Bibliometric study of seafood quality literature

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ABSTRACT

This study investigates characteristics of seafood quality literature through application of bibliometric techniques. No previous studies that examined this field of science. The objectives are to examine seafood literature's growth, document types, place/language of publishing, and author productivity patterns (analysed using Lotka's law). A total of 2267 records were retrieved (up to 11 May 2016) from Web of Science and Scopus. Literature grew exponentially from 2000 to 2013 following the development of this field. Values obtained were c = 1.038, g = 1.118 and R^2 = 0.946. Annual growth rate was 11.8%. The bibliography duplicates every 6.2 years. The most common publications were journal articles (64%), as expected. Per country, the U.S.A. made most major contributions, and English was the most-used language. A total of 5,583 authors, including co-authors, were retrieved; every paper's author was given one credit to measure productivity. The majority (75%; 4175 authors) contributed only one article. These data do not fit Lotka's law.

Keywords: Lotka's law. Author. Publications. Productivity. Food.

Estudo bibliométrico sobre a literatura que aborda a qualidade do pescado

RESUMO

Este estudo investigou as características da literatura de qualidade do pescado através da aplicação de técnicas de bibliometria. Não há estudos prévios que tenham analisado a bibliografia deste campo da ciência. Os objetivos foram examinar o crescimento da literatura, tipos de documento, lugar/idioma de publicação padrões de produtividade (analisados usando a lei de Lotka). O total de 2.267 registros foi recuperado (até 11 de maio de 2016) da Web of Science e Scopus. A literatura cresceu exponencialmente de 2000 para 2013 acompanhando o desenvolvimento deste campo. Valores obtidos foram c = 1.038, g = 1.118 e R^2 *= 0.946. Taxa de crescimento anual foi de 11,8%. A bibliografia neste campo duplica a cada 6,2 anos. A publicação mais comum foi artigo de periódico (64%), conforme o esperado. Por país, os Estados Unidos fizeram a maioria das grandes contribuições e o inglês foi o idioma mais utilizado. O total de 5.583 autores, incluindo coautores, foi recuperado. A maioria (75%; 4175 autores) contribuiu com apenas um artigo. Estes dados não se ajustam à Lei de Lotka.*

***Palavras chave**: Lei de Lotka. Autor. Publicações. Produtividade. Alimentos.*

Estudio bibliométrico de la literatura que aborda la calidad del pescado

RESUMEN

Este estudio investigó las características de la literatura de calidad del pescado mediante la aplicación de técnicas de bibliometría.. No existen estudios que han analizado la bibliografía sobre este campo de la ciencia. Los objetivos fueron estudiar el crecimiento de la literatura, tipos de documento, lugar/idioma de los estándares de productividad de publicación (analizada ley de Lotka). Se recuperaron un total de 2267 registros (hasta el 2016 11 de mayo) de Web of Science y Scopus. La literatura ha crecido exponencialmente desde el año 2000 a 2013, tras el desarrollo de este campo. Valores obtenidos fueron c = 1.038, g = 1.118 y R2 = 0946. Tasa de crecimiento anual fue del 11,8%. La literatura en este campo se duplica cada 6,2 años. El más común fue a publicar artículos de revistas (64%), como se esperaba. Por país, Estados Unidos hizo contribuciones más grandes y el inglés era el idioma principal utilizado. Un total de 5.583 autores, incluyendo los coautores, fueron recuperados. La mayoría (75%; 4175 autores) contribuyó un artículo. Estos datos no se ajustan ley de Lotka.

***Palabras clave**: Ley de Lotka. Autor. Publicaciones. Productividad. Alimentos.*

INTRODUCTION

The growing demand for food and natural resources promotes global effort to ensure food security. Consequently, scientists develop research seeking to improve upon and discover new techniques to maintain food quality, fully utilize raw materials and promote sustainability in all fields. Seafood is one of the most complete and healthy foods, with high nutritional value (FAO, 2014A) that makes it a source of energy and protein for most of the world's population (PIGOTT;TUCKER, 1990). Consumption has been increasing in recent decades (FAO, 2014), as well as the volume of international trade (GEPHART;PACE, 2015).

Seafood quality is a field of science that combines biochemistry (JIANG, 2000; 2007), biology (WONG et al., 2015), physics (PIVARNIK et al., 2001), chemistry (TAHERGORABI et al., 2012), economics (KIM, 2008), marketing (KO;NA, 2011), engineering (GREEN-PETERSEN et al., 2012; GIANNOGLOU et al., 2014), geography (MANSFIELD, 2003a; b) and many other areas with the objective of offering the world population a healthy and nutritious food source (SIKORSKI, 1990).

Some scientometrics studies have been carried out in the fields of agriculture (SIEGMEIER;MÖLLER, 2013), fish stocks (ALVES;MINTE-VERA, 2013; CHONG-CARRILLO et al., 2015), scientific academic production concerning seafood (Martins et al., 2015) and sturgeon research (JARIC;GESSNER, 2012). However, to date there are no scientometrics studies on seafood quality.

People, government and industry have demonstrated increasing interest in seafood in the past decades. Aquaculture has provided an increase in raw material for the seafood industry (FAO, 2014). It is important to know where the field's most productive research team are and where it is developing.

This study investigates some characteristics of seafood quality literature through application of bibliometric techniques. The objectives of the study are to examine seafood literature's growth, mode of publication (e.g., journal article, congress, review article, etc.), language, place of publication, and author productivity patterns.

METHODS

This is an exploratory study applying a quantitative approach and bibliometric methods.

A database was created and data were downloaded from Web of Science and Scopus. Web of Science is an online indexing service maintained by Thomson Reuters Corporation. Scopus is a bibliographic database containing abstracts and citations for academic journal articles. It is owned by Elsevier and available online by subscription. Data were collected using the reference management software package ENDNOTE Web, by Thompson Reuters. Information about seafood quality was collected by searching for the keywords 'seafood*quality', 'seafood AND quality' and 'seafood quality' in titles, abstracts and keywords. Articles, reviews, proceedings papers, meeting abstracts, editorial materials and news items were collected during the period between January 2000 and May 2016. Data were processed and tabulated using Microsoft Excel for Windows and IBM SPSS 20.0. The numbers of authors and co-authors were collected using Sticci, a free application for pre-processing and converting bibliometric datasets (Gomez-Jauregui et al., 2014).

The hypotheses of this research are as follows:

H1: This area is under development and there is significant growth in the literature.

H2: The literature studied adheres to Lotka's law.

In assessing literature growth, we can assume that the relationship between the independent variable (years) and the dependent variable (publications) can be modelled. To evaluate the fit of the model, a chart based on the observed data was designed. Exponential growth assumes a concave form, as the values of the variable y form a geometric progression and the corresponding values of the variable x form an arithmetic progression (GUPTA; KARISIDDAPPA, 2000).

To estimate the growth of literature, the nonlinear regression model proposed by Egghe and Rao (1992) was used, as follows (Eq. 1):

$$C(t) = c.gt$$
$$C > 0;\ g > 1;\ yt \geq 0 \qquad (1)$$

To estimate duplication of the bibliography, the equation described by Urbizagastegui (2009) was employed.

According to Lotka's law, the number of authors Y(x), each with a total of x works, is inversely proportional to x, which is the productivity of each individual author (PAO, 1985).

This is expressed as **$x^n \cdot y_x = c$; x = 1, 2, .., xmax; c>0; n>1**, where **yx** represents the probability of an author publishing x times in that field; **xmax** represents the maximum value of productivity; and **n** and **c** are two parameters estimated for each specific set of data (Pao, 1985).

For calculation of parameter **n**, the method proposed by Pao (1985) was used (Eq. 2), where **N** is the number of pairs considered, **X** is the logarithm of **x** and **Y** is the logarithm of **Y(x)**:

$$n = \frac{N\Sigma XY - \Sigma X \Sigma Y}{N\Sigma x^2 - (\Sigma X)^2} \qquad (2)$$

For calculation of parameter c, the method proposed by Pao (1985) was used (Eq. 3):

$$\sum_{x=1}^{\infty}\frac{1}{x^n} = \left[\sum_{x=1}^{p-1}\frac{1}{x^n} + \frac{1}{n-1\left(p^{n-1}\right)} + \frac{1}{2p^n} + \frac{n}{24(p-1)^{n+1}}\right] \qquad (3)$$

Finally, to verify the significance of the degree of fit of the model, the statistical test of non-parametric Kolmogorov-Smirnov goodness-of-fit proposed by Pao (1985) was used:

H_0: The data fit Lotka's law.

H_1: The data do not fit Lotka's law.

The critical value c.v. was calculated as follows (Eq. 4):

$$c.v. = \frac{1,63}{\sqrt{\sum y}} \qquad (4)$$

RESULTS AND DISCUSSION

A total of 2267 records were retrieved (up to 11 May 2016) from Web of Science and Scopus. Web of Science provided 1039 records, and Scopus 1228. After removing duplicate records, 1855 records were considered for analysis. The Web of Science collection starts from 1969 and Scopus collection starts from 1972.

GROWTH OF LITERATURE

Table 1 lists the number of articles published and their accumulated values each year. The collection of seafood quality literature started in 1969, in which year only one article was published.

There was a slight recession in 1995 and in 1998. The number of published articles rose (Fao, 2014b)), the record trade figures in 2013 reflect the strong growth in aquaculture output and the high prices for a number of species, such as salmon and shrimp. This is underscored by firm underlying demand for fish products in the world market.

Table 1 – Annual production of subject indexing literature

Year	No. of Items	Cumulative	Year	No. of Items	Cumulative
1969	1	1	1994	23	123
1971	1	2	1995	13	136
1972	1	3	1996	24	160
1974	1	4	1997	60	220
1975	2	6	1998	28	248
1976	1	7	1999	25	273
1977	1	8	2000	30	303
1978	2	10	2001	25	328
1979	4	14	2002	45	373
1980	2	16	2003	55	428
1981	3	19	2004	57	485
1982	2	21	2005	48	533
1983	3	24	2006	56	589
1984	1	25	2007	75	664
1985	2	27	2008	112	776
1986	5	32	2009	95	871
1987	6	38	2010	129	1000
1988	5	43	2011	128	1128
1989	5	48	2012	154	1282
1990	5	53	2013	196	1478
1991	15	68	2014	187	1665
1992	15	83	2015	150	1815
1993	17	100	2016	40	1855

The sharp growth in 1997 can be attributed to increased use of the World Wide Web for exchange of information (TREMAYNE;DUNWOODY, 2001; EYSENBACH;WYATT, 2002) and to the streamlined processes for submission of periodical publications. The exchange of information between various institutions (HAYTHORNTHWAITE, 1996) and researchers may have been an important factor in development of this field.

The development of aquaculture (FAO, 2014) figure 1, and the technological packages (HASAN, 2000), mainly in fish and crustacean nutrition (SOOKYING et al., 2013), boosted the chain that likely demanded further academic investigation, but development of deeper studies to correlate this information is needed.

The growth of literature was exponential from 2000 to 2013, figure 2, following the development of this field.

Figure 1 − World capture fisheries and aquaculture production between 1950–2012 (FAO, 2014)

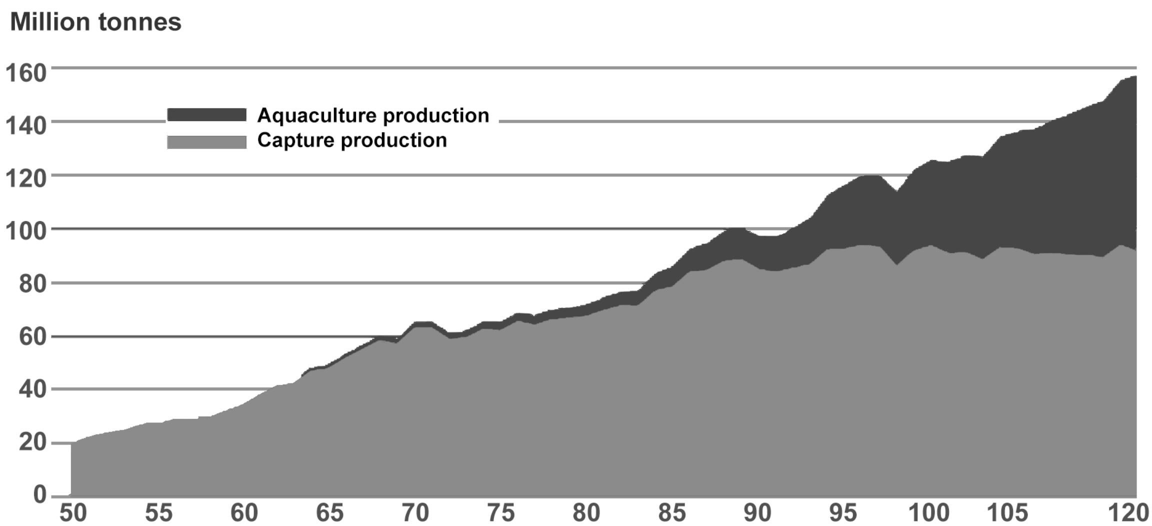

Figure 2 − Growth of seafood quality literature during 1969–2016 and predicted values

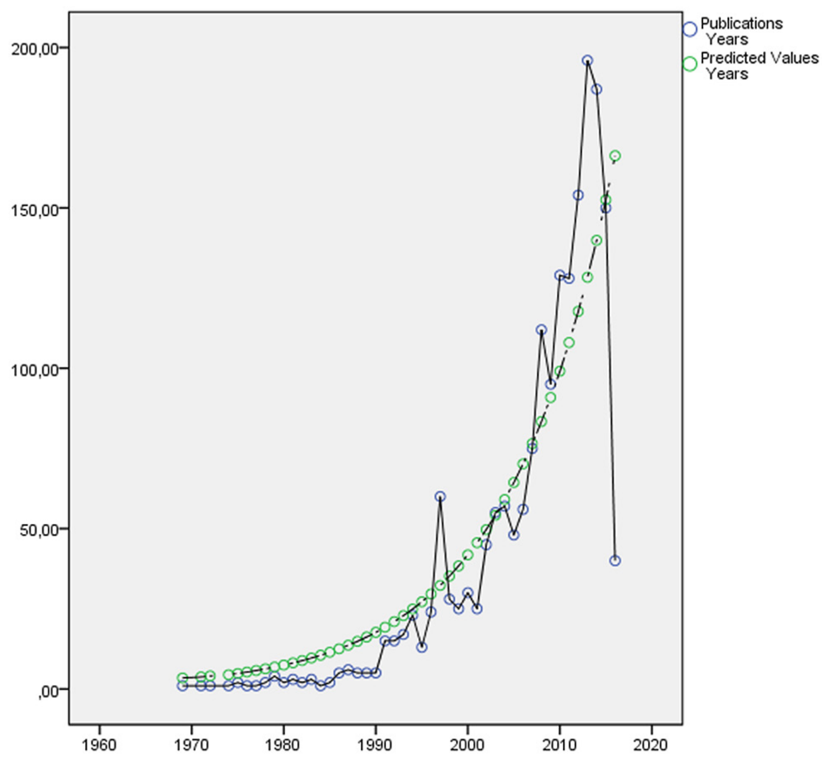

Table 2 shows the variance analysis results acquired using SPSS 20.0, showing the sum of squares values, degrees of freedom and estimate mean squares.

The values obtained showed in table 3 are c = 1.038, g = 1.118 and R^2 = 0.946 (R^2 indicates that this model explains 94.6% of the variance of the associations between the independent and dependent variables). The annual growth rate is 11.8%.

Knowing these parameters (i.e., c and g), it is possible to establish the equation that predicts exponential growth of publications in this field (URBIZAGASTEGUI, 2009), as follows (Eq. 5):

$$
\begin{aligned}
n\,(log\ 1.118) &= log\ 2 \\
n &= (log\ 2)\ /\ (log\ 1.118) \\
n &= 6.21
\end{aligned}
\tag{5}
$$

We consider the bibliography in this field of science to duplicate every 6.2 years.

Publication Types

The distribution of document types is displayed in table 4. As expected, most common are journal articles, which constitute 64% of the total literature. This is a standard consistent with other areas of science, including social science (GUPTA et al., 2002), digital libraries (SINGH et al., 2007), theoretical population genetics (GUPTA;KARISIDDAPPA, 2000) and automatic indexing (PULGARÍN; GIL-LEIVA, 2004). It is clear that scientific articles are the most widely used document type, followed by reviews and then book chapters. Notably, reviews comprise 13% of the total literature and seem to have become very important, because this area is a developing field and researchers gather new information using the studies that already exist.

Table 2 − Analysis of variance and calculation of R2

Source	Sum of Squares	Df	Mean Squares
Regression	195176.225	2	97588.112
Residual	7126.775	45	158.373
Uncorrected Total	202303.000	47	
Corrected Total	132213.106	46	

R^2 = 1: (Residual Sum of Squares) / (Corrected Sum of Squares) = 0.946.

Table 3 − Estimated parameters

Parameters	Estimated	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
c	1.038	0.286	0.461	1.615
g	1.118	0.007	1.104	1.133

Table 4 – Distribution of document types

Document type	No. of Items	%	Cumulative Items	Cumulative %
Article	1193	64	1193	64
Review	250	13	1443	78
Book Chapter	130	7	1573	85
Proceedings Paper	125	7	1698	92
Conference Paper	71	4	1769	95
Book	26	1	1795	97
Article in Press	16	1	1811	98
Short Survey	9	0	1820	98
Meeting Abstract	8	0	1828	99
Undefined	8	0	1836	99
Note	6	0	1842	99
Editorial Material	6	0	1848	100
Conference Review	3	0	1851	100
News	2	0	1853	100
Letter	2	0	1855	100
TOTAL	1855			

Table 5 – Ten most productive countries according to Web of Science and Scopus

Web of Science			Scopus		
Place of Publication	Publications	%	Place of Publication	Publications	%
United States	342	33.1	United States	302	39.6
Spain	120	11.6	Spain	69	9.1
China	99	9.6	China	65	8.5
Norway	78	7.6	Italy	55	7.2
United Kingdom	75	7.3	Canada	53	7.0
Canada	70	6.8	Australia	51	6.7
Australia	67	6.5	Brazil	44	5.8
Italy	67	6.5	Norway	43	5.6
France	65	6.3	Denmark	42	5.5
India	50	4.8	France	38	5.0
TOTAL	1033	100.0	TOTAL	762	100.0

PLACE OF PUBLICATION AND LANGUAGE

As shown in table 5, most seafood quality literary production is distributed worldwide, with the exception of the African continent. The most productive countries are the United States, China and Spain. This is not a surprising scenario, as these countries move high figures annually on imports of fish and have demonstrated significant growth in imports in recent decades (table 6). The two databases used as sources for this investigation are Western, and concentrate a large number of publications from English-speaking Western countries (table 7). The United States demonstrates a high consumption of seafood according to its imports, as well as a significant difference in volume of publications in relation to other countries.

AUTHORS AND LOTKA'S LAW

A total of 5583 authors, including co-authors, were retrieved, and every author of a paper was given one credit to measure author productivity. The majority (i.e., 4,175 authors; 75%) contributed only one article. Table 8 illustrates the number of authors contributing one, two or more articles. The percentage of authors contributing only one article is much larger than the 60% from Lotka's original data. This indicates that, as in other fields, the number of authors who publish and then disperse is very significant. The number of authors who have 10 or more articles is expressive when compared to the Lotka's model. The calculation of n = 3.270792859 and c = 0.864972675 followed the steps showed by Pao (1985). The c.v. obtained by the non-parametric Kolmogorov-Smirnov goodness-of-fit test was 0.021815. The maximum difference D max between the observed and estimated accumulated frequencies was 0.117167. Thus, we conclude that the data do not fit Lotka's law, because the c.v. is higher than the D max and rejects the null hypothesis.

Table 6 – Top ten seafood importers (FAO, 2014)

Importer	2002 (US$ millions)	2012 (US$ millions)	Annual Percentage Growth (%)
Japan	13646	17991	2.8
United States	10634	17561	5.1
China	2198	7441	13.0
Spain	3853	6428	5.3
France	3207	6064	6.6
Italy	2906	5562	6.7
Germany	2420	5305	8.2
United Kingdom	2328	4244	6.2
Republic of Korea	1874	3739	7.2
China, Hong Kong SAR	1766	3664	7.6
Top Ten Subtotal	44830	77998	5.7
Rest of World Total	17323	51390	11.5
World Total	62153	129338	7.6

Table 7 – Publication languages

Language	Publications	%
English	1820	98.0
Portuguese	10	0.5
Spanish	9	0.5
French	5	0.0
German	5	0.0
Japanese	3	0.0
Chinese	1	0.0
Italian	1	0.0
Turkish	1	0.0
TOTAL	1855	100.0

Table 8 − Author productivity and Kolmogorov-Smirnov test of observed and expected distribution

Publications (x)	No. of Authors (y)	Observed Frequency (y/Σ y)	Σ (y/Σ y)	Expected Frequency (fe)	Σ fe	D max
1	4175	0.747806	0.747806	0.864973	0.864973	**0.117167**
2	1008	0.180548	0.928354	0.089618	0.954591	0.026237
3	220	0.039405	0.967759	0.023792	0.978383	0.010624
4	79	0.014150	0.981909	0.009285	0.987668	0.005759
5	45	0.008060	0.989970	0.004475	0.992144	0.002174
6	17	0.003045	0.993015	0.002465	0.994609	0.001594
7	16	0.002866	0.995880	0.001489	0.996097	0.000217
8	4	0.000716	0.996597	0.000962	0.997059	0.000463
9	11	0.001970	0.998567	0.000654	0.997714	0.000853
10	1	0.000179	0.998746	0.000464	0.998178	0.000569
11	2	0.000358	0.999104	0.000339	0.998517	0.000587
12	1	0.000179	0.999284	0.000255	0.998772	0.000511
14	1	0.000179	0.999463	0.000197	0.998969	0.000494
15	1	0.000179	0.999642	0.000154	0.999123	0.000518
16	2	0.000358	1.000000	0.000123	0.999246	0.000754

CONCLUSION

The majority participation of scientific articles allows us to conclude that originality and timeliness are the most important factors for this field, showing interest in news and indicating the characteristics of development of this area.

The literature on seafood quality has grown in recent decades, following the interest of society (e.g., industry, academia, government) in seafood and the development of technologies that allow for full exploitation of aquatic organisms as raw material for food production. Exponential growth since early 2000's demonstrates that significant growth occurred only recently. The large number of authors with only one publication in this field demonstrates that there is an evasion of professionals; however, the number of researchers with high production also is expressive. Lotka's law presented a significant difference with the observed number of authors, and the Kolmogorov-Smirnov test confirmed that Lotka's law cannot be applied to this field of the science.

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