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Global status of production and commercialization of soft-shell crabs

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Abstract Commercial exploration of swimming crab is rapidly increasing worldwide. In 2015, total production of crabs (fisheries plus aquaculture) reached almost 1300 thousand tons. One of the most valuable marketing forms is called "soft-shell crab". The internet is one of the most important marketing channels for soft-shell crab, with prices starting at US$3.5 a unit, but going up to US$8.00–10.00, depending on the size and presentation form of the product (live, cooled, frozen, or processed). In luxury restaurants, a dish containing one large animal may cost well over US$75.00. Increasingly, this market requires exporting companies to present some kind of quality certification of the product or process (mainly certifications related to food safety). Almost all soft-shell crab production is based on crabs caught in the wild, by either trawling or trapping. Crab populations are suffering from environmental impacts associated with human activity, so much that obtaining the raw material (crabs in pre-molt stage) has become the biggest challenge for companies that market soft-shell swimming crab nowadays. Even recognizing the aquaculture as an alternate form to acquire crabs, it is necessary to understand that technology for commercial crab cultivation is still incipient and restricted to some species of few genera, such as *Scylla*, *Portunus*, and *Callinectes*. The present article reviews and discusses the problems and challenges related to

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the productive chain of soft-shell swimming crab, and presents an overview of the worldwide market, identifying the main exporting and importing centers, and their respective trading methods.

Keywords Portunidae · Molting · Farming · Fishing · Market

Introduction

Swimming crabs are decapod crustaceans of the Portunidae family, characterized by the adaptation of the last pair of pereiopods into flattened paddles for swimming. Commercial exploration of swimming crabs is an old industry. There is evidence of crabs being consumed in America prior to the arrival of English settlers at Chesapeake Bay (Rathbun 1887). According to the Global Biodiversity Information Facility (2016), there are about 714 known portunid crabs species in the world. Few of them are of commercial interest, and only a handful are cultured or sold as soft-shell swimming crabs, classified into three main genera: *Scylla*, *Portunus*, and *Callinectes* (Keenan and Blackshaw 1997; Zmora et al. 2005; Azra and Ikhwanuddin, 2015a; FAO 2015).

Crabs grow by shedding the old exoskeleton and replacing with a new one, through a periodic process known as molting cycle (Chang and Mykles 2011). Traditionally, they are sold as a whole piece (to be eaten by extracting the meat out of the exoskeleton) or sold as crabmeat (meat already extracted, manually or mecahnically) (Oesterling 1988). However, if captured soon after molting, while still bearing an unconsolidated exoskeleton, the entire body of the animal can be consumed, without necessity of extracting its meat, which has become a more profitable means for soft-shell crab production (Perry et al. 2010; FAO 2015; He 2015).

At the beginning of the nineteenth century, this relatively simple process became known as "soft-shell" crab. The production is based on the capture and maintenance of adult animals in under controlled conditions until molting occurs (Oesterling 1988). The animals are then collected before the beginning of exoskeleton hardening and are sold for higher prices (Mwaluma 2002; Primavera et al. 2010). Since then, soft-shelled crabs have gained popularity, especially in high gastronomy, thanks to characteristics such as excellent taste, high levels of protein together with a virtual absence of carbohydrates and fat, in addition to a general perception as a healthy food (Dana et al. 2015).

Soft-shell crab production process

Perry et al. (1982) divided the molting cycle of swimming crabs into four stages: intermolt, pre-molt, molt, and post-molt. Crustaceans generally spend the majority of their time in the intermolt stage. The pre-molt stage is the beginning of the ecdysis and may last several days. It is characterized by morphological cues of its progression. The molt stage is, in turn, relatively fast, with the crab rapidly shedding the old exoskeleton, followed by a process of calcification and hardening of the new exoskeleton, when the animal reaches the post-molt stage.

The market value of the product reduces as the crab exoskeleton hardens, therefore, elapsing time after molting is an extremely important issue to the trade of soft-shell crabs. Soon after molting, the new exoskeleton can be considered "truly soft", characterized by a high water content and low levels of calcification (Taylor and Kier 2003). This is the stage the crab must be consumed. As the calcification process advances, the exoskeleton begins to harden and in less than 1 h, the "leathery" consistency is reached (Wheatly 1999). After about 3 h, the consistency of the exoskeleton becomes very firm (Freeman et al. 1987) and the animal cannot be traded as soft-shell crab anymore.

The first experiments to keep crabs in captivity were conducted in America more than 150 years ago, using a system of cages (Perry et al. 1982). In southwest Asia, first trials began 50 years later, involving animals in enclosures (Keenan and Blackshaw 1997). In more recent decades, closed systems using water recirculation were developed for crab culture, both in the USA and Asia (Oesterling 1988, Perry et al. 2001, Geoff and Fielder 2004; Gaudé and Anderson 2011). Despite the higher costs associated with the installation and operation of closed systems, they allow greater control over environmental factors, facilitate animal handling and restraint, and minimize mortality losses (Perry et al. 1982). Although it is technically possible to maintain crabs in intermolt stage in captivity until molting, as a whole, the productive process will be faster and more efficient if the crabs are transferred to the shedding tanks already at pre-molt stage, because crabs at this stage take time less to begin molting (Oesterling 1988; Gaudé and Anderson 2011). Identifying animals at pre-molt stage requires a good knowledge about the molting cycle and the ability to observe early signs of molting stage. The main characteristic the detachment of the epidermis from the old exoskeleton. This can be done by visual inspection of the last pair of modified pereiopods, which will appear transparent. Among other characteristics, pre-molt animals will show a hyaline line in the region where the old exoskeleton detaching from the new, among other characteristics (Fig. 1). In such case, molting generally occurs in less than 13 days (Oesterling 1988).

Current risks and limitations to the swimming crab production

In industrial fisheries, crabs can be captured by bottom trawling or direct trap fishing (Guillory and Prejean 1997; Boutson et al. 2009; Songrak et al. 2013; Anderson and Alford 2014). Bottom trawling is targeted toward fish and shrimp while, crabs are considered incidental or ancillary catches (bycatch). The fishing gear used for trawling causes significant environmental impacts, mainly due to damage of benthic communities, habitats, and the large number of aquatic animals captured, killed, and discarded (Dinmore et al. 2003; Brandt and Gabriel 2005; FAO 2012). The use of traps specifically designed for crab minimizes environmental impacts associated with bycatch (Guillory and Prejean 1997; Songrak et al. 2013; Anderson and Alford 2014).

In recent years, the fishery production of soft-shell crabs has suffered from frequent and significant fluctuations, mainly due to irregular crab fishery landings (Kennedy and Cronin 2007; Shelley 2008; Gaudé and Anderson 2011; Shelley and Lovatelli 2011; Southern Regional Aquaculture, C., et al. 2011). About 73.5% of commercial-scale swimming crab production originates from wild-caught animals (FAO 2016), resulting in large variations in seasonal supply and commercialization of individual specimen size (Walton et al., 2006, Azra and Ikhwanuddin, 2015a). Natural stocks are very vulnerable to climatic and environmental changes and, particularly, to commercial fishing pressure (Lindner 2005; Shelley 2008; Shelley and Lovatelli 2011; Ikhwanuddin et al. 2012). Regardless of the fishing method, either trawling or trapping, the crab industry dependence of natural stocks is deemed unsustainable in the medium- and long-term (Lindner 2005; Shelley 2008; Shelley and Lovatelli 2011; Ikhwanuddin et al. 2012).

There is evidence that the reductions in natural stocks might have already started, as evident by the annual fluctuations in swimming crab fishing in some regions (Chesapeake Bay and Bi-State Blue Crab Technical Advisory 2006; Seitz et al. 2008; Johnston et al. 2011; FAO 2013). Uncontrolled fishing and environmental degradation were reported as the main causes behind the 70% reduction recorded in the *C. sapidus* populations in the Chesapeake Bay (USA), once one of the most productive crab fishing areas in North America (Zohar et al. 2008). The uncontrolled fishing of juvenile crabs for farming also has led this abrupt decline in natural stocks in crabs of the genera *Scylla* and *Portunus* in Southeast Asia (Shelley 2008, Johnston et al. 2011).

The socio-economic impacts of the reduction of natural stocks of swimming crabs has forced local governments to institute public policies to regulate captures (Beem 2010). Multiple projects have been developed with an interest in the conservation of natural stocks, and promotion of a deeper understanding of the interactions between these organisms (Keenan and Blackshaw 1997; Zohar et al. 2008; Lorenzen et al. 2010; Hart 2015). In 2002, experiments in Chesapeake Bay (USA) were conducted to study the feasibility of blue crab stock enhancement (Zohar et al. 2008). During 4 years of work, over 290,000 cultured crabs were experimentally released into the bay's nursery habitats, and increased local populations at release sites by 50–250%.

Crab aquaculture

One possible way to overcome the dependence on natural stocks for soft-shell crab industry is to rely the development of technology for reproduction, larval rearing, and cultivation of crabs in captivity (Zohar et al. 2008; Baticados et al. 2014; Mirera et al. 2014). Commercial crab aquaculture is practiced only in the USA and Asia. Unfortunately, the process is at a very early stage of technological development for most species (Zohar et al. 2008; Igarashi 2009; Paterson and Mann 2011; Azra and Ikhwanuddin 2015a).

Large-scale production of larvae and juveniles of *C. sapidus* in captivity is technically possible, although the final survivorship rates and overall results of the process are still unsatisfactory. The main obstacles are the excessive losses due to dietary and nutritional problems, as well as the high rates of cannibalism. To circumvent these problems, Zmora et al. (2005) suggest more research over different feeding strategies, use of shelters inside the larviculture tanks, and optimization of culture densities. The authors further suggest research on different ways to reduce megalopae size variability, such as separation of early megalopae by size, and even synchronization of molting, through hormonal or genetic control. More recently, a highly pathogenic reovirus (Bowers et al. 2011; Flowers et al. 2016) has been affecting the US commercial crab production facilities, may significantly compromise the pace of development of this species' rearing commercial technology.

Captive breeding of *Portunus* spp. has similar problems reported to *C. sapidus* (Paterson and Mann 2011). The larviculture of *Portunus* spp. depends entirely on wild-caught ovigerous females (Anand and Soundarapandian 2011; Azra and Ikhwanuddin 2015a). In addition, low survivorship during larviculture prevents the production of large numbers of healthy larvae (Azra and Ikhwanuddin 2015b). Much of this mortality is caused by cannibalism (Mann et al., 2007, Azra and Ikhwanuddin 2015a), and by lack of knowledge about nutritional requirements for each larval stage (Keenan and Blackshaw 1997; Geoff and Fielder 2004; Paterson and Mann 2011; Azra and Ikhwanuddin 2015a).

The greatest technological advances, in reproduction, larval rearing and juveniles and adults crab cultivation are being obtained for the mud crab *Scylla* spp. (Azra and Ikhwanuddin 2015, FAO 2015). The present state-of-art of the technology allows these crabs to be regularly cultivated in captivity and marketed as soft-shell swimming crabs (Shelley 2008). It is presently possible to carry out the entire production cycle of the *Scylla* species in captivity, from larvae to breeders, independently of natural stocks (Anand and Soundarapandian 2011; Azra and Ikhwanuddin 2015). The wide distribution of *Scylla* species in mangroves forests in Southeast and East Asia, associated with the dominance of this technology, explains why Asian countries are the largest producers of soft-shell crabs in the world. Among all species of *Scylla*, *S. serrata* is the most commercially attractive, because it is the largest and the most broadly distributed. So much that other species of the genus, such as *S. olivacea*, *S. tranquebarica*, and *S. paramamosain*, are often sold as *S. serrata* (Shelley and Lovatelli 2011).

The worldwide crab market

According to FAO (2016) data, the world fishery crabs' production (not only soft-shell crab but crab in general) is primarily comprised of *Scylla serrate* (Forsskål, 1775),*Scylla olivacea* (Herbst, 1796), *Portunus pelagicus* (Linnaeus, 1758), and *Callinectes sapidus* (Rathbun, 1896). Production has increased from 343 thousand t, in 1990, to more than 951,000 t, in 2015 (Fig. 1: 1- Fifth pereiopod of a pre-molt individual (*Callinectes ornatus*). A) Hyaline line

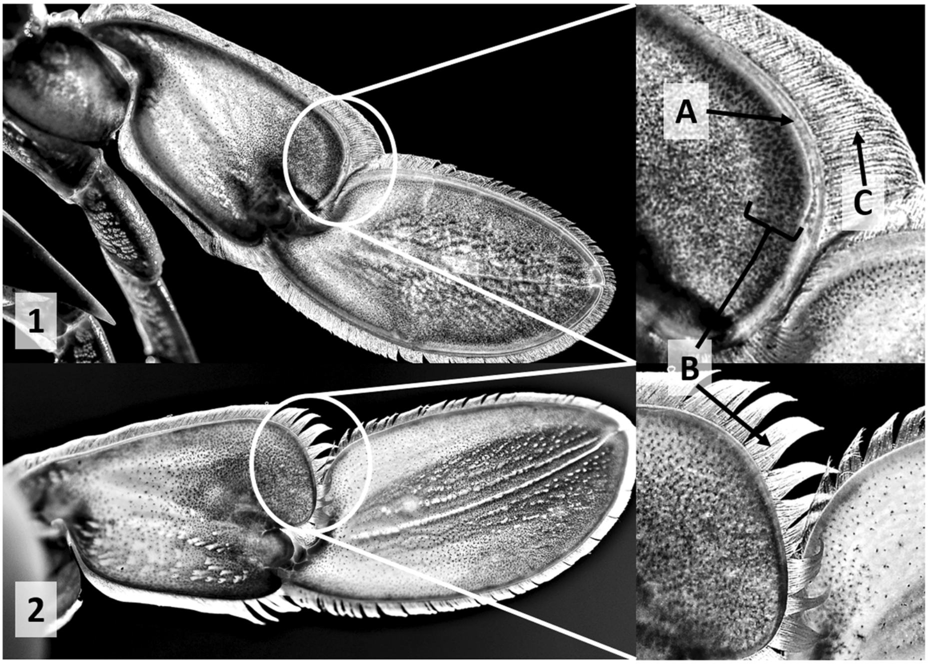

Fig. 1 1- Fifth pereiopod of a pre-molt individual (*Callinectes ornatus*). A) Hyaline line shows the old exoskeleton detaching from the new. B) The darker band stems from the folding of new exoskeleton bristles. C) Old exoskeleton bristles. 2 – Details of the pereiopod of the same individual in the post-molt stage (by Diogo Barbalho Hungria)

shows the old exoskeleton detaching from the new. B) The darker band stems from the folding of new exoskeleton bristles. C) Old exoskeleton bristles. 2 – Details of the pereiopod of the same individual in the post-molt stage (by Diogo Barbalho Hungria) Fig. 2). China accounts for 71.9% of the world annual production (684,400 t), followed by Indonesia (77,700 t), USA (72,400 t), and Philippines (27,200). However, precise information of the global production is limited as most production systems are small-scale or family-owned, and when carried out on an industrial scale, there is usually no interest in the disclosure of data or, very often, trade secrets are involved (Guillory et al. 2001). This difficulty limits the knowledge about real production data and often leads to the underestimation of the total amount produced (Caffey et al. 1993, Guillory et al. 2001).

Currently, the international market for soft-shell swimming crabs can be divided into two categories: (i) artisanal, in which animals are sold to local fishmongers, markets, and restaurants; (ii) industrial, in which import and export companies specialize in wholesale and retail, operating either over the internet or by direct sale to larger restaurants and markets. In the industrial market, electronic commerce (e-commerce) is becoming increasingly prominent, attracting the interest of investors and entrepreneurs worldwide (Table 1). Crabs are sold as a fresh, frozen, or processed product, thereby involving a complex structure of logistics for worldwide distribution (Paolisso 2007; Ferdoushi et al. 2010; Gaudé and Anderson 2011, Dana et al. 2015). The trade of live soft-shell swimming crabs is exclusively aimed at local niche markets.

Currently, the demand for soft-shell swimming crabs is higher than its supply. Companies with access to raw material do not find difficulties in marketing the product (Ferdoushi et al. 2010). To supply the world demand for soft-shell swimming crabs, these companies have sought to obtain quality certificates related to food safety management systems, such as the International Organization for Standardization 22,000 (ISO) and Hazard Analysis and Critical Control Points (HACCP) (Lawlor et al. 1997). ISO 22000 is an international seal that certifies the requirements of a food safety management system, covering all the organizations that operate in a given food chain. HACCP, is a management tool used to protect consumers from

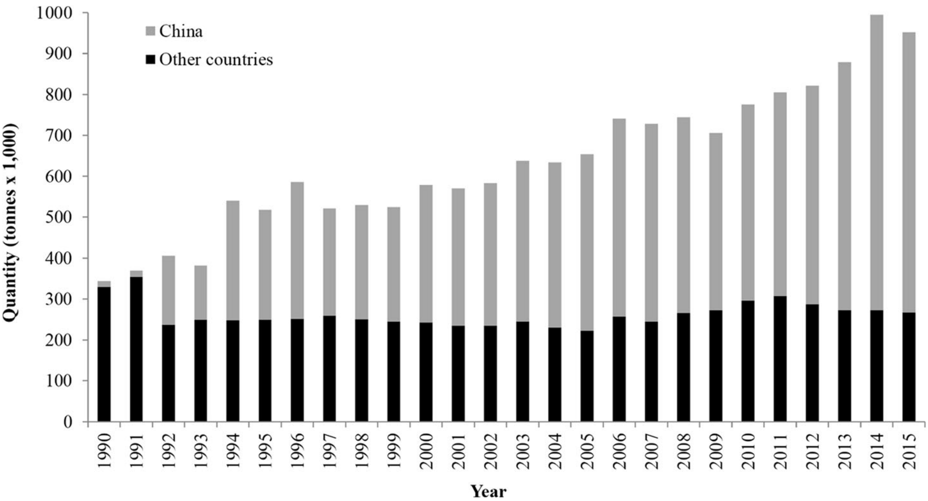

Fig. 2 Worldwide fisheries captures (in thousands of ton) of *Portunus* and *Scylla* swimming crabs between 1990 and 2013. Font: FAO (2016)

Table 1 Summary of percentage soft-shell swimming crab species marketed worldwide, different forms of commercialization and application of international quality certificates by trading companies, based on data (80 references) from soft-shell swimming crab trading companies and internet sites. See source details in supplementary material

Countries	Main species sold %	Delivery form (%)				Certificate (%)		Buyers
		Froz	Li	Fre	Indef	HACCP	ISO 22000	
China	*C. sapidus* *Portunus spp.* *Scylla spp.*	78	0	0	22	60	60	South Asia, Southern and Northern Europe, and Central America
	Undefined					40	40	
Singapore	*Scylla spp.*	100	0	0	0	100	0	Asia and Africa
	Undefined					0	100	
Indonesia	*Scylla spp.*	60	0	0	40	20	0	United States, Europe, Japan, Singapore, Taiwan, Hong Kong,and Malaysia.
	Undefined					80	100	
United States of America	*C. sapidus* *Portunus spp.* *Scylla spp.*	62	15	23	0	32	4	China, Vietnam, Malaysia, and Thailand
	Undefined					68	96	
Philippines	*Scylla spp.*	100	0	0	0	0	0	Asia
	Undefined					100	100	
Thailand	*Portunus spp.* *Scylla spp.*	100	0	0	0	60	40	North and South America, Europe, Asia (Malaysia and Singapore)
	Undefined					40	60	
South Korea	*Scylla spp.*	100	0	0	0	0	0	Vietnam, China, and Thailand
	Undefined					100	100	
Vietnam	*C. sapidus* *Portunus spp.* *Scylla spp.*	100	0	0	0	36	45	China, Australia, Japan, Taiwan, Malaysia, United States, and New Zealand.
	Undefined					64	55	
Mexico	*C. sapidus*	100	0	0	0	0	0	Undefined
	Undefined					100	100	
Taiwan	*Scylla spp.*	100	0	0	0	0	0	Undefined
	Undefined					100	100	
Australia	*Portunus spp.*	50	0	50	0	0	0	Undefined
	Undefined					100	100	
Japan	*Scylla spp.*	100	0	0	0	50	50	Asia and Europe
	Undefined					50	50	
United Kingdom	*C. sapidus* *Scylla spp.*	100	0	0	0	0	0	Europe
	Undefined					100	100	
Brazil	*C. sapidus*					0	0	United States
	Ubdefined	100	0	0	0	100	100	
Myanmar	*Scylla spp.*	100	0	0	0	0	0	Singapore, Malaysia, Vietnam, Australia, Thailand, Hong Kong, China, and Taiwan
	Undefined					100	100	
United Arab Emirates	*Scylla spp.*	100	0	0	0	100	100	Undefined
	Undefined					0	0	
Malaysia	*Scylla spp.*	50	0	50	0	50	0	Asia, Middle East, South Africa, Europe, Australia, and New Zealand
	Undefined					50	100	
Netherlands	*Scylla spp.*	100	0	0	0	0	0	Undefined
	Undefined					100	100	
Turkey	*Scylla spp.*	100	0	0	0	0	100	Undefined
	Undefined					100	0	
India	*C. sapidus*	100	0	0	0	0	0	Undefined

Table 1 (continued)

Countries	Main species sold %	Delivery form (%)				Certificate (%)		Buyers
		Froz	Li	Fre	Indef	HACCP	ISO 22000	
	Scylla spp.							
	Undefined					100	100	
Bangladesh	*Scylla spp.*	100	0	0	0	0	0	Asia (Japan, Hong Kong, China, Taiwan and Singapore), Europe, and Oceania (Australia)
	Undefined					50	50	

Froz: soft-shell swimming crab frozen; **Li**: soft-shell swimming crab live; **Fre**: soft-shell swimming crab fresh; **Indef**: soft-shell swimming crab marketed in a unknown manner

biological, chemical and physical hazards related to food products. These certifications ensure the realization of health standards set by major importing countries, such as the USA and Japan (Fisher et al. 1998). By ensuring the food safety of consumers, quality seals can also increase the market value of soft-shelled crabs (Ferdoushi et al. 2010).

Asian countries

The Asian continent is the main source of the soft-shell swimming crabs sold worldwide (Shelley and Lovatelli 2011; Tobias-Quinitio et al. 2015). In China, soft-shell crab industry is almost centenary (Yalin and Qingsheng 1994), while in other Asian countries the production started more recently, approximately 30 years ago (Dana et al. 2015). Regardless of its origin, either from fisheries or aquaculture, the main species produced as soft-shell swimming crab are *S. serrata* and *S. olivacea*. Regarding only aquaculture, FAO data began to incorporate Chinese portunids production only from 2003. According to FAO (2016), between 2003 and 2015, the worldwide production more than doubled, from 151,900 to 344,100 t (80% of this total produced by China, beyond Vietnam, Myanmar, Singapore, Indonesia, and Philippines),

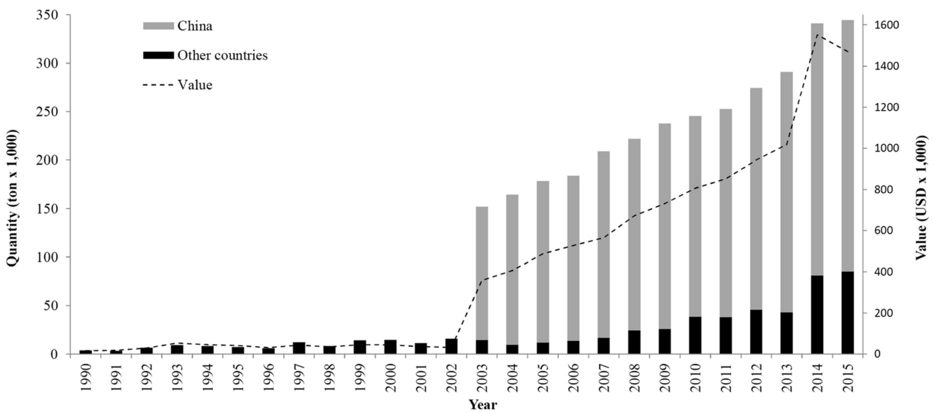

Fig. 3 Worldwide aquaculture production in thousands of ton (Bars) and values generated in thousands of USD (dotted line) of *Portunus* and *Scylla* swimming crabs between 1990 and 2015 Font: FAO (2016)

Table 2 Main crab-producing countries and produced species (FAO 2016)

Countries	Total crab production [10^3MT/year]	Capture crab production [10^3MT/year]	Aquaculture crab production [10^3MT/year]	Species
China	943.2	684.4	258.8	*Portunus trituberculatus* *Charybdis japonica* *Portunus* spp. *Scylla* spp. *Portunus pelagicus*
Indonesia	90.2	77.7	12.5	*Scylla spp.* *Portunus spp.* *Portunus pelagicus*
United States of America	72.4	72.4	0	*Carcinus maenas* *Callinectes sapidus*
Vietnam	53.3	0	53.3	*Scylla spp.*
Philippines	43.3	27.2	16.1	*Scylla spp.* *Portunus spp.*
Thailand	24.9	24.8	0.1	*Scylla spp.* *Portunus spp.*
Mexico	15.1	15.1	0	*Callinectes sapidus*
Venezuela	6.8	6.8	0	*Callinectes sapidus*
Bahrain	4.6	4.6	0	*Portunus spp.*
Australia	3.7	3.7	0	*Portunus spp.*
Taiwan Province of China	3.5	3.5	0.03	*Scylla spp.* *Portunus spp.*
Myanmar	2.8	0	2.8	*Scylla olivacea* *Scylla spp.*
Brazil	2.0	2.0	0	*Callinectes spp.*
United Kingdom	1.7	1.7	0	*Portunus pelagicus* *Carcinus maenas*
Nicaragua	0.8	0.8	0	*Callinectes sapidus*
Saudi Arabia	0.3	0.3	0	*Portunus spp.*
United Arab Emirates	0.3	0.3	0	*Portunus spp.*
Cuba	0.2	0.2	0	*Callinectes sapidus*
Singapore	0.1	0.07	0.1	*Scylla spp.* *Portunus spp.*
Spain	0.1	0.1	0	*Necora puber* *Carcinus maenas*
Africa	0.07	0.01	0.06	*Scylla spp.*
Malaysia	0.06	0	0.06	*Scylla spp.*
Cambodia	0.05	0	0.05	*Scylla spp.*
Madagascar	0.05	0	0.05	*Scylla spp.*
Portugal	0.04	0.04	0	*Portunus pelagicus* *Carcinus maenas* *Necora puber*

generating an overall revenue of USD 1,469,819.00 in 2015 (Fig. 3 and Table 2). Of this value, 72% is based on *Scylla* spp. and 28% in *Portunus* spp.

Frozen crabs are usually sold over the internet to countries such as Japan, Hong Kong, China, Taiwan, Singapore and Australia, at an approximate cost of USD 8.00/Kg (Diytrade™). Live animals are sold only in local markets for domestic consumption (Ferdoushi et al. 2010). The largest producer and distributor of soft-shell swimming crabs in the world is Aung Moe Khine Manufacturing™, from Myanmar. Their monthly production is over 40 t, primarily sold over the Internet and exported to other Asian countries, such as Singapore, Malaysia, Vietnam, Thailand, Hong Kong, China, and Taiwan. The production may be redistributed to Mexico, the USA, New Zealand, Australia, and some African countries.

USA

In the USA, large-scale production of soft-shell crabs started in New Jersey around 1855 and by 1905, the products were being been exported to Europe (Roberts 1905). Production is based solely on *Callinectes sapidus*, the most abundant species in the country's fisheries. Although the USA was a pioneer in soft-shell crab production and demand has increased globally, large-scale production of soft-shell crabs in America has experienced a significant decline in the number of companies producing soft-shell crabs and quantities produced over de last decades.

McDonald et al. 1986) reported the existence of approximately 2300 soft-shell producers in Maryland, Virginia, North Carolina, South Carolina, and Georgia and an estimated production of 3600 t, which yielded approximately US$26.7 million. A few years later, in the same regions, Wickins and Lee (2002) recorded less than 300 active producers and an estimated production volume in 1400 t. According to Louisiana Sea Grant (2016), in Louisiana State, soft-shell crab's production fell from 1075 t, in 1945, to only 4 t, in 2015. Data presented by Guillory et al. (2001) and by NOAA (2016) show that in 2005 about 6% (1335 t) of US total catches were pre-molt crabs (peelers), intended for the production of soft-shell crab. However, between 2006 and 2015, this relative value had fallen to less than 2% (793.2 t). It is difficult to precisely address the reasons for the observed decline in the number of companies producing soft-shell crabs in America, but some authors relate this decline to the fallen in peeler catch in recent years (NOAA, *op. cit.*) and/or to the high mortality rate recorded in production systems due to a recently identified fatal reovirus of the blue crab, *Callinectes sapidus* (Bowers et al. 2011; Flowers et al. 2016).

In the US market, live or frozen products are traded by fishmongers, regional markets, or restaurants (Keenan and Blackshaw 1997). In restaurants, soft-shell crabs can be sold from US$10.00 to US$75.00 per unit, depending on the size of the animal (classified as small, medium, large, or jumbo) and how the dish is prepared (Backfins crab house® and Iron Gate restaurant®). The highest concentration of specialized restaurants is found in Virginia, Louisiana, Washington, North Carolina, and New York (Eater 2017). However, internet sales play a prominent role in the North American market. Frozen soft-shell swimming crabs are sold over the Internet for up to US$99.00 a tray with 12 units (The Crab Depot Carryout™), and the price can be as high as US$103.50, if the crab is pre-fried (The Crab Place™). The J&W Seafood® company, located in Deltaville, Virginia, one of the largest processors of Chesapeake Bay crabs, sells frozen soft-shell swimming crabs for up to US$42.00 a dozen.

Other countries

Countries like Australia, the Netherlands, and more recently, Brazil are gradually becoming emerging players in the global soft-shell swimming crab market. There are no precise monetary data about values or volumes traded, but it is known that the companies from these countries almost always sell its products over the internet. In Brazil, both production and marketing of soft-shell swimming crabs are in the early stages of development. One company, the Blueshell Brasil®, has pioneered the production of soft-shell swimming crab. It sells wild-caught animals of the species *C. sapidus* and *Callinectes danae* (Smith, 1869), primarily to *haute cuisine* restaurants and specialty retail markets. In the Netherlands, Culimer B.V® is the leading soft-shell swimming crab distributor, importing *S. serrata* from Vietnam and distributing it to various countries in the world. In Australia, some companies have gained prominence in the international market by exporting frozen soft-shell swimming crabs *P. pelagicus* to Europe, USA, Japan, and Malaysia (Queensland Aquaculture Industries Federation 2015).

In Mexico, for several years entrepreneurs have attempted to produce soft-shell crab. The only successful company, located in Tampico, was based on closed circulation systems and had a daily production capacity of 800 crabs, which were mainly destined for the Japanese market. However, for undisclosed reasons, the production process was ceased in 2011 (Cap Log Group L 2013).

Conclusions

The Internet, through websites and platforms that teach you to prepare and that disseminate the qualities of the product, has played an important role in making the act of eating fried, grilled, or sauteed soft-shell crabs in a rich and pleasurable food experience for an ever-increasing number of people worldwide. At the same time, the Internet has increasingly been used as a trading tool, reducing distances and speeding up negotiations between producers and traders from different countries. In this scenario, the demand for soft-shell crabs has become greater than production capacity, raising sales prices and making the marketing of this product a highly attractive business.

However, this productive chain is highly dependent on fishing and natural stocks. About 73.5% of the crabs marketed in the world originates from fisheries and there is no evidence that fisheries stocks can withstand significant increases in volumes caught. On the contrary, factors such as climate change, overfishing, environmental pollution, and degradation of habitats tend to significantly reduce the supply of animals in the coming years or decades.

Aquaculture, in turn, is still far from a viable solution to guarantee the sustainability of this productive chain in most of the countries. The expansion of aquaculture based on captured juveniles or intermolt animals can increase the pressure on the wild stocks too. The hatchery and rearing technology for crabs are still incipient to support industrial-scale development. The high costs of production and the general risks associated (as the highly pathogenic reovirus newly identified) are all factors limiting the aquaculture development, placing it in an unfavorable situation to compete with fishing.

Therefore, it is important the joint effort between fisheries companies, research institutions, funding, and regulatory agencies by carrying out studies on the fisheries biology of populations of commercially exploited species, developing less predatory practices and more selective fishing gears, thus reducing impacts associated with bycatch.

In terms of aquaculture, the main challenges involve increasing efficiency in the productive process, which goes through the field of larviculture techniques, with particular emphasis on minimizing losses by cannibalism; by the nutrition of larvae and juvenile; by the reduction of impacts caused by viral diseases, and by and technological development of the cultivation systems themselves.

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