Fisheries Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Full length article

Approach to reduce the zoonotic parasite load in fish stocks: When science meets technology

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ARTICLE INFO

Handled by George A. Rose

Keywords:
Zoonotic parasites
Anisakids
TEDEPAD
Environmental health
Discarding

ABSTRACT

The increasing public awareness on the presence of anisakids in the viscera and mostly the flesh of commercially important fish species provoked the search of technical solutions to reduce the abundance of infective viable larvae at sea. During the last decade, a technological device was tested and improved to check its viability to reduce the presence of parasites in a hot spot epidemiological area with high prevalence on anisakids. The device was monitored under laboratory conditions and at sea in Grand Sole fishing ground. The Technological Device for Avoiding Parasite Discarding at Sea (hereafter TEDEPAD®) is industrial equipment designed to process the viscera are generated on board commercial fishing vessels. This equipment inactivates the zoonotic parasites present in the viscera, especially those of the genus *Anisakis* (and congeners) affecting humans (anisakidosis and related allergies) and markets, before the offals are returned to the sea. This process would contribute to a substantial reduction of viable infective larvae returning to the water mass, which otherwise would reinfestate the food system if remained untreated. As a consequence, and bearing in mind than a single female of *Anisakis* spawn about 1.5 million eggs, a minimization of the incidence of infective parasite larvae (firstly in the water mass of the fishing grounds and later on major fish stocks of commercial interest) is expected. The cost-benefit analysis indicates important benefits from different perspectives: the minimization of the dispersion of viable larvae parasites, the reduction of the recruitment of parasites into fish species of commercial interest, the decrease of rejected fishing products, reduction in sanitary expenses to attend parasite-induced pathologies, and increase of the consumer confidence that derives in highest fish purchases. Overall, all these issues will improve the environmental health of the fishing grounds and, in parallel, will provide an important economic positive impact for the fishing sector.

1. Introduction

The food safety problem produced by the presence of visible zoonotic parasites associated with European fish resources is being a matter of concern, both in the field of veterinary inspection and in the commercial agreements between operators in the sector. Specifically, the major concern is on the “ante-mortem” recruitment of viable parasitic larvae into the flesh of fish, which may be provoked by the use of poorly recommended fishing practices and the absence of more stringent and appropriate restrictions and prevention measures (EFSA, 2010). This is a recurrent problem that has become more acute in recent years. This scenario can be turned round by allowing the introduction of counter-epizootic measures in the ecosystem to minimize the exposure to the risk, and further evaluate its effectiveness and impact over time.

Changes in the structure of ecosystems and climate, whether artificial or natural, can influence the ecological traits of different organisms, including parasite populations and their communities (Sousa and Grosholz, 1991; Marcogliese, 2001; Rokicki, 2009; Kuhn et al., 2016). Parasites are excellent integrators of environmental conditions as being organisms with complex life-history patterns and well adapted to food webs at different hierarchically levels. Parasitism may be the most common lifestyle worldwide, but ecologists often ignore these organisms to perform their trophic models. That means parasites are under-represented in food webs, the map like visualizations of the trophic

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http://dx.doi.org/10.1016/j.fishres.2017.08.016
Received 30 June 2017; Received in revised form 4 August 2017; Accepted 18 August 2017

ecology. Previous analyses of the few datasets that contain parasites have indicated that their inclusion alter the network structure. However, it is unclear whether those alterations were a result of the unique role that parasites play, or resulted from the changes in diversity and complexity that would occur when any type of species is added to a food web (Dunne et al., 2013).

The environmental stress and exploitation may cause shifts in the distribution and abundance of host populations, and in turn in their parasite communities (Gardner and Campbell, 1992; Marcogliese and Cone, 1997a,b). The role of oceanographic disturbances on host-parasite recruitment dynamics was underlined by Pascual et al. (2007). These authors showed that combined epidemiological data obtained from both fish and cephalopod exploited populations underlined that variability in recruitment of parasite tends to be associated with major current systems worldwide. In general, unstable water masses seem to produce impoverished parasite faunas, especially for heteroxenous parasites with complex, multiple-host life cycles. The likely relationship between parasite recruitment and oceanographic regime should be extremely useful to the fishing industry and also as an indicator of ecosystem health.

Besides the problems associated to the integration of parasites in food trophic webs and the role they represent from an holistic perspective, there is another important issue that points directly to the health of the consumers: the public concern on zoonotic parasites such as the larvae of anisakids. These larvae frequently invade the viscera and musculature of many finfish species, which ingest them through intermediate hosts like crustaceans and fishes (Gregori et al., 2015; Gómez-Gutierrez et al., 2017; Levsen et al., 2017). Thus, there has been an increase of reported cases worldwide of human anisakiasis during the last 30 years (Cipriani et al., 2016). Reinforcing this evidence, based on a quantitative risk assessment (QRA) model for the anchovy value chain, Bao et al. (2017) advised policy makers, fishing industry, health professionals and consumers about this underdiagnosed zoonosis. There are also indirect effects of the epidemiology of visible parasites, which is the repulsion of consumers produced by the presence of worms in fish products.

The increasingly presence of anisakids in the viscera and flesh of commercially important fish species provoked the search for solutions to reduce the accumulation of viable larvae at sea. The re-infestation process that increases the average number of larvae in the system is quite simple, especially in heavily exploited fisheries. Once the fish is eviscerated on board, the offals are returned at sea with their viable anisakid loads, which provoke the increase of thousands of millions larvae every fishing season. For scavenger species that live in areas where discarding is continuous, such additional inputs could be a major trophic resource (Bozzano and Sardá, 2002). For this reason, continuous anthropogenic inputs may bring about environmental perturbations that can alter benthic ecology and community stability. The evident effect is that some of the main commercialised species increases their presence of anisakid larvae, which finally render an emergent or re-emergent exposure to the risk (McClelland et al., 1990; Abollo et al., 2001). Derived from that, we have been working during the last decade in a technological system to reduce the presence of parasites in the main site that has to be monitored: at sea in the main fishing grounds. The aim of this study is to present the proof of concept carried out under the umbrella of the EU PARASITE project (GA 312068) to reduce the presence of viable larvae of anisakids at sea by killing the larvae before the offal are returned after evisceration. Herein, we also present a cost-benefit scenario of the elimination/inactivation onboard using the TEDEPAD® device.

2. Materials and methods

2.1. Technological device for avoiding parasite discards at sea (TEDEPAD®)

The TEDEPAD® is an innovative equipment that generates high frequency pulses. It was designed to irradiate automatically the offals generated during the evisceration process onboard fishing vessels, avoiding any potential interaction or control by fishermen. Thus, its use does not interfere the fishing/eviscerating/processing activities onboard the fishing vessel. This system inactivate and kill the parasites contained in the offals, especially anisakids, before they are returned to the sea, and prevent the re-infestation of viable parasites that could re-enter the trophic webs.

The equipment installation does not require important modifications in the fishing deck. The TEDEPAD® were designed and built according with EU standards (2004/108 Electromagnetic Compatibility Directive and 2006/95 CE of Low Voltage Directive).

The equipment consists basically of three main blocks:

- Storage Module: It consists of a tank for fish guts with a capacity of 150 L (configurable as installed) having a first heating dual chamber rounded with an electrical heating system, and an outer insulating chamber, filled rockwool for a full thermal insulation to the outside, heating the guts once they are introduced in this storage tank. This module is equipped with several level and temperature sensors as well as an internal system of water and air injection for a self-cleaning process. All elements are made of AISI316 stainless steel and hi-tech polymers. Its function is to store and heat all the guts that are generated in the gutting line in the vessel fishing hold.
- Reactor Module: It consists of a stainless steel tank with capacity of approximately 14 L. This reservoir is surrounded by electronic elements that generate high frequency pulses to irradiate the guts. The reactor is surrounded and protected by rockwool for a full thermal insulation to the outside and with double chamber specially designed to cooling the critical inside components. The Reactor Module is completed with two (input and output) big diameter pneumatic knife gate valves with a diameter of 150 mm mouth. This module is equipped with several level and temperature sensors as well as an internal system of injection of water and air for self-cleaning process. All elements are made of AISI316 stainless steel, high-tech polymers and ceramics. Its function is to heat quickly the gusts and consequently all viable anisakid larvae by reaching temperatures up to 80 °C. This reactor module is directly connected to the line inserted where the fish waste are discarded to the sea. The TEDEPAD® contains a manual valve of "bypass" in order to continue work in case of adjustments, maintenance and/or equipment damage.
- Command and Control Module: The electric and pneumatic cabinet is independent and can be installed near the equipment or any other adjacent to the fishing hold. It houses all the electronic components, microprocessor control system, pneumatic devices, the control panel, data logger system and electrical protections. This module is responsible for managing the TEDEPAD® computer to operate automatically without assistance. During operations, the control module indicates the monitoring process in real-time by a panel light indicators.

2.2. Amount of offal produced by the Grand Sole Spanish fleet in 2013

To give an idea about the impact of effectively implementing the TEDEPAD® device in the fleet, we first gathered information on the amount of offals produced by the Grand Sole Spanish fishing fleet in 2013. Data have been obtained from the logbooks of vessels belonging to ANASOL (Spanish Association of vessels in Grand Sole), compiled and provided by the Statistics Department of the Fisheries Ship-owners Cooperative Puerto de Vigo (ARVI), and treated to the report by the R & D Department of ARVI-INNOVAPESCA. These data allowed estimations for the whole Grand Sole fleet for an average vessel.

The Spanish fleet operating in Grand Sole consists of ships with two main types of gear: bottom trawlers and bottom longliners. In the current census of ANASOL from Galicia, a total of 43 trawlers and 50