SCIENTOMETRIC PORTRAIT OF RAM GOPAL RASTOGI

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Scientometric analysis of 312 papers by Ram Gopal Rastogi published during 1954 to 1992 in various domains: (a) Luni - solar activity and quiet – time E & F – region (57); (b) Equatorial electric field and low and mid latitude ionosphere (78); (c) Ionospheric E – region irregularities (19); (d) Ionospheric F – region irregularities (32); and (e) Magnetic disturbance effects on the equatorial low and mid latitude ionosphere (23) were analysed. Inter-domainery contents and of the number of papers: a+b were 36; b+c and b+d were 20 each; b+e were 16; c+e were 5; a+e were 3; d+e were 2; and a+d had only one publication. Highest collaborations were with H. Chandra (61), M. R. Deshpande (42), and G. Sethia (19) out of his total 97 collaborators. His highest productivity was during 1978 with 28 papers followed by 19 papers during 1977. The core journals preferred by him for publishing papers were: Indian Journal of Radio & Space Physics, India, and Journal of Atomic & Terrestrial Physics, UK (59 each), followed by Proceedings of the Indian Academy of Sciences, India (34). Most prolific title keywords with their frequencies were : Ionosphere (92); Equatorial (61); F-region (53); Equatorial electrojet region (40), and Magnetic equator (30).

INTRODUCTION

The earth and planetary sciences have received great research interest during the past century[1-4]. Bibliometric indicators and science policy have gained worldwide importance during the past two decades[5-7]. But so far no scientometric study has been carried out with contributions of an individual geoscientist and his collaborators, hence the present study was undertaken. Ram Gopal Rastogi was born on 26th of December 1929 at Allahabad and started his research career in 1951. He completed his doctorate degree in physics from Gujarat University during 1956. He was a lecturer in physics at Saugar University, Saugar during 1949-51 and a Research Associate, Physical Research Laboratory, Ahmedabad during 1951-58. He was a post doctoral research fellow at National Research Council Canada, 1958-60; Post Doctorate Research Fellow of High Altitude Observatory, and guest worker of Central Radio Propagation Laboratory at Boulder, Colorado, USA during 1960-61; and Reader/Professor, Physical Research Laboratory, Ahmedabad during 1962-77 and 1980. He was Senior Research Associate at Air Force Geophysics Laboratory, National Research Council of USA from 1977-80. Rastogi was one of the foremost scientists on the equatorial aeronomy having studied diverse fields in radio propagation, ionosphere and geomagnetism. His initial studies were concerned with the propagation of radio waves during solar eclipses, culminating in a detailed report on the subject. He was the first member of the Physical Research Laboratory to start regular study on the ionosphere. He has been responsible for the efficient operation of the ionosphere sounding station for providing the longest unbroken observations in India. He is an authority in the world on equatorial electrojet currents, transionospheric equatorial scintillations and equatorial ionospheric irregularities. Besides organising the radio research group at Ahmedabad, he with his students was the first to establish the Ionospheric Research Station at Thumba Rocket Launching Station that has been transformed now to Vikram Sarabhai Space

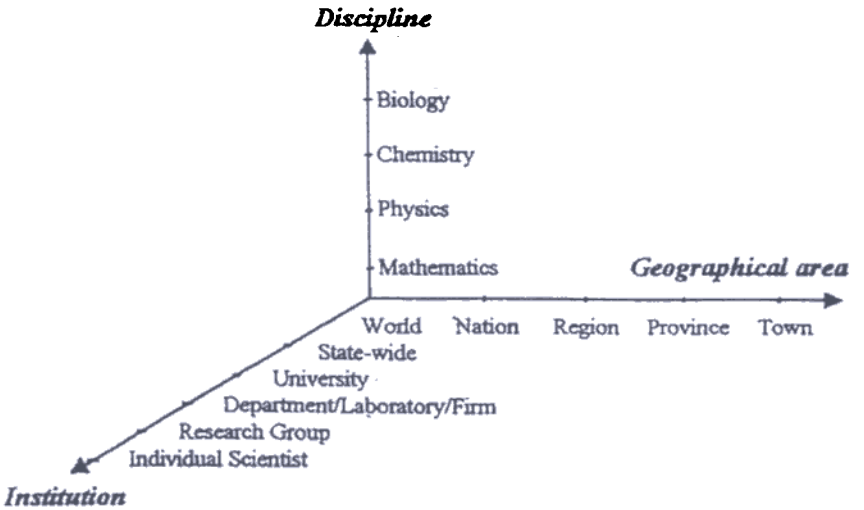

Fig. - The three-dimensional Space to be Explored by Bibliometricians

Centre. He was responsible for the planning, operation and investigation of the most sophisticated experiments on the study of radio beacon transmissions from the Applications Technology Satellite - 6 (ATS-6) during 1975-76 at Ootacamund (Ooty) now called Udhagamandalam in Tamil Nadu. He has contributed extensively to the understanding of electron density distributions in ionosphere at low latitudes under quiet and disturbed conditions, lunar tidal and geomagnetic storm effects.

Prof. Rastogi worked in several national and international committees. He is a Life Fellow of Indian Academy of Sciences, Bangalore; Fellow of National Academy of Sciences of India, Allahabad; Fellow of Association of Exploration Geophysics, Hyderabad; Fellow of Indian National Science Academy, Delhi; Life Member of Indian Physics Association, Mumbai; Member of American Geophysical Union, Washington, USA; Member of Society of Terrestrial Magnetism & Electricity of Japan; Senior Member of the Institution of Radio Engineers, USA; Member of Executive Committee of the International Association of Geomagnetism and Aeronomy (IAGA); Chairman, Special Committee to Promote Geomagnetism and Aeronomy in developing countries. He was bestowed with Hari Om Ashram Award during 1971-76.

From 1980-89 onwards, he was the Director of Indian Institute of Geomagnetism, Colaba, Mumbai, and had organised significant expansions of the research and technical activities of the institute till his retirement in 1989. He has guided 20 students for their doctorates. His active post-retirement life as INSA Senior Scientist at the School of Sciences, Gujarat University, Ahmedabad is exemplary.

A three-dimensional space such as the one depicted in Fig. 1 can be used to describe all kinds of bibliometric questions that can be phrased in terms of *discipline, geographic area* and *institution.* Along the geographic dimension it is possible to reach different levels of granularity: world, nations, regions, provinces, towns; similarly, institutions can be subdivided into state-wide ones, local universities, single branches of departments, laboratories, firms [8]. This can be further extended to a research group and pivotal mentorship by an individual scientist. Disciplinewise orientation may include basic sciences like mathematics, physics, chemistry, biology or interdisciplinary approaches like biophysics, biochemistry, biostatistics or multidisciplinary approaches.

There is reasonably a good correlation between the eminence of scientists and their sustained production of scholarly writing [9]. Currently focus is on quantitative documentation of performance of individual scientists [10 – 60] as a unit of information generation.

The target groups of the present study are:

- Administrators of scientific establishments
- Biobibliographers

Documentalists
Educationalists
Engineers
Historians of science
Information scientists
Library and information science professionals
Research and development managers
Science journalists
Science policy makers
Science and technology managers
Senior scientists
Scientometricians
Technologists
Young scientists; etc.

MATERIALS AND METHODS

Measuring science quantitatively has become a major aim and concern for a variety of reasons to study evolution of science epistemologically, to know history or sociology of scientists, or to assist in decision making for the management of science.. Comparison and assessment of scientific impact of research teams are very difficult, but it appears to be an urgent need for science policymakers and for the researchers themselves.

The following definitions explained in alphabetical order were used to analyse the biobibliography compiled and database sorted after consulting various methods [61 – 66]:

Authorship credit: The credit given to each author of a collaborative paper. Normally each author figuring in a collaborative paper gets one credit regardless of the position as first or last in the byline.

Authorship status: The position of the author, i.e. first, second, third, etc. sequence in the byline of a paper.

Channels of communication: The sources preferentially chosen by the author to communicate results of research.

Collaboration coefficient: The ratio of the number of collaborative papers to the total number of papers published.

Core collaborators: Those authors who have made substantial contributions (in terms of number of papers) in association with the principal author.

Fifty percentile age: The number of years during which 50% of the papers were published starting from the year of publication of the first paper.

Normal count procedure: One score is given for every occurrence.

Principal author: The common author among the authors forming a collaborative group. In the present case study – Ram Gopal Rastogi.

Productivity coefficient: The ratio of 50 percentile age to the total productivity age.

Productivity life (age): The count from the year in which first paper by an author was published till the latest year of publication.

Publication concentration: The ratio in percentage of the number of channels accounting for half of the papers to the total number of channels used.

Publication density: Frequency of papers per channel.

RESULTS AND DISCUSSION

R. G. Rastogi has published 312 papers during 1954-92. He has to his credit 106 single-authored papers and 97 two-authored papers. Three-authored papers are 63, and four-authored papers are 23. One of his papers has 13 authors. Five- to 13-authored papers are 23. Table 1 shows that he has 752 total authorships to his papers. Fifty percent of authorships were in two and three-authored papers. Comparison of Quinquennial Scientific Publications career of Indian Role Model Scientist and Ram Gopal Rastogi is depicted in Fig. 2.

Chronological collaboration activity as per distribution of his papers is provided in Table 2. He published his first paper in the year 1954 at the age of 25 years. He had four peaks of publishing more than 15 papers in a year. The first peak occurred at the age of 41 in the year 1970 having 16 papers when his productivity life (age) was 17 years. Second peak occurred in 1977 at the age of 48 having 19 papers at productivity life of 24.

Table 1

Distribution of papers by Ram Gopal Rastogi as per number of authors in bylines during 1954-1992

Authors in bylines	No.of papers	Cumulative papers	Percent of papers	Cumulative percent	Authorships	Percent of author-ships	Cumulative authorships
One	106	106	33.97	33.97	106	14.09	106
Two	97	203	31.09	65.06	194	25.8	300
Three	63	266	20.2	85.26	189	25.13	489
Four	23	289	7.37	92.63	92	12.23	581
Five	7	296	2.24	94.87	35	4.65	616
Six	4	300	1.29	96.16	24	3.19	640
Seven	3	303	0.96	97.12	21	2.8	661
Eight	2	305	0.64	97.76	16	2.13	677
Nine	2	307	0.64	98.4	18	2.4	695
Ten	2	309	0.64	99.04	20	2.66	715
Twelve	2	311	0.64	99.68	24	3.19	739
Thirteen	1	312	0.32	100	13	1.73	752

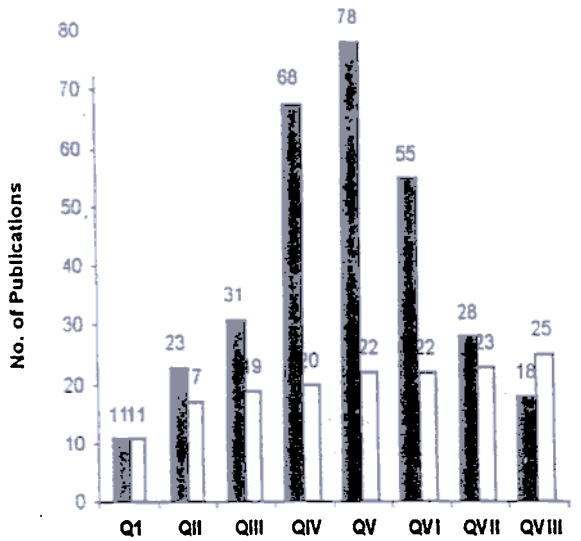

Fig. 2 - Comparison of Quinquennial Scientific Publications Career of Indian Role Model Scientist (□) and Ram Gopal Rastogi (■)

He published a maximum of 28 papers in 1978 at the age of 49. The fourth peak of 17 papers was in the year 1980 at 51 years of age.

Multi-authored papers were highest during the years 1974-1978 (Fig.3). This was mainly due to the collaboration at national level [67] involving the following research organisations to undertake research on ATS-6: Punjabi University, Patiala; Rajasthan University, Jaipur; University of Udaipur, Udaipur; A. V. Parekh Technical Institute, Rajkot; Indian Institute of Geomagnetism, Mumbai; and Andhra University, Waltair.

Maximum single-authored papers were 22 during the period 1959-63. The stable collaboration was found during 1964 to 1988. During 1967, 1979, 1987, 1990, 1991, and 1992 he had all papers in collaboration, hence collaboration coefficient was one. He published only single-authored papers during 1954, 1957-62, and 1984.

Table 2

Publication yearwise distribution of papers by Ram Gopal Rastogi as per bylines

Quinquennium	Publication year	Number of authors in bylines					Publications		Total	CC	Age of R. G. Rastogi	Productivity life (age)
		One	Two	Three	Four	Five to Thirteen	Main author	Co-author				
	1954	1	-	-	-	-	1	-	1	0	25	
	1955	1	1	-	-	-	2	-	2	0.5	26	2
Q	1956	1	1	1	1	-	3	1	4	0.75	27	3
	1957	2	-	-	-	-	2	-	2	0	28	4
	1958	2	-	-	-	-	2	-	2	0	29	5
	1959	4	-	-	-	-	4	-	4	0		
	1960	4	-	-	-	-	4	-	4	0		
Q II	1961	4	-	-	-	-	4	-	4	0		
	1962	4	-	-	-	-	4	-	4	0		
	1963	6	1	-	-	-	7	-	7	0.14		
	1964	3	1	-	-	-	4	-	4	0.25		
	1965	3	1	-	-	-	4	-	4	0.25		
Q III	1966	1	3	4	-	-	7	1	8	0.86		
	1967	-	2	-	-	-	-	2	2	1		
	1968	3	8	2	-	-	7	6	13	0.77		
	1969	4	7	-	-	-	5	6	11	0.64		
	1970	2	11	2	1	-	4	12	16	0.88		
	1971	3	6	5	-	-	7	7	14	0.79		
	1972	5	6	2	1	-	7	7	14	0.64		
	1973	5	4	3	1	-	6	7	13	0.62		
	1974	3	8	-	-	-	6	5	11	0.73		
	1975	6	3	3	-	2	10	4	14	0.62		
Q V	1976	2	2	1	-	1	4	2	6	0.67		
	1977	7	4	4	2	2	12	7	19	0.63		
	1978	1	9	6	6	6	10	18	28	0.96		
	1979	-	1	5	2	6	1	13	14	1		
	1980	4	1	4	4	4	6	11	17	0.76		
	1981	2	2	3	-	1	4	4	8	0.75		
	1982	4	-	3	1	-	6	2	8	0.5		
	1983	5	-	2	-	1	6	2	8	0.38		
	1984	3	-	-	-	-	3	-	3	0		
	1985	1	2	2	1	-	2	4	6	0.83		
	1986	4	4	2	1	-	5	6	11	0.64		
	1987	-	3	1	-	-	1	3	4			
	1988	2	1	1	-	-	2	2	4	0.5		
	1989	4	3	4	2	-	8	5				
	1990	-	1	2	-	-	2	1				
	1991	-	-	1	-	-	1	-				
	1992	-	1	-	-	-	1	-				
	Total	106	97	63	23	23	174	138	312			
	Percent	33.97	31.09	20.2	7.37	7.37	55.76	44.24				
	Cumulative Percent	33.97	65.06	85.26	92.63	100						

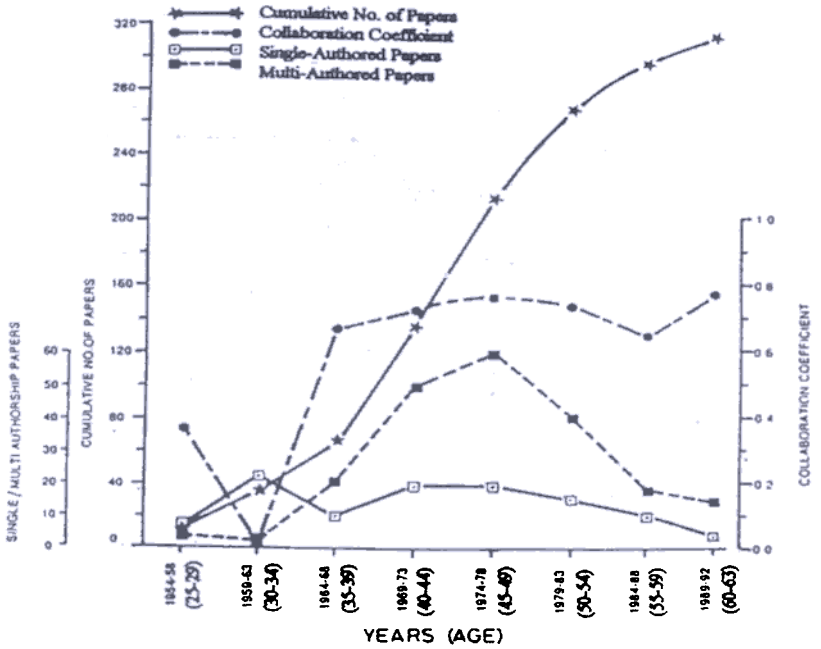

Fig 3 — Publication Productivity of Ram Gopal Rastogi

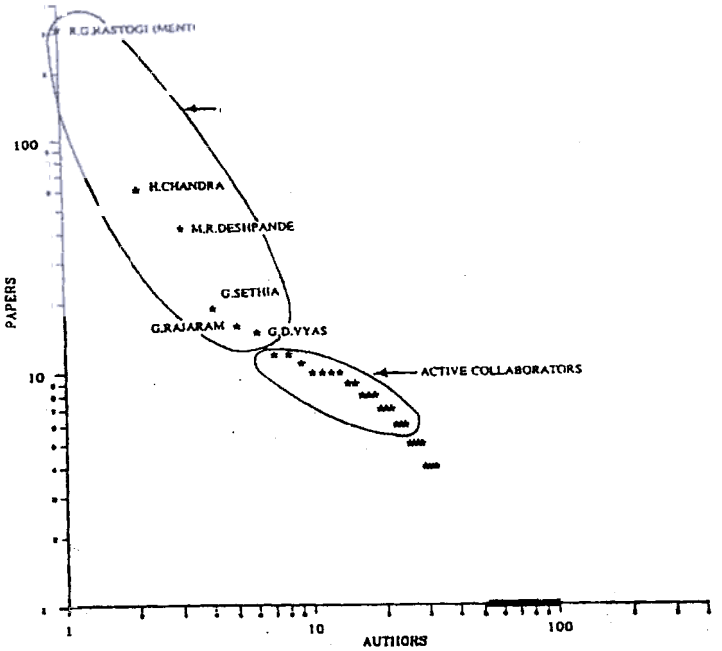

Fig 4 — Publication Productivity of Ram Gopal Rastogi and Collaborators (Log-Log Scale)

He published ten or more papers as main (i.e., first) author during 1975, 1977 and 1978 at the age of 46, 48 and 49 respectively. Sixty-five percent of his papers include single-authored papers (33.97%) and two-authored papers (31.09%). He was first author in 174(55.76%) and co-author in 138(44.24%) papers. The genius does not function equally well throughout the years of adulthood as propounded by Lehman [68].

Authorship pattern of R. G. Rastogi and his collaborators is provided in Table 3. He collaborated with 97 scientists. Out of the 61 papers published by the top ranking collaborator, H. Chandra, he had 24 papers as main author, and 37 papers were as co-author during 1968 to 1989. M. R. Deshpande published 42 papers in collaboration with R. G. Rastogi, out of which he was the main author in 8 papers, and co-author in 34 papers during 1966-1989.

Biobibliographics of the publication productivity (Fig.4) shows three distinct groups. The first group of active researchers includes R. G. Rastogi

Authorship pattern of Ram Gopal Rastogi and his collaborators

		One	Two		Three			Four				Five to Eighteen		Publications Main	Co-	Total	Period
	Authors	I	I	II	I	II	III	I	II	III	IV	I	Co	author	author		FPY LPY
1	Rastogi,R.G.	106	31	66	26	4	33	5	4	6	8	6	17	174	138	312	1954-1990
2	Chandra,H.	-	14	2	7	16	2	2	6	3	1	1	7	24	37	61	1968-1989
3	Deshpande,M.R.	-	4	-	1	8	3	1	1	5	2	2	15	8	34	42	1966-1989
4	Sethia,G.	-	1	-	3	1	1	5	-	1	-	-	7	9	10	19	1977-1985
5	Rajaram,G.	-	10	2	1	2	-	-	-	-	1	-	-	11	5	16	1965-1977
6	Vyas,G.D.	-	-	2	5	3	-	1	1	-	1	-	2	6	9	15	1977-1989
7	Iyer,K.N.	-	5	2	1	2	-	-	1	-	-	-	1	6	6	12	1974-1983
8	Sharma,R.P.	-	8	1	-	1	1	-	-	1	-	-	-	8	4	12	1967-1977
9	Vats,H.O.	-	-	-	-	1	-	-	1	2	-	1	6	1	10	11	1977-1980
10	Alex,S.	-	2	1	5	1	1	-	-	-	-	-	-	7	3	10	1986-1992
11	Koparkar,P.V.	-	2	1	1	3	1	-	2	-	-	-	-	3	7	10	1985-1992
12	Misra,R.K.	-	5	-	1	1	2	-	1	-	-	-	-	6	4	10	1970-1973
13	Janve,A.V.	-	-	-	-	-	-	-	1	-	-	1	8	1	9	10	1978-1981
14	Agarwal,A.K.	-	-	-	3	1	1	3	-	-	1	-	-	6	3	9	1978-1986
15	Rai,R.K.	-	-	-	-	-	-	-	-	-	-	-	9	-	9	9	1977-1981
16	Singh,B.P.	-	-	-	1	2	1	-	3	-	1	-	-	1	7	8	1978-1986
17	Jain,A.R.	-	-	-	-	-	-	-	-	-	-	2	6	2	6	8	1977-1981
18	Chakravarthy,S.C.	-	4	-	-	-	1	-	-	-	-	-	3	4	4	8	1969-1976
19	Davies,K.	-	-	-	-	-	-	-	-	-	2	1	4	1	6	7	1977-1970
20	Singh,M.	-	-	-	-	-	-	-	-	-	-	1	6	1	6	7	1977-1981
21	Gurm,H.S.	-	-	-	-	-	-	-	-	-	-	-	7	-	7	7	1977-1981
22	Patil,A.R.	-	-	2	2	2	-	-	-	-	-	-	-	2	4	6	1985-1992
23	Trivedi,N.B.	-	2	2	-	1	1	-	-	-	-	-	-	2	4	6	1966-1970
24	Murthy,B.S.	-	-	-	-	-	-	-	-	1	1	-	4	-	6	6	1977-1977
25	Woodman,R.F.	-	-	2	1	1	1	-	-	-	-	-	-	1	4	5	1977-1978
26	Bhattacharyya,A.	-	4	-	1	-	-	-	-	-	-	-	-	5	-	5	1985-1992
27	Patel,V.P.	-	1	-	2	1	-	-	-	-	-	1	-	4	1	5	1985-1991
28	Kaushika,N.D.	-	-	-	-	2	3	-	-	-	-	-	-	-	5	5	1966-1968
29	Klobuchar,J.A.	-	1	1	-	-	-	1	-	-	-	-	1	2	2	4	1977-1992
30	Sengupta,A.	-	-	-	-	-	-	-	-	-	-	2	2	2	2	4	1980-1983
31	Patwari,V.M.	-	-	-	-	-	-	-	-	-	-	-	4	-	4	4	1978-1980
32	Subbarao,B.S.	-	-	-	-	-	-	-	-	-	-	-	4	-	4	4	1977-1980
33	Sastri,N.S.	-	-	1	-	-	1	-	-	1	-	-	-	-	3	3	1974-1985
34	Sanatani,S.	-	-	3	-	-	-	-	-	-	-	-	-	-	3	3	1963-1968
35	Mullen,J.P.	-	-	1	-	1	-	-	-	-	-	-	1	-	3	3	1980-1981
36	Roy,M.	-	1	-	-	2	-	-	-	-	-	-	-	1	2	3	1987-1989
37	Rangarajan,G.K.	-	1	-	-	1	-	-	-	-	-	-	1	1	2	3	1981-1983
38	Kasturirangan,K.	-	-	-	-	-	-	-	-	-	-	3	-	3	-	3	1975-1976
39	Nagpal,O.P.	-	-	-	-	-	-	-	-	-	-	-	3	-	3	3	1980-1981
40	Setty,C.S.G.K.	-	-	-	-	-	-	-	-	-	-	-	3	-	3	3	1980-1981
41	Rao,U.R.	-	-	-	-	-	-	-	-	-	-	-	3	-	3	3	1975-1976
42	Sharma,D.P.	-	-	-	-	-	-	-	-	-	-	-	3	-	3	3	1970-1972
43	Alurkar,S.K.	-	-	2	-	-	-	-	-	-	-	-	-	-	2	2	1964-1966
44	Sheriff,R.M.	-	-	1	-	1	-	-	-	-	-	-	-	-	2	2	1954-1956
45	Aarons,J.	-	-	1	-	-	-	-	-	-	-	-	1	-	2	2	1980-1980
46	Das,A.C.	-	-	-	1	1	-	-	-	-	-	-	-	1	1	2	1971-1973
47	Sastri,J.H.	-	-	-	-	1	-	-	-	-	-	-	1	-	2	2	1979-1989
48	Arora,B.R.	-	-	-	-	2	-	-	-	-	-	-	-	-	2	2	1983-1985
49	Devanathan,S.N.	-	-	-	-	-	-	-	-	-	2	-	-	-	2	2	1978-1978
50	Nityananda,N.	-	-	-	-	-	-	-	-	1	1	-	-	-	2	2	1978-1980
51	Grubb,R.N.	-	-	-	-	-	-	-	-	-		-	2	-	2	2	1977-1979
52-98	Others having only one authorship each	-	1	4	1	1	10	5	2	2	2	2	17	9	38	47	
	(1 - 98)	106	97	97	63	63	63	23	23	23	23	23	148	312	440	752	

Table 4
Author productivity in the research team of Ram Gopal Rastogi

Number of publication credits	Total No. of collaborators observed	Total author-ships	Cumulative total authorships	% for total authorships	Cumulative % for total authorships	Lotka's Law (alpha =2) Values
312	1	312	312	41.49	41.49	0.005
61	1	61	373	8.11	49.6	0.013
42	1	42	415	5.59	55.19	0.03
19	1	19	434	2.53	57.72	0.13
16	1	16	450	2.13	59.85	0.18
15	1	15	465	1.99	61.84	0.21
12	2	24	489	3.19	65.03	0.33
11	1	11	500	1.47	66.5	0.39
10	4	40	540	5.32	71.82	0.47
9	2	18	558	2.39	74.21	0.58
8	3	24	582	3.19	77.4	0.73
7	3	21	603	2.79	80.19	0.96
6	3	18	621	2.39	82.58	1.31
5	4	20	641	2.66	85.24	1.88
4	4	16	657	2.13	87.37	2.94
3	10	30	687	3.99	91.36	5.22
2	9	18	705	2.39	93.75	11.75
	47	47	752	6.25	100	47

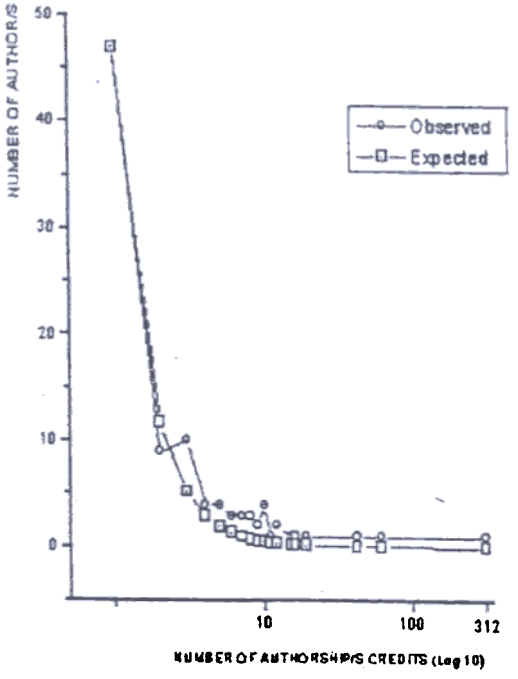

Fig 5 — Author Productivity: Observed Values as per the Bio-bibliography of Ram Gopal Rastogi and Expected (Alpha=2) Values as per the Lotka's Law

(Mentor), H. Chandra, M. R. Deshpande, G. Sethia, G. Rajaram and G. D. Vyas. The second group of 18 active collaborators had publication productivity of six to twelve papers. The third group of 74 collaborators had one to five publication productivity each.

The author productivity is provided in Table 4. Total authorships were 752. The 47 collaborators had only one paper to their credit with R. G. Rastogi. 21 authors out of the team of 98 (i.e., 21.43%) have contributed to the productivity of 80.19 % authorships. Whereas the remaining 77 collaborators (78.57 % of the team) have contributed to only 19.81% of the authorships. The author productivity approximately follows 80/20-rule [69]. The productivity also follows the expected trend of Lotka's Law (Fig. 5).

Table 5 provides information pertaining to the channels of communication used by R. G. Rastogi. Scientific periodicals are the main channels for the scientists to communicate their research works. Two top ranking journals wherein he has published 59 papers each were '*Indian Journal of Radio and Space Physics* ', and '*Journal of*

Table 5

Channelwise scattering of publications of Ram Gopal Rastogi

Sl. No.	Channels of communication	Country of publishing	No. of papers	Cumulative papers	Percent	Cumulative percent	Period of usage FPY	Period of usage LPY	JCR 1992 Impact factor	JCR 1992 Immediacy index
1	Indian J. of Radio & Space Phys.	India	59	59	18.91	18.91	1972	1989	0.049	0.019
2	J. of Atmo. & Terr. Phys.	UK	59	118	18.91	37.82	1956	1989	0.799	0.34
3	Proc. Ind. Acad. Sci.	India	34	152	10.9	48.72	1954	1984		
4	Annales de Geophys.	USA	27	179	8.66	57.38	1966	1988	1.162	0.275
5	J. Geophy. Res.	USA	22	201	7.06	64.44	1959	1992	2.1	0.9
6	Nature	UK		218	5.45	69.89	1961	1978		
7	Curr. Sci.	India		234	5.13	75.02	1974	1989		
8	J. Geomag. Geoelect.	Japan		244	3.21	78.23	1971	1991		
9	J. Inst. Telecom. Engrs.	India		254	3.21	81.44	1964	1972		
10	Planet, Space Sci.	UK		261	2.24	83.68	1971	1973		
11	Annales Geophysicae	USA		266	1.6	85.28	1985	1989		
12	Advances in Space Exploration Vol. 8	UK		271	1.6	86.88	1980	1980		
13	Geophys. Res. Letters	USA		275	1.28	88.16	1975	1987	1.937	0.535
14	J. Pure & Appl. Geophys.	Italy		279	1.28	89.44	1970	1971		
15	Radio Sci.	USA		283	1.28	90.72	1979	1990	0.609	0.161
16	Indian J. Meterology & Geophys.	India		286	0.96	91.68	1957	1969		
17	J. Sci. & Ind. Res.	India		289	0.96	92.64	1955	1959	0.062	0.033
18	Geofisca Pure e Applicata	Italy		291	0.64	93.28	1958	1960		
19	Indian J. Pure & Appl. Phys.	India		293	0.64	93.92	1970	1970		
20	Pramana	India		295	0.64	94.56	1974	1977	0.39	0.064
21	Proc. Indian National Sci. Acad.	India	2	297	0.64	95.2	1982	1982	-	-
22	Rivista Italiana di Geofisica	Italy	2	299	0.64	95.84	1973	1973	-	-
23	Zeitschrift fur Geophysik	Germany	2	301	0.64	96.48	1961	1965	-	-
24	"Acta Geodetica, Geophysics et Montanistica	Hungary	1	302	0.32	96.8	1983	1983	-	0
25	Advances in Space Res.	UK	1	303	0.32	97.12	1988	1988	-	-
26	Astrophys. & Space Sci.	Netherlands	1						0.325	0.155
27	Canadian J. Phys.	Canada	1						0.461	0.099
28	"Geodaet, Geophys, et Montanish Acad." Sc. Hung Tamus	Hungary	1							
29	Indian Acad. of Sci. (Earth & Planet. Sc.)	India	1	307	0.32	98.4	1983	1983		
30	J. of Res.(NBS)	USA	1	308	0.32	98.72	1962	1962		
31	Phys. Earth Planetary Inter.	Netherlands	1						1.186	0.175
32	Phys. News	India	1							
33	Space Res.	Berlin	1							
34	The Electrojet in Magnetic & " Ionospheric Effects, in Geomagnetism" Vol. 3. Academic Press Ltd.	India		312	0.32	100	1989	1989		

"(JCR = Journal Citation Report of Science Citation Index, FPY = First Paper publication Year, and LPY = Last Paper publication Year)"

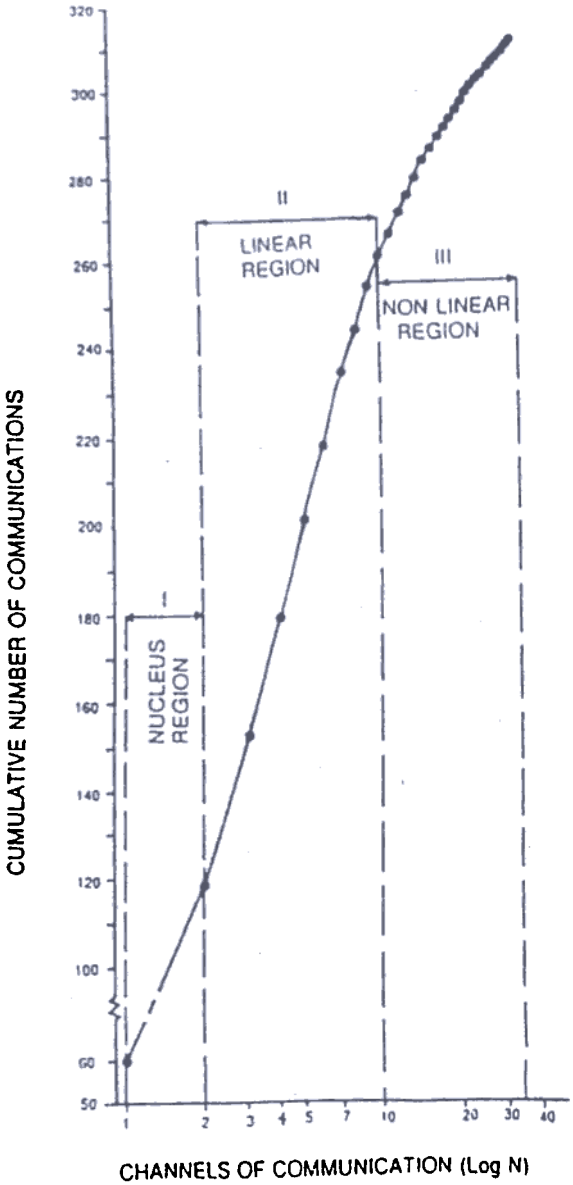

Fig 6 — Bradford-Zipf Bibliograph on Channels of Communication Used by Ram Gopal Rastogi

Atmospheric and Terrestrial Physics '. He has published 34 papers in '*Proceedings of Indian Academy of Sciences*', and 27 papers in '*Annales de Geophysics* '. He has contributed 17 papers (IF 22.139) `*Nature* ', one of the highest impact factor journal in multidisciplinary areas. Another high impact factor journal '*Journal of Geophysical Research*' contained 22 papers by R. G. Rastogi.

Majority of his papers (134) were in Indian sources (12), followed by US sources (6) having 63 papers, and UK sources (5) having 89 papers.

Table 6
Distribution of articles among channels of communications

CH	C	CH.C	Cumulative of CH	Cumulative of CH.C
2	59	118	2	118
1	34	34	3	152
1	27	27	4	179
1	22	22	5	201
1	17	17	6	218
1	16	16	7	234
2	10	20	9	254
1	7	7	10	261
2	5	10	12	271
3	4	12	15	283
2	3	6	17	289
6	2	12	23	301
11	1	11	34	312

(CH = Channels or journals; C = Communications or number of publications and CH.C = Total Communication)

The publication density was found to be 9.18, whereas publication concentration was 11.76.

Citation studies have established that in any given subject, a substantial proportion of articles is concentrated in a relatively small number of journals, and the remaining articles are scattered in a very large number of journals peripheral to or outside the subject. S. C. Bradford [70-71] first investigated this phenomenon of scattering of journal articles.

The distribution of the articles among channels of communication is provided in Table 6 and Fig. 6. As indicated above the top two journals formed the nucleus region. Linear region had 3-10 sources. Non-linear region had 11-34 sources.

Some degree of dispersion of articles in various journals may be desirable to promote cross-fertilization of ideas and serendipitous discoveries. But the disadvantages of the dispersion of papers in numerous journals have far outweighed the

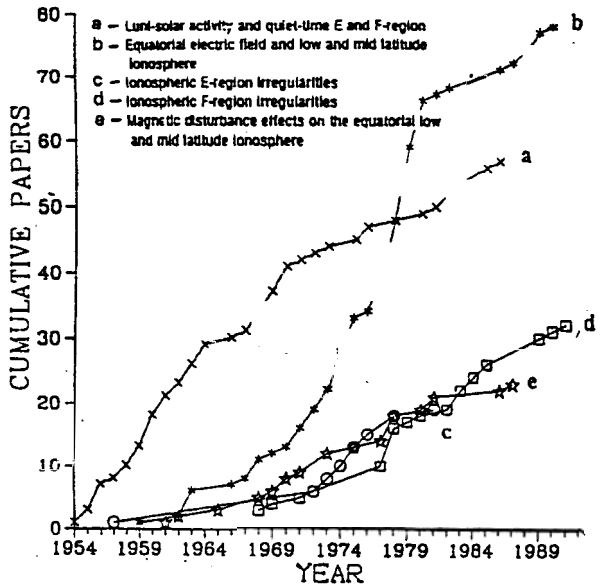

Fig 7 — Domainwise Productivity of Ram Gopal Rastogi

Table 7

Content analysis of publications of Ram Gopal Rastogi

Domain	a	b	c	d	e
a	**57**	36	-	1	3
b	-	**78**	20	20	16
c	-	-	**19**	-	5
d	-	-	-	**32**	2
e	-	-	-	-	**23**

(a = Luni-solar activity and quiet-time E and F-region;
b = Equatorial electric field and low and mid latitude ionosphere;
c = Ionospheric E-region irregularities;
d = Ionospheric F-region irregularities;
e = Magnetic disturbance effects on the equatorial low and mid latitude ionosphere. Bold tuples for the number of publicationsin single domain; and others indicate interdomainary inter-action documented in the contents of the publications)

advantages of dispersion. The twin problems of proliferation of journals and dispersion of papers are of concern to authors, librarians, bibliographers, publishers and secondary services, and users of scientific literature. Editors of abstracting and indexing services and bibliographers have to scan large numbers of journals including those in field's peripheral or unrelated to their areas of interest to be reasonably sure of comprehensiveness. A typical scientist usually scans 6 to 8 journals regularly for current awareness. The effort of individual scientists to

Table 8

Bibliometrics on papers of Ram Gopal Rastogi

Parameters per paper	Range	Mean	Standard Deviation	Standard Error
No. of pages	1-30	7.92	4.49	0.39
No. of references	3-206	20.64	19.74	1.69
No. of self-citations	0-64	5.17	6.57	0.56
No. of tables	0-6	0.65	1.16	0.1
No. of figures	0-32	6.72	4.84	0.41

remain well informed of current developments in their fields of interest is always beset with the frightening possibility of their missing items that may be of crucial importance to their research [72].

The matrix of distribution of articles as per their major thought contents are provided in Table 7. The domain (a) Luni-solar activity and quiet time E and F - region had 57 papers. The domain (b) Equatorial electric field and low- and mid- latitude ionosphere had 78 papers. The domain (c) Ionospheric E-region irregularities had 19 papers. The domain (d) Ionosphere F-region irregularities had 32 papers. The domain (e) Magnetic disturbance effect on the equatorial low and mid-latitude ionosphere had 23 papers.

The number of papers having inter-domainery contents were as follows: a + b (i.e., Luni-solar activity and quiet time E and F - region + Equatorial electric field and low and mid latitude ionosphere) had 36 papers; a + d (i.e., Luni-solar activity and quiet time E and F - region + Ionosphere F-region irregularities) had one only; a + e (i.e., Luni-solar activity and quiet time E and F - region + Magnetic disturbance effect on the equatorial low and mid latitude ionosphere) had three; b + c (i.e., Equatorial electric field and low- and mid-latitude ionosphere + Ionospheric E-region irregularities) and b + d (i.e., Equatorial electric field and low and mid latitude ionosphere + Ionosphere F-region irregularities) had 20 each; b + e (i.e., Equatorial electric field and low- and mid- latitude ionosphere + Magnetic disturbance effect on the equatorial low and mid latitude ionosphere) had 16; c + e (i.e., Ionospheric E-region irregularities + Magnetic disturbance effect on the equatorial

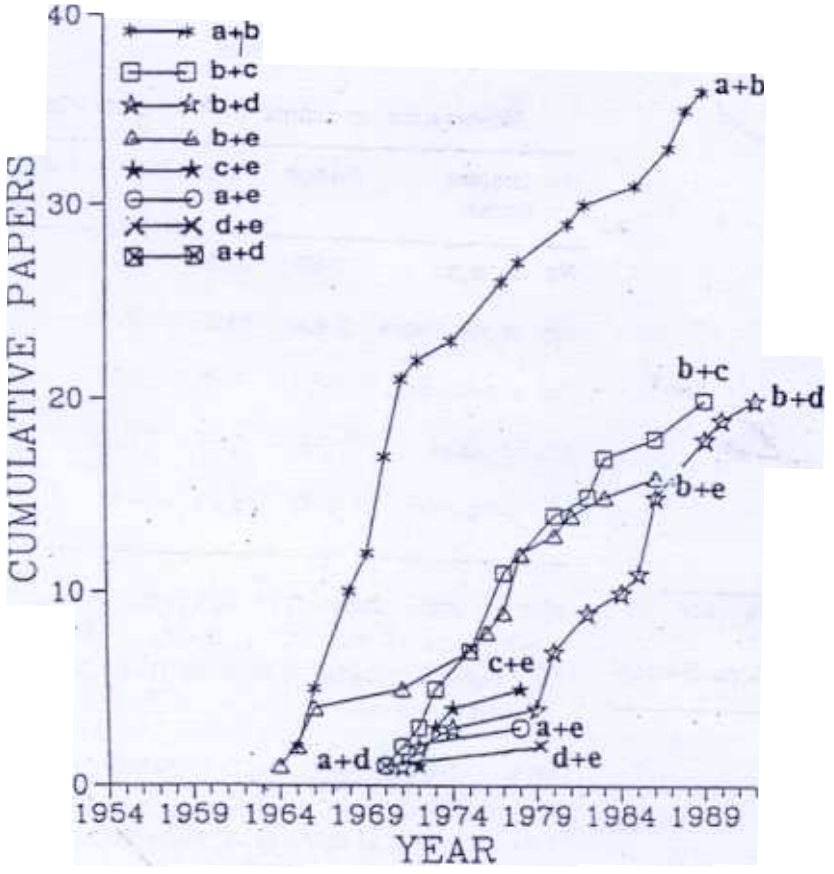

Fig 8 — Interdomainary Productivity of Ram Gopal Rastogi

low and mid latitude ionosphere) had five; d + e (i.e., Ionosphere F-region irregularities + Magnetic disturbance effect on the equatorial low and mid latitude ionosphere) had 2 papers.

Growth in research productivity in various domains is depicted year-wise in Fig. 7. The inter-domainary papers having thought contents of two domains and their productivity are shown in Fig. 8.

The quality of a research can be measured quantitatively by analysing the size of a publication, the number of references cited in each publication, and the expertise by number of self-citations in an article. Samples of 135 papers were taken into consideration to measure these factors. The data is provided in Table 8.

An author's synchronous self-citations are those contained in the citations the author gives to his/her own publications along with the references listed in the same paper.

In general an author's synchronous self-citations rate is determined by considering all the papers he/she has published and finding the number of his/her own papers listed in the references, and expressing this as a percentage of the total number of references in all the papers [73]. In case of Ram Gopal Rastogi, synchronous self-citation rate was 25.08%.

Natural languages share some gross scaling properties [74-75] as per Zipf's Law. Tables 9 and 10 document frequencies of title keywords in publications by R. G. Rastogi. The highest frequency, Ionosphere (92) shows his concentration of research followed by Equatorial (61), F- region (53), Equatorial Electrojet region (40), and Magnetic equator (30). The results show his interest in various microtheme topics related to Geophysics and Geomagnetism.

Table 9

Keyword frequencies in the titles of publications by Ram Gopal Rastogi

Keyword	frequency	Keyword	frequency	Keyword	frequency
Ionosphere	92	Night time	5	Temperate latitude	2
Equatorial	61	Ootacamund	5	Transient celestial gamma ray	2
F-region	53	Total electron content	5	Transient celestial x-ray	2
Equatorial electrojet region	40	Equatorial Es-layer	4		
Magnetic equator	30	Equatorial Spread	4		
India	28	Horizontal drifts	4		
Lunar latitude	28	Ionospheric scintillation	4		
Spread F	26	Magnetic control	4		
Ahmedabad	22	Satellites	4		
Geomagnetism	21	Solar flare	4		
Low latitude	19	Asian zone	3		
E-layer	18	Day time	3		
H-Component field	17	Geomagnetic variation	3		
Huancayo	17	Kink	3		
Scintillation	16	Lunar oscillations	3		
Electron content	14	Puerto Rico	3		
Radio waves	14	VHF back scattering	3		
Solar cycle	13	VHF scintillation	3		
Sporadic-E	13	Anisotropy parameters	2		
Equatorial Ionosphere	12	Disturbance	2		
Thumba	12	Diurnal	2		
Electron density	11	D-region	2		
American zone	10	Electric fields	2		
E-region drifts	9	Equatorial electric fields	2		
foF2	9	Equatorial magnetic fields	2		
Geomagnetic storm	9	F1-region	2		
Solar eclipse	9	Geomagnetic dist-urbance effects	2		
IGY/IGC	8	Horizontal magnetic field	2		
Interplanetary magnetic field	8	IMF	2		
Kodaikanal	8	Ionospheric F-region	2		
Ionospheric irregularity	7	Latitude stations	2		
Ionospheric drifts	7	Morning flare	2		
Radio scintillation	7	North-South movement	2		
Tiruchirapalli	7	Oscillations	2		
ATS-6 beacon satellite	6	Panama	2		
Counter electrojet currents	6	Plasma density	2		
Daily variation	6	Post sun-rise	2		
Equatorial station	6	Spaced fading records	2		
Geomagnetic equator	6	Solar activity	2		
Es-q	5	Solar control			
Electric field	5	Sq current	2		
Electron drift	5	Storm time			
Geomagnetic field	5	Sunspot years	2		
Ionisation	5				
Lunar	5				

Table 10
Keywords used only once in the titles of publications by Ram Gopal Rastogi

Keyword	Keyword
Australia	North-south components
Black scatter	Northern-southern
Blanketing	Hemisphere
Bombay	Numerical model
Canada	Ottawa
Central Africa	Phase scintillation
Crest	Plasma distribution
Critical frequency	Plasma drifts
Colambo	Plasma irregularities
Core components	Plasma redistribution
Cosmic gamma rays	Post mid night
East Asia	Post sun-rise
Echoes	Post sun-set
Equatorial fountain	Quiet day dynamo
Equatorial Ionograms	Quiet day geomagnetic
Equatorial power	variations
Equatorial radio	Radio field strenghts
scintillations	San Juan
Equatorial storms	Satellite Radio
Ethiopia	scintillation
foR2	Satellite signals
Faraday polarisation	Space borne
FGG	Spaced receiver
FGR	technique
Folkland	Semi-diurnal
Global ionosphere	Singapore
Grand Bahama	Solar disturbances
Horizontal F-region	Solar flare chrochet
Horizontal polarization	Solar noon
Indo-Soviet	Solar wind
Interplanetary magnetary	Southern high latitude
magnetic fields(Bz)	Sunrise
Ionospheric currents	Tidal oscillations
Ionospheric horizontal	Topside
drifts	Tropical
Jaipur	Ultra high frequency
Jamica	waves
Luni-solar	VHF scattering
MAGSAT	
Magnetic storm	
Mid latitude	
Moon	
Multi-station data	
Noon electron density	
North-south asymmetry	

CONCLUSION

Ram Gopal Rastogi had a brilliant academic and research career. The number of publications to his credit in various domains and interdomainery nature clearly indicates that under very limited facilities also he had proved his merit. Thus, he can be taken as an exemplary role model for younger generations to follow his leadership style in science management. A few case studies conducted recently and the present case study on R. G. Rastogi have clearly indicated that there is no dearth of local role models in India to motivate other scientists. Hence the hypothesis "Most of the developing countries lack local `role models' to motivate other scientists" [76-77] is rejected. R. G. Rastogi had collaborated with 97 scientists during 1954-1990 which indicates his exceptional capability to motivate contemporaries and harness their expertise through mentorship.

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