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Fish research in India based on the Scopus database: A scientometric analysis

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Abstract

The research contribution of Indian fish needs to be studied and the Fish and aquaculture research in India has been the Scopus online database during 2009-2020. It is identified from the study a total number of 11695 research publications are contributed during the study period. Out of that, the maximum of 1435(12.27%) research publications are contributed in the year 2020 and CAGR is 9.63. The Maximum of 106 (11.62%) research publications are contributed by Lakra, W.S, and the maximum of 4811(46.18%) research publications are contributed by Agricultural and Biological Sciences, The Maximum of 10107(86.42%) research publications are contributed by article, and the maximum of 394(21.09%) research publications are contributed by Indian Journal of Fisheries, During the Maximum of 3869(15.18%) research publications are contributed by Article, The institutions contributions are identified the Maximum of 848(19.88%) contributions are Indian Council of Agricultural Research, The Funding Agencies contributions are identified the study Maximum of 610(21.97%) contributions are Indian Council of Agricultural Research, During the India Collaborating Countries contributions are identified the study Maximum of 484(24.41%) contributions are United States, The average degree of collaboration is 0.99. The average CC is 0.92, CI is 6.15, and MCC is 6.15. The highest citations of Akerboom, J. *et al.* (2012) Optimization of a GCaMP calcium indicator for neural activity imaging, *Journal of Neuroscience*, 32(40), 13819-13840.

Keywords: Indian fisheries research, scientometric study, international collaboration, compound annual growth rate, relative citation index

Introduction

Fisheries is an important sector in India. It provides employment to millions of people and contributes to the food security of the country. With a coastline of over 8,000 km, an Exclusive Economic Zone (EEZ) of over 2 million sq km, and with extensive freshwater resources, fisheries play a vital role. The gross value added of the fisheries and aquaculture sector during 2016-17 was Rs. 1, 33, 492 Crores which is about 0.96% of the National Gross Value Added (GVA) and 5.37% to the agricultural GVA (2016-17). During the year 2017-18, the country has exported 13, 77, 244 tonnes of fish and fisheries products worth Rs. 45106.89 crore (7.08 billion US \$). Presently India is the second-largest fish producing and second-largest aquaculture nation in the world after China. The total fish production during 2017-18 (provisional) is registered at 12.61 million metric tonnes (MMT) with a contribution of 8.92 MMT from the inland sector and 3.69 MMT from the marine sector. The marine fishery potential in the Indian waters has been estimated at 5.31 MMT constituting about 43.3% demersal, 49.5% pelagic and 4.3% oceanic groups.

Marine Fisheries contributes to food security and provides direct employment to over 1.5 mn fisher people besides others indirectly dependent on the sector. There are 3,432 marine fishing villages and 1,537 notified fish landing centres in 9 maritime states and 2 union territories. According to the CMFRI Census 2010, the total marine fisherfolk population was about 4 million comprising 864,550 families. Nearly 61% of the fishermen's families were under the BPL category. The average family size was 4.63 and the overall sex ratio was 928 females per 1000 males. The Indian coastline can be delineated into 22 zones, based on the ecosystem structure and functions. The Indian boat type ranges from the traditional catamarans, masula boats, plank-built boats, dugout canoes, machwas, and dhonis to the present day motorized fibre-glass boats, mechanized trawlers and gillnetters. In the marine fisheries sector, there were 194,490 crafts in the fishery out of which 37% were mechanized,

37% were motorized and 26% were non-motorized. Out of a total of 167,957 crafts fully owned by fisherfolk 53% were non-motorized, 24% were motorized and 23% were mechanized. Among the mechanized crafts fully owned by fishermen, 29% were trawlers, 43% were gillnetters and 19% did letters^[1].

Scientometric Study

There are some important bibliometric studies done on Indian contributions to various fields. Rajendran and Parihar (2007)^[2] presented a bibliometric study of Laser literature in India for 1995-2005. Ramakrishnan and Ramesh Babu (2007)^[3] studied bibliometric analysis of literature on Hepatitis for the period 1984-2003. Sangam and Meera (2008)^[4] describes the research collaboration pattern in Indian contributions to Chemical Sciences. Amudhavalli and Florence (2001)^[5] presented a profile on Indian productivity in Human Nutrition. Senthilkumaran and Vadivel (2003)^[6] presented a bibliometric study on Indian Spices. Amudhavalli and Senthilkumaran (2007)^[7] have made crossnational comparison of Spices research amongst the Asian countries over a period 1968-2002. Sooryamorthy (2009)^[8] shows that collaboration research in South Africa has been growing steadily and the scientists are highly oriented towards collaborative research. Manuelraj and Amudhavalli (2008)^[9] studied the literature on health science and found very high degree of collaboration but correlation amongst the productivity and collaboration is low.

Review Literature

Subbiah and Jayashree (2000)^[10] studied the fish and aquaculture research productivity of India based on six databases. About 460 papers, roughly 5.5% of the world output, come from India every year, of which 82% are journal articles. Close to 70% of journal articles have appeared in 113 Indian journals. Less than a third of the journal articles are published in journals indexed in SCI. Liao and Huang (2014)^[11] studied the global trends in aquatic ecosystem research from 1992 to 2011 and found that North America was leading the subject. Aquatic ecosystem research trends were shifting from water environment to aquatic ecosystem issues. Subbiah and Jayashree (2001)^[12] studied the fisheries and aquaculture literature productivity of People's Republic of China and compare with India for six years 1994 – 1999 has been mapped using data from six databases – three abstracting services and three citation indexes. The results are compared with fish science research in India. During the six years China has published 2035 papers (roughly 4.5 –5% of the world output) and India 2454. More than 95% of China's papers are journal articles, compared to 82.8% of Indian papers.

Dasari bhoomaiah *et al.* (2020)^[13] examined the Scientometric assessment of research publications from fisheries institutes under the Indian Council of Agricultural Research (ICAR) during 2009-2018. The current study was undertaken to assess the temporal trends in research publications during the period 2009-2018, from 8 fisheries research institutes under ICAR using 'SciVal', a web-based scientometric tool of Elsevier for measuring research performance. The assessment revealed that a total of 3263 papers were published by the fisheries research institutes under ICAR during the study period, which received 24,253

citations in total. The number of publications from the ICAR fisheries research institutes and their quality showed a steady increase over the years. The foremost journal for publishing Indian fisheries research outputs during the assessment period was the Indian Journal of Fisheries (408 papers; 12.5%) published by ICAR, New Delhi.

Ramasamy Kumaresan *et al.* (2018)^[14] analyzed the Mapping of *Cyprinus carpio* research global perspective there were 8582 publications contributed by the researchers in *Cyprinus carpio* research globally. The maximum number of publications was brought out during 2014 and the minimum of publications in 1990. The mean annual growth rate was found to be 13.41. Multiple authored publications were predominant in *Cyprinus carpio* research and the degree of collaboration was 0.94. Out of 8582 publications. The rest of 8577 publications were contributed by 18051 authors, of which Svobodova, Z from the Czech Republic contributed 109. The USA had absolute dominance both in terms of publications and international collaboration, RCI the 8582 publications were contributed by 1168 journals. Among these, Aquaculture scored 1st rank with 500 publications. 192935 references appended in 8370 publications. The average reference per publication was 23.05.

Nirmal Singh *et al.* (2019)^[15] examined the research dynamics in Indian fisheries and aquaculture: a scientometric analysis, the study was carried out to map out the dynamics of scientific output in fisheries and aquaculture in India during the decade 2007–2016. The data was retrieved from the 'Scopus' database for phrases such as 'fisheries', 'fishery', and 'aquaculture' as main operators. The search results were filtered for journal articles. The authorship, geographical, and keyword landscapes were visualized using free-to-use visualization software. The study revealed that the number of articles on fisheries and aquaculture has more than doubled from 2007 to 2016. The results indicated a significant correlation between the number of citations and the number of years from which the article has been published. The United States emerged to be the topmost collaborator of India to work in this field.

Ramasamy Kumaresan *et al.* (2014)^[16] analyzed the Indian research contributions in the aquaculture journal during 1972 – 2011: a scientometric study, the data was retrieved from the 'Scopus' database. The total number of publications contributed by the Indian authors in the Aquaculture journal was 374 during the study period 1972 – 2011. The highest numbers of papers were published during 2002 – 2006 with 103 contributions; especially in 2006, there were 47 contributions. The least number of papers was recorded during 1972 – 1976 with 9 contributions. The percentage of Indian contribution was 2.74. Overall, 1373 authors contributed 374 publications in the Aquaculture journal. Among these, two authored publications were 114 (30.48%), more than that of any other authorship pattern. The degree of collaboration was 0.98. A total of 1373 authors contributed 374 publications with an average of 3.67 authors per paper. 600 (43.70%) authors contributed one publication each. Among the Indian authors, A. S. Sahul Hameed scored the first rank with 27 publications.

Objectives of the Study

The objectives of this study are as follows:

- To analyses the year-wise distribution of publications,
- To identify the highly productive Indian authors

- To identify the highly productive institutions and their relative citation impact
- To identify the highly preferred journal of Indian authors
- To identify the highly collaborative countries with India
- To identify the document type and language-wise distribution
- To analysis of degree of collaboration and authorship pattern.
- To analysis of CC,CI,MCC Collaborative index,
- To study the highly cited articles.

Methodology

The fish research publications are identified using the Scopus multidisciplinary online database from 2009 to 2020 using the following search keyword: (TITLE-ABS-KEY ("Fish") AND PUBYEAR > 2008 AND PUBYEAR < 2021 AND (LIMIT-TO (Affilcountry, "India"))). The data was collected for this study is 01.02.2021. The collected

Year-wise distribution of Indian Fish Research Publications

Table 1: Year-wise distribution of Indian Fish Research Publications

| S. No | Years | Publications | % | Cumulative | % |
|-------|-------|--------------|--------|------------|--------|
| 1 | 2009 | 572 | 4.89 | 572 | 0.86 |
| 2 | 2010 | 624 | 5.34 | 1196 | 1.80 |
| 3 | 2011 | 749 | 6.40 | 1945 | 2.93 |
| 4 | 2012 | 922 | 7.88 | 2867 | 4.32 |
| 5 | 2013 | 933 | 7.98 | 3800 | 5.73 |
| 6 | 2014 | 958 | 8.19 | 4758 | 7.17 |
| 7 | 2015 | 926 | 7.92 | 5684 | 8.57 |
| 8 | 2016 | 1019 | 8.71 | 6703 | 10.10 |
| 9 | 2017 | 1144 | 9.78 | 7847 | 11.83 |
| 10 | 2018 | 1169 | 10.00 | 9016 | 13.59 |
| 11 | 2019 | 1244 | 10.64 | 10260 | 15.47 |
| 12 | 2020 | 1435 | 12.27 | 11695 | 17.63 |
| | Total | 11695 | 100.00 | 66343 | 100.00 |
| | | CAGR | 9.63 | | |

Table - 1 shows that year wise growth of Fish related research publications in India from Scopus online database during 2009-2020 It is identified from the study a total number of 11695 research publications are contributed during the study period. Out of that, the maximum of 1435(12.27%) research publications are contributed in the year 2020, followed by 1244(10.64%) research publications in the year 2019. And 1169(10.00) research publications are contributed in the year 2018. The CAGR 9.63.

Citation Index (RCI)

Relative citation index (RCI) was developed by the Institute of Scientific Information (now Thomson Reuters, USA) and examine the impact of different countries and institutions in the field of Pollution Control research publications. The scientific impact of leading countries was examined by using two relative indicators, namely citations per paper (CPP) and relative citations index (RCI). Citations per paper

data's were analyzed using Micro Soft Excel work sheet.

Analysis and Interpretation

Compound Annual Growth Rate [CAGR]

The Compound Annual Growth Rate [CAGR] is one of the useful measures to identify the growth, over the multiple time periods. It can be measure from the initial number of publications to ending number of publications. The mathematical formula of CAGR is used Ashok kumar and Gopala krishnan (2013) [17].

The compound annual growth rate was calculated by the following formula,

$$CAGR = \left[\frac{\text{Ending Value}}{\text{Beginning Value}} \right]^{\frac{1}{\# \text{ of Years}}} - 1$$

During the 10- year study period compound annual growth rate is calculated by the publications of beginning year and ending year. From the study it is identified that the CAGR = 9.63.

(CPP) are a relative indicator computed as the average number of citation per paper. It has been broadly used into the bibliometric studies as it normalizes a large difference in the volumes of publications among most productive countries, institutions and authors.

To measure the both influence and visibility of a country research in global wise, the following formula has been used by Bharvi Dutt and Khaiser Nikam (2016) [18].

$$RCI = \frac{\text{A Country share of the World Citations}}{\text{A Country share of the World Publications}}$$

RCI = 1 indicate that a country's citation rate is equal to the world citation rate

RCI > 1 indicate that a country's citation rate is greater than the world citation rate

RCI < 1 indicate that a country's citation rate is lower than the world citation rate

High Profile Indian Author in Fish Research Publications

Table 2: High Profile Indian Author in Fish Research Publications

| S. No | Author | Country | Publications | % | Citations | % | H-index | CPP | RCI |
|-------|-------------|----------------|--------------|-------|-----------|-------|---------|-------|------|
| 1 | Lakra, W.S. | United States | 106 | 11.62 | 1837 | 14.07 | 21 | 17.33 | 1.21 |
| 2 | Das, B.K. | South Korea | 92 | 10.09 | 611 | 4.68 | 13 | 6.64 | 0.46 |
| 3 | Sahu, N.P. | United Kingdom | 85 | 9.32 | 1036 | 7.94 | 18 | 12.19 | 0.85 |

| | | | | | | | | | |
|----|------------------|--------------|-----|--------|-------|--------|----|-------|------|
| 4 | Harikrishnan, R. | Japan | 84 | 9.21 | 2163 | 16.57 | 26 | 25.75 | 1.80 |
| 5 | Jena, J.K. | China | 81 | 8.88 | 693 | 5.31 | 14 | 8.56 | 0.60 |
| 6 | Balasundaram, C. | Germany | 74 | 8.11 | 1975 | 15.13 | 25 | 26.69 | 1.86 |
| 7 | Pal, A.K. | Australia | 73 | 8.00 | 1367 | 10.47 | 19 | 18.73 | 1.31 |
| 8 | Sarkar, U.K. | Saudi Arabia | 68 | 7.46 | 609 | 4.67 | 14 | 8.96 | 0.63 |
| 9 | Nagpure, N.S. | Italy | 65 | 7.13 | 1017 | 7.79 | 16 | 15.65 | 1.09 |
| 10 | Raghavan, R. | Malaysia | 62 | 6.80 | 575 | 4.40 | 14 | 9.27 | 0.65 |
| 11 | Lal, K.K. | France | 61 | 6.69 | 574 | 4.40 | 12 | 9.41 | 0.66 |
| 12 | Mohindra, V. | Canada | 61 | 6.69 | 597 | 4.57 | 13 | 9.79 | 0.68 |
| | Total | | 912 | 100.00 | 13054 | 100.00 | | | |

From the Table - 2, it is identified that, the maximum of 106 (11.62%) research publications are contributed by Lakra, W.S. the United States, followed by Das, B.K. South Korea with 92 (10.09%) research publications, Sahu, N.P. the United Kingdom with 85 (9.32%) research publications. In

this study highest reading, 2163(16.57%) citations, CPP is 26.69, RCI is 1.21, h- index is 26. And lowest reading 574(4.40%) citations, CPP is 9.41, RCI is 0.66, and h-index is 13.

Subject wise Year-wise Distribution of Indian Fish Research Publications

Table 3: Subject wise Distribution of Indian Fish research Publications

| S. No | Subject | Publications | % |
|-------|--|--------------|--------|
| 1 | Agricultural and Biological Sciences | 4811 | 46.18 |
| 2 | Arts and Humanities | 26 | 0.25 |
| 3 | Biochemistry, Genetics and Molecular Biology | 2693 | 25.85 |
| 4 | Business, Management and Accounting | 94 | 0.90 |
| 5 | Chemical Engineering | 543 | 5.21 |
| 6 | Chemistry | 645 | 6.19 |
| 7 | Computer Science | 431 | 4.14 |
| 8 | Decision Sciences | 54 | 0.52 |
| 9 | Dentistry | 16 | 0.15 |
| 10 | Earth and Planetary Sciences | 693 | 6.65 |
| 11 | Economics, Econometrics and Finance | 105 | 1.01 |
| 12 | Energy | 308 | 2.96 |
| | Total | 10419 | 100.00 |

From the Table - 3, subject wise distribution of India is identified that, the maximum of 4811(46.18%) research publications are contributed by Agricultural and Biological Sciences, followed by Biochemistry, Genetics and

Molecular Biology, with 2693 (25.85%) research publications, Earth and Planetary Sciences, with 693 (6.65%) research publications, and lowest subject of Decision Sciences of 15(0.15%) research publication.

Document wise distribution of Indian Fish Research Publications

Table 4: Document wise Fish research Publications

| S. No | Document | Publications | % | Cumulative | % |
|-------|------------------|--------------|--------|------------|--------|
| 1 | Article | 10107 | 86.42 | 10107 | 6.81 |
| 2 | Review | 571 | 4.88 | 10678 | 7.20 |
| 3 | Conference Paper | 442 | 3.78 | 11120 | 7.50 |
| 4 | Book Chapter | 347 | 2.97 | 11467 | 7.73 |
| 5 | Note | 104 | 0.89 | 11571 | 7.80 |
| 6 | Book | 42 | 0.36 | 11613 | 7.83 |
| 7 | Letter | 31 | 0.27 | 11644 | 7.85 |
| 8 | Editorial | 19 | 0.16 | 11663 | 7.86 |
| 9 | Erratum | 15 | 0.13 | 11678 | 7.87 |
| 10 | Short Survey | 8 | 0.07 | 11686 | 7.88 |
| 11 | Data Paper | 6 | 0.05 | 11692 | 7.88 |
| 12 | Retracted | 2 | 0.02 | 11694 | 7.88 |
| 13 | Undefined | 1 | 0.01 | 11695 | 7.89 |
| | Total | 11695 | 100.00 | 148308 | 100.00 |

Document types are identified during the 12 - year study period on fish research publications are shows from table - 4. From the table - 4, it is identified that, the maximum of 10107(86.42%) research publications are contributed by article, followed 571 (4.88%) research publication are review and third placed in Conference paper with

442(3.78%) research publications. This study confirmed that more than 95.08% of research publications are contributed by article and review, conference paper. Remaining nearby 4.92% of research publications are identified in the Book Chapter, Note, Book, Letter, Editorial, erratum, short survey, data paper, editorial, retracted, undefined.

Highly productive journals in Indian fish research Publications**Table 5:** Top 12 highly productive in India Fish journals Publications

| S. No | Journal | Publications | % | Citations | % | h-index | CPP | RCI |
|-------|--|--------------|--------|-----------|--------|---------|-------|------|
| 1 | Indian Journal Of Fisheries | 394 | 21.09 | 951 | 6.78 | 11 | 2.41 | 0.32 |
| 2 | Indian Journal Of Geo Marine Sciences | 207 | 11.08 | 219 | 1.56 | 6 | 1.06 | 0.14 |
| 3 | Fish And Shellfish Immunology | 184 | 9.85 | 4364 | 31.11 | 35 | 23.72 | 3.16 |
| 4 | Aquaculture | 181 | 9.69 | 2872 | 20.48 | 27 | 15.87 | 2.11 |
| 5 | Aquaculture Research | 133 | 7.12 | 1338 | 9.54 | 21 | 10.06 | 1.34 |
| 6 | Journal Of Environmental Biology | 129 | 6.91 | 682 | 4.86 | 14 | 5.29 | 0.70 |
| 7 | Journal Of Applied Ichthyology | 119 | 6.37 | 720 | 5.13 | 14 | 6.05 | 0.81 |
| 8 | Fish Physiology And Biochemistry | 114 | 6.10 | 55 | 0.39 | 3 | 0.48 | 0.06 |
| 9 | Journal Of Parasitic Diseases | 114 | 6.10 | 476 | 3.39 | 12 | 4.18 | 0.56 |
| 10 | Ecology Environment And Conservation | 112 | 6.00 | 1942 | 13.85 | 23 | 17.34 | 2.31 |
| 11 | International Journal Of Pharma And Bio Sciences | 93 | 4.98 | 227 | 1.62 | 8 | 2.44 | 0.33 |
| 12 | Indian Journal Of Animal Sciences | 88 | 4.71 | 180 | 1.28 | 5 | 2.05 | 0.27 |
| | Total | 1868 | 100.00 | 14026 | 100.00 | | | |

Table - 5 shows that top 12 journals contributions in the field of fish research. From the Table- 5 it is identified that the maximum of 394(21.09%) research publications are contributed by Indian Journal of Fisheries, followed by Indian Journal of Geo Marine Sciences 207(11.08%) research publication, Third placed is Fish And Shellfish

Immunology with 184(9.85%) research publications In this study highest reading, 4634(31.11%) citations, CPP is 23.72, h-index is 35, and RCI is 3.16. And lowest reading of Fish Physiology and Biochemistry, 55(0.39%) citations, CPP is 0.48, h-index is 3, and RCI is 0.06.

Top 12 Keyword Fish Research Contributions Publications**Table 6:** Top 12 Keyword Fish Research Contributions Publications

| S. No | Keyword | Publications | % |
|-------|-------------------|--------------|--------|
| 1 | Article | 3869 | 15.18 |
| 2 | Nonhuman | 3183 | 12.49 |
| 3 | Fish | 3045 | 11.95 |
| 4 | Animals | 2833 | 11.12 |
| 5 | Animal | 2295 | 9.00 |
| 6 | Controlled Study | 2208 | 8.66 |
| 7 | India | 1916 | 7.52 |
| 8 | Priority Journal | 1439 | 5.65 |
| 9 | Human | 1221 | 4.79 |
| 10 | Metabolism | 1215 | 4.77 |
| 11 | Animal Tissue | 1138 | 4.46 |
| 12 | Animal Experiment | 1126 | 4.42 |
| | Total | 25488 | 100.00 |

Table - 6 shows that top 12 keyword contributions in India the field of fish research. From the Table- 6 it is identified that the maximum of 3869(15.18%) research publications are contributed by Article, followed by Nonhuman

3183(12.489%) research publication, Third placed is Fish with 3045(11.95%) research publications, and the lowest keyword 1126(4.42%)research publications of an animal experiment.

High profile Indian institutions and their Citation impact in Fish Research Publications**Table 7:** Top 12 High profile in Indian institutions in Fish Research Publications

| S. No | Institutions | Publications | % | Citations | % | h-index | CPP | RCI |
|-------|---|--------------|--------|-----------|--------|---------|-------|------|
| 1 | Indian Council of Agricultural Research | 848 | 19.88 | 5054 | 12.71 | 28 | 5.96 | 0.64 |
| 2 | ICAR - Central Institute of Fisheries Education, Mumbai | 660 | 15.47 | 5914 | 14.88 | 35 | 8.96 | 0.96 |
| 3 | ICAR - Central Marine Fisheries Research Institute, Kochi | 445 | 10.43 | 2219 | 5.58 | 21 | 4.99 | 0.54 |
| 4 | ICAR - National Bureau of Fish Genetic Resources, Lucknow | 412 | 9.66 | 3957 | 9.95 | 29 | 9.60 | 1.03 |
| 5 | ICAR - Central Institute of Freshwater Aquaculture, Bhubaneswar | 376 | 8.81 | 4094 | 10.30 | 31 | 10.89 | 1.17 |
| 6 | Annamalai University | 324 | 7.59 | 3297 | 8.29 | 28 | 10.18 | 1.09 |
| 7 | ICAR - Central Inland Fisheries Research Institute, Barrackpore | 277 | 6.49 | 2011 | 5.06 | 20 | 7.26 | 0.78 |
| 8 | ICAR - Central Institute of Fisheries Technology, Cochin | 197 | 4.62 | 1662 | 4.18 | 21 | 8.44 | 0.91 |
| 9 | University of Calcutta | 195 | 4.57 | 1900 | 4.78 | 23 | 9.74 | 1.05 |
| 10 | Bharathidasan University | 194 | 4.55 | 3637 | 9.15 | 34 | 18.75 | 2.01 |
| 11 | Council of Scientific and Industrial Research India | 175 | 4.10 | 3709 | 9.33 | 31 | 21.19 | 2.27 |
| 12 | Bharathiar University | 163 | 3.82 | 2298 | 5.78 | 27 | 14.10 | 1.51 |
| | Total | 4266 | 100.00 | 39752 | 100.00 | | | |

During the 12 year study period, top 12 institutions contributions are identified from Table 7, from the study the maximum of 848(19.88%) contributions are Indian Council of Agricultural Research, followed by ICAR - Central Institute of Fisheries Education, Mumbai contributed with 660(15.47%) research publications, ICAR - Central Marine Fisheries Research Institute, Kochi with 445(10.435%)

research publications, 6 institutes were ICAR institutions. In this study highest reading, 5914(14.88%) citations, h-index is 35, CPP is 8.96, and RCI is 0.96. And the lowest ICAR - Central Inland Fisheries Research Institute, Barrackpore 2011(5.06%) citations. H-index is 20, CPP is 7.26, and RCI is 0.78.

Funding research contribution in Indian Fish Research Publications

Table 8: Funding research in Indian Fish Research Publications

| S. No | Funding Agencies | Publications | % |
|-------|---|--------------|--------|
| 1 | Indian Council of Agricultural Research | 610 | 21.97 |
| 2 | University Grants Commission | 482 | 17.36 |
| 3 | Department of Science and Technology, Government of Kerala | 299 | 10.77 |
| 4 | Department of Biotechnology, Government of West Bengal | 262 | 9.44 |
| 5 | Bangladesh Council of Scientific and Industrial Research | 247 | 8.90 |
| 6 | University Grants Committee | 212 | 7.64 |
| 7 | Science and Engineering Research Board | 174 | 6.27 |
| 8 | Department of Science and Technology, Ministry of Science and Technology, India | 150 | 5.40 |
| 9 | Council of Scientific and Industrial Research, India | 108 | 3.89 |
| 10 | Department of Biotechnology, Ministry of Science and Technology, India | 98 | 3.53 |
| 11 | Indian Council of Medical Research | 83 | 2.99 |
| 12 | National Research Foundation of Korea | 51 | 1.84 |
| | Total | 2776 | 100.00 |

During the 12 - year study period, top 12 Funding Agencies contributions in India are identified from Table - 8, from the study the maximum of 610(21.97%) contributions are Indian Council of Agricultural Research, followed by University Grants Commission contributed with 482(17.36%) research

publications, Department of Science and Technology, Government of Kerala contributed with 299(10.77%) research publications, and the lowest Funding agency 51(1.84%) National Research Foundation of Korea.

International Collaboration Countries Fish Research Publications

Table 9: Top 12 international collaborative countries Fish Research Publications

| S. No | Country | Publications | % | citation | % | h-index | CPP | RCI |
|-------|--------------------|--------------|--------|----------|--------|---------|-------|------|
| 1 | United States | 484 | 24.41 | 12592 | 25.84 | 55 | 26.02 | 1.06 |
| 2 | South Korea | 219 | 11.04 | 4591 | 9.42 | 35 | 20.96 | 0.85 |
| 3 | United Kingdom | 209 | 10.54 | 5238 | 10.75 | 34 | 25.06 | 1.02 |
| 4 | Japan | 148 | 7.46 | 3788 | 7.77 | 31 | 25.59 | 1.04 |
| 5 | China | 137 | 6.91 | 3626 | 7.44 | 29 | 26.47 | 1.08 |
| 6 | Germany | 130 | 6.56 | 4044 | 8.30 | 32 | 31.11 | 1.27 |
| 7 | Australia | 122 | 6.15 | 2750 | 5.64 | 25 | 22.54 | 0.92 |
| 8 | Saudi Arabia | 121 | 6.10 | 1577 | 3.24 | 19 | 13.03 | 0.53 |
| 9 | Italy | 114 | 5.75 | 2888 | 5.93 | 26 | 25.33 | 1.03 |
| 10 | Malaysia | 104 | 5.24 | 1993 | 4.09 | 20 | 19.16 | 0.78 |
| 11 | France | 98 | 4.94 | 2356 | 4.83 | 24 | 24.04 | 0.98 |
| 12 | Canada | 97 | 4.89 | 3295 | 6.76 | 24 | 33.97 | 1.38 |
| | Total | 1983 | 100.00 | 48738 | 100.00 | | | |
| | Others country-123 | 1444 | | | | | | |

During the 12 - year study period, top 12 International Collaborating Countries contributions are identified and others country 123 of total publications 1444 from the Table - 9, from the study the maximum of 484(24.41%) contributions are United States, followed by South Korea contributed with 219(11.04%) research publications, United

Kingdom contributed with 209(10.54%) research publications. In this study highest reading United States, 12592(25.84%) citations, h-index is 55, CPP is 26.02, and RCI is 1.06. And the lowest citations of Saudi Arabia 1577(3.24%), h-index is 19, CPP is 13.03, and RCI is 0.53.

Top 12 Language Fish research Publications

Table 10: Top 12 Language Fish research Publications

| S. No | Language | Publications | % |
|-------|------------|--------------|-------|
| 1 | English | 11684 | 99.74 |
| 2 | Portuguese | 7 | 0.06 |
| 3 | Spanish | 7 | 0.06 |
| 4 | Turkish | 7 | 0.06 |
| 5 | Croatian | 3 | 0.03 |

| | | | |
|----|------------|-------|--------|
| 6 | French | 2 | 0.02 |
| 7 | German | 1 | 0.01 |
| 8 | Italian | 1 | 0.01 |
| 9 | Lithuanian | 1 | 0.01 |
| 10 | Polish | 1 | 0.01 |
| 11 | Russian | 1 | 0.01 |
| | Total | 11715 | 100.00 |

During the 12 - year study period, top 12 India contributions are identified from table - 10, from the study the maximum of 11684(99.74%) contributions are English Language,

followed by Portuguese contributed with 7(0.06%) research publications, Spanish contributed with 7(0.06%) research publications.

Authorship pattern fish research Publications

Table 11: Authorship pattern fish research Publications

| Authorship pattern | | | | | | | | | | | |
|--------------------|-----|------|------|------|------|------|-----|-----|-----|-----|-------|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | >9 | Total |
| 2009 | 26 | 172 | 158 | 96 | 54 | 25 | 15 | 5 | 5 | 16 | 572 |
| 2010 | 33 | 164 | 145 | 120 | 70 | 32 | 25 | 14 | 7 | 14 | 624 |
| 2011 | 47 | 163 | 194 | 114 | 115 | 52 | 20 | 19 | 8 | 17 | 749 |
| 2012 | 28 | 205 | 233 | 156 | 114 | 61 | 50 | 26 | 13 | 36 | 922 |
| 2013 | 44 | 211 | 211 | 164 | 122 | 72 | 42 | 26 | 12 | 29 | 933 |
| 2014 | 51 | 198 | 201 | 163 | 122 | 78 | 54 | 33 | 18 | 40 | 958 |
| 2015 | 36 | 203 | 176 | 160 | 142 | 71 | 56 | 28 | 20 | 34 | 926 |
| 2016 | 35 | 188 | 197 | 168 | 144 | 111 | 63 | 43 | 19 | 51 | 1019 |
| 2017 | 53 | 213 | 228 | 184 | 150 | 114 | 89 | 48 | 20 | 45 | 1144 |
| 2018 | 43 | 209 | 225 | 188 | 166 | 120 | 82 | 45 | 30 | 61 | 1169 |
| 2019 | 31 | 230 | 229 | 202 | 162 | 142 | 98 | 55 | 32 | 63 | 1244 |
| 2020 | 40 | 244 | 247 | 253 | 180 | 170 | 109 | 74 | 49 | 69 | 1435 |
| Total | 467 | 2400 | 2444 | 1968 | 1541 | 1048 | 703 | 416 | 233 | 475 | 11695 |

Table - 11 identified that year wise authorship pattern in the field of Fish research in India during the 12 - year study period. From the study, it is identified that, out of 11695 research publications, 467 research publications are contributed by single authors and remaining 11192 research publications are multi author's contributions. From the multi authors publications, the maximum of 2444 research

publications are contributed by three authors, followed by 2400 publications are contributed by two authors, 1968 publications are four authors 1541 publications are five authors, 1048 publications are six authors, 703 publications are seven authors, 475 publications are more than nine authors, 416 publications are eight authors and 233 publications are nine authors.

Degree of Collaborations Fish Research Publications

Table 12: Degree of Collaborations Fish Research Publications

| Year | Single author publications | Multi authors publications | Total No. of authors publications | Degree of collaboration DC= NM/NM+NS |
|-------|----------------------------|----------------------------|-----------------------------------|--------------------------------------|
| 2009 | 26 | 546 | 572 | 0.95 |
| 2010 | 33 | 591 | 624 | 0.95 |
| 2011 | 47 | 702 | 749 | 0.94 |
| 2012 | 28 | 894 | 922 | 0.97 |
| 2013 | 44 | 889 | 933 | 0.95 |
| 2014 | 51 | 907 | 958 | 0.95 |
| 2015 | 36 | 890 | 926 | 0.96 |
| 2016 | 35 | 984 | 1019 | 0.97 |
| 2017 | 53 | 1091 | 1144 | 0.95 |
| 2018 | 43 | 1126 | 1169 | 0.96 |
| 2019 | 31 | 1213 | 1244 | 0.98 |
| 2020 | 40 | 1395 | 1435 | 0.97 |
| Total | 467 | 11228 | 11695 | |

The Degree of collaboration is relationship between single author and multi author contributions. The degree of collaboration is calculated by the Subramaniam (1983) [19] formula, used by), Vivekanandhan (2016) [20] Sivasamy (2020) [21], Ravichandran. (2020) [22].

Where DC = Degree of Collaboration
 N_m = Number of Multi authored publications
 N_s = Number of single authored publications
 In the present study, N_m = 11228, N_s= 467
 So that the degree of collaboration is =11228/ (467+11228) = 0.96

$$DC = \frac{Nm}{(Nm+Ns)}$$

Table - 12 shows that the degree of collaboration in Fish research publications for the 12 - year studies period. From this study it is identified that the degree of collaboration is between 0.95 in the year 2009 and 0.97 in the year 2020. The average degree of collaboration is 0.90. From this study it is identified that, majority of Fish research publications are contributed by collaborative authors.

Collaborative of Co-efficient (CC)

The pattern of co-authorship collaboration among the authors can be measured with the following formula suggested by Ajiferuke, *et al.* (1988) [23].

$$CC = 1 - \left[\sum_{j=0}^k \left(\frac{1}{j} \right) \times F_j / N \right]$$

Whereas,

F_j = Number of publications with j author papers

N = Total number of the research publications and

k = the greatest number of authors/papers in the given field

Collaboration Index (CI)

The simple indicator is presently employed in the publications to the collaboration index among the co-authors, which is to be understood nearly as the mean number of authors per paper are suggested by Ajiferuke, *et al.* (1988) [23].

Collaborative index of CC, CI, MCC Research Publications

$$CI = \frac{\sum_{j=1}^k jf_j}{N}$$

where

J - The number of co-authored papers appearing in a discipline

N - The total number of publications in the field over the same time period of interval and

k - The highest number of authors per paper in the same time field.

Modified Collaboration Coefficient

The modified collaboration coefficient (MCC) counted by the formula which is suggested by Savanur and Srikanth (2010) [24]

Which is given below:

Where,

$$MCC = \frac{N}{N-1} \left[1 - \frac{\sum_{j=1}^k jf_j}{N} \right]$$

j = the number authors in an article i.e. 1, 2, 3.....

F_j = the number of j authored articles

N = the total number of articles published in a year, and

A = the total number of authors per article

Table 13: Collaborative index of CC, CI, MCC Research Publications

| Years | Authorship pattern | | | | | | | | | | CC | CI | MCC |
|-------|--------------------|-----|------|------|------|------|------|-----|-----|-----|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | >9 | | | |
| 2009 | 0 | 27 | 169 | 155 | 100 | 55 | 25 | 15 | 5 | 21 | 0.75 | 4.48 | 4.49 |
| 2010 | 0 | 33 | 165 | 142 | 123 | 69 | 31 | 26 | 14 | 21 | 0.75 | 4.68 | 4.69 |
| 2011 | 0 | 48 | 162 | 191 | 114 | 114 | 54 | 21 | 20 | 25 | 0.76 | 4.77 | 4.78 |
| 2012 | 1 | 27 | 203 | 234 | 155 | 116 | 60 | 51 | 25 | 50 | 0.77 | 5.02 | 5.02 |
| 2013 | 0 | 45 | 210 | 209 | 165 | 122 | 71 | 44 | 26 | 41 | 0.76 | 4.94 | 4.94 |
| 2014 | 0 | 48 | 202 | 197 | 165 | 124 | 77 | 54 | 32 | 59 | 0.77 | 5.12 | 5.13 |
| 2015 | 0 | 37 | 201 | 176 | 160 | 142 | 72 | 55 | 29 | 54 | 0.77 | 5.16 | 5.17 |
| 2016 | 1 | 31 | 188 | 197 | 167 | 147 | 112 | 60 | 46 | 70 | 0.78 | 5.41 | 5.41 |
| 2017 | 1 | 49 | 212 | 230 | 185 | 148 | 116 | 90 | 48 | 65 | 0.78 | 5.32 | 5.32 |
| 2018 | 0 | 44 | 209 | 223 | 191 | 165 | 119 | 79 | 49 | 90 | 0.78 | 5.44 | 5.44 |
| 2019 | 0 | 28 | 234 | 226 | 201 | 162 | 146 | 96 | 56 | 95 | 0.79 | 5.53 | 5.54 |
| 2020 | 3 | 36 | 243 | 251 | 250 | 180 | 171 | 112 | 73 | 116 | 0.79 | 5.61 | 5.61 |
| Total | 6 | 453 | 2398 | 2431 | 1976 | 1544 | 1054 | 703 | 423 | 707 | | | |

It is observed from Table -13 the collaborative co-efficient is calculated and presented during the 12-year study period for Fish research publications. It is observed from the Table highest collaboration coefficient is 0.79 in the year 2020, 2019, and lowest CC is 0.75 in the year 2009, 2010 and the average CC is 0.92. The collaboration index observed from

Table 7 the maximum of the collaboration Index is 5.61 in the year 2020, a minimum of CI 4.48 in the year 2009, and the average CI is 6.15. The Modified collaboration co-efficient observed the Table 7 the maximum MCC is 5.61 in the year 2020, a minimum of MCC 4.49 in the year 2009, and the average modified collaboration co-efficient is 6.15.

Highly Cited articles in Fish Research Publications

Table 14: Highly Cited articles in Fish Research Publications

| S.No | Description of the Publication | Citations | Document | Authors |
|------|--|-----------|----------|---------|
| 1 | Akerboom, J. <i>et al.</i> (2012) Optimization of a GCaMP calcium indicator for neural activity imaging, <i>Journal of Neuroscience</i> , 32(40), 13819-13840. | 715 | Article | 32 |
| 2 | Ambati, R.R. <i>et al.</i> (2014) Astaxanthin: Sources, extraction, stability, biological activities and its commercial applications - A review, <i>Marine Drugs</i> , 12(1), 128-152. | 634 | Review | 4 |
| 3 | Dash, T.K. <i>et al.</i> (2012) Poly-ε-caprolactone based formulations for drug delivery and tissue engineering: A review, <i>Journal of Controlled Release</i> , 158(1), 15-33. | 613 | Review | 2 |
| 4 | Chalamaiah, M. <i>et al.</i> (2012) Fish protein hydrolysates: Proximate composition, amino acid composition, | 403 | Review | 4 |

| | | | | |
|----|--|-----|---------|----|
| | antioxidant activities and applications: A review, <i>Food Chemistry</i> , 135(4), 3020-3038. | | | |
| 5 | Loutfi, A., <i>et al.</i> , (2015) Electronic noses for food quality: A review, <i>Journal of Food Engineering</i> , 144, 103-111. | 393 | Review | 5 |
| 6 | Levin, L.A. <i>et al.</i> , (2009) Effects of natural and human-induced hypoxia on coastal benthos, <i>Biogeosciences</i> , 6(10), 2063-2098. | 378 | Article | 9 |
| 7 | Satoh, T. <i>et al.</i> (2014) Lapatinib plus paclitaxel versus paclitaxel alone in the second-line treatment of HER2-amplified advanced gastric cancer in Asian populations: TyTAN - A randomized, phase III study, <i>Journal of Clinical Oncology</i> , 32(19), 2039-2049 | 350 | Article | 19 |
| 8 | Bourdichon, F. <i>et al.</i> , (2012) Food fermentations: Microorganisms with technological beneficial use, <i>International Journal of Food Microbiology</i> , 154(3), 87-97. | 347 | Review | 19 |
| 9 | Jayathilakan, K., <i>et al.</i> (2012) Utilization of byproducts and waste materials from meat, poultry and fish processing industries: A review, <i>Journal of Food Science and Technology</i> , 49(3), 278-293. | 334 | Review | 4 |
| 10 | Harikrishnan, R. <i>et al.</i> (2011) Impact of plant products on innate and adaptive immune system of cultured finfish and shellfish, <i>Aquaculture</i> , 317(4Jan), 1-15. | 319 | Review | 3 |
| 11 | Citarasu, T. (2010) Herbal biomedicines: A new opportunity for aquaculture industry, <i>Aquaculture International</i> , 18(3), 403-414. | 316 | Review | 1 |
| 12 | Novarino, G <i>et al.</i> , (2014) Exome sequencing links corticospinal motor neuron disease to common neurodegenerative disorders, <i>Science</i> , 343(6170), 506-511. | 303 | Article | 52 |

Its observed from Table -14 the highest cited paper the Akerboom, J. *et al.* (2012) Optimization of a GCaMP calcium indicator for neural activity imaging, *Journal of Neuroscience*, 32(40), 13819-13840, citations of 715, document type of article, and authorship of 32. Ambati, R.R. *et al.*, (2014) Astaxanthin: Sources, extraction, stability, biological activities and its commercial applications - A review, *Marine Drugs*, 12(1), 128-152. citations of 634, document type of review, and authorship of 4. Dash, T.K, *et al.* (2012) Poly- ϵ -caprolactone based formulations for drug delivery and tissue engineering: A review, *Journal of Controlled Release*, 158(1), 15-33., citations of 613, document type of review, and authorship of 2. During the study period of top 12 highly cited articles of 4, and review 8.

Major Finding

- Fishes related research publications in India from Scopus online database during 2010-2019. It is identified from the study a total number of 11695 research publications are contributed during the study period. Out of that, the maximum of 1435(12.27%) research publications are contributed in the year 2020, followed by 1244(10.64%) research publications in the year 2019. And 1169(10.00) research publications are contributed in the year 2018.
- During the Maximum of 106 (11.62%) research publications are contributed by Lakra, W.S. followed by Das, B.K. with 92 (10.09%) research publications, Sahu, N.P. with 85 (9.32%) research publications.
- From it is identified that, the maximum of 4811(46.18%) research publications are contributed by Agricultural and Biological Sciences, followed by Biochemistry, Genetics and Molecular Biology, with 2693 (25.85%) research publications, Earth and Planetary Sciences, with 693 (6.65%) research publications.
- During the Maximum of 10107(86.42%) research publications are contributed by article, followed 571 (4.88%) research publication are review and third placed in Conference paper with 442(3.78%) research publications.
- From it is identified that Maximum of 394(21.09%) research publications are contributed by Indian Journal Of Fisheries, followed by Indian Journal Of Geo Marine Sciences 207(11.08%) research publication,

Third placed is Fish And Shellfish Immunology with 184(9.85%) research publications.

- During the Maximum of 3869(15.18%) research publications are contributed by Article, followed by Nonhuman 3183(12.489%) research publication, third placed is Fish with 3045(11.95%) research publications in Document type.
- During the institutions contributions are identified the Maximum of 848(19.88%) contributions are Indian Council of Agricultural Research, followed by ICAR - Central Institute of Fisheries Education, Mumbai contributed with 660(15.47%) research publications, ICAR - Central Marine Fisheries Research Institute, Kochi with 445(10.43%) research publications.
- During the Funding Agencies contributions are identified the study Maximum of 610(21.97%) contributions are Indian Council of Agricultural Research, followed by University Grants Commission contributed with 482(17.36%) research publications, Department of Science and Technology, Government of Kerala contributed with 299(10.77%) research publications.
- During the India Collaborating Countries contributions are identified the study Maximum of 484(24.41%) contributions are United States, followed by South Korea contributed with 219(11.04%) research publications, United Kingdom contributed with 209(10.54%) research publications.
- During the Language study Maximum of 11684(.99.74%) contributions are English Language, followed by Portuguese contributed with 7(0.06%) research publications, Spanish contributed with 7(0.06%) research publications.
- The authorship pattern in the field of Fish research during the ten year study period., the maximum of 2431 research publications are contributed by four authors, followed by 2398 publications are contributed by three authors, 1976 publications are five authors.
- From this study it is identified that the degree of collaboration is between 0.95 in the year 2009 and 0.97 in the year 2020. The average degree of collaboration is 0.90. From this study it is identified that, majority of Fish research publications are contributed by collaborative authors.
- During the highest collaboration coefficient is 0.79 in the year 2020, 2019, and lowest CC is 0.75 in the year 2009, 2010 and the average CC is 0.92. The

collaboration index observed from Table 7 the maximum of the collaboration Index is 5.61 in the year 2020, a minimum of CI 4.48 in the year 2009, and the average CI is 6.15. The Modified collaboration coefficient observed the Table 7 the maximum MCC is 5.61 in the year 2020, a minimum of MCC 4.49 in the year 2009, and the average modified collaboration coefficient is 6.15.

- The highest cited paper Akerboom, J. *et al.* (2012) Optimization of a GCaMP calcium indicator for neural activity imaging, *Journal of Neuroscience*, 32(40), 13819-13840, Ambati, R.R. *et al.* (2014) Astaxanthin: Sources, extraction, stability, biological activities and its commercial applications - A review, *Marine Drugs*, 12(1), 128-152. Dash, T.K, *et al.* (2012) Poly- ϵ -caprolactone based formulations for drug delivery and tissue engineering: A review, *Journal of Controlled Release*, 158(1), 15-33.,

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