

Botanical Survey of India (1971–2010): a scientometric analysis

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The present study reports on the research performance of the Botanical Survey of India (BSI) between 1971 and 2010, based on number of parameters, including publications, citations, impact in terms of average citation per paper, international and national collaboration output, share of publication by different circles of BSI, type of communication, most preferred journals, highly cited papers, authorship pattern and most productive authors. The study analyses 40 years (1971–2010) of publication data drawn from *Web of Science (SCI-Expanded)*. A total of 423 papers were published in 40 years (10.57 papers per year), which received 892 citations with an average of 2.1 citations per paper, *h*-index of 12 and a *p*-index of 12.34. It has been observed that during 1977–1986, number of publications was comparatively better. Between 1987 and 2005, a long recession was observed; again it is on rise from 2006 onwards, the citations were following almost the same trend. BSI has published 72 and 38 collaborative papers with involvement of 56 national and 22 foreign institutions respectively. *Current Science* is the most preferred journal, Council of Scientific and Industrial Research is major domestic collaborator (21 papers), University of Rhode Island, Kingston is the major foreign collaborator (11 papers), USA is the major collaborator country (16 papers) and BSI, Kolkata has contributed maximum number of publications (41%).

Keywords: Botanical Survey of India, botany, mapping, scientometric, taxonomy.

THE Botanical Survey of India (BSI) is the premier survey organization of the country engaged in floristic surveys and inventorization of plant resources of India. It was established in 1890. After independence, reorganization of BSI was taken up in 1952. The headquarters of the organization is in Kolkata and 11 regional circles are at Dehra Dun, Pune, Coimbatore, Shillong, Itanagar, Sikkim, Allahabad, Port Blair, Noida, Jodhpur and Hyderabad. It holds about 3 million plant specimens and more than 300 new species have been discovered by the organization. In the near future, BSI will play a significant role because about 15–20% of flowering plants on the earth are yet to be discovered. In non-flowering plants, the percentage of

missing species is much higher^{1,2}. Apart from survey, BSI is involved in other activities such as conservation of rare species, custodian for the Convention on International Trade in Endangered Species (CITES) of Wild Flora and Fauna, taxonomical studies and publication of flora and monograph, ethnobotanical studies, development of national database of Indian plants, environmental awareness, technical and consultancy services in plant identification, nomenclature and distribution.

The public-funded research needs to be measured because: (i) resources are limited and public fund should be allocated properly; (ii) expenditure on research is growing continuously; (iii) inputs are required for policy making, and (iv) contribution of institution and individual researcher should be highlighted³. Quantitative evaluation of publication and citation data are the fundamental methods to measure the impact and influence of research and identify the significant papers^{3–5}. Counting of cited references is highly efficient and productive because it relies upon the judgements of authors/researchers; they are more familiar with the content of published literature than others⁶. Although citations do not fully indicate the quality of a paper, they serve as a key to evaluating impact and influence of research^{5,7}. It has been observed that the highly cited papers have high-quality research and provide new insights or avenues of research; also citations show that the researcher/author depended on earlier work to conduct his/her own investigation⁸. However, a bibliometric analysis of BSI has not been done so far. Therefore, the publications and citations of BSI were mapped with the following objectives: (a) to analyse year-wise publications and citations of BSI in terms of its broad characteristics; (b) identify the nature of collaborations with authors, institutions and countries; (c) identify highly preferred journals for publications; (d) identify prolific authors by publications and citations count, impact, *h*-index and *p*-index and (e) study the distribution of publication in different circles of BSI.

Methodology

The present study is based on publications and citations as indexed by *Web of Science (WoS)* for the period 1971–2010. The *WoS* published by Thomson Reuters, USA, is the on-line version of *Science Citation Index (SCI)-Expanded*

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Table 1. Growth of publications and citations of BSI from 1971 to 2010 (40 years)

Year	Paper	Citation*	Impact**	Year	Paper	Citation*	Impact**
1971	0	0	0.00	1991	14	5	0.36
1972	3	0	0.00	1992	8	1	0.13
1973	8	10	1.25	1993	7	0	0.00
1974	8	2	0.25	1994	9	1	0.11
1975	9	4	0.44	1995	6	1	0.17
1976	8	0	0.00	1996	4	0	0.00
1977	13	2	0.15	1997	7	1	0.14
1978	11	4	0.36	1998	8	0	0.00
1979	15	9	0.60	1999	2	0	0.00
1980	21	1	0.05	2000	2	1	0.50
1981	16	1	0.06	2001	7	4	0.57
1982	12	2	0.17	2002	5	1	0.20
1983	22	2	0.09	2003	3	5	1.67
1984	14	0	0.00	2004	10	9	0.90
1985	15	1	0.07	2005	7	7	1.00
1986	11	1	0.09	2006	19	11	0.58
1987	5	0	0.00	2007	26	13	0.50
1988	8	6	0.75	2008	24	30	1.25
1989	12	7	0.58	2009	18	11	0.61
1990	7	3	0.43	2010	32	25	0.78

*Three years window. **Impact = Citations/Publications.

Table 2. Journals (top 25) preferred by scientists of BSI for publication, 1971–2010

Journal	No. of papers	Impact factor (2012)	Country
<i>Current Science</i>	101	0.905	India
<i>Taxon</i>	43	2.782	Slovakia
<i>Nordic Journal of Botany</i>	34	0.595	Denmark
<i>Mycotaxon</i>	30	0.821	USA
<i>Indian Journal of Traditional Knowledge</i>	23	0.492	India
<i>Proceedings of the Indian Academy of Sciences, Plant Sciences</i>	19	NA	India
<i>Proceedings of the Indian Academy of Sciences, Section B</i>	18	NA	India
<i>National Academy Science Letters, India</i>	17	0.067	India
<i>Economic Botany</i>	13	1.925	USA
<i>Bangladesh Journal of Botany</i>	10	0.258	Bangladesh
<i>Nova Hedwigia</i>	10	0.809	Germany
<i>Blumea</i>	9	0.266	The Netherlands
<i>Lichenologist</i>	9	1.135	England
<i>Journal of the Indian Chemical Society</i>	8	0.251	India
<i>Bangladesh Journal of Plant Taxonomy</i>	5	0.489	Bangladesh
<i>Acta Botanica Indica</i>	4	NA	India
<i>Aquatic Botany</i>	4	1.593	The Netherlands
<i>Botaniska Notiser</i>	4	NA	Sweden
<i>Candollea</i>	4	0.370	Switzerland
<i>Journal of Bryology</i>	4	1.351	England
<i>Mykosen</i>	4	NA	Germany
<i>Adansonia</i>	3	0.639	France
<i>Boreas</i>	3	2.457	Denmark
<i>Cryptogamie Mycologie</i>	3	1.044	France
<i>Novon</i>	3	0.295	USA

of Institute for Scientific Information, Philadelphia, USA. The *WoS* includes more than 12,000 journals from 256 categories and more than 1,600 regional journals. It also covers open access journals and over 148,000 proceedings from the most significant conferences, symposia, seminars, colloquia, workshops and conventions worldwide. The *WoS* was the primary source of data because it

provides addresses of all the authors and includes selected journals (top 10–12% from every disciplines).

Data collection was done by using the keyword ‘Bot Survey****’. The results obtained were further restricted to publication years 1971–2010. The data were then manually checked to avoid redundancy and anomalies and non-relevant records were removed. The data were collected

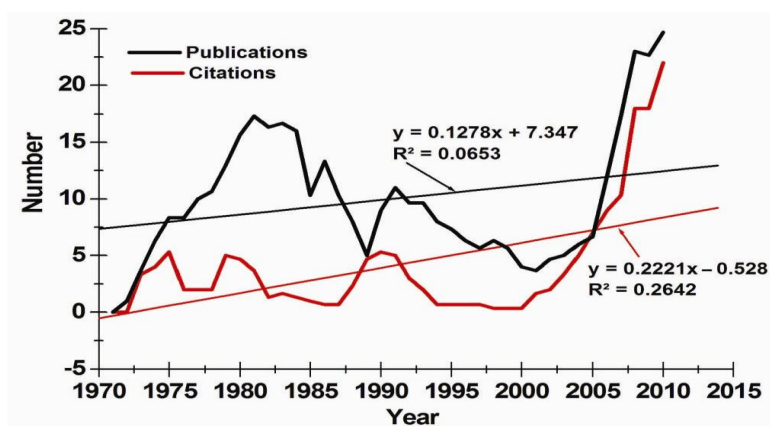


Figure 1. Publication and citation patterns tracked over three years rolling average window from 1971 to 2010 (40 years).

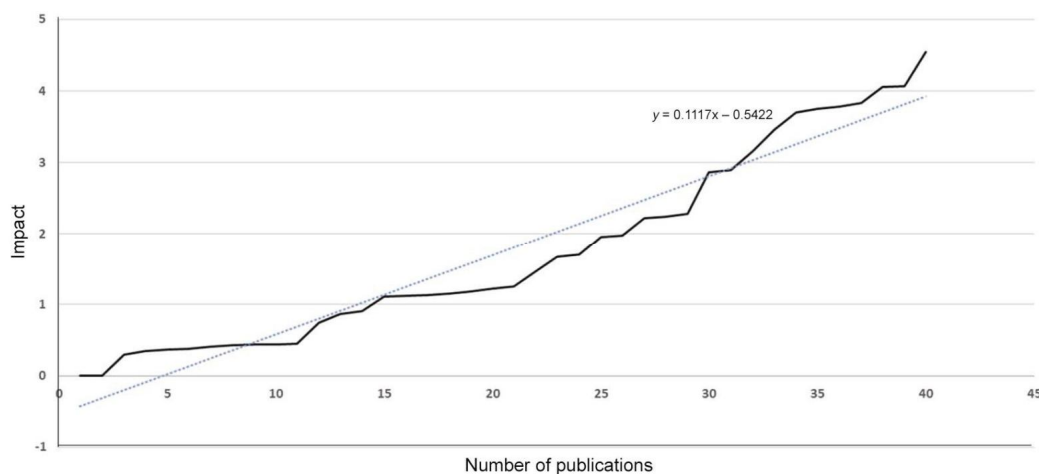


Figure 2. Five years rolling average window of quantity and impact from 1971 to 2010.

Table 3. Type of document published, 1971–2010

Document type	Number	Percentage share
Article	296	69.97
Note	77	18.20
Letter	34	8.03
Editorial material	7	1.65
Review	3	0.70
Biographical item	2	0.47
Meeting abstract	2	0.47
Book chapter	1	0.23
Correction	1	0.23
Total	423	100

Table 4. Authorship collaboration

Authorship pattern	No. of publications	Percentage share
Single author	114	26.95
Two authors	193	45.62
Three authors	77	18.20
Four or more authors	39	9.21
Total	423	100

on 25 December 2013. The present article includes only those records which are available on *Web of Science*.

Three years rolling window for each publication year was counted for citations. The citations of leading authors and highly cited papers were screened on the basis of total citations. All the collaborations were counted by papers and not by number of researchers. The concept of ‘relative measure, not just absolute count’ was applied during the study^{5,9}. Therefore, different performance indicators have been used for mapping: (i) counting of publications and citations; (ii) impact of publications; (iii) extent of collaboration, viz. co-authored, national and international; (iv) distribution of publications in different circles of BSI and (v) *h*-index and *p*-index.

Discussion

Between 1971 and 2010, a total of 423 papers have been published by BSI with an average output of 10.57 papers per year; 892 citations were received with an average of 2.1 citation per paper, *h*-index of 12 and *p*-index of 12.34 (Table 1). The average citation per paper (2.1) is

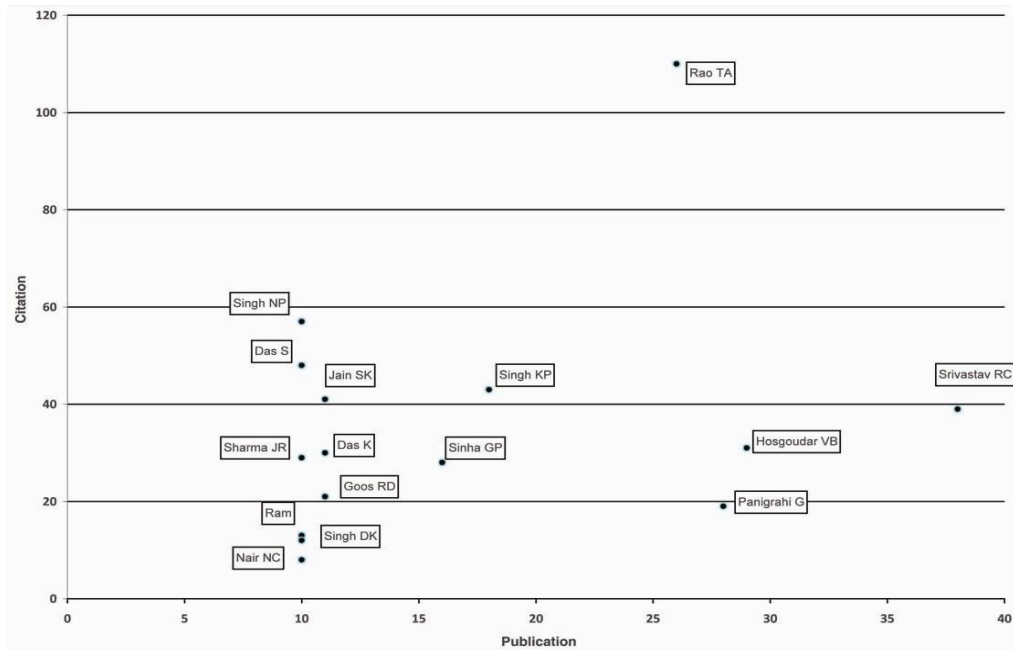


Figure 3. Relationship between quality (citation without self-citation) and quantity (publication) of leading authors (10 or more publications).

Table 5. Distribution of publications in different subject categories

1971–1980		1981–1990		1991–2000		2001–2010		1971–2010	
Category	Papers	Category	Papers	Category	Papers	Category	Papers	Total	% share
Angiosperm	59	Angiosperm	72	Angiosperm	32	Angiosperm	41	206	48.69
Gymnosperm	1	Gymnosperm	0	Gymnosperm	0	Gymnosperm	1	2	0.47
Pteridophyte	4	Pteridophyte	9	Pteridophyte	0	Pteridophyte	5	18	4.25
Bryophyte	1	Bryophyte	0	Bryophyte	0	Bryophyte	11	12	2.83
Algae	0	Algae	2	Algae	1	Algae	2	5	1.18
Fungi	8	Fungi	12	Fungi	17	Fungi	11	48	11.34
Lichen	5	Lichen	2	Lichen	3	Lichen	18	28	6.61
Ethnobotany	3	Ethnobotany	5	Ethnobotany	4	Ethnobotany	26	38	8.98
Conservation	0	Conservation	2	Conservation	0	Conservation	8	10	2.36
Multidisciplinary	13	Multidisciplinary	11	Multidisciplinary	4	Multidisciplinary	30	58	13.71
Total	94		115		61		153	423	

Table 6. Scientometric data for leading authors of BSI, 1971–2010

Author	Paper	Total citation	Without self-citation	<i>h</i> -index	<i>p</i> -index	Impact	<i>p</i> -index/ <i>h</i> -index
Srivastav, R. C.	38	42	39	4	3.59	1.11	0.90
Hosgoudar, V. B.	29	42	31	4	3.93	1.45	0.98
Panigrahi, G.	28	20	19	2	2.43	0.71	1.21
Rao, T. A.	26	143	110	5	9.23	5.5	1.84
Singh, K. P.	18	49	43	5	5.11	2.72	1.02
Sinha, G. P.	16	34	28	3	4.16	2.13	1.39
Jain, S. K.	11	42	41	4	5.43	3.82	1.36
Das, K.	11	44	30	4	5.60	4.00	1.40
Goos, R. D.	11	27	21	3	4.05	2.45	1.35
Singh, N. P.	10	57	57	3	6.87	5.7	2.29
Das, S.	10	53	48	4	6.55	5.30	1.64
Sharma, J. R.	10	40	29	4	5.43	4.00	1.36
Ram, T. A. M. J.	10	17	13	2	3.07	1.70	1.53
Singh, D. K.	10	12	12	2	2.43	1.20	1.22
Nair, N. C.	10	8	8	2	1.86	0.80	0.93

Table 7. Indian institutions in the collaborative networks (three or more publications), 1971–2010

Institute	Papers
CSIR-National Botanical Research Institute, Lucknow	9
Central Agricultural University, Pasighat, Arunachal Pradesh	9
CSIR-National Institute of Science Communication and Information Resources, New Delhi	7
Tamil Nadu Agriculture University, Coimbatore	6
Banaras Hindu University, Varanasi	5
Central Agriculture Research Institute, Port Blair	5
Agharkar Research Institute, Pune	4
Manglore University, Karnataka	4
Indian Institute of Science, Bangalore	3
CSIR-National Chemical Laboratory, Pune	3

Table 8. International collaborative publication

Country	Publications
USA	16
Mexico	3
Germany	3
Australia	3
England	3
South Africa	2
The Netherlands	2
Brazil	1
Nepal	1
Sweden	1
France	1
Finland	1
Canada	1
Belgium	1

Table 9. Publications from collaborations with international institutes (two or more papers are enlisted), 1971–2010

Institution	Publications
University of Rhode Island, USA	11
Australian National University, Australia	3
University of Kwazulu Natal, South Africa	2
ABL Herbarium, The Netherlands	2
University of Konstanz (Universität Konstanz), Germany	2
University of Wyoming, USA	2
Royal Botanic Gardens, England	2
Institute of Ecology (Institute de Ecologia), Mexico	2

good for plant taxonomy because publication on classical plant taxonomy attracts fewer citations. The number of publications of BSI was good during 1978–1986; thereafter a long recession (1987–2005) was observed; the publication gained momentum from 2006 onwards, the citations are following almost the same trend (Table 1 and Figure 1). The increase in publication from 2006 onwards may be due to recruitment of manpower and inclusion of more journals in *SCI* database. Analysis of data indicates that counts of publication and relative citation per paper have positive correlation for BSI; almost the same trend was reported from other studies^{10,11}. This means the quality of publication is not falling with increase in quantity (Figure 2). A total of 60 journals were

used for publication. *Current Science* is the most preferred journal sharing 24% of the publications, followed by *Taxon* (10%), *Nordic Journal of Botany* (8%), *Mycotaxon* (7%) and *Indian Journal of Traditional Knowledge* (5.4%) (Table 2). A multi-disciplinary journal (i.e. *Current Science*) is most preferred because: (i) none of the Indian journal dedicated to plant taxonomy is indexed in *SCI-Expanded* databases; (ii) *Current Science* has wide circulation, short gestation period and offers free publication and access. Out of 423 publications, about 70% are articles, followed by note (18%), letter (8%), editorial (1.6%), etc. (Table 3). About 46% of the manuscripts are published by two authors, followed by single authorship (27%), three authors (18%) and four or more authors (9%; Table 4).

It has been observed that most of the publications are on angiosperm (48.69%), followed by multidisciplinary sciences (13.71%), fungi (11.34%), etc. (Table 5). In between 2001–2010, publications on angiosperm have been decreased and on multidisciplinary sciences, cryptogamous and ethnobotany have been increased significantly. Sudden increase in papers on ethnobotany are may be due to inclusion of an Indian journal (*Indian Journal of Traditional Knowledge*) in *SCI-Expanded* database in 2007. Since past two decades (1991–2010) less number of articles on angiosperm are appearing in good journals due to journals approach in article selection has been shifted, i.e. giving priority to molecular studies over morphological studies, unfortunately BSI works on morphological/classical plant taxonomy. The cryptogamous are comparatively less explored than angiosperm and gymnosperm. Therefore, frequency of getting new species is very high in cryptogamous, consequently articles on algae, fungi, lichen, bryophyte and pteridophyte are getting reputed journals. Most of the authors enlisted in Table 6 are from cryptogamous due to same reason.

On a global level, research collaboration is increasing because researchers and policy makers believe that collaboration is good¹². BSI has made collaborations with 56 Indian and 22 foreign institutions and produced 72 and 38 papers respectively (Tables 7–9). Usually collaborative publications get higher citation than non-collaborative publications and it is highest when the collaboration is

Table 10. List of papers that received 10 or more citations, 1971–2010

Cites	Publication year	Title/source	Author	BSI circle	Collaborative institution
40	2001	Genetic diversity across natural populations of three montane plant species from the Western Ghats, India revealed by intersimple sequence repeats. <i>Mol. Ecol.</i> , 10 (10), 2397–2408.	Deshpande, A. U. <i>et al.</i>	[2] Western Circle, Pune [4] BSI, Kolkata	[1] National Chemical Laboratory, Pune [3] Indian Institute of Science, Bangalore
39	1973	Typology of sclereids. <i>Proc. Indian Acad. Sci. Sect. B</i> , 77 (2), 41–55.	Rao, T. A. and Bhuwal, O. P.	[1] BSI, Kolkata	[2] Bangabasi College, Kolkata
29	1979	Leaf sclereids occurrence and distribution in the angiosperms. <i>Bot. Not.</i> , 132 (3), 319–324.	Rao, T. A. and Das, S.	BSI, Kolkata	
23	1983	Ethnobotanical studies of the tribes of Andaman and Nicobar Islands, India.1. <i>Ongc. Econ. Bot.</i> , 37 (1), 110–119.	Bhargava, N.	Andaman & Nicobar Circle, Port Blair	
18	1980	Ethnobotany of the Mikirs of India. <i>Econ. Bot.</i> , 34 (3), 264–272.	Jain, S. K. and Borthakur, S. K.	BSI, Kolkata	
15	1991	Plant folk medicines among the Nicobarese of Katchal Island, India. <i>Econ. Bot.</i> , 45 (1), 114–119.	Dagar, H. S. and Dagar, J. C.	Andaman & Nicobar Circle, Port Blair	
14	1998	Antibacterial activity of <i>Syzygium</i> species. <i>Fitoterapia</i> , 69 (4), 365–367.	Chattopadhyay, D., Sinha, B. K. and Vaid, L. K.	[2] Andaman & Nicobar Circle, Port Blair	[1] Regional Medical Research Centre, Port Blair [3] Calcutta Medical College, Kolkata
12	2008	Bamboo taxonomy and diversity in the era of molecular markers. <i>Bot. Res.: Incorporating Adv. Plant Pathol.</i> , 47 , 225–268.	Das, M., Bhattacharya, S., Singh, P., Filgueiras, T. S. and Pal, A.	[3] BSI, Kolkata	[1] Unites States Environmental Protection Agency, USA [2] Bose Institute, Kolkata, [4] Reserva Ecologia, IBGE, Brazil
12	2001	Some less known ethnomedicinal uses from Mysore and Coorg districts, Karnataka state, India. <i>J. Ethnopharmacol.</i> , 75 (2–3), 231–238.	Kshirsagar, R. D. and Singh, N. P.	[2] BSI, Kolkata	[1] Nicholas Piramal India Ltd, Mumbai
12	1974	Preliminary observations of ethnobotany of genus Coix. <i>Econ. Bot.</i> , 28 (1), 38–42	Jain, S. K. and Banerjee, D. K.	[1] Eastern Circle, Shillong [2] BSI, Kolkata	
11	2006	Sustainable development of the Indian Himalayan region: linking ecological and economic concerns. <i>Curr. Sci.</i> , 90 (6), 784–788.	Singh, J. S.	[2] Central Circle, Allahabad	[1] Banaras Hindu University, Varanasi

(Contd)

Table 10. (Contd)

Cites	Publication year	Title/source	Author	BSI circle	Collaborative institution
11	1988	<i>Halophila decipiens</i> Ostenf in southern India. <i>Aquat. Bot.</i> , 32 (1–2), 179–185.	Parthasarathy, N., Ravikulmar, K. and Ramamurthy, K.	Southern Circle, Coimbatore	
11	1972	Origin of mango (<i>Mangifera indica</i>). <i>Econ. Bot.</i> , 26 (3), 260–264.	Mukherjee, S. K.	BSI, Kolkata	
10	2010	Assessing species admixtures in raw drug trade of <i>Phyllanthus</i> , a hepato-protective plant using molecular tools. <i>J. Ethnopharmacol.</i> , 130 (2), 208–215.	Srirama, R. <i>et al.</i>	[3] BSI, Kolkata	[1] University of Agricultural Sciences, Bangalore [2] Ashoka Trust for Research in Ecology and the Environment, Bangalore [4] University of Agricultural Science, Bangalore [5] College of Agriculture, Shimoga [6] Kuvempu University, Shimoga [7] University of Agricultural Sciences, Bangalore
10	2007	Ethnoveterinary plants of Uttaranchal – A review. <i>Indian J. Traditional Knowledge</i> , 6 (3), 444–458.	Pande, P. C., Tiwari, L., and Pande, H. C.	[2] Northern Circle, Dehra Dun	[1] Kumaon University, Almora
10	2007	Traditional fermented foods of the Naga tribes of Northeastern, India. <i>Indian J. Traditional Knowledge</i> , 6 (1), 37–41.	Mao, A. A. and Odyuo, N.	Eastern Circle, Shillong	
10	1990	Meliolaceous Fungi from the state of Kerala, India. 2. Genus <i>Meliola</i> . <i>Mycotaxon</i> , 37 , 217–272.	Hosagoudar, V. B. and Goos, R. D.	[2] Southern Circle, Coimbatore	[2] University of Rhode Island, USA
10	1979	Studies on Indian Solanum. 1. Alkaloid content and detection of solasodine. <i>Econ. Bot.</i> , 33 (1), 75–77.	Maiti, P. C., Mookherjee, S., Mathew, R. and Dan, S. S.	BSI, Kolkata	

Table 11. Distribution of publications in different circles of BSI, 1971–2010

Circle	Year of establishment	States/Union Territories covered	Publication	Percentage share
BSI, Kolkata (headquarters)	1890	West Bengal, Jharkhand, Bihar	177	40.97
Southern Circle, Coimbatore	1955	Kerala, Tamil Nadu, Lakshadweep, Minicoy Islands	74	17.12
Central Circle, Allahabad	1962	Madhya Pradesh, Chhattisgarh, Uttar Pradesh	45	10.41
Eastern Circle, Shillong	1956	Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura	35	8.10
Arunachal Pradesh Circle, Itanagar	1977	Arunachal Pradesh	24	5.55
Northern Circle, Dehra Dun	1956	Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Uttarakhand, Chandigarh	22	5.09
Western Circle, Pune	1955	Goa, Karnataka, Maharashtra, Dadra and Nagar Haveli, Daman, Diu	20	4.62
Andaman & Nicobar Circle, Port Blair	1972	Andaman & Nicobar Islands	20	4.62
Himalayan Circle, Gangtok	1979	Darjeeling District and Sikkim	11	2.54
Botanic Garden of Indian Republic, Noida	2002	National Capital Territory Region of Delhi	3	0.46
Arid Zone Circle, Jodhpur	1972	Rajasthan and Gujarat	1	0.00
Deccan Circle, Hyderabad	2005	Andhra Pradesh and Odisha	Nil	0.00

international¹². This trend is more or less the same in the present study; top two-cited articles are published by collaborations (Table 10). Out of 18 highly cited papers, 9 are published by involvement of two or more institutes including 2 papers with international collaborations. Among the highly cited papers, only two have single authorship (Table 8). BSI, Kolkata has contributed maximum number of publications (41%), followed by Southern Circle (17.12%), Central Circle (10%), Eastern Circle (8%), etc. (Table 11).

Fifteen authors have 10 or more publications. R. C. Srivastav has published maximum number of papers, but T. A. Rao received maximum citations (140; Table 6). T. A. Rao and K. P. Singh had the highest *h*-index (5 each)¹³. The *h*-index is insensitive to uncited papers and highly cited papers¹⁴. Therefore, *p*-index was calculated and T. A. Rao has the highest *p*-index of 9.23 (Table 6). The ratio of *p*-index/*h*-index provides interesting information about distribution between citations and publications. If the ratio is more than 1.5, not many papers are below the *h*-index and if the ratio is around 0.5, then most of the papers are not cited (<http://giridharmadras.blogspot.in/2009/07/p-index.html>). K. P. Singh has maximum *p*-index/*h*-index score, i.e. 2.29, followed by T. A. Rao with 1.84. It may be due to better average citations and less *h*-index than T. A. Rao. Analysis of quality (citation without self-citation) verses quantity (publication) of leading authors denotes that T. A. Rao was the most productive author during 1971–2010; he has published 25 papers with 4.40 average citations, *p*-index of 9.35 and *h*-index of 5 (Figure 3).

Conclusions

BSI publications and citations were good during 1978 to 1986, followed by a long recession between 1987 to 2005; it again increased from 2006 onwards. BSI has published 72 papers with domestic collaboration and 38

papers with foreign collaboration. The *Current Science* is the most preferred journal, followed by *Taxon*, both accounting for 34% publication share. The Kolkata Centre (headquarters) of BSI has published maximum papers (41%).

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