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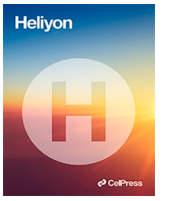

Research article

Larimichthys crocea (large yellow croaker): A bibliometric study

Hongyan Zhang [a], Jiacan Wang [b], Yuan Jing [c,*]

[a] *Library, Zhejiang Ocean University, Zhoushan, 316000, PR China*
[b] *School of Economics and Management, Zhejiang Ocean University, Zhoushan, 316000, PR China*
[c] *Periodicals Agency, Zhejiang Sci-Tech University, Hangzhou, 310018, PR China*

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ABSTRACT

Larimichthys crocea is an important economic fish of East Asia, and numerous studies have been conducted on its breeding, aquaculture, preservation and processing; however, there is no systematic review of the literature on the research of *Larimichthys crocea*. Derwent Data Analyzer (DDA) was used to analyze 1192 *Larimichthys crocea* research papers indexed by SCI-E, CSCD and KCI from 2001 to 2023. The number of research publications on *Larimichthys crocea* has rapidly increased, and institutions and scholars from China, the United States, South Korea, Japan, and Norway have conducted the majority of *Larimichthys crocea* research. The immune response, *Pseudomonas plecoglossicida*, gene expression, lipid immune response, transcriptomics and other areas have attracted the most attention. To increase the immunity and disease resistance of *Larimichthys crocea* and improve its survival, growth, storage and transport, researchers have carried out a large amount of research, which has promoted not only the culture of *Larimichthys crocea* but also the restoration of wild *Larimichthys crocea* and the rehabilitation of the ecological environment.

1. Introduction

Larimichthys crocea, also known as large yellow croaker and *Pseudosciaena crocea*, belongs to the order Perciformes, family Sciaenide, subfamily Larimichthys and genus *Larimichthys*. *Larimichthys crocea* is distributed throughout the west coast of the Pacific Ocean south of 35°N and often inhabits the inshore lower and middle layers at depths of 60 m. It is one of the most important economic fishes in China and other East Asian countries and is also very famous in European and North American countries [1].

Larimichthys crocea is a seawater fish with high economic value and high nutritional value. The muscle of *Larimichthys crocea* contains 17 amino acids, 7 of which are essential for humans. Due to its rich amount and variety as well as balanced ratio of amino acids, large yellow croaker is a high-quality protein source [2]. *Larimichthys crocea* is rich in trace elements and unsaturated fatty acids, such as vitamin B1, vitamin B2, vitamin E, iron, zinc, calcium, phosphorus and selenium [3]. In addition, the fact that *Larimichthys crocea* is highly regarded by people in East Asia and has become a major marine economic fish is also related to its golden body color and red lips, which imply auspiciousness and wealth.

Larimichthys crocea resources have been rapidly depleted by overfishing. By the end of the 1970s, all the important spawning grounds of *Larimichthys crocea* had failed to form fishing seasons, and the fishery existed in name only [4]. In the 1980s, research on artificial *Larimichthys crocea* broodstock began in southern China. In recent years, the scale of *L. crocea* aquaculture has undergone

* Corresponding author.
E-mail address: jingyuan@zstu.edu.cn (Y. Jing).

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rapid development. It has become one of the world's largest artificially cultured economic fishes in terms of annual production. This breakthrough in artificial breeding technology for *Larimichthys crocea* has also provided conditions for restoring wild *Larimichthys crocea* resources [5].

However, there is significant uncertainty in the sustainable development of *Larimichthys crocea* aquaculture and the recovery of wild *Larimichthys crocea* populations [6]. Compared with wild *Larimichthys crocea*, cultured *Larimichthys crocea* lives in a limited area of water and a poor environment, and its food is dominated by artificial feed, which has resulted in germplasm degradation [7]. *Larimichthys crocea* is a difficult fish to farm, and farmed *Larimichthys crocea* is prone to diseases such as iridovirus disease, Pseudomonas disease, and peltate ciliopathy [8]. Germplasm degradation has also caused *Larimichthys crocea* to be lighter in body color, greater in fat content, and greater in fishy odor and have fewer flavor-presenting substances and unsaturated fatty acids, which severely affects the flavor quality of *Larimichthys crocea*.

A literature search revealed that many studies have been carried out on *Larimichthys crocea* population cultivation [9], growth mechanisms [10], antioxidant capacity [11], disease resistance [12], preservation [13], and processing methods [14]. However, few studies have reviewed the literature on *Larimichthys crocea*.

Four reviews of *Larimichthys crocea* research were found in our search. In 2008, Liu, M. et al. traced the process of the collapse of the wild population of *Larimichthys crocea* and assessed the reasons for the failure of management and mariculture to restore the wild population, suggesting that overfishing is the main factor leading to population decline and that pollution, habitat degradation, and changes in the marine ecosystem are other causes [15]. In 2012, Ma, XX. et al. studied the formation of egg envelopes in *Larimichthys crocea* via light microscopy [16]. In 2019, Yu, X. et al. surveyed the acute and sublethal toxicity of methylmercury (MeHg) to *Larimichthys crocea* larvae and embryos and reported that the hatching, survival, and growth of *Larimichthys crocea* could be used as sensitive biomarkers of marine MeHg contamination [17]. He, YL et al. (2022) explored the effects of phytosterol supplementation on the growth performance, body composition, serum biochemical indices and lipid metabolism of *Larimichthys crocea* larvae fed high-fat diets [18]. However, these papers are all related to *Larimichthys crocea* research.

To the best of our knowledge, no systematic review of *Larimichthys crocea* research has been published. This paper introduces bibliometric methods to carry out quantitative and qualitative performance analyses; analyze influential countries, institutions, journals, scholars and publications; summarize existing knowledge structures; and identify emerging themes. Finally, a general overview of *Larimichthys crocea* research is provided. Among them, which papers are most influential in the academic community and which topics are of most interest to researchers are the focus of this study.

Bibliometrics is a cross-science method that quantitatively analyzes all knowledge carriers via mathematical and statistical methods [19]. Pareto published the first paper on bibliometrics in 1926. In recent decades, this research methodology has been rapidly developed. Currently, bibliometric methodology has been widely used in various disciplines, and it plays an active role in systematically reviewing the development process of a discipline's research field and predicting future research hotspots. It is used in quantitative research in fields such as materials science [19,20], computer science [21], business management [22], art design [23,24], biotechnology [25], pharmacology [26], public administration [27], and public health [28].

This paper aims to provide a bibliometric analysis of *Larimichthys crocea* research and is organized as follows: (1) materials and methods for describing the paper's quantitative sources, data processing procedures, analysis methods, and tools; (2) results for discovering leading countries, institutions, and authors and collaboration patterns between them, analyzing research topics and highly cited papers; (3) discussion of the process, status, and prospects of *Larimichthys crocea* research; and (4) conclusions and summary of our findings as well as the limitations of the study.

2. Materials and methods

This analysis is based on papers related to *Larimichthys crocea* published between 2001 and 2023. Our work consists of four steps. First, a bibliometric approach was adopted to investigate the studies of *Larimichthys crocea*. Second, the data were cleaned and prepared for analysis. Third, the scientific map method was used to analyze the selected papers. Finally, our findings were discussed qualitatively. After several trials and a reference to related studies, we settled on a retrieval formula of "*Larimichthys crocea*", "Larimichthys croceus", "large yellow croaker", or "*Pseudosciaena crocea*". Papers were collected from the Web of Science (WoS) with the defined retrieval formula. Our retrieval was limited to the most relevant source, the Science Citation Index-Expanded (SCI-E). The retrieval date was February 18, 2024, the retrieved field was restricted to "topic" (the title, abstract, author keywords, and keywords plus a paper), and 1451 papers were retrieved. Since *Larimichthys crocea* is distributed mainly offshore in the northwestern Pacific Ocean and is an economically important fish in countries such as China and South Korea, we also retrieved *Larimichthys crocea*-related papers from these countries' databases, such as the Chinese Science Citation Database (CSCD) in China and the Korean Journal Database (KCI) in South Korea, and the results were used to supplement the SCI-E results.

Prior to the data analysis, the following steps were taken to clean the data according to the retrieval criteria: filtering only "article" and "review" papers; detecting and removing duplicates on the basis of DOI; manual screening to exclude papers not closely related to *Larimichthys crocea* research; placing England, Scotland, Wales and Northern Ireland into the United Kingdom; harmonising the spelling of institutions; distinguishing between authors with the same name based on information such as ORCID; and organising keywords based on narrative lists. The data cleaning in this paper was achieved by a combination of computerized and manual cleaning. As a result, 1192 papers were retained for further analysis.

We used Derwent Data Analyzer 12 (DDA12.1 build 30406 64-bit) as the data cleaning and analytical tool. DDA is a data-mining platform that converts patent data, scientific literature and business intelligence into visualized, actionable insights [29]. As a tool under Clarivate, DDA can seamlessly interface with the WoS database and perform multidimensional cleaning and visualization of WoS

data. The author, institution, country/region, and keyword data were cleaned by using the DDA built-in narrative table. The distinction of authors with the same name was achieved by associating author names with information such as institution and ORCID. The papers retrieved were organized and visualized into tables and DDA charts. Tables were constructed to show the output, collaboration and influence of institutions, and authors, as well as highly cited papers; a line chart plotted with Excel was used to illustrate the publication trend; collaboration matrix maps created with DDA were employed to explain the collaborative relationships among countries/regions, institutions, and authors; and bubble charts were adopted to more intuitively show the development trends of journals and keywords with DDA. The analysis of most influential papers in the field was performed using the bibliometrix R package. It provides a set of tools for quantitative research in bibliometrics and scientometrics.

3. Results

The 1192 papers were authored by 3196 authors of 869 institutions from 109 countries, with 282 journals publishing papers related to *Larimichthys crocea* research.

The distribution of the number of publications and citations on *Larimichthys crocea* since 2001 is shown in Fig. 1, which shows that the number of research findings related to *Larimichthys crocea* has rapidly increased since 2001. The period from 2001 to 2005 can be considered the foundation stage of *Larimichthys crocea* research. Although only a few research papers on *Larimichthys crocea* were published every year during this period, five papers published in 2003 alone achieved an average citation of 96. Since 2006, the number of achievements has increased significantly. In 2016, the study of *Larimichthys crocea* peaked, with 93 papers being published and 2562 citations by various journals being recorded. In the following two years, the number of papers decreased somewhat but soon returned to a growth trajectory. A climax in *Larimichthys crocea* research occurred in 2022 and 2023, with more than 170 papers being published each year.

3.1. Collaborations of countries/regions

Research on *Larimichthys crocea* has been carried out mainly in China, the United States, South Korea, Japan and Norway. The top 10 countries/regions in terms of the number of published papers and their cooperation intensity are shown in Fig. 2. In the figure, each dot represents a country/region, the size of the dot represents the number of papers, the lines between the dots represent cooperation between countries/regions, and their thickness indicates the intensity of cooperation. The thicker the line is, the more frequent the cooperation.

China is the absolute mainstay in terms of research on *Larimichthys crocea*, with Chinese scholars accounting for more than 90 % of the papers and the earliest published papers coming from Chinese researchers. This phenomenon is closely related to the long culture history, tremendous breeding scale and large research team of *Larimichthys crocea* in China. Many studies in other countries are also closely related to China.

Since 2008, several papers have been published almost every year with the participation of North American institutions and scholars. The United States has made itself the second-largest country involved in research on *Larimichthys crocea*, largely because American institutions have maintained their dominance in other areas related to *Larimichthys crocea* research, attracting researchers from China and other countries to seek collaborations. The same is true of Norway in northern Europe and Canada in North America.

South Korea, Japan, and Taiwan, where *Larimichthys crocea* abounds, have successively published relevant papers since 2005, ranking third, fourth and sixth, respectively, in the number of published papers. Scholars have made contributions in areas such as

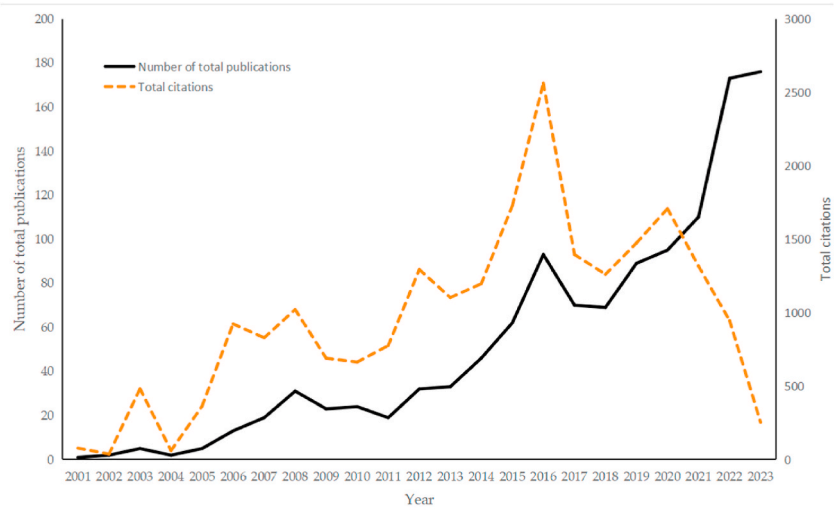

Fig. 1. Trends in the number of papers and citations related to *Larimichthys crocea* research.

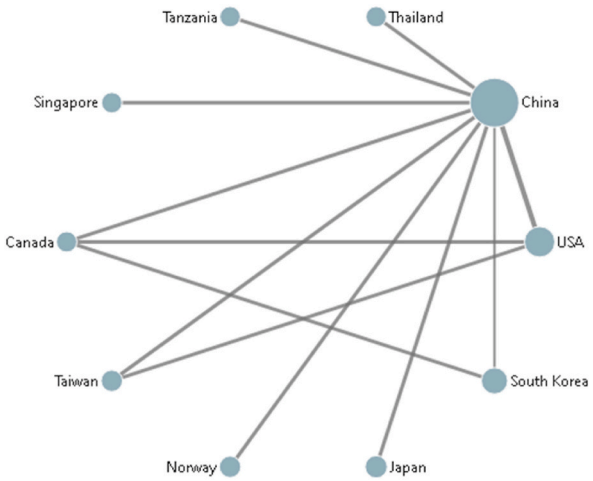

Fig. 2. Collaboration matrix map of the top 10 most productive countries/regions.

sequencing the *Larimichthys crocea* genome and developing detection reagents. In addition to close collaboration with China, which is a major research power, the collaborations between South Korea and Canada and between Taiwan in China and the United States are also strong.

Notably, Tanzania from the African coast has become an emerging force in *Larimichthys crocea* research, and its papers have come mainly from collaboration with Chinese institutions since 2020.

3.2. Contribution and collaborations of leading institutions

A list of 20 research institutions with the most fruitful results and the greatest contributions to *Larimichthys crocea* research is shown in Table 1. These 20 institutions published a total of 1060 papers, corresponding to 89 % of the total.

Ocean University of China, Qingdao Natl Lab Marine Sci & Technol, and Jimei University are the three institutions that have produced the most research papers on *Larimichthys crocea*. Ocean Univ China is one of the earliest institutions to carry out research on *Larimichthys crocea*, and it is also the institution with the largest number of papers and citations, highest h index, and the most frequently cited papers. Growth performance, intestinal morphology and antioxidant capacity of *Larimichthys crocea* are the focus of scholars from Ocean University of China. They have conducted fruitful research on the adhesion characteristics of Vibrio alginolyticus to the epidermal mucus of *Larimichthys crocea*, and the effects of replacing fish oil by rapeseed oil, flaxseed oil, and soybean oil in the feed on the fatty acid composition and gene expression of *Larimichthys crocea* in liver and muscle. Major professional journals in the field of aquaculture, such as *Aquaculture*, *Aquaculture Research*, *Fish & Shellfish Immunology*, *Aquaculture Nutrition*, *British Journal of*

Table 1
The top 20 leading institutions in *Larimichthys crocea* research.

Institution	TP	HC	TC	ACPP	h-index
Ocean Univ China	204	253	5931	29	41
Qingdao Natl Lab Marine Sci & Technol	173	79	2629	15	28
Jimei Univ	158	124	2587	16	31
Zhejiang Ocean Univ	146	152	2199	15	24
Xiamen Univ	135	152	2690	20	27
Ningbo Univ	132	108	1833	14	22
Fujian Agr & Forestry Univ	107	87	1230	11	16
Shanghai Ocean Univ	93	102	1186	13	19
Chinese Acad Fishery Sci	74	87	1020	14	20
Ningde Fufa Fisheries Co LTD	69	87	1008	15	15
State Ocean Adm	66	220	2276	34	28
Zhejiang Univ	62	220	1500	24	18
Chinese Acad Sci	46	152	1447	31	23
Southern Marine Sci & Engn Guangdong Lab Zhuhai	35	46	196	6	7
Zhejiang Gongshang Univ	32	261	1198	37	13
Shanghai Engn Res Ctr Aquat Prod Proc & Preservat	26	66	350	13	11
Zhejiang Marine Fisheries Res Inst	26	23	188	7	5
Dalian Polytech Univ	24	19	113	5	7
Ningbo Acad Oceanol & Fishery	23	61	267	12	9
South China Agr Univ	22	56	366	17	12

TP: total number of papers; HC: highest citations; TC: total citations; ACPP: average citations per paper.

Nutrition, have published a range of *Larimichthys crocea* research results from Ocean University of China.

The Qingdao National Lab Marine Sci & Technol is a relatively new institution, but its position in this field has improved quite rapidly since its establishment in 2015. Since 2018, it has been ahead of other institutions in terms of the number of relevant papers published each year, and the gap between its total number of papers and that of Ocean Univ China has narrowed rapidly. They have published a series of papers in *Fish & Shellfish Immunology*, *Aquaculture*, *Frontiers in Immunology*, *Aquaculture Nutrition*, *Developmental and Comparative Immunology* and other publications. research results in the direction of digestive tract flora of *Larimichthys crocea*, stimulation of pathogenicity of Cryptosporidium, and the effect of Chinese herbs on enzyme activity of *Larimichthys crocea*.

Another important base for *Larimichthys crocea* research is Jimei University, whose number of papers ranks third among all institutions, and whose h-index is second only to that of Ocean Univ China. The scholars from Jimei University mainly focus on the effects of Vibrio alginolyticus, Vibrio parahaemolyticus and other pathogens on the immune function of *Larimichthys crocea*, microsatellite markers, net-pen culture and other topics. Their findings were mainly published in *Fish & Shellfish Immunology*, *Aquaculture*, *Chinese Journal of Oceanology and Limnology*, *Gene*, *Marine Biotechnology* and other journals.

Other institutions with high outputs include Zhejiang Ocean University, Xiamen University, Ningbo University, Fujian Age & Forestry University, and Shanghai Ocean University, all of which are in China.

The collaboration between the abovementioned 20 research institutions is shown in Fig. 3, where each dot represents an institution, the size of the dot represents the number of papers, and the connecting line between dots represents the intensity of collaboration between institutions. Specifically, the thicker the connecting line is, the more frequent the collaboration.

As shown in Fig. 3, close cooperation is maintained between major research organizations. Among them, there is a close collaboration between Ocean University of China and Qingdao Natl Lab Marine Sci & Technol, between Zhejiang Ocean University and Zhejiang Marine Fisheries Res Inst, between Xiamen University and Ningde Fufa Fisheries Co LTD, between Ningbo University and Ningbo Acad Oceanol & Fishery, between Fujian Agr & Forestry University and Ningde Fufa Fisheries Co LTD, and between Fujian Agr & Forestry Uni and Southern Marine Sci & Engn. Guangdong Lab Zhuhai, especially between Shanghai Ocean University and Zhejiang Marine Fisheries Res Inst.

3.3. Contribution and collaboration of leading authors

The top 20 leading authors in *Larimichthys crocea* research are listed in Table 2. These authors published 500 papers, accounting for 42 % of the total number of *Larimichthys crocea* studies. Among the top 20 leading authors, eight scholars are from Ocean Univ China, five scholars are from Xiamen Univ, and the other seven scholars are from Fujian Agr & Forestry Univ, Jimei Univ, Shanghai Ocean Univ and Zhejiang Ocean Univ.

Kangsen Mai and Qinghui Ai from Ocean University, China, were the two scholars with the most publications and citations and the highest h-index. They also coauthored one of the most frequently cited papers on *Larimichthys crocea* in the world.

Chen Xinhua from Fujian Agr & Forestry Univ and Wang Zhiyong from Jimei Univ ranked 3rd and 4th in terms of publications. The most highly cited author was Xu Wei from Fujian Agr & Forestry Univ, who ranked 3rd in total citations and 7th in publications, followed by Wang Jun from Xiamen Univ and Zhang Wenbing from Ocean Univ China.

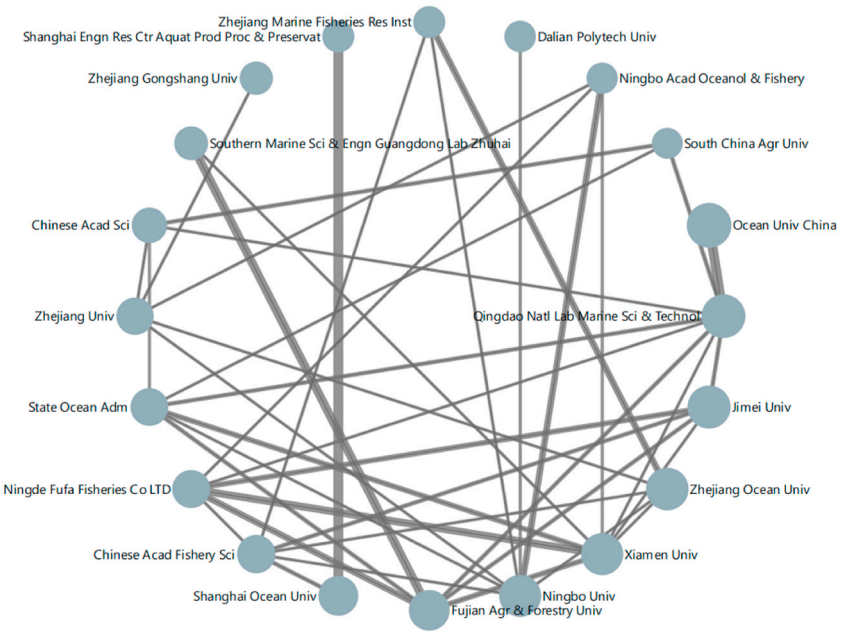

Fig. 3. Collaboration matrix map of the top 20 leading institutions in *Larimichthys crocea* research.

Table 2
The top 20 leading authors in *Larimichthys crocea* research.

Author	TP	HC	TC	ACPP	h-index	Institution
Mai, Kangsen	171	253	4824	28	37	Ocean Univ China
Ai, Qinghui	142	253	3915	28	33	Ocean Univ China
Chen, Xinhua	95	220	2341	25	29	Fujian Agr & Forestry Univ
Wang, Zhiyong	76	124	1294	17	20	Jimei Univ
Ao, Jingqun	53	220	1675	32	22	Fujian Agr & Forestry Univ
Xie, Jing	53	66	562	11	15	Shanghai Ocean Univ
Xu, Wei	47	253	2830	60	28	Ocean Univ China
Mu, Yinnan	38	220	1214	32	15	Fujian Agr & Forestry Univ
Zhang, Wenbing	35	253	1543	44	21	Ocean Univ China
Ke, Qiaozhen	31	87	463	15	11	Xiamen Univ
Xu, Peng	31	65	371	12	8	Xiamen Univ
Wu, Changwen	30	152	518	17	12	Zhejiang Ocean Univ
Liu, Yongtao	29	79	324	11	9	Ocean Univ China
Wang, Jun	29	238	1350	47	12	Xiamen Univ
Cui, Kun	26	59	401	15	12	Ocean Univ China
Xiang, Xiaojun	25	79	484	19	13	Ocean Univ China
Xu, Dan	23	79	364	16	9	Ocean Univ China
Yao, Cuiluan	23	124	616	27	6	Jimei Univ
Zhou, Tao	23	65	215	9	8	Xiamen Univ
Zhao, Ji	22	65	280	13	8	Xiamen Univ

TP: total number of papers; HC: highest citations; TC: total citations; ACPP: average citations per paper.

We also analyzed the collaboration map among the top 20 leading authors in *Larimichthys crocea* research (Fig. 4).

As shown in Fig. 4, several relatively stable research groups have been formed in the research of *Larimichthys crocea*. Among them, Ocean Univ China is the strongest, followed by Xiamen Univ and Fujian Agr & Forestry Univ. There is some collaboration between these groups, but the intensity is limited. Zhiyong Wang and Cuiluan Yao of Jimei Univ and Jing Xie of Shanghai Ocean Univ, unlike other groups in terms of research directions, carry out studies in a more independent manner.

3.4. Contributions of the leading journals

Among the 282 journals involved in *Larimichthys crocea* research, the top 30 journals with the most publications account for 61 % of the total number of publications. The basic information of these 30 journals is shown in Table 3.

Fish & Shellfish Immunology and *Aquaculture* from Elsevier are the two most significant academic platforms for *Larimichthys crocea* research, ranking far ahead of other journals in terms of publication and citation frequency. Many outputs have also been published in journals such as *Aquaculture Research*, *Developmental and Comparative Immunology*, *Fish Physiology and Biochemistry*, *Food Chemistry* and *Frontiers in Marine Science*.

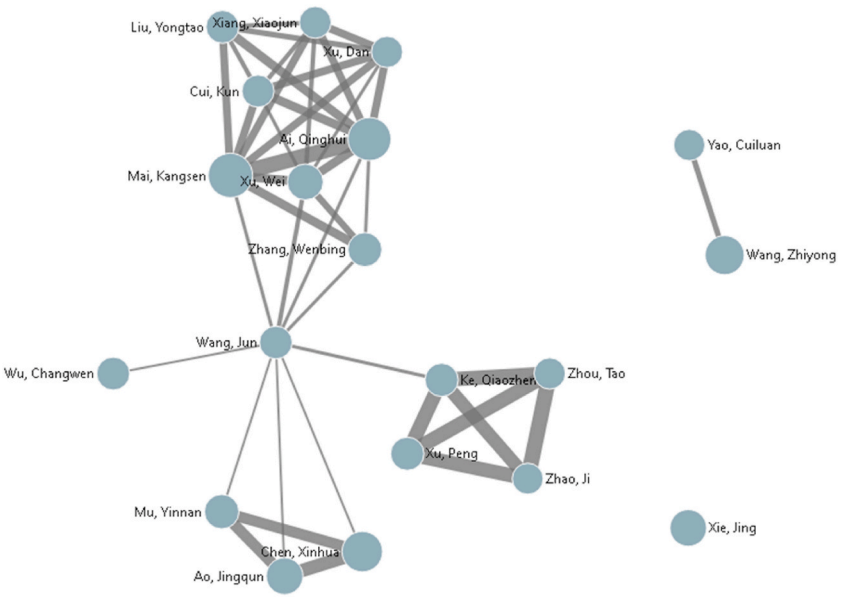

Fig. 4. Collaboration map of the top 20 leading authors in *Larimichthys crocea* research.

Table 3
The top 30 leading journals in *Larimichthys crocea* research.

Journal	TP	HC	TC	ACPP	IF2022	Publisher
Fish & Shellfish Immunology	193	253	4761	25	4.7	Elsevier
Aquaculture	117	238	3743	32	4.5	Elsevier
Aquaculture Research	36	78	607	17	2	Wiley
Developmental and Comparative Immunology	27	35	377	14	2.9	Elsevier
Fish Physiology and Biochemistry	26	54	334	13	2.9	Springer
Food Chemistry	25	135	511	22	8.8	Elsevier
Frontiers in Marine Science	22	11	51	2	3.7	Frontiers
Aquaculture Reports	19	56	202	11	3.7	Elsevier
Marine Biotechnology	19	61	300	16	3	Springer
Acta Oceanologica Sinica	18	38	140	8	1.4	Springer
Aquaculture Nutrition	18	31	167	9	3.5	Wiley
Comparative Biochemistry and Physiology B-Biochemistry & Molecular Biology	17	58	211	12	2.2	Elsevier
Frontiers in Immunology	17	65	239	14	7.3	Frontiers
Gene	16	119	285	18	3.5	Elsevier
Chinese Journal of Oceanology and Limnology	13	23	110	8	–	Science
Journal of Fish Diseases	13	126	439	34	2.5	Wiley
International Journal of Molecular Sciences	12	58	178	15	5.6	MDPI
British Journal of Nutrition	11	83	220	20	3.6	Cambridge Univ Press
Foods	11	16	50	5	5.2	MDPI
Lwt-Food Science and Technology	11	32	99	9	6	Elsevier
Plos One	11	153	429	39	3.7	Public Library Science
Food Control	10	261	445	45	6	Elsevier
Journal of Ocean University of China	10	27	52	5	1.6	Ocean Univ China
Journal of The Science of Food And Agriculture	10	23	46	5	4.1	Wiley
Journal of Food Processing and Preservation	9	17	45	5	2.5	Wiley
Journal of the World Aquaculture Society	9	19	69	8	2.8	Wiley
Scientific Reports	9	77	292	32	4.6	Nature Portfolio
Biochemical Systematics and Ecology	8	21	84	10	1.6	Pergamon-Elsevier
Fishes	8	9	23	3	2.3	MDPI
Journal of Agricultural and Food Chemistry	8	77	191	24	6.1	Amer Chemical Soc

TP: total number of papers; HC: highest citations; TC: total citations; ACPP: average citations per paper; IF2022: impact factor of 2022.

The three most frequently cited papers appeared in *Food Control*, *Fish Shellfish Immunol* and *Aquaculture*, all of which were published by Elsevier.

With respect to average citations, *Food Control*, which published the most frequently cited papers, ranked first, followed by *Plos One* of Public Library Science and Wiley's *Journal of Fish Diseases*. Papers in journals such as *Aquaculture*, *Scientific Reports*, *Fish & Shellfish Immunology*, and *the Journal of Agricultural and Food Chemistry* also had satisfactory average citations.

Fig. 5 shows a bubble chart of the number of papers published in the 30 journals mentioned above. The number inside the bubble represents the number of specific papers published. Specifically, the larger the bubble is, the more research papers on *Larimichthys crocea* are published that year.

As shown in Fig. 5, *Fish & Shellfish Immunology* and *Aquaculture* have long been the most popular journals for researchers of *Larimichthys crocea*. Aquaculture entered this field earlier than *Fish & Shellfish Immunolog* but has published fewer papers than the latter did over the years.

Some journals, such as *Aquaculture Nutrition* and the *Chinese Journal of Oceanography and Limnology*, although they have a long history, are limited by journal size, author preference and direction of acceptance and fail to gain a foothold in mainstream platforms in the field.

Some journals, such as *Biochemical Systematics and Ecology*, *Plos One* and the *Chinese Journal of Oceanology and Limnology*, published a moderate number of papers regarding *Larimichthys crocea* but have not published related studies in recent years. In contrast, *Food Chemistry*, *Comparative Biochemistry and Physiology B-Biochemistry & Molecular Biology*, *Frontiers in Marine Science* and *Foods,* have emerged.

3.5. An analysis of emerging topics

The 30 most commonly used keywords in the study of *Larimichthys crocea* are shown in Fig. 6. Keywords with similar meanings were classified as the same item. Some commonly used keywords, such as large yellow croaker, *Larimichthys crocea*, and *Pseudosciaena crocea*, and meaningless keywords, such as growth, fish, quality and expression, were removed from the list in advance. In the figure, topics are ranked from top to bottom according to their total frequency of occurrence, with larger bubbles indicating that the topic has received more attention in recent years.

Fig. 6 shows that research directions such as the immune response, *Pseudomonas plecoglossicida*, gene expression, lipid metabolism, *Cryptocaryon irritans* and the transcriptome are the research topics most associated with *Larimichthys crocea*.

Early on, topics of academic interest included *Vibrio alginolyticus*, disease resistance, microsatellites, *Cryptocaryon irritans*, and Poly (I:C).

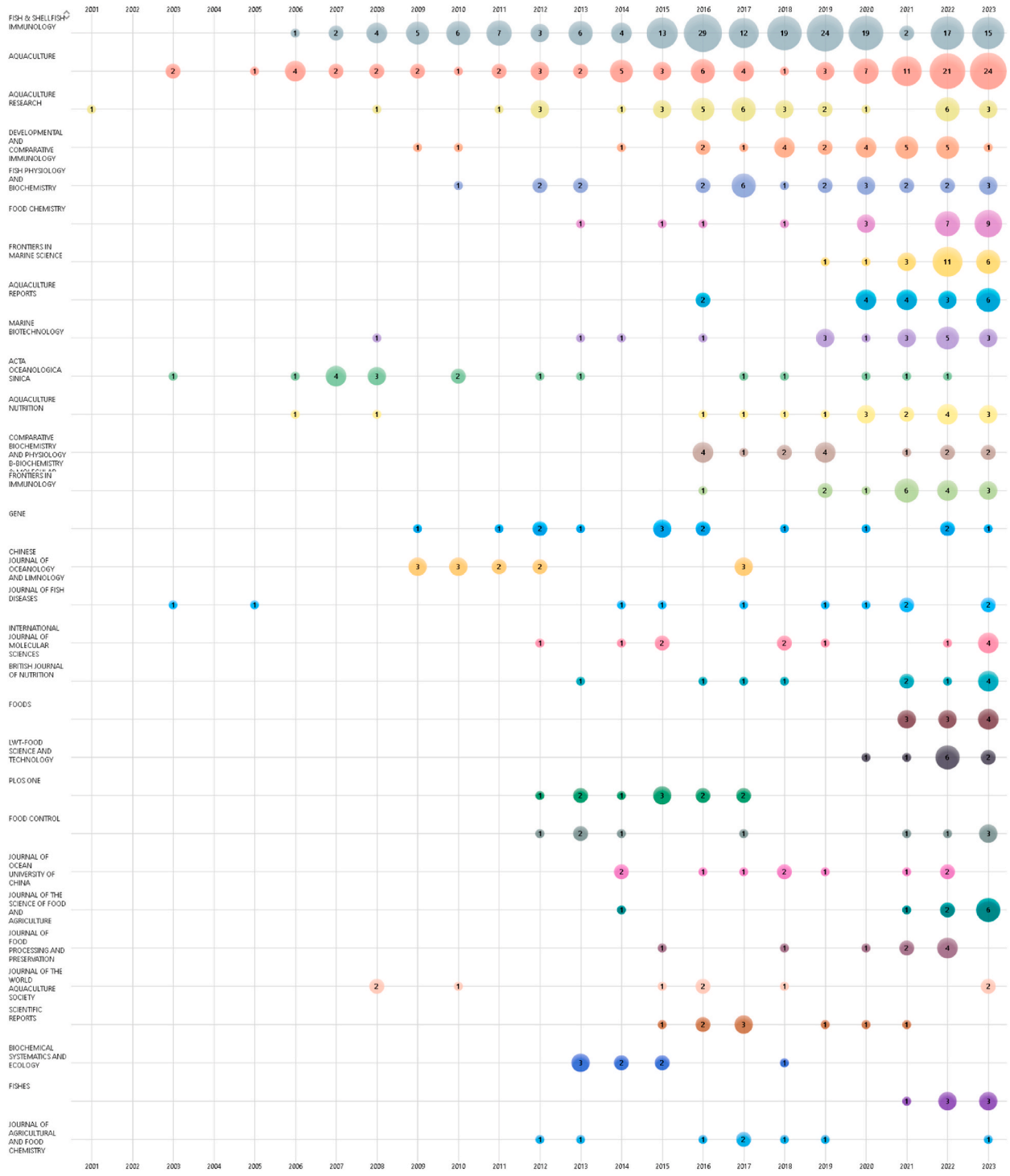

Fig. 5. Bubble chart of the top 30 leading journals in *Larimichthys crocea* research.

In 2003, a study was conducted to determine the effects of traditional Chinese medicines formulated with Astragalus and Angelica on nonspecific immunity and disease resistance in *Vibrio alginolyticus* from *Larimichthys crocea* [30]. Subsequently, studies on disease resistance in *Vibrio alginolyticus* of *Larimichthys crocea* were carried out in multiple aspects, such as the study of the adhesion of pathogenic *Vibrio alginolyticus* by the isotope tracer method [31] and the study of the pharmacokinetic mechanism of immune-enhancing agents such as enrofloxacin, ciprofloxacin [32], and astragalosan polysaccharide (APS) [33] in *Larimichthys crocea* infected by *Vibrio alginolyticus*.

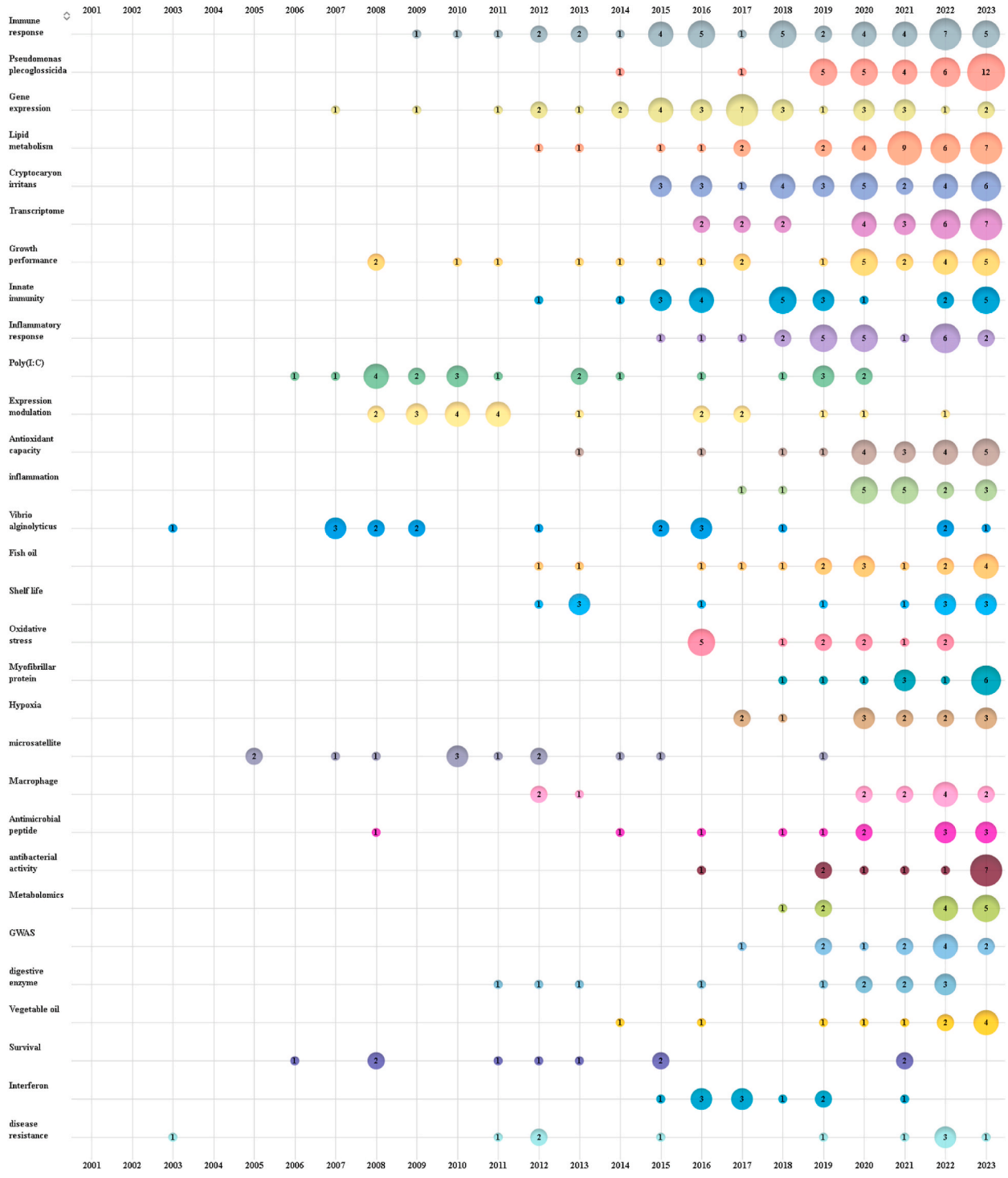

Fig. 6. Bubble chart of the top 30 author keywords in *Larimichthys crocea* research.

The identification of microsatellite loci via nonradioactive polymerase chain reaction (PCR) and other technologies can provide useful markers for population genetic research on *Larimichthys crocea* [34]. Since 2005, to estimate the reproductive success rate of *Larimichthys crocea*, scholars have built a genetic linkage map of *Larimichthys crocea* via microsatellite markers [35] and conducted a series of microsatellite analyses on the artificially bred *Larimichthys crocea* population [36].

As effective virus simulators, polynucleotides can help us to further understand the changes in liver physiological processes in fish

infected by viruses [37]. Since 2006, scholars have established an *in vitro* viral infection model by using polynucleotides to explore the expression pattern and internal mechanism of the antiviral response in *Larimichthys crocea* [38], constructed sRNA libraries via high-throughput sequencing technology, and analyzed the expression of miRNAs in *Larimichthys crocea* infected with poly(I:C) by sequencing [39].

Analysis revealed that the activity of some research directions has declined recently. Since 2017, keywords such as "microsatellites" and "gene expression" have appeared significantly less frequently in papers. In contrast, some new research hotspots are emerging.

Pseudomonas is a temperature-dependent opportunistic pathogen that mediates visceral granulomas in numerous fish species, including *Larimichthys crocea* [40]. In 2020, researchers began to explore the interaction between the immune response and the intestinal bacterial community of *Pseudomonas plecoglossicida* during infection [41] and compared the immune responses caused by various strains of [42] to study how and to what extent the intestinal bacterial community responds to infection [43,44]. Moreover, the transcriptome also appeared heavily in the keyword lists of the papers. Scholars have carried out transcriptome analysis of key tissues such as the liver, blood and gills of *Larimichthys crocea* [45] and have explored the infection mechanism and disposition of pathogens such as the ciliate parasite Cryptocaryonosis via transcriptome analysis [46].

Lipid metabolism disorders have become an important threat to human health, and metabolomics and lipid metabolism have become the focus of academic attention since 2020. Scholars have added ingredients such as galactose oligosaccharide and AICAR to the diets of *Larimichthys crocea* to reduce the total liver lipid and TAG contents to improve lipid metabolism [47,48]. Metabolomic analysis revealed that LYCRPLs rich in the eggs of *Larimichthys crocea* can regulate blood lipids and treat lipid metabolism disorders [49].

Inflammation and the inflammatory response have constituted another major branch of *Larimichthys crocea* research in recent years. Scholars have analyzed the expression and activity of proinflammatory genes and inflammatory-related genes in *Larimichthys crocea* [50], studied the molecular mechanism of liver inflammation induction and the role of autophagy in the regulation of

Table 4
Most cited papers by year from 2005 to 2023 in *Larimichthys crocea* research.

Year	Authors	Title	TC	ACPY	Source
2005	Ma, HM et al.	Activities of selected digestive enzymes during larval development of large yellow croaker (Pseudosciaena crocea)	137	7	*Aquaculture*
2006	Ai, QH et al.	Effects of dietary vitamin C on survival, growth, and immunity of large yellow croaker, Pseudosciaena crocea	194	11	*Aquaculture*
2007	Ai, QH et al.	Effects of dietary β-1,3 glucan on innate immune response of large yellow croaker, Pseudosciaena crocea	253	15	*Fish & Shellfish Immunology*
2008	Zhang, XD et al.	Effects of fasting on the meat quality and antioxidant defenses of market-size farmed large yellow croaker (Pseudosciaena crocea)	177	11	*Aquaculture*
2009	Wang, KJ et al.	Cloning and expression of a hepcidin gene from a marine fish (Pseudosciaena crocea) and the antimicrobial activity of its synthetic peptide	143	10	*Peptides*
2010	Mu, YN et al.	Transcriptome and expression profiling analysis revealed changes of multiple signaling pathways involved in immunity in the large yellow croaker during Aeromonas hydrophila infection	143	10	*Bmc Genomics*
2011	Ai, QH et al.	Effects of dietary supplementation of Bacillus subtilis and fructooligosaccharide on growth performance, survival, non-specific immune response and disease resistance of juvenile large yellow croaker, *Larimichthys crocea*	238	18	*Aquaculture*
2012	Li, TT et al.	Coating effects of tea polyphenol and rosemary extract combined with chitosan on the storage quality of large yellow croaker (Pseudosciaena crocea)	261	22	*Food Control*
2013	Wang, B et al.	Isolation and Characterization of Collagen and Antioxidant Collagen Peptides from Scales of Croceine Croaker (Pseudosciaena crocea)	125	11	*Marine Drugs*
2014	Wu, CW et al.	The draft genome of the large yellow croaker reveals well-developed innate immunity	152	15	*Nature Communications*
2015	Ao, JQ et al.	Genome Sequencing of the Perciform Fish Larimichthys crocea Provides Insights into Molecular and Genetic Mechanisms of Stress Adaptation	220	24	*Plos Genetics*
2016	Hui, GH et al.	Effects of chitosan combined with nisin treatment on storage quality of large yellow croaker (Pseudosciaena crocea)	135	17	*Food Chemistry*
2017	Dong, XJ et al.	Regulation of FADS2 transcription by SREBP-1 and PPAR-α influences LC-PUFA biosynthesis in fish	77	11	*Scientific Reports*
2018	Mu, H et al.	High level of dietary soybean oil depresses the growth and anti-oxidative capacity and induces inflammatory response in large yellow croaker *Larimichthys crocea*	78	13	*Fish & Shellfish Immunology*
2019	Li, XS et al.	High percentage of dietary palm oil suppressed growth and antioxidant capacity and induced the inflammation by activation of TLR-NF-κB signaling pathway in large yellow croaker (*Larimichthys crocea*)	59	12	*Fish & Shellfish Immunology*
2020	Gu, HX et al.	Nanoplastics impair the intestinal health of the juvenile large yellow croaker *Larimichthys crocea*	102	26	*Journal of Hazardous Materials*
2021	Ma, XA et al.	Effects of multi-frequency ultrasound on the freezing rates, quality properties and structural characteristics of cultured large yellow croaker (*Larimichthys crocea*)	66	22	*Ultrasonics Sonochemistry*
2022	Bian, CH et al.	Effects of single-, dual-, and multi-frequency ultrasound-assisted freezing on the muscle quality and myofibrillar protein structure in large yellow croaker (*Larimichthys crocea*)	35	18	*Food Chemistry-X*
2023	Zheng, Y et al.	Flammulina velutipes polysaccharide improves the water-holding capacity in the dorsal muscle of freeze-thawed cultured large yellow croaker (*Larimichthys crocea*)	11	11	*Food Chemistry*

TC, total citations; ACPY: average citations per year.

inflammation in *Larimichthys crocea* [51], and performed controlled experiments to study the effects of supplementation with tributyltin (TB) and other components on the expression of inflammation-related genes in juveniles *Larimichthys crocea* [52].

Furthermore, since 2020, the academic community has also started a series of studies on replacing expensive fish oil with more affordable vegetable oils [53]. Scholars have reported that the addition of some vegetable oils, such as coconut oil, to fish feed can improve the growth rate and antioxidant capacity of *Larimichthys crocea* [54], whereas the substitution of fish oil with vegetable oil can alter the fatty acid and volatile compound composition in the muscle of *Larimichthys crocea* [55]. Scholars have also reported that the substitution of fish oil with different vegetable oils can affect the muscle sensory quality indices of juvenile *Larimichthys crocea* by altering fat deposition in muscle [56].

3.6. An analysis of the most cited papers

In addition to high-frequency keywords, highly cited papers can reveal research trends in a field. Table 4 lists the most frequently cited papers from 2005 to 2023.

The study of highly cited papers reveals that research on *Larimichthys crocea* has been associated with different concerns at different times, which can be categorized chronologically into the following directions.

From 2005 to 2011, the academic community was concerned mainly with the cultivation of *Larimichthys crocea* and studied how to make *Larimichthys crocea* survive and grow better, as well as improve immunity and disease resistance. In 2005, Ma, HM et al. [57] studied the occurrence and development of the main digestive enzymes in larvae of *Larimichthys crocea* and reported that compound feed could be successfully fed from the early stage. In 2006, Ai, QH et al. [58] determined the effects of vitamin C on the survival, growth, ascorbic acid content and immunity of *Larimichthys crocea* and concluded that vitamin C had a significant effect on the immune response and disease resistance of *Larimichthys crocea*. In 2007, Ai, QH et al. [59] explored the effects of β-1,3 glucan on the innate immune response and protection against *Vibrio harveyi* infection in *Larimichthys crocea*. Low glucan levels improved the growth and innate immunity of *Larimichthys crocea*, whereas high glucan levels had no significant effect. In 2008, Zhang, XD et al. [60] explored the effects of fasting on fish composition and antioxidant defense in *Larimichthys crocea* and reported that fasting technology effectively improved the final product of *Larimichthys crocea* while causing protein loss and oxidative stress in the fish. In 2009, Wang, KJ et al. [61] identified the calcitonin gene PC-hepc from *Larimichthys crocea*. PC-hepc showed strong activity against *Aeromonas hydrophila*, *Vibrio parahaemolyticus*, *Vibrio alginolyticus* and *Vibrio havelii*, which may play a role in the innate immunity of *Pseudosciaena crocea*. In 2010, Mu, YN et al. [62] investigated the mechanism of the immune response to bacterial infection in *Larimichthys crocea* and studied the transcriptome and comparative expression profiles of *Larimichthys crocea* infected with *Aeromonas hydrophila* via high-throughput deep sequencing, suggesting that the inflammatory response may play an important role in the early stages of infection. In 2011, Ai, QH et al. [63] reported that *Bacillus subtilis* and fructo-oligosaccharides (FOSs) improved the growth performance, feed efficiency ratio, survival rate, nonspecific immune response and disease resistance of juvenile *Larimichthys crocea*.

In 2012 and 2013, research on *Larimichthys crocea* focused on refrigerated storage of adult fish. In 2012, Li, TT et al. [64] reported that tea polyphenol (TP) and rosemary extract (R) combined with a chitosan (Ch) coating more effectively maintained the good quality of *Larimichthys crocea* and prolonged its shelf-life. In 2013, Wang, B et al. [65] successfully isolated acid-soluble collagen (ASC) from *Larimichthys crocea* scales and further prepared three antioxidant peptides, which could reduce oxidative changes during storage.

In 2014 and 2015, the most significant issue of academic interest was the gene sequencing and assembly of *Larimichthys crocea*. In 2014, Wu, CW et al. [66] reported a draft genome of wild *Larimichthys crocea* established via a whole-genome sequencing strategy. In 2015, Ao, JQ et al. [1] sequenced and assembled the genome of *Larimichthys crocea* via a bacterial artificial chromosome and whole-genome shotgun stratification strategy, revealing the molecular and genetic basis of fish adaptation and response to hypoxia and air exposure.

The papers most cited in 2016 focused on the storage and transportation of *Larimichthys crocea*. Hui, GH et al. [67] noted that the combination of chitosan with different concentrations of nysin improved the sensory scores, volatile putractis, total survival number and physicochemical indices of *Larimichthys crocea*, which was expected to extend the shelf-life of *Larimichthys crocea*.

From 2017 to 2019, academic interest shifted to the lipid sources of *Larimichthys crocea*. In 2017, Dong, XJ et al. [68] studied the mechanism leading to differences in the ability of different fish species to biosynthesize long-chain polyunsaturated fatty acids (LC-PUFAs) and reported that the substitution of fish oil with vegetable oil led to changes in the fatty acid content in the muscle and liver of *Larimichthys crocea*. In 2018 and 2019, Mu, H et al. [69] and Li, XS et al. [70] reported that the replacement of fish oil with dietary soybean oil and palm oil (PO) inhibited the growth performance and liver antioxidant capacity of *Larimichthys crocea* and induced inflammatory responses.

The highly cited papers in 2020 were related to the marine environment. Gu, HX et al. [71] reported that nanopolystyrene (nano-PS) is detrimental to the health of juvenile fish, decreasing digestive enzyme activity, altering the proportions of three major bacterial phyla (Bacteroidetes spp., Aspergillus spp., and Firmicutes spp.), and increasing mortality.

Since 2021, the research focus of *Larimichthys crocea* has returned to the cold storage of adult fish. Ma, XA et al. [72] and Bian, CH et al. [73] published papers in 2021 and 20222, respectively, both revealing that multifrequency ultrasonic-assisted freezing (UAF) could significantly improve the freezing rate of *Larimichthys crocea*, reduce lipid oxidation, and maintain the muscle fiber structure, thus improving the quality characteristics of *Larimichthys crocea*. In 2023, Zheng, Y et al. [74] showed that flammulina velutipes polysaccharide (FVP) could effectively improve the water holding capacity (WHC) of frozen-thawed *Larimichthys crocea* by inhibiting the growth of ice crystals, protein denaturation and potential protein oxidation and reducing thawing loss and cooking loss.

In addition, we analyzed the citations in the field, that means the number of citations in the present dataset of 1192 documents, using the bibliometrix tool. Citations in the field may better reflect the importance of a document in the field than citations in Web of

Science Core Collection, Scopus, Google Scholar, and other databases. The 10 most cited documents in the field are shown in Fig. 7, where local citations are citations in the dataset.

An observation of Fig. 7 reveals that gene sequencing and assembly of *Larimichthys crocea* is the most concerned direction for scholars, and the two papers published by Ao, JQ et al. and Wu, CW et al., in 2015 and 2014 are not only the most cited in the dataset for that year, but also ranked 1st and 3rd among them in the specialized field of *Larimichthys crocea* research. The paper Liu M et [15] published in 2008 on how overfishing, mismanagement and environmental pollution have caused the failure of wild populations to recover was ranked 2nd in local citations. Other topics that ranked high in local citations were: how the *Larimichthys crocea* gut microbiome responds to environmental changes [75], the role of cyclic dipeptide oxidase in Streptomyces noursei [76], the effects of adding dehulled Lupinus angustifolius added to fish feeds [77], iridovirus disease outbreaks in *Larimichthys crocea* aquaculture [78], protein to lipid ratios [79], characterisation of polyribonucleotide-induced de-repeat sequences of the *Larimichthys crocea* splenic transcriptome [80], and the effect of feeds with different lipid levels on the deposition of lipids in *Larimichthys crocea* livers [81].

4. Discussion

The study of *Larimichthys crocea* is a demand-driven research field. As seen from the previous analysis, the scale of related studies has also rapidly expanded with the rapid expansion of the breeding scale of *Larimichthys crocea*. Countries with major *Larimichthys crocea* aquaculture areas, such as China, Korea, and Japan, are the main forces in *Larimichthys crocea* research. At the same time, institutions in the United States, Canada, and other marine countries learn from other countries in terms of scientific research. Therefore, countries such as Canada have carried out research on *Larimichthys crocea* independently or in cooperation with institutions in other countries that rely on advanced technology, equipment and concepts. Surprisingly, Tanzania on the African coast is also involved in many related studies, with support from China and other countries.

Notably, as in many areas of academic research, universities are at the core of *Larimichthys crocea* research, but *Larimichthys crocea*-related research is derived more from the actual needs of aquaculture breeding, cultivation, storage, transportation and processing. Therefore, much of the research on *Larimichthys crocea* is closely related to industry, and Ningde Fufa Fisheries Co., Ltd., and others are also directly involved in numerous studies.

An analysis of the high-frequency keywords and highly cited papers revealed that research on *L. crocea* has focused mainly on germplasm innovation, breeding, preservation and processing, and the research hotspots have also changed with changes in the demand environment.

The decline of the wild *Larimichthys crocea* population triggered the rapid development of the *Larimichthys crocea* breeding industry, and academic circles have started to find ways to improve the quality of cultured *Larimichthys crocea* through genetic selection, improvements in the breeding environment and the provision of nutrients. Researchers have mapped the genome of *Larimichthys crocea* and continuously cultivated new varieties and strains through techniques such as population breeding, family breeding, gynogenesis and genome selection breeding to realize germplasm innovation in *Larimichthys crocea*. Explorations in this area also include the establishment of an all-female *Larimichthys crocea* population by inducing sex reversal through sex control techniques and the synchronized growth of *Larimichthys crocea* populations through gene regulation. The deepening of germplasm innovation research has also contributed to the return of the wild *Larimichthys crocea* population.

The improvement in the survival rate, immunity and disease resistance of *Larimichthys crocea* was the main concern in early academic circles. Accordingly, keywords such as *Vibrio alginolyticus*, disease resistance, microsatellite, *Cryptocaryon irritans*, poly(I:C), and inflammatory response frequently appeared in relevant papers. Researchers have also analyzed the role of various *Larimichthys crocea* receptor genes in hypoxic responses and bacterial infections in recent years. Specialized assays have been developed for early

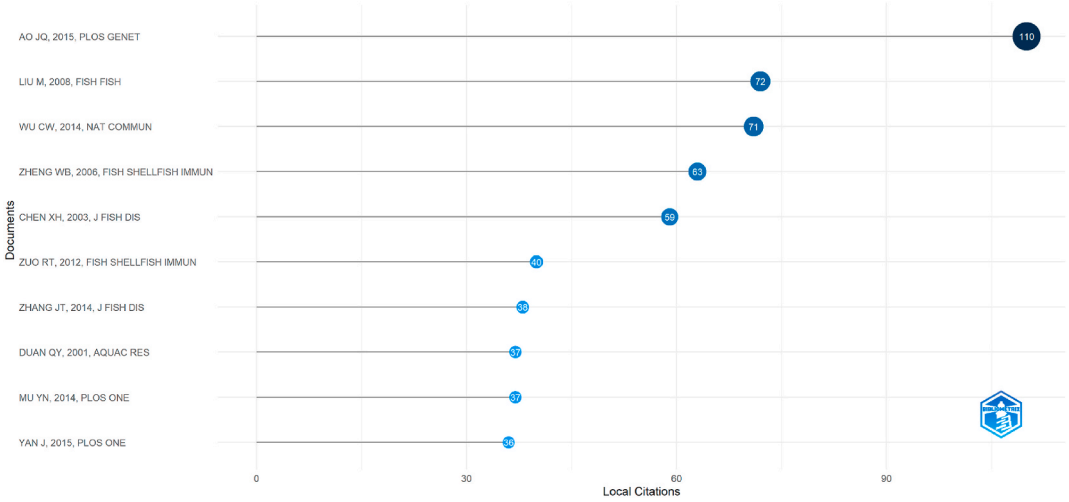

Fig. 7. Most local cited documents in *Larimichthys crocea* research.

warning and routine monitoring of common *Larimichthys crocea* diseases such as visceral white nodule disease.

With the refinement of basic theories, research on *Larimichthys crocea* will likely be more concentrated in the middle and lower reaches of the *Larimichthys crocea* industry chain in the coming period to realize the sustainable aquaculture and economic value development of *Larimichthys crocea* and achieve a wider crossover with other research in the field. Issues such as how to store and transport live *Larimichthys crocea* more economically and efficiently, how to improve the treatment process and enhance the flavor of *Larimichthys crocea*, and how to reduce the use of antibiotics and the environmental pollution caused by aquaculture will become the focus of researchers' attention. With improvements in culture technology and expansion of the culture scale, delaying the deterioration of fish quality during storage and transportation and extending the shelf-life of *Larimichthys crocea* have become the focus of research on *Larimichthys crocea*. Low-temperature preservation, chemical preservation, air-conditioning preservation, biological preservation and composite preservation are commonly used methods to inhibit the growth and reproduction of microorganisms and prolong the shelf-life of *Larimichthys crocea*. Low-temperature preservation to delay fish oxidation is the most commonly used method to extend the shelf-life of *Larimichthys crocea*. Vacuum packaging can delay the degradation of adenosine triphosphate (ATP)-related compounds in *Larimichthys crocea* by specific spoilage organisms. In addition to preservation, the use of oxygen, low temperature, anesthesia and other methods to regulate the temperature, oxygen, water quality and salinity in the transport box can also prolong the life of *Larimichthys crocea* to achieve preservation of transportation.

Larimichthys crocea is rich in nutrients, and the processing of pickled *Larimichthys crocea* products, smoked *Larimichthys crocea* products, fermented *Larimichthys crocea* products, and *Larimichthys crocea* snack foods is an important link in the industrial chain of *Larimichthys crocea*. Fish skin, fish bones, fish scales, swim bladders, fish eggs and other byproducts are also rich in substances such as DHA phospholipids (LYCRPLs), which are useful for regulating blood lipids and treating lipid metabolism disorders. Studies in academic circles have focused on the processing of *Larimichthys crocea* and its byproducts. Some scholars have evaluated the effects of adding different concentrations of sodium chloride salt [82] and adding different edible fungal soups [83] on the flavor of *Larimichthys crocea*. Fermentation with *Pentose Schizococcus* has been found to attenuate the grassy and fishy flavor of *Larimichthys crocea* and enhance consumer acceptance. Ultrasound-assisted heating was found to improve the quality and protein stability of *Larimichthys crocea* during thawing [84]. *Larimichthys crocea* egg oil was found to improve bread quality. Some scholars have studied the extraction of protein isolates and lipids from dry powders of *Larimichthys crocea* rooted as functional materials in the food industry [85]. Research on the processing of *Larimichthys crocea* and its byproducts is growing, and this direction could be a new flashpoint in the future.

Protecting the environment means protecting the *Larimichthys crocea* industry. Another interesting direction is the integration of *Larimichthys crocea* research with environmental pollution research, but there is currently an insufficient number of related studies. *Larimichthys crocea* is closely related to environmental pollution and is a suitable biological indicator for monitoring short-term cadmium emission in coastal areas [86]. Concerns have been raised about the biotoxicity and ecological risks of pollutants such as the succinate dehydrogenase inhibitor fungicide fludioxonil (FX) [87] and polystyrene nanoplastics (PS NPs) [88] with respect to *Larimichthys crocea* and about the effects of *Larimichthys crocea* aquaculture on water and sediment contamination [89], the phytoplankton community structure, and water properties [90], and the most cited *Larimichthys crocea* research paper of 2020 focused on the effects of polystyrene nanoparticles (nano-PSs) on the intestinal health and growth performance of juvenile fish.

To achieve sustainable development, in addition to improving the environment, it is necessary to develop a multidimensional approach from economic and social perspectives to strengthen process management, reduce the use of high-priced fishmeal as well as antibiotics, and make aquaculture more economical and systematic. Over the years, high-density aquaculture has led to the frequent occurrence of diseases caused by pathogens such as bacteria, viruses, and parasites, and epidemiological investigations are receiving increasing attention. The use of widely distributed saline water to farm *Larimichthys crocea* instead of seawater has been shown to be feasible. Researchers have assessed the feasibility of genetic selection to improve the tolerance of land-based animal or plant proteins to accelerate the replacement of fishmeal with other proteins. Studies on the effects of the addition of relevant Chinese herbal mixtures (CHMs) to diets on the growth performance, antioxidant and immune responses, and intestinal and liver histology of *Larimichthys crocea* larvae are beginning.

In addition, researchers need to intensify their studies on antibiotic alternatives to avoid the potentially devastating consequences of antibiotic misuse. Infectious diseases of *Larimichthys crocea* caused by viruses, bacteria and parasites are becoming more frequent and serious [91], but the increased uptake of antibiotics and other chemicals is not only damaging to the environment [92] but also leads people to refuse to consume fish because of antibiotic residue concerns. Many countries have banned the import of fish to avoid antibiotic-resistant bacteria in fish [93]. Moreover, studies have shown that *Larimichthys crocea* is resistant to a wide range of antibiotics. Therefore, antibiotic residue detection, contamination assessment and risk management in aquaculture should be strengthened, and efforts should be made to develop alternatives to antibiotics. Antimicrobial peptides have been shown to be potentially promising alternatives to antibiotics in *Larimichthys crocea*, but antibiotics will still be necessary to address various infectious diseases caused by viruses, bacteria and parasites [94] until more efficient vaccines are available.

Research on *Larimichthys crocea* is aimed at improving the economic efficiency of the *Larimichthys crocea* farming industry, ensuring environmental sustainability, and meeting consumer demand for high-quality seafood. The academic community has sequenced the *Larimichthys crocea* genome and explored genetic improvement through selective breeding or gene editing techniques, and the physiology and molecular mechanisms of *Larimichthys crocea* are increasingly understood. Future research may fill the blanks or improve the identification of new pathogens and improvement of disease management strategies, microbiome and host health, genomics and genetic improvement, innovation and application of refrigeration and preservation technologies, and assessment of consumer acceptance and exploration of market development strategies.

5. Conclusion

This paper systematically reviewed the research results of *Larimichthys crocea* indexed in the SCI-E, CSCD and KCI from 2001 to 2023. After the depletion of wild *Larimichthys crocea* resources, institutions and scholars from China, the United States, South Korea, Japan and other countries have made great efforts in breeding, culturing, preserving and processing *Larimichthys crocea* manually, as well as keeping this highly important economic fish in stock. Research directions, including the immune response, *Pseudomonas plecoglossicida*, gene expression, lipid metabolism, *Cryptocaryon irritans* and the transcriptome, have been the research topics of greatest interest for *Larimichthys crocea*, although the research focus related to *Larimichthys crocea* during different periods has varied.

Previous results cover a wide range of topics relevant to *Larimichthys crocea* research, from immune responses to lipid metabolism. Compared with existing studies, this work provides an overall view of the research on *Larimichthys crocea* over the past 20 years. This work is helpful for current and potential researchers of *Larimichthys crocea* to better understand related research on a global basis, discover new research directions, and find suitable collaborators and academic journals.

There are still some limitations in this study. A comprehensive search of SCI-E, CSCD, KCI and other databases ensures that the vast majority of important papers are in the research dataset, but some relevant works that exist only in Scopus or PubMed will be missed. Some relevant papers that are not included in our findings because they cannot be detected by their title, keywords or abstract.

Supplementary materials

None.

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Institutional review board statement

Not applicable; the study did not involve humans or animals.

Informed consent statement

Not applicable; the study did not involve humans.

Data availability statement

All the data generated or analyzed during this study will be made available upon request.

CRediT authorship contribution statement

Hongyan Zhang: Writing – original draft, Funding acquisition, Conceptualization. **Jiacan Wang:** Visualization, Data curation. **Yuan Jing:** Writing – review & editing, Supervision, Software.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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