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Dietary risk ranking for residual antibiotics in cultured aquatic products around Tai Lake, China

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ABSTRACT

Antibiotics are widely used in aquaculture and therefore may be present as a dietary risk in cultured aquatic products. Using the Tai Lake Basin as a study area, we assessed the presence of 15 antibiotics in 5 widely cultured aquatic species using a newly developed dietary risk ranking approach. By assigning scores to each factor involved in the ranking matrices, the scores of dietary risks per antibiotic and per aquatic species were calculated. The results indicated that fluoroquinolone antibiotics posed the highest dietary risk in all aquatic species. Then, the total scores per aquatic species were summed by all 15 antibiotic scores of antibiotics, it was found that Crab (*Eriocheir sinensis*) had the highest dietary risks. Finally, the most concerned antibiotic category and aquatic species were selected. This study highlighted the importance of dietary risk ranking in the production and consumption of cultured aquatic products around Tai Lake.

1. Introduction

As one of the most important sources of protein, aquatic products have satisfied the dietary demands of human beings (Bosma and Verdegem, 2011). In China, the primary means of harvesting aquatic products is high intensity aquaculture (Cao et al., 2015), which not only requires the sustainable input of formulated feed, but also various measures for preventing disease (Wang and Chen, 2006; Han et al., 2016). It has been reported that high intensity aquaculture contributed to more than half of the total production of inland fisheries in 2016, reaching 30 million tons (Fishery Bureau, 2016). This increase in production should ideally be accompanied by research into fishery medicine use, as it may influence the dietary safety of aquatic products (Zhao et al., 2015; Zhong et al., 2016).

Of all fishery medicines, antibiotics are the most important and widely used in the production of aquatic products for preventing gram-positive and gram-negative pathogens (Nhung et al., 2016). For example, the fluoroquinolone antibiotic enrofloxacin is often used to treat *Aeromonas* infected food animals (Ministry of Agriculture, 2007b; Andrieu et al., 2015). Statistical data showed that approximately 100,000 t of antibiotics are used annually in the production of food animals in China, including aquatic products. However, 10,000 t of these antibiotics are not absorbed and are therefore discharged into the surrounding environments, such as rivers, lakes and other natural water bodies (Li et al., 2014; Zhang et al., 2015).

As a result of toxicological effects and antimicrobial resistance, residual antibiotics in aquatic products have become of increasing concern (Liu and Pop, 2009; He et al., 2012a; Martins et al., 2012; Xiong et al., 2015; Li et al., 2016). For example, antibiotics usage is considered to be a significant factor contributing to the burden of aquaculture environments in the Pearl River Delta in South China (He et al., 2016). Fluoroquinolones such as ciprofloxacin and enrofloxacin have been detected in a variety of fish samples, including values as high as 254.58 $\mu g\ kg^{-1}$, exceeding the maximum residue limit (100 $\mu g\ kg^{-1}$) set by the Chinese government (JECFA, 1998; Ministry of Agriculture, 2002). Additionally, all 3 analyzed sulfonamides were also detected in the muscle tissue of fish samples. Other antibiotics are used to control the biomass of primary productivities in fishponds. For example, erythromycin is used to eliminate surplus blue-green algae in crab (*Eriocheir sisensis*) culture ponds (Liang et al., 2013). In summary, the use of

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different antibiotics results in residuals in aquatic products. More than 6 categories of antibiotics have been used in aquaculture, including sulfonamides, fluoroquinolones, tetracyclines, β-lactams, amphenicols and macrolides. To date, antibiotic residues in food animals have become a global health hazard. It was been acknowledged that antibiotics at low dosage have been demonstrated to have growth promoting effect (Wang et al., 2016). The epidemiological study of children aged 3- 18 years found evidence of progressive effect of antibiotic intake on body mass index (BMI) (Schwartz et al., 2016). At super- therapeutic level, the antibiotics were responsible for histological alterations on human cardiovascular tissues (Buzzi et al., 2014). Moreover, the chronic exposure of antibiotics would cause bacterial resistance, which have become an emerging public-health threat (Schwaber et al., 2004). However, in almost all previous reports, the dietary risk of each antibiotic category was based on the estimated daily intake (EDI) and assessed separately (Rico et al., 2014; He et al., 2016). Thus, it was not possible to explicitly discriminate which antibiotic category or aquatic species was associated with the highest risk.

To address the above issue, a risk ranking approach was applied to a case study of the area surrounding the Tai Lake in East China. Using this approach, we explored which aquatic species and antibiotic categories posed the highest dietary risk and therefore should be monitored in the future. We have provided suggestions for the safe production and consumption of aquatic products in this region.

2. Materials and methods

The dietary risk ranking approach was performed with the aim of prioritizing the associated dietary risks per antibiotic and per aquatic species. Thus, an assessment of the associated antibiotics and aquatic products surrounding Tai Lake was necessary.

2.1. Aquatic species

Tai Lake Basin, located in the middle and lower reaches of the Yangtze River, is the primary aquaculture area of China (Fig. 1). Five main aquatic species are cultured in this area (Song et al., 2016), including bream (*Megalobrama amblycephala*), perch (*Lateolabrax japonicus*), crab (*Eriocheir sinensis*), shrimp (*Macrobrachium nipponensis*) and prawn (*Litopenaeus vannamei*).

2.2. Antibiotics

According to the specifications for antibiotics usage in aquaculture published by the Chinese government (Ministry of Agriculture, 2007a, 2007b), 15 widely used antibiotics were selected, including 5 sulfonamides, 2 fluoroquinolones, 3 β- lactams, 3 tetracyclines, 1 amphenicol and 1 macrolide. Detailed information is included in Table S1.

2.3. Sampling strategy

Water and fish samples were collected based on the following strategy, with the aim of determining antibiotic content and subsequently calculating the total dietary risk scores. To obtain sufficient representative samples, 4 geographically distinct regions were sampled around Tai Lake, detailed in our previous study (Fig. 1). In brief, we assessed antibiotic usage in 24 fishponds, covering 4 regions, 5 sampling times (from May to October) was investigated. A total of 163 fish samples and 100 water samples were obtained during the aquaculture season. Here, fish and water samples were collected based on a "blended method." For fish samples, 3–6 individuals were captured in each fishpond and an equivalent quantity of muscle tissue from the 3 individuals was combined, resulting in a single sample. For the water sample collection, 1000 mL water obtained from 20 cm below the surface from 5 sites of a single pond was blended

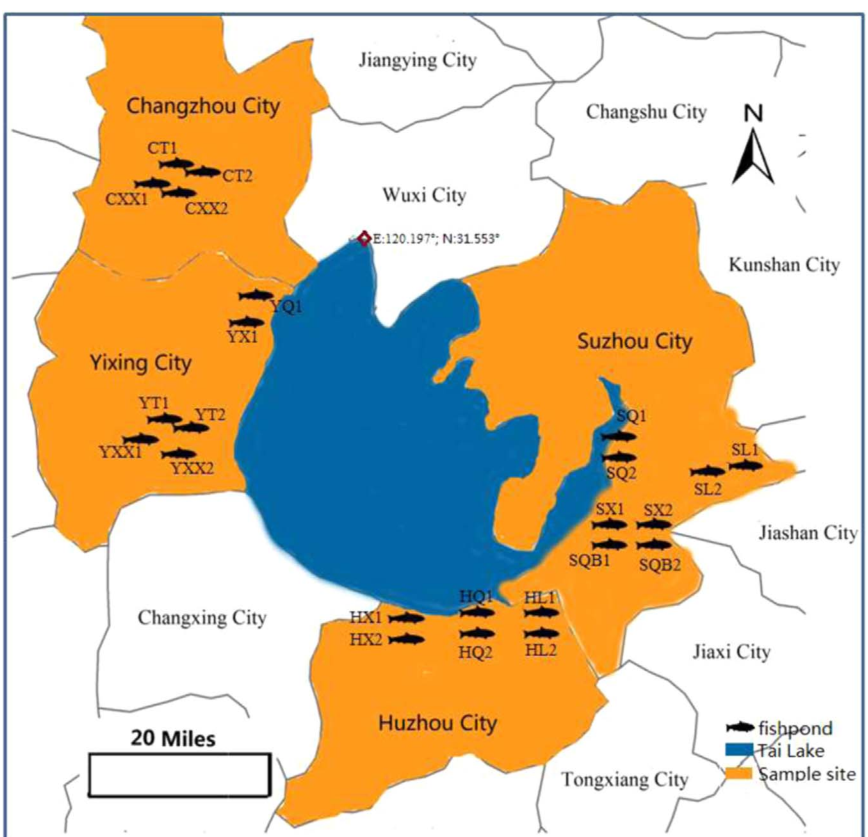

Fig. 1. Sampling fishponds around Tai Lake, cited from our previous study (Song et al., 2016). A total of 24 fishponds located in 4 sampling regions were monitored (4 ponds for Changzhou City, 8 ponds for Yixing City, 6 ponds for Huzhou City and 6 ponds for Suzhou City). Each pond has its own label, for example, there are 4 ponds labeled CT1, CT2, CXX1 and CXX2 in Changzhou City. Of these 24 labels, C, Y, H and S represent Changzhou, Yixing, Huzhou and Suzhou City, respectively; T, XX, X, Q, L, and QB represent bream (*Megalobrama amblycephala*), crab / shrimp (*Eriocheir sinensis / Macrobrachium nipponensis*), crab, shrimp, perch (*Lateolabrax japonicus*), and prawn (*Litopenaeus vannamei*), respectively. The numbers 1 and 2 are used to discriminate different ponds located in the same region farming the same fish species, for example, CT1 represents the first fishpond farmed with bream located in Changzhou City. Fish farmers in the above areas prefer the polyculture of shrimp and crab to increase profits.