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## INDIAN RESEARCH CONTRIBUTIONS IN THE *AQUACULTURE* JOURNAL DURING 1972 – 2011: A SCIENTOMETRIC STUDY

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### Abstract

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 collaborations 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 first rank with 27 publications. Central Institute of Freshwater Aquaculture (ICAR), Bhubaneswar, Odisha scored first rank with 40 publications among Indian Institutions. Tamil Nadu secured first position with 133 contributions. Original articles were predominant in the *Aquaculture* journal. The publication of I. Karunasagar et al. (1994) has highest citation both in SCOPUS database (240) and Google Scholar database (380). More research was carried out in the *Penaeus monodon* with 39 publications.

**Keywords:** Aquaculture, scientometric study, literature productivity, Indian authors, authorship pattern.

### 1. Introduction

The potential of fisheries sector in providing quality food and nutrition, creating employment to rural livelihoods, advancing socio-economic development in the rural and far flung areas is widely demonstrated and globally recognised as a powerful tool for poverty reduction and fostering rural development. Annual fish production reached the level of 8.30

million tonnes during 2010 -11 (P). Annual export earning crossed US \$ 2.9 billion mark contributing about 17 per cent to national agricultural export. About 14.5 million people are engaged in fishing, aquaculture and other allied activities of which about 75 per cent are in inland fisheries and the remaining in marine fisheries (Planning Commission, 2013)<sup>14</sup>. The fisheries sector contributed 0.7 per cent of total GDP at factor cost and 5.0 per cent of GDP at factor cost from agriculture, forestry and fishing in the year 2010 – 11 (QE) (Department of Economic Affairs, Ministry of Finance, GOI, 2012)<sup>3</sup>. World aquaculture production of fish, crustaceans, molluscs, etc was estimated at 66.63 million tonnes worth 137.73 billion US Dollars. India is the 2<sup>nd</sup> largest producer of fish in the world with 4.21 million tonnes worth of 9.25 million US Dollars and a share of 6.32% of the total fish production world wide (FAO, 2014)<sup>7</sup>.

Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants (FAO, 2014)<sup>7</sup>. Aquaculture production is potentially important and economically valuable worldwide. India and many other South East Asian countries continue to be very much concerned with the development of methods for increasing aquaculture production. India stands second in inland fish production, next only to China.

Scientometrics is the study of measuring and analysing science research. In practice, scientometrics is often done using bibliometrics which is a measurement of the impact of (scientific) publications. We measured the research publications Indian scientists in the *Aquaculture*, an international peer-reviewed journal. .

## **2. Source Journal**

*Aquaculture* (ISSN: 0044-8486) <http://www.journals.elsevier.com/aquaculture/> is an international journal for the exploration, improvement and management of all freshwater and marine food resources. It publishes novel and innovative research of world-wide interest on farming of aquatic organisms, which includes finfish, mollusks, crustaceans and aquatic plants for human consumption. Research on ornamental fishes is not a focus of the Journal. This journal was started in 1972 by Elsevier Science, Amsterdam, The Netherlands. *Aquaculture* publishes papers with a clear relevance to improving aquaculture practices or a potential application only. The articles published in this journal are indexed in Aquatic Sciences and Fisheries Abstracts, BIOSIS, Elsevier BIOBASE, Current Contents/Agriculture, Biology & Environmental Sciences, Marine Science Contents Tables, Freshwater and Aquaculture Contents Tables, GEOBASE, Scopus and EMBiology. It covers original articles,

review articles, short communications, supplements, brief technical notes, abstracts, conference proceedings, and book reviews. The impact factor of the journal is 1.828.

### 3. Review of Literature

Few studies were carried out in the field of fisheries in world, at regional and country levels. Among these studies, Kanakaraj and Esmail (2014)<sup>11</sup> analysed world aquaculture research productivity based on Web of Science database and found out Chinese Academy of Sciences, University of Stirling and Fisheries & Ocean Canada as the most productive institutions. Kumaresan et al (2014)<sup>12</sup> studied the global literature productivity on WSSV based on Web of Science databases and inferred China as the top literature productive country, followed by India. Chinese Academy of Sciences, Beijing stood first place followed by National Taiwan University, Taipei. C. F. Lo contributed more literature on WSSV. Dastidar et al. (2013)<sup>2</sup> studied global shrimp disease research productivity. Though it is practiced in around 70 countries, it is primarily dominated by China, Thailand, Indonesia, Vietnam, Ecuador and India. The study highlighted the role of research in the development of the industry by taking examples of *Penaeus vannamei* and *P. monodon*. Dias et al. (2012)<sup>4</sup> studied global literature productivity on net cages in fish farming using Thomson Reuters Database (Web of Knowledge) from 1990 to 2009 and selected 238 articles published during this study period. There was a temporal increase in the number of articles published. Jaric et al (2012)<sup>9</sup> investigated the trends in fisheries science research from 2000 to 2009 based on the Web of Science database and the results indicate that the most frequently studied group of species was *Salmonidae*. The United States was the most productive country over the last few decades with a gradually increasing output over the time. Jaric and Gessner (2012)<sup>8</sup> analysed the world literature productivity on Sturgeon. Sturgeon species are among the commercially most valuable and the most endangered groups of fish. The analysis was performed based upon articles obtained from the ISI Web of Knowledge online database. White sturgeon (*Acipenser transmontanus*) was the most frequently studied species, but it was recently surpassed by Persian sturgeon (*A. persicus*). A steady increase in the number of published articles over time was observed. During the period reviewed, the sturgeon research published in peer reviewed journals dominantly originated from the USA and EU. International and inter-institutional collaboration both tended to increase the impact of the research. Nikolic et al. (2011)<sup>13</sup> studied the contribution of world diadromous fish research productivity of seven fish species, Atlantic salmon (*Salmo salar*), Brown and Sea trout (*Salmon trutta*), Allis shad

(*Alosa alosa*), Twaité shad (*Alosa fallax*), Eel (*Anguilla Anguilla*), Sea lamprey (*Petromyzon marinus*) and River lamprey (*Lampetra fluviatilis*) from 1970s to 2010. The results revealed a clear difference in the evolution of scientific studies by species and by countries. Ezhilrani (1999)<sup>5</sup> studied the four leading fish culture journals viz., *Aquaculture*, *The Progressive Fish Culturist*, *The Israeli Journal of Aquaculture* and *Journal of Aquaculture in Tropics*. The analysis made revealed that the contributions of Indian scientists largely appeared in domestic journals rather than in international journals. USA was the leading contributor in the two international journals viz., *Aquaculture* and *The Progressive Fish Culturist*. *The Israeli Journal of Aquaculture* invariably published articles from different countries. *The Progressive Fish Culturist* and *Journal of Aquaculture in Tropics* showed strong national bias.

Very few studies were conducted in national level. Jayashree and Arunachalam (2000)<sup>10</sup> studied the mapping fish research in India and found out that 460 papers came from India every year, of which 82% were journal articles. About 70% of journal articles were published by 113 Indian journals. About 61% of the publications were contributed by government laboratories and over 25% by academic Institutions. Tamil Nadu and Kerala were the leading states in literature contributions. Ezhilrani (1998)<sup>6</sup> investigated the research papers published in the Indian Journal of Fisheries during 1987 - 1991. She also attempted to analyse the citations referred by the authors in their articles to determine the most frequently cited periodicals by the fisheries scientists. Rana and Agarwal (1994)<sup>15</sup> studied authorship trends in Indian wildlife and fisheries literature. The data were collected from Wildlife Review and Fish Review published from 1980 to 1989. This study revealed that single authored papers decreased from 63.68% in 1980 to 52.74% in 1989. During the same period, there was an increase in the average number of authors per paper from 1.57 in 1980 to 1.70 in 1989. The degree of collaboration also increased from 0.36 to 0.47. Sylvain (1993)<sup>17</sup> analysed Canadian publications in the field of aquaculture which reveals that Canada is one of the world's major contributors in this area. The study showed bibliometric analysis, by describing the actual strength and weaknesses of Canadian research and identified the agents of this research activity.

#### **4. Objective of the study**

The main objective of the present study is to quantify the literature contribution by the Indian scientists in the *Aquaculture* journal for the last four decades. The present study attempted to:

- i) quantify the Indian contribution in the *Aquaculture* (an international journal),
- ii) study the year-wise distribution of the publications,
- iii) study the authorship pattern,
- iv) identify the most prolific Indian authors,
- v) identify the most prolific Indian Institutions,
- vi) study the collaborative research pattern among Indian institutions nationally and Internationally,
- vii) study the document types,
- viii) analyse the characteristics of highly cited papers,
- ix) length-wise analyses of articles and to
- x) analyse the keywords appended by the authors.

## **5. Hypothesis**

The following hypotheses were formulated for this study:

1. Research contributions of Indian Council of Agricultural Research (ICAR) Institutes were more than that of the State Universities.
2. Collaborative research was predominant in *Aquaculture* among the Indian Scientists.

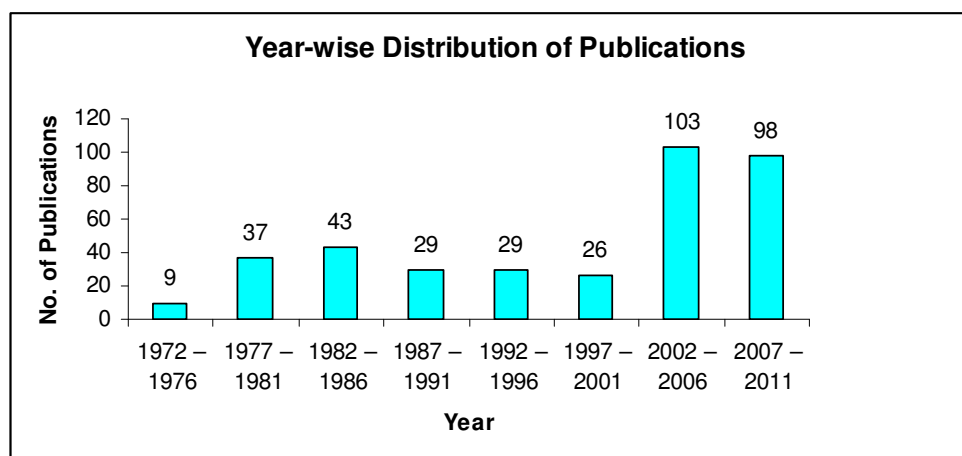
## **6. Methodology and source of Data**

The selection of journal is based on the criteria of relevance and importance. The data were collected from the <http://www.sciencedirect.com/> using advanced search and select journal option. The keywords used for this search were journal “*Aquaculture*” in the “Journal Title” field and “India” in the “Affiliation” field and the time period is limited to 40 years from 1972 to 2011 ( Vol.1-323) and includes all types of documents. Overall, 374 papers were retrieved from this journal published by Indian scientists. The data were tabulated and analysed using MS-Excel.

## **7. Results and Discussion**

The analysis of data was done to measure the Indian contributions in the *Aquaculture* journal over the years, authors’ productivity, Institutional productivity, collaboration among the Indian and International organizations, highly cited articles, document type, length-wise and keyword. The year-wise distribution of Indian author’s contributions in the *Aquaculture* journal is shown in Fig. 1. Most papers were contributed during 2002 – 2006 with 103 contributions; especially in 2006 there were 47 articles. The least number of papers was

recorded during 1972 – 1976 with 9 contributions. There was no publication in 1973 and 1974.



**Fig. 1. Five-yearly distribution of Indian Contributions in *Aquaculture* journal**

### 7.1. Comparison of Total publications in *Aquaculture* journal

Table 1 shows comparison of total publications in the *Aquaculture* journal with Indian authors' contributions. There were 13,655 publications during the study period (1972 – 2011) in the journal. Out of 13,655 publications, 374 publications were contributed by the Indian authors. The percentage of Indian contribution was 2.74.

**Table 1- Five-yearly Comparison of Indian contributions with Total number of publications**

| Sl. No. | Year        | No. Indian of Contributions | Rest of the world | Total No. of publications |
|---------|-------------|-----------------------------|-------------------|---------------------------|
| 1       | 1972 – 1976 | 9                           | 491               | 500                       |
| 2       | 1977 – 1981 | 37                          | 708               | 745                       |
| 3       | 1982 – 1986 | 43                          | 1390              | 1433                      |
| 4       | 1987 – 1991 | 29                          | 1632              | 1661                      |
| 5       | 1992 – 1996 | 29                          | 2014              | 2043                      |
| 6       | 1997 – 2001 | 26                          | 1608              | 1634                      |
| 7       | 2002 – 2006 | 103                         | 2668              | 2771                      |
| 8       | 2007 – 2011 | 98                          | 2770              | 2868                      |
|         | Total       | 374                         | 13281             | 13655                     |
|         | %           | 2.74                        | 97.26             | 100.00                    |

### 7.2. Authorship pattern and collaborative measures in the *Aquaculture* journal

Table 2 shows the authorship pattern of Indian contributors in the *Aquaculture* journal. 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,

followed by three authored papers 73 (19.52%). Single authored publications were 25 (6.68%), a very low contribution when compared with multi-authored contributions. Collaborative research was predominant among the Indian scientists. The multi-authored publications were 349 (93.32%). The degree of collaboration was 0.98.

**Table 2: Authorship pattern of Indian authors in the *Aquaculture* journal**

| Sl. No. | Authorship pattern      | No. of contributions | Total No. of Authors | Percentage |
|---------|-------------------------|----------------------|----------------------|------------|
| 1       | Single                  | 25                   | 25                   | 6.68       |
| 2       | Two                     | 114                  | 228                  | 30.48      |
| 3       | Three                   | 73                   | 219                  | 19.52      |
| 4       | Four                    | 60                   | 240                  | 16.04      |
| 5       | Five                    | 37                   | 185                  | 9.90       |
| 6       | Six                     | 32                   | 192                  | 8.56       |
| 7       | Seven                   | 18                   | 126                  | 4.81       |
| 8       | More than seven authors | 15                   | 158                  | 4.01       |
|         | Total                   | 374                  | 1373                 | 100.00     |

The Degree of Collaboration (DC) is measured by proportion of multiple authored papers derived by Subramanyam (1983)<sup>16</sup> as,

$$DC = \frac{N_m}{N_m + N_s}$$

Where, DC = degree of collaboration in a discipline.

$N_m$  = Number of multiple-authored research papers in the discipline published during a year.

$N_s$  = Number of single-authored research papers in the discipline published during the same year.

Degree of Collaborations:  $1348/1373 = 0.98$

### **7.3. Author productivity in the *Aquaculture* journal**

The authors contribution were counted one, two, or more using “full productivity” of their authorship, i.e. full credit was given to all individual authors irrespective of their position in the name list in every publication (Ahmed, 2007-2008)<sup>1</sup>. Table 3 shows the frequency distribution of author productivity in the *Aquaculture* journal by the Indian authors. A total of 1373 authors contributed 374 publications with an average of 3.67 authors per paper. Out of 834 unique authors, 600 (43.70%) authors contributed one publication each, 123



(17.92%) authors contributed two publications each, 58 (12.67%) authors contributed three publications each, 21 (6.12%) authors contributed four publications each, 10 (3.64%) authors contributed five publications each, 3 (1.31%) authors contributed six publications each, 6 (3.06%) authors contributed seven publications each, 3 (1.74%) authors contributed eight publications each, 4 (2.62%) authors contributed nine publications each, 2 (1.46%) authors contributed ten publications each and 4 ( 5.76%) authors contributed more than ten publications. One author contributed the maximum number of 27 publications.

**Table 3- Author Frequency distribution of Indian contributions in the *Aquaculture* journal**

| No. of Publications       | No. of Authors | Total No. of Author | Percentage (%) |
|---------------------------|----------------|---------------------|----------------|
| Single publications       | 600            | 600                 | 43.70          |
| Two publications          | 123            | 246                 | 17.92          |
| Three publications        | 58             | 174                 | 12.67          |
| Four publications         | 21             | 84                  | 6.12           |
| Five publications         | 10             | 50                  | 3.64           |
| Six publications          | 3              | 18                  | 1.31           |
| Seven publications        | 6              | 42                  | 3.06           |
| Eight publications        | 3              | 24                  | 1.74           |
| Nine publications         | 4              | 36                  | 2.62           |
| Ten publications          | 2              | 20                  | 1.46           |
| Fifteen publications      | 1              | 15                  | 1.09           |
| Seventeen publications    | 1              | 17                  | 1.24           |
| Twenty publications       | 1              | 20                  | 1.46           |
| Twenty seven publications | 1              | 27                  | 1.97           |
| Total                     | 834            | 1373                | 100.00         |

#### 7.4. Most prolific Indian authors in the *Aquaculture* journal

Overall, 1373 Indian and International authors contributed 374 publications in the *Aquaculture* journal during the study period 1972 - 2011. Table 4 shows the top 50 prolific Indian authors contributing four and above publications. Among the top 50 authors, A. S. Sahul Hameed scored first rank with 27 publications; followed by Indrani Karunasagar who scored second rank with 20 publications and Iddya Karunasagar scored third position with 17 publications.

**Table 4 – Top 50 prolific Indian authors in the *Aquaculture* journal**

| Sl. No | Name of the Author    | No. of publications |
|--------|-----------------------|---------------------|
| 1      | A.S. Sahul Hameed     | 27                  |
| 2      | Indrani Karunasagar   | 20                  |
| 3      | Iddya Karunasagar     | 17                  |
| 4      | B.B. Jana             | 15                  |
| 5      | I.S. Bright Singh     | 10                  |
| 6      | P. V.G.K. Reddy       | 10                  |
| 7      | Chellam Balasundaram  | 9                   |
| 8      | J.K. Jena             | 9                   |
| 9      | Rosamma Philip        | 9                   |
| 10     | T. J. Pandian         | 9                   |
| 11     | K. Yoganandhan        | 8                   |
| 12     | M. Peter Marian       | 8                   |
| 13     | S. Ayyappan           | 8                   |
| 14     | G. Balasubramanian    | 7                   |
| 15     | P. Sreenivasula Reddy | 7                   |
| 16     | Ramasamy Harikrishnan | 7                   |
| 17     | Rina Chakrabarti      | 7                   |
| 18     | W.S. Lakra            | 7                   |
| 19     | C.V. Mohan            | 6                   |
| 20     | K.K. Vijayan          | 6                   |
| 21     | T.C. Santiago         | 6                   |
| 22     | Balakrishnan Pradeep  | 5                   |
| 23     | G.V. Kowtal           | 5                   |
| 24     | M. Sarathi            | 5                   |
| 25     | N.P. Sahu             | 5                   |
| 26     | P. C. Das             | 5                   |
| 27     | P. K. Sahoo           | 5                   |
| 28     | P. Ramasamy           | 5                   |
| 29     | R. Sudhakaran         | 5                   |
| 30     | S. Syed Musthaq       | 5                   |
| 31     | S.D. Gupta            | 5                   |
| 32     | A. K. Pal             | 4                   |
| 33     | A. K. Reddy           | 4                   |
| 34     | A.G. Jhingran         | 4                   |
| 35     | A.R. Thirunavukkarasu | 4                   |
| 36     | B. Madhusoodana Kurup | 4                   |
| 37     | Bhavanath Jha         | 4                   |
| 38     | Chavali Gopal         | 4                   |
| 39     | David Stephen         | 4                   |
| 40     | I.S. Azad             | 4                   |
| 41     | Kanta Das Mahapatra   | 4                   |
| 42     | M.N. Kutty            | 4                   |
| 43     | N. Munuswamy          | 4                   |
| 44     | R. Nagabhushanam      | 4                   |
| 45     | R.A. Sreepada         | 4                   |
| 46     | S. K. Otta            | 4                   |

|    |                      |   |
|----|----------------------|---|
| 47 | S. Ravichandra Reddy | 4 |
| 48 | V. Sivaram           | 4 |
| 49 | V.P. Ishaq Ahmed     | 4 |
| 50 | Z.A. Ansari          | 4 |

### 7.5 Contributions by Indian Institutions in the *Aquaculture* journal

The study found 563 national and international Institutions which contributed 374 in publications in the *Aquaculture* journal. Out of these, 465 Institutions were in India. Table 5 shows the top 30 Indian Institutions which contributed to the *Aquaculture* journal. Among the top 30, Central Institute of Freshwater Aquaculture (ICAR), Bhubaneswar, Odisha (Orissa) scored first rank with 40 publications, followed by College of Fisheries, Karnataka Veterinary, Animal and Fisheries Sciences University, Mangalore, Karnataka which scored second place with 38 publications, C. Abdul Hakeem College, Vellore, Tamil Nadu secured third place with 25 publications. Out of 374 publications, Indian Council of Agricultural Research (ICAR) Institutions were contributed 148 publications.

**Table 5 - Top 30 Indian Institutions which contributed to the *Aquaculture* journal**

| Sl. No | Name of the Institute   | No. of Publications |
|--------|---|---------------------|
| 1      | Central Institute of Freshwater Aquaculture (ICAR), P.P. Kausalyagan, Bhubaneswar-751002, Odisha (Orissa) India | 40                  |
| 2      | College of Fisheries, Karnataka Veterinary, Animal and Fisheries Sciences University, Mangalore, 575 002, India | 38                  |
| 3      | C. Abdul Hakeem College, Melvisharam-632 509, Vellore Dt., Tamil Nadu, India                                    | 25                  |
| 4      | Central Institute of Fisheries Education (ICAR), Versova, Mumbai-400061, India                                  | 24                  |
| 5      | Central Institute of Brackishwater Aquaculture (ICAR), Chennai-600 028, Tamil Nadu, India                       | 21                  |
| 6      | Central Marine Fisheries Research Institute (ICAR), P.B. 1912, Cochin 682018, Kerala, India                     | 18                  |
| 7      | Cochin University of Science and Technology, Lakeside Campus, Cochin, Kerala, India, 682016                     | 17                  |
| 8      | Madurai Kamaraj University, Palkalai Nagar, Madurai 625 021, India  | 16                  |
| 9      | University of Kalyani, Kalyani 741235, West Bengal India  | 16                  |
| 10     | Anna University, Madras-600 025, India  | 13                  |
| 11     | National Institute of Oceanography, Dona Paula-403 004, Goa, India  | 12                  |
| 12     | Central Inland Fisheries Research Institute (ICAR), Barrackpore-743101, West Bengal India                       | 11                  |
| 13     | University of Madras, Madras 600025, India  | 10                  |
| 14     | University of Delhi, Delhi-110007, India  | 8                   |
| 15     | Bharathidasan University, Tiruchirapalli-620024, India  | 8                   |
| 16     | Sri Venkateswara University, Tirupati-517502, India   | 7                   |

|    |  |   |
|----|--|---|
| 17 | Central Inland Fisheries Research Substation (ICAR), Cuttack, Odisha (Orissa) India                                  | 7 |
| 18 | Central Inland Fisheries Research Institute (ICAR), KVK/TTC, Kausalyagang, Bhubaneswar, Odisha (Orissa), India       | 7 |
| 19 | Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai - 608 502, Tamil Nadu, India         | 6 |
| 20 | National Bureau of Fish Genetic Resources (ICAR), Canal Ring Road, PO Dilkusha, Lucknow 226002, Uttar Pradesh, India | 6 |
| 21 | Aligarh Muslim University, Aligarh India   | 6 |
| 22 | Fisheries College and Research Institute, Tamil Nadu Fisheries University, Thoothukudi – 628008, India               | 5 |
| 23 | Banaras Hindu University, Varanasi-221005, India   | 5 |
| 24 | Manonmanium Sundaranar University, Tirunelveli, Tamil Nadu, India  | 5 |
| 25 | Visva-Bharati University, Santiniketan-731235, India   | 4 |
| 26 | Tuticorin Research Centre of CMFRI (ICAR), Thoothukudi- 628 001, India   | 4 |
| 27 | Central Inland Fisheries Research Substation (ICAR), Allahabad, Uttar Pradesh India                                  | 4 |
| 28 | Bangalore University, Jnana Bharathi, Bangalore 560 056 India  | 4 |
| 29 | National Centre for Cell Science, Pune University Campus, Ganeshkhind, Pune, India                                   | 4 |
| 30 | Marathwada University, Aurangabad-431004 India   | 4 |

#### 7.6. International collaboration of Indian institution

It was found that 63 International Institutions from 20 countries had collaborated 98 times with Indian Institutions and contributed publications to the *Aquaculture* journal. Among the 20 countries, Norway had 15 collaborations with Indian Institutions, followed by Australia which had 11 collaborations and UK and The Netherlands had 9 collaborations each. Table 6 shows the top 10 International Institutions which collaborated with Indian Institutions. Among them, Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, School of Marine Biomedical Sciences & Marine and Environmental Research Institute, Jeju National University, Jeju 690-756, South Korea collaborated seven times with Bharathidasan University, Tiruchirappalli, Institute of Aquaculture, University of Stirling, Stirling, UK collaborated five times with University of Agricultural Sciences (UAS), Bangalore and one time with Indian Veterinary Research Institute (IVRI), Izatnagar and Fish Culture and Fisheries Group, Wageningen Institute of Animal Sciences, P.O Box 338, 6700 AH Wageningen, Wageningen University, The Netherlands collaborated four times with the University of Agricultural Sciences (UAS), Bangalore and the Cochin University of Science and Technology, Cochin.

**Table 6 – Top 10 International Institutions collaborated with Indian Institutions**

| Sl. No | International Institute  | Country         | No. of Collaborations |
|--------|--|-----------------|-----------------------|
| 1      | Marine Applied Microbes and Aquatic Organism Disease Control Lab, Department of Aquatic Biomedical Sciences, School of Marine Biomedical Sciences & Marine and Environmental Research Institute, Jeju National University, Jeju 690-756, South Korea | South Korea     | 7                     |
| 2      | Institute of Aquaculture, University of Stirling, Stirling, UK   | UK              | 5                     |
| 3      | Fish Culture and Fisheries Group, Wageningen Institute of Animal Sciences, P.O Box 338, 6700 AH Wageningen, Wageningen University, The Netherlands   | The Netherlands | 4                     |
| 4      | Akvaforsk Genetics Center, N-6600 Sunndalsora, Norway  | Norway          | 3                     |
| 5      | AusVet Animal Health Services, Post Office Box 3180, South Brisbane Queensland 4101, Australia   | Australia       | 3                     |
| 6      | CSIRO Livestock Industries, Australian Animal Health Laboratory, 5 Portarlington Road, Geelong, Victoria 3220, Australia   | Australia       | 3                     |
| 7      | Network of Aquaculture Centers Asia-Pacific, Suraswadi Building, Kasertsart University Campus, Ladyao, Jatujak, Bangkok, 10900, Thailand   | Thailand        | 3                     |
| 8      | Nofima Marine, P.O. Box 5010, N-1432 Ås, Norway  | Norway          | 3                     |
| 9      | Pathogens and Immunity, CNRS/UM2, Universite Montpellier II, cc-80, Place Eugene Bataillon, Montpellier, France  | France          | 3                     |
| 10     | School of Biology and Biochemistry, The Queen's University of Belfast, 97 Lisburn Road, Belfast BT9 7BL Northern Ireland, UK   | UK              | 3                     |

### 7.7. National level collaboration of Indian Institutions in the *Aquaculture* journal

In the case of national level collaborations, 66 Indian Institutions collaborated 149 times at the national level. Table 7 shows the top 20 national level Institutions which collaborated among them. Among them, C. Abdul Hakeem College, Melvisharam, Vellore Dist., Tamil Nadu collaborated 13 times with other Indian Institutes, followed by Anna University, Chennai, Tamil Nadu which collaborated 10 times with other Indian Institutes and Central Institute of Brackishwater Aquaculture, Chennai (ICAR), Tamil Nadu collaborated 9 times with other Indian Institutes. All the above three Institutions are in Tamil Nadu.

**Table 7- Top 20 National level Institutional collaborations in the *Aquaculture* journal**

| Sl. No. | Name of the Institute   | No. of Collaborations |
|---------|---|-----------------------|
| 1       | C. Abdul Hakeem College, Vellore Dist., Melvisharam 632 509, Tamil Nadu, India  | 13                    |
| 2       | Anna University, Madras-600 025, India  | 10                    |
| 3       | Central Institute of Brackishwater Aquaculture, Santhom High Road, R.A. Puram, Chennai-600 028, India   | 9                     |
| 4       | Central Institute of Fisheries Education, Versova, Mumbai 400061, India   | 9                     |
| 5       | Central Institute of Freshwater Aquaculture, Bhubaneswar-751002, Odisha (Orissa)  | 7                     |
| 6       | Cochin University of Science and Technology, Lakeside Campus, Cochin, Kerala, India, 682016   | 7                     |
| 7       | College of Fisheries, Mathsyangar, Mangalore — 575 002, Karnataka, India  | 7                     |
| 8       | Central Marine Fisheries Research Institute, Vizhinjam-695 521, Thiruvananthapuram, India   | 5                     |
| 9       | Indian Council of Agricultural Research, Krishi Anusandhan Bhawan-II, Indian Council of Agricultural Research, Pusa, New Delhi 110 012, India | 5                     |
| 10      | National Centre for Cell Science, Pune University Campus, Ganeshkhind, Pune, India  | 4                     |
| 11      | Visva-Bharati University, Santiniketan-731235, India  | 4                     |
| 12      | Madurai Kamaraj University, Madurai, India  | 3                     |
| 13      | Manonmanium Sundaranar University, Alwarkurichi-627412, Tirunelveli, Tamil Nadu, India  | 3                     |
| 14      | National Bureau of Fish Genetic Resources Canal Ring Road, PO Dilkusha Lucknow-226002, Uttar Pradesh, India                                   | 3                     |
| 15      | National Centre for Sustainable Aquaculture, 69-17-8, SBI Officers Colony, Rajendra Nagar, Kakinada 533003, Andhra Pradesh, India             | 3                     |
| 16      | University of Kalyani, Kalyani-741 235, West Bengal, India  | 3                     |
| 17      | Fatima Mata National College, Kollam, Kerala, India   | 2                     |
| 18      | Fisheries College and Research Institute, Tamil Nadu Fisheries University, Thoothukudi – 628008, India  | 2                     |
| 19      | Malankara Catholic College, Mariagiri, Kaliakavilai-629 153, Kanyakumari District, India  | 2                     |
| 20      | University of Madras, Guindy Campus, Chennai 600025, Tamil Nadu, India  | 2                     |

### 7.8. State-wise distributions of publications

Table 8 shows the state-wise contributions reported in the *Aquaculture* journal from India. There were 19 States which contributed 465 contributions. Among them, Tamil Nadu contributed 133 (28.60%) publications and scored first rank, followed by Odisha (formerly

Orissa) with 63 (13.55%) publications, Karnataka with 50 (10.75%) publications and Kerala with 43 (9.25%) publications securing second, third and fourth position respectively. Among the Indian states Southern states of India, viz., Tamil Nadu, Karnataka, Kerala and Andhra Pradesh contributed 51.61% of the Indian contributions in the *Aquaculture* journal.

**Table 8 – State-wise contributions in the *Aquaculture* journal**

| Sl. No. | Name of the state | No. of Publications | Percentage (%) |
|---------|-------------------|---------------------|----------------|
| 1       | Tamil Nadu        | 133                 | 28.60          |
| 2       | Odisha            | 63                  | 13.55          |
| 3       | Karnataka         | 50                  | 10.75          |
| 4       | Kerala            | 43                  | 9.25           |
| 5       | West Bengal       | 41                  | 8.82           |
| 6       | Maharashtra       | 38                  | 8.17           |
| 7       | Uttar Pradesh     | 32                  | 6.89           |
| 8       | Delhi             | 16                  | 3.44           |
| 9       | Andhra Pradesh    | 14                  | 3.01           |
| 10      | Goa               | 12                  | 2.58           |
| 11      | Haryana           | 5                   | 1.08           |
| 12      | Gujarat           | 4                   | 0.86           |
| 13      | Punjab            | 4                   | 0.86           |
| 14      | Rajasthan         | 3                   | 0.65           |
| 15      | Meghalaya         | 2                   | 0.43           |
| 16      | Uttarakhand       | 2                   | 0.43           |
| 17      | Jammu Kashmir     | 1                   | 0.21           |
| 18      | Lakshadweep       | 1                   | 0.21           |
| 19      | Puducherry        | 1                   | 0.21           |
|         |                   | 465                 | 100.00         |

### **7.9. Document-wise distribution of Indian authors in the *Aquaculture* journal**

Table 9 shows the document-wise distribution of Indian authors' contribution in the *Aquaculture* journal. The original articles scored first position with 342 (91.45%) publications, followed by short communications with 17 (4.55%) publications, Brief Technical Notes with 4 (1.07%) publications scoring second and third places, respectively.

**Table 9 – Document-wise distribution in the *Aquaculture* journal**

| Sl. No | Document Type           | No. of Contribution | Percentage (%) |
|--------|-------------------------|---------------------|----------------|
| 1      | Original Articles       | 342                 | 91.45          |
| 2      | Short Communications    | 17                  | 4.55           |
| 3      | Brief Technical Note    | 4                   | 1.07           |
| 4      | Conference publications | 3                   | 0.80           |
| 5      | Review articles         | 3                   | 0.80           |
| 6      | Book Review             | 2                   | 0.53           |
| 7      | Supplement              | 2                   | 0.53           |
| 8      | Abstract                | 1                   | 0.27           |
|        |                         | 374                 | 100.00         |

**7.10. Highly cited Indian authors' publications in the *Aquaculture* journal**

The 374 Indian authors' publications published in the *Aquaculture* journal had received 6070 citations in SCOPUS database. The characteristics of highly cited papers are listed in Table 10. Citation received as on 23<sup>rd</sup> September 2014 by the top 10 Indian authors publications was accumulated, 1143 citations in SCOPUS database and 1768 in Google Scholar database were considered. All cited publications have more than one authors and it seems that the team contribution is more effective than the single author contribution. The Top cited publication was I. Karunasagar, R. Pai, G.R. Malathi and Indrani Karunasagar, 1994. Mass mortality of *Penaeus monodon* larvae due to antibiotic-resistant *Vibrio harveyi* infection. *Aquaculture*, 128 (3-4), p. 203 - 209, DOI: 10.1016/0044-8486(94)90309-3 in both citation databases with 240 citations in SCOPUS and 380 citations in the Google Scholar.

**Table 10 - Highly cited Indian authors' publications of the *Aquaculture* journal**

| Sl. No. | Author/Year/Title/Journal  | No. of Times Cited in SCOPUS (as on 23.09.2014) | No. of Times Cited in Google Scholar (as on 23.09.2014) |
|---------|--|---|---|
| 1       | I. Karunasagar, R. Pai, G.R. Malathi and Indrani Karunasagar, 1994. Mass mortality of <i>Penaeus monodon</i> larvae due to antibiotic-resistant <i>Vibrio harveyi</i> infection. <i>Aquaculture</i> , V. 128 (3-4), p. 203 - 209, DOI: 10.1016/0044-8486(94)90309-3. | 240   | 380   |
| 2       | T.J. Pandian and , S.G. Sheela, 1995. Hormonal induction of sex reversal in fish.  | 214   | 326   |



|   |   |     |     |
|---|---|-----|-----|
|   | <i>Aquaculture</i> , 138 (1-4), p. 1-22, DOI: 10.1016/0044-8486(95)01075-0  |     |     |
| 3 | R. Harikrishnan , M. Nisha Rani and C. Balasundaram, 2003. Hematological and biochemical parameters in common carp, <i>Cyprinus carpio</i> , following herbal treatment for <i>Aeromonas hydrophila</i> infection. <i>Aquaculture</i> , 221 (1-4), p. 41-50, DOI: 10.1016/S0044-8486(03)00023-1 | 121 | 177 |
| 4 | J. Ravi and K.V. Devaraj, 1991. Quantitative essential amino acid requirements for growth of catla, <i>Catla catla</i> (Hamilton). <i>Aquaculture</i> , 96 (3-4), p. 281-291, DOI: 10.1016/0044-8486(91)90158-4   | 101 | 129 |
| 5 | K.M. Das and S.D. Tripathi, 1991. Studies on the digestive enzymes of grass carp, <i>Ctenopharyngodon idella</i> (Val.). <i>Aquaculture</i> , 92, p. 21-32, DOI: 10.1016/0044-8486(91)90005-R   | 85  | 163 |
| 6 | A.S. Sahul Hameed, M Anilkumar, M.L Stephen Raj and Kunthala Jayaraman, 1998. Studies on the pathogenicity of systemic ectodermal and mesodermal baculovirus and its detection in shrimp by immunological methods. <i>Aquaculture</i> , 160 (1-2),p. 31-45, DOI: 10.1016/S0044-8486(97)00221-4  | 77  | 116 |
| 7 | R. Chythanya, Indrani Karunasagar and Iddya Karunasagar, 2002. Inhibition of shrimp pathogenic <i>vibrios</i> by a marine <i>Pseudomonas</i> I-2 strain. <i>Aquaculture</i> , 208 (1-2), p. 1-10, DOI: 10.1016/S0044-8486(01)00714-1  | 75  | 128 |
| 8 | V Sivaram, M.M Babu, G Immanuel, S Murugadass, T Citarasu and M.P Marian, 2004. Growth and immune response of juvenile greasy groupers ( <i>Epinephelus tauvina</i> ) fed with herbal antibacterial active principle supplemented diets against <i>Vibrio</i>                                   | 82  | 111 |

|    |   |      |      |
|----|---|------|------|
|    | <i>harveyi</i> infections. <i>Aquaculture</i> , 237 (1-4), p. 9-20, DOI: 10.1016/j.aquaculture.2004.03.014  |      |      |
| 9  | Ayyaru Gopalakannan and Venkatesan Arul, 2006. Immunomodulatory effects of dietary intake of chitin, chitosan and levamisole on the immune system of <i>Cyprinus carpio</i> and control of <i>Aeromonas hydrophila</i> infection in ponds. <i>Aquaculture</i> , 255 (1-4), p. 179-187, DOI: 10.1016/j.aquaculture.2006.01.012 | 82   | 136  |
| 10 | Chandra Kanta Misra, Basanta Kumar Das , Subhas Chandra Mukherjee and Phalguni Pattnaik, 2006. Effect of long term administration of dietary $\beta$ -glucan on immunity, growth and survival of <i>Labeo rohita</i> fingerlings. <i>Aquaculture</i> , 255 (1-4), p. 82-94, DOI: 10.1016/j.aquaculture.2005.12.009            | 66   | 102  |
|    | Total   | 1143 | 1768 |

### 7.11. Keywords in the *Aquaculture* journal

The Indian research contributions in the *Aquaculture* journal can be obtained by analyzing the author keywords appended to the research publications for the study period. Keywords are the one of the best Scientometric indicators to understand the content of the publications and to find out the growth of the subject field. In this journal, 1413 keywords were appended by the Indian authors in 374 publications. Table 11 shows the top 20 keywords appended in the articles. Among them, *Penaeus monodon* scored first position with 39 occurrences, followed by White Spot Syndrome Virus (WSSV) with 34 and *Labeo rohita* with 28 occurrences which scored second and third positions, respectively. Table – 11 shows the list of top 20 Keywords appended more than 7 times by the authors in their publications.

**Table – 11. Top 20 Keywords appended by the authors in their publications**

| Sl. No | Keywords                         | No. of Publications |
|--------|----------------------------------|---------------------|
| 1      | <i>Penaeus monodon</i>           | 39                  |
| 2      | White spot syndrome virus (WSSV) | 34                  |
| 3      | <i>Labeo rohita</i>              | 28                  |

|    |                                  |    |
|----|----------------------------------|----|
| 4  | <i>Cirrhinus mrigala</i>         | 19 |
| 5  | <i>Macrobrachium rosenbergii</i> | 18 |
| 6  | <i>Cyprinus carpio</i>           | 17 |
| 7  | Growth                           | 16 |
| 8  | Survival                         | 14 |
| 9  | Shrimps                          | 13 |
| 10 | <i>Catla catla</i>               | 12 |
| 11 | Indian major carps               | 12 |
| 12 | <i>Heteropneustes fossilis</i>   | 11 |
| 13 | <i>Penaeus indicus</i>           | 11 |
| 14 | <i>Clarias batrachus</i>         | 10 |
| 15 | common carp                      | 9  |
| 16 | grass carp                       | 8  |
| 17 | <i>Aeromonas hydrophila</i>      | 7  |
| 18 | Carp                             | 7  |
| 19 | Immunostimulants                 | 7  |
| 20 | <i>Vibrio harveyi</i>            | 7  |

### 7.12. Length-wise analyses of articles

The length of the publications does not indicate the quality of research, but it shows the comprehensiveness and effort made by the authors. Table 12 shows the length-wise distribution of the publications published by the Indian authors in the Aquaculture journal. There were 374 publications by the Indian authors published in 3200 pages. The average number of pages per publication is 8.56. The study reveals that 3 publications had the maximum of 22 pages and one publication had just one page.

**Table – 12. Length-wise distribution of Indian authors publications in the *Aquaculture* journal**

| No. of pages | No. of Publications | Total No. of pages |
|--------------|---------------------|--------------------|
| 1            | 1                   | 1                  |
| 2            | 3                   | 6                  |
| 3            | 9                   | 27                 |
| 4            | 28                  | 112                |
| 5            | 29                  | 145                |
| 6            | 42                  | 252                |
| 7            | 53                  | 371                |
| 8            | 43                  | 324                |
| 9            | 36                  | 324                |
| 10           | 32                  | 320                |

|       |     |      |
|-------|-----|------|
| 11    | 20  | 220  |
| 12    | 23  | 276  |
| 13    | 16  | 208  |
| 14    | 14  | 196  |
| 15    | 10  | 150  |
| 16    | 8   | 128  |
| 17    | 1   | 17   |
| 18    | 2   | 36   |
| 19    | 0   | 0    |
| 20    | 0   | 0    |
| 21    | 1   | 21   |
| 22    | 3   | 66   |
| Total | 374 | 3200 |

## 8. Conclusion

The total number of publications contributed by the Indian authors in the *Aquaculture* journal was 374 during the study period 1972 – 2011. The highest number of papers was 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 collaborations 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. Only one author contributed the maximum of 27 publications. Among the Indian authors, A. S. Sahul Hameed scored first rank with 27 publications. Central Institute of Freshwater Aquaculture (ICAR), Bhubaneswar, Odisha scored first rank with 40 publications among Indian Institutions. ICAR institutes were contributed 148 publications in the *Aquaculture* journal. Indian Institutes had collaborations with 20 countries. Norway had more collaboration with Indian Institutes. Nationally C. Abdul Hakeem College, Vellore, Tamil Nadu collaborated 13 times with other Indian Institutes and scored first rank. Tamil Nadu secured first position with

133 contributions. Original articles were predominant in the *Aquaculture* journal with 342 (91.45%) articles. I. Karunasagar, R. Pai, G.R. Malathi and Indrani Karunasagar, 1994. Mass mortality of *Penaeus monodon* larvae due to antibiotic-resistant *Vibrio harveyi* infection. *Aquaculture*, V. 128 (3-4), p. 203 - 209, DOI: 10.1016/0044-8486(94)90309-3 has highest citation both in SCOPUS database (240) and Google Scholar database (380). More research was carried out in the *Penaeus monodon* with 39 publications. There were 374 publications by the Indian authors published in 3200 pages. The average number of pages per publication is 8.56.

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