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Bibliometrics of Indian veterinary science research output during 2001-2020

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The paper is an analysis of 7,056 papers published by Indian scientists during 2001-2020 in the discipline of veterinary sciences. The study indicates that there is a steep decline in the Indian research output in veterinary sciences after the two years block of 2009-2010. Most of the prolific institutions except Sri Venkateswara University, Tirupati were funded by Indian Council of Agricultural Research (ICAR) published about 71% of the total output. Of these, Indian Veterinary Research Institute (IVRI), Izatnagar produced the highest number of papers and Central Institute of Fisheries and Aquaculture (CIFA), Bhubaneswar had the highest value of CPP. Highest number of prolific authors was also from Indian Veterinary Research Institute (IVRI). About three-fourth of the papers were published in low impact factor journals. Of the total published papers, about one-third remained uncited. All the highly cited papers were written either in domestic or international collaboration. About 45% papers were published in journals of Indian origin and the remaining papers in journals originating from other countries. Among countries from abroad, highest number of papers was published in journals originating from USA and UK.

Keywords: Bibliometrics; Scientometrics; Veterinary Science; Citation analysis; India

Introduction

India has vast livestock resources which includes animal husbandry, dairy and fisheries. Together with its allied activities, livestock provides milk and milk products, meat and meat products, and is a major supplier of food and food articles, raw materials, and finished products. Therefore, the livestock sector plays a vital role in national economy and in the socio-economic development of the country. Its role is very important in the rural economy by supplementing family incomes and generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and women. Livestock sector contributes 4.11% to the GDP and 25.6% to total agriculture GDP[1].

In view of the above, the field of veterinary medicine or veterinary science plays an important role for Indian economy. The outstanding advance in veterinary science in India was made with the establishment of the Imperial Bacteriological Laboratory in 1889 at Izatnagar, Uttar Pradesh (UP), which is now known as Indian Veterinary Research Institute (IVRI), a deemed university under Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) including Veterinary and Animal Science/Fisheries Science Universities, spread over different agro-ecological zones of India, have played a key role in transforming livestock production in the country through sustained animal health research, teaching and extension services backed by competent human resource generated from these institutions[2]. The present paper examines the Indian research output and its citation impact in veterinary sciences during the 20 years period of 2001-2020 using bibliometric techniques.

Review of literature

Kasa, Ibrahim and Momoh[3] analysed the publication research output of the faculty members of Agriculture and Veterinary Complex of Ahmadu Bello University, Zaria from 2002-2012. The findings of the study revealed that of the 1,134 articles, 159 (13.98%) were published in the year 2006 making it the most productive year. The results of the analysis revealed dominance of multi-authored papers. Freire and Nicol[4] carried out a bibliometric analysis of

papers published in the sub-discipline of animal welfare (AW) indexed in Web of Science from 1968-2017. University of Bristol, UK emerged as the main contributor of original research articles. Numerous low-cited articles originated from Germany and were published in journals published from Germany.

Beside these studies other studies dealt with bibliometric analysis of journals related to veterinary sciences, authorship and collaboration trends in veterinary sciences, identification of highly cited articles.

Vijayakumar, Sivasubraminiyan and Saraswati Rao[5] examined 1,954 papers published in *Veterinary World* during the years 2008-2017. Authors examined parameters like distribution of papers by year, authorship pattern, and distribution of papers by institution, length of the papers, type of the document published, international authored contributions and citation etc. Authors found that the highest number of publications were in the year in 2016 (250 articles, 12.8%) and the lowest was in 2008 (132 articles, 6.7%). Almost 96.7% papers were joint authored and Indian researchers contributed 72.6% papers during the study period.

Crawley-Low[6] analysed 25,000 bibliographic references cited in *American Journal of Veterinary Research* during the period of 2001 to 2003 for type of documents cited, date of their publication and frequency of journals cited. Based on the cited journals, the author prepared a core list of journals in the field of veterinary sciences. Arya and Sharma[7] examined the authorship and collaboration trend in veterinary sciences all over the world with special reference to India using the data from ''*CABI abstracts*" for the period of 2006-2010. The findings of the study revealed that the field of veterinary science research is highly collaborative as indicated by the high value for degree of collaboration.

ELsinghorst[8] examined articles published in 123 journals indexed in the *Journal Citation Reports* under the category of "Veterinary Sciences" during 2002 and 2003 and identified articles those were cited 20 or more times. Author identified 96 articles published in 34 journals out of the 123 journals. Based on the country of the first author, the articles originated from 24 countries. Among these, USA published the highest (34) number of highly cited articles followed by England (15). The category "microbiology" and related subjects published highest (48) number of articles.

The review of literature indicates that no study has been published that dealt with the bibliometric analysis of Indian research output in veterinary sciences. However, two studies dealing with agricultural science research in India has been carried out by Arunachalam and Umarani[9] and Garg, Kumar and Lal[10]. Arunachalam and Umarani analyzed 11,855 publications of agricultural research output of Indian scientists indexed by CAB Abstracts 1998 and found that majority of papers were published on 'pests, pathogens and biogenic diseases' followed by 'plant production'. Highest contributions were made by State Agricultural Universities. Indian researchers preferred to publish in journals that originated from UK, USA and India. Majority of papers were published in journals not indexed by *Science Citation Index*.

Garg, Kumar, and Lal analyzed 16,891 papers published by Indian agricultural scientists indexed by *Science Citation Index Expanded (Web of Science)* during the ten years period of 1993-2002. The study found that the major research focus was on 'dairy and animal sciences' followed by 'veterinary sciences'. Agricultural universities and institutes under the aegis of ICAR produced maximum research output. The present study makes a bibliometric analysis of papers published by Indian scholars in the discipline of veterinary sciences during the 20 years period of 2001-2020.

Objectives of the study

The present study focuses on the following aspects of the scientific output of veterinary science research in India.

- To examine the distribution of the output by type of documents;
- To examine the chronological distribution of the research output during the study period of 2001-2020 in block of two years each;
- To identify most prolific institutions / authors and to examine the citation impact of their research output using different impact indicators like Citation per Paper (CPP), i10 index, papers not cited (PnC) for prolific institutions and h-index for authors. These have been described in succeeding paragraphs;
- To examine the distribution of citations and to identify highly cited papers; and
- To examine the communication pattern of scientists in terms of publishing country of

journals and their impact factor and to list the most preferred journals used for communicating research results;

Methodology

The source of data for the present bibliometric study is "Web of Science-Core Collection", a product of Clarivate Analytics (USA). Authors downloaded all records published by Indian authors using the "Advance Search" mode and the string CU= "India" for the years 2001-2020 in the second week of March 2021. The data was refined for Web of Science subject category "Veterinary Science". The downloaded data included name of all authors with their affiliations, name of the journal with its place of publication, type of publications, i.e., research articles, reviews, notes, letters, meeting abstracts, editorials, corrections, news item and book reviews etc and citations obtained by each paper. However, authors have used only research articles, reviews, notes, and letters in the final bibliometric analysis. Other document types have not been subjected to detailed bibliometric analysis as the impact of such type of records is negligible and thus dilutes the impact of institutes and authors. The data was enriched with the impact factor of the journals. Each record was standardized for its affiliation as there were variations in their names.

Bibliometric indicators used

Several bibliometric indicators have been proposed in literature to assess the productivity and impact of countries, institutions, and authors. In the present study, authors have used six bibliometric indicators. These are total number of publications (TNP) published during 2001-2020, total number of citations (TNC) received by these papers during 1990-2021 (March 10, 2021), citation per paper (CPP), i10-index, papers not cited (PnC) and h-index. The values of TNP and TNC were directly obtained from the downloaded data. CPP is the average number of citations per paper (Total citations/total papers). It has been widely used in bibliometric studies to normalize the large disparity in the volume of published output among countries and institutions for a meaningful comparison of research impact. i10 - index developed by Google Scholar was obtained by analyzing the citation data. It tells about the number of publications that received 10 or more citations. PnC is the number of papers which were not cited during the period of study and h-index proposed by Hirsh[11]. Hirsh proposed h-index as a single number that can capture both the quantity and quality attribute. A scholar has an index of h if each of his/her papers has been cited by others at least h times. In the present study, these indicators have been used to compare the performance of most prolific institutions and authors.

Results and discussion

Distribution of output by type of documents

During the 20 years period of 2001-2020, Indian scholars working in different Indian institutes published 7,272 documents on different aspects of veterinary sciences. An analysis of data indicates that highest number 6,816 (93.9%) records were published as research articles followed by review articles 154 (2.1%). The share of records published as proceeding papers and letters each were 43 (0.6%). Thus, these four types of documents constituted 7,056 (97%) of total output. Authors have made a detailed bibliometric analysis of these 7,056 records. Remaining 216 records were published as meeting abstracts (139), editorials (33), corrections (21), articles early access (17), news item and book reviews each three. These together constituted about 3% of document types. These have not been subjected to detailed bibliometric analysis.

Chronological growth of output

Figure 1 depicts the chronological growth of Indian output in veterinary sciences during the 20 years period of 2001-2020 in blocks of two years each.

With a start of 885 publications in the two years block of 2001-2002, the publications reached a peak of 1262 publications in the two years block of 2007-2008. The publication output started declining after that. The lowest number of papers was published in the two years block of 2015-2016 with 464 publications only. In remaining blocks, the number of publications was more than 500. The proportion of output varied from 6.6% to 13.3% during the study period. Possible reason for low output of India after 2008 was the exclusion of *Indian Veterinary Journal* (official publication of the Indian Veterinary Association) from Web of Science after 2008. The journal published 2799 (39.6%) papers during 2001-2008 of the total 7056 papers published by Indian scholars during 2001-2020.

Distribution of output and impact of prolific institutions

A raw analysis of data indicates that 1,910 institutions scattered in different parts of India

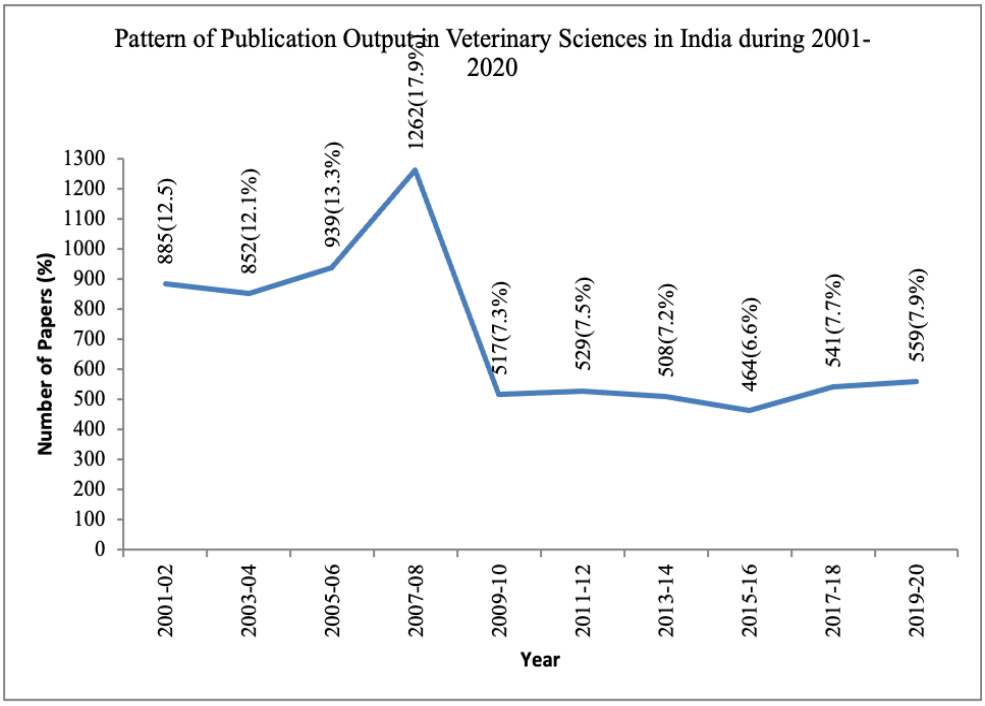

Fig. 1 — Pattern of Indian Output (growth rate %) in Veterinary Sciences during 2001-2020

published 7,056 papers. Table 1 lists 26 institutions which produced one per cent or more of the total output during the study period. These 26 institutions published more than two-third (71%) of the total output and the remaining 1,884 institutions published 29% of the total output. The publication output is highly skewed as 1,884 institutions produced 2,548 papers, each institution producing 1.4 papers.

All the most productive institutions listed in Table 1 except Sri Venkateshwara University (Tirupati) are supported by the Indian Council of Agricultural Research (ICAR), the apex body for funding the agricultural and veterinary science research in India. Among all the institutes, IVRI (Izatnagar), the oldest institute of India in veterinary sciences and a deemed university topped the list of most prolific institutions with about ~ 12 % of the total output closely followed by TNVASU (Chennai) with 10 % output. Thus, these two institutes produced slightly less than one-fourth of the total output. Of the total publications, 1,527 (21.6 %) papers were cited 10 or more times and 2,502 (35.5 %) papers remained uncited and the value of CPP for the entire output is 7.1.

Among all the 26 institutes listed in Table 1, the value of CPP was less than 7.1 for 15 institutions. The CPP was highest (38.4) for Central Institute of Freshwater and Aquaculture (CIFA), Bhubaneswar followed by Central Institute for Fisheries Education (CIFE), Mumbai with CPP value of 32.6. These two institutes have a high value of CPP, because 79 % papers published by CIFA were cited 10 or more times and of the 84 papers published by CIFA only three papers remained uncited. Similar were the reasons for high value of CPP for CIFI. Lowest value of CPP was for RUVAS (Bikaner) as only four papers of 209 were cited 10 or more times and more than half (58 %) papers remained uncited resulting in low value of CPP. Percentages of i-10 index and PnC have been round off to nearest whole number.

Calculation for i-10 index (%) = (Number of papers in i-10 index/TNP) x100 and
PnC = (PnC/TNP) x100

Distribution of output by prolific authors and impact of their output

Total output was published by 11,941 authors scattered in different Indian and foreign institutions. Table 2 lists 26 authors who contributed half or more percent of output. These 26 authors produced about ~ 13 per cent of the total output and belonged to different institutions located in different parts of India.

Highest number of prolific authors was from IVRI. Seven authors from IVRI contributed 305 papers. The next in output were three authors from Tamil Nadu Veterinary and Agriculture Science University

Table 1 — Distribution of output and citation impact of most prolific institutions

Sl. no.	Institute*	TNP	TNC	CPP	i-10 index (%)	PnC (%)
1	IVRI (Izatnagar)	858	8179	9.5	292 (34.0)	160 (18.6)
2	TNVASU (Chennai)	715	1895	2.7	52 (7.3)	398 (55.7)
3	GADVASU (Ludhiana)	341	2049	6.0	60 (13.9)	99 (29.0)
4	NDRI (Karnal)	299	2258	7.6	82 (27.4)	58 (19.4)
5	AAU (Jorhat)	282	480	1.7	9 (3.2)	137 (48.6)
6	RUVAS (Bikaner)	209	265	1.3	4 (1.9)	123 (58.8)
7	KVAFSU (Bidar)	208	800	3.8	25 (12.0)	104 (50.0)
8	NRCC (Bikaner)	203	677	3.3	19 (9.4)	89 (43.8)
9	MAFSU (Nagpur)	202	454	2.2	10 (5.0)	119 (58.9)
10	GBPUAT (Pant Nagar)	149	874	5.9	31(20.8)	65 (43.6)
11	WBUAFS (Kolkata)	143	1340	9.4	40 (28.0)	42 (29.4)
12	CCSHAU (Hisar)	122	987	8.1	35 (28.7)	35 (28.7)
13	KVASU (Kozhikode)	119	289	2.4	11 (9.2)	58 (48.7)
14	NDVSU (Jabalpur)	105	215	2.0	4 (3.8)	62 (59.0)
15	CSWRI (Avikanagr)	103	763	7.4	26 (25.2)	20 (19.4)
16	SVVU (Tirupati)	99	290	2.9	12 (12.1)	47 (47.5)
17	SVU (Tirupati)	99	393	4.0	11 (11.1)	52 (52.5)
18	SKUAST (Kashmir)	97	433	4.5	14 (14.4)	28 (28.9)
19	IVRI (Uttarakhand)	89	1898	21.3	59 (66.3)	5 (5.6)
20	NIANP (Bangalore)	88	979	11.1	35 (39.8)	14 (15.9)
21	CIFA (Bhubaneswar)	88	3377	38.4	70 (79.6)	3 (3.4)
22	NRCE (Hisar)	81	873	10.8	33 (40.7)	12 (14.8)
23	CIRG (Mathura)	80	743	9.3	23 (28.8)	20 (25.0)
24	CIFE (Mumbai)	79	2574	32.6	47 (59.5)	2 (2.2)
25	PAU (Ludhiana)	78	535	6.9	18 (23.1)	32 (41.0)
26	SKUAST (Jammu)	72	275	3.8	7 (9.7)	32 (44.4)
	Sub total	5008	28610	6.4	864 (19.2)	1711 (37.9)
	Other institutions (1884)	2048	21252	8.3	663 (26.0)	791 (31.0)
	Total	7056	49862	7.1	1527 (21.6)	2502 (35.5)

* Full names of institutions given in Appendix

Table 2 — Distribution of output and citation impact of most prolific institutions

Sl. no.	Most Productive Authors	TNP	TNC	*CPP	h-index	*PnC (%)
1	Manohar, B. Murali, (TNVASU, Chennai, TN)	70	115	1.6	6	44 (63)
2	Balachandran, Chidambaram, (TNVASU, Chennai, TN)	69	155	2.3	5	41 (59)
3	Harikrishnan, Ramasamy, (Pachaiyappa College for Men, Kanchipuram, TN)	61	1299	21.3	22	2 (3)
4	Dhama, Kuldeep, (IVRI, Izatnagar, UP)	60	940	15.7	16	8 (13)
5	Balasundaram, Chellam, (Bharathidasan University, Tiruchirappalli, TN)	52	1184	22.8	22	3 (6)
6	Sarkar, Mihir, (IVRI, Izatnagar, UP)	51	290	5.7	11	16 (31)
7	Amarpal, (IVRI, Izatnagar, UP)	45	339	7.5	12	10 (22)
8	Kumaresan, Arumugam, (NDRI, Karnal, Haryana)	44	323	7.3	10	7 (16)
9	Gahlot, T. K. (RUVAS, Bikaner Rajasthan)	42	44	1.1	3	21 (50)
10	Goswami, R. N. (AAU, Jorhat, Assam)	40	71	1.8	5	12 (30)
11	Kataria, A. K. (RUVAS, Bikaner, Rajasthan)	40	73	1.8	5	17 (43)
12	Kinjavdekar, Prakash, (IVRI, Izatnagar, UP)	39	299	7.7	11	7 (18)
13	Rajkhowa, Chandan, (National Research Centre for Pigs, Guwahati, Assam)	39	153	3.9	7	8 (21)
14	Balamurugan, Vinayagamurthy, (Project Directorate Animal Disease Monitoring & Surveillance, Bangalore, Karnataka)	38	737	19.4	19	1(3)
15	Patil, N. V. (NRCC, Bikaner Rajasthan)	38	56	1.5	3	18 (47)

(*Contd*.)

Table 2 — Distribution of output and citation impact of most prolific institutions (*Contd*.)

Sl. no.	Most Productive Authors	TNP	TNC	*CPP	h-index	*PnC (%)
16	Sivakumar, T.(Livestock Research Station, Kattupakkam, Chennai , TN)	38	30	0.8	2	25 (66)
17	Arockiaraj, Jesu, (SRM University, Chennai,TN)	37	690	18.6	16	2 (5)
18	Chakrabarti, Arunaloke, PGIMER, Chandigarh	37	699	18.9	13	10 (27)
19	Chauhan, M. S., (IVRI, Izatnagar, UP)	37	432	11.7	12	3 (8)
20	Palta, P. (NDRI, Karnal, Haryana)	37	378	10.2	12	2 (5)
21	Pawde, Abhijit Motiram, (IVRI, Izatnagar, UP)	37	253	6.8	10	9 (24)
22	Dhinakar, R.G. (TNVASU, Chennai (TN)	37	309	8.4	10	4 (11)
23	Sahoo, Pramoda Kumar, (CIFA, Bhubaneswar (Odisha)	37	1267	34.2	21	0 (0)
24	Aithal, Hari Prasad, (IVRI, Izatnagar, UP)	36	285	7.9	11	5 (14)
25	Bujarbaruah, K. M. (AAU Jorhat, Assam)	35	175	5.0	9	8 (23)
26	Ranjan, Rakesh, ICAR- Directorate of Foot & Mouth disease, Nainital (UttraKhand)	35	434	12.4	10	12 (34)
	Sub-total	901	8452	9.4	41	257 (29)
	Others authors (11915)	6155	41410	6.7	64	2245 (37)
	Total	7056	49862	7.1	69	2502 (36)

*Rounded off to the nearest whole number

(TNVASU), Chennai (Tamil Nadu) who published 176 papers. These 10 authors together published more than half (53.4%) of the papers contributed by most prolific authors. Impact of output in terms of CPP indicates that of the 26 prolific authors, value of CPP for 11 authors was less than the average CPP (7.1) for the entire output. These 11 authors had low values of CPP, because a large proportion of the papers published by these authors remained uncited (Table 2).

Sahoo, Pramoda Kumar of CIFA had the highest CPP (34.2) because none of his paper remained uncited. Also, he had a high value of h-index (21) which indicates that of the 37 papers published by the author, 21 papers were cited 21 or more times. The next in rank was Balasundaram, Chellam of the Bharathidasan University, Tiruchirappalli, (Tamil Nadu) and Harikrishnan, Ramasamy of the Pachaiyappa College for Men, Kanchipuram, (Tamil Nadu). The value of CPP for these two authors was 22.8 and 21.3 respectively and the value of h-index for both the authors was 22. The reason for high value of CPP for these authors is the high values of h-index for these authors as well as only a small number of uncited papers. The lowest value of CPP and h-index was for Gahlot, T. K. of the Rajasthan University of Veterinary and Animal Sciences (RUVAS), Bikaner because 50 per cent of his papers remained uncited. Similarly, for Manohar, B. Murali of the TNVASU, Chennai, 62.8% papers remained uncited resulting in low CPP.

Table 3 — Distribution of citations

Range of Citations	Number of Papers	Percentage of Papers	Total citations
0	2502	35.5	0
1	960	13.6	960
2	551	7.8	1102
3	377	5.3	1131
4	269	3.8	1076
5	235	3.3	1175
6	210	3.0	1260
7	160	2.3	1120
8	132	1.9	1056
9	133	1.9	1197
10	130	1.8	1300
11-20	731	10.4	10749
21-30	278	3.9	6889
31-40	159	2.3	5497
41-50	85	1.2	3780
51-100	116	1.6	7739
100	28	0.4	3831
Total	7056	100.0	49862

Distribution of citations

Citations are a measure of the impact of an article obtained by counting the number of times the article was cited by other articles. High levels of citation to a scientific publication are interpreted as signs of scientific influence, impact, and visibility. An author's visibility can be measured through a determination of how often his/her publications have been cited in publications by other authors. Table 3 shows the citation pattern of the papers published on veterinary research during 2001-2020. Citations were

examined till 10 March 2021, on which the data were downloaded.

During this period, 49,862 citations were received by 7,056 papers and the average rate of CPP was 7.1. Of the total papers included in the analysis, 2502 (35.5%) remained uncited and rest were cited one or more times. Of the 2,502 uncited papers, 1711 (37.9) were published by most prolific institutions and the rest 791 (31%) papers by other non-prolific institutes.

The share of uncited papers was 50 % or more for TNVASU (Chennai), RUVAS (Bikaner), KVAFSU (Bidar), MAFSU (Nagpur), NDVSU (Jabalpur), and SVU (Tirupati). Of the total cited papers about one-third (33.8 %) were cited between 1-5 times and 10.9 % were cited 6-10 times. Thus, 44.7 % papers were cited between 1-10 times. Remaining papers were cited more than 10 times. Of these, 2 % papers received more than 50 citations, of which only 28 papers received more than 100 citations.

Highly cited papers

Table 4 lists 29 highly cited papers which were cited 100 or more times. These 29 papers received 3931 (7.9 %) of all citations. However, it will be important to mention here that none of the highly cited paper has been authored by the prolific authors. Further analysis of highly cited data indicates that of

Table 4 — Highly cited papers

Sl. no.	Highly cited papers	Number of Citations	CPY	Type of collaboration
1	Mahler M., Berard M., Feinstein R. et al., Laboratory Animals 48 (3) 2014, 178 -192.	234	39	IC
2	Rao Y. V., Das B. K., Jyotyrmayee P. et al., Fish & Shellfish Immunology 20 (3) 2006, 263 – 273.	218	16	DC
3	Feng Yaoyu, Ortega Ynes, He Guosheng, et al., Veterinary Parasitology 144 (1-2), 2007, 1–9.	202	16	IC
4	Kumar N. Pradeep, Rajavel A. R., Natarajan R. et al., Journal of Medical Entomology 44 (1) 2007, 1 – 7.	179	14	DC
5	Dhar P., Sreenivasa B.P., Barrett T., et al., Veterinary Microbiology 88 (2) 2002, 153 – 159.	168	9	IC
6	Chakrabarti Arunaloke, Bonifaz Alexandro, Gutierrez-Galhardo Maria, et. al., Medical Mycology 53 (1) 2015, 3 – 14.	165	33	IC
7	Selvaraj V, Sampath K, Sekar V Fish & Shellfish Immunology 19 (4) 2005, 293 – 306.	161	32	DC
8	Christybapita D., Divyagnaneswari M., Michael R. Dinakaran Fish & Shellfish Immunology 23 (4) 2007, 840 – 852.	150	12	DC
9	Li Chao, Zhang Yu, Wang Ruijia, Nandi Simiram, et. al., Fish & Shellfish Immunology 32 (5) 2012, 816 – 827.	144	18	IC
10	Kumar Rajesh, Mukherjee S. C., Ranjan Ritesh et. al., Fish & Shellfish Immunology 24 (2) 2008, 168 – 172.	140	12	DC
11	Citarasu Thavasimuthu, Sivaram Veeramani, Immanuel Grasian, Ruat Namita, et. al., Fish & Shellfish Immunology 21 (4) 2006, 372 – 384.	135	10	IC
12	Kumar S., Sahu N. P., Pal A. K., et. al., Fish & Shellfish Immunology 19 (4) 2005, 331 – 344.	133	9	DC
13	Swain P., Nayak S. K., Nanda P. K., et .al., Fish & Shellfish Immunology 25 (3) 2008, 191 – 201.	133	11	DC
14	Giri Sib Sankar., Sukumaran V., Oviya M. Fish & Shellfish Immunology 34 (2) 2013, 660 – 666.	130	19	DC
15	Chakrabarti Arunaloke., Das Ashim, Mandal Jharna, et. al., Medical Mycology 44 (4) 2006, 335 – 342.	125	9	DC
16	Jha Ashish Kumar, Pal A. K., Sahu N. P., et. al., Fish & Shellfish Immunology 23 (5) 2007, 917 – 927.	124	10	DC
17	Nayak S. K., Swain P., Mukherjee S. C. Fish & Shellfish Immunology 23 (4) 2007, 892 – 896.	116	9	DC
18	Renukaradhya G J., Isloor S., Rajasekhar M. Veterinary Microbiology 90 (1-4) 2002, 183 – 195.	114	6	DC
19	Singh R. P., Sreenivasa B. P., Dhar, P. et. al., Veterinary Microbiology 98 (1) 2004, 3- 15.	113	7	DC

(*Contd*.)

Table 4 — Highly cited papers

Sl. no.	Highly cited papers	Number of Citations	CPY	Type of collaboration
20	Papp Hajnalka Laszlo, Brigitta Jakab Ferenc, Ganesh Balasubramanium, et. al., Veterinary Microbiology 165 (3-4) 2013, 190 – 199.	112	16	IC
21	Kumar S. Rajesh, Ahmed V. P. Ishaq, Parameswaran V. et. al., Fish & Shellfish Immunology 25 (1-2) 2008, 47 – 56.	111	9	DC
22	Misra C. K., Das B. K., Mukherjee S. C., et. al., Fish & Shellfish Immunology 20 (3) 2006, 305 – 319.	110	8	DC
23	Kumari J., Sahoo, P. K. Journal of Fish Diseases 29 (2) 2006, 95 - 101	104	7	DC
24	Sevilla I, Singh S.V., Garrido J.M. et. al., Revue Scientifique et Technique-office International des Epizooties 24 (3) 2005, 1061 – 1066.	103	7	IC
25	Parida S., Muniraju M., Mahapatra M., et. al., Veterinary Microbiology 181 (1-2) 2015, 90 – 106.	102	20	IC
26	Selvaraj V., Sampath K., Sekar Vaithilingam, Veterinary Immunology and Immunopathology 114 (1-2) 2006, 15 – 24.	102	7	DC
27	Sahoo P.K., Mukherjee S.C., Fish & Shellfish Immunology 11 (8) 2001, 683 – 695.	102	5	DC
28	Arunakumari G., Shanmugasundaram N., Rao V. H., Theriogenology 74 (5) 2010, 884 - 894	101	10	DC
29	Sahu Swagatika Kumar, Das Basanta Pradhan, Jyotirmayee P. et. al., Fish & Shellfish Immunology 23 (1) 2007, 109 – 118.	100	8	DC
	Total	3931	-	

the 29 papers, 12 papers were published in the journal "Fish and Shellfish Immunology"; a journal published from England with an impact factor more than 3. Of the 29 highly cited papers, 20 papers were written in domestic collaboration (DC) and the remaining nine in international collaboration (IC). Authors also examined Citation per Year (CPY) to normalize the variation in citations of highly cited papers as the number of citations obtained depends upon the citation window. Based on the ranking of CPY, it is observed that the papers ranked higher based on total citations changes slightly, if ranked by CPY. For instance, papers ranked at 6 and 7 will change to rank 2 and 3 if ranked by CPY. Similarly, paper ranked at 20 will move to rank 4 if ranked by CPY.

Communication pattern of Indian scholars

Communication pattern of Indian scholars have been examined using two different indicators. These are the publishing country of journals and the impact factor (IF) of these journals as obtained from Journal Citation Reports 2018. Journals published from the advanced countries of the West command more respect and mainstream connectivity as compared to journals published from developing countries including India. Impact factor is an indicator of the prestige of the journal. Papers published in journals with higher IF by and large indicate more recognition than papers published in journals with low IF. The findings based on these two indicators have been described below.

Domestic versus international journals

Table 5 depicts the distribution of papers by publishing country of journals. Analysis of data on papers published by Indian scholars in the discipline of veterinary sciences indicates that 7,056 papers were published in 146 journal titles published from 32 different countries of world including India. Of these 146 titles used for publishing research results only four are Indian journals. These four journal titles published 3,233 (45.8%) papers and the remaining 3,823 (54.2%) papers appeared in journals published from abroad. Of these, about 14.6% papers appeared in journals published from the UK, followed by the journals published from the USA (14.1%) and the Netherlands (13%). This indicates that about 41.7% papers published by Indian scholars appeared in journals published from UK, USA and the Netherlands.

These findings are similar to the findings of Arunachalam & Umarani and Garg, Kumar & Lal for agricultural sciences. Remaining 12.5 % papers appeared in journals originating from other developed and developing countries excluding India. Remaining 286 papers appeared in journals published from 22 different countries. Of these 173 papers were appeared in journals from Switzerland (43), Italy (40),

Table 5 — Distribution of output by publishing country of journals

Sl. no.	Journal Publishing Country	TNP	TNP (%)	No. of Journals	% of Journals
1	India	3233	45.8	4	2.74
2	England	1033	14.6	24	16.44
3	USA	996	14.1	44	30.14
4	Netherlands	918	13.0	12	8.22
5	Croatia	151	2.1	1	0.68
6	Turkey	91	1.3	1	0.68
7	Iran	90	1.3	1	0.68
8	Pakistan	90	1.3	4	2.74
9	Germany	86	1.2	7	4.79
10	France	82	1.2	6	4.11
	Sub-total	6770	95.9	104	71.22
	Other 22 countries	286	4.1	42	28.78
	Total	7056	100.0	146	100.00

South Korea (38), Israel (32), and Japan (20). Remaining 113 papers were published in journals originating from 16 countries. The number of papers published by Indian scholars in journals originating from these 16 countries varied in between 1 to 15.

Distribution of papers according to impact factor

Based on the lowest and highest values of impact factor of journals where 7,056 papers were published, authors divided the impact factor into five categories. These categories are ≤ 1.00 (very low), > 1.00 ≤ 2.00 (low), > 2.00 ≤ 3.00 (medium), > 3.00 ≤ 4.00 (high) and ≥ 4 (very high). Distribution of output according to the range of impact factor is depicted in Table 6. It indicates that more than half (57.4 %) of the papers are published in very low impact factor (≤ 1.00) journals. Of these, 3233 papers appeared in Indian journals followed by papers in journals originating from Croatia (151), Turkey (91), Iran (90) and France (72) respectively. This indicates that papers published by Indian scholars is not connected to mainstream science as about 20.8% papers appeared in medium, high and high impact journals and rest in very low and low impact factor journals. Similar results were found for agricultural science research in India by Arunachalam & Umarani and Garg, Kumar & Lal.

Most common journals used for publishing research results

Analysis of data indicates that 7,056 papers were published in 146 journal titles. Table 7 lists 20 journals where the Indian veterinary scientists published more than 70 papers. These 20 journals published 5744 (81.4 %) papers. Remaining 1312 (19.6 %) papers were published in other journals. Regarding country of publication of most common

Table 6 — Distribution of papers by Impact Factor

Range of IF	Category	Number of papers	Percent
≤ 1.0	Very low	4053	57.4
> 1.00 ≤ 2.00	Low	1533	21.7
> 2.00 ≤ 3.00	Medium	899	12.7
> 3.00 ≤ 4.00	High	475	6.7
> 4.00	Very high	96	1.4
Total		7056	100.0

Table 7 — Most common journals used by scholars from India

Sl. no.	Most common journals (Journal publishing country)	IF 2018	No. of papers
1	Indian Veterinary Journal (India)	0.060	2799
2	Tropical Animal Health and Production (Netherlands)	1.333	388
3	Fish & Shellfish Immunology (England)	3.370	340
4	Journal of Camel Practice and Research (India)	0.137	239
5	Theriogenology (USA)	2.094	217
6	Veterinary Practitioner (India)	0.020	175
7	Veterinary Research Communications (Netherlands)	1.293	166
8	Reproduction in Domestic Animals (USA)	1.641	162
9	Research In Veterinary Science (England)	1.892	158
10	Veterinary Parasitology (Netherlands)	2.157	154
11	Veterinarski Arhiv (Croatia)	0.426	151
12	Medical Mycology (England)	2.822	109
13	Veterinary Microbiology (Netherlands)	3.030	93
14	Veterinary Record (England)	2.442	92
15	Turkish Journal of Veterinary & Animal Sciences (Turkey)	0.513	91
16	Iranian Journal of Veterinary Research (Iran)	0.978	90
17	Journal of Animal Physiology and Animal Nutrition (USA)	1.597	84

(*Contd*.)

Table 7 — Most common journals used by scholars from India

Sl. no.	Most common journals (Journal publishing country)	IF 2018	No. of papers
18	Comparative Immunology Microbiology and Infectious Diseases (England)	1.573	82
19	Transboundary and Emerging Diseases (USA)	4.188	82
20	Revue Scientifique Et Technique-Office International Des Epizooties (Fr)	0.563	72
	Sub-total		5744 (81.4%)
	Others (Journals =117; Proceedings = 9)		1312 (18.6%)
	Total (146)		7056

journals used for publishing research results, three titles originated from India, four each from the Netherlands, England and the USA. One journal each was published from Croatia, Turkey, Iran and France.

Discussion and Conclusion

This is the first bibliometric study on the Indian veterinary science research output which provides an insight of Indian publication output in veterinary sciences during 2001-2020. The study points out a steep decline in output during the later period of 2009-2010 to 2019-2020. The reason for this steep decline after 2009-2010 was the exclusion of *Indian Veterinary Journal* from Web of Science database.

Data on the output of institutions indicates a highly skewed distribution of output. For instance, 26 prolific institutions produced more than two-third (71%) of the total output and 1884 institutions produced 29% papers, each institution producing 1.4 papers. Among all the institutions IVRI produced the highest number of papers. However, the highest citation impact in terms of CPP was for CIFA followed by CIFE. These two institutes had considerably higher CPP as compared to IVRI. Value of CPP for institutions not listed in Table 1 is more than prolific institutions listed in Table 1 and is also more than the average CPP 7.1 for prolific institutions. Most of the prolific authors belonged to prolific institutions except nine authors who belonged to non-prolific institutions.

The study also found that no highly cited authors were among the prolific authors. Most of the highly cited papers were published in journals with impact factor more than two and were written either in domestic or international collaboration. Like institutions and authors, the output is scattered in more than 100 journals. Highest number of these journals was published from USA followed by UK. More than three-fourth of the papers were published in journals with very low and low impact factor journals. Veterinary science research plays an important role in Indian economy. The findings of the study may be useful for policy makers as well researchers working in the field of veterinary sciences.

References

1 Singh R, Livestock's contribution to Indian economy available at https://www.pashudhanpraharee.com/livestocks-contribution-to-indian-economy/ (Accessed on April 26, 2021.)

2 Rana N and Kumar A, Veterinary education in India: Shaping the future agenda with focus on veterinary public health education, *Indian Journal of Animal Sciences*, 87 (9) (2017) 1052-1061. Available from: https://www.researchgate.net/publication/320135791. (Accessed on April 26, 2021).

3 Kasa MG, Ibrahim U and Momoh KA, Bibliometric analysis of publication output patterns of faculty members of agriculture and veterinary complex of a Nigerian University, *The Information Manager*, 14 (1-2) (2014) 21-28.

4 Freire R and Nicol C, A bibliometric analysis of past and emergent trends in animal welfare science, *Animal Welfare*, 28 (4) (2019) 465-485. https://doi.org/10.7120/09627286.28.4.465

5 Vijayakumar P, Sivasubraminiyan G and Saraswati Rao M, Publication output of journal 'Veterinary World' (2008-2017): A Bibliometric Analysis, *Library Philosophy and Practice (e-journal)*. 2400. https://digitalcommons.unl.edu/libphilprac/2400

6 Crawley-Low J, Bibliometric analysis of the American Journal of Veterinary Research to produce a list of core veterinary medicine journals, *Journal of Medical Library Association*, 94 (4) (2006) 430-434

7 Arya C and Sharma S, Authorship trends and collaborative research in veterinary sciences: A bibliometric study, *Chinese Librarianship: An International Electronic Journal*, 34. URL: http://www.iclc.us/cliej/cl34AS.pdf

8 ELsinghorst TA, Analysis of the 96 most often cited articles published in veterinary journals in 2002 and 2003, *Veterinary Quarterly*, 27 (4) (2005) 183-189, DOI: 10.1080/01652176.2002.9695199

9 Arunachalam S and Umarani K, Mapping agricultural research in India: A profile based on CAB Abstracts 1998, *Current Science*, 81 (8) (2001) 896-906. (https://tspace.library.utoronto.ca/retrieve/3252/896.pdf Accessed on 25/11/2020)

10 Garg KC, Kumar S and Lal K, Scientometric profile of Indian agricultural research as seen through Science Citation Index Expanded, *Scientometrics*, 68 (1) (2006) 151-166.

11 Hirsh JE, An index to quantify an individual's research output, *Proceedings of the National Academy of Sciences of the USA*, 146 (1) (2005)16569-16572

APPENDIX

Name of the institute with their abbreviation
IVRI: Indian Veterinary Research Institute, Izatnagar
TANVASU: Tamil Nadu Veterinary and Animal Sciences University, Chennai
GADVASU: Guru Angad Dev Veterinary & Animal Sciences University, Ludhiana
NDRI: National Dairy Research Institute, Karnal
AAU: Assam Agricultural University, Guwahati
RUVAS: Rajasthan University of Veterinary and Animal Sciences, Bikaner
KVAFSU: Karnataka Veterinary, Animal and Fisheries Sciences University, Bengaluru
NRCC: National Research Centre on Camel, Bikaner
MAFSU: Maharashtra Animal and Fishery Sciences University,
GBPUAT: Govind Ballabh Pant University of Agriculture and Technology, Pant Nagar
WBUAFS: West Bengal University of Animal and Fishery Sciences, Kolkata
CCSHAU: CCS Haryana Agricultural University, Hisar
KVASU: Kerala Veterinary and Animal Sciences University,
NDVSU: Nanaji Deshmukh Vetinary Science University, Jabalpur
CSWRI: Central Sheep and Wool Research Institute, Avikanagr
SVVU: Sri Venkateswara Vetinary University
SVU: Sri Venkateswara University, Tirupati
SKUAST: Shere Kashmir University of Agricultural Sciences and Technology, Kashmir
IVRI: Indian Veterinary Research Institute, Uttrakhand
NIANP: National Institute of Animal Nutrition and Physiology, Bengaluru
CIFA: Central Institute of Freshwater and Aquaculture, Bhubaneswar
NRCE: National Research Centre for Equines
CIRG: Central Institute for Research on Goats
CIFE: Central Institute of Fisheries Education, Mumbai
PAU: Punjab Agricultural University, Ludhiana
SKUAST: Sere Kashmir University of Agricultural Sciences and Technology, Jammu