

AUTHORSHIP PATTERN AND COLLABORATIVE RESEARCH IN INDIAN BIOINFORMATICS RESEARCH

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Presents the authorship pattern and collaborative research in the field of Bioinformatics in India as indexed in Web of Science database for the period of five years (2010-2014). The study examined 6187 publications in Bioinformatics and found that the Bioinformatics research in India is gradually growing. The analysis of the authorship pattern, productivity pattern, degree of collaboration and co-authored index in the field of Bioinformatics research output in India was done. The authorship pattern showed a remarkable increase in the number of multi authored papers. The degree of collaboration was found to be 0.91. The study concludes that the researchers in Bioinformatics prefer team research than solo research.

Keywords: Bioinformatics; Authorship Pattern; Productivity; Degree of collaboration; Co-authorship Index; India.

INTRODUCTION

Bioinformatics is the art and science of electronically representing and integrating biomedical information that is, the genetic makeup. Bioinformatics is used for predicting gene functions and predict which genomic changes could give rise to each known inherited disease that is identification of genes causing disease and also genetic therapies that can reverse disease phenotype [1]. The most rudiment definition of Bioinformatics is any use of computers and computer based technology to handle biological information.

The National Center for Biotechnology Information (NCBI) defines it as field of study in which biology, information technology and computer science merge together to form a single discipline [2]. Bioinformatics uses computer programs and other aspects of the field of computer science to manage, catalogue and access the wide area of biological information. Bioinformatics has made it possible to trace the migration patterns of ancient humans from the traces of chromosomal sequences left in the genomic patterns of modern day society descendants. Today, maternity and paternity can be traced, assessed and certified through modern Biotechnology and Bioinformatics tools with chromosomal sequences of X and Y chromosomes as well as the evolutionary process involved in the polity of sexes [3]. The applications of Bioinformatics are visible in different walks of human life like molecular medicine, personalised medicine, preventive medicine, gene therapy, drug development, waste cleanup, climate change studies, crop improvement and so on.

The literature in Bioinformatics is growing exponentially. The area of Bioinformatics has made a significant impact in the research field within a short period. Many countries in the world have developed their own ways of research in the area of Bioinformatics.

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But as far as Bioinformatics is concerned, the collaborative study and sharing of data among countries have increased the research in the field. Research and development in Bioinformatics is growing rapidly and it can be easily observed that extensive cooperation is required among different research groups (often located in different countries) as primary data output is information oriented. The human, yeast, rice and other genome sequencing projects are particularly good examples of this multinational collaboration. GenBank at National Centre for Biotechnology Information (NCBI), together with the DNA Data Bank of Japan (DDBJ) and European Micro Biology Laboratory (EMBL), exchange data on daily basis. Most of the databases are publicly free of cost. However in recent years, commercial interests have created a few databases with restricted entry. Due to the fast evolving nature of Bioinformatics and close transition from technology driven science to an information driven science, the analysis of informatics in Bioinformatics is a challenge. But many efforts have been made to map research trends in Bioinformatics using published literature from NCBI [4], Web of Science [5] and Pub Med Central [6].

PREVIOUS STUDIES

Authorship trend and collaborative research form the important facets of bibliometric studies. The main aspects of authorship pattern include the type of authors, nature and degree of collaboration among them, collaborative trend of authors and the pattern of co-authorship. **Ngozi** [7] considers authorship as the prestige of all academic professions and the identification card through which academics are counted and recognized. Modern science shows an increased trend towards multiple authorship. **Macrina** [8] suggests that collaboration is inevitable in natural sciences and multidisciplinary areas to make significant advances and break through. The study of publication trends and authorship pattern is a relevant area of knowledge generation. **De Solla Price** [9] was the first to study the authorship pattern and based on his survey of Chemical Abstracts, observed that there is a steady trend towards multi authorship and if it continues at the present rate, the single author papers will be extinct by 1980s. A decrease in the number of papers published by the single authors is clearly evident in the recent research which goes side by side with the above postulate.

Authorship Pattern in Different Disciplines

In the past, the studies dealing with the authorship pattern of different subjects were done. **Senthilkumar & Muthukrishnan** [10] studied the authorship pattern and collaborative research of the oncology research output in India as listed in Web of Science. In the field of space craft technology, the authorship pattern and collaborative research have been done [11]. The authorship studies in LIS by **Shivcharan & Sandeep** [12] admitted the fact that the research in the field is collaborative in all respect. **Amsaveni & Manjula** [13] studied the applications of statistical models to the collaborative publications in the field of Bioinformatics for the period 1999-2013. **Tunga** [14] presented a case study of the authorship pattern and degree of collaboration in the field of horticulture. The authorship pattern and collaborative research in the field of network security [15], chemical sciences [16] and information technology [17] has been done. **Elango & Rajendran** [18] studied the pattern of authorship in marine sciences and **Arya & Sharma** [19] in veterinary science. The trends in the authorship pattern and collaborative research in Indian chemistry literature was done by **Pradhan, Panda & Chandrakar** [20].

Kumbar & Girish Kumar [21] attempted to identify the authorship trend and collaborative research in the field of Genetics and Plant breeding. **Zafrunnisha & Reddy** [22] studied the authorship pattern and degree of collaboration in psychology by sampling 141 PhD theses of universities and found predominance of multi authored papers over single authored. **Sudhier** [23] made a study of the trends in authorship pattern and collaborative research in physics in journal articles and book citations collected from the doctoral dissertations of IISc and found that the average degree of collaboration in journals was 0.08 and 0.44 for books. **Bandyopadhyay** [24] has studied the authorship collaboration in physics, philosophy and political science.

Krishna & Kumar; Kumbar, Harinarayan & Tejaswini and Farhat [25] [26] [27] have studied the authorship trend in the field of agriculture science. The authorship pattern of different disciplines such as mathematics, physics, mechanical engineering, philosophy and political science have been studied [28]. **Vimala & Pullareddy** [29]

studied the research collaboration and authorship pattern in zoology and **Arora & Pawan** [30] studied the correlation between multiple authorship and citedness in the field of immunology. The authorship pattern in zoology by **Begum & Rajendra** [31] and of various disciplines of physical sciences by **Maheswarappa and Mathias** [32] can be considered as the early studies in the field.

Authorship Pattern in Journals

Studies have been done on the authorship pattern and research collaboration of articles published in different journals. The authorship patterns and collaborative research in the journal “Collaborative Librarianship” has been studied [33]. The study on Hepatitis C covered in the journal ‘Gastroenterology’ presents the bibliometric analysis of the authorship pattern [34]. **Velmurugan & Radhakrishnan** [35] studied the growth and collaborative research pattern of scientific publications of ‘Journal of Intellectual Property Rights’ and found the authorship research trend to be collaborative. The authorship pattern of the journals ‘Malaysian Journal of Library and Information Science’ was done by **Thavamani** [36]. **Vijayanathan** [37] studied the authorship pattern in ‘Singapore journal of Library and Information Management’ and **Vijayanathan and Vijayakumar** [38] analyzed the authorship trend in ‘Open Software Engineering journals’.

The present study makes a detailed investigation on the pattern of authorship and research collaboration in the field of Bioinformatics during the period 2010-2014.

OBJECTIVES OF THE STUDY

- To analyze the nature of authorship pattern in Bioinformatics.
- To estimate the productivity pattern of authors.
- To study the single vs. multiple authored papers.
- To determine the degree of collaboration.
- To assess the co-authorship index in Bioinformatics research output.

METHODOLOGY

The data for the study was collected from the Web of Science (WoS) of the Thomson Reuters,

Philadelphia, USA which has a wide acceptance and is frequently used as a standard database of choice for doing the scientometric studies. The period of study selected was five different years from 2010-2014 which shows the flourishing of research in the field of Bioinformatics in India. Here, a publication from India refers to the publications contributed by an author who is affiliated to any Indian organisation being main author or co-author. The search strategy followed was:

(TS= ((“Bioinformatics” OR “Computational biology” OR “Computational Molecular Biology” OR “Molecular Biology” OR “Genomics” OR “Biology, Computational Molecular” OR “Biology, Computational” OR “Molecular Biology, computational” OR “Bio-informatics” OR “Bioinformatic” OR “sequence analysis”))).

To get the publications of India, the address and country field option was chosen to “India” in the advanced search option of the database. Again, that data was refined by selecting the subject categories or areas defined in the database itself. After the search, all the records were imported to MS Excel file, analysed and tabulated for making observations.

To calculate the degree of collaboration of authors, the mathematical formula proposed by **Subramanian** in 1983 is used. According to him, the degree of collaboration among authors in a discipline is the ratio of the number of multi authored papers published to the total number of papers published in a discipline during the certain period of time [39]. The degree of collaboration among authors is defined mathematically as

$$C = Nm / Nm + Ns$$

Where, C = Degree of collaboration in a discipline.

Nm = number of multi-authored papers in the discipline.

Ns = number of single-authored papers in the discipline.

Garg and Padhi [40] proposed a formula in order to find out how the pattern of co-authors has changed, and this formula was used for finding the Co-Authorship Index (CAI). The formula was suggested as

$$CAI = ((N_{ij} / N_i) / (N_{oj} / N_{oo})) 100$$

Where N_{ij} =number of papers having j authors in block i .

N_{i0} =Total output of block i .

N_{0j} =Number of papers having j authors for all blocks.

N_{00} = Total number of papers for all authors in all blocks.

$J=1, 2, 3 \dots N$

DATA ANALYSIS AND RESULTS

The search yielded 6095 records that dealt with the different aspects of Bioinformatics research in India. **Pendelbury** [41] and **Moed** [42] have suggested the standardization of the names of authors and their affiliation. So each record were scrutinized for authenticity and reliability of analysis.

Year-wise Distribution of Publications

From 2010 to 2014 constituting the five different years 2010, 2011, 2012, 2013 and 2014, a total of 6187 records from Web of Science database were found. Of these, 92 records were by anonymous authors. Since the author is an important factor in the authorship study, those records were not considered for the analysis. An attempt was made to calculate the year-wise distribution of Bioinformatics literature during the period as reflected in the Table 1.

Table 1: Year-Wise Distribution of Publications

| Year | No. of Records | % |
|--------------|----------------|------------|
| 2014 | 1371 | 22.49 |
| 2013 | 1509 | 24.76 |
| 2012 | 1296 | 21.26 |
| 2011 | 1024 | 16.8 |
| 2010 | 895 | 14.69 |
| Total | 6095 | 100 |

The year-wise distribution of 6095 articles published in Web of Science during the period 2010-2014 (5 years) is presented in the table. It is seen that the number of articles published is highest in the year 2013 with 1509 (24.76%) articles. 1371 (22.49%) is the publication rate of the year 2014 followed by 1296 (21.26%) in 2012, 1024 (16.80%) in 2011 and 895 (14.69%) in 2010. The result shows

that there was a steady increase in the number of publications from the year 2010 to 2013 and the year 2014 showed a slight decrease in the publication number. This study of year-wise distribution of publication gives a clear picture of the growth of literature in the field of Bioinformatics during the prescribed period.

Pattern of Productivity of Authors

The year-wise productivity pattern of authors in the field of Bioinformatics is presented in Fig.1. From the figure it is revealed that 505 papers (8.20%) were contributed by single authors while 5590 papers (90.3%) were contributed by multiple authors.

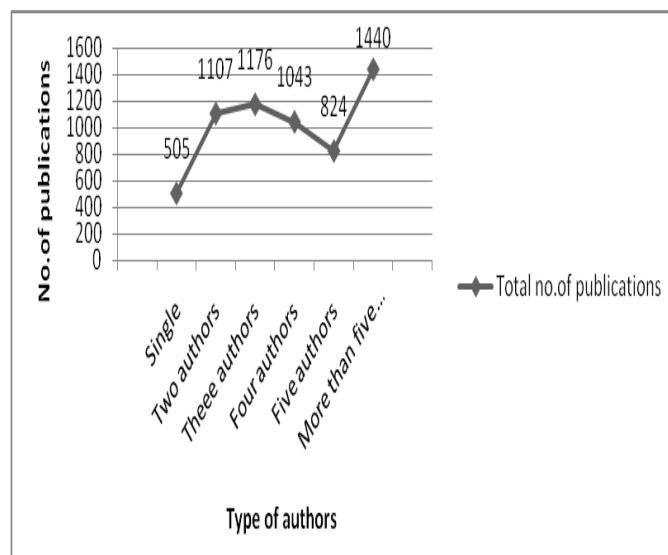


Fig 1: Productivity Pattern of Authors in Bioinformatics

Single vs. Multiple Authorship

It is clear from the analysis that majority of the papers were contributed by authors in collaboration. Each year shows that the multi author is predominant over the single authors. Number of single authors and number of multiple authors are calculated for each year and it was found that the highest percentage of multi authored papers is 94.67% in the year 2014 and the lowest, 89.05% in 2010. This analysis indicates that the researchers in Bioinformatics field prefer to do research in collaboration.

Table 2: Single vs. Multiple Authorship

| Year | Single Author | Multiple Author | Total Publications |
|--------------|------------------------|--------------------------|--------------------|
| 2010 | 98 (10.94%) | 797 (89.05%) | 895 |
| 2011 | 102 (9.96%) | 922 (90.03%) | 1024 |
| 2012 | 123 (9.49%) | 1173 (90.5%) | 1296 |
| 2013 | 109 (7.22%) | 1400 (92.77%) | 1509 |
| 2014 | 73 (8.29%) | 1298 (94.67%) | 1371 |
| Total | 505 (8.29%) | 5590 (91.71%) | 6095 |

8.3% of the papers are contributed by single authors and the two author contributions account for 18.2%. The study shows that more and more papers are being contributed under joint authorship. This shows that the researchers in Bioinformatics prefer team research.

Interestingly, it is also seen that maximum number of papers are written by either two (18.2%), three (19.3%) or four (17.1%) authors and there is a decreasing trend in the number of authors in team research as depicted in Fig.3. The sliding graph shows the decreasing trend in the number of authors in terms of group research with respect to more than five authors.

Authorship Pattern

Table 3 highlights the analysis of the authorship pattern of papers in Bioinformatics as observed in this study. The analysis reveals that

Table 3: Authorship Pattern in Bioinformatics

| S. No. | No. of Authors (Units) | No. of Articles | Total No. of Authors | % of Articles | %of Authors | Cum of Articles |
|--------|------------------------|-----------------|----------------------|---------------|-------------|-----------------|
| 1 | Single | 505 | 505 | 8.3 | 2 | 8.3 |
| 2 | Two | 1107 | 2214 | 18.2 | 8.6 | 26.5 |
| 3 | Three | 1176 | 3528 | 19.3 | 13.6 | 45.8 |
| 4 | Four | 1043 | 4172 | 17.1 | 16.1 | 62.9 |
| 5 | Five | 824 | 4120 | 13.5 | 15.9 | 76.4 |
| 6 | Six | 550 | 3300 | 9.1 | 12.8 | 85.5 |
| 7 | Seven | 325 | 2275 | 5.3 | 8.8 | 90.8 |
| 8 | Eight | 204 | 1632 | 3.4 | 6.3 | 94.2 |
| 9 | Nine | 142 | 1278 | 2.3 | 4.9 | 96.5 |
| 10 | Ten | 81 | 810 | 1.3 | 3.1 | 97.8 |
| 11 | Eleven | 36 | 396 | 0.6 | 1.5 | 98.4 |
| 12 | Twelve | 35 | 420 | 0.6 | 1.6 | 99 |
| 13 | Thirteen | 21 | 273 | 0.3 | 1.1 | 99.3 |
| 14 | Fourteen | 14 | 196 | 0.2 | 0.8 | 99.5 |
| 15 | Fifteen + | 32 | 748 | 0.5 | 2.9 | 100 |
| | Total | 6095 | 25867 | 100 | 100 | |

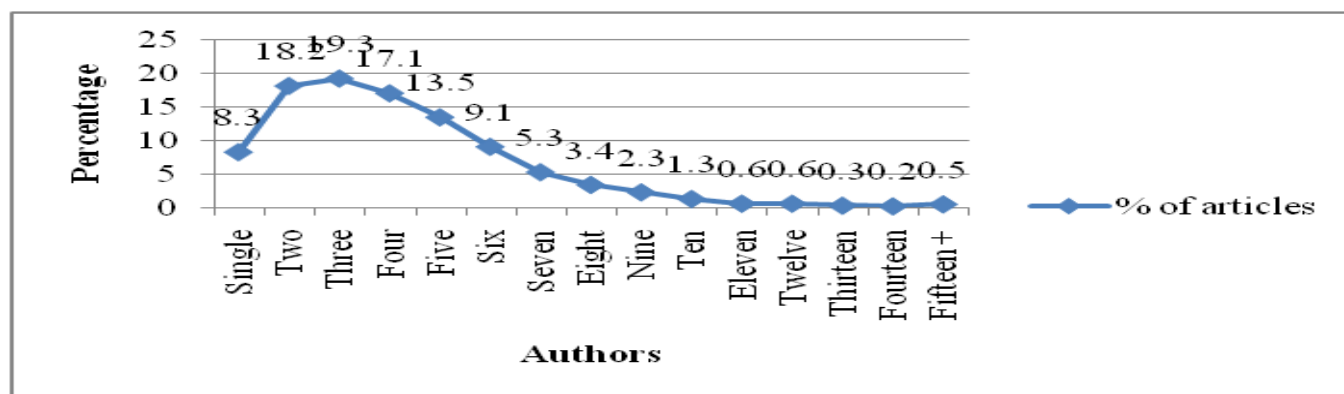


Fig 2: Authorship Trend Graph

Author's Productivity

The productivity of authors for the period 2010 to 2014 is depicted in Table 4. The Average Author per Paper (AAPP) = Number of author / Number of papers. Productivity per author = Number of papers / Number of authors.

Table 4 shows the data related to author's productivity. The total average number of authors per paper is 4.243 and the average productivity per author is 0.235. The highest number of author's productivity 1509 (0.235%) was in 2013. The minimum number of author's productivity 895 (0.246%) was in 2010.

Table 4: Author's Productivity

| S. No | Year | Total No. of Papers | Total No. of Authors | AAPP | PPA |
|-------|--------------|---------------------|----------------------|--------------|--------------|
| 1 | 2010 | 895 | 3636 | 4.062 | 0.246 |
| 2 | 2011 | 1024 | 4303 | 4.202 | 0.237 |
| 3 | 2012 | 1296 | 5330 | 4.112 | 0.243 |
| 4 | 2013 | 1509 | 6418 | 4.253 | 0.235 |
| 5 | 2014 | 1371 | 6180 | 4.507 | 0.221 |
| | Total | 6095 | 25867 | 4.243 | 0.235 |

Degree of Collaboration

The degree of collaboration in different years is calculated according to the formula proposed by Subramanyam and is presented in Table 5.

The degree of collaboration over the years 2010 to 2014 is calculated and it varies from 0.89 to 0.95. The mean value is found to be 0.91.

Table 5: Year wise Degree of Collaboration

| Year | Total No. of Articles | Total No. of Authors | No. of Single Authored Articles | % of Articles | No. of Multi Authored Articles | % of Articles | Degree of Collaboration |
|--------------|-----------------------|----------------------|---------------------------------|---------------|--------------------------------|---------------|-------------------------|
| 2010 | 895 | 3636 | 98 | 1.6 | 797 | 13.1 | 0.89 |
| 2011 | 1024 | 4303 | 102 | 1.7 | 922 | 15.1 | 0.9 |
| 2012 | 1296 | 5330 | 123 | 2 | 1173 | 19.2 | 0.9 |
| 2013 | 1509 | 6418 | 109 | 1.8 | 1400 | 23 | 0.93 |
| 2014 | 1371 | 6180 | 73 | 1.2 | 1298 | 21.3 | 0.95 |
| Total | 6095 | 25867 | 505 | 8.3 | 5590 | 91.7 | 0.91(Mean) |

Pattern of Co-authorship Index (CAI)

The pattern of Co- authorship Index (CAI) is calculated using the formula proposed by Garg and Padhi and the findings of CAI are tabulated in Table 6. The table shows that more than two author papers are highest when compared to the single authored papers and two authored papers. The results clearly

indicate that collaborative research is increasing in Bioinformatics research area.

The value of CAI of single authored papers shows a declining trend from one year to the other year. On the other hand for multi authors, the CAI reveals an increasing trend. Co-authored papers tend to be cited more frequently and Bioinformatics research in India is no exception to this.

Table 6: Pattern of Co- Authored Index (CAI)

| Year of Publication | Single Authors | CAI | Two Authors | CAI | More than Two Authors | CAI | Total |
|---------------------|----------------|--------|-------------|-------------|-----------------------|---------|-------------|
| 2010 | 98 | 132.16 | 165 | 101.5048977 | 632 | 96.006 | 895 |
| 2011 | 102 | 120.22 | 182 | 97.85826699 | 740 | 98.25 | 1024 |
| 2012 | 123 | 114.55 | 247 | 104.934438 | 926 | 97.142 | 1296 |
| 2013 | 109 | 87.18 | 274 | 99.97407904 | 1126 | 101.45 | 1509 |
| 2014 | 73 | 64.26 | 239 | 95.98127953 | 1059 | 105.017 | 1371 |
| Total | 505 | | 1107 | | 4483 | | 6095 |

CONCLUSION

A comparative study of literature growth during the five years indicates that Indian has contributed a good portion to the Bioinformatics research. The authorship trend and the degree of collaboration of papers of Bioinformatics research publications in India for the period 2010-2014 was studied.

A gradual growth of Indian research output in the field of Bioinformatics is observed. The single author publication is very less with 505 articles. The authorship pattern reveals a remarkable difference between the number of single and multiple authors. Patra & Mishra studied the growth of Bioinformatics literature using NCBI Pub Med for the period from 1990-2004 and the study revealed that a large proportion of publications were either single authored or two authored [4]. The study also found that most of the multi authored papers appeared after the year 2000. It is to be noted that in the present study, there was a marginal increase in the number of multi authored papers. Each year of study showed a clear increase in the multi authored papers. This high author number suggests the multi disciplinary nature of research and collaboration among different scientists in the field of Bioinformatics. The study found that the single authored papers maintained a low profile among the Bioinformatics researchers. The overall degree of collaboration for 5 years was

found to be 0.91 and the mean of degree of collaboration is also 0.91. The study concludes that the researchers in Bioinformatics prefer team research than solo research.

According to Arora & Pawan “Increase in multiple authorship and collaboration between researchers is an indication of growing professionalism in different fields. The collaboration and team work are among the most important necessities of scientific and technological work today” [30]. Further studies are required to establish inter-disciplinary and inter-institutional collaboration in Bioinformatics. Studies can also be done in various areas like co-authorship, bibliographic coupling, and bibliometric laws.

REFERENCES

- [1] Chaudhuri, A. & Chaudhuri, S. Role of bioinformatics in cancer. *Science Reporter*, 2010, 46-48.
- [2] NCBI, 2016.
<http://www.ncbi.nlm.nih.gov/About/primer/bioinformatics.html>
- [3] Tripathi, K K. Bioinformatics: The foundation of present and future biotechnology. *Current Science*, 79(5), 2000, 570-575.

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- [4] Patra, S K & Mishra. Bibliometric study of bioinformatics literature. *Scientometrics*, 67, 2006, 477-489.
- [5] Manoharan, A *et al.* Bioinformatics research: an informetric view. In: International Conference on Information Communication and Management. Singapore, 14-16, October 2011, Singapore, 199-204.
- [6] Song, M. *et al.* Productivity and influence in bioinformatics: a bibliometric analysis using PubMed Central. *Journal of American Society of Information Science & Technology*, 65, 2014, 352-371.
- [7] Ngozi, O. Authorship and co-authorship: Some basic facts librarians should know, *Journal of Applied Information Science and Technology*, 3, 2010, 25-29.
- [8] Macrina, F L. Scientific integrity: an introductory text with case studies. Washington: ASM Press, 2000.
- [9] Price, D J. Little Science Big Science. New York: Columbia University Press, 1963.
- [10] Senthilkumar, R. & Muthukrishnan, M. Authorship patterns and collaborative research of oncology research output in India: A scientometric study. *Kong. Research journal*, 3(2), 2016, 123-128.
- [11] Iqbalahmed, U R & Ashalatha, L. Authorship pattern and collaborative research trends in the field of spacecraft technology. *The Electronic Library*, 33(4), 2015.
- [12] Shivcharan & Sandeep Kumar. Authorship pattern and collaborative research trends in the field of library and information science. *Indian streams Research Journal*, 5(8), 2015, 1-7.
- [13] Amsaveni, N & Manjula, M. Application of Statistical models to the collaborative publications in bioinformatics. *International Journal of Computer Science and mobile Computing*, 3(2), 2014, 606-616.
- [14] Tunga, S K. Authorship pattern and degree of collaboration in journal articles: A citation study on doctoral dissertations 1991-2010. *Information Studies*, 20(2), 2014, 85-96.
- [15] Amsaveni, N & Vasanthi, R. Authorship pattern and collaborative research in the field of network security. *Indian Journal of Applied Research*, 3(1), 2013, 52-54.
- [16] Goyal, G., Gupta, G K & Kumar, A. Authorship pattern and collaborative research trends in the field of chemical sciences. *International Journal of Information Dissemination and Technology*, 3(3), 2013, 184-186.
- [17] Khaparde, V & Pawar, S. Authorship pattern and degree of collaboration in Information Technology. *Journal of Computer Science and Information Technology*, 1(1), 2013, 46-54.
- [18] Elango, B & Rajendran, P. Authorship trend and collaboration pattern in the marine science literature: A scientometric study. *International Journal of Information Dissemination and Technology*, 2(3), 2012, 166-169.
- [19] Arya, C & Sharma, S. Authorship trends and collaborative research in veterinary science: a bibliometric study. *Chinese Librarianship: An International Electronic Journal*, 34, 2011, 38-46.
- [20] Pradhan, P; Panda, S & Chandrakar, R. Authorship pattern and degree of collaboration in Indian chemistry literature. In: 8th International CALIBER-2011, Goa, India. 2011, 65-70.
- [21] Kumbar, M & Girish Kumar, N. Authorship trend and collaborative research in genetics and plant breeding. *SRELS Journal of Information Management*, 48(2), 2011, 43-58.
- [22] Zafrunnisha, N & Pullareddy, V. Authorship pattern and degree of collaboration in psychology. *Annals of Library and Information Studies*, 56(1), 2009, 255-261.
- [23] Sudhier, K G. Authorship pattern in physics literature: An informetric study on citations in doctoral theses of the Indian Institute of Science. *Annals of Library and Information Studies*, 54, 2007, 90-94.
- [24] Bandyopadhyay, A K. Authorship collaboration in physics, philosophy and political science. In: 11th IASLIC National Seminar, Kolkata. 2004, 405-409.
- [25] Krishna, K M & Kumar, S. Authorship trends in agriculture research. *SRELS Journal of*
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- Information Management*, 41(2), 2004, 229-234.
- [26] Kumbar, M.; Harinarayan, N S & Tejaswini, T. Authorship trend and collaborative research in Agricultural Science. *IASLIC Bulletin*, 50(4), 2004, 241-248.
- [27] Farhat, H. Authorship patterns in agriculture science in Egypt. *Scientometrics*, 55(2), 2002, 157-170.
- [28] Bandyopadhyay, A K. Authorship pattern in different disciplines. *Annals of Library and Information Studies*, 48(4), 2001, 139-147.
- [29] Vimala, V & Pullareddy, V. Authorship pattern and collaborative research in the field of zoology. *Malaysian journal of library and information science*, 1(2), 1996, 43-50.
- [30] Arora, J & Pawan, U. Collaborative research and authorship pattern in Immunology: Correlation between multiple authorship and citedness. *IASLIC Bulletin*, 40(2), 1995, 73-83.
- [31] Begum, K J & Rajendra, N. Research collaboration in zoological sciences. *IASLIC Bulletin*, 35(2), 1990, 79-82.
- [32] Maheswarappa, B S & Mathias, S A. Authorial collaboration in various disciplines of the physical sciences in India: A Bibliometric study. *Journal of Library and Information Science*, 12(2), 1987, 136-155.
- [33] Thavamani, K. A study of authorship patterns and collaborative research in Collaborative Librarianship. 2009-2014. *Collaborative Librarianship*, 7(2), 2016, 84-95.
- [34] Ramakrishnan, J & Thavamani, K. Authorship pattern and collaborative research in the field of Hepatitis C. *Asian Journal of Information Science and Technology*, 5(1), 2015, 23-32.
- [35] Velmurugan, C & Radhakrishnan, N. Collaborative research and authorship pattern of Intellectual Property Rights. *Journal of Information Management*, 2(2), 2015, 90-101.
- [36] Thavamani, K. Authorship patterns and collaborative research in Malaysian Journal of Library and Information Science. 1996-2012. *Library Philosophy and Practice*, 2014, 1177.
- [37] Vijayanathan, R. Authorship and collaborative patterns in the Singapore Journal of Library and Information Management. 2008-2012. *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, 2(6), 2014, 137-142.
- [38] Vijayanathan, R & Vijayakumar, K. Authorship and collaborative patterns in the Open Software Engineering Journals. 2007-2012. *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, 2(10), 2014, 263-267.
- [39] Subramanian, K. Bibliometric studies of research in collaboration: A review. *Journal of Information Science*, 1983, 637.
- [40] Garg, K C & Padhi, P. A study of collaboration in laser science and technology. *Scientometrics*, 51, 2001, 415-427.
- [41] Pendelbury, D A. White paper: Using bibliometrics in evaluating research. Thomson Reuters. Philadelphia, USA, 2010, 8.
- [42] Moed, H F. Problems with the names of authors and institutions and with the delimitation of subfields. In: *Citation analysis in Research Evaluation*. Springer, 2005, 181-189.
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