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Analysis of Notifications of Rapid Alert System concerning Parasites in Fishery Products

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ABSTRACT

Fish and fishery products are one of Morocco's most important export products. Fish parasitism is a natural worldwide phenomenon. Fish parasites have a very wide distribution and are found in both the northern and the southern hemispheres of the globe. The present study aimed to assess parasitic infestation in fishery products by analyzing notifications available in the European rapid alert system for food and feed. The analysis involved 663 notifications registered from 2001 to 2019 on the grounds of parasitic infestation. For Morocco, 651 notifications concerning the different exported food products were analyzed. Among the 663 notifications for the presence of parasites, 161 (24.3%) were border rejections. A total number of 20 countries have been detected with the presence of parasites in their exported fish and fish products. The main fish species concerned with this hazard were Hake (26%), Silver Scabbardfish (10.5%), and Angler (9.3%). In Morocco, among the 651 notifications, 373 concerned with seafood (57.2%). The number of border rejections of fishery products was 220 that is 33.8% of overall notifications. Fish and fish products category are the most concerned with 170 rejections (26.1%), with 64 notifications due to the presence of parasites (37.6%). The Silver Scabbardfish was the species most affected by parasite infestations (23.5%), followed by European Anchovy (12.5%) and Swordfish (10.9%). In conclusion, the nematode *Anisakis* is the most common parasite in fish infestation while the plerocercoïd larvae of the Cestoda *Gymnorhynchus gigas* seems to have a predilection to infest the Atlantic Pomfret (*Brama brama*).

Keywords: Fish, Morocco, Notification, Parasite, Rapid alert system for food and feed

INTRODUCTION

The fishing sector plays a major socio-economic role in Morocco and it is one of the pillars of the national economy. Morocco is one of the major fish producers worldwide, ranked 15 after Malaysia (FAO, 2020). In 2018, national fishery production reached a volume of more than 1.37 million metric tons, which represents 2% of world production. More than half of this production (52.7%) was exported to the European Union (EU) and Japan (DPM, 2018).

Fishery products represent a valuable source of nutrients and micronutrients that are crucial for healthy and diverse diets (FAO, 2018). The role of these products in the transmission of parasitic diseases to humans has been recognized (Koepper et al., 2020; Teixeira et al., 2020). The range of parasites involved is very wide, including nematodes, trematodes, and cestodes (Huss, 1998; Chai et al., 2005). Among nematodes, the *Anisakidae* family is the most overwhelming in human infestations with essentially two genera of *Anisakis* and *Pseudoterranova* (Smith and Wootten, 1978; Oshima, 1987).

Anisakiasis is a disease caused by ingestion of the L3 larva of parasites belonging to the anisakidae family, in raw fish, undercooked, or having undergone little or no sanitizing treatment (marinating, cold smoking, etc; Oshima, 1987). In addition, it is well established that the anisakid infestation has a significant economic impact, especially during export and discarding infested fishery products from the market at the national level since it can pose risks to customers.

The main objective of this study was to assess the extent of the parasitism phenomenon in Moroccan fishery products through the analysis of data from the European Rapid Alert System for Food and Feed (RASFF) portal between 1979 and 2019 and the development of a map of RASFF notifications concerning parasites in fishery products covering all countries, including Morocco.

MATERIALS AND METHODS

Description of the rapid alert system for food and feed system

The European RASFF was introduced in 1979. It is a notification system which mentions the hazards related to agri-food products exported to EU countries. This system is governed by Regulation (European Commission) n° 178/2002 (European Commission, 2002) and Regulation (European Union) n° 16/2011 which relates to the modalities of

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its application (European Commission, 2011). It has been repealed by Regulation (European Union) 2019/1715 laying down rules for the functioning of the system.

Search procedure in the rapid alert system for food and feed portal

The scope of this study was at first the notifications received from the RASFF system concerning the hazard "parasitic infestation" on a global scale, in particular, all countries exporting their fishery products to the EU market, then, as a practical case study, notifications from Morocco.

World database

Data were retrieved from the RASFF portal (Accessed April 23, 2020). The search criteria for RASFF notifications of parasites in fishery products are as follows: date of notification (From 01/01/1979 to 31/12/2019), type of product (Food and product category, entailing Fish and fish products), and Risk category, including parasitic infestation. This research on the RASFF portal provided access to 663 entries.

Morocco database

The RASFF notifications from Morocco are as follows: date of notification: From 01/01/1979 to 31/12/2019, type of product: Food, Country (flagged as origin: Morocco). Searching on "Morocco database" yielded 651 entries representing all the notifications involving Moroccan food exported to the EU. The obtained findings from RASFF notifications are summarized in Table 1.

Table 1. Results for notifications on the rapid alert system for the food and feed portal

Database	Search time interval	Effective time interval (given by the portal RASFF)	Reason for notifications	Number of data
World database	From 01/01/1979 to 31/12/2019	01/01/2001-31/12/2019	Parasitic infestation	663
Morocco database	From 01/01/1979 to 31/12/2019	01/10/1981 -31/12/2019	All hazards motives	651

Data processing

For the World database, the data was processed according to the type of notifications. Subsequently, a detailed analysis of backflow notifications was carried out according to the country of origin, species of fish, and parasites. Regarding the Morocco database, an overall analysis of notifications by product was carried out to show the importance of notifications of fishery products. Afterwards, rejections were analyzed according to the category and the nature of the fishery products, and the evolution of the rejections between 2008 and 2019. Furthermore, an analysis of the causes for rejections of fish exports was carried out to highlight the importance of parasitic infestation in fish and fish products. Finally, an analysis of parasite rejections, depending on the species of fish and the species of parasite, was conducted.

RESULTS AND DISCUSSION

Global analysis of the rapid alert system for food and feed portal notifications concerning parasites in fishery products

Global analysis of notifications

Over the past 40 years (1979 to 2019), the RASSF portal has reported 663 notifications of parasites for fishery products exported from countries. Those notifications (Table 2) can be divided into alerts (21%), information (22.2%) and border rejections accounting for 161 notifications (24.3%). The average annual number of parasite notifications is 35 (one notification/10 days). The maximum number of notifications was recorded in 2009, 2010, and 2011 with a total of 250 notifications. Since 2011, the number of notifications has gradually decreased to stabilize at 39 during 2017-2019 (Figure 1). Official control on the European market was the main source of these notifications (50.4%), followed by border control (32%). Notifications following consumer complaints and the establishment of self-monitoring accounted for 8.1% and 5.1%, respectively (Table 3). The reporting basis was not defined in 2001 and 2002 (3.2%).

Table 2. Distribution of notifications concerning parasites in fishery products

Type of notifications	Number	Percentage
Rejection	161	24.3
Information	147	22.2
Alert	139	21.0
information for follow-up	136	20.5
Information for attention	80	12.0
Total	663	100

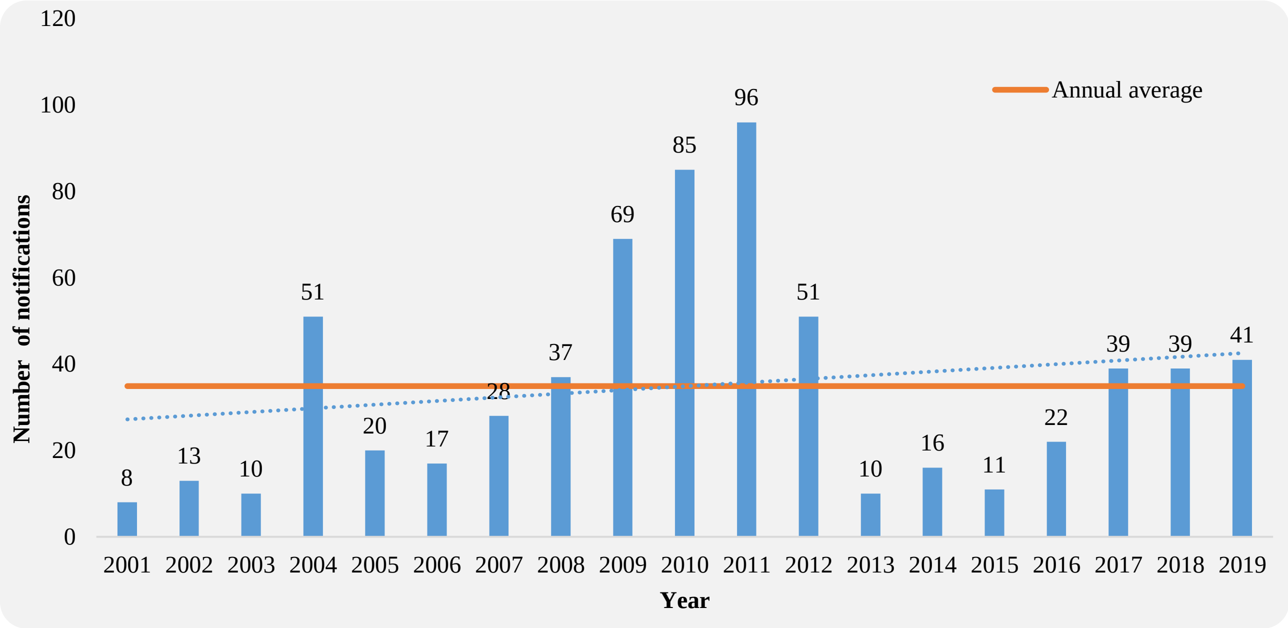

Figure 1. Evolution of rapid alert system for food and feed notifications of fishery products for parasitic infestation

Table 3. Main sources of notifications for the parasitic infestation in fishery products

Notification base	Number	Percentage
Border control	212	32
Establishment self-monitoring	34	5.1
Consumer complaints	54	8.1
Official control on the market	334	50.4
Official control after of notifications RASFF	8	1.2
Without notification base	21	3.2
Total	663	100

Analysis of rejections

Evolution of rejections between 2008 and 2019

The number of rejections is a valuable indicator of the effectiveness of control and self-monitoring systems implemented by third-world countries exporting their products to the EU. Their analysis allows establishing a health profile by the country. The first rejections of fishery products due to parasitic infestation were recorded in the portal in 2008. Over 12 years, the total number of rejections concerning parasites in fishery products was 161, which represents an average of 13 to 14 rejections per year. The most critical period was between 2009 and 2011, during which 105 rejections (65%) were notified. Subsequently, the number gradually decreased to reach only 8 rejections in 2019 (Figure 2).

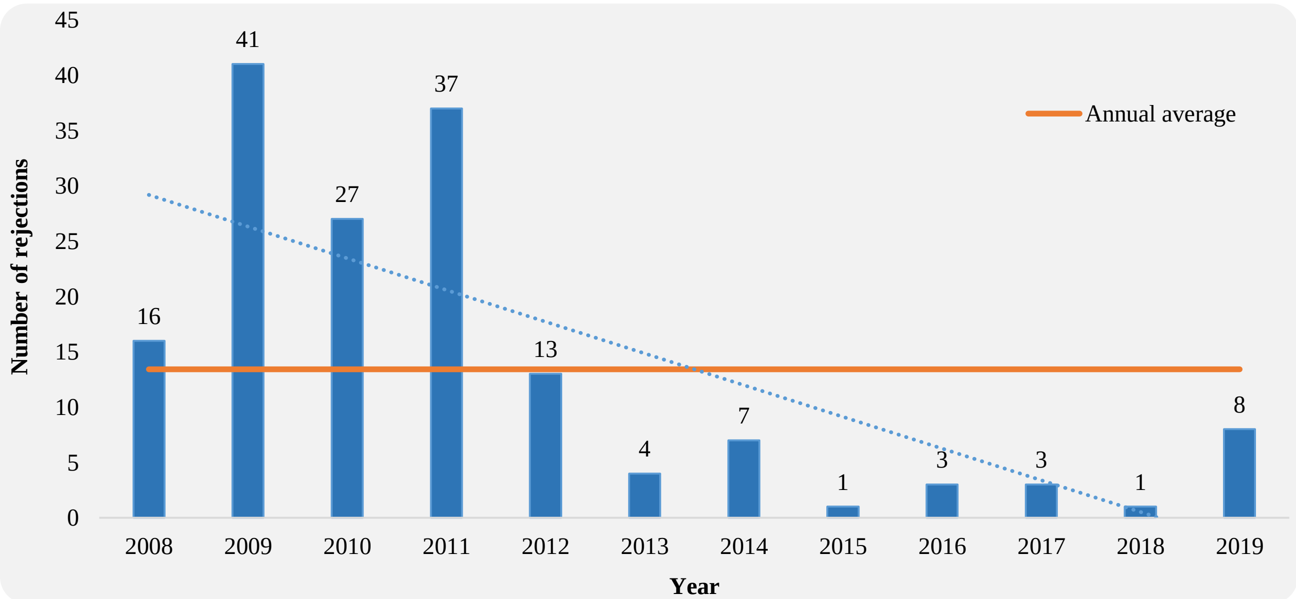

Figure 2. Evolution of rejections of fishery products for parasitic infestation

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Main causes for fish products rejections

Notifications by countries

About 20 countries have been notified on grounds of parasitic infestation. Table 4 presents the concerned countries as well as their corresponding number of seafood rejections. As shown in Table 4, Morocco was mostly notified for rejections with 64 notifications, followed by Croatia (21 rejections), China (15 rejections), and Argentina (12 rejections).

These numbers should be treated with caution as they must be related to the number and/or the quantities of exported seafood. Furthermore, it should be noted that fishery products most affected by parasites were fresh products. Given Morocco's geographic proximity to EU countries, it is common to export large quantities of fresh fishery products, which explains Morocco's ranking as the first notified country, which is much more related to the nature of the exported product. Still, these data showed with supporting evidence that the parasite infestation of fish products is a worldwide concern.

Regarding worldwide repartitions of rejections by continent, the African countries record the maximum rejections number with 49% due to parasite infestation, followed by European (22%) and American countries (15%). Asian countries and Australia account for only 10% and 4%, respectively. Table 5 shows the rejections of fishery products according to the countries of origin and the reporting countries. Spain is the gateway for fishery products to the EU. As a result, it a notified products just from 9 countries. Italy comes second by 6 countries, followed by Lithuania (n = 4). For countries of origin, China has been notified by 5 member states, followed by Argentina (n = 4).

Table 4. List of countries notified of parasitic infestation in fishery products

Country of origin	Number of rejections	Country of origin	Number of rejections
Morocco	64	Spain	3
Croatia	21	Namibia	3
China	15	South Africa	2
Argentina	12	Albania	2
Tunisia	7	Chile	2
USA	6	Ghana	1
New Zealand	6	Mauritania	1
Russia	5	Senegal	1
Canada	4	Sri Lanka	1
Falkland Islands	4	Ukraine	1

Table 5. Notifications of rapid alert system for parasitic contamination of food and feed in different countries and origins

		Notifying countries							
		Germany	Bulgaria	Spain	Estonia	Greece	Italy	Lithuania	Poland
Notified countries	South Africa			2					
	Albania						2		
	Argentina	2		3		3	3		
	Canada					1		2	1
	Chile	2							
	China		4	5	3	1		2	
	Croatia						21		
	Spain								3
	USA						5		
	Falkland Islands			4					
	Morocco			64					
	Mauritania			1					
	Namibia			3					
	New Zealand			6					
	Russia							5	
	Senegal			1					
	Sri Lanka						1		
	Tunisia						7		
	Ukraine							1	

Notifications by category of commodity

Fresh, frozen, chilled, and canned fishery products have been subjected to border rejection. The maximum number of rejections was for fish in the chilled state (n = 76), followed by fish in the frozen state (n = 43). Notifications for which the nature of the product was not specified constitute a proportion of 25%. The occurrence of parasites was hence more prevalent in chilled and frozen fish. The parasitic infestation was a minor problem with canned goods.

Notifications by fish species

Regarding families and fish species, Figure 5 illustrates the main fish species as well as their corresponding number of rejections. The number of notified species is 23, but this number could be higher since several notifications do not mention the species name. During the last 12 years, hake (*Merluccius merluccius*) was the most rejected species for the presence of parasites (n = 42, 26.4%), followed by Silver Scabbardfish (*Lepidopus caudatus*, n = 17, 10.7%), and John Dory (*Zeus faber*) recorded 12 rejections (7.5%). Swordfish (*Xiphias gladius*) and European anchovy (*Engraulus encrasicolus*) were reported 10 and 8 times, respectively, for parasitic infestation (Figure 3). As can be seen in Figure 3, the two species of freshwater fish were subjected to rejections (Northern pike, *Esox lucius*) and pike-perch (*Stizostedion lucioperca*). The Hake family was the most rejected family for parasitic infestation (26.7%), followed by the Trichiuridae (10.6%), and Lophiidae (9.3%) families. The families of Gadidae and Zeidae constitute 7.5% of rejections each. Xiphiids represents 6.2% of the rejections.

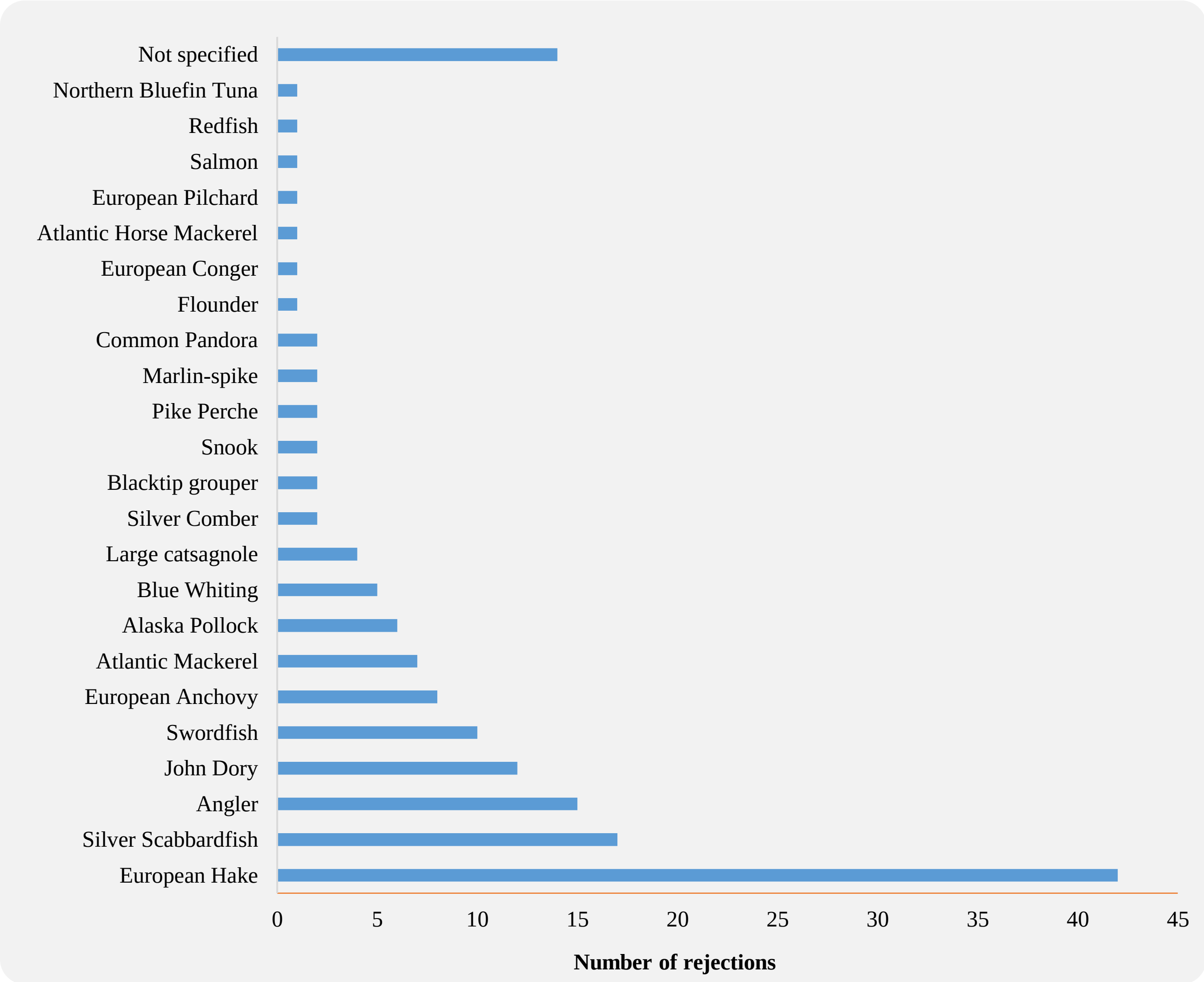

Figure 3. Number of rejections depending on the species of fish between 2008 and 2019

Parasite species

Concerning parasite species, out of 161 border rejections for parasitic infestation, *Anisakis* represents the most frequently implicated parasite responsible for 72.7% of rejections, followed by the plerocercoïd larvae of the Cestoda *Gymnorhynchus gigas*, *Microsporidia*, and *Philometra* spp. with the same proportion, 2.5% each (Table 6). Nematodes of the genus *Anisakis* are, therefore, a problem of a global dimension. Table 7 shows a list of fish species rejected for *Anisakis* infestation as well as their countries of origin. Using the data in tables 4 and 7, a map was established to show the origin of the fishery products rejected for parasite reasons (Figure 4). This map shows that fish parasites have a very wide distribution and are found in both the northern and the southern hemispheres.

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Table 6. Number of rejections depending on the species of parasite

Group	Type	Species	Number of rejections	Percentage
Helminths	Nematodes	*Anisakis*	117	72.7
		Philometra spp.	4	2.5
		Other	2	1.2
	Cestodes	*Gymnorhynchus gigas*	4	2.5
		Nybelinia spp.	1	0.6
		Trypanorhyncha	1	0.6
Total			129	80.2
Microsporidia		*Microsporidia*	4	2.5
		Spraguealophii	1	0.6
Myxosporidia		*Kudoa*	1	0.6
Total			6	3.7
Not-specified			26	16.1

Table 7. Rejections of fish species infested by *Anisakis* and their countries of origin

Species	Number of rejections	Countries of origin (rejections)
European Hake	32	Croatia (18) Argentina (4) China (3) Morocco (3) New Zealand (1) Canada (1) Spain (1) Albania (1)
Silver Scabbardfish	13	Morocco
John Dory	10	Morocco (6) Tunisia (3) Mauritania (1)
EuropeanAnchovy	8	Morocco
Swordfish	7	Morocco
Angler	5	United States
Chub Mackerel	4	Croatia (2) Morocco (2)
Atlantic mackerel	3	Croatie Morocco Tunisia
Hake	3	Albania Canada China
Silver Hake	2	Argentina Spain
Largehead Hairtail	2	Morocco
Silver Comber	2	Argentina
Blacktip Grouper	1	New Zealand
Southernhake	1	
European Conger	1	Morocco
European Pilchard	1	
Northern Bluefin Tuna	1	
Flounder	1	China
Alaska Pollock	1	
North Pacific Hake	1	Canada
Redfish	1	
Atlantic Horse Mackerel	1	Croatia
Blue Whiting	1	Falkland Islands
Common Pandora	1	Argentina
Pike-Perch	1	Ukraine
Pink Salmon (*Oncorhynchus gorbuscha*)	1	Russia
Not specified	13	Morocco

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Figure 4. Distribution of the fishery products rejected for the presence of parasites

Important actions taken by the notifying countries

The major source of rejection notifications is border control. Fishery products turned away due to parasites are either disposed of at border posts (37.3%) or returned to the countries of origin (35.4%). These two actions are not well specified in some cases (13.7%). The rest of the products are owned by member states (6.2%) or banned from entering European territory (5%, Figure 5). The majority of notifications were reported by Spain (55.3%), followed by Italy (24.2%), Lithuania (6.2%), and Greece (3.1%, Table 8).

Table 8. List of notifying countries with the number of notifications

Notifying countries	Number of notifications (%)
Spain	89 (55.3)
Italy	39 (24.2)
Lithuania	10 (6.2)
Greece	5 (3.1)
Bulgaria	4 (2.5)
Germany	4 (2.5)
Poland	4 (2.5)
Estonia	3 (1.9)
France	1 (0.6)
Romania	1 (0.6)
United Kingdom	1 (0.6)

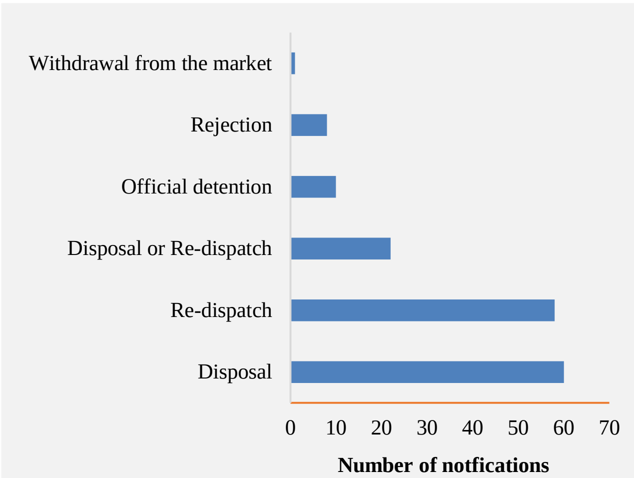

Figure 5. Importance of actions taken by notifying countries

Analysis of rapid alert system for food and feed notifications of Moroccan fishery products exported to the European Union

Analysis of notifications relating to fishery products number and evolution of notifications

Between 1981 and 2019, the RASFF portal reported 373 notifications for fishery products exported from Morocco to the EU. The "Fish and fish products" category is the one most affected with 295 notifications (80%). The two categories "Cephalopods and derived products" and "Crustaceans and derived products" constitute 9.4% and 9% of the notifications, respectively (Table 9).

Global analysis of border rejections of Moroccan fishery products

Over 12 years, the total number of rejections of fishery products was 220, which corresponds to an average rejections number of 18 per year. Fishery products account for more than two-thirds of rejected products (70%). Table 10 indicates the number and percentage of rejections for each category of fishery products. The "Fish and derived products"

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category was the most affected with 170 rejections (77.3%), followed by cephalopods and derived products with 33 rejections (15%, Table 10).

Table 9. Notification numbers of fishery products between 1981 and 2019

Product category	Number de notifications	Percentage
Fish and fish products	295	79.1
Cephalopods and derived products	35	9.4
Crustaceans and derived products	34	9.1
Bivalve molluscs and derived products	9	2.4
Total	373	100

Table 10. Notifications of rejections of the different categories of fishery products between 2008 and 2019

Product category	Number of rejection	Percentage
Fishery products	220	70.1
Fish and fish products	170	77.3
Cephalopods and derived products	33	15.0
Crustaceans and derived products	14	6.3
Bivalve molluscs and derived products	3	1.4
Other types of food	94	29.9
Total	314	100

Evolution of rejection notifications of fishery products from 2008 to 2019

During 2008-2010, the number of rejections contributes to 16.8% (n = 37) in fishery product rejections. Most of them involve the category of fish and fish products (n = 33) and the rest crustaceans and their products. The main reasons for rejections are parasite infestation and poor hygiene. The rejections between 2010 and 2019 constitute 83.2% of rejections of fishery products (n = 183). Regarding the rejections of fishery products exported via Morocco to the EU, the first three years had several rejections, especially in 2011 (23%) due to the large number of rejections resulted from parasites of the fish products. The number of rejections fell from 2013 and rise again in 2019 (11.4% of rejections). During this period, most of the rejections were due to the failure of the cold chain and parasitic infestation. This can be explained by the reinforced control of the competent authorities. The findings indicated that after 2011, there was a steady decrease in rejections year after year. The same observation, therefore, concerns the rejection of fishery products (Figure 6). In 2019, the number of rejections of fishery products was higher than the previous five years, reaching 21 out of 23.

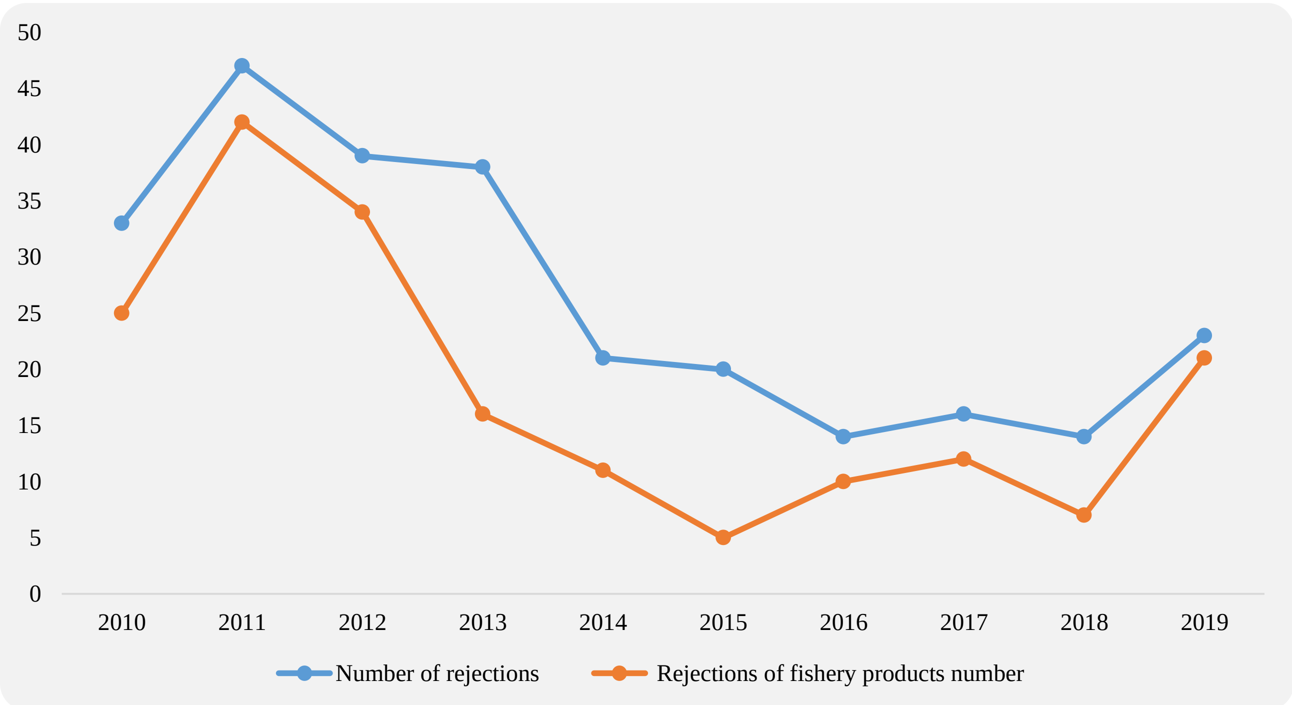

Figure 6. Rejections numbers of fishery products from 2010 to 2019

The decrease in the number of rejections notifications can be attributed mainly to strengthening the sanitary control of fishery products in terms of parasite research by the competent Moroccan authorities following the publication of law 28-07 underlying food safety, as well as by professionals within the framework of self-control (NFSO, 2010). The 2011 peak is attributed to the presence of rejections for parasitic hazards and also to notifications for the presence of high histamine levels. Following this increase, the Moroccan competent authority has put in place an action plan by

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strengthening controls along the food chain. Food business operators (FBOs) for their part have reviewed their health control plans. The collaboration and cooperation between the Moroccan competent authority and FBOs led to good results in the following years and which is confirmed in the results of this synthesis (Elhariri et al., 2017). In April 2010, the European Food Safety Authority (EFSA) adopted a scientific opinion on the assessment of the risk associated with parasites in fishery products. This scientific advice includes information for the health risk versus the presence of viable parasites in fishery products. According to EFSA opinion, all wild fish caught in seawater or freshwater is likely to contain parasites that pose a risk to human health. Fish to be used to produce raw or almost raw seafood products should be frozen prior to processing. However, the competent authorities may adopt national measures granting an exemption from the freezing treatment obligation for fishery products. These national measures must be notified to the committee (EFSA, 2010).

Analysis of rejections for parasitic infestation

During 1981-2019, notifications of rejections concerning fish and their derivatives for the presence of parasites constitute 37.6% of the notifications in this category or 64 rejections. The trend in rejections from 2010 to 2019 peaked in 2011 with 19 rejections accounting for 11%. Subsequently, the number of rejections gradually decreased with an average of 3 rejections per year (Figure 7). Scabbard fish is the species most affected by rejection due to parasitic infestation with 15 rejections for silver Scabbard fish and 2 for the common Scabbard fish. Anchovy registered the second position with 8 rejections in 2011 and 2014, followed by the Swordfish with 7 rejections. According to the obtained results, John Dory had 6 rejections, 5 of which have been recorded over the past three years, and hake had 4 border rejections (Table 11). Scabbard fish is the most infested species by parasites in Moroccan fishery products and hake is the most infested globally. This heavy infestation is mainly related to their diet and their large size. A positive correlation between the size of the fish and the number of parasites collected has already been observed in the Silver Scabbard fish (Bouchriti et al., 2015).

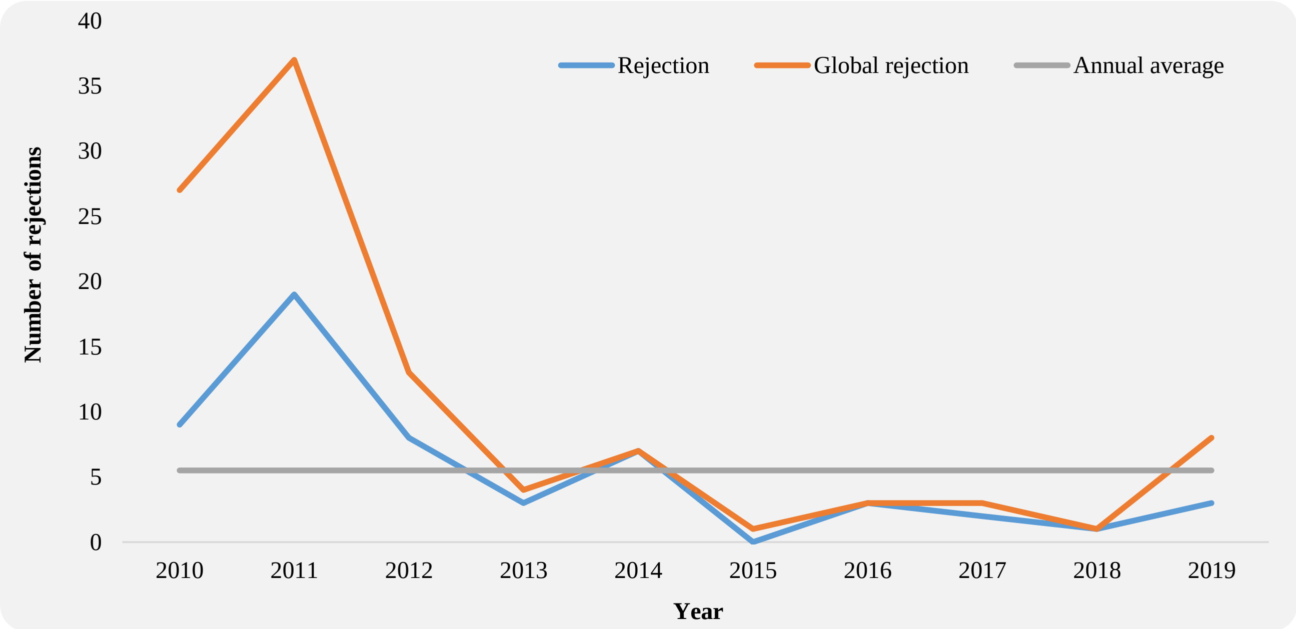

Figure 7. Rejection numbers of fish and derived products infested with parasites during 2010-2019

Based on the living environment of the fish, a possible difference was noticed. Bathypelagic species are the most prone to parasitism with a percentage of 47.1%. Pelagic fish represents 39.2% of rejections for parasitic reasons while benthic fish indicates only 13.7% (Table 12). The Silver Scabbard fish has a silvery, elongated, and compressed body, which is commonly 50 to 150 cm long and can reach up to 210 cm, with a maximum weight of 8 kg. *Lepidopus caudatus* is benthopelagic fish. It lives 60 meters on the continental shelf and beyond the slope up to 600 meters deep, generally on sandy and muddy bottoms from 100 to 300 m, but sometimes in coastal areas of the resurgence of deep water (Nakamura and Parin, 1993). The Scabbardfish are active predators that feed on fish, squid, and crustaceans that are intermediate hosts for the parasites. The hake is a benthopelagic or bathypelagic fish generally living at depths of 70-370 m on the edge of the continental slope, but it can be found in coastal waters up to about 1000 m depth. It measures up to 130 cm in length. Adult hake feeds mainly on fish (anchovies, sardines, herring, and cod) and squid. The young feed on crustaceans (especially euphausiids and amphipods, Cohen et al, 1990). Regarding parasite species, the two main species of parasite incriminated in fish infestations are *Anisakis* spp. (90.5%) in several species of fish and *Gymnorhynchus gigas* found in the Atlantic Pomfret (Table 13).

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Table 11. Number of rejections of fishery products based on the species of fish

Family	Scientific name	Common name	Number of rejections	Year
Bramidae	*Brama brama*	Atlantic Pomfret	4	2009
Trichiuridae	*Lepidopus caudatus*	Silver Scabbard fish	1	2009
			1	2010
			1	2011
			3	2012
			3	2013
			3	2014
			2	2016
			1	2017
	Trichiurus lepturus	Largehead Hairtail	1	2010
			1	2011
Xiphiidae	*Xiphias gladius*	Swordfish	4	2009
			3	2010
Engraulidae	*Engraulis encrasicholus*	European Anchovy	7	2011
			1	2014
Merlucciidae	*Merluccius merluccius*	European Hake	2	2011
			1	2016
Clupeidae	*Sardina pilchardus*	European Pilchard	1	2012
Scombridae	*Scomber* spp.	Atlantic Mackerel	1	2012
			2	2014
	Thunnus thunnus	Northern Bluefin Tuna	1	2012
Zeidae	*Zeus faber*	John Dory	1	2012
			1	2017
			1	2018
			3	2019
Congridae	*Conger conger*	European Conger	1	2014

Table 12. Occurrence of rejections of fishery products based on the living environment of fish types

Types of fish	Species	Number of rejections	Percentage (%)
Pelagic	European Anchovy Atlantic Mackerel European Pilchard Swordfish Northern Bluefin Tuna	20	39.2
Benthic	European Conger John Dory	7	13.7
Bathypelagic	Atlantic Pomfret European Hake Large head Hairtail Silver Scabbardfish	24	47.1

Table 13. Number of repressions depending on the species of parasite and fish

Species parasites	Species	Number of rejections	Percent
Anisakis spp.	Silver Scabbardfish, Largehead Hairtail (*Lepidopus caudatus*, *Trichiurus lepturus*)	15	23.4
	European Anchovy (*Engraulis* spp.)	8	12.5
	Swordfish (*Xiphias gladius*)	7	10.9
	John Dory (*Zeus faber*)	6	9.4
	Atlantic Mackerel (*Scomber* spp.)	3	4.7
	European Hake(*Merluccius merluccius*)	3	4.7
	European Pilchard (*Sardina pilchardus*)	1	1.6
	European Conger (*Conger conger*)	1	1.6
	Northern Bluefin Tuna (*Thunnus thunnus*)	1	1.6
	Not specified	13	20.2
Gymnorhynchus gigas	Atlantic Pomfret (*Brama brama*)	4	6.3
Not specified	Silver Scabbardfish (*Lepidopus caudatus*)	2	3.2

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It should be noted that the number of fishery products exported from Morocco during 2010-2019 was 5,363,674 metric tons (DPM, 2019). The total quantity of rejections due to parasite presence during these 10 years was 165 tons. The quantities rejected for the presence of parasites represent 0.003% of the total exported quantity, which is a very low rate. Despite the importance of parasitic infestation notifications, their economic impact is of a low magnitude nationwide. However, this impact may be severe for packaging the fishery products affected by the infestation.

According to previous field studies, nematodes (*anisakis* and acanthocephalic complex) are the parasites frequently found in seafood on the Moroccan coast, with a prevalence of 21.4% in the Atlantic coast and 24.9% in the Mediterranean (Benabbes and Boudakkou, 2019). The plerocercoïd larva of the Cestoda *Gymnorhynchus gigas* was exclusively found in the Atlantic Pomfret (*Brama brama*) with a prevalence of 89.5%. This internal parasite, found in the flesh of the fish, seems to have a certain predilection for this species. The silver Scabbardfish (*Lepidopus caudatus*) is known to be frequently and sometimes heavily infested by *Anisakis* spp. (Benabbes and Boudakkou, 2019).

A comparison of the research undertaken on the occurrence of parasites in Moroccan coastal waters revealed that this natural phenomenon of parasitism had slightly increased in the Mediterranean and decreased in the Atlantic. According to a study carried out between 1978 and 2015 on changes in the abundance of the two genera of nematodes (*anisakis* and *pseudoterranova*), it was found that the abundance of *Anisakis* spp. saw a significant 283-fold increase and no modification for *Pseudoterranova* spp. (Fiorenza et al., 2020). The worldwide increase in the abundance of *Anisakis* spp. may have faster consequences for human health, the health of marine mammals, and the performance of fisheries.

Fish parasitism is a worldwide phenomenon and is more commonly associated with marine environments than continental ones. The factors responsible for the re-emergence of parasites in different regions of the world are the intensification of fish production, environmental alteration, movement of animals and humans, and increased trade in fishery products (Chai et al., 2005).

The *Anisakis* complex, in particular, is expanding across the global ocean. Several answers can be advanced about the spread of this parasite in recent decades. Several potential factors may be involved, including climate change, increased nutrients, and increased marine mammal populations. As parasites with a complex life cycle, anisakidae can respond to changes in abundance of any definitive or intermediate host (marine mammal, crustacean, or fish) (Arneberg et al., 1998). However, it is almost impossible to know the most critical host in the abundance of anisakidae, that is, the bottleneck in the parasite’s life cycle (Lafferty, 2012).

Since the adoption of the Marine Mammal Protection Act in 1972 and the adherence of many countries to the moratorium on commercial whaling imposed by the International Whaling Commission in 1982, the abundance of many species of marine mammals (definitive host) increased (Magera et al., 2013). This increase could lead to an increase in transmission of anisakidae in case the definitive mammalian hosts are the bottleneck of the life cycle (Lafferty, 2012). The replenishment of many populations of marine mammals may explain the increase in the abundance of *Anisakis*.

On the other hand, fish, crustaceans, and cephalopods are key intermediate and paratenic hosts for anisakidae, and their abundance has fluctuated widely over the past half-century (Christensen et al., 2014). Fishing has altered the abundance and density of many fish (Anderson et al., 2008). For example, Atlantic cod have experienced a decline on the northeastern coast of North America (Lilly et al., 2008) while cephalopods have increased in abundance (Doubleday et al., 2016).

Intensification of fish production or increased fishing pressure may lead to a decrease in the abundance of host fish and consequently, reduced transmission and abundance of *Anisakis* (Lafferty, 2012). However, if host fish are not the life cycle bottleneck, decreases in the abundance of intermediate hosts could lead to an increase in the concentration of parasites in the remaining hosts, resulting in an increase in the abundance of parasites (Wood et al., 2013). Long-term climate change could also influence the abundance of anisakid nematodes. The increase in temperature increases the susceptibility of hosts to disease and increases the pathogenicity of pathogens and parasites (Harvell et al., 2002; Burge et al., 2014). This could lead to an increased infestation of host fish, as these species lose their ability to resist infection when temperatures rise beyond the optimum. The temperature rise can also lead to the faster growth of Anisakis nematodes (Marcogliese, 2001).

On the other hand, the increased nutrient load of coastal ecosystems can produce phytoplankton blooms that can feed filter crustaceans (intermediate hosts) (Trainer et al., 2003). Increases in nutrients may facilitate increases in *Anisakis* spp., as crustacean hosts of Anisakid nematodes are sensitive to these environmental alterations.

CONCLUSION

The analysis of the data available on the rapid alert system for the food and feed portal has enabled us to draw some conclusions on the parasite profile of fishery products. The main hazard for fish and fish products border rejections is a parasitic infestation. Spain is the main reporting country as it is the gateway for fishery products to the EU. Since 2011, the number of rejections of fish and fish products has decreased steadily due to the strengthening control by the Moroccan health authority and professionals. Border control in the EU plays a crucial role in detecting and preventing

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nonconformities before the distribution of products in the market. The occurrence of parasites prevails in fresh fish. The silver Scabbardfish (*Lepidopus caudatus*) is the species most affected by parasitic infestations in Morocco and hake (*Merluccius* spp.) is the most infested by parasites worldwide because of their living environment and diet. The *Anisakis* complex is a parasite frequently implicated in the infestation of fish. The parasite *Gymnorhynchus gigas* seems to specifically infest the species *Brama brama*.

DECLARATIONS

Authors' contribution

All the authors contributed to the research in RASFF portal of the notification data, their analysis as well as the writing of the final manuscript. The authors confirmed the content of the final manuscript for publication in this journal.

Competing interests

The authors of the present study declared that there is no financial or unethical conflict related to this work, which can negatively impact its publication.

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Ethical considerations

All ethical issues (including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) have been checked and approved by all authors.

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