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Trade of live bait in Portugal and risks of introduction of non-indigenous species associated to importation

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ABSTRACT

Different invertebrate groups are often exploited on sediment shores and mudflats, including polychaetes, sipunculids, bivalves and crustaceans. The commercial importance of polychaetes and sipunculids, that has increased in the early 2000's because of its use as a food source for the aquaculture sector and a growing demand of worms for use as sea angling bait, seems to be declining nowadays. In Portugal bait harvesting from natural populations became insufficient to meet market demands and as a result, polychaetes and sipunculids have been imported in recent years. Due to this it was important to know the ways of the live bait import to Portugal, and to assess the risk of introduction of non-indigenous species associated to that live bait trade. The origin and quantities of imported live bait were determined by examining the landing's records at Lisbon airport, from two periods: 2002–2003 and 2012–2015. Live worms imported to Portugal arrived almost exclusively from China, USA and Vietnam. Monthly import data and bait registers at fish auction landings were significantly correlated, showing that bait captures and imports are directly related to higher bait demand. In addition, the risk of live bait's importation as an introduction vector for non-indigenous species was evaluated by examining the bait boxes content. Five worm species were identified in bait boxes with foreign species: *Glycera dibranchiata*, *Namalycastis rhodochorde*, *Perinereis cultrifera*, *Perinereis linea*, and *Sipunculus (Sipunculus) nudus*. The examination of bait boxes in Portugal suggested that there is a low risk of associated hitchhiker species introduction and dissemination, mostly because of packaging procedures, which should be advised. The same is not true to the non-indigenous live bait species.

1. Introduction

The ancient activity of worm-collecting on sediment shores or by revolving the mudflats where dense worm's populations are present is frequently observed in different countries (Brown and Wilson, 1997; Fidalgo e Costa et al., 2006). It is the main source of income for the livelihood of many people living in coastal areas. This activity may have a variety of effects depending on local biotic characteristics, area disturbed and harvesting pressure, which vary among different harvesting methods and digging areas (Brown and Wilson, 1997). Several groups of worms are often exploited, in particular polychaete annelids (e.g. Arenicolidae, Glyceridae, Nereididae, Nephyidae, Eunicidae, Onuphidae), and sipunculids. Their commercial importance has increased since polychaetes became an important food source for the aquaculture sector (Dinis, 1986). Also,

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the request of worms for use as sea angling bait stimulated the growth of a large global business leading to the development of an economically viable aquaculture sector providing different cultured species, mainly by Asian countries.

The introduction of non-indigenous species may have different pathways and vectors and the unintentional introduction of organisms by human aided transport procedures has become a major contributor to the global homogenization of marine biota (Ruiz and Carlton, 2003; Lockwood et al., 2005; Fowler et al., 2016). For this reason, potential vectors of introduction of non-indigenous species vectors must be identified and evaluated (Chapin et al., 2000; Pimental et al., 2005). The identification of these vectors and associated risk should be used by environmental managers to reduce future introductions and related impacts as well (Ricciardi and Rasmussen, 1998). Live bait trade is a potential vector of introduction of non-indigenous species, since bait species and associated organisms are often used and sometimes released in natural habitats, where they can successfully establish and spread viable populations (Wittenberg and Cock, 2001; Fowler et al., 2016). Although live bait trade has received much less attention than other vectors of introduction, there is evidence on the transport of 'hitchhiking' organisms associated with live bait and algal packing materials (Fowler et al., 2016), as well as on the introduction of some of these hitchhikers (Lau, 1995). Moreover, a recent study (Arias et al., 2013) on the Mar Menor lagoon, Spain, reported the first occurrence of an established population of the polychaete *Perinereis linea* (Treadwell, 1936) outside its native distribution range (NW Pacific).

In Portugal, the collection of worms from natural populations became insufficient to meet market demands. The demand for bait worms has led to import of polychaetes and sipunculids from other countries (Fidalgo e Costa et al., 2006; V. Santos, ValBaits, personal communication). The majority of these worms arrive at the Lisbon and Porto airports imported by a few local distributors and are partially exported to Spain and other countries (V. Silva, importer at Porto Airport, pers. comm.; V. Santos, Vailbaits, pers. comm.), and partly commonly sold at retail shops along the Portuguese coast.

This study had three major objectives, namely i) to understand the live bait trade structure in Portugal, ii) to determine the importance of live bait importation and iii) to assess the risk of introduction of non-indigenous species having live bait importation as vector. Live bait trade was assessed by identifying major landings locations, quantities and species. The relationship between bait importation and bait harvesting at national level was examined to understand if the availability at national level constrains the imported quantities. Imported bait species and potential hitchhiker species (excluding microorganisms) were identified to assess the risk of introduction of non-indigenous species through this vector.

2. Material and methods

2.1. Live worm's: importation and local captures

Live worms imported to Portugal arrived at Lisbon and Porto airports several times every week in refrigerated containers to reduce worm metabolism and assure their survival. Organisms arriving at the Porto airport are in transit to Galicia (Spain) (according to the information of the Customs services of Porto Airport and the major importer), and for this reason, only imports arriving at the Lisbon airport were evaluated in this work. The origin and quantities (biomass) of imported live bait were investigated by examining the landing's registers at the Lisbon airport, from 2002 to 2003 and 2012–2015. Bait registers at the Aveiro, Setúbal, Sesimbra, Portimão and Olhão fish auction landings (the only data available concerning worms capture) were also examined for the period 2012–2015 (there are no records for the 2002–2003 period). The import data was compared to the fish auction landings in order to understand if annual and monthly variations on imports were related to temporal fluctuations on bait captures. Differences between years and countries from which bait was imported were assessed using PERMANOVA (Anderson, 2005), performed on PRIMER® v6 (Clarke and Gorley, 2006), with a two-way fixed-effect crossed design (Factors: year; country). When significant differences ($p < 0.05$) were detected, these were further examined using *a posteriori* pair-wise comparisons. The Euclidean distance coefficient was used as a resemblance measure on log (X+1) transformed data. A correlation analysis between monthly imports and fish auction bait landings (Pearson coefficient) was performed using IBM SPSS Statistics 23.0.

2.2. Inspection of live bait boxes

Species identification could not be conducted directly at the airport since packages of live worms are not currently controlled or inspected by veterinary authorities to check for potential risks of protozoans, bacterial or virus introduction. The potential of live bait's importation as an introduction vector was, therefore, evaluated by examining the bait box contents sold at Portuguese bait stores. Although it was not possible to examine species at the airport and the fact of having to buy the bait boxes on stores, this did not bring a substantial weakness to this work, since the risk of introduction is only important on the marketing phase. A total of 53 bait boxes containing worms from different origins and from four different companies (which are all the companies that sell imported live bait in Portugal), were purchased at several Portuguese bait stores. In this way, it was ensured that all live bait species imported and used in Portugal, both for aquaculture and fishing, were checked and identified in the present work. Packaging materials of all bait boxes were carefully observed for associated species and for material characterization. Each box was examined at the laboratory and worms were separated from the packaging material. They were identified to the lowest possible taxonomic level with a binocular stereomicroscope and the packaging material was sorted in order to detect the presence of other associated flora and fauna organisms. Apart from protozoans, bacterial and virus which were not searched, other organisms found in bait boxes were also identified to the lowest possible taxonomic level with a binocular stereomicroscope and/or an optical microscope.

Additionally, 15 boxes commercialized by two different companies, containing other species of Portuguese likely origin were purchased at three different stores (north, center and south) with the aim of confirming the identification of the majority of live worms sold at Portuguese stores and the accuracy of the information provided in the bait boxes. These worms were also identified to the lowest possible taxonomic level.

3. Results

3.1. Live worm's: importation and local captures

The examination of the landing's records at Lisbon airport, from two periods, 2002–2003 and 2012–2015, indicated that live worms imported to Portugal arrived mainly from China, USA and Vietnam (Fig. 1). A single landing register of 100 Kg of lugworms from Turkey was noticed and it was not included in the current analysis since it was an outlier. From China, USA and Vietnam, a yearly average of 49.52 t was imported between 2002 and 2003 and this mean annual value decrease to 14.24 t on the second period (2012–2015). China was the major supplier in both periods with

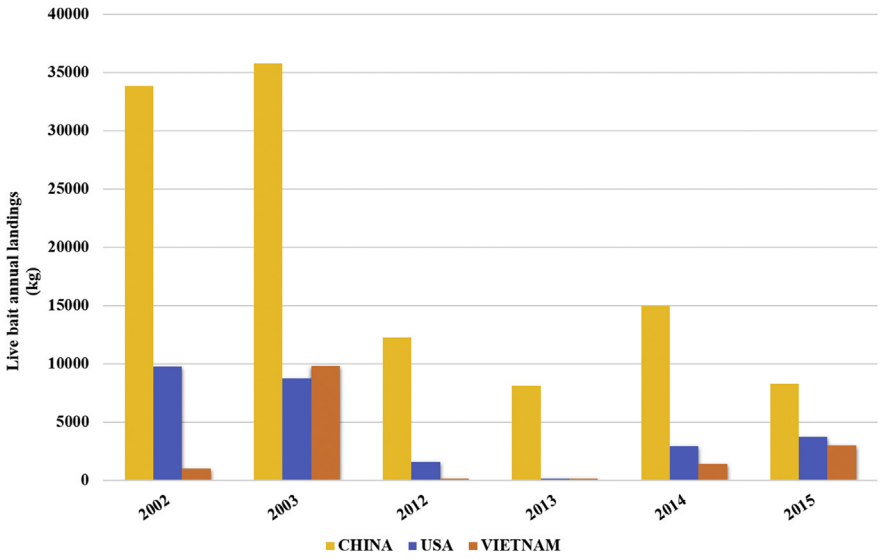

Fig. 1. Live bait annual landings (kg) and origins at the Lisbon airport, for the periods of 2002–2003 and 2012–2015.

70.36% and 76.76%, respectively. USA was the second supplier with 18.71% and 14.88%, while Vietnam was a minor supplier with 10.93% and 8.36%, respectively.

PERMANOVA analysis showed significant differences for bait landings between countries (*pseudo-F* = 94.95; *P*(perm) = 0.001) and years (*pseudo-F* = 22.63; *P*(perm) = 0.001), with a significant interaction between those factors (pseudo-*F* = 8.09; *P*(perm) = 0.001).

Pair-wise tests indicated significant differences between the two periods but not within years from each period for China. The imported quantities from USA were lower in 2012 and 2013, which caused the significant differences between these two years and, with all the other years (Table 1). On the other hand, for USA data, there were not significant differences inside the first period and between 2014 and 2015 (Table 1). Regarding the imported quantities from Vietnam, significant differences inside both periods and to some years between periods were found, depending of the imported quantities (Table 1 and Fig. 1).

Pair-wise tests also indicated significant differences between China and USA, and China and Vietnam for all years (Table 1). For USA and Vietnam significant differences occurred only for 2002 and 2012 (Table 1).

The main period of worm arrivals at the Lisbon airport in recent years was the spring-summer period between April and October, with an increase from May to August, and a decrease after that (Fig. 2).

Most fish auction landings of worms in Portugal occurred during the same period (Fig. 3). Only three species were landed and identified by fish auction between 2012 and 2015, namely *Diopatra neapolitana* Delle Chiaje, 1841, *Marphysa sanguinea* (Montagu, 1813) and *Sabella spallanzanii* (Gmelin, 1791), representing 91.92%, 7.17% and 0.90% of landings, respectively (Fig. 4). Landings of these three species decreased along this period (Fig. 4).

These landings data refer to five different harvesting locations, namely Aveiro (Ria de Aveiro), Setúbal (Tagus and Sado estuaries), Sesimbra (Tagus and Sado estuaries), Portimão (Arade estuary) and Olhão (Ria Formosa), with the highest worm landings recorded at Olhão (48%) and the lowest recorded at Sesimbra (3%) from a total of 31.67t registered (Fig. 5). The variation of bait imports and fish auction landings was significantly correlated (R = 0.447; p < 0.001; N = 48) showing a similar annual cycle for both market sectors.

Table 1
Results of the PERMANOVA pair-wise tests performed to detect differences on live bait annual landings between years and countries. Statistical significance: $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$; ns: not significant.

Groups	China		USA		Vietnam	
	t	P (perm)	t	P (perm)	t	P (perm)
2002–2003	0.1824	ns	0.34696	ns	3.2581	**
2002–2012	3.4169	**	2.9394	*	0.43294	ns
2002–2013	4.8595	***	7.6971	***	0.31613	ns
2002–2014	2.4996	*	1.4586	ns	3.3414	**
2002–2015	4.8546	***	1.0548	ns	5.1758	***
2003–2012	2.9598	**	2.5959	*	4.0035	**
2003–2013	4.2582	***	7.1236	***	3.7549	**
2003–2014	2.2305	*	1.0694	ns	0.79633	ns
2003–2015	4.2414	***	0.56775	ns	0.14995	ns
2012–2013	1.5068	ns	3.2905	**	0.12208	ns
2012–2014	4.19E-02	ns	1.7329	**	4.7602	***
2012–2015	1.3209	ns	2.7187	**	7.7258	***
2013–2014	1.1201	ns	6.4751	***	4.4633	***
2013–2015	0.26567	ns	10.182	***	7.3232	***
2014–2015	0.98742	ns	0.89295	ns	1.9649	**
	China, USA		**China, Vietnam**		**USA, Vietnam**	
2002	2.5786	***	8.2958	***	5.1415	**
2003	2.7939	***	2.6271	**	0.62882	ns
2012	4.3108	***	10.268	***	2.6514	**
2013	11.68	***	8.7581	***	0.86304	ns
2014	2.7356	**	4.1323	***	0.9346	ns
2015	3.0358	**	3.817	**	0.60708	ns

3.2. Inspection of live bait boxes

Worms were packaged in two different materials: Styrofoam boxes with cardboard cover (10 × 10 cm) and plastic boxes (11 × 8 cm). Inside the boxes, worms were involved in three types of synthetic material: polyester fiber, plastic sponge and paper pulp; and two types of natural material: sawdust and sand.

Taxonomic identification allowed to determine five different bait species: *Glycera dibranchiata*, Ehlers, 1868 (48 specimens), *P. linea* (458 specimens), *Sipunculus (Sipunculus) nudus*, Linnaeus, 1766 (41 specimens), *Namalycastis rhodochorde* Glasby, Miura, Nishi & Junardi, 2007 (11 specimens) and *Perinereis cultrifera* (Grube, 1840) (1 specimen). These species had different origins regarding

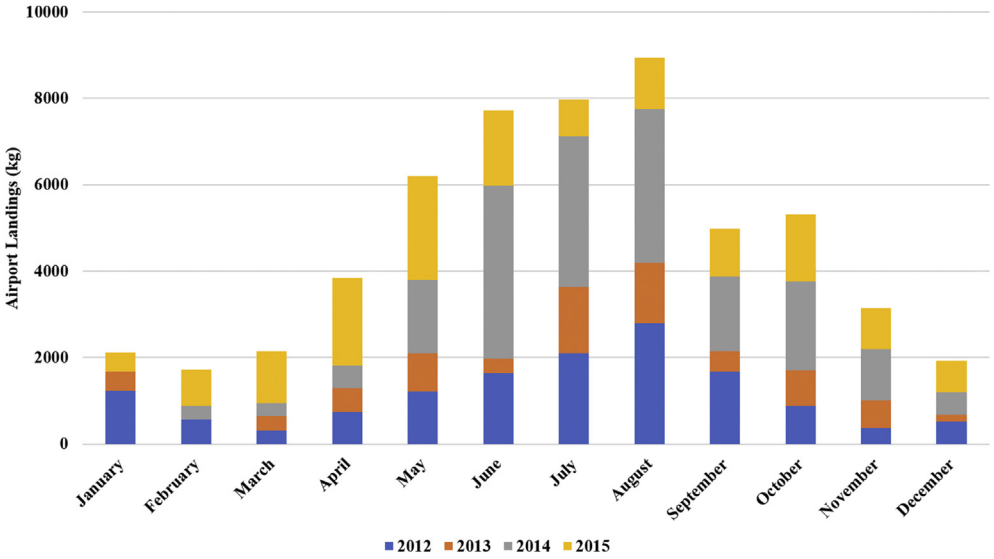

Fig. 2. Monthly airport landings (kg) of worms at the Lisbon airport from 2012 to 2015.

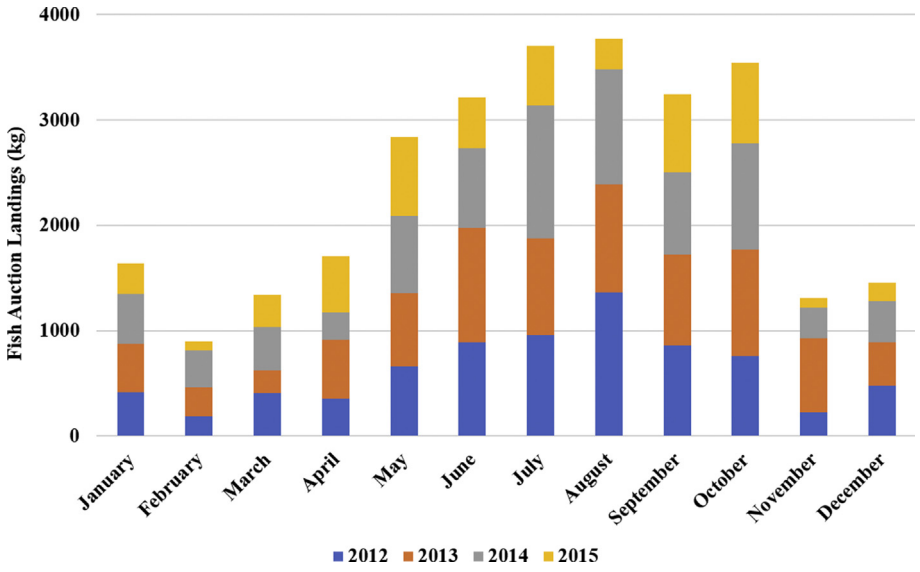

Fig. 3. Monthly landings (kg) of worms at Portuguese fish auctions for the period 2012–2015.

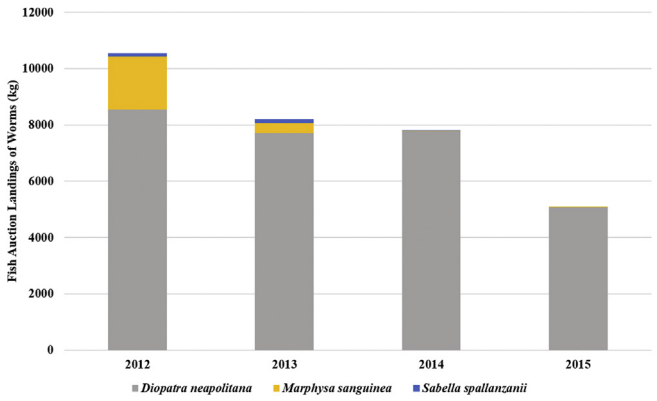

Fig. 4. Quantity of worm species landed on fish auctions for the period 2012–2015.

the importers, arriving exclusively from three different countries (Fig. 6).

No associated flora and fauna organisms were found in examined bait boxes, except in three different boxes where three individuals of *Enchytraeidae* oligochaetes were found. These three individuals appeared in boxes with polyester fiber and sand (Table 2). The three oligochaetes were in very bad conditions which did not allow to progress in the taxonomic identification. Due to this it was only possible to identify their family, and a more detailed taxonomic identification was not viable, making impossible to infer its possible origin.

Taxonomic identification of specimens likely to be native from Portugal indicated the occurrence of, at least, six different native species, usually used as bait: *D. neapolitana, M. sanguinea*, *Ophelia radiata* (Delle Chiaje, 1828), *Ophelia bicornis* Savigny in Lamarck, 1818, *Nephtys hombergii* Savigny in Lamarck, 1818 and *Hediste diversicolor* (O.F. Müller, 1776).

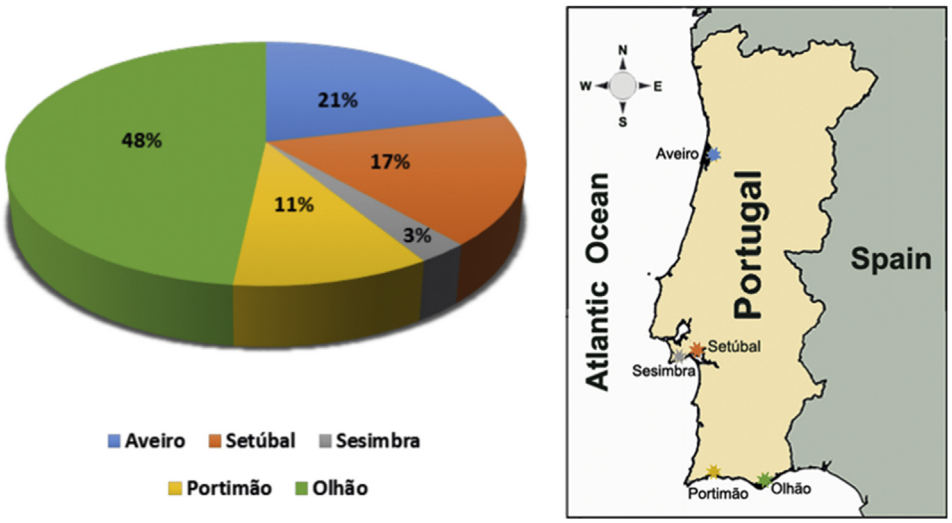

Fig. 5. Relative importance (%) of principal Portuguese fishing areas regarding the total fish auction landings of worms (31.67t) for the period 2012–2015.

Fig. 6. Origins of the species imported by Portuguese importers.

Table 2
Details of boxes examined. Packaging material: A-polyester fiber; B - sponge; C - sawdust; D – sand; E – Paper pulp. (*Portuguese common name; **English common name).

Company	Number of boxes	Packaging material	Common name	Species	Accompanying flora and fauna
I	5	D	*Americano **Bloodworm	*Glycera dibranchiata*	Present
	10	A and C	*Coreano **Korean ragworm	*Perinereis linea*	Absent
	5	A and C	*Coreano XL ** Korean ragworm	*Perinereis linea*	Absent
	5	A and C	*Coreano Red ** Korean ragworm **Ragworm	*Perinereis linea* *Perinereis cultrifera*	Absent
	5	B	*Tita media **Peanut worm	*Sipunculus (Sipunculus) nudus*	Absent
	5	E	*Cordel **Nuclear worm	*Namalycastis rhodochorde*	Absent
II	4	D	*Americano **Bloodworm	*Glycera dibranchiata*	Absent
	5	A and C	*Coreano ** Korean ragworm	*Perinereis linea*	Present
III	5	A and C	*Coreano ** Korean ragworm	*Perinereis linea*	Absent
IV	4	A and C	*Coreano ** Korean ragworm	*Perinereis linea*	Absent

4. Discussion and conclusions

The activity of worm-collecting on sediment shores or by revolving the mudflats where dense worm's populations are present, is frequently observed on coastal areas in Portugal (Fidalgo e Costa and Cancela da Fonseca, 2000; Cunha et al., 2005; Carvalho et al., 2013; Fidalgo e Costa et al., 2016). Portuguese regulation (Portaria nº 1228/2010) requires that bait gatherers have a personal license and it provides a list of species allowed to be captured, including annelids (*Sabella pavonina* Savigny, 1822, *M. sanguinea*, *Diopatra* spp. and *Nereis* spp.) and sipunculids (*Sipunculus* spp). *S. pavonina* have not to be found in retail shops, neither was it meant from fish auction activities during this work. Captures are supposed to be landed on fish auction throughout the country. Not surprisingly Aveiro, Setúbal and Olhão (north, center and south, respectively) in the vicinity of the principal harvested areas (Ria de Aveiro, Sado estuary and Ria Formosa) were the fish auctions with more worms landed. Landings data indicated only three different species of worms arriving the different fish auction areas along the country. These species were *M. sanguinea, D. neapolitana* and *S. spallanzanii* and there was a significant decrease of captures for this species between 2012 and 2015, particularly for the first and the last one. However, surveys conducted at fishing stores (unpublished data) indicated that fish auction data underestimate the harvesting effort since some companies employ their own harvesters, which catches are not registered at the fish auctions. That was the case of the six different species purchased from two different providers: besides *D. neapolitana* and *M. sanguinea*, they also sold *O. radiata*, *O. bicornis*, *N. hombergii* and *H. diversicolor*. Moreover, data obtained by those surveys revealed a wide range of marketed species captured in the country: including the former referred species and also *Halla parthenopeia* (Delle Chiaje, 1828), *S. nudus* and *Scoletoma* spp. Some of these species are not reported because they are not included in the list of harvesting species regulated by Portaria nº 1228/2010 (*e.g. N. hombergii, H. parthenopeia and Scoletoma* spp.). Additionally, although the surveyed stores indicated species such as *S. spallanzanii, H. parthenopeia* and *Scoletoma* spp. as commercialized at their stores, they were never available for sale. *S. spallanzanii* is commonly used for fishkeeping and not as fishing bait and that is the most likely explanation for its absence at the fishing stores. This information confirms the underestimation of fish auctions data and the significant bias on the Portuguese fish auction system. Similarly to what happens in other regions (e.g. Fowler, 1999; Miller and Smith, 2012), the Portuguese regulation requires an individual license for commercial harvesting of bait. Nevertheless, a large number of unlicensed harvesters are involved in the collection of live bait in Portugal (Cunha et al., 2005; Carvalho et al., 2013). Unfortunately, nowadays is not possible to supervise this activity because there are no sufficient fish auction locals or checkpoints for bait catches control. A controlled and sustainable bait business does not comply with these insufficiencies, contributing for the persistence of a parallel economy (Castro, 1993; Cunha et al., 2005; Carvalho et al., 2013).

Polychaetes and sipunculids are currently imported from other countries to Portugal since gathering of worms only from natural populations became insufficient to meet market demands. The majority of catches occurred between April and October, and most worms imported through the Lisbon Airport also arrived during the same period. The monthly variation of bait registers and fish auction landings show a similar annual cycle and this seems to be a consequence of higher demands (e.g. sport and professional fishing) during the same period of the year. These findings confirm that in Portugal the exploitation of polychaetes occurs throughout the year, being more intense in warmer months (Cunha et al., 2005; Pires et al., 2012a, 2012b; Carvalho et al., 2013), as well as their importation, due to the increase of those activities in that period. Airport live bait importations examined in this study were from China, USA and Vietnam. Significant differences were found between countries of bait origin and years of importation, due to lower importation amounts in 2012 and 2013 in which China was by far the major supplier, with irrelevant arrivals from USA and Vietnam (cf. Fig. 1). However, there is an undetermined quantity of worms arriving to Portugal by land, from Spain and/or other close European countries, which should be thoroughly investigated to provide a better understanding of its importance and associated risks. The difference of minus 35.28 t in the mean annual landings between the 2002–2003 and 2012–2015 periods (a reduction of 28.75%) may be related to an increased harvesting in Portuguese systems or importation by terrestrial transportation or even to a reduction on the market demand, namely in what concerns the aquaculture industry needs (João Guerra/Lusobait, pers. comm.).

Opening and inspection of the imported bait worm's boxes on the Lisbon airport was not possible due to legal and bureaucratic constraints. Previous studies (*i.e.* Haska et al., 2012; Fowler et al., 2016), indicated that bait worms used in the USA industry were mostly *G. dibranchiata* and *Alitta virens* (M. Sars, 1835), which are usually packed in cardboard boxes filled with macroalgae (e.g. *Ascophyllum nodosum* (Linnaeus) Le Jolis, 1863 and *Fucus* sp.) to keep live worms moist during transportation. Surprisingly, no macroalgae was found as packaging material in bait worms' boxes purchased in Portuguese stores. All boxes purchased contained only synthetic or non-natural organic material and no seaweeds were detected. In all examined boxes only three individuals of oligochaetes (*Enchytraeidae*) were found, in three different boxes and the packaging material was not macroalgae but polyester fiber and sand. Previous studies have indicated that bait worm packaging is a potential vector of invasive species (Silva, 1979; Dawson and Foster, 1982; Carlton, 2001) but the present examination of bait boxes purchased in Portugal suggests that there is a low risk of accompanying species introduction in natural environments through this vector. Importers also indicated that species arriving from China are produced in aquaculture (V. Santos, ValBaits, pers. comm.), which further reduces the risk of introduction of accompanying species. Moreover, the major importer in Portugal indicated that all imported species are kept in clean water tanks after being transported from the Lisbon airport, and placed in new boxes to be sold in the Portuguese market. This procedure used to preserve the species alive and in good condition, also decreases the risk of hitchhiker species dissemination, reducing significantly the risk of introduction of non-indigenous species through live bait trade in Portugal. These results support a recommendation for the adoption of these handling procedures by all importers, both in Portugal and other European Union countries. The current study strengthens the evidence of the biosecurity hazards of live fishing-bait importing to Portugal, previously discussed by Fidalgo e Costa et al. (2006). Although this procedure, as far as it is known, is being adopted only by one of the importers, everything shows that the other importers also have some type of procedure once very few accompanying species were detected. Nevertheless, there may be a proliferation of both imported and accompanying species, through the sewers of the facilities where they are kept in tanks for washing, before being placed on the market. Unfortunately, it was not possible to verify this situation during this work but this will be one of the main objectives in a future study.

Species identified in bait boxes, such as *G. dibranchiata*, *N. rhodochorde* and *P. linea* are non-indigenous species with a potential risk of introduction, because they are used still alive and a larger number of bait boxes are found in recreational fishing hotspots often with live baitworms inside. These three species are imported by Portugal in large quantities, which increases the

probability of a possible involuntary introduction. Moreover, the temperature and salinity ranges from the origin of the main imported species (e.g. Choi and Lee, 1997; Glasby et al., 2007; Cohen, 2012) may be found in some Portuguese brackish systems increasing the risk of the settlement of these species like it happened with *P. linea* at the Mar Menor lagoon (Arias et al., 2013). In the case of *P. cultrifera* and *S. nudus*, in spite of their allochthonous origin, they are thought to be cosmopolitan and are already present in Portuguese ecosystems (Dexter, 1992; Gil, 2011). The first evidence of the introduction of an imported bait species was recorded in the Mediterranean Sea (Mar Menor lagoon, SE Iberian Peninsula), where a reproductively-active population of the Korean ragworm (*P. linea*) was registered outside its native distribution range. The presence of this species in the Mediterranean waters was an unwanted collateral effect of its import and use as baitworm for recreational fishing (Arias et al., 2013). These authors, inspected 40 females from Mar Menor lagoon and 61% were infected by ciliates and the percentage of infestation was higher in females coming from Korea (87%). Only the females were attacked by ciliates because they feed the vitellus pellets of eggs and for that reason, males were clean. However, and as far as it is known, all individuals of *P. linea* imported to Portugal come from Chinese aquacultures, and being from a controlled environment, the danger of ciliates infestation eventually may decrease. The success of the *P. linea* in establishing a reproductively-active population in Mar Menor indicates a high invasive potential of this species in receiving ecosystems and shows a high reproductive flexibility (e.g. this species can reproduce in two different ways), which may have facilitated their colonization (Arias et al., 2013). The Mar Menor lagoon is within a biogeographical region shared with the south of Portugal (Spalding et al., 2007) and this occurrence suggests a high probability of introduction and possible establishment of this species in national waters too. Therefore, this risk should be closely monitored in Portuguese systems. For the other two species, *G. dibranchiata* and *N. rhodochorde*, there is no information about introduction consequences or if they have reproductive success in new environments. It is known that *G. dibranchiata* inhabit the intertidal and subtidal regions of mud flats, and they can survive in areas with low oxygen levels and have the ability to tolerate fluctuating salinity levels (Klawe and Dickie, 1957). The Vietnamese worm *N. rhodochorde* was only recently described by Glasby et al. (2007) and its range is still imperfectly known. Howsoever, it is known that *N. rhodochorde* inhabits mud banks and mudflats of estuaries and rivers from full seawater to almost freshwater, has a natural tolerance to hot, low-oxygen conditions and they are tolerant of wide salinity variations (Glasby et al., 2007), and all these characteristics indicates that, probably, they are great invaders of new environments and control measures are imperative. Further studies about this species are required mainly because they are known as a likely vector for introducing of hitchhikers such as multiple species of *Vibrio* bacteria along with diatoms, ciliates, flagellates, amoebae and nematodes (Cohen, 2012 and references therein).

In what concerns the major question of this work it seems that in this case the risk of introducing non-indigenous fauna/flora associated with the imported live worms is a minor problem. But an eventual non-problem with hitchhiker species does not means an absence of risk but “only” a risk of introduction of non-indigenous worm species imported alive, and eventually other undesirable hitchhikers not evaluated in this study (virus, bacteria, protozoans – Cohen, 2012; Arias et al., 2013; Micael et al., 2016 and references therein). Environmental monitoring is an essential measure to reduce such risks. The production of native species of polychaetes in aquaculture to fill the national bait demand should be considered a good alternative measure to reduce the risk of introduction of non-indigenous species and environmental impacts associated to the natural populations' exploitation of worms.

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