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A Scientometric Study of Aquaculture Research Output from Scopus Database During 1999 to 2013

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Abstract **- This study aims to study the research output of aquaculture research indexed in the Scopus database during 1999-2013. About 106,227 bibliographical records were downloaded from Scopus database during 1999 to 2013. This analysis shows that the mean of relative growth and Doblin Time for overall productivity year was 0.093 and 9.53 years. The 93% of outputs have come out through collaborative mode. The average rate of citation per articles (C/A) was 12.43.**
Keywords: **Relative Growth Rate, Time Series Analysis, Collaborative Productivity, Prolific Authors, Degree Of Collaboration, Aquaculture**

I. INTRODUCTION

Scientometric is to provide quantitative characterization of scientific activity; scientometric is a branch of Library and Information Science. 'Scientometric' is the branch of Science that described the output traits in terms of organizational research structure, resource inputs and outputs, develops benchmarks to evaluate the quality of information output. Scientometic studies characterize the disciplines using growth pattern and other attributes. In 1969, Vassily V. Nalimov and Z.M. Mulchenko coined the term 'scientometric' ('nalkometriyas') (Nalimov andMulchenko, 1969). As the name imply, this is the term mainly used for the study of all aspectsof the literature of science and technology. The term had gained wide recognition by the foundation in 1978 of scientometrics by Tibor Brawn in Hungary.

II. RELEVANCE OF THE STUDY

It is necessary and useful to review the available literature in order to know the areas that have invited the attention of the researcher so far, and the areas that seek the attention of the future researchers. Hence, a brief review of related literature and theories of the study under consideration is presented in this chapter. Karpagam *et* al. (2011) have studied the growth pattern of Nano science and Nanotechnology literature in India during 1990–2009 (20 years), using Scopus International Multidisciplinary Bibliographical Database. The study identifies the Indian contributions in the field of nano science and nanotechnology. Further, the authors measured in terms of country annual growth rate, authorship pattern, collaborative index, collaborative coefficient, modified collaborative coefficient, subject profile, etc. Sangam (2012) has tried in his study to investigate the pattern of authorship and Collaborative studies in the field of demography. The data was made available from the population index for the time span 1988 -1999. The span of three years period was considered for assessment. The results of the study shows that the collaborative index increases from 1.47 during 1988 and 1990 to 1.79 during 1997 and 1999. It is found that the growth in the proportion of collaborated publication shows decreasing value.

III. DATA AND METHODOLOGY

In order to get an idea about similar studies done in informetrics, an exhaustive literature search was carriedout. For this the necessary data were collected from the Scopus database using search term of "aquaculture", collecting, organizing and analyzing of data were done on the basis of established informetric / scientometric methods. The downloaded data was transformed to MS-Excel format. The data was sorted to prepare tables and figures using MS-Excel software. This data has downloaded limits the duration of 1999 to 2013 and the major topic of aquaculture.

IV. OBJECTIVES OF THE STUDY

1. To find out the Relative Growth Rates and Doubling Time for aquaculture research output during 1999 to 2013.
2. To observe the future growth trend in aquaculture research.
3. To find out the continent wise contributing countries and articles.
4. To find out the Productivity of authors and degree of collaboration.

V. ANALYSIS AND INTERPRETATION

The selected period taken for this analysis of aquaculture research productivity is from 1999 to 2013 and it is totally fifteen years. Totally 106227 number of records were downloaded from the database of Scopus during the sample period in the subject of aquaculture. Among those 106227 publications; the year of 2013 with highest number of publications of 13474 (12.68 %); year 2012 has 11822 (11.13 %) records published and the year 2010 has 11403 (10. 73 %) records were found from the Scopus database and the years 2013, 2012 and 2011 were having highest number of publications and its occupied the first, second and third rank positions among the sample fifteen years.

TABLE I YEAR WISE DISTRIBUTION OF AQUACULTURE RESEARCH PRODUCTIVITY

Year	No. of countries	Global publications	Average articles	Global Citations	Mean value	No. of Authors	Average authors
1999	92	3314	36.02	93642	28.26	10732	3.24
2000	89	3426	37.24	95954	28.01	11401	3.33
2001	89	3802	41.33	102913	27.07	12829	3.37
2002	93	4105	44.62	104749	25.52	14574	3.55
2003	95	4774	51.89	112830	23.63	17289	3.62
2004	95	5011	54.47	114016	22.75	18549	3.70
2005	98	5489	59.66	109455	19.94	20799	3.79
2006	102	6760	73.48	119703	17.71	26520	3.92
2007	82	7256	78.87	113895	15.70	29128	4.01
2008	111	7834	85.15	102501	13.08	32558	4.16
2009	91	8052	87.52	84137	10.45	34048	4.23
2010	94	9705	105.49	76884	7.92	42226	4.35
2011	89	11403	123.95	54475	4.78	50112	4.39
2012	91	11822	128.50	27271	2.31	55474	4.69
2013	84	13474	146.46	8250	0.61	68730	5.10
Total	1395	106227	7081.8	1320675	247.73(12.43)	444969	4.19

The following results were acquired from this table analysis; such that, generally 82 to 111 countries were contributed from various continents during the study period, more number of countries contributed in the year 2008. The year 2013 having highest publications, the overall average article per country is 7081.8 articles by 1395 countries; individual years average article by 84 countries publications is 146.46 in 2013; total citations scores is 1320675 and its mean value is 247.73 citation scores; among the fifteen years, the year 2006 having highest citation scores value of 119703, totally 444969 authors were contributed from various countries at different years; 318.97 authors were calculated by country wise and 29664.6 average authors per year. The year 2013 having highest number of contributing authors. Finally it is identified that there is no relation between the productivity of publication between the citation scores. It could be identified from this analysis, more number of countries contributed in 2008, highest publications have in 2013, highest citation scores in 2006 and highest number of authors were contributed in 2013.

TABLE II RELATIVE GROWTH RATE AND DOUBLING TIME OF AQUACULTURE RESEARCH OUTPUT

Year	R. o/p	$log_e 1^p$	$log_e 2^p$	Rt(P)		Dt(P)	
1999	3314	-	8.106	-		-	
2000	3426	8.106	8.139	0.033		20.85	
2001	3802	8.139	8.243	0.104	0.073	6.66	8.228
2002	4105	8.243	8.320	0.077		9.04	
2003	4774	8.320	8.471	0.151		4.59	
2004	5011	8.471	8.519	0.048		14.30	
2005	5489	8.519	8.611	0.091		7.60	
2006	6760	8.611	8.819	0.208	0.099	3.33	8.812
2007	7256	8.819	8.890	0.071		9.79	
2008	7834	8.890	8.966	0.077		9.04	
2009	8052	8.966	8.994	0.027		25.25	
2010	9705	8.994	9.180	0.187		3.71	
2011	11403	9.180	9.342	0.161	0.108	4.30	11.55
2012	11822	9.342	9.378	0.036		19.20	
2013	13474	9.378	9.509	0.131		5.30	
	106227			1.403	0.093	142.959	9.53

It is observed that its relative growth rates have contracted gradually from 0.033 at 1999 to 0.131 in the year of 2013. The whole study period sample mean relative growth rate of 0.093. The year groups during 1999 to 2003 has the relative growth rate value of 0.073; the year groups during 2004 to 2008 has the relative growth rate value of 0.099 and the year groups during 2009 to 2013 has the relative growth rate value of 0.108. Contrary to this, the Doubling Time for International publication of all sources in aquaculture research output has decreased from 20.85 in 1999 to 5.30 in 2013. The year groups during 1999 to 2003 has the doubling time value of 8.228; the year groups during 2004 to 2008 has the doubling time value of 8.812 and the year groups during 2009 to 2013 has the relative growth rate value of 11.55. The whole study period doubling time is 9.53 years. However, its relative growth rate has shown a wealthy trend, which means the rate of increase is low in terms of proportion, and this has been highlighted by doubling time for publications, which is more than the relative growth rate.

TABLE III TIME SERIES ANALYSIS OF AQUACULTURE RESEARCH OUTPUT

Years	No. of pubs.	X	X^2	XY
1999	3314	-7	49	-23198
2000	3426	-6	36	-20556
2001	3802	-5	25	-19010
2002	4105	-4	16	-16420
2003	4774	-3	9	-14322
2004	5011	-2	4	-10022
2005	5489	-1	1	-5489
2006	6760	0	0	0
2007	7256	1	1	7256
2008	7834	2	4	15668
2009	8052	3	9	24156
2010	9705	4	16	38820
2011	11403	5	25	57015
2012	11822	6	36	70932
2013	13474	7	49	94318
	106227		280	199148

Straight line equation is applied to arrive at estimates for future growth under the Time Series analysis.

Straight Line equation $Y_c = a + bX$; Since $\sum x = 0$,

$a = \sum Y/N = 106227 / 15 = 7081.8$; $b = \sum XY/\sum x^2 = 199148 / 280 = 711.24$

Estimated literature in 2020 is, when $X = 2020 - 2006 = 14$

$= 7081.8 + 711.24 * 14$

$= 7081.8 + 9957.36$

$= 17039.16$

Estimated literature in 2023 is, when $X = 2023 - 2006 = 17$

$= 7081.8 + 711.24 * 17$

$= 7081.8 + 12091.08$

$= 19172.88$

On the application of the formula of Time Series Analysis and subsequently, from the results obtained separately for the years 2023, 2020 and 2017, it is found that the future trend of growth in Research Literature output may take an increasing trend during the years to come. The inference is that there is a positive growth level in research literature output in aquaculture Research Literatures.

TABLE IV CONTINENT WISE RESEARCH OUTPUT OF AQUACULTURE

Continents	No. of Countries	Percent	Research output	Percent
Europe	54	30.68	35579	33.49
Asia	42	23.86	31356	29.52
North American	26	14.77	24841	23.38
Australia	6	3.41	5887	5.54
South America	11	6.25	5899	5.55
Africa	32	18.18	2594	2.44
Oceania	5	2.84	71	0.07
Total	176	100	106227	100

The Table IV reveals that the continents contribution countries of the research output on Aquaculture during 1999 to 2013 (fifteen years) from 176 different countries. At the comprehensive level, the highest research productivity by Europe and lowest research productivity by Oceania. Found from this table analysis, the status of research shows the variation during these year groups.European continents have 35579 (33.49 %) of research output were produced by the 54 (30.68 %) of different countries; followed by Asian continent produced 31356 (29.52 %) publications from 42 (23.86 %) of different countries; North America continent produced 24841 (23.38 %) publications from 26 (14.77 %) of different countries; Australia continent produced 5887 (5.54 %) publications from 6 (3.41 %) of different countries; South America continent produced 5899 (5.55 %) publications from 11 (6.25 %) different countries; Africa continent produced 2594 (2.44 %) publications from 32 (18.18 %) different countries; and Oceania continent produced 71 (0.07 %) publications from 5 (2.84 %) different countries in aquaculture research output respectively. it could be identified the European continent has highest contribution of aquaculture research output.

TABLE V DISTRIBUTION OF THREE YEAR GROUPS VS. CONTINENTS WISE RESEARCH OUTPUT OF AQUACULTURE

Rank	Continents	Recs	1999-01	2002-04	2005-07	2008-10	2011-13
1	Europe	35579	4121	4914	6579	8408	11557
2	Asia	31356	2041	3339	5277	7988	12711
3	North America	24841	3106	3814	4938	5730	7253
4	South America	5899	336	549	970	1521	2523
5	Australia	5887	711	994	1242	1272	1668
6	Africa	2594	218	273	475	667	961
7	Antarctica / Oceania	71	9	7	24	5	26
	Total	106227	10542	13890	19505	25591	36699

The researcher concludes result from this analysis based on the three year groups output of the overall percentage analysis that the three year groups are 1999 to 2001; 2002 to 2004; 2005 to 2007; 2008 to 2010 and 2011 to 2013. Among those three year groups, 2011 to 2013 has produced more number of publications in the selected area of aquaculture. Followed it shows the reverse wise highest publications. It shows the recent years (last ten years) increased the aquaculture publications. The first year group of 1999 to 2001 has 10542 publications; it's measured less number of publications among other year groups. It could be noted that the European continent establishes the highest publication among other continents.

Single Author Contributions

In this analytical study period during 1999 to 2013; totally 444969 scientists have produced 106227 articles contributions scattered over 3519 different journals / source. Here the fourth hypothesis is subsequently proved. In accordance to this the researcher has ranked according to their highest publications in the field of aquaculture research. Among those 444969 authors, 7350 articles were produced by single author contributions. Table VI reveals that the single contributing active authors based on their highest contributing times in aquaculture research. It shows 7350 articles were produced by the single authors, among those articles were contributed by 6615 single authors. 16 authors were identified the most productive authors among the 6615 contributors.

TABLE VI SHOWING PROLIFIC AUTHORS OF SINGLE CONTRIBUTION

	Active authors in			
Years	**Single contribution**	**Contributing times**	**Total authors**	**Total articles**
1999	Fagbenro O.A.	4	376	391
2000	Kozinska A	4	362	385
2001	Voonyaratalin M	5	424	447
2002	Udo M T	3	381	411
2003	Woods CMC	4	405	435
2004	Mistry, M	4	342	378
2005	Gershwin L.-A.	3	421	465
2006	Alfaro A C	4	284	515
2007	Bernoth E.-M.	4	485	529
2008	Camargo J A	3	474	514
2009	Woodward K N	7	449	489
2010	Jobling M	6	576	607
2011	Cho S H & Wetengere K	Each 4	642	689
2012	Tidwell J H	6	571	613
2013	Agastsuma Y	4	423	482
Total	16		6615	7350

The author "Woodward K N" has contributed 7 times as single author in 2009, so this author identified the active author of single contribution in aquaculture research output. The authors "Jobling M" and "Tidwell J H" were contributed each six times in 2010 and 2012; followed by nine were contributing each 4 times; and remaining two authors were contributed each 3 times at respected years productivity. It could be identified the author "Woodward K N" is an active author of Individual contribution of single authored articles in aquaculture research output during the sample time span.

Degree of Collaboration

Table VII shows the single Vs multi-authored paper on aquaculture research productivity during 1999 to 2013. In the year 1999 only 391 articles have been produced by the single authored papers showed growth trend of 6.56% whereas in 2013 and in 2012 it shows an increasing trend of 454 articles. At the overall level the single authored papers constitute 27.71 % of the total publication reported in the study and the remaining 72.29 % of the publications are contributed by multi-authors. The analysis of the extent of collaboration in Aquaculture research reveals that the following facts; the year 1999 shows 2.96 percent and it raised in 2013 as13.14. percent. The overall multi-authored collaboration is 72.29 % in the subject of Aquaculture research output. The study found that single author papers maintained a low profile among Aquaculture research scientists. In recent years, scientists/researchers target for communal participation in research problem solving activities. It has resulted in the dilapidated of single author papers and thereby an increase in multiple author papers.

A study of the above data indicates the degree of collaboration in the research output on Aquaculture. The degree of collaboration is 93.08 during the study period 1999 to 2013. i.e., out of the total 106227 literature published, 98.35% of them are published under combined undertaking. During the year 1999 to 2013 the degree of collaboration was not a constant value, it shows differs of 88.20 and 96.42. It is seen clearly from the above that the degree of collaboration in producing research output on Aquaculture research has shown an increasing trend during the study period since it is a new discipline. Based on this study, the result of the degree of collaboration C = 0.93. i.e, 93% of collaborative authors' articles published during the study periods.

TABLE VII SINGLE VS MULTI-AUTHOR AND DEGREE OF COLLABORATION OF AQUACULTURE RESEARCH

Year	Single authors		Multi authored		Total	Degrees of Collaboration
	No of output	%	No. of output	%		
1999	391	5.32	2923	2.96	3314	88.20
2000	385	5.24	3041	3.08	3426	88.76
2001	447	6.08	3355	3.39	3802	88.24
2002	411	5.59	3694	3.74	4105	89.99
2003	435	5.92	4339	4.39	4774	90.89
2004	378	5.14	4633	4.69	5011	92.46
2005	465	6.33	5024	5.08	5489	91.53
2006	515	7.01	6245	6.32	6760	92.38
2007	529	7.20	6727	6.80	7256	92.71
2008	514	6.99	7320	7.40	7834	93.44
2009	489	6.65	7563	4.65	8052	93.93
2010	607	8.26	9098	9.20	9705	93.75
2011	689	9.37	10714	10.84	11403	93.96
2012	613	8.34	11209	11.34	11822	94.81
2013	482	6.56	12992	13.14	13474	96.42
	7350 (6.92)	100	98877	100	106227	93.08

V. CONCLUSION

The researcher has derived the result from this aquaculture research analysis, the last three years of 2011, 2012 and 2013 has highest publications; 1,395 countries were contributed 106,227 articles from seven difference continents; averagely 7,082 articles per country; total citation is 13,20,675; average citation per year is 247.73 and per article average citation is 12.43; totally 444969 authors were contributed during study period; averagely 4.19 authors per article; the mean of relative growth rate of 0.093 whereas the mean for Doubling Time 9.53 years. It is found that from the time series analysis future trend of growth output may take a positive growth trend during the years to come. The European continent has produced highest number of research publications in aquaculture research output. The author of "Woodward K N" is an active author for his individual contribution. 93% of authors were contributed aquaculture publications through collaborative mode; it shows that the team work could be leads in aquaculture research output during the study period.

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