The potential of *Eisenia foetida* usage in aquaculture

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Abstract. According to recent statistics the fastest global development in animal production was recorded in the industrial fisheries and aquaculture. Thus, international strategic objectives became the reduction of fishing from natural waters in order to restore fish populations. Meanwhile, another core activity is related to increased efficiency in the usage of the natural resources, halting environmental pollution by proper management of the organic waste. In latest years focus was directed in earthworm production as a feasible solution for organic waste transformation into valuable protein, partially replacing fish meal in farming animals and fisheries nutrition. The usage of *Eisenia foetida* for processing organic waste and its transformation in vermi compost and protein biomass is proving to be a valuable resource of nutrients for aquaculture. Vermi compost can be used mainly in semi intensive fisheries as organic fertilizer with the aim of improving the natural productivity of ponds. Thus, availability of natural feed is increasing and the need for added feeds is limited. In intensive and super-intensive fisheries usage of earthworm biomass can be a non-conventional protein resource.
Key words: vermicomposting, ponds, aquafeed, protein, earthworm meal.

Introduction. Ichtyofauna has an important role in today's global aquaculture economy, fishing becoming the fastest developing area in the current food resourcing. Annually over 80 million metric tonnes of fish products are harvested from the oceans and seas while only 12 million metric tonnes from inland waters. Current demand of fish meat is 100% higher than it was in 1950. For 2030 it is believed that this demand for water derived food will rise over 200 million annually, while only half of it could be covered through fishing (FAO 2014; 2016). International strategic objectives related to reduced human environmental foot print and biodiversity preservation will depend as well on decreased fishing activities to allow fish populations to be naturally restored. This can only happen by identification of novel animal protein resources (Beg et al 2016; Sakthika et al 2014; Sogbesan & Ugwumba 2008) which could replace the fish meal, currently the main protein ingredient in aquafeed industry (Ayadi et al 2012; Mamauag 2016).

According to latest studies aquaculture was the fastest developing food resource activity in the last decade (FAO 2014) covering more than half of the global fish consumption (Naylor et al 2009; FAO 2016). Based on the targeted production, fish density, human workload and intervention, aquaculture can be classified as extensive, semi-intensive and intensive/super-intensive with water recirculation systems (Cristea et al 2002; Grozea 2007). The extensive and semi-intensive fish production will rely mainly on producing fish meat based on natural feed existing in lakes and ponds. The more intensive and super intensive systems will not rely on natural feed resources of the waters while it would imply a rigorous control over its parameters (Pricope et al 2012).

Thus, aquaculture will depend always on the existence of land, water, aquatic sites and obviously, on supplementary feeding. Feed and its compounds will need to contain nutrients (proteins, lipids, sugars, vitamins and minerals), all essential for fish growth, reproduction and health, whatever if the feed source is natural or artificial (Oprea 2000). Also, whatever the production system it is clear that economic efficiency cannot be sustainable without a substantial protein resource which is the fish meal especially (Ayadi et al 2012; Mamauag, 2016). The high content of proteins and essential amino acids, rich in phospholipids and essential fatty acids (Stanković et al 2011) is the main attribute for which fish meal is considered to be the best source of proteins in aquafeed. However, usage of fish meal in aquafeed is limited by high prices and resources (FAO 2016; Vodounnou et al 2016). Thus, identifying sustainable sources of novel proteins became a challenging aim for research community and farmers.

Total or partial fish meal substitution can be performed by using non-conventional sources as the earthworm derived protein (Sogbesan & Ugwumba 2008). Intensive earthworm production proved to be an efficient solution for organic waste recycling from various sources doubled by achievement of low cost protein biomass (Dynes 2003; Vielma-Rondón et al 2003; Kostecka & Paczka 2006) with a nutritional value close to the fish meal (Fadaee 2012; Vielma-Rondón et al 2003).

Vermi-compost usage in fertilizing ponds. Fish production in freshwater lakes and ponds it is the most known system of harvesting the natural productivity of these inland waters (Grozea 2007; Stanković et al 2011). It is performed usually as poly-culture of the common carp (*Cyprinus carpio*) with other cyprinidae and carnivorous species. Ponds have large surfaces and variable water depth thus the productivity will depend on certain area, altitude and seasonal factors. Feeding supplementary nutrients is applied in different proportions depending of fish density, targeted harvest quantity and available water sources (Grozea 2007; Bud et al 2016).

Natural nutrient productivity of the ponds is sustained by the fish excretion by products and the supplementary feed which was not consumed. After harvesting and water drainage these ponds can lose large quantities of nutrients (Pricope et al 2012). Thus, in order to stimulate the recovery of this natural productivity, ponds are drained over winter and organic or mineral fertilizers and amendments are applied (Stanković et al 2011) with the aim of stimulating phytoplankton and zooplankton growth (Chakrabarty et al 2010). Most common organic fertilizer is animal manure (Chakrabarty et al 2009; Grozea, 2007).

As the fresh or fermented manure it is highly reach in nitrogen and phosphorous the pollution risk is increased by over fertilization and in excess nutrients leading to decreased water quality. In order to avoid this event vermi-compost produced through digestion by the earthworm can be a valid alternative solution. It is proven that usage of vermi-compost for fertilizing ponds improves the soil structure and stimulates nutrient production (Chakrabarty et al 2009; Chakrabarty et al 2010; Fadaee 2012) and fish efficient growth (Kaur & Ansal 2010). Using intensively *Eisenia foetida* for vermi-compost production is possible due to its high reproductive rate and low mortality when environmental conditions are optimum (Yeo & Binkowski 2010). The earthworm is largely used for organic waste recycling (sewage sludge, animal manure and industrial waste) while end product is the vermi-compost (Pereira & Gomes 1995; Dynes 2003; Marsh et al 2005; Yeo & Binkowski 2010).

Use of eartworm *Eisenia foetida* in aquaculture diets. As chemical composition the earthworm is high in protein (50-60%), lipids (7-9%) and sugars (11-14%) (Beg et al 2016; Fadaee 2012; Mamauag 2016). The high content of essential amino acids (mainly lysine and methionine) it is comparable to the one in fish or meat meal (Bou-Maroun et al 2013; Sakthika et al 2014; Vodounnou et al 2016).

Outstanding traits of *E. foetida* as protein resource were assessed through various chemical and digestibility analysis doubled by nutrition experiments performed mainly on land animal species but on fish and other aquatic species as well. By replacing 30% of the fish meal with earthworm *E. foetida* interesting production performances where achieved in several fish such as *Oreochromis niloticus*, *Oncorhynchus mykiss* and *Cyprinus carpio* (Bou-Maroun et al 2013; Beg et al 2016; Mamauag 2016). In the case of the *Parachanna obscura* brood the highest growth rate and feed conversion efficiency was achieved with the fish's diet containing 50% of earthworm meal (Vodounnou et al 2016). In the case of the *Clarias gariepinus* fed with earthworm *E. foetida* a higher stress resistance, survival and growth rate was recorded (Fadaee 2012). It was proved as well that the earthworm meal protein has positive effect on reproductive performances and stimulate feed intake in broods of *Oxyeleotris marmoratus* and *Pangasianodon hypophthalmus* (Ngyuon & Yang 2007 cited by Sakthika et al 2014). Earthworms are also used as a dietary supplement for ornamental fish for growth and development, but also for improving the breeding performance (Kostecka & Paczka 2006; Lowe et al 2014).

Conclusions. Beside its ability to recycle manure through earthworms an important source of protein can be produced and used in animal nutrition and aqua feeds. *E. foetida* production is a genuine and valuable technology with positive impact on ecology and animal nutrition. This earthworm is able to help in animal manure management and recycling and is a cheap resource of protein as well. As the Romanian carp production is performed mainly in lakes and ponds it is clear that vermi-compost usage could have a large impact on the efficiency and productivity. This way of fertilizing the ponds can lead to savings in required supplementary feeding. Thus, using earthworms in aquaculture has potential positive ecological and economic effects while solves the challenge of organic waste recycling.

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