Field assessment of antibiotic use in fish farms in Southwestern Nigeria

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Keywords

Aquaculture, good agricultural practices, antibiotics, resistance to antibiotics, tetracycline, Nigeria

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Summary

Antibiotic resistance is a global public health issue linked to antimicrobial use in food animals. However, little is known of antibiotic use in aquaculture in developing countries and its link to antibiotic resistance. This study investigated antibiotic use in 50 aquaculture farms in Southwestern Nigeria using a structured questionnaire. Twenty-seven (54%) farms used antibiotics (n = 24), antiparasitics (n = 2) or both (n = 1) as additive to feed or water. The most frequently used antibiotics were tetracycline (11 farms), beta-lactams and furazolidone (4 farms each), aminoglycosides and chloramphenicol (3 farms each), enrofloxacin (2 farms) and metronidazole (1 farm). Only 16 farmers knew the antibiotics used in their ponds and no farm had data on the quantity used. The drugs were sourced from veterinary (59%) and human medicine stores (15%), veterinary doctors (4%), or other fish farmers (4%); 19% did not answer this question. Many farmers (n = 15), among whom 11 held a technician diploma or a university degree, did not know of any risk entailed by the use of antibiotics in their ponds. Direct addition of antibiotics to pond water practiced in these farms can create local reservoirs of antibiotic resistance and is a risk to public health.

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■ INTRODUCTION

Resistance to antimicrobial drugs is presently a key challenge in the control of infectious diseases worldwide (UN-IACG, 2019). Human and agricultural uses of antibiotics have been implicated as important contributors to the development and spread of antibiotic resistance in pathogenic and commensal bacteria strains (Tang et al., 2017). Currently, more antibiotics are used in food animal production to promote growth and prevent disease than in the entire human population. Global antibiotic consumption in livestock was conservatively estimated at 63,200 tons in 2010 (van Boeckel et al., 2015), accounting for about two-thirds of the estimated worldwide annual production of 100,000 tons of antibiotics.

Among intensive types of livestock production that use antimicrobial agents, particular attention should be paid to fish farms because of their direct impact on the aquatic environment (Cabello et al., 2013). Large quantities of antimicrobials are used in aquaculture in low- and middle-income countries, often without professional supervision with consequences for development and spread of resistance and global public health. In Nigeria, policy regulating the availability and use of pharmaceutical substances are weakly enforced; hence, antimicrobial drugs are used widely in human, veterinary and agricultural applications often without professional advice or supervision. Accordingly, Nigeria was cited among the 50 countries with the largest amounts of antibiotic use in livestock in 2010 (Van Boeckel et al., 2015).

Recommended action plans to combat the spread of antibiotic resistance include the collation of national and local data on antibiotic use in human, veterinary, and other agricultural applications (O'Neill and

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the Review Committee, 2016) which should be made publicly available to inform policy decisions on the control of antibiotic resistance. Very little is known about the types and quantity of antibiotics used in livestock production in Nigeria. However, available evidence suggests that antibiotics are used widely in poultry, swine and aquaculture production (Adelowo et al., 2009; 2014; Adebowale et al., 2016) with little or no information on the types and quantity used, frequency of administration, and reasons for use. This knowledge gap limits the understanding of the link between antimicrobial use and the development and spread of antibiotic resistance in the Nigerian fish production chain, creating an urgent need for studies investigating these issues. The primary objective of this paper was to investigate antibiotic use in selected fish farms in Southwestern Nigeria. The information generated will be an important addition to the knowledge of antibiotics use in food animal production in the country.

■ MATERIALS AND METHODS

Participating farms and data collection

The procedure used for data collection was a volunteer-based convenience sampling method. Prospective participants were enlisted by peer contact using one of the farmers in the study area who had earlier been briefed about the overall objective of the study. The peer contact made a preliminary visit to the fish farmers in the study area, who generally operate in clusters, to solicit consent before questionnaire administration. During the preliminary visit (as well as during questionnaire administration), a detailed description of the study and the type of data to be collected were presented to the farmers after which questions raised were addressed as much as possible before the farmers were asked to indicate their interest in the study. The peer-contact method was adopted because a previous attempt to collect similar data among poultry farmers in the same area failed as many of the farmers expressed open reservations about the intention of the researchers.

Antimicrobial-use information was collected from each participating farmer on a second visit using a structured questionnaire administered to either farm owners or farm hands in a guided format. A brief description of what antimicrobials are and some examples that are used in aquaculture production were orally provided to each respondent when necessary. Only one questionnaire was administered per farm. The questionnaire was designed to capture basic information about the farm and the respondent, including: educational qualification of the respondent; age of the farm; fish species raised; culture method; type of feed used and their components; drugs used and categories; frequency of use; dosage and types used; reason for use; administration mode; source of the drugs and who the farmers consulted before antibiotic use; and whether the farmers were aware of any hazard associated with antibiotic use on their fish farms.

Data manipulation and statistical analysis

Data generated by the questionnaire were analyzed by descriptive statistics using Excel 2010 (Microsoft, USA).

■ RESULTS AND DISCUSSION

Participating farms

At the end of the peer contact's work, 50 farms made up of 3 farms in Lagos and 47 farms in Oyo town, Southwestern Nigeria, agreed to participate in the study. The peer-contact person was based in Oyo town, a reason that might be responsible for the large number of participants from this location. The average age of the participating farms was 7.5 years with the youngest and oldest being 2 and 24 years, respectively. All farms were involved in small- to medium-scale operation with a minimum of two and a maximum of seven ponds. Thirty-five farmers (70%) were involved in the production of *Clarias gariepinus*, 2 (4%) of *Heterotis* spp. in monoculture, in either earthen ponds (64%), artificial recirculation tanks (28%), or a combination of both (8%). The remaining 13 did not respond to the question. The educational qualification of the farmers ranged from basic elementary education (23.5%), to secondary education (17.5%), technician diploma (39%) and university degree (20%).

Antibiotics use on the study farms

Twenty-five farmers (50%) (including one who used a combination of antibiotics and antiparasitics) admitted using antibiotics in their farms, whereas two (4%) used only antiparasitics. Among these groups, nine (36%) had no idea of the type of antibiotics they were using. Surprisingly, three held higher education degrees whereas the remaining had elementary or secondary education. Two farmers in this group provided us with the packages of the products used and the information indicated the products contained a combination of "antibiotics and anti-stress". However, the specific nature of these molecules was not listed. The responses also showed that six of the antibiotic users used more than one class of antibiotics, with the most common (n = 3) combination being neomycin, tetracycline and furazolidone. The other combinations were ampicillin, tetracycline and metronidazole (n = 1), and ampicillin and tetracycline (n = 2). These findings were not unexpected, as policy regulating the availability and use of antimicrobial substances in developing countries is either non-existent or weakly enforced. In Nigeria, antimicrobials and other important drugs are available over the counter, making it easy for fish farmers to obtain them for use in their farms. The ease of availability may be a relevant factor promoting the use of these drugs in Nigerian fish farms. Dispensing antibiotics without prescription has been implicated as a link in the antibiotic resistance chain (Plachouras et al., 2010).

None of the 27 farmers using antibiotics and/or antiparasitics could supply information on their quantities used on their farms. Neither did they have any idea of the effective dose of the antibiotics administered. However, 16 farmers (59%) were able to supply the type(s) of antibiotics used in fish health management (Table I). The others either did not know the type used or did not respond to the question. Tetracyclines (oxytetracycline and doxycycline) were the most commonly administered antibiotics, used in 11 farms. Beta-lactams and furazolidone were each used in 4 farms, neomycin and chloramphenicol were each used in 3 farms, enrofloxacin (fluoroquinolone family) was used in 2 farms and metronidazole in 1 farm. None of the farmers using antiparasitics had an idea of the name of the product. It is of concern that all antibiotics mentioned as used on farms are categorized as important, highly important or critically important for human medicine (Table I) by WHO (2019). Thus, development of resistance to any of these drugs will have an effect on the ability to treat human infections.

This scarcity of data for quantitative antibiotic use from most countries engaged in aquaculture (Chuah et al., 2016) makes assessing the risk associated with their use a difficult task. This situation is compounded by the present rapid growth of the aquaculture industry in Nigeria where a large proportion of the unemployed population is embracing small-scale agro-enterprises as a means of generating much needed income. Under this condition, the pressure to maximize profit in a very short time will result in widespread use of antibiotics to prevent bacterial infections.

An important discovery worth mentioning among the study population is that 82% of the farmers used poultry waste in their pond either as feed supplement or for pond fertilization, although residues of antibiotics are often found in poultry waste (OIE/FAO/WHO, 2006). This

Table I

Common antibiotics cited as being used by fish farmers and administration mode in Southwestern Nigeria

Antibiotic class	Importance to human medicine[a]	Priority level	Use of specific class[b] (%)	Administration mode			
				Feed	Water	Feed + water	DNS
Tetracycline Doxycycline and oxytetracycline	High	NA	44	3	7	1	0
β-lactam Penicillin and ampicillin	Critical	High	16	1	2	1	0
Nitrofuran Furazolidone	Important	NA	16	1	3	0	0
Aminoglycoside Neomycin	Critical	High	12	0	3	0	0
Amphenicol Chloramphenicol	High	NA	12	0	3	0	0
Fluoroquinolone Enrofloxacin	Critical	High	8	2	0	0	0
Nitroimidazole Metronidazole	Important	NA	4	0	0	1	0
No idea[c]			36	3	0	0	6

Of the 50 farmers surveyed, 27 used antibiotics (n = 24), antiparasitics (n = 2) or both (n = 1)

[a] WHO (2019); [b] The total percentage sums up to more than 100% because some farmers were using more than one antibiotic class; [c] Have no idea of the type used or antibiotic class; NA: Not applicable (prioritization is only applied to critically important antimicrobials); DNS: Did not specify

practice is therefore an additional risk factor for the development and spread of antibiotic resistance (OIE/FAO/WHO, 2006).

The antibiotic types used in fish production in the present study were very similar to those used in poultry and swine production in Nigeria (Adelowo et al., 2014; Amaechi, 2014; Oluwasile et al., 2014; Adebowale et al., 2016). Fewer varieties of antibiotics were, however, used in fish production. Whereas Adelowo et al. (2014), Oluwasile et al. (2014) and Adebowale et al. (2016) report, respectively, the use of 16, 12 and 11 antibiotics, belonging to 8 antibiotic classes, among poultry farmers in Ogun and Oyo states, results of the present study showed that a total of 9 antibiotics belonging to 7 classes were used in fish production within the same region. In sharp contrast, 23 antibiotics belonging to 10 antibiotic classes were used in 94 Vietnamese aquaculture farms (Pham et al., 2015).

Tetracyclines were also reported as the most commonly used antibiotics in two studies dealing with the same issue in various countries (Tuševljak et al., 2013; Pham et al., 2015). However, in addition to tetracycline, Tuševljak et al. (2013) report a high prevalence of fluoroquinolone use among fish farmers in the United States (70%) and Canada (67%), whereas Pham et al. (2015) report a similar high prevalence use of trimethoprim and sulfonamides in addition to tetracyclines in Vietnamese aquaculture farms. In the present study, only two farms used fluoroquinolone and no farm used trimethoprim and/or sulfonamides.

The main drug (antibiotics and antiparasitics) administration modes were addition to feed (n = 10) or water (n = 8). One farm used both modes whereas six did not specify the mode of administration (Table I). Administering antibiotics through these modes is risky from the point of view of public health as synthetic antibiotics such as fluoroquinolones are expected to be persistent in aquatic sediments where they can select for fluoroquinolone resistance in sediment bacteria (Martinez, 2009). The persistence of the residues of some of the drugs used in the pond environment or in aquatic feeds could in addition modify the composition and activity of the pond microbiota (Martinez, 2009), or expose aquatic-food consumers to risks associated with drug residues. Concerns have been expressed about the genotoxicity, embryo- and feto-toxicity, and carcinogenic potentials of chloramphenicol and its metabolites in humans as well as the carcinogenic and mutagenic potential and thyroid toxicity of sulfonamides. Similarly, beta-lactams, streptomycin (and other aminoglycosides), sulfonamides and, to a lesser extent, tetracyclines are known to cause allergic reactions in sensitive persons (OIE/FAO/WHO, 2006). Thus, most countries have banned the use of these antibiotics in food-animal production, including aquaculture.

Most farmers (n = 14) used drugs (antibiotics and antiparasitics) in the ponds when they noticed infection among the fish stock whereas nine (including two farmers using antiparasitics) used drugs in disease prevention. One farmer did not know the reason behind his use of drugs and three did not respond to the question (Table II). Sixteen of the farmers sourced the antibiotics used from local veterinary medicine stores, four from local human medicine stores, and one each from

Table II

Sources and reasons for antibiotic and antiparasitic use by fish farmers in Southwestern Nigeria

Source	Num. (%) of farmers
Veterinary medicine store	16 (59)
Patient medicine store	4 (15)
Veterinary doctor	1 (4)
Other farmer	1 (4)
Local pharmacy	0
DNS	5 (19)
Most common reason for use	
Treatment of diseased fish	14 (52)
Disease prevention	9 (33)
Did not know reason for use	1 (4)
DNS	3 (11)

Of the 50 farmers, 27 mentioned using the drugs; DNS: Did not specify

local veterinary doctors and other fish farmers. Five of the farmers did not respond to this question. Surprisingly, all respondents to this question used only one source (Table II).

None of the farmers retained the services of a veterinary or a fishery specialist, but seven farmers consulted them occasionally, and three farmers consulted with other fish farmers. However, although six farmers did not respond to the question, the remaining four indicated they did not consult with anybody before drug administration on their farms because "they consider their experience sufficient to qualify them as specialists." It is interesting to report that three of these farmers held a technician diploma or a university degree.

Among the 25 farmers who used antibiotics, a large number (n = 15; 60%) did not know of any risk associated with their indiscriminate use in ponds or did not respond to the question (n = 8). Among the two who responded in the affirmative, one did not specify the risk involved, and the other mentioned weight loss as a consequence of antibiotic use in animals. It appeared that the level of education was not positively correlated with an appreciation of the risk as 11 of those who did not know the risk involved in antibiotic use in fish production held either a technician diploma or a university degree.

■ CONCLUSION

Antimicrobial use has been identified as a risk factor for the development and spread of antibiotic resistance. However, the lack of accurate information on the quantity of antimicrobials used in animal production is an important drawback in the evaluation of the impact of veterinary antibiotic utilization on the selection of resistance and release of antibiotics into the environment. Although the present study covered a narrow geographical region, it provided important data on antibiotic use in fish production in Southwestern Nigeria. However, it is not yet clear how much selection pressure is being exerted by this practice and how such pressure is contributing to the development and spread of antibiotic resistance from Nigerian fish farms. A much wider study designed to examine antimicrobial drug use and its link to resistance on fish farms will go a long way in answering this important question.

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Conflicts of interest

The study was carried out without any conflict of interest.

Author contributions statement

OOA conceived and designed the study, analyzed and interpreted data and wrote the first draft of the manuscript. IO collected data and reviewed the manuscript.

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Résumé

Adelowo O.O., Okunlola I. Evaluation de l'utilisation d'antibiotiques dans les élevages piscicoles du sud-ouest du Nigeria

La résistance aux antibiotiques est un problème de santé publique mondial lié à l'utilisation d'antimicrobiens en production animale. Cependant, on connaît peu de choses sur l'utilisation d'antibiotiques en aquaculture dans les pays en développement et sur son lien avec la résistance aux antibiotiques. Cette étude s'est intéressée à l'utilisation des antibiotiques dans 50 fermes aquacoles du sud-ouest du Nigeria en se fondant sur un questionnaire structuré. Vingt-sept (54 %) exploitations utilisaient des antibiotiques (n = 24), des antiparasitaires (n = 2) ou les deux (n = 1) comme additifs dans l'alimentation ou l'eau. Les antibiotiques les plus fréquemment utilisés étaient la tétracycline (11 fermes), les bêta-lactamines et la furazolidone (4 fermes chacune), les aminoglucosides et le chloramphénicol (3 fermes chacun), l'enrofloxacine (2 fermes), et le métronidazole (1 ferme). Seuls 16 éleveurs connaissaient les antibiotiques utilisés dans leurs mares et aucune ferme ne disposait de données sur les quantités utilisées. Les médicaments provenaient de magasins de médecine vétérinaire (59 %) ou humaine (15 %), de vétérinaires (4 %), ou d'autres pisciculteurs (4 %) ; 19 % n'ont pas répondu à cette question. De nombreux éleveurs (n = 15), parmi lesquels 11 détenaient un diplôme de technicien supérieur ou universitaire, ignoraient les risques liés à l'utilisation d'antibiotiques dans leurs mares. L'ajout direct d'antibiotiques dans l'eau des mares pratiqué dans ces fermes peut créer des réservoirs locaux de résistance aux antibiotiques et constitue un risque pour la santé publique.

Mots-clés : aquaculture, bonnes pratiques agricoles, antibiotiques, résistance aux antibiotiques, tétracyclines, Nigeria

Resumen

Adelowo O.O., Okunlola I. Evaluación de campo del uso de antibióticos en explotaciones piscícolas de Nigeria sudoccidental

La resistencia a los antibióticos es un problema de salud pública mundial, relacionado con el uso de antimicrobianos en los animales destinados a la alimentación. Sin embargo, se sabe poco sobre el uso de antibióticos en la acuicultura en los países en desarrollo y su relación con la resistencia a los antibióticos. En el presente estudio investigó el uso de antibióticos en 50 fincas de acuicultura en el sudoeste de Nigeria, mediante un cuestionario estructurado. Veintisiete (54%) explotaciones utilizaron antibióticos (n = 24), antiparasitarios (n = 2) o ambos (n = 1) como aditivo en el alimento o el agua. Los antibióticos más utilizados fueron la tetraciclina (11 explotaciones), los betalactámicos y la furazolidona (4 explotaciones cada uno), los aminoglucósidos y el cloranfenicol (3 explotaciones cada uno), la enrofloxacina (2 explotaciones) y el metronidazol (1 explotación). Sólo 16 agricultores conocían los antibióticos utilizados en sus estanques y ninguna finca poseía datos sobre la cantidad utilizada. Los medicamentos procedían de comercios de medicina veterinaria (59%) y humana (15%), de médicos veterinarios (4%) o de otros piscicultores (4%); el 19% no respondió a esta pregunta. Varios productores (n = 15), entre los cuales 11 con un diploma de técnico o un título universitario, no sabían de ningún riesgo relacionado con el uso de antibióticos en sus estanques. La adición directa de antibióticos al agua de los estanques practicada en estas explotaciones, puede crear reservorios locales de resistencia a los antibióticos y constituye un riesgo para la salud pública.

Palabras clave: acuicultura, buenas prácticas agrícolas, antibióticos, resistencia a los antibióticos, tetraciclina, Nigeria