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# Authorship Productivity and Applicability of Lotka's Law in Phytochemistry Literature

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## Abstract

*This article aims to present the results of the Scientometric analysis in the Phytochemistry literature. A total of 13215 records from 2014 to 2018 were taken for the analysis. The Data were downloaded from SCOPUS online database. This study mainly concentrates the authorship productivity, applicability of Lotka's law, Price square root law and Pareto's 80/20 rule. The Chi square value is 225.65 which is higher than the table value in the analysis of Lotka's law. The square root of total authors, who have contributed 7.94 % of the total contribution, is found to be 255.52 in Price square Root Law. The findings of Pareto's 80/20 rules state that 20% of the authors contributed only 46.60% of the total contribution.*

**Keywords:** Scientometrics, Phytochemistry, Authorship Productivity, Lotka's Law, Price's square root, Pareto's 80/20.

## 1. INTRODUCTION

Bibliometrics is defined as the quantitative analysis of written publications, such as articles or books. Bibliometrics/Scientometrics are used to find the growth of academic literature. It comes under the major discipline Statistics. Because it uses statistical tools for the analysis. Since it is used to quantify the academic literature only, it is considered as a different discipline. But the Several research fields use bibliometrics and scientometrics to discover the impact of their field and the impact of a particular paper. It is also used for the development of thesauri, assessment of reader usage and descriptive linguistics.

The word Phyto is derived from Greek word "Phuton" which means plant. The study of Phytochemicals is called Phytochemistry. Phytochemicals are chemical compounds found in the plants. The earliest records of the usage of the plant chemicals in Chinese medicine is found in the text "The Great Native Herbal" written by the Chinese emperor Shen Nong around BC 2800. Plants produce phytochemicals to defend themselves against diseases and pest attacks. Phytochemicals are found in the plants that provide grains, vegetables, nuts and other edibles are

considered as the main sources of human energy and also have many health benefits. Many kinds of chemical compounds are found in plants. But these chemical compounds are classified into four major classes, the alkaloids, glycosides, polyphenols, and terpenes. Phytochemistry comes under the sub-fields of chemistry or botany. The applications of Phytochemistry can be for the discovery of new drugs or for the discovery of biofuels or for the discovery of bioplastic and so on.

## 2. REVIEW OF LITERATURE

**Ahmed, S.M. Zabed & Rahman, Md. Anisur. (2009)**<sup>1</sup> examined the applicability of Lotka's law to authorship productivity in the nutrition research literature in Bangladesh. A list of articles published in nutrition research literature in Bangladesh during the period 1972-2006 was taken for analysis. In authorship productivity, a total of 998 author names were identified. The results suggest that Lotka's law is found to be fit to nutrition research of Bangladesh. **Baskaran, Chinnasamy. (2013)**<sup>2</sup> analysed the Research productivity of Alagappa university with the tools of Scientometrics. The study focused productivity of authors, subject-wise and institution-wise collaboration and ranking of authors. Relative growth rate was found to be fluctuating trend during the study period. The mean value of Degree of collaboration is found to be 0.963. The top three institutions collaborated with Alagappa University are Central Electro Chemical Research Institute, National Cheng King University, and Anna University. **Baskaran, Chinnasamy & Karuilancheran, C. (2015)**<sup>3</sup> carried out a Scientometric analysis in Diabetes and Allied Diseases literature during the period of 1995-2013. The study focused on the relative growth rate, doubling time, activity index and Lotka's law. The study found that stable relative growth rate in during the period of study. There was a sudden raise observed in 2002, 2009, and 2012 while a fall was noticed in 1996, 2003, and 2013. The Chi square table Value is 42.56. The chi square value is calculated at 0.05 significant level. The degree of freedom for this calculation is 29. The calculated value of Chi-Square  $\chi^2$  is 5309.368. **Baskaran, Chinnasamy & Saravanan, S. (2018)**<sup>4</sup> carried out a Scientometric study on Bioremediation Research Output in India during the period of 1994 to 2018. A total of 1981 articles published by Indian scientists were taken for the analysis. The data were downloaded from Web of Science online Database. This study focused the number of publications, Relative growth rate and doubling time, dispersion of publication over journals, authorship patterns and Global citation score using the HistCite, VOSviewer software. In India, IIT, BARC and CSIR are the major producer in bioremediation research output. **Batcha M, Sadik. (2018)**<sup>5</sup> analysed the research productivity of Annamalai University with Scientometric tools. Two datasets of the research papers (936 and 3370) contributed by authors and researchers of Annamalai University during the period of 2000-2006 and 2011-2017 were taken for the analysis. The data were downloaded from Web of Science online Database. In this study, an effort has been made to study the applicability of the Lotka's Law to the

publications of a Higher Educational institution of a region consisting of academic authors and researchers in various disciplines. It was found that the inverse square law of Lotka does not fit.

**M, Muthukrishnan. (2017)<sup>6</sup>** carried out research in oncology research output in India during the period of 2005-2015. A total of 10298 research articles were analysed for this study. The study concentrated the author productivity, authorship pattern, applicability of Lotka's law. Data were collected from Web of Science online database. The analysis was carried out using Histcite software.

The total numbers of authors were 21443 and oncology research output conformed particularly fit to Lotka's law with table value  $C = 0.618$ . **Nisonger, Thomas. (2008)<sup>7</sup>** examined the Pareto distribution 80/20 rule and explained the historical origins of the term. The relationship between Pareto 80/20 rule and Bradford's Law is also explored. Some of the research related to the 80/20 rule is also reviewed. The utility of the 80/20 rule for defining the core collection in serials collection management is discussed in this study. It is found that the 80/20 rule is a valid method for determining the core concept in journal collection management. **Saravanan, S, & Baskaran, Chinnasamy. (2019)<sup>8</sup>**

studied the thirty Years of Global Literature on Bioleaching for the period of 1989 - 2018. A total of 2477 papers were collected from Web of Science Databases. This study focused on Relative growth rate, Doubling Time, Degree of Collaboration, document wise distribution, keyword analysis and Bibliographic Coupling of the institution. The study discovers that most of the researchers chose to publish their findings in the form of journal articles. The authorship pattern shows that 95% of the articles were published under the joint authorship. Central South University is topped in the first rank in the institutional wise distribution. **Sen, B. & Taib, Che Azlan & Hassan, M.F.b. (1996)<sup>9</sup>** presented the findings of the study to test the applicability of Lotka's Law in the library and information science discipline (LIS). The Data of personal authors from the annual Name Index of Library and Information Science Abstracts (LISA) for 1992 and the annual Author Index of LISA for 1993 were taken for the analysis. The chi square value for the Lotka's law was found to be 3.23 for 1992 data and 3.1 for 1993 data. The study reveals that the Lotka's Law is found to be fit in this study.

### **3. OBJECTIVIES**

The Main purpose of the study is to present the results of the scientometrics analysis of Phytochemistry literature. The analysis focused mainly the authorship productivity, applicability of Lotka's law, Price square root law and Pareto's 80/20 rule.

#### 4. METHODOLOGY

The data on Phytochemistry literature were taken from SCOPUS online database for the year 2014 - 2018. The collected data were analysed with MS office Excel Spreadsheet and presented the findings in the form of Tables and Graphs.

#### 5. ANALYSIS AND INTERPRETATIONS

##### 5.1 Author at any Position:

**Table 1**

**Ranking of 25 Authors: Authors at any position (65288 Authors)**

S. No	Name of Authors	Publications in Phytochemistry	Percentage	Rank
1	Zhang, Y	91	0.14	1
2	Li, Y	85	0.13	2
3	Wang, Y	79	0.12	3
4	Zhang, J	71	0.11	4
5	Li, J	59	0.09	5
6	Liu, Y	58	0.09	6
7	Zhang, L	55	0.08	7
8	Wang, X	53	0.08	8
9	Kumar, S	52	0.08	9
10	Li, X	51	0.08	10
11	Wang, J	49	0.08	11
12	Zhang, X	47	0.07	12
13	Ragasa, C.Y	45	0.07	13
14	Zhang, H	45	0.07	13
15	Boligon, A.A	43	0.07	14
16	Wang, L	42	0.06	15
17	Wang, Z	41	0.06	16
18	Liu, J	40	0.06	17
19	Chen, Y	38	0.06	18
20	Singh, A	38	0.06	18
21	Wang, W	38	0.06	18
22	Liu, X	37	0.06	19
23	Zhao, Y	37	0.06	19
24	Singh, S	36	0.06	20
25	Ahmad, S	34	0.05	20

During the study period of 2014-2018, it is found that there are 42513 unique authors who have contributed 65288 times in the total publications on Phytochemistry literature. Authors at any position and their rankings are shown in the decreasing order of productivity. Out of 42513 authors, only top ranked first 25 authors are shown in the table 1. The analysis reveals that Zhang, Y., is ranked in first position with maximum number of 91 publications. Li, Y., has got the 2nd rank with 85 publications followed by Wang. Y., Zhang, J., Li, J., in 3rd , 4th and 5th rank with 79, 71 and 59 publications respectively.

## 5.2 Lotka's Law of author Productivity

**Table 2**

**Lotka's Law of author Productivity**

No. of Papers	No. of observed authors With N publications (O)	Observed percentage of authors	Expected No. of authors (E)	(O-E) <sup>2</sup>	(O-E) <sup>2</sup> /E
1	33158	100.00	33158.00	0.00	0
2	10538	31.78	8289.50	5055752.25	5055752.25
3	5472	16.50	3684.22	3196149.38	3196149.38
4	3308	9.98	2072.38	1526769.14	1526769.14
5	2280	6.88	1326.32	909505.54	909505.54
6	1680	5.07	921.06	575996.67	575996.67
7	1099	3.31	676.69	178342.46	178342.46
8	896	2.70	518.09	142813.13	142813.13
9	846	2.55	409.36	190656.21	190656.21
10	570	1.72	331.58	56844.10	56844.10
11	462	1.39	274.03	35331.57	35331.57
12	420	1.27	230.26	35999.79	35999.79
13	351	1.06	196.20	23962.67	23962.67
14	336	1.01	169.17	27831.09	27831.09
15	300	0.90	147.37	23296.26	23296.26
16	272	0.82	129.52	20299.57	20299.57
17	204	0.62	114.73	7968.50	7968.50
18	162	0.49	102.34	3559.37	3559.37
19	152	0.46	91.85	3617.97	3617.97
20	100	0.30	82.90	292.58	292.58
21	126	0.38	75.19	2581.84	2581.84
22	286	0.86	68.51	47302.66	47302.66
23	69	0.21	62.68	39.94	39.94

24	96	0.29	57.57	1477.17	1477.17
25	150	0.45	53.05	9398.76	9398.76
26	78	0.24	49.05	838.09	838.09
27	81	0.24	45.48	1261.37	1261.37
28	28	0.08	42.29	204.30	204.30
29	58	0.17	39.43	344.96	344.96
30	90	0.27	36.84	2825.75	2825.75
31	93	0.28	34.50	3421.82	3421.82
32	96	0.29	32.38	4047.40	4047.40
33	99	0.30	30.45	4699.36	4699.36
34	102	0.31	28.68	5375.33	5375.33
36	36	0.11	25.58	108.47	108.47
37	74	0.22	24.22	2477.99	2477.99
38	114	0.34	22.96	8287.81	8287.81
40	40	0.12	20.72	371.57	371.57
41	41	0.12	19.73	452.62	452.62
42	42	0.13	18.80	538.38	538.38
43	43	0.13	17.93	628.36	628.36
45	90	0.27	16.37	5420.74	5420.74
47	47	0.14	15.01	1023.33	1023.33
49	49	0.15	13.81	1238.33	1238.33
51	51	0.15	12.75	1463.20	1463.20
52	52	0.16	12.26	1579.06	1579.06
53	53	0.16	11.80	1697.09	1697.09
55	55	0.17	10.96	1939.41	1939.41
58	58	0.17	9.86	2317.78	2317.78
59	59	0.18	9.53	2447.73	2447.73
71	71	0.21	6.58	4150.24	4150.24
79	79	0.24	5.31	5429.78	5429.78
85	85	0.26	4.59	6465.87	6465.87
91	91	0.27	4.00	7568.29	7568.29
	<b>65288</b>		<b>53864.47</b>	<b>12154413.06</b>	<b>225.65</b>

Lotka's Law describes the frequency of publication by authors in a given subject. It states that "the number of authors making n contributions is about  $1/n^2$  of those making one; and the proportion of all contributors, that make a single contribution, is about 60 percent". Lotka's law is also examined with application of scientific productivity Chi-Square model in relation to the number of authors who contributed n number of publications. The results of the applicability of Lotka's law in the productivity of authors in the Phytochemistry literature are presented in table 2. From the table it is clear that the expected value of authors (**53864.47**) is less than the observed value of authors (**65288**). But when checking with the calculated chi square value **225.65** at the level of

significance 0.05 percentage, the table value **70.993** is less than the calculated Chi square value **225.65**. For this calculation, the degree of freedom is 53. The observed analysis clearly shows that the calculated chi square value is higher than the table value. This result clearly conforms that the Lotka's law is found to be unfit in the productivity of authors in Phytochemistry literature.

### 5.3 Price's Square Root Law

**Table 3**

**Price's Square Root Law**

<b>No. of Papers</b>	<b>No. of Authors</b>	<b>percentage</b>	<b>No. of contributions</b>	<b>Percentage</b>
1	33158	77.99	33158	50.79
2	5269	12.39	10538	16.14
3	1824	4.29	5472	8.38
4	827	1.95	3308	5.07
5	456	1.07	2280	3.49
6	280	0.66	1680	2.57
7	157	0.37	1099	1.68
8	112	0.26	896	1.37
9	94	0.22	846	1.30
10	57	0.13	570	0.87
11	<b>42 (255.52)</b>	0.10	<b>462 (5183.87)</b>	<b>0.71 (7.94)</b>
12	35	0.08	420	0.64
13	27	0.06	351	0.54
14	24	0.06	336	0.51
15	20	0.05	300	0.46
16	17	0.04	272	0.42
17	12	0.03	204	0.31
18	9	0.02	162	0.25
19	8	0.02	152	0.23
20	5	0.01	100	0.15
21	6	0.01	126	0.19
22	13	0.03	286	0.44
23	3	0.01	69	0.11
24	4	0.01	96	0.15
25	6	0.01	150	0.23
26	3	0.01	78	0.12
27	3	0.01	81	0.12
28	1	0.00	28	0.04
29	2	0.00	58	0.09
30	3	0.01	90	0.14
31	3	0.01	93	0.14
32	3	0.01	96	0.15



33	3	0.01	99	0.15
34	3	0.01	102	0.16
36	1	0.00	36	0.06
37	2	0.00	74	0.11
38	3	0.01	114	0.17
40	1	0.00	40	0.06
41	1	0.00	41	0.06
42	1	0.00	42	0.06
43	1	0.00	43	0.07
45	2	0.00	90	0.14
47	1	0.00	47	0.07
49	1	0.00	49	0.08
51	1	0.00	51	0.08
52	1	0.00	52	0.08
53	1	0.00	53	0.08
55	1	0.00	55	0.08
58	1	0.00	58	0.09
59	1	0.00	59	0.09
71	1	0.00	71	0.11
79	1	0.00	79	0.12
85	1	0.00	85	0.13
91	1	0.00	91	0.14
	<b>42513</b>	<b>100</b>	<b>65288</b>	<b>100</b>

Price's law or Price's square root law is invented by Derek John de Solla Price. Price's square root law describes the relationship between the literature on a subject and the number of authors in the subject area. The law states that half of the publications come from the square root of all contributors. Price's law is related to Lotka's law. The result of the study reveals that 77.99% (33158) of the authors have contributed as 50.79% of total contribution. At the same time 22.01 % of the total authors have contributed with 49.21% of total contribution. The square root of total contributions is found to be 255.52. The analysis reveals that the square root of total authors (255.52) contributed only 7.94 % of the total contribution, which is much below 50% (half of the literature on a subject); so this result is unfit with Price's Square Root Law.

N=65288

Price Square root=  $\sqrt{N}$ =255.52

#### 5.4 Paret's 80/20 Rules

**Table 4**

<b>Paret's 80/20 Rules</b>			
<b>Authors</b>	<b>No of Authors</b>	<b>No of Contributions</b>	<b>Percentage</b>
Square root of Total no. of Authors	255.5151659	5183.87	7.94
10%	4251.3	21922.6	33.58
20%	8502.6	30424.4	46.60
30%	12753.9	35528.9	54.42
40%	17005.2	39780.2	60.93
50%	21256.5	44031.5	67.44
60%	25507.8	48282.8	73.95
70%	29759.1	52534.1	80.47
80%	34010.4	56785.4	86.98
90%	38261.7	61036.7	93.49
100%	42513	65288	100

#### **Pareto's 80/20 Rules**

The Pareto principle states that, for many events, roughly 80% of the effects come from 20% of the causes. Joseph M. Juran named it after Italian economist Vilfredo Pareto. Vilfredo Pareto noticed the 80/20 connection and published this principle in 1896 in his work *Cours d'économie politique*. In his book, Pareto developed this principle based on the distribution of income and wealth among the population. Pareto described that approximately 80% of the land in Italy was owned by 20% of the population. This principle is also known as the 80/20 rule, the principle of factor sparsity, or the law of the vital few. In Mathematics, the 80/20 rule is roughly followed by a power law distribution for a particular set of parameters, and many natural phenomena have been shown 80/20 connection empirically to show such a distribution. This principle is applied to author productivity. In any subject field, 20 percent of the most productive authors contribute 80 percent of the total research papers. In the same way it is found from table 4 that 20% of the authors contributed only 46.60% of the total contribution. This is much below the 80% as predicted by 80/20 rule. Hence, the result of th analysis is found to be unfit with Pareo's 80/20 rules.

## **Conclusions**

The study reveals that there are 42513 unique authors who have contributed 65288 times in the total publications on Phytochemistry literature. The analysis reveals that Zhang, Y., is ranked in first position with maximum number of 91 publications. The observed analysis in the Lotka's law clearly shows that the calculated chi square value **225.65** is higher than the table value **70.993**. This result clearly conforms that the Lotka's law is found to be unfit in the productivity of authors in Phytochemistry literature. The analysis in the Price's square root law reveals that the square root of total authors (**255.52**) contributed only 7.94 % of the total contribution, which is much below 50% (half of the literature on a subject). This result of the analysis is found to be unfit with Price's Square Root Law. The findings in the Pareo's 80/20 rules discloses that 20% of the authors contributed only 46.60% of the total contribution. This is much below the 80% as expected by 80/20 rule. Therefore the result of the analysis is found to be unfit with Pareo's 80/20 rules.

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