Scientometric Analysis of World Biodiversity Literature

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Abstract - *The study presents the scientometric analysis of world biodiversity literature based on the publications indexed in the Web of Science Core Collection during the period from 1989 to 2016. Overall total 154654 records were retrieved. BibExcel toolbox and MS-Excel spreadsheet were used to analyze the data.Findings of the analysis revealed that relative growth rate of article contributions of biodiversity literature has shown a decreasing trend, whereas the doubling time for publications has shown increasing trend.The most prolific contributor in the field of biodiversity literature among the authors are Gastone, KJ gets the first rank with 257 (0.17%) publications.The multi authored papers rank first in order with a total of 139206 (90.01%) contributions and remaining 15448 (9.99%) contributions are from the single authors.The Chinese Academy of Sciences occupies the first rank among the top institutions contributing Biodiversity literature by contributing 2305 publications during the study period. It is also found that 24223 (15.66%) publications on world biodiversity literature did not receive any citations.*

Keyword: Scientometric; BibExcel; Relative Growth Rate; Doubling Time; Bibliometrics; Citation study.

INTRODUCTION

Human health and biodiversity are indistinguishably related. Any ecosystem with a high biodiversity has the potential to have a relationship between predators, prey, hosts, vectors and parasites. Maintaining or restoring human health is directly proportionate with the naturally based medicines depends on the existence of the species from which they are derived. Changes in biodiversity and ecosystems cause both directly and indirectly, affects the services provided by the ecosystem to the human beings which may prove to be dangerous when balance fluctuates with both the sides. The ecological consequences of the changed landscape due to economical and other development al purposes have led the great danger to one of the most diverse ecosystems in the world. In the present study, a scientometric analysis was performed to targeting the scientific production related to biodiversity area during the particular period. The biological knowledge about the flora and fauna in these areas is very little. The lack of studies in this area may façade the dangers for this ecosystem and hence might result in wrong management decisions by the policymakers.

LITERATURE REVIEW

Schoffel et al. (2017)studied the scientific research output in the area of Diabetic retinopathy. The data from Web of Science database for the duration of 1900- 2008 were analyzed. The results found that Joslin Diabetes Center produced highest number of articles. **Liu, Zhang, &Wang (2017)** analyzed the history and status of publications in Rice research. The results found a gap a between USA andAsia. **Magnone (2015)** studied the research output of Buddhism-related publications.The United States was producing highest numbers of research articles. Numen: International Review for the History of Religions was the journal which got highest no of citations.**Sun, Wang & Ho (2012)** explained the growth trend in the publications of global Estuary pollution research. The results found that highest numbers of articles were published by The Chinese Academy of Sciences.**Zhang, Qian & Ho (2009)** conducted a bibliometric analysis on ocean circulation-related research for the period 1991– 2005. An indicator, Citation Per Publication(CPP) was applied to evaluate the scientific impact of a publication. **Jing et al. (2009)** conducted a study on conservation biology using Web of Science and Chinese Journals Full-Text Database. The results indicated that core research groups working in the field of conservation biology in China have been already formed, although the distribution of research groups was scattered over institutions and universities.

OBJECTIVES OF THE STUDY

- To examine the Relative Growth Rate and Doubling Time of biodiversity literature publications
- To identify the language-wise publications and length of publications of biodiversity literature published during the period 1989- 2016.
- To identify the nature of authorship pattern.
- To know the patterns of research communication in most productive journals.
- To apply to Bradford's Law of scattering in the field of biodiversity literature.
- To know the institution-wise distribution of publications and geographical distribution of publications.
- To analyse of frequently used keywords and keyword co-occurrence.
- To identify the pattern of citations of the research output and identification of highly cited papers.
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METHODOLOGY

The data required for the investigation was downloaded from the WOS database was searched in May 2017 to get overall picture of the size of the Biodiversity Literature. The data augmented by using the seven search key terms, including "biodiversity", "biological diversity", "bio-diversity", "genetic diversity", "ecosystem diversity", "species diversity" and ''landscape diversity''. The time period considered in this study from 1989-2016. The data obtained finally resulted as of May 2017, a total of 154654 publications were published during the period 1989-2016. To study the growth of publication, author productivity, degree of collaboration, citation analysis, various scientometric indicators and bibliometric laws mentioned below have been implemented to explore biodiversity literature at the global level. The researcher applied BibExcel toolbox, MS Excel and Pajektools for data analysis according to the objectives the study.

DATA ANALYSIS AND INTERPRETATION

1 Relative Growth Rate and Doubling Time Publications

Table 4.2 shows the relative growth rate and doubling time for publications from 1989 to 2016 for Biodiversity literature. In 1989 the number of publications was 80 which rose to 15069 in 2015 with 3.60% of multiplication in publications during the period of 1989 to 2016.

Table 1: Relative Growth Rate and Doubling Time Publications

Sl. No	Periods	Total Number of Publications	Cumulative Total Number of Publications	W1	W2	RGR (a) W2-W1	Mean R (a) (1-2)	Doubling Time Dot (a)	Mean Dot (a) (1-2)
1	1989	80	80	0.00	4.38	4.38		0.16	
2	1990	140	220	4.38	5.39	1.01		0.69	
3	1991	495	715	5.39	6.57	1.18		0.59	
4	1992	732	1447	6.57	7.28	0.70		0.98	
5	1993	813	2260	7.28	7.72	0.45	1.54	1.55	0.79
6	1994	1078	3338	7.72	8.11	0.39		1.78	
7	1995	1326	4664	8.11	8.45	0.33		2.07	
8	1996	1504	6168	8.45	8.73	0.28		2.48	
9	1997	1727	7895	8.73	8.97	0.25		2.81	
10	1998	2088	9983	8.97	9.21	0.23		2.95	
11	1999	2308	12291	9.21	9.42	0.21		3.33	
12	2000	2640	14931	9.42	9.61	0.19		3.56	
13	2001	2980	17911	9.61	9.79	0.18		3.81	
14	2002	3330	21241	9.79	9.96	0.17		4.06	
15	2003	3916	25157	9.96	10.13	0.17	0.24	4.10	3.10
16	2004	4319	29476	10.13	10.29	0.16		4.37	
17	2005	5231	34707	10.29	10.45	0.16		4.24	
18	2006	5878	40585	10.45	10.61	0.16		4.43	
19	2007	6899	47484	10.61	10.77	0.16		4.41	
20	2008	7910	55394	10.77	10.92	0.15		4.50	
21	2009	8775	64169	10.92	11.07	0.15		4.71	
22	2010	9971	74140	11.07	11.21	0.14		4.80	
23	2011	11308	85448	11.21	11.36	0.14		4.88	
24	2012	12172	97620	11.36	11.49	0.13		5.20	
25	2013	13192	110812	11.49	11.62	0.13	0.15	5.47	4.70
26	2014	14101	124913	11.62	11.74	0.12		5.79	
27	2015	15069	139982	11.74	11.85	0.11		6.08	
28	2016	14672	154654	11.85	11.95	0.10		6.95	
Total		154654					0.43		3.60

The table1 clearly enumerates the relative growth rate of total contributions published has increased drastically from year to year. The mean relative growth rate for the period of 1989-1993 is 1.54 for the period of 1994-2003 is 0.24 and 0.15 for the period of 2004-2013, whereas the whole study witnessed a mean relative growth rate of 0.43. The mean doubling time for the above periods are 0.79, 3.10 and 4.70 respectively. The whole study period resulted the mean doubling time 3.60 for total 28 years. In general, the relative growth rate of article contributions of biodiversity literature has shown a decreasing trend, whereas the doubling time for publications has shown increasing trend.

2 Language-wise Distribution of Publications

Table 2:Language wise Distribution of Publication

Language	Block periods					percentage
	1989-1995	1996-2002	2003-2009	2010-2016	Grand Total	
English	4449	16023	41845	88583	150900	97.57
Spanish	23	102	301	688	1114	0.72
French	71	212	246	277	806	0.52
Portuguese	1	21	261	503	786	0.51
German	32	57	99	143	331	0.21
Russian	73	102	80	45	300	0.19
Polish	0	3	26	90	119	0.08
Japanese	2	13	16	20	51	0.03
Chinese	0	29	10	11	50	0.03
Croatian	1	0	9	37	47	0.03
Czech	5	3	7	17	32	0.02
Turkish	0	0	6	22	28	0.02
Hungarian	1	5	1	12	19	0.01
Korean	0	0	5	14	19	0.01
Italian	0	1	6	6	13	0.01
Finnish	4	1	3	0	8	0.01
Other	2	5	7	17	31	0.02
Total	4664	16577	42928	90485	154654	100

Table 2 shows the language wise distribution of publications. Majority i.e., 150900 (97.57%) publications in biodiversity literature were written in English language. Much of the non-English publications were written in Spanish 1114 (0.72%) trailed by French 806 (0.52%), followed by Portuguese 786 (0.51%), German 331 (0.21%), Russian 300 (0.19%) Polish 119 (0.08%) and Japanese 51 (0.03%), Chinese 50 (0.03%), Croatian 47(0.03%), Turkish 28 (0.02%), Hungarian and Korean each 19 (0.01%)Italian 13 (0.01%) and Finnish (0.01%) language.

3 Ranked list of most prolific contributor

Table 3: Ranked list of most prolific contributor

Sl. No	Name of Author	Total Number of Contribution	Percentage (n=154654)
1	Gaston, KJ	257	0.17
2	Possingham, HP	249	0.16
3	Li, Y	238	0.15
4	Zhang, Y	227	0.15
5	Wang, Y	225	0.15
6	Tscharntke, T	213	0.14
7	Lindenmayer, DB	210	0.14
8	Li, J	188	0.12
9	Wang, J	185	0.12
10	Liu, Y	171	0.11

*Total no of contributor 274232

Table 3shows the most prolific contributor in the field of biodiversity literature. Among the authorsGastone, KJ gets the first rank with 257 (0.17%) publications. The second rank goes

to Possingham, HP with 249(0.16%). The third rank goes to Li, Y with 238 (0.15%).The fourth rank goes to Zhang, Y with 227 (0.15%), followed by Wang, Y with 225 (0.15%), Tscharntke, T with 213 (0.14%) and the other ranks have been given in detail in table 4.8.

4 Block Vs. Co-authorship pattern

For the purpose of the analysis Authorship pattern for 28 years are grouped in to four different blocks. The details of block wise distribution of authorship pattern are presented in the below table.

Table 4: Block Vs Co-authorship pattern

No of authors	Block Periods				Grand Total
	1989-1995	1996-2002	2003-2009	2010-2016	
Single	1629	3707	4980	5568	15884
Two	1263	4268	8637	12802	26970
Three	831	3195	8654	15636	28316
Four	450	2235	6958	15280	24923
Five	247	1245	4886	12276	18654
Six	106	676	3196	9056	13034
Seven	59	431	1919	6129	8538
Eight	26	277	1186	4131	5620
Nine	16	180	734	2654	3584
Ten	9	118	524	1859	2510
Above Ten	28	245	1254	5094	6621
Total	4664	16577	42928	90485	154654

Table 4 shows that out of 154654publications on biodiversity literature, three author publications are highest with the 28316 publications. In the block of 1989 to 1995, single authored publications are highest with the 1629 publications, in the block of 1996 to 2002, two authored publications are highest with the 4268 publications, while in the block 2003 to 2009 and 2010-2016, three authorship publications are highest that is reported by 8654 and 15636 publications respectively. It highlights that the scientists intended to take collaborative participation in research activities.

5 Single Vs Multi Authors

Table 5: Single Vs Multi Authors

Sl No	Authorship Patron	Publications	Percentage
1	Single Author	15448	9.99
2	Multi Author	139206	90.01
	Total	154654	100

Table 5shows the distribution of single Vs multiple author papers published in the Biodiversity literature. The multi authored papers rank first in order with 139206 (90.01%) of the total contributions and remaining contributions that is 15448 (9.99%) from the single authored paper to the total contributions.

6 Journal wise Publication

Table 6: Journal wise Publication

Sl No.	Rank	Name of The Journal	Publication
1	1	Plos One	4499
2	2	Biodiversity and Conservation	2394
3	3	Biological Conservation	2312
4	4	Molecular Ecology	1936
5	5	Forest Ecology and Management	1687
6	6	Conservation Biology	1519
7	7	Ecology	1135
8	8	Journal of Biogeography	1029
9	9	Hydrobiologia	1025
10	10	Conservation Genetics	1000
Total		5206	152481

The table 6shows the ranking of journals. Out of 5247, the first 640 journals are ranked in order of their productivity. Some of the most productive journals are: POLOS One published 4499 articles, followed by Biodiversity and Conservation with 2394 articles, Biological Conservation with 2312 articles, Molecular Ecology with 1936 articles, Forest Ecology and Management with 1687 articles, Conservation Biologywith 1519 articles, Ecology with 1135 articles, Journal of Biogeography with 1029 articles, Hydrobiologiawith 1025 articles, Conservation Genetics with 1000 articles,

7 Scattering of journals over Bradford Zone

Bradford law states that when a large collection of articles is ranked in order of decreasing productivity of journals (sources) relevant to a given topic, three zones can be marked off so that each zone produces one-third of the total relevant papers. In this case 152481 articles were published in 5206 journals. Each zone should account for roughly one-third of the number that is 50827. The table 7 given data of the number of articles in each zone with corresponding number of journals.

Table 7: Scattering of journals over Bradford Zone

Zone	Number of Journals	Number of publications	%
1	68	50988	33.44
2	315	50874	33.36
3	4823	50619	33.20
Total	5206	152481	100

According to Bradford law the ratio between three zones should be in the ration $1: n: n^2$ While the ratio in the present study is 68:315:4823. It can be inferred that it does not fit into Bradford's distribution.This shows that core contributions are given by 68 journals, i.e. less than Bradford formulated theory and the final zones contain a very large number of journals, i.e. much more than the Bradford's formula. This is a clear indication that core zone is more concentrated and the other zone is much extended showing the scattering of journals on Biodiversity literature. When this analysis is done for a wider range of periods, the extent of

scattering can increase. Hence the analysis of data clearly discounts Bradford's Law of scattering.

8 Keyword Occurrence

Table 8: KeywordOccurrence

Rank	Keyword	Occurrence	Rank	Keyword	Occurrence
1	Biodiversity	14980	11	Biogeography	1742
2	Genetic diversity	11228	12	ecosystem services	1603
3	Conservation	5178	13	Population structure	1553
4	Diversity	3502	14	phylogeography	1535
5	species richness	2879	15	RAPD	1534
6	climate change	2668	16	Phylogeny	1532
7	Microsatellites	2514	17	Population genetics	1432
8	species diversity	2383	18	Disturbance	1251
9	Taxonomy	2054	19	AFLP	1177
10	Microsatellite	1877	20	Biodiversity conservation	1171

In the current study the keywords appeared in the 'Keywords' field of publications in biodiversity literature are analysed. The total number of keywords appeared in Biodiversity literature were 171439. A list of most frequently occurred 20 keywords (at least 1171 times occurred) were given in Table 8. The highly-occurred keywords among them were: Biodiversity (14980 times), Genetic diversity (11228), Conservation (5178), Diversity (3502), species richness (2879), climate change (2668), microsatellites (2514), species diversity (2383), Taxonomy (2054).

9 Keyword Co-occurrence

Table 9: Keyword Co-occurrence

SL No	Keyword	Co-occurring	frequency
1	Biodiversity	conservation	1056
2	Biodiversity	taxonomy	636
3	Genetic diversity	Population structure	569
4	genetic diversity	microsatellites	545
5	Biodiversity	Species richness	492
6	Genetic diversity	RAPD	474
7	Genetic diversity	Microsatellite	417
8	AFLP	genetic diversity	378
9	Biodiversity	climate change	369
10	Biodiversity	Biogeography	341

Table 9 shows that list of the top co-occurring pairs of keywords. The pair of *Biodiversity* and *conservation* occurring most frequently by appearing 1056 times together. Followed by this pair, the pair of *Biodiversity* and *taxonomy* appeared 636 times together. Further, pair of *Genetic diversity* and *Population structure* occurred 569 times. pair of *genetic diversity* and *micro satellites* occurred 545 times, pair of *Biodiversity* and *Species richness* occurred 492 times, pair of *Genetic diversity* and *RAPD* occurred 474 times, pair of *Genetics diversity* and *Microsatellite* occurred 417 times, pair of *AFLP* and *genetic diversity* occurred 378 times, pair of *Biodiversity* and *climate change* occurred 369 times, pair of *Biodiversity* and *Biogeography* occurred 341 timesoccurred most frequently as it did in the overall periods.

10 Country wise Publication

Table 10: Country wise Publication

Sl No	Country	Block Periods				Grand Total	Percent (n=154654)
		1989-1995	1996-2002	2003-2009	2010-2016		
1	USA	2045	5555	12550	23256	43406	28.07
2	United Kingdom	525	2708	6611	13755	23599	15.26
3	Republic of China	27	381	2457	9035	11900	7.69
4	France	272	1346	3115	6881	11614	7.51
5	Australia	253	997	2734	7568	11552	7.47
6	Germany	147	788	3053	7516	11504	7.44
7	Brazil	55	427	1981	6565	9028	5.84
8	Canada	265	1029	2648	5072	9014	5.83
9	Spain	76	502	2229	5809	8616	5.57
10	Italy	68	496	1995	4875	7434	4.81
11	India	107	453	1620	3699	5879	3.80
12	Japan	95	514	1453	2921	4983	3.22
13	Switzerland	75	349	1175	2902	4501	2.91
14	Sweden	89	485	1106	2454	4134	2.67
15	SouthAfrica	101	360	913	2447	3821	2.47
16	Mexico	56	278	932	2398	3664	2.37
17	Belgium	26	241	911	2037	3215	2.08
18	Portugal	7	109	558	2073	2747	1.78
19	NewZealand	56	243	757	1626	2682	1.73
20	Finland	39	301	756	1532	2628	1.70

The table presents the distribution of number of publications in Biodiversity literature in different countries. It is found that USA is the top productivity country, with 43406 (28.07%) publications out of the total output and it has highest publicationsi.e., 23256 during the block period of 2010-2016,followed by United Kingdom with 23599 (15.26%) publications, the Republic of China with 11900 (7.69%) publications, France with 11614 (7.51%) publications, Australia with 11552 (7.47%) publications, Germany with 11504 (7.44%) publications, Brazil with 9028 (5.84%) publications, Canada with 9014 (5.83%) publications, Spain with 8616 (5.57%) publications, Italy with 7434 (4.81%) publications, India with 5879 (3.80%) publications, and Japan with 4983 (3.22%) publications. The highest number of publicationsfrom all countries are found during the block period of 2010-2016. The USA is the clear leader with highly productive country while United Kingdom ranked second, Republic of China ranked third and France fourth.

11 Institution wise publications

Table 11: Institution wise publications

Sl No	Name of Institution	Total Publications
1	Chinese Academy of Sciences	2305
2	INRA	936
3	Russian academy of sciences	904
4	CSIC	833
5	University of Calif Davis	787
6	University of NaclAutonoma Mexico	779
7	University of Queensland	696
8	University of Sao Paulo	691
9	Swedish University of Agr Sci	664
10	University of Helsinki	626

Table 11shows distribution of Biodiversity literature by top 10institutions during the study period. The Chinese Academy of Sciences occupies the first rank in order by contributing 2305 publications. Followed by 936 publications from INRA, 904 publications by Russian academy of science, 833 publications by CSIC, 787 publications by University of Calif Davis, 779 publications by Universidad Nacional Autonoma, 696 publications by University of Queensland, 691 publications by University of Sao Paulo, 664 publications by Swedish University of Agricultural Sciences and 626 publications by University of Helsinki.

12 Citation Analysis

Table 12: Citation wise publications

Sl. No	Total Citation	Total Publication	Percent
1	No Citation	24223	15.66
2	1-100	124714	80.64
3	101-200	3863	2.50
4	201-300	875	0.57
5	301-400	398	0.26
6	401-500	212	0.14
7	501-600	100	0.06
8	601-700	68	0.04
9	701-800	45	0.03
10	801-900	32	0.02
11	901-1000	28	0.02
12	1001>	96	0.06
Total	3414103	154654	100

Table 12shows the citation wise distribution of publication on world biodiversity literature. 3414103 citations are identified for 154654 publications during the study period. And it is observed that only 24223 (15.66%) publications did not receive any citation, 124714 (80.64%) publications received 1 to 100 citations, 3863 (2.50%) publications received 101 to 200 citations, 875 (0.57%) publications received 201 to 300 citationsand remaining 979 (0.63%) of publications received more than 301 citations.

Table 13: Top 10 Proceedings publication

Sl No	Name of Proceedings	Total Publication	%
1	Proceedings of The National Academy of Sciences of The United States of America	1160	0.75
2	Proceedings of The Royal Society B-Biological Sciences	784	0.50
3	Proceedings of The National Academy of Sciences India Section B-Biological Sciences	36	0.02
4	Biology and Environment-Proceedings of The Royal Irish Academy	35	0.02
5	Proceedings of The Entomological Society of Washington	35	0.02
6	Proceedings of The Biological Society of Washington	22	0.01
7	Proceedings of The Academy of Natural Sciences of Philadelphia	15	0.01
8	Proceedings of The Geologists Association	13	0.008
9	Proceedings of The Linnean Society of New South Wales	11	0.007
10	Proceedings of The Nutrition Society	10	0.006

Table 13 shows the top 10 proceedings publications of biodiversity literature during 1989 to 2016 and it is noticed that among these Proceedings of The National Academy of Sciences of The United States of America occupies first place with 1160 (0.75%) publications and

Proceedings of The Royal Society B-Biological Sciencesoccupies second place with 784 (0.50%) publications, followed by Proceedings of The National Academy of Sciences India Section B-Biological Sciences published 36 (0.02%) articles, Biology and Environment-Proceedings of The Royal Irish Academy and Proceedings of The Entomological Society of Washington published 35 (0.02%) articles, Proceedings of The Biological Society of Washingtonpublished 22 (0.01%) articles, Proceedings of The Academy of Natural Sciences of Philadelphia published 15 (0.01%) articles, Proceedings of The Geologists Association published 13 (0.008%) articles, Proceedings of The Linnean Society of New South Wales published 11 (0.007%) articles andProceedings of The Nutrition Society published 10 (0.006%) articles.

MAJOR FINDINGS

- The relative growth rate of article contributions of biodiversity literature has shown a decreasing trend, whereas the doubling time for publications has shown increasing trend.
- The most prolific contributor in the field of biodiversity literature among the authors are Gastone, KJ gets the first rank with 257 (0.17%) publications.
- In first block (1989 - 1995) CAI is more than 100 for single and two authors. It reflects higher than average co authorship effort; from three to above ten CAI is less than 100 it reflects lower than average co authorship effort. In this case it is inference that an increase in authors there is a decrease in CAI.
- The multi authored papers rank first in order with a total of 139206 (90.01%) contributions and remaining 15448 (9.99%) contributions are from the single authors.
- It is found that 171439 keywords are appeared in Biodiversity literature. Among them highly occurred keyword is Biodiversity (14980 times),
- The Chinese Academy of Sciences occupies the first rank among the top 100 institutions contributing Biodiversity literature by contributing 2305 publications during the study period.
- It is found that 24223 (15.66%) publications on world biodiversity literature did not receive any citations.
- It is found that leading proceedings publication are The National Academy of Sciences of The United States of America occupies first place with 1160 (0.75%) publications.

CONCLUSION

In recent years, an increasing number of studies have focused on the importance of biodiversity in regulating the balanced lifestyles for us as well as generations to come. Hence the study of literature in the field of biodiversity and its scientific output, and its analysis and mapping will definitely help the information scientists as well as scientific community.

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