Applicability of Lotka's law in Mustard research publications in India - a scientometric study

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Abstract

The paper is based on analyses of 3588 papers collected from CAB Direct. Studies authorship pattern and applicability of Lotka's Law by counting number of publications by each author. Applies Chi-square test to test hypothesis and finds the law still applicable on this research.

Keywords: Bibliometrics, Authorship pattern, Lotka's law, Mustard, Brassica

1 Introduction

Alfred J. Lotka (1926) in his paper on " Analysis of the number of publications in Chemical Abstracts from 1907 to 1916 on frequency distribution of scientific productivity" proposed an inverse square law of scientific productivity which reads 'if X authors contribute exactly one paper each, then a the number of the authors contributing n papers will be expressed in the terms of the equation

$$A_n = x/n^2 \qquad \text{for n= 1,2,3,....etc.}$$

Where, A_n= number of authors contributing n papers: x=number of authors contributing one paper; n= 1,2,3,.....i

It is also expressed as $1/n^2$ where 1= X

Lotka's article was not cited for 15 years until 1941 and his distribution was not termed as Lotka Law until 1949. This law has been tested by many studies. Murphy (1973) mapped in humanities and Schorr (1975) on librarianship, Pao (1986) has also tested this law. Booksteen (1977) gave modified theoretical models for Lotka's Law

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$$Y_a=k/x^a \qquad\qquad \text{.......... (1)}$$

Where, Y_a= the relative frequency of authors publishing; x= the number of papers, k & a = constant

Considering the fact that n authors have produced one article each, the value of constant k can be easily derived, by putting the value of Y_a= 1 and a=2 in equation 1 .

$$Y_a=k/x^a$$

$$1=k/1^2$$

$$K=1$$

In the other words the number of authors with x papers is proportional to $1/x^2$.

Price (1963) has stated that half of the scientific papers are contributed by the square root of the total number of scientific authors. i. e. $N^{1/2}$ sources yield a fraction ½ of the items. There has been difference of opinion in counting number of papers of an author as her position at number 1 or.... n

There are four methods of counting of number of publications: -

1. Total counting: - Each author receives equal treatment and gets equal credit of 1. This is easiest enrolled and is commonly used.
2. Straight counting: - Only the first author is counted. This was adopted by Lotka. May be due to manual counting method.
3. Adjusted /fractional counting: - Each of the N authors receives a score of 1/n.
4. Proportional counting: - Each author receives score as per rank. 2/n(1- R/N+1).

This method is being used by UGC in API score.

To find the suitability of Lotka's law in the mustard research in India, the data has been collected for the duration of 2000 to 2013. Mustard is the one of important oilseed crops in India. Rajasthan, Madhya Pradesh, Haryana and Uttar Pradesh contribute more than 77% of area and 82% of production of mustard in India (2015). But India is still importing huge quantity of oilseeds including palm oil and mustard oil in spite of good research on the subject.

2 Review of literature

Some bibliometric studies have been reviewed on authorship patterns, collaboration coefficient, collaboration index and dominance factor etc. Khatun and Ahmed(2011) presented quantitative analysis to identify the literature growth, authorship pattern, collaboration and journal distribution on diarrhoeal disease research and found Lotka's Law unfit. Jain and Kumar (2013) have analyzed Indian contributions to world soybean research

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for 20 years (1989-2008). Many bibliometric methods have been applied on the data like activity index, growth rate and doubling time, prolific authors and their dominance factor etc. Meena, Kumar and Jain (2014) have used degree of collaboration, dominance factors, RGR & DT in their study on pigeon pea for the duration of 9 years (2000-2008).

Many studies have been made on applicability of Lotka's law. Lemoline (1992) studied frequency distribution of papers in CSIR. Gupta (1996) conducted a study of productivity of authors in potato research, Gupta and Kumar (1998) studied on population genetics, Kawamura and others (1999) studied on dental research. The study of Narendra Kumar (2010) is based on productivity of CSIR (India). Murphy (1973) mapped humanities. The study by Gupta and others (1999) were based on productivity of CSIR (India). Sabrino and others (2008) studied scientific productivity in the field of information science and applied Kolmogorov- Smirnov test to check applicability of Lotka's Law.

3 Methodology

The data for the present study is collected for the years 2000-2013 from CAB Direct available at Directorate of Soybean Research (ICAR), Indore (M. P.). The data has been transferred on excel sheets and used for the present study. The present study is an outcome of research for Ph. D. in Library and Information Science.

4 Objectives

- To study the authorship patterns.
- To study the number of contributions by the authors and find applicability of Lotka's law.

5 Hypothesis

Following null hypotheses have been formulated and tested based on data collected.

H_0: Lotka's law is applicable on the Indian publications in mustard research.

H_1: Lotka's law is not applicable on the Indian publications in mustard research.

Mathematically: -

$$H_0: \quad \chi2_c < \chi2_t \qquad \text{Where, } \chi2_c = \text{Calculated Value}$$
$$H_1: \quad \chi2_c \geq \chi2_t \qquad \qquad \chi2_t = \text{Tabulated Value}$$

6 Formulae Following formulae have been used.

1. Lotka's inverse square law of scientific productivity: - Formula by Alfred J Lotka (1926)

$$\frac{1}{n^2}$$

Where,
1= Number of authors making only single contribution
n= Number of contributions (1, 2, 3.....)

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2. Chi-square test:-

$$\chi2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

7 Analysis

The analyses of the data have been done from the excel data sheet as follows:-

a) **Authorship patterns: -**

Table 1 calculates authorship pattern in mustard research publications. Most of the articles published are of joint authorship. Total 3332(92.86%) articles have been published in co-authorship whereas only 256 (7.13%) articles have been published by single author each. Highest 1147(31.97%) articles have been published by three authors each, followed by 1035(28.95%) articles by two authors each, 681(18.98%) by four authors each, 252(7.30%) by five authors each. 207(5.77%) articles have been published by more than five authors each. Highest number of authors was 28 for one single paper. The research shows trend of more number of authors each article.

Table 1
Author wise distribution of publications on mustard research in India

S.N.	Year	Single Author	Two Authors	Three Authors	Four Authors	Five Authors	VI and More Authors	Total	Percentage
1	2000	17	69	84	48	6	9	233	6.49%
2	2001	19	83	64	36	10	8	220	6.13%
3	2002	16	103	96	53	19	10	297	8.28%
4	2003	27	100	89	50	15	15	296	8.25%
5	2004	24	83	84	48	14	12	265	7.39%
6	2005	26	91	109	57	17	14	314	8.75%
7	2006	14	75	92	35	18	15	249	6.94%
8	2007	15	71	95	42	21	14	258	7.19%
9	2008	17	59	79	62	29	13	259	7.22%
10	2009	10	64	79	51	23	14	241	6.72%

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11	2010	16	56	66	51	21	19	229	6.38%
12	2011	19	47	60	56	23	18	223	6.22%
13	2012	15	78	77	48	25	20	263	7.33%
14	2013	21	56	73	44	21	26	241	6.72%
	Total	256	1035	1147	681	262	207	3588	100.00%
	%	7.13%	28.85%	31.97%	18.98%	7.30%	5.77%	100.00%	

Author wise distribution of mustard research
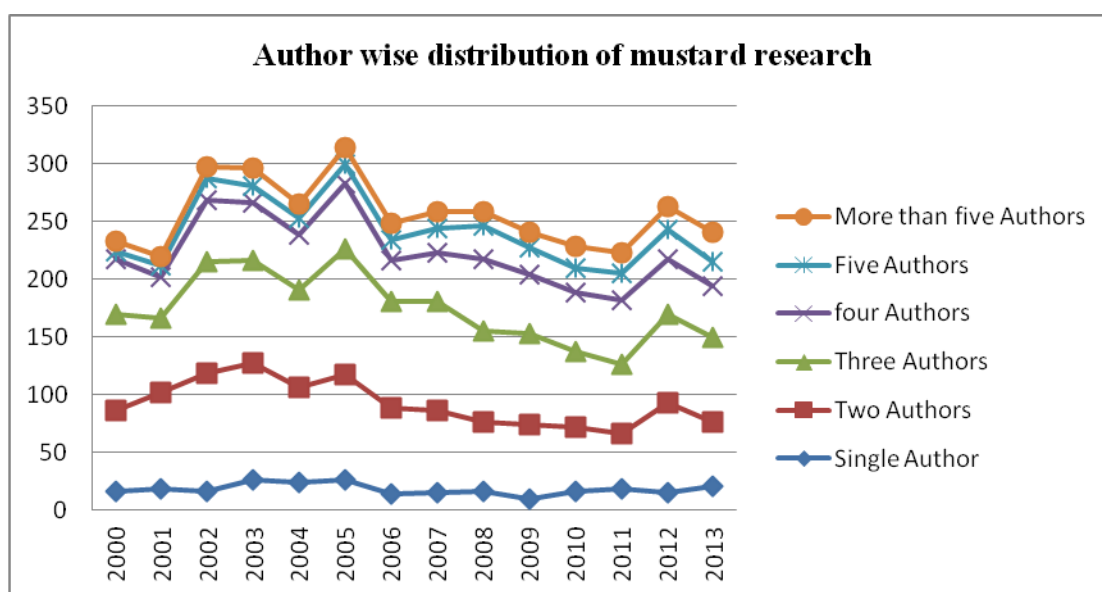
b) **Number of contributions: -**

Table 2 examines the number of contributions made by individual authors. There are total 5664 authors who have contributed 3588 articles on the subject out of which 3696 (65.2%) authors made only one contribution each while 1011 (17.9%) authors made two contributions each, 363(6.4%) authors made three contributions each and 193 (3.4%) authors made four contributions each.

On the other hand highest 50 contributions have been made by one author followed by 43 contributions by another one, and 41 contributions by another author. Four authors made more than 30 articles. 20-29 articles have been contributed by 14 authors while 11-19 articles have been contributed by 71 authors. This can be seen in table 2.

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Table 2

Distribution of authorship in mustard research in India

S. No.	No. of Authors	Numbers of Contributions by each authors	Percentage of contribution	Total Authorship	Percentage of total authorship
1	1	50	0.02%	50	0.44%
2	1	43	0.02%	43	0.38%
3	2	41	0.04%	82	0.73%
4	1	38	0.02%	38	0.34%
5	2	34	0.04%	68	0.60%
6	1	31	0.02%	31	0.28%
7	1	29	0.02%	29	0.26%
8	1	27	0.02%	27	0.24%
9	1	26	0.02%	26	0.23%
10	1	25	0.02%	25	0.22%
11	3	24	0.05%	72	0.64%
12	1	23	0.02%	23	0.20%
13	2	22	0.04%	44	0.39%
14	4	20	0.07%	80	0.71%
15	1	19	0.02%	19	0.17%
16	3	18	0.05%	54	0.48%
17	7	17	0.12%	119	1.06%
18	8	16	0.14%	128	1.14%
19	5	15	0.09%	75	0.67%
20	7	14	0.12%	98	0.87%
21	11	13	0.19%	143	1.27%
22	17	12	0.30%	204	1.81%
23	12	11	0.21%	132	1.17%
24	24	10	0.42%	240	2.13%
25	28	9	0.49%	252	2.24%
26	44	8	0.78%	352	3.13%
27	46	7	0.81%	322	2.86%
28	64	6	1.13%	384	3.41%
29	102	5	1.80%	510	4.53%
30	193	4	3.41%	772	6.86%
31	363	3	6.41%	1089	9.68%
32	1011	2	17.85%	2022	17.97%
33	3696	1	65.25%	3696	32.86%
Total	5664		100.00%	11249	100.00%

c) **Applicability of Lotka's law**

Lotka's law has been tested on the basis of authors with 10 or less articles individually. Calculations can also be made for more than 10 contributions but this is not required here to test the applicability of Lotka' law. Table 3 calculates observed and expected number of authors with ten or less contributions to test applicability of Lotka's law. Table found

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partial similarity between observed number and expected number of authors. The differences between expected values and observed values are less than 1.3%. So, we can infer that the Lotka's law is still applicable in the study even after 90 years of its origin.

Table 3
Lotka's law on publications on mustard research in India

S.N.	No. of contributions 'n'	Observed no. of authors	Percentage	Total Authorship	Expected no. of authors	Percentage	Difference in authors	Differen in Percenta
1	Single	3696	100.00%	3696	3696	100.00%	0	0.00%
2	Two	1011	27.35%	2022	924	25.00%	-87	-2.35%
3	Three	363	9.82%	1089	411	11.11%	48	1.29%
4	Four	193	5.22%	772	231	6.25%	38	1.03%
5	Five	102	2.76%	510	148	4.00%	46	1.24%
6	Six	64	1.73%	384	103	2.78%	39	1.05%
7	Seven	46	1.24%	322	75	2.04%	29	0.80%
8	Eight	44	1.19%	352	58	1.56%	14	0.37%
9	Nine	28	0.76%	252	46	1.23%	18	0.48%
10	Ten	24	0.65%	240	37	1.00%	13	0.35%
11	More than Ten	93	2.52%	1610				
	Total	5664		11249	5727.94			

d) **Testing of Hypothesis**

The hypothesis have been tested with formulae given in section

H_0: Lotka's law is applicable on the Indian publications in mustard research.

H_1: Lotka's law is not applicable on the Indian publications in mustard research.

Mathematically

$$H_0: \quad \chi2_c < \chi2_t \qquad \text{Where, } \chi2_c = \text{Calculated Value}$$
$$H_1: \quad \chi2_c \geq \chi2_t \qquad \qquad \chi2_t = \text{Tabulated Value}$$

Table 4 presents calculation made for Chi-square test.

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Table 4
Chi square test for check applicability of Lokta's Law

S.N.	No. of contributions 'n'	Observed no. of authors (Fi)	Expected no. of others (Pi)	Fi-Pi	$(Fi-Pi)^2$	$X^2= (Fi-Pi)^2/Pi$
1	Single	3696	3696	0	0	0.00
2	Two	1020	924	96.00	9216.00	9.97
3	Three	367	411	-43.67	1906.78	4.64
4	Four	195	231	-36.00	1296.00	5.61
5	Five	104	148	-43.84	1921.95	13.00
6	Six	63	103	-39.67	1573.44	15.33
7	Seven	46	75	-29.43	866.04	11.48
8	Eight	41	58	-16.75	280.56	4.86
9	Nine	26	46	-19.63	385.32	8.44
10	Ten	24	37	-12.96	167.96	4.54
	Total	5582	5728	-145.94	17614.06	3.08

In this study, Chi-square test has been calculated.

$$\chi2 = \sum \frac{(Observed - Expected)^2}{Expected}$$

$$\chi2 = \sum \frac{(Fi - Pi)^2}{Pi}$$

$$\chi2 = \frac{17614.06}{5728}$$

$$\chi2 = 3.08$$

In the Chi-square test table (A pre-prepared standard table), The value of 9 (10 observation-1 as given in table 4), the value is 16.9.

So, $\chi2 = 3.08 < 16.9$

Hence, since the calculated value of $\chi2$ is less than standard value, the null hypothsis is accepted.
So, conclusionly Lotka's law is admissible on the data in this research.

8 Conclusion

The study reveals that collaboration of more number of authors per article dominates in publications activities in this research. There are only 7.1% single authored papers. In few cases, there were very high numbers of collaborations. 13% articles have five and more authors per articles. The study also reveals that out of 5664 total authors 65.2% authors have contributed only one article. Two articles have been contributed by only 17.9% authors. Three articles have been contributed by 6.4% authors only. Four and five articles each have been contributed by 3.4% and 1.8% of total authors. Similarly percentages of number of articles have been shown in the table 2. There is only 1 author (0.02%) have contributed highest number of articles (50 articles). So, the number of authors decreases with the increase in number of articles. There is always very few authors in any field who contribute more number of articles. Even after 90 years, Lotka's law is still applicable and the trend has not changed.

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