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Short Communication

Analysis of the scientific research structure regarding the genus *Macrobrachium* (Decapoda: Caridea: Palaemonidae) between 1980 to 2016 based on the Web of Science

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ABSTRACT. The freshwater shrimp genus *Macrobrachium* is highly diverse, distributed in tropical and subtropical regions around the world, and of considerable commercial importance in many countries. Here we present the results of an analysis of the scientific production regarding *Macrobrachium* published between 1980 and 2016 in the database Web of Science. The evaluated indicators were key words and authors producing the scientific literature about this genus. Concept maps and cluster analysis techniques were used to display the relationships between them. The results of the study visualize the temporal development of scientific knowledge of the genus *Macrobrachium* and describe the development of authorship networks during 36 years study period. Moreover, the results of the analysis show emerging research trends in the field of *Macrobrachium* studies.

Keywords: *Macrobrachium*, freshwater prawns, domain analysis, scientometrics, map, cluster.

The genus *Macrobrachium* is one of the most diverse freshwater shrimp group with its highest diversity in the Oriental region followed by the Neotropical region (De Grave *et al.*, 2008). The genus is distributed in tropical and subtropical regions of the world, and many *Macrobrachium* species constitute an important fishery resource and are cultivated commercially (New *et al*., 2009). Not surprisingly, the species of the *Macrobrachium* genus have been the subject of numerous studies in different fields including fisheries, aquaculture, limnology, zoology, molecular biology, pollution, among others (García-Guerrero *et al*., 2013). While Chong-Carrillo *et al.* (2015, 2016) analyzed the literature about the structure of scientific and technological research of *Macrobrachium*, only limited information is available about scientific networks related to the study of these freshwater shrimps. Therefore, the present study aimed to provide new information on the temporary development of scientific knowledge of the *Macrobrachium* domain. A domain of knowledge is a system where the components of the community (researchers), knowledge structures, information, disciplines or areas of knowledge interact as subsystems (Romero-Quesada, 2013).

Here we analyzed scientific literature published in international journals, which were available in the main collection of Web of Science (Master Journal List) (http://mjl.clarivate.com/). The search was carried out selecting scientific articles that contained the word *Macrobrachium* in the title, and the analyzed period comprised the years from 1980 to 2016. In order to analyze the temporal development of the topic studied herein, the articles were divided in four production periods: 1980-1990, 1991-2001, 2002-2012, and 2013-2016. The software VOSviewer (version 1.6.4; Van Eck & Waltman, 2010) was used to display the terms. VOSviewer extracts terms from the corpus file and, based on the extracted terms, creates a term map. This is a map where terms are located in such a way that the distance between two terms provides an indication of the number of co-occurrences of the terms. The smaller the distance between two terms, the larger the number

of co-occurrences of the terms (Van Eck & Waltman, 2013).

The maps were created using the VOS layout and VOS clustering techniques, which search for similar principles both in the mapping and the clustering (Gálvez, 2016). The VOSviewer software produces co-occurrence and frequency maps, introducing a probability analysis using the Kernel algorithm (Van Eck & Waltman, 2010). The application of this algorithm, along with an iterative process that it develops, provides not only the recount (frequency of appearance of terms) but it also provides the meaning of the term proximity. For example: the fact that a term is represented next to another provides evidence that both terms are associated under some relationship criteria; it also represents other aspects such as grouping in clusters and the node size according to term appearance frequency. The techniques of mapping and clustering were chosen to analyze the development of the main research fields, the fundamental topics, and to interpret the way in which the thematic areas were related during the study period (1980 to 2016).

A total of 1617 scientific articles were encountered and analyzed. Based on these articles, maps was generated with the most relevant authors and key words. Figure 1a displays the most important author nodes from 1980 to 1990: considering the 46 nodes identified, three stand out and refer to the authors D. Cohen (Israel), J.C. McNamara (Brazil) and R. Nagabhushanam (India); another three minor but relevant nodes correspond to G.S. Shukla (India), S. Harpaz (Israel) and S.R. Reddy (India).

In the period from 1991 to 2001, a total of the 48 nodes were detected (Fig. 1b); the most prominent ones were those of J.H. Tidwell (USA), K. Aida (Japan), L. Vázquez (Mexico), A. Sagi (Israel), I. Karplus (Israel), and B. Poolsanguan (Thailand). Other notable nodes were those of S. Koshio (Japan), J.C. Chen (China), P. Sithigorngul (Thailand), R.J. Pollero (Argentina), J.C. McNamara, and R.O. Cavalli (Brazil).

The production period 2002-2012 revealed a substantial increase in the number of nodes, rising from 48 during the previous period to 76 (Fig. 1c); principal authors of the seven main author nodes were: A.S.S. Hameed (India), W.C. Valenti (Brazil), S. Bhassu (Malaysia), C.H. Liu (China), P. Sobhon (Thailand), M.N. Wilder (Japan), and P. Geraldine (India). Among the remaining nodes of this production period, the more relevant nodes were J.H. Tidwell (USA), H. Heras (Argentina), and N.P. Sahu (India).The number of author nodes encountered between 2013 to 2016 are shown in Figure 1d. For this period, at total of 50 nodes were recorded, and the following three were the most distinguished: W. Wang, W.Y. Zhang and S.M. Sun (all three Chinese). Other notable authors of this production period were W.C. Valenti (Brazil), C.D.M. Sampaio (Brazil), P.B. Mather (Australia), P.S. Bhavan (India), K. Anger (Germany), and C.C. Chang (China).

It is interesting to note in these maps that the evolution of authorship networks implies the emergence of nodes of authors directed by a center or centroid author. Most of these nodes do not last for a long time and appear and disappear from one decade to another. Nevertheless, some authors appeared as lead authors for at least two decades, and the following three authors remained present for three production periods: J.H. Brown (1980-2012), J.C. McNamara (1980-2012) and W.C. Valenti (1991-2016).

The following countries stood out concerning the number of leading authors: India (8 lead authors) >3 (Brazil, Malaysia, USA), >3(Thailand), >2 (Australia), 1>(Germany, Israel, Mexico, Scotland). It is noteworthy that even though China shows currently a high production of scientific articles (Chong-Carrillo *et al.*, 2015) and patents (Chong-Carrillo *et al.*, 2016), there have been no lead authors that have transcended for more than one decade.

The most commonly used keywords in scientific articles about *Macrobrachium* during each analyzed production period are shown in the thematic maps (Fig. 2). It was not possible to obtain a proper map visualizing the research development, during the period 1980-1991 since the use of keywords was not obligatory. During the production period of 1991-2001 (Fig. 2a), *M. rosenbergii* occupied the central position, clearly connected with other surrounding nodes. A total of 166 keywords within ten main subjects were identified.

During the production period of 2002-2012 (Fig. 2b), *M. rosenbergii* remained to be the most used keyword. Although there were only six main subjects during this period, the number of keywords increased to 226. During the most current time period analyzed herein (2013-2016), both the number of subjects (10) and keywords (325) further increased (Fig. 2c). The key word "*Macrobrachium rosenbergii*" ceased to be the only predominant one, coexisting with emerging ones such as "*Macrobrachium nipponense*" and "*Macrobrachium amazonicum*". The present data suggest that the *Macrobrachium* domain is still in a ascending phase, even though it had suffered its ups and downs in time (Chong-Carrillo *et al.*, 2015). The results of our analysis of the *Macrobrachium* domain revealed that physiological aspects related to the survival, temperature, and osmoregulation predominated during the early production period (1991-2001). The publication of research results on reproduction, ovarian maturation and nutrition of *M. rosenbergii* may have favored its application as study model for research in other *Macrobrachium* species in subsequent years. During

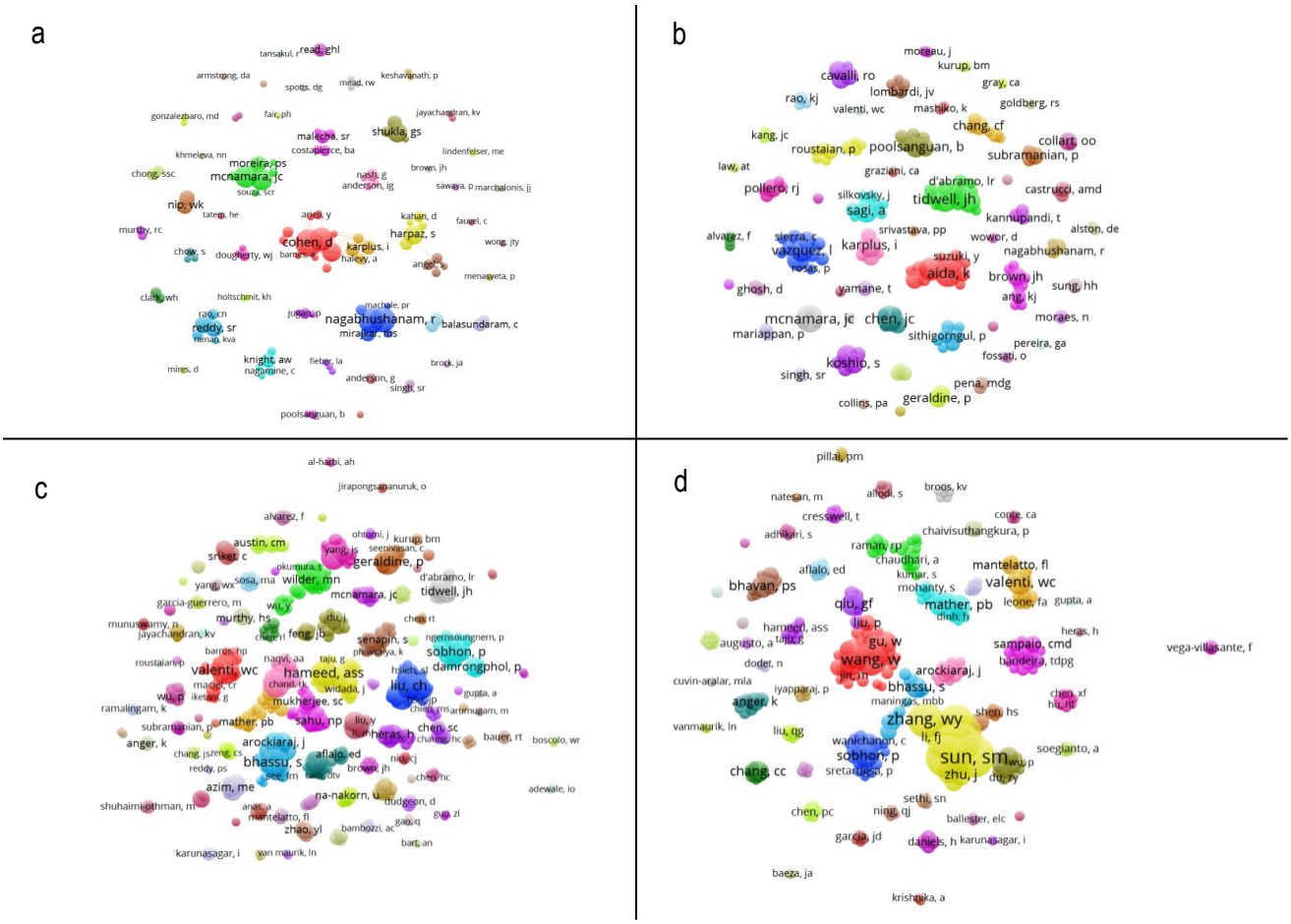

Figure 1. Author nodes of the time periods. a) 1980-1990, b) 1991-2001, c) 2002-2012 and d) 2013-2016, based on the database provided by Web of Science.

the production period 2002 to 2012, topics such as genetics and pathology emerged with high incidence in the published results. The growing interest in topics such as viruses, stress and immunologyis was evident during this time period. Aquaculture was a constant topic in all periods analyzed herein, and in terms of ecology, the term "population structure" increased its presence starting in the period 2000-2012 to date. Finally, during the most recent time period (2013-2016), "genetics" sharply gained importance together with topics such as pathology and reproduction. The results of the keyword analysis is in agreement with those reported by Chong-Carrillo *et al.* (2015).

Not all *Macrobrachium* species have been investigated equally. While practically all research areas have been studied in *M. rosenbergii*, investigations in other *Macrobrachium* species with potential or confirmed culture interest are in an initial phase. Due to this economic importance these species have been introduced as an research object, and the methodologies established for *M. rosenbergii* were gradually incorporated and adapted for these other *Macrobrachium* species. Interestingly, during the decade of 1980 to 1990 numerous *Macrobrachium* species emerged as research subject, but most of them disappeared subsequently in the literature analyzed herein (results not shown in the maps). The reason for the discontinued research interest in these species remains to be studied. It is speculated that one of the reasons might have been the absence of economic support necessary to develop research programs on potential species without immediate culture prospects. For example, the collaboration network formed by R. Nagabhushanan, M.S. Mirajkarand and P.R. Machale (production period 1980-1990) disappeared during the subsequent period (1991-2001), which provoked a decrease in publications about *M. kistnensi*, the study object of this network (Figs. 1a-1b).

It is concluded that science maps improve our understanding of the structure and dynamics of the ana-

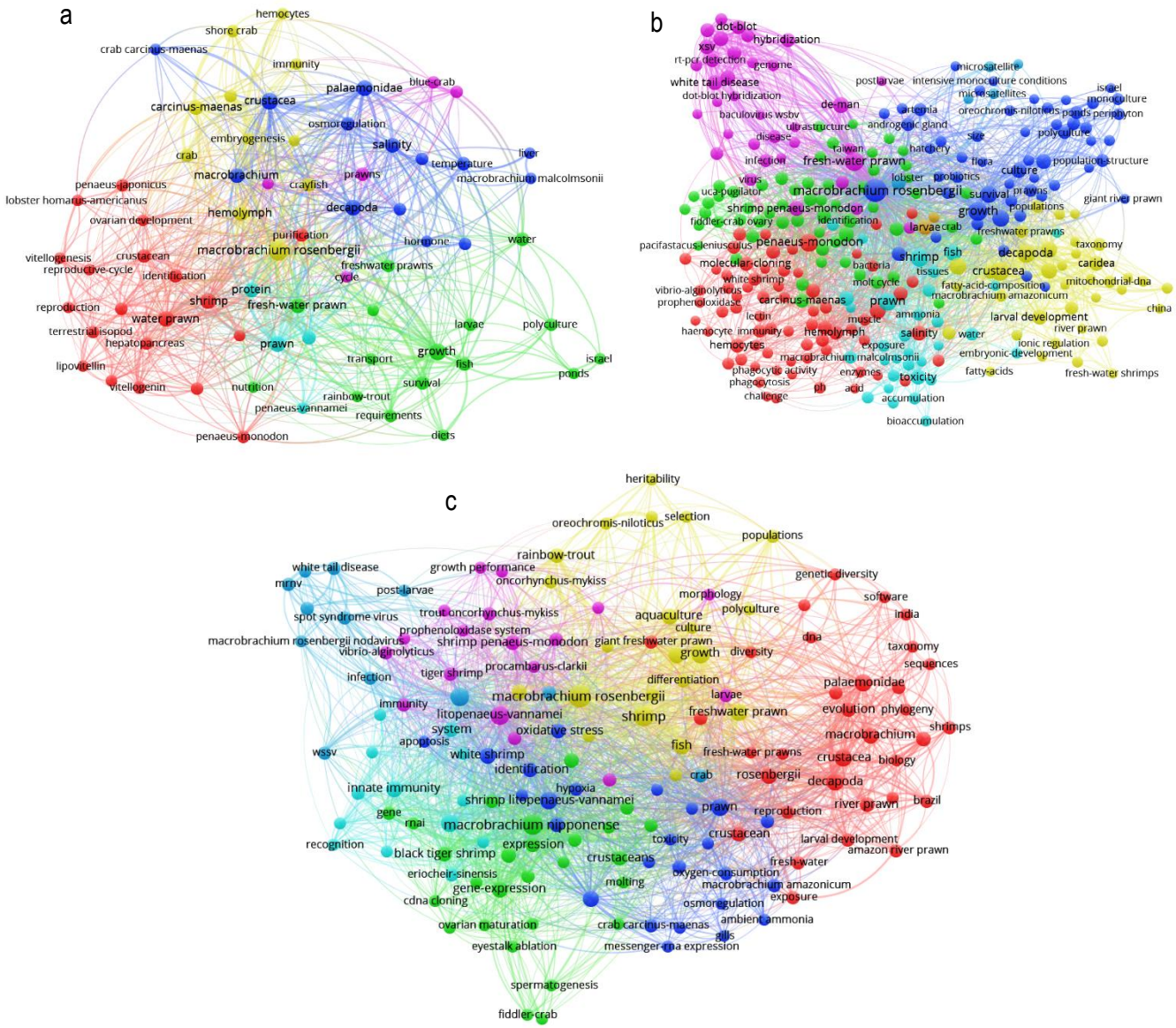

Figure 2. Most commonly used keywords of the time periods a) 1991-2001, b) 2002-2012 and c) 2013-2016, based on the database provided by Web of Science.

lyzed topic, in this case the *Macrobrachium* domain, demonstrating where research trends are heading and who are the scientists that are predominantly participating in its global development.

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