Scientometric Portrait of Sir K.S. Krishnan

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[K.S. Krishnan, the well known Indian physicist was widely recognized as a very successful scientist. His publications were analysed by year, domain, collaboration pattern, channels of communications used, keywords etc. The results indicate the temporal variations of his productivity and of the types of papers published by him is of such a nature that he is eminently qualified to be taken as a 'role model' for the younger generation to emulate. He had to his credit 135 papers, out of which 50 papers were in 'Spectroscopy', 60 papers in 'Mangnetism', 23 papers in 'Thermionics', and 2 papers of 'Popular' nature.

The highest collaboration coefficient was observed during 1937-38, 1944-45, 1951-53, 1955, and 1961. The productivity coefficient was 0.32. The publication density was 6.43 and publication concentration was 7.69. Average synchronous selfcitations rate was 13.82. Bradford's multiplier was 4.34. The keywords from the titles of the article having high frequency were Crystals (24), magnetic anisotropy (14), Graphite (10) and Liquids (10).]

1. Introduction

Kariamanikkam Srinivasa Krishnan was born on 4th December 1898 in the village of watrap near Srivilliputtur in the Tirunelveli (Now Ramnad) district in Tamilnadu. Krishnan had his early education in Watrap and Srivilliputtur. He had his college education first in the American college, Madura and later in the Christian College, Madras. He worked as a demostrator for some time in the same college immediately after his graduation. He later went to Calcutta to study physics under C.V. Raman.

Realising the potentials of Krishnan, C.V. Raman took him as a Research Associate in the Indian Association for the Cultivation ofScience. He collaborated with Raman in making a detailed examination of the changes in the frequency and polarization of light which was found to be associated with molecular scattering. These studies ultimately led to the discovery of the 'Raman effect' in 1928.

Keyword / Descriptors

K.S. Krishnan, Spectroscopy, magnetism, Thermionics, Biblometrics, Scientometrics, Productivity coefficient, Publication concentration, Publication density, History of science, Sociology of science, Individual scientist, Scientometric portrait, Biobibliomerics, Role model scientist.

Krishnan was a Reader in Physics at Dacca University during 1929-1933. He was invited to take up the Mahendralal Sircar Professorship at Calcutta University in 1933 and held the post till 1942. He accepted the offer of professoship of physics at Allahabad University in 1942 and was holding the post till 1947. He became the Director of national Physical Labortory, New Delhi, in 1947 and remained its Director till his death.

He was closely associated with Department of Atomic Engergy since its inception. He was a member of Atomic Energy Commission during 1948-1961.

Many honours and awards were bestowed on him in recognition of his contribution in the field of physics. Important ones being :

Liege University medal (1937), Krishna Rajendra Jubilee Gold Medal (1941), Knighthood (1946), Padma Bhushan (1954), Bhatnagar Memorial Award (1958), Fellow of the Royal Society (1940), President, Indian Science Congress (1949), Chairman, Board of Research in Nuclear Sciences, Chairman, Indian National Committee for International Geophysical Year (1957-58), Vice-President, International Union of 'Pure and Applied Physics', and Vice-President, International Council of Scientific Union (1955-57).

He was also Honorary Fellow of several national and International Scientific Academies [1-3].

2. Objectives

Objectives of present work are to highlight quantitative aspects of the research communications :

- authorship pattern,
- domainwise contribution,
- author productivity,
- use of Channels of Communication,
- Citation behaviour, and
- documentation of keywords from titles.

3. Methodology

The informing activities of K.S. Krishnan's Research Group [4] were considered for the present study. The entries in the bibliography were arranged in a classified order under the following domains :

A = Sepectroscopy
B = Magnetism
C = Thermionics
D = General

Normal count procedure [5] was followed. Full credit was given to each author regardless of whether he happens to be the first or the last author. It is widely recognised that scientists all over the world look at their own papers exclusively in that way. Similarly titles of the articles were analysed and one score was alloted for each keyword, subject, journal etc.

The degree of collaboration [6] in a discipline was defined as the ratio of the number of collaborative research papers to the total number of research papers published in the discipline during a certain period of time.

Vinkler [7] defined publication density as the ratio of the total number of papers published to the total number of journals in which the papers published, and publication concentration as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study.

Sen and Gan [8] defined productivity coefficiet as the ratio of 50 percentile age to the total productivity age.

Frequency of keywords from the titles of the articles were recorded. Data obtained from above study were presented in tables and figures.

4. Results and Discussion

During 1925-1961 K.S. Krishnan had published 135 papers out of which single authorship papers were 31(22.96%), two authorship papers were 5(3.70%).

Frequencies of single authorship and multiauthorship papers, cumulative number of papers, and collaboration coefficient are depicted in figure 1. His first single authored paper was published when he was of 27 years of age which was published in 'Philosophical Magazine' (London) in 1925 while he was research scholar at Indian Association for the cultivation of science at Calcutta.

Out of his 99 two authorship papers published by him, he was first author in 64 papers. He was first author in all five

three authorship papers. Thus he had 100(74.07%) papers to his credit as main (first) author. He published 13 papers in 1928 at 30 years of age. He had published 9 papers per year during 1927, 1933, 1952 and 1954. However he did not publish any paper during 1946-47, 1949, and 1957-59 during his tenure of Director of National Physical laboratory.

Highest collaboration coefficient was observed during 1937-38, 1944-45, 1951-53, 1955, and 1961. Details of his publication pattern are provided in Table 1. His productivity coefficient was 0.32 which is clear indication of his produtivity within first 12 years of his publication career.

Domainwise collaboration pattern of K.S. Krishnan's research group is provided in Table 2 and Figure 2.

His major interest throughout was in Spectroscopy and magnetism. It is only in 1952 he started his publications in Therminoics. His research group had published 50 papers and 90 (26-89%) authorships in the domain 'Spectroscopy'. He had to his credit 60 papers and 108 (44.26%) authorships in the domain 'magnetism'. He had published 23 papers and 44 (18.03%) authorships in the domain 'Thermionics'. He had published only two papers which are of general popular nature.

In all he had collaborated with 24 researchers. He came in contact with C.V. Raman in 1923 and published first paper with him in the year 1926. It has been well recognized that he had actively contributed in the publication of C.V. Raman due to which Nobel prize was bestowed on C.V. Raman (9). Thus C.V. Raman was his 'Mentor' (10).

Figure 1 clearly indicates that after accepting the professorship position his publication productivity was slowed down due to administrative responsibilities which is in cotrast with the several findings that head of the department seem to be most productive researcher.

This may be due to his interest and devotion to the developmental activities of the research institute.

Figure 3 clearly shows the active researchers associated with him like S. Banerji and S.C. Jain. It may be noted that S.C. Jain came into his contact only at the later part of his life during 1952-55 producing 18 papers.

The three active collaborators who had produced five or more than five papers were N. Ganguli, A. Mookerji and S.K. Roy.

Total authorships to the credit of the research group of K.S. krishnan were 244.

Author productivity and distribution of authorships by domains is shown in Table 3.

The 85 percent of the authorships belong to five persons (20%) out of the 25 persons involved in this research group. Thus it follows 80/20 rule [11].

In the present case study 129 papers were published in 20 journals and six papers were published in Symposia, conference proceedings, meetings etc. Top ranking journals wherein he has published papers were 'Nature' (46), (34.07%), 'Proceedings of the Royal Society - A' (24), (17.78%), Indian Journal of Physics' (9), (6.68%), and 'Philosophical Magazine' (9), (6.68%).

The Countrywise distribution of journals publishing the articles of K.S. krishnan were UK (7), India (7), US(2), Germany (2), France (1), and Switzerland (1) as shown in Table 4.

His publication density was 6.43 and publication concentration was 7.69"

Distribution of articles vide Bradford Law of Scatter among journals is provided in Table 5 and Figure 4.

When we apply Bradford distribution in four zones (Table 6) we found that he had very high concentration in first zone having publised 46 papers in only one journal. Second and third zones include 42 and 47 papers respectively. We are left with nil papers for zone four. This is in the same pattern as found in publication distribution pattern of C.V. Raman [9]. Average Bradford multiplier was 4.34.

Domainwise synchronous self citations rate for the publications of K.S. krishnan is given in Table 7 and indicated that the highest syncronous self citation rate 19.02 was for the domain 'Thermionics'. It was 9.75 for the domain 'Spectroscopy' and 14.77 for the domain 'Magnetism'. Average synchronous self citations rates were 13.82. This has sociological implications indicating that K.S. Krishnan was a highly productive and key figure in his research speciality [12].

The bibliographic characteristics such as range, mean standard deviation and percent coefficient of variation for number of pages, visuals, tables, references, and self citations per article in the publications of K.S. Krishnan are provided in Table 8.

Keywords from the titles of the articles were counted and their frequencies more than two included in Table 9. Highest frequency of 24 was for the key word 'Crystals'. The keywords having high frequency were 'Magnetic anisotropy' (14), 'Graphite' (10), and 'Liquids' (10). The results indicate that he had wide ranging interests in microtheme and super-specializations in physics.

Keywords from the titles of the articles used only once are presented in Table 10. These keywords indicate his wide spectrum of interest, materials, methods, instruments used and the subjects addresed to in the course of his 37 years of research paper publishing life span.

Krishnan created new specialities which have wide ranging applications in the fields of Spectroscopy, Magnetism, and Thermionics and research is being done in these specialities to explore the applications and uses of the principles enunciated by him. Specialities just cannot be created, it requires hard work, dedication and continuous intellectual intercourse among the people who seize concepts.

A few studies, have been carried out on scientists and Scientific Organizations [9, 12-58]. It is felt that more studies should focus attention on the functioning of research group and their accountability in the economic crisis that the country is facing. Already there is decline in support for science and technology. India was investing 1.1 percent of the GNP which was reduced in 1991 to less than 0.9 percent. As budgets for research are being restrained a better allocation of the existing resources is necessary. A rational distribution of budgets according to the established priorities is of course needed in order to promote the desired areas of research. Neverthless, while designing national priorities, the perception of the human scientific potential that a country has is as important as the funds for research.

Nagpaul and Gupta [30] have concluded after study of 1460 research units in six countries that professional competence is a necessary but not a sufficient condition for effective leadership, but professional competence is much more important than managerial competence. This implies, inter-alia, that the quality of leadership cannot be improved merely through management development programmes. It would also be essential and desirable to imporve the level of expertise of the leaders through a package of incentives like sabbatical leave to enable them to work at centres of excellence within or outside the country and by inviting leading scientists from such centres to work in the research institutions.

Librarians have been invisible members of the science community for too long. Through the studies in the interdisciplinary domain of scientiometrics they can show their visibility. Librarians should begin to understand that their economic value is not to publishers so much as it is to the community of interests that we call research and development, national defence, industry, higher education, and national economy.

The library profession should share the concern of educators, public servants, and scientists regarding the science literacy crisis [59]. To date, there has been relatively little written in the literature of librarianship about science literacy. The library profession has to play its potentially significant role in the promotion of science literacy.

5. Conclusion

Publications productivity analysis of the successful scientist, K.S. Krishnan, carried out here has thrown light on his pivotal contributions to science and technology. He can be considered as a 'role model' for younger researchers to follow. Knowledge is valuable for its own sake and research has cultural value, Desire of being creative is built in our genes. Who knows this effort may switch on genes for creativity in some of those who happen to read this article. Narrating success stories always has an encouraging effect. It is also important to recognise that excellence in science is not just a matter of a few individual success, what is required is a wide base of high quality, which would enable peaks to come up more frequently

and on a more definite basis. New ways to motivate scientists seems as important to contest outcome as new sources of funds. Science policy makers interested to know about functioning of active research teams as centres of excellence outputs may find further interest in scientometrics. As per Indian Scientific Policy Resolution 1958, which our scientists regard as their charter, "to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity" all must work gogether with holistic approach.

There is no dearth of ideal role model scientists in India, what we lack is the systematic and continuous studies on such scientists. Hence, the comment "Most of the developing countries lack role models to motivate other scientists" [60] does not hold good at least for India.

It is further suggested that citation analysis of K.S. Krishnan's publications should be undertaken to assess the impact of his research.

REFERENCES

1. LONSDALE (K) and BHABHA (HJ). Biographical Memoirs of Fellows of the Royal Society, V.13, London, The Royal Society, 1967, 245-255.
2. RAMANATHAN (KR). Professor K.S. Krishnan, F.R.S. *Journal of Scientific and Industrial Research.* 17-A, 1958, 485-488.
3. SING (J). Some eminent Indian Scientists, New Delhi, Ministry of Information and Broadcasting; 1966, 89-95.
4. NATIONAL PHYSICAL LABORATORY. Collected Works of K.S. Krishnan, New Delhi, NPL, 1988.
5. PRAVDIC (N) and OLUIC-VUKOVIC (C). Dual approach to multiple autorship in the study of collaboration/ scientific output relationship. *Scientometrics.* 10(5-6), 1986, 259-280.
6. SUBRAMANYAM (K). Bibliometric studies of research collaboration; a reviw. *Jl. Inf. Sci.* 6(1), 1983, 33-38.
7. VINKLER (P). Bibliometric analysis of publication activity of a scientific research institute. *In* Informetrics 89/90. Edited by EGGHE (L) and ROUSSEAU (R). Elsevier Science Publishers. B.V., 1990, 309-334.

8. SEN (SK) and GAN (SK). Biobibliometrics : concept and application in the Study of productivity of Scientists. *Int. Forum Inf. and Doc.* 15(3), 1990, 13-21.
9. KADEMANI (BS), KALYANE (VL), and KADEMANI (AB). Scientometric portrait of Nobel Laureate Dr. C.V. Raman. *Indian Journal of Information, Library & Society,* 7(3-4), 1994, 215-249.
10. LONG (JS) and McGINNIS (R). The effect of the mentor on the academic career. *Scientometrics.* 7(3-6), 1985, 255-280.
11. EGGHE (L). On the 80/20 rule. *Scientometrics* 10 (1-2), 1986, 55-68.
12. LAWANI (SM). On the heterogeneity and Classification of author self-citations. *J. Am. Soc. Inf. Sci.* 33,1982, 281-284.
13. GUPTA (DK). Plate tectonics : a case study of transmission of ideas. *Ann. Lib. Sci. Doc.* 25(1–4), 1978, 86–92.
14. COLE (S). Age and Scientific Performance. *Am. J. Sociol.* 84, 1979, 958–977.
15. RUFF (I). Citation analysis of a scientific career : a cae study. *Social Studies of Science* 9, 1979, 81-90.
16. CAWKELL (T) and GARFIELD (E). Assessing Einstein's impact on today's Science by citation analysis. *In* Einstein : the first hundred years. Edited by Goldsmith (M), MACKAY (A) and WOUDHUYSEN (J). Oxford, Pergamon press, 1980, 31-40.
17. KNORR (KD) and MITTERMEIR (R). Publication productivity and professional position : Cross-national evidence on the role of organizations. *Scientometrics.* 2(2), 1980, 95-120.
18. SINHA (SC) and BHATNAGAR (MS). The information profile of a plant pathologist : a bibliometric study. *Ann. Lib. Sci. Doc.* 21(1-4), 1980, 106-113.
19. LONG (JS) and McGINNIS (R). Organizational context and scientific productivity. *Am. Soc. Rev.* 46, 1981, 422-442.
20. OVER (R). Does research productivity decline with age ? *Higher Education.* 11, 1982, 511.

21. GUPTA (DK). Citations analysis : a case study of a most cited author and his most cited article on sea floor spreading. IASLIC Bull. 28 (1), 1983, 1-12.
22. GUPTA (DK). Chandrasekhar : Winner of the 1983 Nobel Prize for Physics : a citation analysis study of his works. *Ann. Lib. Sci. Doc.* 30 (3–4), 1983, 177-184.
23. FOX (MF). Publication productivity among scientists : A critical review. *Social Studies of Science.* 13, 1983, 285-305.
24. GUPTA (DK) and GUPTA (S). A citography on Lepichon's article on sea-floor spreading and continental drift; appliction of Bradford's law. IASLIC Bull. 28 (2), 1983, 49–58.
25. SIMONTON (DK). Quality, Quantity and age : the careers of ten distinguished psychologists. *Int. J. Aging. and Human Development.* 21, 1985, 241
26. DIEKS (D) and SLOOTEN (WJ). Historic papers in physics - The case of Hugo Martin Tetrode, 1895–1931. *Czech. J. Phys.* B-36, 1986, 39-42.
27. GUAY (Y). Emergence of basic research on the periphery : organic chemistry in India, 1907-1926. *Scientometrics.* 10 (1-2), 1986, 77-94.
28. HORNER (KL) RUSHTON (JP) and VERNON (PA). Relation between aging and research productivity of academic psychologists ? *Psychology and Aging.* 1, 1986, 319.
29. BELGUM (KJ) and SAMI (LK). Research collaboration in agricultural Science. *International Library Review.* 20, 1988, 57–63.
30. NAGPAUL (PS) and GUPTA (SP). Effect of professional competence, managerial role and status of group leaders to R & D performance. *Scientometrics.* 17(3-4), 1989, 301-331.
31. KRAGH (H). Dirac Bibliometrics. *In* Dirac : a scientific biography. Cambridge, Cambridge University press; 1990, 293-301.
32. KALYANE (VL). Sugarcane breeding Institute, Coimbatore. *Biology Education.* 7(2), 1990, 141-145.

33. KALYANE (VL) and VIDYASAGAR RAO (K). Collaboration trends in Sugarcane research – A case study. *Ann. Lib. Sci. Doc.* 39(1), 1991, 9-11.

34. MURTY (I). C.N.R. Rao - Interview. *Science Today 2001.* July, 1991, 41-42 and 65-68.

35. KALYANE (VL) and KALYANE (SV). Scientometric dimensions of innovation communication productivity system. *Ann. Lib. Sci. Doc.* 38 (1), 1991, 8-29.

36. TODOROV (R) and WINTERHAGER (M). An overview of Mike Moravosik's publication activity in physics. *Scientometrics.* 20 (1), 1991, 163-172.

37. KALYANE (VL). Dr. M.S. SWAMINATHAN - Biologist par excellence. *Biology Education.* 9 (30) 1992, 246-248.

38. GARG (KC) and KARKI (MMS) Bibliometrics of research communication of INSA fellows. *J.Sci. Ind. Res.* 51, 1992, 929-935.

39. LANCASTER (FW), ZETER(MJ) and METZLER (L). Ranganathan's influence examined bibliometrically. *Libri* 42(3), 1992, 268-281.

40. KALYANE (VL) and KALYANE (SV). Biohistorical perspective of sugarcane research for Bihar State. *Bharatiya Sugar.* Oct. 1993, 25-27.

41. SINHA (SC) and ULLA H (MF). Citation profile of Dr. V.S. Ramacandran : a bibliometric analysis of his highly cited articles and books in the area of cement and conrete Chemisty. *Ann. Lib. Sci. Doc.* 40(1), 1993, 21-31.

42. LANOUETTE (W) and SILARD (B). Genius in the shadows : a biography of Leo Szilard the man behind the Bomb. New York. Charles Scribner's Sons, 1992, 441.

43. MUNSHI (UM), VASHISHTH (CP) and GAUTAM (JN). Research collaboration in agricultural sciences. *ILS Bulletin* 28 (3-4), 1993, 57-60.

44. KALYANE (VL). Informetrics on neem research in India. *Library Science with a slant to documentation and information studies.* 30 (4), 1993, 130-214.

45. KALYANE (VL). Establishing scientometric database for harnessing expertise and information sciences,

International Information Communication and Education, 13(2), 1994, 208-212. (RS).

46. KALYANE (VL) and DEVARAJ. Informetrics on C.S. Venkata Ram. *In* New Horizons in Library and Information Science : Dr. Velaga Venkatappaiah Festschrift, Edited by Vashishth (CP), Ramaiah (LS), Jagga Rao (NV), and Prafulla Chandra (TV), Madras, T.R. Publications, 1994, 475-478.
47. KALYANE (VL) and KALYANE (SV). Scientometric portrait of M.S. Swaminathan. *Lib. Sci. with a Slant to Documentation and Information Studies.* 31, 1; 1994, PP 31–46.
48. KADEMANI (BS), KALYANE (VL), and BALAKRISHNAN (MR). Scientometric portrait of P.K. Iyengar. *Lib. Sci. witha Slant to Documentation and Information Studies.* 31 (4), 1994, 155-176.
49. KALYANE (VL) and KADEMANI (BS). Scientometric portrait of U.R. Murty, *Timeless Fellowship,* 16, 1994, 1–23.
50. RAMANA (PV), KALYANE (VL) and MUNNOLLI (SS). Informetrics on Mushrooming growth of Mushroom research in India. *Timeless Fellowship.* 16, 1994.
51. KALYANE (VL) and SAMANTA (RK). Informetrics on K. Ramiah, *In* New Vistas in Library and Information Science : Papers in honour of Prof. G.V.S.L. Narshinha Raju, Edited by Raju (AAN), Ramaiah (LS), Laxman Rao (N), and Prafulla Chandra (TV), New Delhi, Vikas, 1995, 565-578.
52. MUNNOLLI (SS) and KALYANE (VL). Scientometric portrait of R.G. Rastogi. (in press).
53. KALYANE (VL) and VIDYASAR RAO (K). Quantification of credit for authorshp. *ILA Bulletin.* 30 (3-4), 1995, 94-96.

54. KALYANE (VL) and KALYANE (SV). R & D Comunication staratagy vis-a-vis librarianship. *Journal of Information Science,* 4 (3), 1994, 105-135.

55. KALYANE (VL). scientometric portrait of Vinodini Reddy. *J. Info. Sciences* 4(1), 1993, 25-47.

56. KADEMANI (BS) and KALYANE (VL). Outstandingly cited and most significant publictions of R. Chidambaram. a Nuclear Physicist, Malaysian Journal of Library & Information Science Vol.1, No.1, pp. 21-36.(1996)

57. KALYANE (VL) and MUNNOLLI (SS). Scientometric portrait of T.S. West. *Scientometrics,* 33(2), 1995, 233-256,

58. KALYANE (VL) and SEN (BK). A Bibliometric Study of the Journal of Oilseeds Research, *Annals of Library Science and Documentation,* 42(4), 1995, pp. 121-141.

59. SAPP (G) Science literacy through popularization : problems and potential. *Sci. Tech. Lib.* 12; 1991, 43–57.

60. KRISHNA (VV). Book review – Scientists in the Third World by JACQUES (G). Lexington; 1991. *In J. Sci. Ind. Res.* 50, 1991, 463–466.

Table 1 : Authorship pattern in publications of K.S.Krishnan with collaboration coefficient and age

Year	I	II		III	Total	Collaboration coefficient	Main author	Age
	a	a	b	a				
1925	1	-	-	-	1	0.00	1	27
1926	2	-	2	-	4	0.50	2	28
1927	1	-	8	-	9	0.89	1	29
1928	3	-	10	-	13	0.77	3	30
1929	2	1	1	-	4	0.50	3	31
1930	1	1	-	-	2	0.50	2	32
1931	2	1	-	-	3	0.33	3	33
1932	2	-	-	-	2	0.00	2	34
1933	1	6	-	2	9	0.89	9	35
1934	2	5	-	-	7	0.71	7	36
1935	-	8	-	-	8	1.00	8	37
1936	1	3	1	-	5	1.00	4	38
1937	-	5	-	-	5	1.00	5	39
1938	-	8	-	-	8	1.00	8	40
1939	2	4	-	1	7	0.71	7	41
1940	3	-	-	2	5	0.40	5	42
1941	1	-	1	-	2	0.50	1	43
1944	-	1	-	-	1	1.00	1	46
1945	-	1	-	-	1	1.00	1	47
1948	2	-	2	-	4	0.50	2	50
1950	1	-	-	-	1	0.00	1	52
1951	-	3	-	-	3	1.00	3	53
1952	-	7	2	-	9	1.00	7	54
1953	-	1	1	-	2	1.00	1	55
1954	1	3	5	-	9	0.89	4	56
1955	-	1	2	-	3	1.00	1	57
1956	1	2	-	-	3	0.67	3	58
1960	2	2	-	-	4	0.50	4	62
1961	-	1	-	-	1	1.00	1	63
Total	31	64	35	5	135		100	
Percentage	22.96	47.41		25.93	3.70			
Cumulative %	22.96	70.37		96.30	100			

I = Single author Papers

II = Two author Papers

III = Three author Papers

a = First author

b = Second author

Table 2 : Domainwise collaboration of K.S. Krishnan

Sl. No.	Name	A						B						C			D	Total	Year		
		I	II		III			I	II		III			I	II		I		FPY	LPY	Total
			a	b	a	b	c		a	b	a	b	c		a	b					
1.	Krishnan, K.S.	12	20	16	2	–	–	15	34	8	3	–	–	2	12	9	2	135	1925	1961	37
2.	Raman, C.V.	–	14	–	–	–	–	–	6	1	–	–	–	–	–	–	–	21	1926	1929	4
3.	Ramachandra Rao, S.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1929	1929	1
4.	Dasgupta, A.C.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1930	1933	4
5.	Sarkar, A.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1931	1931	1
6.	Banerji, S.	–	–	4	–	–	–	–	–	11	–	–	2	–	–	–	–	17	1933	1939	7
7.	Mitra, S.M.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1933	1933	1
8.	Mukhopadhyay, S.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1933	1933	1
9.	Guha, B.C.	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	1933	1933	1
10.	Chakravorty, N.C.	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	1933	1933	1
11.	Guha, A.C.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1934	1934	1
12.	Seshan, P.K.	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	4	1934	1938	5
13.	Gangali, N.	–	–	–	–	–	–	–	1	4	–	–	–	–	–	–	–	5	1935	1941	7
14.	Narayanaswami, L.K.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1935	1935	1
15.	Lonsdale, K.	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1	1936	1936	1

16.	Mookerji, A.	–	–	–	–	–	–	–	–	8	–	1	–	–	–	–	–	9	1938 – 1939	2
17.	Bose, A.	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	2	1938 – 1939	2
18.	Chakrabarty, D.C.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1938 – 1938	1
19.	Ananthapadmanabhan, T.S.	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	2	1940 – 1940	1
20.	Chorghade, S.L.	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	2	1940 – 1940	1
21.	Bhatia, A.B.	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	4	1944 – 1948	5
22.	Roy, S.K.	–	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	9	1951 – 1956	6
23.	Jain, S.C.	–	–	–	–	–	–	–	–	–	–	1	–	–	9	9	–	18	1952 – 1955	4
24.	Klemens, P.G.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1952 – 1952	1
25.	Sundaram, R.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2	1960 – 1960	1
	Total	12	36	36	2	2	2	15	42	42	3	3	3	2	21	21	2	244		
	Demainwise authorship		90				108				44					2				
	Percentage		36.89				44.26				18.03					0.82				

A = Spectroscopy, B = Magnatism, C = Thermionics, D = General, a = First author, b = Second author, c = Thrid author, FPY = First paper published year, LPY = Last paper published year, I = Single author papers, II = Two author papers, and III = Three author papers.

Table 3 : Author Productivity and distribution of authorsips by domains

No. of Papers	Domainwise authorships A	B	C	D	No. of authors	Total No. of authorships	Prominent collaborators
1	6	3	1	–	10	10	
2	8	2	2	–	6	12	
4	8	–	–	–	2	8	
5	–	5	–	–	1	5	
9	–	18	–	–	2	18	Mookerji, A & Roy, S.K.
17	4	13	–	–	1	17	Banerji, S.
18	–	–	18	–	1	18	Jain, S.C.
21	14	7	–	–	1	21	Raman, C.V.
135	50	60	23	2	1	135	Krishnan, K.S.
Total	90	108	44	2	25	244	
Percentage	36.89	44.26	18.03	0.82			
Cumulative %	36.89	81.15	99.18	100.00			

A = Spectroscopy
B = Magnetism
C = Thermionics
D = General

Table 4 : Communication Channelwise scattering of publications of K.S. Krishnan

Sl. No.	Communication Channels	No. of Papers	Percentage	Cumulative Percentage	Period of Journal usage FPY – LPY	Total	Country of Publication
1.	Nature	46	34.07	34.07	1926 – 1961	36	UK
2.	Proc. R. Soc., A	24	17.78	51.85	1927 – 1960	34	UK
3..	Indian J. Phys.	9	6.68	58.53	1926 – 1933	8	India
4.	Phil. Mag.	9	6.68	65.21	1925 – 1956	32	UK
5.	Phys. Rev.	8	5.93	71.14	1931 – 1952	22	US
6.	Curr. Sci.	6	4.44	75.58	1933 – 1935	3	India
7.	Phil. Trans., A	6	4.44	80.02	1933 – 1939	7	UK
8.	Z. Kristallogr. Krstallogeom	6	4.44	84.46	1934 – 1939	6	Germany
9.	Proc. Indian Acad. Sci., A	2	1.48	85.94	1935 – 1938	4	India
10.	Proc. Natn. Acad. Sci. India.	2	1.48	87.42	1944 – 1955	12	India
11.	Trans. Faraday Soc.	2	1.48	88.90	1939 – 1940	2	UK
12.	Br. J. Appl. Phys	1	0.74	89.64	1954 – 1954	1	UK
13.	C. R. Acad. Sci. Paris.	1	0.74	90.38	1927 – 1927	1	France
14.	Indian Ass. Cultiv. Sci.	1	0.74	91.12	1926 – 1926	1	India
15.	J. Chem. Phys.	1	0.74	91.86	1938 – 1938	1	US
16.	J. Indian Math. Soc.	1	0.74	92.60	1948 – 1948	1	India
17.	Proc. Indian Acad. Sci.	1	0.74	93.34	1934 – 1934	1	India
18.	Proc. Phys. Soc. Lond.	1	0.74	94.08	1926 – 1926	1	UK
19.	Telecomun, J. Geneva.	1	0.74	94.82	1960 – 1960	1	Switzerland
20.	Z. Phys.	1	0.74	95.56	1931 – 1931	1	Germany
21.	Symposia, Conference Proceddings Meetings etc.	6	4.44	100.00	– – –	–	–
	Total	135					

FPY = First paper publishing year, LPY = Last paper Publishing year

Table 5 : *Distribution of articles on Bradford's law of scatter among journals for papers of K.S. Krishnan*

C	CH	CH.C	Σ CH.C
1	15	15	15
2	3	6	21
6	3	18	39
8	1	8	47
9	2	18	65
24	1	24	89
46	1	46	135

C = Communications or No. of publications
CH = Channels of communications
CH.C = Total communications
Σ CH.C = Cumulative total comunications

Table 6 : *Bradford distribution (Four zones) for publications K.S. Krishnan*

Zone	No. of papers	No. of journals	Bradfor multiplier
First	46	1	–
Second	42	3	3.00
Third	47	17	5.67
Fourth	–	–	–

Average Bradford multiplier $(\overline{b}) = 4.34$

Table 7 : References cited by K.S. Krishnan

Domain	No. of Citations	No. of self Citations	Synchronous Self citation rate
Spectroscopy	318	31	9.75
Magnetism	474	70	14.77
Thermionics	163	31	19.02
Total	955	132	13.82

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Thermionics	163	31	19.02
Total	955	132	13.82

Table 8 :

Bibliographic Characteristics of papers of K.S. Krishnan

Feature/Domain	Range	Mean	S.D.	% CV
Pages				
Spectroscopy	1–37	7.71	8.26	107.13
Magnetism	1–34	7.32	7.69	105.05
Thermionics	1–15	6.83	5.15	75.40
Visuals				
Spectroscopy	0–17	2.1	3.92	187.00
Magnetism	0–4	0.42	0.80	190.48
Thermionics	0–4	0.78	1.28	164.10
Tables				
Spectroscopy	0–8	1.33	2.14	160.56
Magnetism	0–12	1.70	2.59	152.35
Thermionics	0–4	1.22	1.17	95.82
Total Citations				
Spectroscopy	0–33	6.2	6.73	108.55
Magnetism	0–36	7.9	7.42	93.94
Thermionics	0-29	7.09	6.73	94.08
Self Citations				
Spectrpscopy	0–5	0.7	1.13	161.43
Magnetism	0–10	1.17	1.71	146.15
Thermionics	0–5	1.35	1.52	112.59

Spectroscopy N = 51, Magnetism N = 60, Thermionics N = 23

Table 9 :

Keyword frequencies in the titles of papers by K.s. Krishnan

Keyword	F	Keyword	F
Crystals	24	Mangetic double-refraction	3
Magnetic anisotropy	14	Magnetic properties	3
Graphite	10	Modes of oscillation	3
Liquids	10	Molecular orientation	3
Crystal Structure	7	Molecules	3

Thermionic Constants	7	Monovalent metals	3
Alkali halides	6	Paramagnetic ions	3
Magne-crystallic action	6	Photo-dissociation	3
Polarization fields	6	Pleochroism	3
Temperature distribution	6	Raman effect	3
Vacuo	6	Temperature variation	3
Copper sulphate pentahydrate	5	Absorption spectra	2
Metals	5	Acoustic modes	2
Scattering of light	5	Anharmonicity	2
Temperature	5	Anisotropy	2
Birefringence	4	Benzene	2
Polarization	4	Crystalline fields	2
Semiconductors	4	Diffraction of light	2
Electrically heated thin tube	3	Diphenyl octateragne	2
Electrically heated rod	2	Electric double -refraction	2
Fluorescence	2	Electrically heated wire	2
Lattice oscillations	2	Iron group	2
Magnetic studies	2	Magnetic behaviour	2
Optical anisotropy	2	Magnetic birefringence	2
Paramagnetic Crystals	2	No 3 ions	2
Secondary radiation	2	Optical properties	2
Unidirectional diamagnetism	2	Polarity	2
		Spectra	2

F= Frequency

Table 10 :

Keywords used only once in the titles of papers by K.S. Krishnan

Absorptin	Magnite Crystal
Absorption Lines	Manganese Carbonate
Ammonium Manganous Sulphate hexhydrate	Manganese Silicate
Anthracene	Manganese trioxide
Aqueous Solutions	Manganous ammonium-Sulphate
Aromatic molecules	Manganous ions
Artificial Crystals	Maxwell effect
Asymmetry	Metallic electrons

Benzene derivatives
Binary alloys
Black sop films
Braunite
Carbon Sulphide
Cation Vacancies
Chrysene Molecule
Co++ions
cobalt tetrachloride
Compton effect
Copper Zinc alloys
Coupling
Crystalline Carbonates
Crystalline Modification
Crystalline nitrates
Degenerate electron gas
Diamagnetic anisotropy
Diamagnetics
Diamagnetism
1, 2, 5, 6, Dibenzenthracene
Dielectric Behaviour
Diffuse scattering
Dimorphiosm
Directional Variations
Dispersion
Dispersion formulae
Doped Crystals
Drude dispesion formula
Elastic constants
Electric constants
Electric birefringence
Electrical Conductivity
Electrical polarity
Electrical properties
Electrical resistance
Electrical resistivities
Electrically heated coils
Metallic screens
Mobile electrons
Molecular impurity
Molecular Scattering of light
Molecular Structure
Napthalene
Napthalene molecule
Negative absorption of radiation
Negative polurization
New radiation
Nitrates

Optical analogue
Optical polarizabilities
Orbital angular momenta
Order-disorder alloys
Orientation
Organic Crystals
Orthorhombic crystallne modification
Para-benzoquinone Crystal
Par-diphenyl benzene
Paramagnetic atoms
Paramagnetic salts
Paramagnetics
Polarized light
Polynuclear hydrocarbons
Potassium nitrates
Quadrature
Quenching
Radiation flux
Raman spectra
Rare earth salts
Rare earth Sulphates
Rare earths
Reflection

Electrically heated filaments
Electrically heated tubes
Electronic specific heat
Energy
Entropy
Equilibrium conditions
Evjen's method
Exciting Light quantum
Feeble anisotropies
Fermi-Dirace energy Distribution
Fermi electrons
Flucuations of Luminosity
Fluids
Fluorescence spectra
Free electrons
Gases
Gaseous Molecules
Heated tubes
High temperature
Homogeneous media
Impurity molecules
Infinite series
Infrared region
Integrals
Ionic crystals
Jahn-Teiler theorum
Landau diamagentism
Large anisotropy
Light
Liquid metals
Low frequency
Low temperature
madelung constants
Magnetic analysis
Magnetic constants
Mangetic field
Magetic measurements
Mangetic suceptibilities
Refraction
Refractivity
Resistivities
Resonance frequencies
Restrahlen frequency
Rhodochrosite
Room temperature
Rotution of molecules
S level
S state
Salts
Scatter light-quanta
Single Crystals
Small Crystals
Sodium Chloride
Sodium Nitrates
Specular reflection
Spherical obstacles
Spin angular moments
Stark splitting
Telecommunication
Thermal conductivity
Thermal elastic waves
Thermal properties
Thermionic properties
Thermo-dynamic potential
Time-lag
Transition elemonts
1, 2, 5 – Triphenylbenzene
Vapours
Water molecules
XO_3 ion
X - ray Scattering

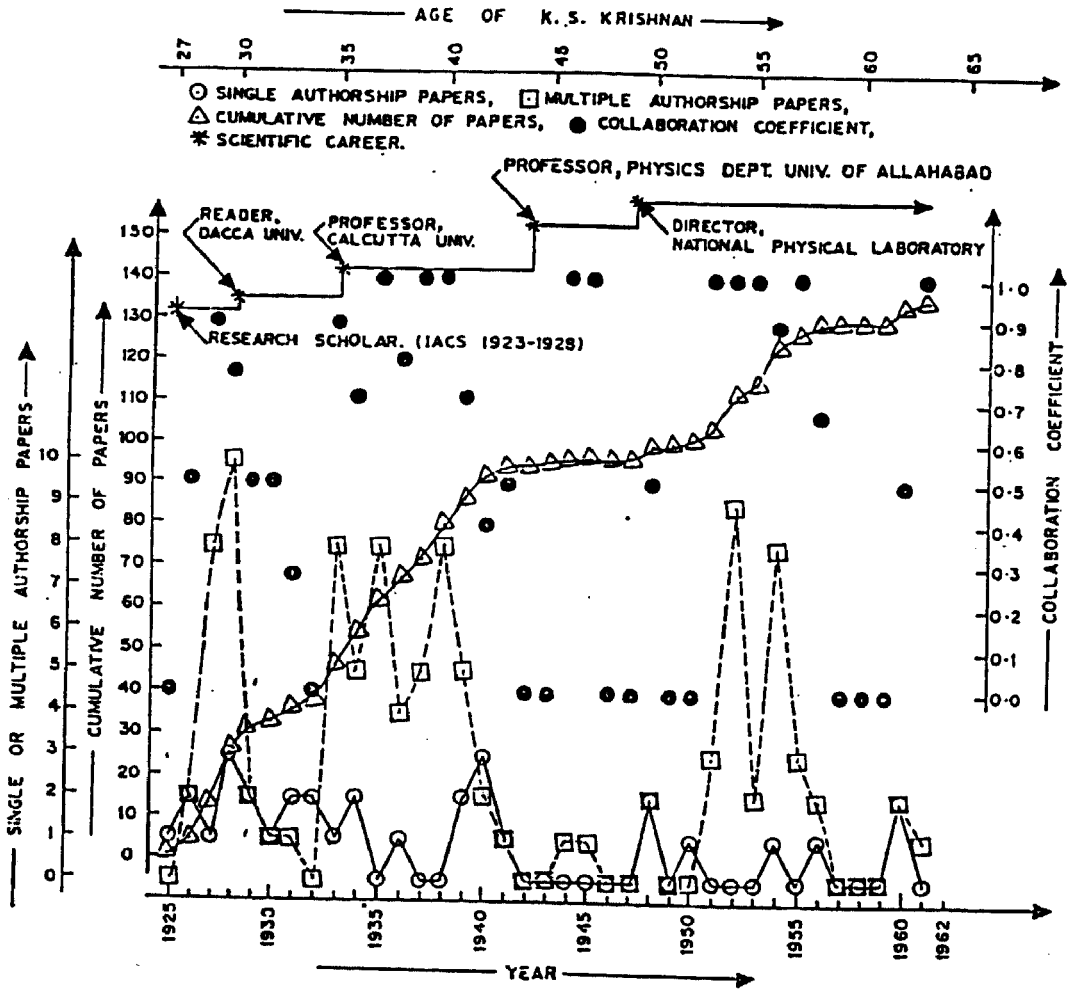

FIG. 1 : PUBLICATION PRODUCTIVITY OF K. S. KRISHNAN

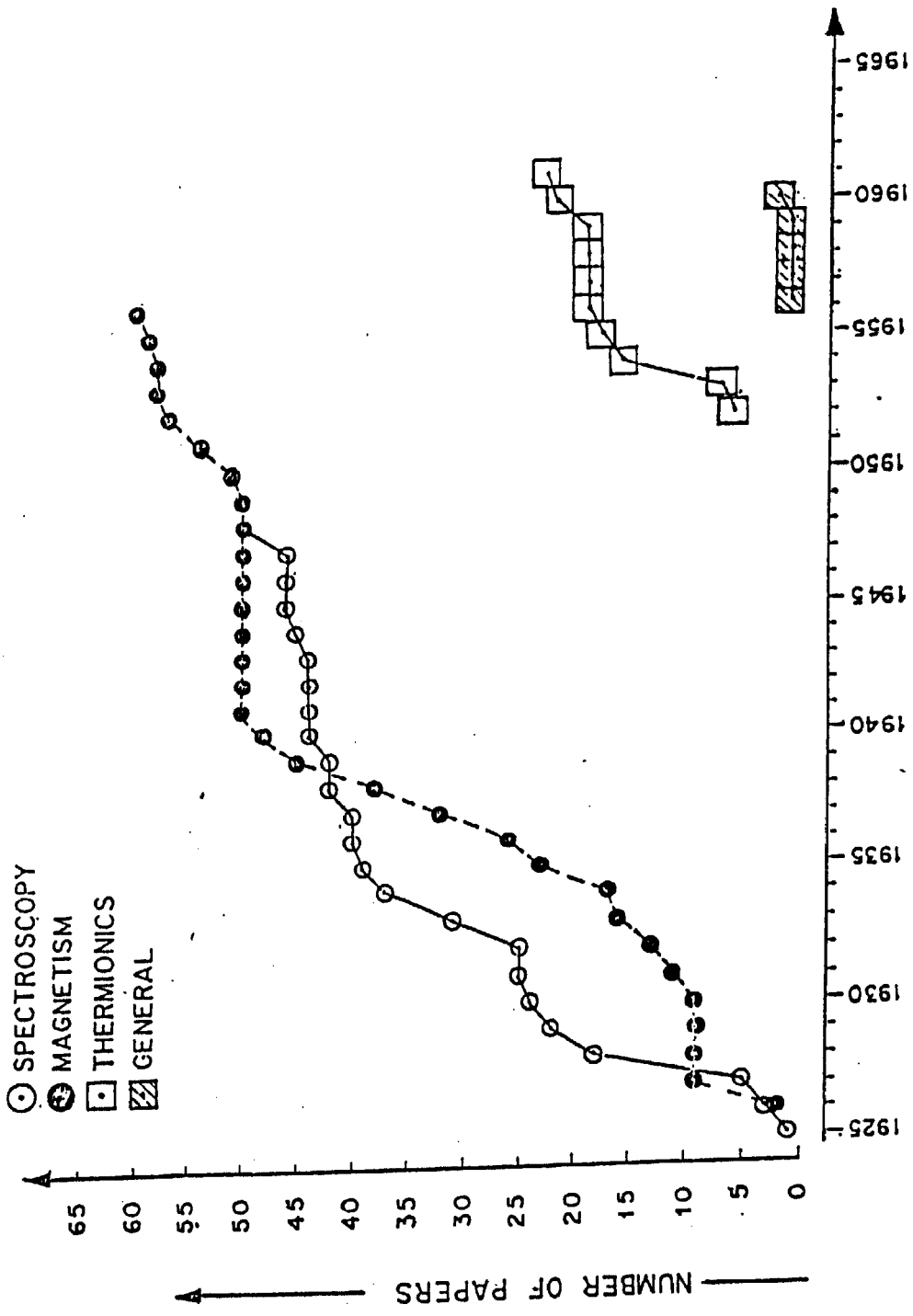

FIG.2: DOMAIN-WISE PUBLICATION PRODUCTIVITY OF K.S.KRISHNAN

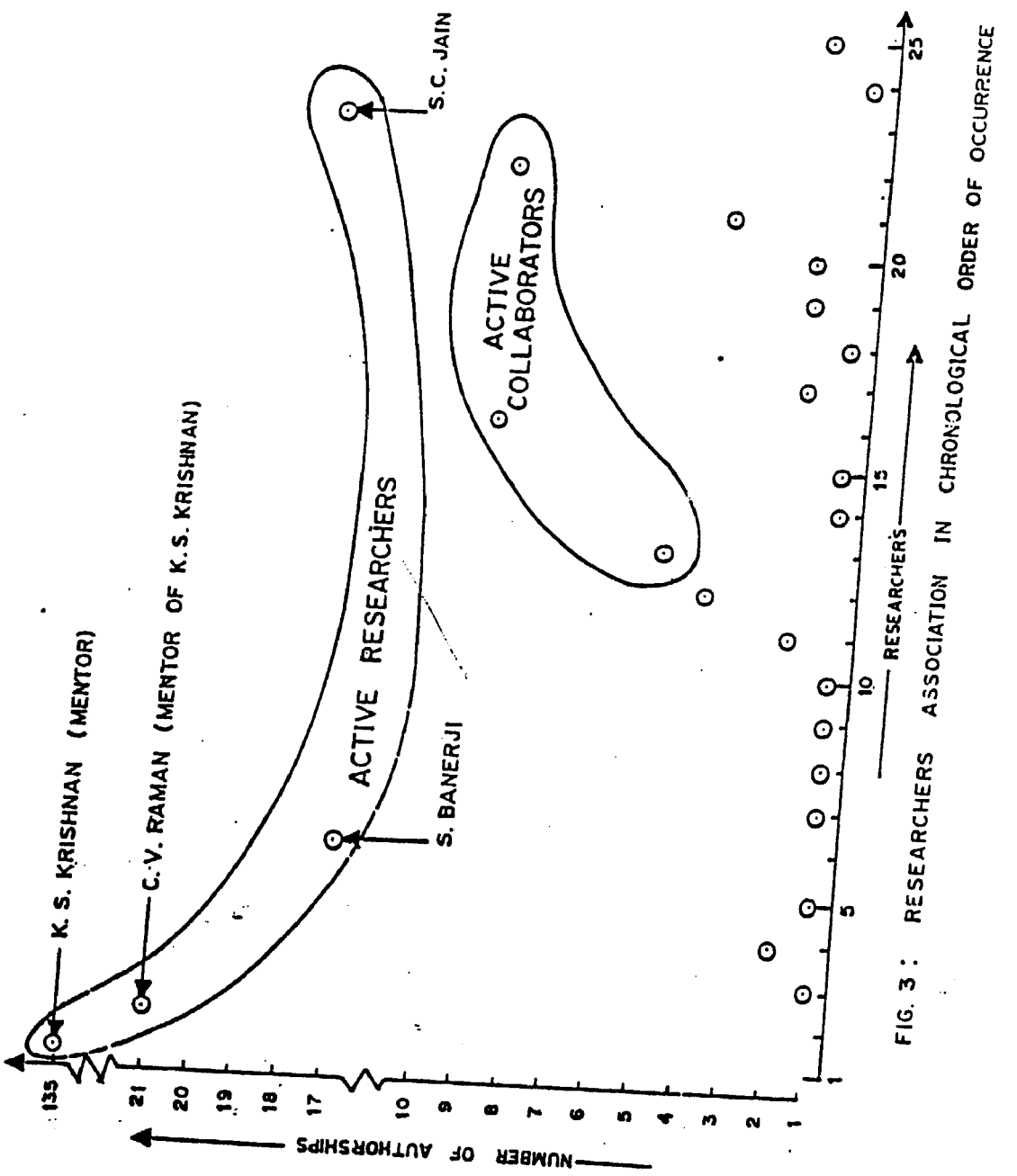

FIG. 3 : RESEARCHERS ASSOCIATION IN CHRONOLOGICAL ORDER OF OCCURRENCE

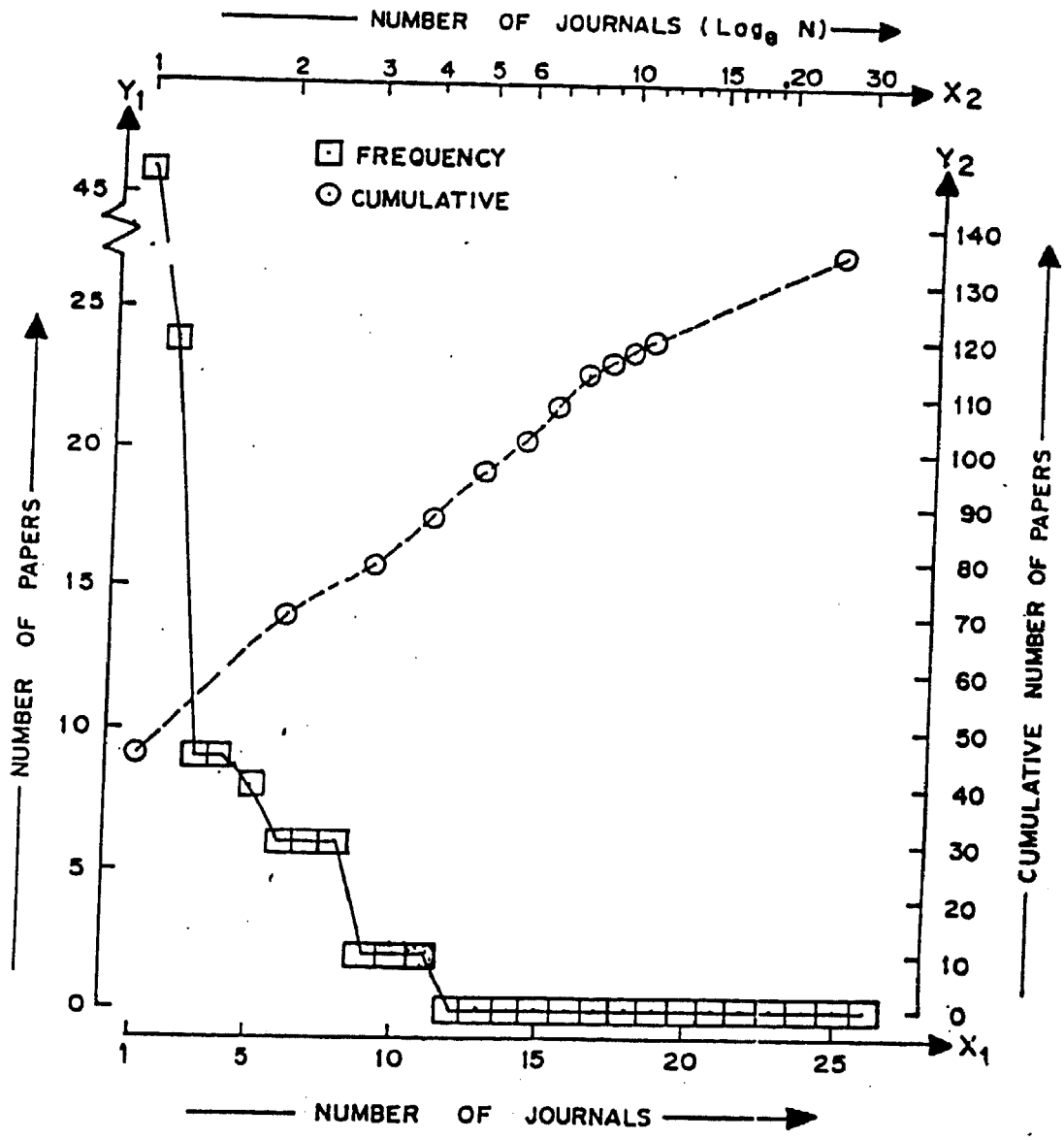

FIG. 4 : BIBLIOGRAPH ON PAPERS OF K. S. KRISHNAN