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ECOSYSTEMS

The use of fisheries resources in the Brazilian patent system

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Abstract: Recent years have seen a significant increase in the number of patents related to products and/or processes from aquatic organisms. Therefore, this paper aims to identify patent documents related to fishery resources available in the Brazilian patent system of the National Institute of Industrial Property. The research involved patents deposited/provided between 1999 and 2019, with the search in the system occurring through the descriptors: fish(s), mollusk(s), crustacean(s), and algae(s). A total of 363 records were found, where the group of fish presented the highest representation (40%), followed by algae (35%), crustaceans (14%), and mollusks (10%). The apex of 34 patent applications was found in the year 2011. Moreover, the results showed that the inventions registered are directed mainly to food, drugs, biocides, cosmetics, cultivation, processing and beneficiation, water treatment, patents for sustainable technologies (green patents), and biotechnology. Brazil holds most patent applications, followed by the United States of America (USA), which focuses its patent applications mainly on algae and fish. Considering the Brazilian biodiversity and the country's technological development in recent years, Brazil needs to expand its technological autonomy and competitive capacity in the aquaculture and fisheries sector, mainly through the strengthening of R&D and innovation activities.

Key words: aquatic organisms, Brazil, information system, innovation, intellectual property, patenting activity.

INTRODUCTION

Human cognitive ability provides the development of systems and processes that offer new ways to solve problems (WIPO, unpublished data). The act of creating and perfecting objects or processes is characterized as "invention" (Levin 2004). In possession of these premises, it is evident that man is constantly using his cognitive skills to solve problems, creating or perfecting objects and processes to meet their needs, as in a constant process of (re) invention (Bessant & Tidd 2009).

Considering the estimates that the world's human population could reach approximately 10 billion by 2050 (UN, unpublished data) with exponential perspectives on needs and challenges, we come to the reflection that a society's ability to innovate will be crucial to addressing adversities (Alonso-Martínez 2018). Moreover, we are in the age of market globalization, techno-scientific revolutions and unbridled reach of the media, and it is undeniable that innovation is recognized as a determining factor in these transformations and even as an indication of the economic growth and social progress of nations (Cantwell & Jane 1999, W. Lesser, unpublished data, Hall et al. 2014, Lema et al. 2018).

The capacity for innovation varies between companies and countries, mainly due to differences in investments in science, technology, and innovation, or the availability of inputs, two contexts are often cited with the following groups: 1) developed countries that use and recognize the importance of industrial property; 2) developing countries that seek to become increasingly competitive in markets and improve the socio-economic conditions of their inhabitants (Furman et al. 2002, WIPO, unpublished data, Eichengreen 2004). An important factor to be highlighted in this innovation process is the need to guarantee credits of an invention to the author (s), as well as to guarantee the so-called Intellectual Property Rights (IPR), establishing a solid national system of intellectual property (IP) (Araújo et al. 2010). And among the mechanisms used for the legal protection of an IP, we can mention the creation of trademarks, the identification of copyrights (Zucoloto & Cassiolato 2013, Hall et al. 2014) and, especially, the patent that will be covered in detail in this article.

Patenting is the process of granting the exclusive right to explore and monopolize technical solutions and inventions; it is one of the most common means of transferring technologies, whether in the form of new products, processes, applications, materials or services, considering the territorial limits of each country and the specific periods established for these transfers by international laws and agreements (Zdrálek et al. 2017). Patents are developed mainly by universities or other governmental institutions and allow scientific and technological development to be accessible to society (Maresova et al. 2019). Also, patenting acts as an incentive to innovate, as it protects and guarantees the benefits of innovations to innovators, and allows the exclusion of potential competitors or imitators (Gilbert 2006, Henry & Stiglitz 2010).

In this context, technological innovation is widely recognized as the main part of the knowledge-based economy, and inventions of this type depend on technological knowledge, which can be combined with scientific knowledge (Ahmadpoor & Jones 2017). Lubango & Pouris (2010) identified that although the scientific and technological networks are different communities, the production of patents and scientific publications tend to coexist in the same author/researcher since they have identified that a large number of high impact patents and articles are related to each other and mainly reflect the science-technology relationship. Inventors have used scientific knowledge more than in the past, and scientific research has become more applied over time (Gazni 2020, Lubango & Pouris 2010).

Thus, a patent, although not a unique consequence of innovation, is an important device for the safe dissemination of R&D (research and development) while stimulating the technological, social, and economic development of countries (Yanagisawa & Guellec 2009, Haber 2016, Stemberková et al. 2017). For this reason, patenting is increasingly being used as a unit of value or “currency” in markets driven by innovation and technology (Kline et al. 2019).

In this regard, several authors have sought to measure the value of patents in terms of financial returns to patent holders, as well as to understand the multiple factors that can influence the value of protected inventions (Sellers-Rubio et al. 2007, Bessen 2009, Ernst et al. 2010, Suzuki 2011, Hussinger & Pacher 2019). In this sense, it is important to note that not every patent achieves financial success; the likelihood that a patent will be economically successful and bring economic benefits to the rights holders of use has been associated with its novelty, technical characteristics, impact on the inventive step and strategic competitive utility (Reitzig 2003, Hussinger & Pacher 2019). But even so, the granting of patents works as a stimulus to technological innovation (Raiteri 2018).

According to Paula (2001), it is difficult to think that there would be no reason to invest in research and technology if there were no possibilities for a profitable return. The financial return to patent holders (ie., private value) corresponds to a mechanism that is based on the idea that free and unprotected knowledge will provide zero financial returns to its creators, which, in turn, would lead to a sub-investment in R&D, underproductive markets and worse economic and social performance (Bektas et al. 2015, Ribeiro & Shapira 2020). In a simplified way and financial terms, patents signal innovation to attract investments and promote national and international financial markets, and therefore they must be monitored and studied, as an indicator of scientific, technological, and economic performance (Encaoua et al. 2006). Currently, there are updated platforms for the circulation and filing of patents, on which it is possible to access and share patented technologies, facilitating the dissemination of knowledge. The Instituto Nacional de Propriedade Industrial (INPI) is the federal body responsible for the Industrial Property System in Brazil.

In this process of evaluating and granting patents based on industrial applicability, inventive merit, and technical conditions for patentability, a very debated question is whether animal and plant products should be subject to patent protection (Bagley 2003).

Brazilian law, through law No. 9279, which deals with Industrial Property (BRASIL, unpublished data) determines that living beings, their biological materials and their natural biological processes (parts/isolated or complete) cannot be considered inventions. However, other processes involving living organisms, such as, for example, methods for the development of transgenic organisms, genetic constructions, recombinant proteins, or arrangements of biological extracts are patentable in Brazil. This determination by following per under the Agreement on Aspects of Trade-Related Intellectual Property Rights in the World Trade Organization (WTO), signed in the mid-1990s, in article 27, which specifies patent protection for all areas of invention, including those related to biological organisms and their components and incorporated into the field of international patent protection (Oldham et al. 2013).

In recent years, there has been a significant increase in the number of life science patents, with 1255 biotechnology patent applications filed in 2015 (Mendes et al. 2013, INPI, unpublished data). Records between the years 2002 and 2011 show that more than 3.4 million patents containing biodiversity elements were deposited worldwide (Oldham et al. 2013). In terms of biodiversity, Brazil is considered a megadiverse country, having more than 100,000 animal species and about 43,000 plant species, spread across six terrestrial biomes and three major marine ecosystems (Mittermeier 1988, 1997), having great biotechnological potential waiting to be well known and exploited. Internationally, our biodiversity is recognized, which has already implied constant attacks on Brazilian natural resources (Batista 2012, Santos 2015). Therefore, there is a need to better understand Brazilian biodiversity from bioprospecting studies, which will enable the use of organisms for medical, agricultural, agro-industrial, and environmental purposes for the country's development; also, of course, the strengthening of the Brazilian patent system (Valois 1998).

Analyzing the importance of biodiversity in the Patent System, Homma (2008) pointed out that between the 1990s and 2008, over 100 patent applications for Amazonian plants were made abroad; França & Vasconcellos (2018), analyzing the patenting of herbal medicines in Brazil, found 1,977 applications filed from 1995 to 2017; Diniz & Diniz (2018), in a study of the regionalization of Innovation, highlighted that the spatial distribution of patents in the Brazilian territory is unequal, where São Paulo filed an average of 5,416 patent filings between 2007 and 2009, in contrast to the states that make up the Legal Amazon, together they only added 288 patent filings, corroborating the results of Albuquerque et al. (2002) and Gonçalves & Fajardo (2011). In the latter case, the few studies addressing this patent theme have focused on patenting analysis of Amazonian plants for use in the areas of herbal medicine, pharmacology, and cosmetology (Homma 2008, França & Vasconcellos 2018); traditional knowledge as cultural heritage (Eloy et al. 2014, Martins 2017, Verzola & Furnival 2019), and the “green patents” (Santos et al. 2015, Ferreira et al. 2016, Menezes et al. 2016, Toledo & Campos 2018), defined as environmentally friendly technologies or so-called green technologies (INPI, unpublished data). Therefore, the results presented, it identified the need for further analysis of the Brazilian patenting system.

It is noteworthy that when we talk about biodiversity, the first Brazilian biomes highlighted are the Amazon and the Cerrado (Fonseca & Venticinque 2018). However, the marine biome also has a wide variety of species and ecosystems that surround the whole of Brazil (Schiavetti et al. 2013). Brazil still needs to invest in information about its biodiversity and its potential to patent products, processes, and services (Valli et al. 2018), especially marine biodiversity. Besides, studies that address the use of fishery resources as products or by-products in innovation/technology processes are still scarce, despite their widespread use in biotechnology, cosmetology, pharmacology, fish processing and processing, water treatment, and many others. Therefore, this study aimed to examine the Brazilian innovation patent system, highlighting the use of biodiversity (fish, mollusks, crustaceans, and algae) by national and international industries, from the database of the National Institute of Industrial Property.

MATERIALS AND METHODS

The search involved patents granted by the Instituto Nacional de Propriedade Industrial (INPI) between 1999 and 2019. The information was collected from July to September 2019, based on patent applications filed with the INPI. The following descriptors were used in the search: fish/s, mollusk/s, crustacean/s, and algae/s. The respective terms were searched in Portuguese and English. The data analyzed in the results of each search were: applicant’s country of origin, year of deposit, and main area of invention, which were classified into food, equipment, cultivation, biocides, cosmetics, pharmaceuticals, water treatment, green patent, biotechnology, processing, and beneficiation.

The “green patent” category was incorporated considering the importance of the “Green Patents” Program (Resolution No. 175/2016) implemented since 04/2012 by the National Institute of Industrial Property. This program offers priority consideration to applications related to “green technologies” such as alternative energy generation, improved transport sources, types of energy conservation, waste management, and sustainable applications for agriculture. Thus, the use of fishing resources in the formulation of these new technologies aimed at sustainable development was analyzed.

It is also worth mentioning that during the research were considered only the patents that used fishing resources during the innovation process and those involving creations aimed at improving the processing, beneficiation, or cultivation stages of organisms. By contrast, patents developed from other materials for general applicability only, even if applicable to fishery resources, were not considered. For a better understanding of the data collected in this study and how the categorization of patents was performed, we present in Table I examples corresponding to each type of "product" and each taxon is considered "fisheries resource".

RESULTS

A total of 363 fishery resource-related patent applications have been identified. Fish were the most representative group in this survey, making up about 40% of the total patents accounted for, followed by algae, which proved to be the central elements of approximately 35% of innovations. The crustacean and mollusk groups represented 14 and 10%, respectively (Table II).

When we analyzed the categories in which the records of patents fell into it was noted that the deposits are mainly related to the creation of new equipment, improvement in processing and beneficiation stages, as well as the development of new techniques for cultivating fishery resources (Table II).

Regarding patent filings involving the "Fish" resource, it was observed that the inventions focused on the creation of devices that would increase aquaculture production and efficiencies, such as an automatic feed supply and distribution system (patent number: BR 10 2017 026956 6); a fish size sorting equipment (patent number: BR 10 2013 016291 4), or a mobile fish processing unit (patent number: BR 20 2012 025213 4).

Other inventions were related to the extraction process of substances capable of curing human diseases, such as patent no. BR 11 2015 032029 5 which proposes the use of fish oil for inflammatory treatment; hybrid species enhancement processes (patent number: PI 0603193 5); cosmetic products such as a fish-based hair composition and "sustainable" applications such as the use of asphalt coating fish oil (patent number: PI 0300806-1).

As for Crustaceans, more than half of patent registrations focused on the creation of equipment used for shrimp and crab processing, such as the crab leg breaker (patent number: BR 10 2016 004578 9) and the shrimp peeling machine (patent number: PI 0405486-5). Some tools have also been designed to improve fishing activity, such as the shrimp trap (patent number: MU 8403449-1); crab-picking gloves (patent number: BR 10 2017 019056 0) and selective catching device; lobster, with accompanying fauna reduction (patent number: BR 10 2013 018182 0). In addition to direct consumption, the use of crustaceans as a food supplement was identified through crab carcasses (patent number: BR 10 2013 027510 7). The areas where crustaceans had less expressive applications were biotechnology, use for pharmacology, and water treatment, ranging from 1% to 4%.

Mollusks showed the lowest representation in the INPI patent system. According to research, mollusks are included as target organisms of most biocidal compounds, since bivalves such as mussels (*Perna*, *Mytella*) and oysters (*Ostrea*, *Crassostrea*), relatively sessile gastropods such as *Colisella*, *Crepidula,* and other clam groups (including gastropods) are actively involved in the phenomenon known as biofouling. Another highlight of the use of mollusks is in the field of

Table I. Information about the areas of application of the main patents identified during the collection of information in the INPI database. –: no results found.

Categories	Patent number and Deposit date			
	Fishes	Crustaceans	Mollusks	Algae
Foods	**PI 1003560-5** September/2010 **PI 0803167 3** July/2008	**BR 10 2013 027510 7** October/2013 **PI 1002212-0** March/2010	-	**BR 11 2012 026241 6** April/2011 **PI 0920280-3** October/2009
Biocides	-	-	**BR 11 2016 020465 4** February/2015 **BR 11 2012 019860 2** September/2011	**BR 11 2016 016842 9** January/2015 **PI 0916075-2** November/2009
Biotechnology	**BR 11 2017 012852 7** December/2015 **BR 11 2012 008115 2** October/2010	**PI 0412282-8** July/2004 **PI 0414157-1** September/2004	**BR 11 2018 071338 4** April/2017	**BR 11 2019 000430 0** July/2017 **BR 11 2012 027045 1** April/2011
Cosmetics	**BR 11 2015 015021 7** December/2013 **PI 0504218-6** September/2005	-	-	**PI 0501467-0** April/2005 **PI 0305378-4** November/2003
Cultivation	**BR 11 2018 000950 4** August/2016 **PI 0114118-0** July/2001	**BR 10 2015 008409 9** April/2015 **PI 0804788-0** August/2008	**BR 10 2017 001625 0** January/2017 **PI 0312222-0** June/2005	**BR 11 2019 015051 0** January/2018 **PI 1001026-2** February/2010
Equipments	**BR 11 2017 025547 2** May/2016 **PI 0802399-9** July/2008	**PI 0205641-0** October/2002 **BR 10 2017 014505 0** July/2017	**BR 20 2015 005955 3** March/2015 **PI 0403476-7** August/2004	**BR 10 2012 012549 8** May/2012 **MU 8402516-6** October/2004
Drugs	**BR 11 2015 032029 5** June/2014 **BR 11 2014 004294 2** August/2012	**PI 0601249-3** March/2006 **PI 0012919-4** July/2000	**BR 11 2018 002883 5** August/2016 **BR 11 2018 000953 9** July/2015	**BR 11 2017 021442 3** April/2016 **PI 1003294-0** August/2010
Processing/ Beneficiation	**BR 10 2017 024280 3** November/2017 **PI 0205501-5** December/2002	**BR 10 2017 022250 0** October/2017 **PI 1004774-3** November/2010	**PI 0705658-3** July/2007 **PI 0102573-2** June/2001	**BR 11 2016 000650 0** July/2014 **PI 1009297-8** March/2010
Green Patent	**BR 10 2015 004697 9** March/2015 **PI 0300806-1** March/2003	-	**BR 11 2013 010693 0** December/2012	**BR 10 2014 022877 2** September/2014 **PI 0903259-2** May/2009
Water treatment	**BR 10 2014 000733 4** January/2014 **BR 20 2013 031259 8** December/2013	**PI 0918538-0** September/2009	-	**BR 11 2018 015753 8** August/2017 **MU 8803208-6** July/2008

pharmacology, with the extraction of adhesive or polyphenolic proteins from mussels and their application in inhibiting skin inflammation, oral mucositis, melanin-related diseases, among others.

Finally, we highlight the application of algae in patent applications. We realize that this group is the second in occurrence among the aquatic resources surveyed, being its most effective application in the “cultivation” area, with 25% of requests, and focused on the improvement of various large-scale microalgae production techniques. Also, 20% of the patent applications for this group were directed to the “biocides” sector, primarily targeting cyanobacterial control. Biotechnology accounted for 15% of deposits, with emphasis on methods for extraction and preparation of organic compounds, production of transgenic fatty acids and polysaccharides, or algae.

The category “water treatment” (6%) contained patents of wide use, aiming from the removal of algae from effluents to the use of organisms for adsorption and capture of metallic species from the environment. In the “green patents” category, the importance of algae for improving environmental quality was evident, with the exploitation of CO_2 capture through microalgae production, biofuel production, and biodegradable products such as beakers (patent number: BR 10 2014 022877 2) and bioactive paper (patent number: BR 11 2019 001673 2). The cosmetics and food sectors, representing less than 4% of the total number of patents, submitted interesting patent applications, for example, for the formulation of seaweed meal supplements (patent number: BR 11 2012 026241 6), bath sponges (patent number: PI 0305378-4) and algae-based depilatory waxes (patent number: PI 0501467-0).

The temporal evolution of the last 20 years of patent registrations with fishing resources in Brazil showed that the registrations were intensified from 2001, reaching the highest values between 2008 and 2011, with a peak of 34 patent filings in 2011 (Figure 1).

The results showed that the main patent applicant in the INPI Database is Brazil, and for information, most of these applications are produced by public universities. Second is

Table II. Number of patents relating to fisheries resources and their respective areas of application based on a survey carried out in the INPI database. –: no results found.

Categories	Fishes	Crustaceans	Mollusks	Algae	Total
Foods	9	3	-	2	14
Biocides	-	-	6	6	12
Biotechnology	10	2	1	19	32
Cosmetics	3	-	-	3	6
Cultivation	25	7	5	32	69
Equipments	56	27	8	15	106
Drugs	8	2	5	11	26
Processing/ Beneficiation	33	9	11	18	71
Green Patent	2	-	1	13	16
Water treatment	2	1	-	8	11
Total	**148**	**51**	**37**	127	363

the United States of America (USA), with a high volume of Unionist priority requests for algae. Also, Germany has reached the third place, and since the country is home to the European Patent Union it is noted its active participation in the patenting of all surveyed fishing resources. With less participation, we highlight Norway and France, which deposited more than 5 innovations with fish and algae, respectively. The other nations, such as Chile, Japan, China, among others, did not reach this amount (<5), as can be seen in Figures 2 and 3.

DISCUSSION

The use of natural resources in the patent system (e.g., marine biotechnology) has been increasing over the years (Oldham et al. 2013, Rotter et al. 2020). Several industries from different sectors, through scientific research and traditional knowledge, have found in marine resources a solution to many problems, especially in health (Uddin & Islam 2019). It is estimated that 40% of the drugs available for treatment were developed from studies based on natural sources; on the other hand, the use of animals for this purpose represents only 3%, among which, the fishing resources (Calixto 2000).

The initial discussion of this review is aimed at the class of fishing resources with the greatest representation in Brazil's patent systems, fish. This fact is due to the great fishing effort directed at this group, being much greater than the efforts to capture other fishing resources (Aramayo 2015) and, consequently, generating more information and products. As an information, the Brazilian fishing sector has been registering a growth above the world average, going from 20.5 thousand tons in 1990 to 547 thousand tons of fish, including shrimp, fish, and mollusk (IBGE, unpublished data). The country is the largest producer of inland catches

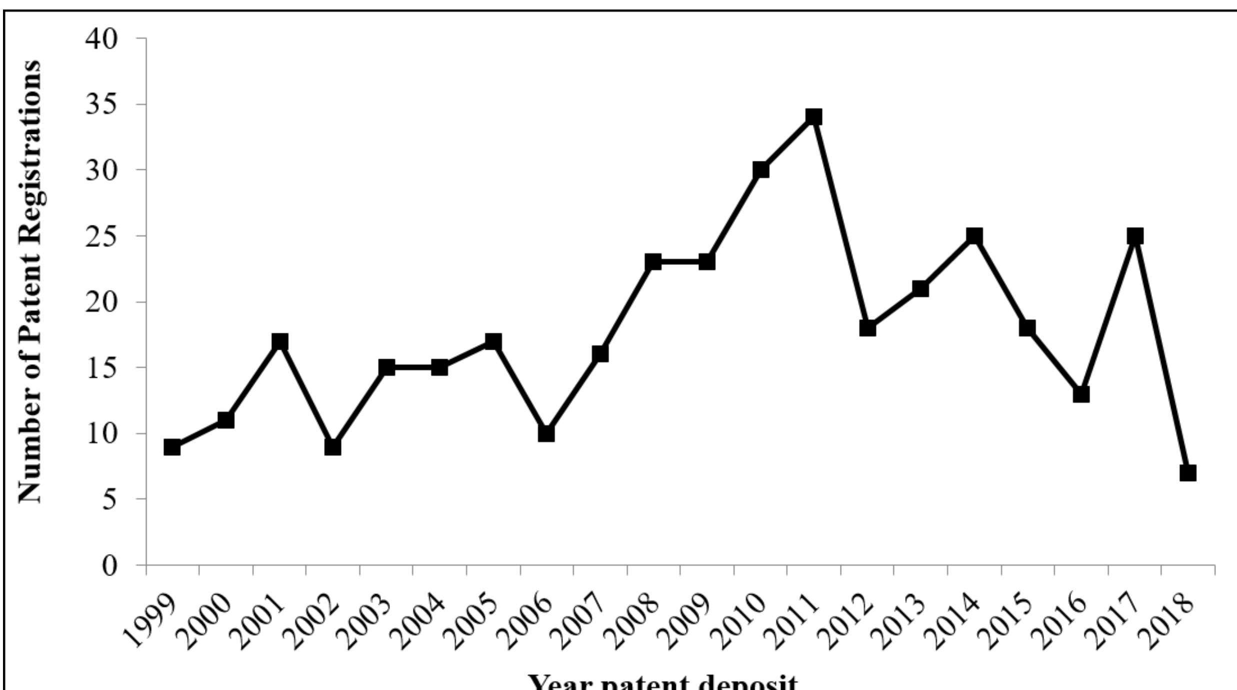

Figure 1. **Annual evolution of patent applications relating to fisheries resources and respective areas of application located in the INPI database.**

in South America, according to the estimates of the Food and Agriculture Organization of the United Nations (FAO, unpublished data). Also, it is one of the emerging Latin markets and a promising exporter, with a projection for 2030 to export more than 1,880 thousand tons of fish from fisheries and aquaculture to the world (FAO, unpublished data). These are important aspects that explain the representativeness of this group in the Brazilian patent bank.

Then we highlight the algae, which are base organisms of aquatic food chains. In addition to their ability to supply oxygen to the planet, algae appear as an alternative source for the production of many items used by society, such as food, industry, aquaculture, quality control of the ecosystem, and cosmetics (Dhargalkar & Pereira 2005, Souza et al. 2007, Matos 2017). According to Brasil & Garcia (2016) and Ariede et al. (2017), seaweed extracts are increasingly used as ingredients for many cosmetics, including soaps, masks, shampoos, and body gels.

Algae-extracted compounds have a wide range of utility in the cosmetics industry (soothing compounds, anti-cellulite, antioxidants, anti-inflammatories, protectors, stimulants, humectants, toners, emollients), which makes them highly precious (Dhargalkar & Pereira 2005, Almeida et al. 2007). Therefore, the great exploitation potential presented by algae and its high profitability justify the high number of patents in the cultivation and biotechnology

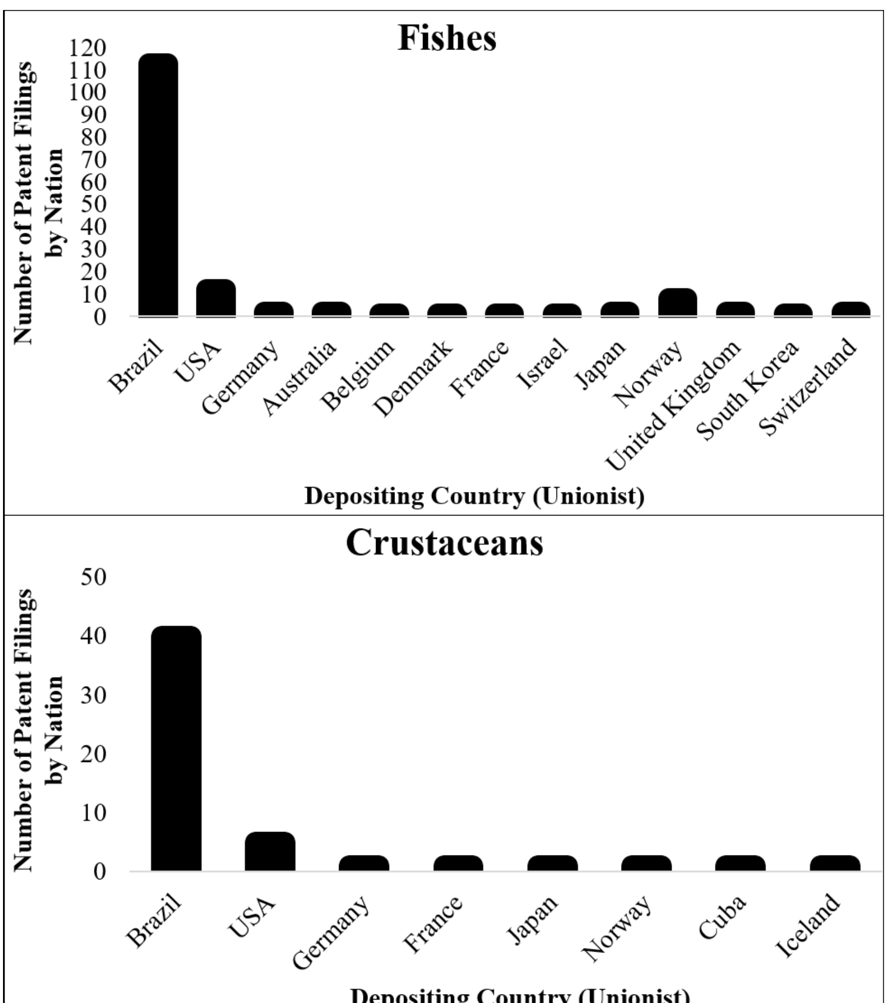

Figure 2. Distribution of patent records from the INPI database related to the Fish and Crustacean groups by country of origin of the request.

areas, mainly due to the interest in producing raw material that has applicability in the most diverse industrial sectors (Kolanjinathan et al. 2014, Wells et al. 2017, Sudhakar et al. 2019).

The use of mollusks in the patent system (Brazil) is related, in particular, to biocidal products. Biofouling is the process resulting from colonization or growth of sessile bacteria, algae, and/or invertebrates on submerged, natural surfaces such as rocks, wood, and other organisms or man-made such as pillars, platforms, ship hulls, buoys, cables, among others (Da Gama et al. 2009). Beginning in the 1960s, antifouling paints containing organotin compounds in their formulation began to be manufactured, including one that would cause serious environmental impacts on the aquatic environment, tributyltin (TBT); this compound caused imposex in mollusks, a disorder that can affect endocrine processes in females, causing them to acquire male characteristics such as penile appearance (Svavarsson 2000). The use of TBT in antifouling paints has been banned since 2008 as a result of the International Maritime Organization (IMO) approval in 2001 of the International Convention on the Control of Antifouling Systems (Dafforn et al. 2011), to which Brazil is a signatory. In 2003, the Brazilian Navy suspended the use of TBT on all vessels, which was regulated by Decree nº 76/DPC, on July 30, 2007 (Kugler 2014). In the current research, there was no patent application for a biocidal substance containing TBT or any other

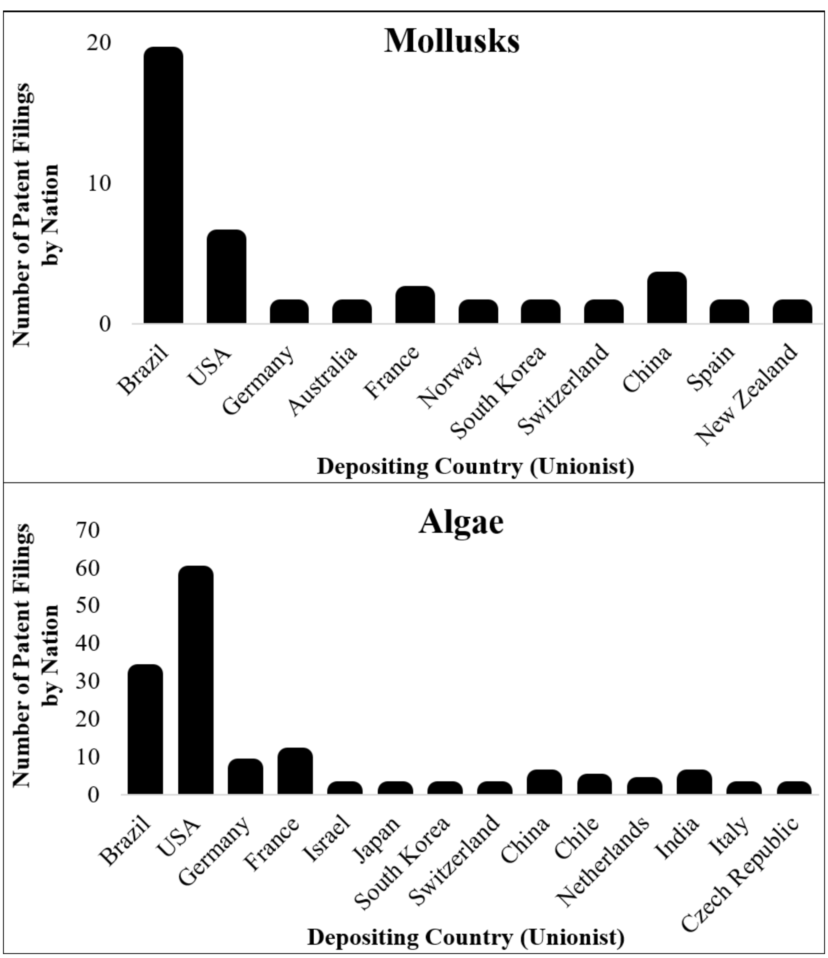

Figure 3. Distribution of patent records from the INPI database related to the Mollusk and Algae groups by country of origin of the request.

organotin compound, reflecting the regulation of the use of this substance.

Crustaceans stood out in the categories involving equipment for processing this resource, and these results highlight important demands from the aquaculture sector of these organisms in Brazil. The shrimp for example, which is the most economically traded organism nationally and internationally among crustaceans (IBGE, unpublished data), generates around 50-60% of waste during the handling process, including head, tail, and shell (Kim & Mendis 2006, Saini et al. 2018). Therefore, it is understandable that inventive activities are committed to improving and/or expanding the processing and processing stages of this group. According to Mao et al. (2017), countries should invest in the use of shrimp waste and strengthen the bioeconomy. In addition to shrimps, important biomaterials of crustaceans, such as proteins, chitin, and carotenoids, have been identified as products with high added value (Kandra et al. 2011, Sila et al. 2012, Kaur & Dhillon 2015).

In general, the data reported here suggest that the number of patents is incipient for such a biologically diverse country (Lewinsohn & Prado 2005) and with recent projections of escalating fisheries and aquaculture development (FAO, unpublished data). This is evidenced, quantitatively, when we compare our findings to the results of Vincent et al. (2017), who analyzed patents related to the fishing sector in 20 countries (China, Japan, USA, France, Russia, Norway, Germany, United Kingdom, Spain, Finland, etc.) during the period from 2000 to 2015. The authors quantified more than 274 thousand patents in total, with more than 10,000 patents related to the fishing sector per nation, annually. In contrast, the last 2018 report showed that 27,444 patent applications were filed in Brazil in their entirety (in the most diverse sectors) (INPI, unpublished data), and approximately 3,738 (in the most diverse sectors) were granted annually among the 2000-2017 years. This leads us to a reflection on the need to stimulate more and more innovative activity and patenting in the country, especially in the Brazilian fishing and aquaculture sector, since Brazil has a vast coastline exploited in fishing and favorable environmental characteristics for aquaculture development.

The first patent involving the use of fisheries organisms in Brazil was registered in 1975, which is consistent with the creation of INPI, through Law nº 5,648 (December 14, 1970). The growth in patent applications since the 1970s may be related to the emergence and improvement of international laws and agreements. In 1970, the World Intellectual Property Organization (WIPO) was created; and on December 24, 1974, the Industrial Property Code for Brazil was created, through Law nº 5,772. These organizations and laws were a milestone in improving trade relations involving patents; it was also in 1974 that WIPO became a United Nations agency to manage intellectual property issues based in Geneva (Menescal 2005).

Law nº 9,279, which deals with Industrial Property (BRASIL, unpublished data), came into force on May 15, 1997. Through it, Brazil granted patents for foods, medicines, and substances obtained from chemical processes, which explains the tendency number of patent applications from that year to its peak in 2005.

The priority principle ensures that, based on the first patent application filed in one of the signatory countries, the applicant can apply for protection for the same invention in any other signatory in the CUP or TRIPS countries (INPI, unpublished data). Countries such as the United States are major research funders and therefore always develop new technologies, so they need to register multiple patents in other nationalities to ensure exclusivity and financial return (Jaffe & Lerner 2011). According to Lucena & Bennett (2013), Brazil's active interaction with these countries, which are economic powers and may invest in our research and/or facilitate our national and social leverage, is important.

It is noteworthy that in addition to economic partnerships, agreements aimed at optimizing bureaucratic procedures are also of great value when it comes to innovation. According to Silva et al. (2019), who analyzed the time and cost variables in the Brazilian patent process, the time taken to review and grant a patent may take up to 11 years, and the registration of a trademark about two years. It is a long time if we consider that in the US a patent applicant has his first response within 13 months (Popp et al. 2004), in Japan the average grant time is between 20 to 30 months, and in Germany, the full process time is 30 months (Silva et al. 2019).

It is worth clarifying that Brazil is far from being seen as a backward country from a scientific and technological point of view, and this analysis of the patent records of fishing resources reinforces the idea of potentiality. According to Albuquerque & Sicsú (2000), Brazilian innovative productivity is regular because the country has an immature innovation system. According to Soares et al. (2016), Brazil has exhibited the highest patenting rates among Latin American countries. Brazil occupies an intermediate position in technological development in the global competitive scenario, more precisely, the 62nd position in the Global Innovation Index (GII) involving 131 economies (WIPO, unpublished data). This position of Brazil in the ranking (GII) has improved since 2018 – 64nd position (WIPO, unpublished data).

In this regard, several authors reinforce that countries such as the USA, Japan, China, and Germany, which were reported during this survey as recurrent patent applicants in the INPI database and have high levels of industrial productivity, are leaders in the electro-industrial complex mainly due to the maintenance of technological capacity (intellectual capital, research institutions, and infrastructure), industry performance standards (diversified multidivisional corporation), international transfer of production stages with coordinated value chain management in a geographically dispersed manner and a robust and stable relationship between public and private investments in R&D (Gereffi et al. 2005, Mamede et al. 2016, Hiratuka & Sarti 2017, Gama et al. 2019). Highlighting the aspect of gross annual R&D spending in these countries, according to GII data in 2018, the US invested 2.8% of its GDP in R&D, equivalent to the US $ 575.1 billion; China designated 2.1% of its GDP (the US $ 285 billion), and Japan and Germany allocated approximately 3.1% of GDP, US $ 159 and US $ 122.4 billion, respectively (WIPO, unpublished data). While Brazil has earmarked little of its GDP to encourage research, including public and business spending, in 2018 1.5% of GDP was earmarked, an amount of US $ 28 million (WIPO, unpublished data). This is much less than the average of the countries previously mentioned, but it is above Latin countries that allocate less than 1% of their GDPs, such as Chile (the US $ 11.93 million) and Argentina (the US $ 2.6 million) (WIPO, unpublished data). The author Schwartzman (2008) warns that this is a very common "mistake" in developing countries, as they cannot see that R&D incentives generate economic advantages. Not surprisingly, the USA, Japan, China, and Germany have high economic indicators and have better chances of facing economic problems, in addition to increasing global competitiveness, strengthening the economy, and generating opportunities for society (Fazzio 2017, Zawalińska et al. 2018).

Looking at investments per capita, the discrepancy appears even greater. While in the USA, R&D expenditure is equivalent to the US $ 1,586.00 per inhabitant and Japan's expenditure is the US $ 1,297.00 per inhabitant, in Brazil this investment is around the US $ 177.89 per inhabitant; this is an "approximate" value for Chinese expenditure (the US $ 388.00), and higher than that of India (the US $ 39.37), due to significant dilution due to the size of its population (WIPO, unpublished data, OECD 2020). Another data to cite is the number of researchers per million inhabitants, Israel impresses with 8,250.5 FTE researchers/ mn pop (full-time equivalence / per million inhabitants), Japan and Germany surpass the mark of 5,000 FTE researchers/mn pop, USA and England have a "network" of more than 4,000 researchers (4,256.3 FTE / mn pop), Brazil has 881.4 FTE / mn pop researchers, Argentina 1,232.6 FTE / mn pop researchers and Chile 503.1 FTE / mn pop researchers (WIPO, unpublished data), proportions considered low in relation to global intellectual capital (UNESCO-UIS, unpublished data). Authors like Betarelli Junior et al. (2020), Arbix et al. (2017), Etzkowitz & Zhou (2017) among others, affirm that robust investments in R&D generate a stock of intellectual knowledge, therefore, the collection of scientists and researchers that a country has is proportional to the nation's development ambitions.

Before the pandemic (COVID-19), it was noted that global intellectual property deposit activity grew at a rapid pace, setting new records in 2018 and 2019, with strong growth also seen in trademarks, industrial designs, and other forms of IP (WIPO, unpublished data). The impacts of the global crisis (arising from the pandemic) on innovation are uncertain and highly dependent on recovery and business scenarios and innovation practices and policies put in place in the coming years (Dutta et al. 2020).

In this context of Brazilian scientific and technological development, we highlight universities and research institutions as the fundamental "driving forces" (Garnica & Torkomian 2009, Angeli et al. 2013). In Brazil, it is mainly in the academic environment that technological production is developed, and as Negri (2018) emphasizes, it is unimaginable for a country to be innovative and scientifically competitive without a strong scientific base and a comprehensive and quality educational system. And even though research in Brazilian universities and research institutions is characterized by freedom of investigation, and does not necessarily have to result in something marketable that meets the market, the participation of these organizations in the patenting activity is highlighted by the relevant academic skills in multiple areas and in reason of the fragility of national companies to invest in the development of R&D (Angeli et al. 2013).

It is also important to emphasize that there is a very complex discussion about the mandatory transfer of technologies and products by universities and research institutions to society and market, what some authors call "the commodification of universities", however, we call attention to the model proposed by Etzkowitz & Leydesdorff (1997, 1998): the "triple helix", which considers that interactions between university-industry-government are the path to economic growth and social development, with the progress of science being converted into better living conditions for all, through cooperative relationships among these promoting agents (Etzkowitz & Zhou 2017). The "triple helix" model already guides Brazil's innovative processes, including legal support in the Innovation Law No. 10,973, which provides for incentives to innovation and scientific and technological research, stimulating partnerships between academic institutions and the Brazilian productive sector (BRASIL, unpublished data). Based on these regulations, the Technological

Innovation Centers and their respective Technological Information Offices were created, which are responsible for managing the intellectual property rights of their respective universities.

In addition to the institutions mentioned above, in the ranking of the twenty largest patent depositors residing in Brazil in 2015, the following stand out: Universidade de São Paulo (USP), Universidade Estadual de Campinas (UNICAMP), Universidade Federal de Minas Gerais (UFMG), Universidade Federal do Paraná (UFPR), Universidade do Estado de São Paulo (UNESP), Universidade Federal do Rio Grande do Sul (UFRGS), Universidade Federal do Rio Grande do Norte (UFRN), Universidade Federal de Pernambuco (UFPE), Universidade Federal do Ceará (UFC), Universidade Federal de Santa Maria (UFSM), Universidade Tecnológica Federal do Paraná (UTFPR), Universidade Federal da Bahia (UFBA), Universidade Federal do Pará (UFPA), Universidade Federal da Paraíba (UFPB) and Universidade Federal de Santa Catarina (UFSC) (INPI, unpublished data). These universities received support to promote research (which resulted in patent applications) through economic subsidies, credits, and research grants mainly by national and state agencies. Large and medium-sized Brazilian universities seem to be more efficient in producing patents. The research analyzed the institutional factors of patent activity at universities in the Czech Republic conducted by Maresova et al. (2020) shows that the ratio of efficiency and patent production is influenced by the size of a university.

In addition to universities and research institutes, it is worth emphasizing the importance of creating incubators and startups in these institutions, which are shared spaces that provide new students from different undergraduate courses get practical experiences and innovate in their respective areas of activity with the production of essential technological products for society (Becker 2015). According to Bronzini & Piselli (2016), business incubators and/or startups appear in a context of major changes in the national and international economic scenario, where innovation is fundamental for companies, in the face of the challenge of becoming more competitive (Betarelli Junior et al. 2020). Besides, these incubators and startups have aroused a growing interest on the part of government entities, both in developed and developing countries, due to a possible strengthening of relations between these partners, which can generate mutual benefits, in addition to contributing strongly to the improvement of the industrial competitiveness of countries (Vedovelo 2000).

In this scenario of contributing with new technologies in the scope of aquatic resources, it is observed that business incubators and startups in biological and fisheries areas in different universities in Brazil created innovative solutions with products aimed at the conservation of biodiversity, environmental monitoring, and several others activities. It is essential to create companies that seek to understand the conservation and use of aquatic resources to improve society, requiring more investments, as the aquatic environments are complex and have biodiversity (still unknown) that can be used for scientific development, economic, social, and environmental.

Also, as Taveira et al. (2019) and Moura et al. (2019) reinforce, Brazil needs to expand business participation in the innovative scenario, and encourage more cooperation between companies and universities. And despite the bottlenecks existing in the Brazilian national patent system, ranging from organizational restrictions, low investment in R&D, costs in the patent process, long waiting times for concession, and difficulties in the process of adding value /

technical merit that make most of the projects (Negri 2018), the country has great potential for greater insertion in international trade, in this case, related to fishing resources, aquaculture or fishing.

Finally, it is worth emphasizing the need to identify results in different regions, since developed countries are directing their research towards new trends, because of the growing number of patents related to Artificial Intelligence, in addition to products associated with new technologies (Abadi & Pecht 2020). Therefore, investing in new trends and technological lines can be a valuable tool for governments, universities, and companies in the development of research that results in patents or products based on the use of aquatic resources.

It is important to note that this study focused on the Brazilian patent system applied to data on fisheries resources. Thus, we encourage further research aimed at understanding the Brazilian patent system and statistics related to the relevance of patents in various sectors, since patents are a valuable source of revenue (private and social gains), and should not be considered simply as an option for the legal protection of inventions.

CONCLUSIONS

Among the fishing resources with the highest number of patent applications in Brazil, fish were more representative, mainly in inventions developed for the transport, capture, and processing machines. The algae group ranks second, as algae concentrate most deposits in the cultivation and biotechnology sectors, mainly for application in the manufacture of medicines, beauty products, biodiesel, fish farming, preparation of organic compounds, and production of fats or acids fatty. Regarding the group of mollusks, the main sector of use was the area of biocides. As for crustaceans, the group showed a greater inclination towards the equipment and processing sector.

Brazil still has few inventions related to fishing resources deposited in the INPI system if we consider investments in inputs, production, creation, and industrialization in the country's fisheries and aquaculture area in the last years analyzed (1999-2019). It is possible to consider that the number of patent applications in Brazil does not reflect the real development of the sector. Besides, these records do not appear to be primarily targeting technologies aimed at increasing food production, a fundamental need considering the growth of the world population. There is a lack of investment in highly biodiverse regions, such as the Amazon, compared to biomes located in the most southern and southeastern parts of the country.

This may be linked to the low investment in research and technology for this region and the low number of Graduate Programs, Incubators, Startups, and Companies, which ensure the conscious production of products from biodiversity. Besides, Brazil needs to reexamine national investments in R&D, as well as improve laws and reinforce existing initiatives, such as the legal framework for science, technology, and innovation. By boosting innovation and expanding its biotechnology market (mainly aquatic organisms), Brazil will be able to strengthen its patenting and economy system. Thus, considering its biological fishing and aquaculture potential, more targeted efforts are needed for selective fishing gear, sustainable industrial vessels, sustainable processing of fish meat, uses of fishery by-products (fish leather, crustacean shell, mollusk shells), among others.

Technological growth focused on the use of fishing resources in the country requires re-education and valorization of fishing products by the Brazilian, encouraging institutions and private companies to seek to develop processes and products aimed at this sector more quickly.

Brazil should strengthen, or better, revive its industrial process and evolve towards a high added value industry. Brazilian companies, whether 100% national or transnational, need support to position themselves in the tertiary sector. The protection of intellectual property in Brazil still has high costs and demands a lot of time in the development stages until the offer of new products and services to society, therefore, there must be stimulation from the primary sector to the tertiary sector, passing fundamentally through the stage of stimulation of R&D, increased intellectual productive capacity and industrial development. Also, the Brazilian industrial property system must be constantly revised and updated, to be efficient in the face of technological evolution obstacles and competition barriers in the markets.

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REFERENCES

ABADI HHN & PECHT M. 2020. Artificial Intelligence Trends Based on the Patents Granted by the United States Patent and Trademark Office. IEEE Access 8: 81633-81643.

AHMADPOOR M & JONES B. 2017. The dual frontier: Patented inventions and prior scientific advance. Science 357 (6351): 583-587.

ALBUQUERQUE EM & SICSÚ J. 2000. Inovação Institucional e Estímulo ao Investimento Privado. Sao Paulo Perspec 14(3): 108-114.

ALBUQUERQUE EM, SIMÕES R, BAESSA A, CAMPOLINA B & SILVA L. 2002. A distribuição espacial da produção científica e tecnológica brasileira: uma descrição de estatísticas de produção local de patentes e artigos científicos. Rev Bras Inov 1: 225-251.

ALMEIDA CS, FEITOSA EMS, SILVA CAS, SANTOS IMS, GUEDES EAC, COLIN FN, CAETANO LC, SILVA BLR & PINOTTI LM. 2007. Obtenção e caracterização de extratos de algas para uso na indústria de cosméticos. Infarma 19: 154-159.

ALONSO-MARTÍNEZ D. 2018. Social progress and international patent collaboration. Technol Forecast Soc Change 134: 169-177.

ANGELI R, DIAS S & FILGUEIRAS R. 2013. Difusão da propriedade intelectual na Universidade Federal do Rio de Janeiro: disciplina de propriedade industrial e inovação em biotecnologia. Rev Gest Inov Tecnol 3: 261-272.

ARAMAYO V. 2015. Lower selectivity can help heavily exploited fish populations. Fish Res 172: 261-264.

ARAÚJO EF, BARBOSA CM, QUEIROGA ES & ALVES FF. 2010. Propriedade Intelectual: proteção e gestão estratégica do conhecimento. Rev Bras Zootecn 39: 1-10.

ARBIX G, SALERNO MS, AMARAL G & LINS LM. 2017. Avanços, Equívocos E Instabilidade Das Políticas De Inovação No Brasil. Novos Estud CEBRAP 36(3): 9-27.

ARIEDE MB, CANDIDO TM, JACOME ALM, VELASCO MVR, CARVALHO JCM & BABY AR. 2017. Cosmetic attributes of algae - A review. Algal Res 25: 483-487.

BAGLEY MA. 2003. Patent first, ask questions later: morality and biotechnology in patent law. Wm & Mary L Rev 45: 469-470.

BATISTA AD. 2012. Biopirataria: a afronta a biodiversidade e propriedade intelectual. Rev EPeQ Fafibe 1: 46-50.

BECKER B. 2015. Public R&D policies and private R&D investment: A survey of the empirical evidence. J Econ Surv 29(5): 917-942

BEKTAS C, PECE A, SIMONA O & SALISTEANU F. 2015. Innovation and economic growth: an empirical analysis for cee countries. Procedia Econ Financ 26: 461-467.

BESSANT J & TIDD J. Inovação e empreendedorismo. 2009. Porto Alegre, Brazil: Bookman, p. 19-49.

BESSEN J. 2009. Estimates of patent rents from firm market value. Res Policy 38(10): 1604-1616.

BETARELLI JUNIOR AA, FARIA WR, MONTENEGRO RLG, BAHIA DS & GONÇALVES E. 2020. Research and development, productive structure and economic effects: Assessing the role of public financing in Brazil. Econ Model 90: 235-253.

BRASIL BSAF & GARCIA L. 2016. Microalgas: alternativas promissoras para a indústria. Agroenergia Rev 10: 6-11.

BRONZINI R & PISELLI P. 2016. The impact of R&D subsidies on firm innovation. Res Policy 45(2): 442-457.

CALIXTO JB. 2000. Biopirataria. A diversidade biológica na mira da indústria farmacêutica. Cienc Hoje 28: 36-43.

CANTWELL JA & JANE M. 1999. Technological globalization and innovative centers: the role of corporate technological leadership and locational hierarchy. Res Policy 28: 119-144.

DA GAMA BAP, PEREIRA RC & COUTINHO R. 2009. Bioincrustação marinha. In: Pereira RC & Soares-Gomes A (Eds), Biologia Marinha, 2nd Ed, Rio de Janeiro: editora Interciência, BRASIL, p. 299-318.

DAFFORN KA, LEWIS JA & JOHNSTON EL. 2011. Antifouling strategies: history and regulation, ecological impacts and mitigation. Mar Pollut Bull 62: 453-465.

DHARGALKAR V & PEREIRA N. 2005. Seaweed: Promising plant of the millennium. Sci Cult 71: 60-66.

DINIZ MB & DINIZ MJT. 2018. Exploração dos recursos da biodiversidade da Amazônia Legal: uma avaliação com base na abordagem do Sistema Nacional/Regional de Inovação. Rev Desenvolv Reg (REDES) 23: 210-237.

DUTTA S, REYNOSO RE, LANVIN B, WUNSCH-VINCENT S, LEÓN LR, GARANASVILI A & BAYONA P. 2020. The global innovation index 2020. Chapter 1, 40 p.

EICHENGREEN B. 2004. Productivity growth, the new economy, and catching up. Rev Int Econ 12: 243-245.

ELOY CC, VIEIRA DM, LUCENA CM & ANDRADE MO. 2014. Apropriação e proteção dos conhecimentos tradicionais no Brasil: a conservação da biodiversidade e os direitos das populações tradicionais. Gaia Scientia Ed Esp 8(2): 189-198.

ENCAOUA D, GUELLEC D & MARTÍNEZ C. 2006. Patent systems for encouraging innovation: lessons from economic analysis. Res Policy 35: 1423-1440.

ERNST H, LEGLER S & LICHTENTHALER U. 2010. Determinants of patent value: Insights from a simulation analysis. Technol Forecast Soc Change 77: 1-19.

ETZKOWITZ H & LEYDESDORFF L. 1997. Introduction to special issue on science policy dimensions of the Triple Helix of university-industry-government relations. Sci Public Policy 24(1): 2-5.

ETZKOWITZ H & LEYDESDORFF L. 1998. The endless transition: A 'Triple Helix' of university industry-government relations. Minerva 36: 203-208.

ETZKOWITZ H & ZHOU C. 2017. Hélice Tríplice: inovação e empreendedorismo universidade-indústria-governo. Estud Av 31(90): 23-48.

FAZZIO D. 2017. Uma breve análise do financiamento da pesquisa no Brasil. Pesq ABC 9: 2-6.

FERREIRA PS, HASNER C & SANTOS D. 2016. O potencial e o perfil das patentes verdes em conservação e renovação de energia no Brasil. Cad Prospec 9: 111-120.

FONSECA CR & VENTICINQUE EM. 2018. Biodiversity conservation gaps in Brazil: A role for systematic conservation planning. Perspect Ecol Conser 16: 61-67.

FRANÇA E & VASCONCELLOS AG. 2018. PATENTES DE FITOTERÁPICOS NO BRASIL: UMA ANÁLISE DO ANDAMENTO DOS PEDIDOS NO PERÍODO DE 1995-2017. Cad Cienc Tecnol 35: 329-359.

FURMAN JL, PORTER ME & STERN S. 2002. The determinants of national innovative capacity. Res Policy 31: 899-933.

GAMA F, BASTOS S & CARDOSO G. 2019. CAPITAL HUMANO E GERAÇÃO DE INOVAÇÃO: UMA ANÁLISE PARA PAÍSES EM DIFERENTES NÍVEIS DE DESENVOLVIMENTO TECNOLÓGICO. Rev Estud & Debate 26(4): 30-46.

GARNICA LA & TORKOMIAN ALV. 2009. Gestão de tecnologia em universidades: uma análise do patenteamento e dos fatores de dificuldade e de apoio à transferência de tecnologia no Estado de São Paulo. Gest Prod 16: 624-638.

GAZNI A. 2020. The growing number of patent citations to scientific papers: Changes in the world, nations, and fields. Technol Soc 62: 101276. https://doi.org/10.1016/j.techsoc.2020.101276.

GEREFFI G, HUMPHREY J & STURGEON T. 2005. The governance of global value chains. Rev Int Political Econ 12: 78-104.

GILBERT R J. 2006. Competition and innovation. J Ind Organ Educ 1: 1-23.

GONÇALVES E & FAJARDO BAG. 2011. A influência da proximidade tecnológica e geográfica sobre a inovação regional no Brasil. Rev Econ Contemp 15: 112-142.

HABER S. 2016. Patents and the wealth of nations. Geo Mason L Rev 23: 811-835.

HALL J, MATOS ST, MARTIN M & MICHAEL JC. 2014. Innovation pathways at the base of the pyramid: establishing technological legitimacy through social attributes. Technovation 34: 284-294.

HENRY C & STIGLITZ JE. 2010. Intellectual property, dissemination of innovation and sustainable development. Glob Policy 3: 237-251.

HIRATUKA C & SARTI F. 2017. Transformações na estrutura produtiva global, desindustrialização e desenvolvimento industrial no Brasil. Rev Econ Polit 37(146): 189-207.

HOMMA AKO. 2008. Extrativismo, biodiversidade e biopirataria na Amazônia. Brasília. Distrito Federal: Embrapa Informação Tecnológica, 97 p.

HUSSINGER K & PACHER S. 2019. Information ambiguity, patents and the market value of innovative assets. Res Policy 48(3): 665-675.

JAFFE AB & LERNER J. 2011. Innovation and its discontents: How our broken patent system is endangering innovation and progress, and what to do about it. Princeton. Oxford: Princeton University Press, 256 p.

KANDRA P, CHALLA MM & JYOTHI HKP. 2011. Efficient use of shrimp waste: present and future trends. Appl Microbiol Biotechnol 93: 17-29.

KAUR S & DHILLON GS. 2015. Recent trends in biological extraction of chitin from marine shell wastes: a review. Crit Rev Biotechnol 35: 44-61.

KIM SK & MENDIS E. 2006. Bioactive com-pounds from marine processing byproducts – A review. Food Res Int 39: 383-393.

KLINE P, PETKOVA N, WILLIAMS H & ZIDAR O. 2019. Who profits from patents? rent-sharing at innovative firms. Q J Econ 134(3): 1343-1404.

KOLANJINATHAN K, GANESH P & SARANRAJ P. 2014. Pharmacological importance of seaweeds: A review. World J Fish Marine Sci 6: 1-15.

KUGLER H. 2014. No silêncio dos mares: substância altamente tóxica é usada de forma ilegal na costa brasileira. Cienc Hoje 311: 32-37.

LEMA R, RABELLOTTI R & SAMPATH PG. 2018. Innovation Trajectories in Developing Countries: Co-evolution of Global Value Chains and Innovation Systems. Eur J Dev Res 30: 345-363.

LEVIN R. 2004. A patent system for the 21st century. Issues Sci Technol 20: 49-54.

LEWINSOHN TL & PRADO PI. 2005. Quantas espécies há no Brasil? São Paulo. Brazil: Megadiversidade, 42 p.

LUBANGO LM & POURIS A. 2010. Is patenting of technical inventions in university sectors impeding the flow of scientific knowledge to the public? a case study of South Africa. Technol Soc 32 (3): 241-248. https://doi.org/10.1016/j.techsoc.2010.07.003.

LUCENA AF & BENNETT IG. 2013. China in Brazil: the quest for economic power meets Brazilian strategizing. Carta Internacional 8 (2): 38-57. https://cartainternacional.abri.org.br/Carta/article/view/112.

MAMEDE M, SANTA RITA LP, OLIVEIRA SÁ EM, RADAELLI V, GADELHA DP, SOUSA JUNIOR CC & UGGIONI N. 2016. Sistema nacional de inovação: uma análise dos sistemas na Alemanha e no Brasil. Rev Gest & Tecnol (NAVU) 6(4): 6-25.

MAO X, GUO N, SUN J & XUE C. 2017. Comprehensive utilization of shrimp waste based on biotechnological methods: A review. J Clean Prod 143: 814-823.

MARESOVA P, SOUKAL I, STEMBERKOVA R & KUCA K. 2020. Innovation in the public sector in a small open economy-initial investigation of patent activity at the Czech universities. J Innov Entrep 9(1): 1-16.

MARESOVA P, STEMBERKOVÁ R & FADEYI O. 2019. Models, Processes, and Roles of Universities in Technology Transfer Management: A Systematic Review. Adm Sci 9(3): 67.

MARTINS LG. 2017. O registro de patentes e conhecimento tradicional: proteção da biodiversidade? Vianna Sapiens 8: 359-385.

MATOS AP. 2017. The impact of microalgae in food science and technology. J Am Oil Chem Soc 94(11): 1333-1350.

MENDES L, AMORIM-BORHER B & LAGE C. 2013. Patent applications on representative sectors of biotechnology in Brazil: and analysis of the last decade. J Technol Manag Innovat 8: 91-102

MENESCAL AK. 2005. Changing WIPO'S Ways: The 2004 Development Agenda in Historical Perspective. J World Intell Prop 8: 761-768.

MENEZES CCN, SANTOS SMD & BORTOLI R. 2016. Mapeamento de Tecnologias Ambientais: Um Estudo sobre Patentes Verdes no Brasil. Rev Gest Ambient Sustentabilidade 5: 18-32.

MITTERMEIER RA. 1988. Primate Diversity and the Tropical Forest Case Studies from Brazil and Madagascar and the Importance of the Megadiversity Countries. In: Wilson EO & Peter FM (Eds), Biodiversity. Washington: National Academy Press, USA, p. 145-154.

MITTERMEIER RA, GIL PR & MITTERMEIER CG. 1997. Megadiversity: Earth's biologically Wealthiest Nations. 1 Ed. Mexico: Cemex, 501 p.

MOURA AMM, GABRIEL JUNIOR RF, MAGNUS APM, BOCHI FS & SCARTASSINI VB. 2019. Panorama das patentes depositadas no Brasil uma análise a partir dos maiores depositantes de patentes na base Derwent Innovations Index. Braz J Inf Sci 13(2): 59-68.

NEGRI F. 2018. Novos caminhos para a inovação no Brasil. 1 Ed. Washington DC: Wilson Center, 159 p.

OECD – ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT. 2020. Gross domestic spending on R&D (indicator). doi: 10.1787/d8b068b4-en.

OLDHAM P, HALL S & FORERO O. 2013.Biological Diversity in the Patent System. PLoS ONE 8: e78737.

PAULA G. 2001. Os desafios da indústria farmacêutica global e o redesenho do negócio pela Merck. Rev Adm Empres 41: 76-87.

POPP D, JUHL T & JOHNSON DK. 2004. Time in purgatory: Examining the grant lag for US patent applications. Topics Econ Anal Policy 4: 29-29.

RAITERI E. 2018. A time to nourish? Evaluating the impact of public procurement on technological generality through patent data. Res Policy 47: 936-952.

REITZIG M. 2003. What determines patent value? Insights from the semiconductor industry. Res Policy 32: 13-26.

RIBEIRO B & SHAPIRA P. 2020. Private and public values of innovation: A patent analysis of synthetic biology. Res Policy 49: 415-427.

ROTTER A ET AL. 2020. A new network for the advancement of marine biotechnology in Europe and beyond. Front Mar Sci 7 (278): 1-9.

SAINI RK, MOON SH & KEUM YS. 2018. An updated review on use of tomato pomace and crustacean processing waste to recover commercially vital carotenoids. Food Res Int 108: 516-529.

SANTOS D, MARTINEZ M, REIS P & OSAWA C. 2015. Inovações patenteadas no âmbito das tecnologias limpas: estudo de casos depositados no programa piloto de patentes verdes do INPI. Blucher Chem Eng Proc 1: 7410-7416.

SANTOS SS. 2015. Perspectivas da proteção do patrimônio genético nacional na concessão de patentes. Cad Prospec 8: 425-431.

SCHIAVETTI A, MANZ J, SANTOS CZ, MAGRO TC & PAGANI MI. 2013. Marine protected areas in Brazil: an ecological approach regarding the large marine ecosystems. Ocean Coast Manage 76: 96-104.

SCHWARTZMAN S. 2008. University and development in Latin America: successful experiences of research centers. Rio de Janeiro: Institute of Labor and Society Studies: Sense, 284 p.

SELLERS-RUBIO R, NICOLAU-GONZALBEZ J & MAS-RUIZ F. 2007. The economic value of patent protection and rivalry in the Spanish electrical sector. Eur J Innov Manage 10: 434-452.

SILA A, NASRI M & BOUGATEF A. 2012. Isolation and characterisation of carotenoproteins from deep-water pink shrimp processing waste. Int J Biol Macromol 51(5): 953-959.

SILVA OR, RAINATTO G, SANTOS FA & VENANZI D. 2019. Análise comparativa do processo de patente brasileiro considerando as variáveis e custos de concessão dos pedidos. Cafi 2: 211-225.

SOARES TJCC, TORKOMIAN ALV, NAGANO MS & MOREIRA FGP. 2016. O SISTEMA DE INOVAÇÃO BRASILEIRO: UMA ANÁLISE CRÍTICA E REFLEXÕES. Interciencia 41(10): 713-721.

SOUZA LAR, AZEVEDO TCG, SILVA FRF, CARDOSO ML, XAVIER CAC, ROCHA HAO, DORES CMPG & LEITE EL. 2007. Caracterização química e ação farmacológica de polissacarídeos sulfatados extraídos da alga marinha *Amanslamultifida*. Infarma 19: 3-7.

STEMBERKOVÁ R, ZDRÁLEK P, MATULOVÁ P, MARESOVÁ P & KUCA K. 2017. Evaluation of Research and Development in Malaysia. Adv Sci Lett 23(4): 2744-2747.

SUDHAKAR MPB, RAMESH KUMAR B, MATHIMANI T, MATHIMANI T & ARUNKUMAR K. 2019. A review on bioenergy and bioactive compounds from microalgae and macroalgae-sustainable energy perspective. J Clean Prod 228: 1320-1333.

SUZUKI J. 2011. Structural modelling of the value of patente. Res Policy 40: 986-1000.

SVAVARSSON J. 2000. Imposex in the dogwhelk (*Nucella lapillus*) due to TBT contamination: improvement at high latitudes. Mar Pollut Bull 40: 893-897.

TAVEIRA JG, GONÇALVES E & FREGUGLIA RDS. 2019. The missing link between innovation and performance in Brazilian firms: a panel data approach. Appl Econ 51(33): 3632-3649.

TOLEDO AGL & CAMPOS LA. 2018. PATENTES VERDES E O SETOR DE FABRICAÇÃO DE ABRASIVOS NO BRASIL: DISCUTINDO O POTENCIAL ESTRATÉGICO DO PROGRAMA À LUZ DO *SHARED VALUE*. Rev Gest Ambient Sustentabilidade 7: 146-161.

UDDIN SA & ISLAM MM. 2019. Blue Biotechnology, Renewable Energy, Unconventional Resources and Products as Emerging Frontiers at Sea. J Ocean Coast Econ (JOCE) 6: 1-25.

VALLI M, RUSSO HM A & BOLZANI VS. 2018. The potential contribution of the natural products from Brazilian biodiversity to bioeconomy. An Acad Bras Cienc 90: 763-778.

VALOIS ACC. 1998. Biodiversidade, biotecnologia e propriedade intelectual (um depoimento). Cad Cienc Tecnol 15: 21-31.

VEDOVELO C. 2000. Aspectos Relevantes de Parques Tecnlógicos e Incubadoras de Empresas. Rev BNDES 7(14): 273-300.

VERZOLA SC & FURNIVAL AC. 2019. A lei da biodiversidade e a relativização dos conhecimentos tradicionais para a inovação. Rev Cereus 11: 32-47.

VINCENT CL, SINGH V, CHAKRABORTY K & GOPALAKRISHNAN A. 2017. Patent data mining in fisheries sector: An analysis using Questel-Orbit and Espacenet. World Pat Inf 51: 22-30.

WELLS ML, POTIN P, CRAIGIE JS, RAVEN JA, MERCHANT SS, HELLIWELL KE, SMITH AG, CAMIRE ME & BRAWLEY SH. 2017. Algae as nutritional and functional food sources: Revisiting our understanding. J Appl Psychol 29: 949-982.

YANAGISAWA T & GUELLEC D. 2009. The Emerging Patent Marketplace. OECD Sci Technol Ind Work Papers, 52 p.

ZAWALIŃSKA K, TRAN N & PŁOSZAJ A. 2018. R&D in a post centrally-planned economy: The macroeconomic effects in Poland. J Policy Model 40: 37-59.

ZDRÁLEK P, STEMBERKOVÁ R, MATULOVÁ P, MARESOVÁ P & KUCA K. 2017. Commercial Potential of University Patents Through Patent Cooperation Treaty Application. Adv Sci Lett 23(4): 2676-2680.

ZUCOLOTO GF & CASSIOLATO JE. 2013. Desenvolvimento tecnológico por origem de capital: a experiência brasileira recente. Rev Bras Inov 12: 133-170.

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