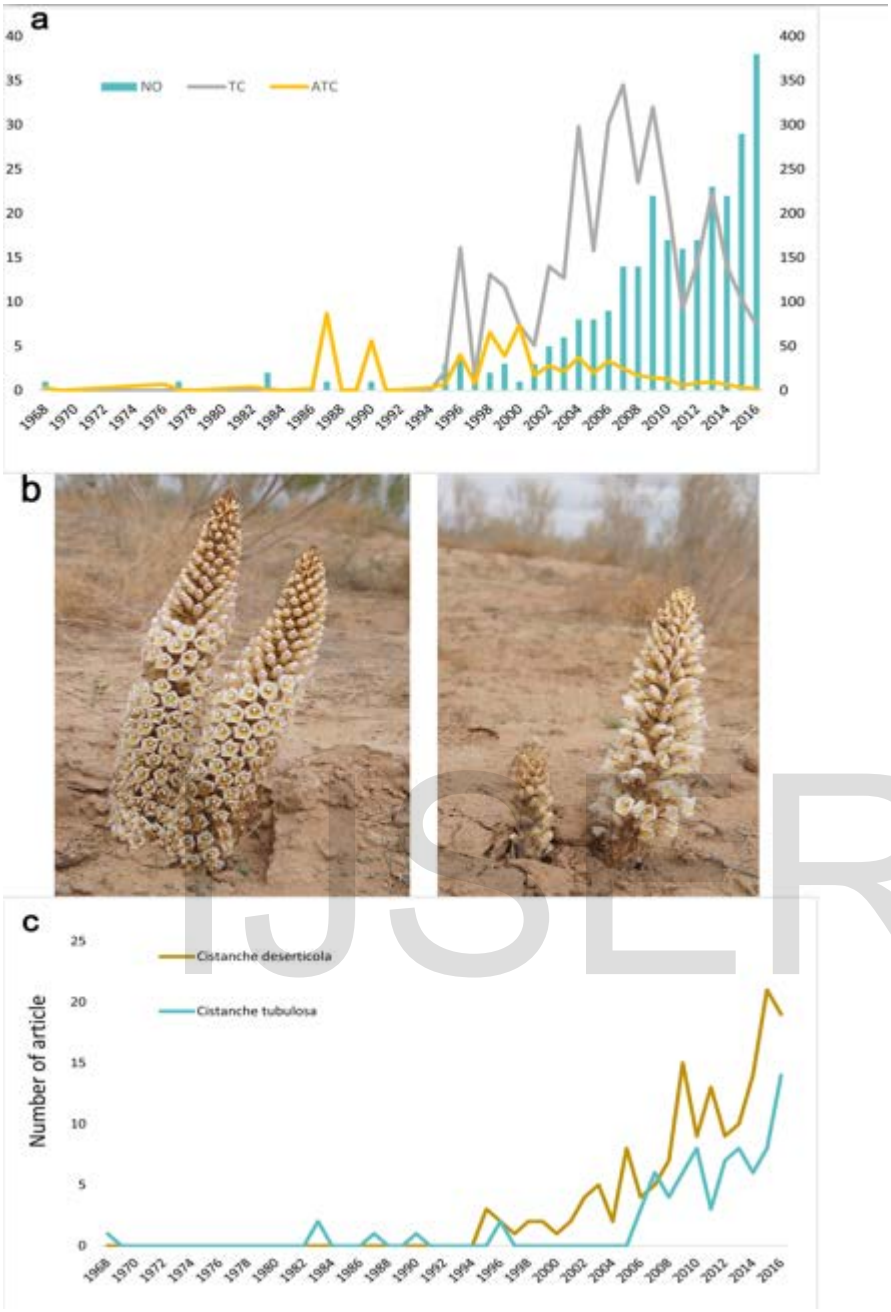

Fig.1 Research trends of *Cistanche* species during the period of 1968-2016(a), including Numbers of articles (NO), total citations of articles (TC) and average citations per article (ATC). Numbers of articles of *C.deserticola* and *C.tubulosa* during the period of 1968-2016(c).

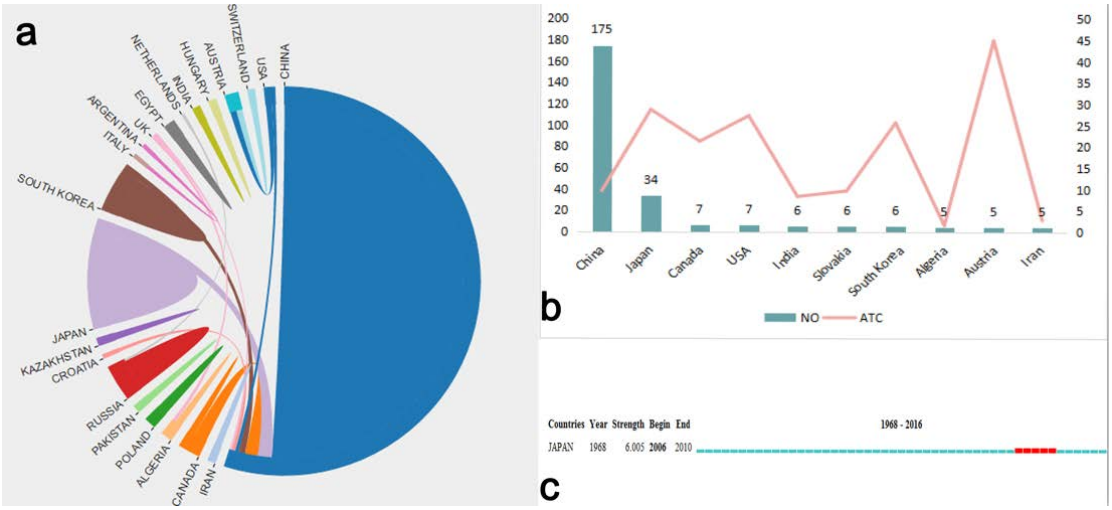

Fig.2 Countries analysis of *Cistanche* species. Cooperation relationship between countries (a), the top 10 productive countries (b), country burst detection (c).

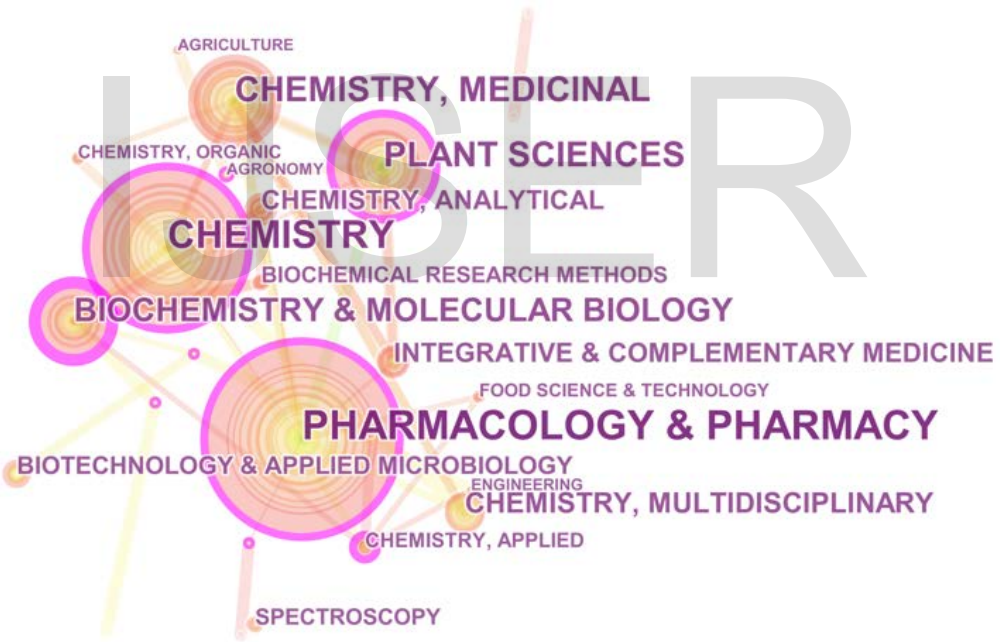

Fig.5 Category analysis of *Cistanche* species.

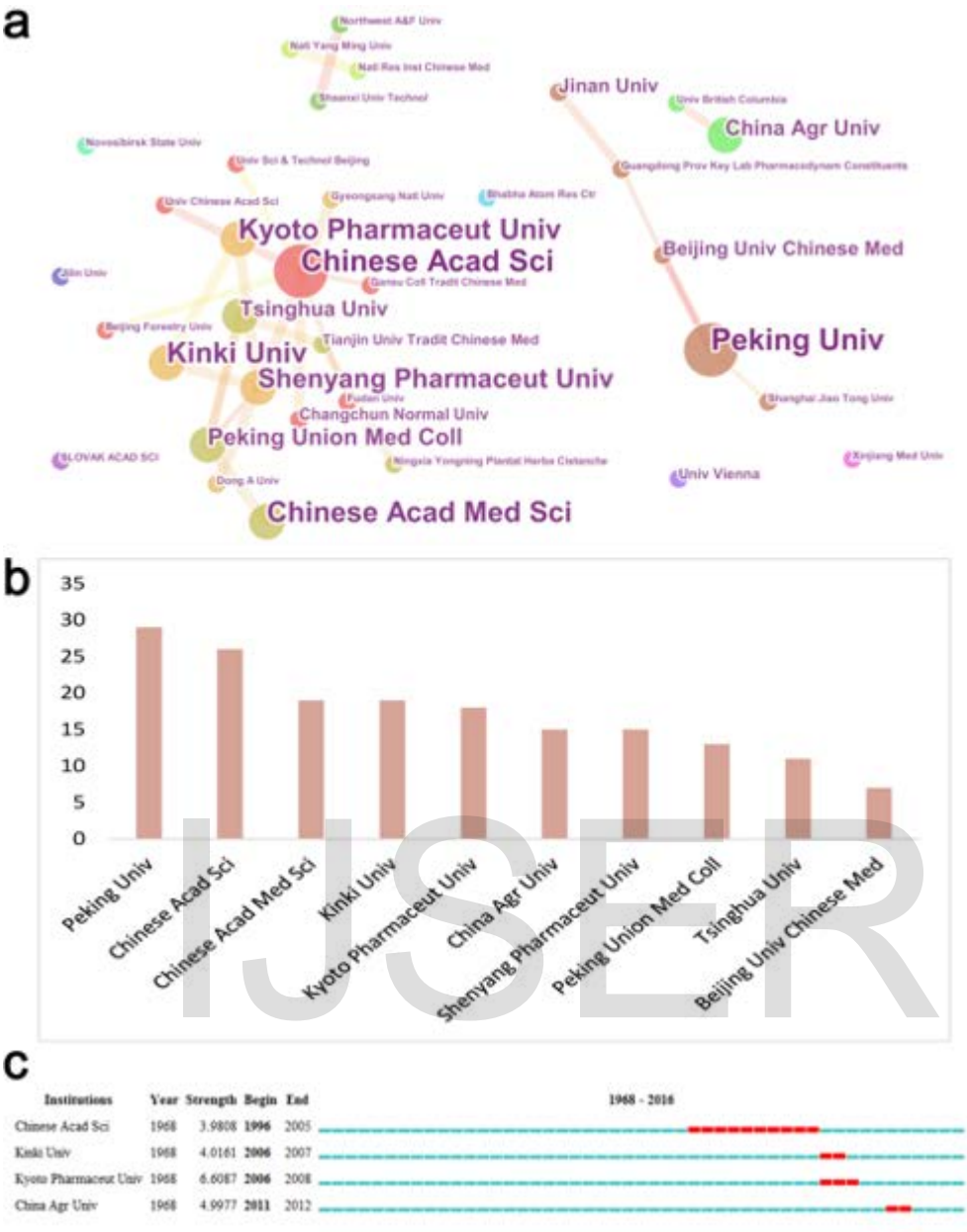

Fig.3Institution analysis of Cistanche species. Cooperation relationships between institutions (a), the top 10 productive Institutions (b), and institutions burst detection (c).

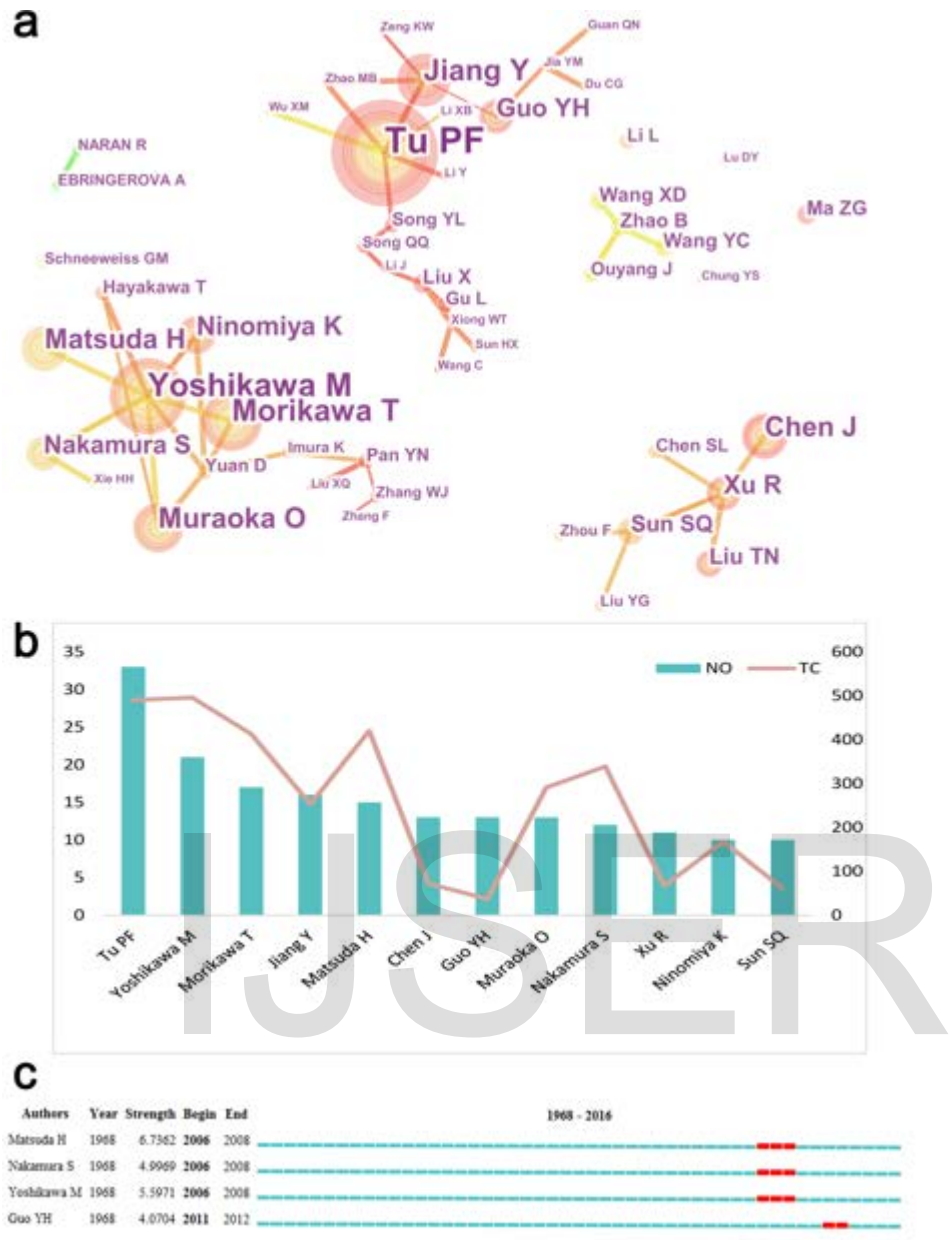

Fig.4 Author analysis of Cistanche species. Cooperation relationships between authors (a), the top 10 productive authors (b), and authors burst detection (c).

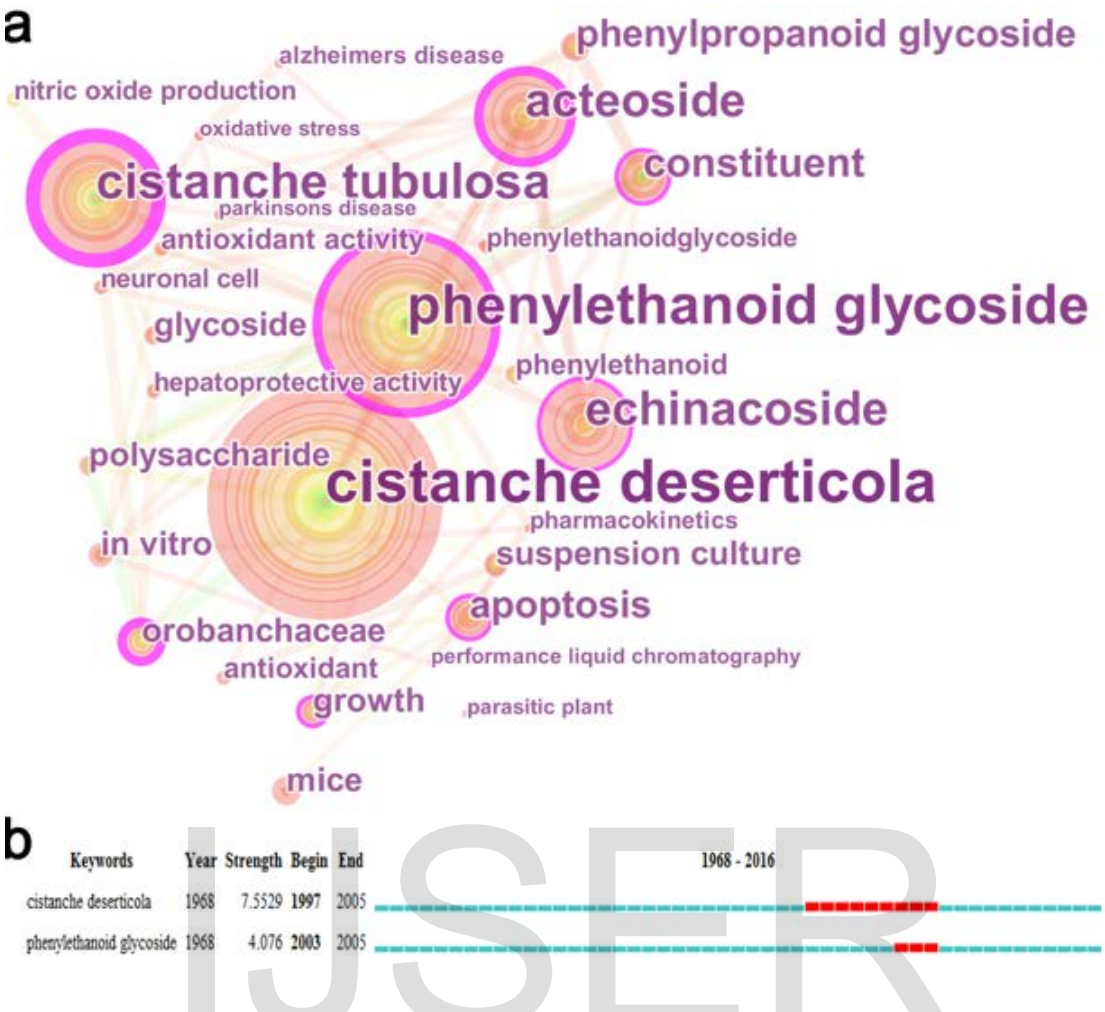

Fig.6 Keyword analysis of *Cistanche* species. Cooperation relationships between authors (a) and authors burst detection (b).