

Re-evaluation of Antimicrobial Use in the Fisheries Sector in Malaysia

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E-ISSN: 2073-3720
<https://doi.org/10.33997/j.afs.2025.38.4.001>

Abstract

Antimicrobial resistance (AMR) is a significant global threat, with antibiotic misuse in aquaculture being a key contributor. This study assesses antimicrobial use (AMU), particularly antibiotics, in the fisheries sector of Malaysia. Data were collected from 297 respondents across 9 of 13 states (2017–2022), including farmers (230), fish exporters (22), feed suppliers (8), veterinary clinics (16), aquatic health professionals (4), zoo/aquatic park managers (7), aquaculture researchers (4) and government hatchery managers (6). Additional evidence was gathered from monitoring programs, literature reviews, and agency reports. The results revealed that only 18 (7.5 %) fish/shrimp farmers used antibiotics, with oxytetracycline being the most common antibiotic (33 %). Other antibiotics include erythromycin, amoxicillin, ampicillin, enrofloxacin, trimethoprim-sulfadiazine, and florfenicol. The maximum annual usage was 40 kg for oxytetracycline, 1 kg for florfenicol, and 0.2 kg for enrofloxacin. Antibiotics were primarily used for treatment (56 %) and never used as growth promoters. Most farmers obtain veterinary prescriptions prior to use. Antibiotic application in aquatic theme parks and R&D was minimal and controlled. These findings suggest that antibiotic use in Malaysian aquaculture is relatively low compared with global trends, reflecting progress toward sustainable practices. However, broader surveys are needed for comprehensive AMU data. This study highlights the importance of continued monitoring, education, and enforcement of responsible antibiotic use to mitigate AMR risks and informs policy development for sustainable aquaculture in Malaysia.

Keywords: antibiotics, AMU, AMR, aquaculture, veterinary drugs

Introduction

Aquaculture fits the United Nations Sustainable Development Goals (SDG) perfectly in terms of supporting food security, poverty mitigation, trade, and other gains. The consistent growth in aquaculture was demonstrated from merely 4 % and 5 % share of total world fish production in the 50s and 70s, respectively, to 20 % in the 1990s, 44 % in the 2010s, and 49 % (88 million metric tonnes, USD265 billion) of the entire global fish production (178 million metric tonnes, USD406 billion) in 2020 (Food and Agriculture Organization [FAO], 2022). Consequently, aquaculture has been acknowledged as the fastest-growing food production sector in the world, with a projection of 140 million metric tonnes of production by the year 2050.

Besides food fish, ornamental fish (non-food fish) also contribute significantly to aquaculture production. Today, the ornamental fish industry is a multibillion-dollar industry worth USD5.4 billion in 2021 and is anticipated to expand at a compound annual growth rate of 8.5 % from 2022 to 2030 (Grand View Research, 2021). The significant progress in aquaculture was made possible by the super-intensive farm production systems that operated with completely developed biosecurity measures, good animal husbandry and management practices, the best hygiene standards, and the use of non-therapeutic antimicrobials to increase growth (Van Boeckel et al., 2017).

Aquaculture is also an important agriculture subsector in Malaysia that complements the capture fisheries

subsector, which has reached its maximum sustainable yield. Aquaculture has been identified as a priority sector in the development of Malaysia's economy (Jumatli and Ismail, 2021). From producing only about 7 % of the national fish production in 1992, the latest statistics indicate the production of aquaculture to be approximately 30 % (Department of Fisheries [DOF], 2022) and expected to be equal in the near future.

Occurrences of disease are one of the primary constraints to sustainable aquaculture production globally (Rodger, 2016) and likewise in Malaysia (Fathi et al., 2018; Jumatli and Ismail, 2021). Among the solutions to this problem are chemicals and drugs used to prevent and treat infections and increase growth in animals, including fish, generally referred to as antimicrobials (antibiotics, antivirals, antifungals, and antiparasitics). Antimicrobials are essential components of intensive farming systems (Prescott, 2008). When properly applied, antimicrobials are certainly useful; however, misuse and imprudent use of antimicrobials are driving antimicrobial resistance (AMR), which is one of the top 10 global public health threats facing humanity in this era (World Health Organization [WHO], 2021). Fish production intensification and the frequent incidence of pathogens are both driving AMU (Cabello and Godfrey, 2016) and AMR (Miller and Harbottle, 2018). The impact of AMR is estimated to cause 10 million deaths worldwide by 2050 (O'Neill, 2014). Antimicrobial application in aquaculture is more harmful to ecosystems than terrestrial animal production. This is because drug dispersal through water may lead to wider environmental manifestations. Besides food fish, the ornamental fish industry also induces the dissemination of resistant bacteria as antibiotics are frequently added to the transport water as a prophylactic measure to prevent the occurrence of disease during transportation. On top of that, antimicrobial utilisation may also present a hazard to the consumer and the individual handling the fish.

The linkage of AMU in aquaculture with human health and environmental risks exemplifies a One Health challenge, where aquatic, human, and ecological systems are intricately linked. Excessive or inappropriate AMU can drive the emergence of antibiotic-resistant bacteria, which may reach humans through consumption of contaminated seafood, direct contact with aquaculture environments, or environmental exposure via water systems. Simultaneously, residual antibiotics and resistance genes from aquaculture effluents disrupt microbial communities, foster resistance among environmental bacteria, and affect non-target aquatic organisms. Compounding this, poor husbandry practices such as overcrowding and stress elevate disease incidence, prompting a vicious cycle of increased AMU and escalating resistance, reduced treatment efficacy, and environmental contamination. Addressing these intertwined risks requires a holistic One Health approach, recognising that AMR transcends sectors and promoting

integrated solutions including improved farm biosecurity, vaccination programs, and viable alternatives to antibiotics like probiotics and phage therapy.

Despite the adverse impact, information on AMU in aquaculture remains widely unrecorded in various parts of the world (Schar et al., 2020). These are probably due to the sensitivity of the issue, difficulty in deriving the facts from the farmers, lack of proper records, and diverse regulation and registration systems. Accurate AMU data is difficult to gather and requires labour-intensive surveys in the absence of reliable figures on antimicrobial sales. Nonetheless, the information on AMU is much needed to support policy formulation to manage AMU and reduce AMR in aquaculture and is in line with the Global Action Plan on AMR advocated by the WHO, FAO, WOA, and UNEP. Neighbouring ASEAN countries including the Philippines, Thailand, Vietnam, Indonesia, and Singapore have documented and published their latest AMU status (Regidor et al., 2020; Lekagul et al., 2023; Luu et al., 2021; Lim et al., 2021). For Malaysia, the information on AMU in aquaculture is limited, out of date, and needs to be updated. Hence, this article is written to present the latest information on AMU in aquaculture in Malaysia. Although the term AMU is used throughout this paper, the main concern is more about the antibiotics used in aquaculture.

Trends in Aquaculture Production and Fish Diseases in Malaysia

Aquaculture production

Aquaculture in Malaysia constitutes different sectors, including food (marine, brackish water fish, freshwater fish, and seaweed) and non-food (ornamental fish and aquatic plant) commodities. In general, total aquaculture production gradually increased from 2000 (167,894 metric tonnes) to 2010 (581,058 metric tonnes) and declined to 506,465 metric tonnes in 2015 and 400,017 in 2020. The production started to increase again in 2021 to 417,187 metric tonnes, and the latest statistic in 2022 recorded 573,682 metric tonnes. Table 1 indicates the trends in total aquaculture production comprising food and non-food items in Malaysia from the year 2000 to 2022. According to the latest statistics, aquaculture (food) contributes about 30 % of total fish production (1,890,287) in Malaysia (Department of Fisheries, 2022). Freshwater aquaculture contributed about 115,868.31 metric tonnes, i.e., 9.4 % of total food fish production; marine and brackish water aquaculture contributed about 149,849.22 metric tonnes (13.2 %); and seaweed production added the most (72.2 %) to total fish production with 307,964.96 metric tonnes (Department of Fisheries, 2022). In 2022, a total of 20,925 fish farmers were involved in aquaculture, with the majority of them (15,948 (76.2 %) in freshwater aquaculture and the remaining 4,977 (23.78 %) in the marine/brackish water sub-sector.

The main freshwater species were catfish (*Clarias* sp.), black and red hybrid tilapia (*Oreochromis* sp.), and riverine catfish (*Pangasius* sp.), while tiger shrimp (*Penaeus monodon* Fabricius, 1798), whiteleg shrimp (*Penaeus vannamei*, Boone, 1931), grouper (*Ephinephelus fuscoguttatus* (Forsskl, 1775)), red snapper (*Lutjanus argentimaculatus* (Forsskål, 1775)), and seabass (*Lates calcarifer* (Bloch, 1790)) dominate marine/brackish water aquaculture. Table 2 lists the main cultured species and the production trends in Malaysia. Similarly, the production of key aquaculture species has been seen to dwindle over the past ten years. One of the main explanations for these patterns could be associated with disease outbreaks.

Main fish diseases in Malaysia

Aquaculture is overwhelmed with frequent disease outbreaks, particularly due to intensification and commercialisation. Among the contributing factors are the movement of broodstocks, post-larvae, fry, and fingerlings; the introduction of new species in aquaculture; stressful farming conditions; deteriorating environmental conditions; a lack of biosecurity measures; and climate change (Bondad-Reantaso et al., 2005). Bacteria, viruses, and protozoa have been the main culprits in Malaysia's outbreaks of infectious illnesses in the aquaculture industry since the 1990s (Sayuthi, 1993). Major bacterial and viral diseases are discussed below.

Table 1. Trend in aquaculture production in Malaysia from 2000-2022.

| Types | Tonnes(MYR) | | | | | | |
|--------------------------|-----------------------------|--------------------------------------|--|---------------------------------------|--------------------------------------|---------------------------------------|--|
| | 2000 | 2010 | 2015 | 2020 | 2021 | 2022 | |
| Marine/ Brackishwater | 117,205.56 (663,340,000) | 217,757.38 (2,440,496.78) | 133,559.80 (2,377,227,469) | 120,746.27 (2,289,393.44) | 132,395.55 (2,516,450,343) | 149,849.22 (2,789,953,616) | |
| Food | Freshwater | 50,688.43 (304,983,000) | 155,398.63 (1,141,715.10) | 112,145.15 (788,855,710) | 97,210.32 (766,471.58) | 105,904.01 (856,354,840) | 115,868.31 (982,035,817) |
| | Seaweed | 16,124.80 (10,158.62) | 207,892.40 (83,159.06) | 260,760.30 (130,380,150) | 182,061.00 (58,873.18) | 178,888.12 (57,535,856) | 307,964.96 (246,796,483) |
| Non-food | Ornamental fish | 306,096,870 (pcs) (71,948,935) | 341,757,064 (pcs) (430,311,447.46) | 383,689,326 (pcs) (341,138,461) | 227,944,067 (pcs) (494,559.28) | 242,498,244 (pcs) (534,359,934) | 234,485,866.00 (pcs) (453,932,451) |
| | Aquatic plants | - | 143,651,684 (14,472,464.40) | 371,449,675 pack (149,168,869.60) | 41,990,762 pack (53,573,049) | 24,413,659 pack (21,449,992) | 307,964.96 pack (246,907.03) |

MYR 1.0 = USD 0.24 (November 2025).

Table 2. Major cultured species in Malaysia from 2000-2022.

| Species | Tonnes(MYR) | | | | | | |
|----------------------|---|---------------------------|-----------------------------|-----------------------------|---------------------------|-----------------------------|-----------------------------|
| | 2000 | 2010 | 2015 | 2020 | 2021 | 2022 | |
| Freshwater fish | Catfish (<i>Clarias</i> sp.) | 9,904.46 (47,141.33) | 63,206.24 (315,622.85) | 50,683.12 (223,056.05) | 29,012.77 (129,666.00) | 31,957.80 (228,969.56) | 39,815.33 (3,074,849.02) |
| | Black and hybrid red tilapia (<i>Oreochromis</i> sp.) | 18,276.61 (127,602.62) | 38,643.27 (347,589.36) | 35,431.3 (295,718.00) | 31,462.56 (328,760.51) | 34,693.26 (527,311.01) | 31,790.24 (1,632,593.41) |
| | Riverine catfish (<i>Pangasius</i> sp.) | 1,625.21 (17,799.17) | 37,884.07 (309,122.08) | 13,901.77 (144,509.66) | 18,227.31 (132,456.90) | 21,144.21 (242,615.45) | 20,861.92 (466,680.46) |
| Marine/Brackishwater | Tiger shrimp (<i>Penaeus monodon</i> Fabricius, 1798) | 15,539.64 (557,597.85) | 18,118.51 (488,790.25) | 4,286.31 (122,551.05) | 13,524.76 (387,813.11) | 18,119.61 (677,346.84) | 15,329.87 (607,226.23) |
| | Whiteleg shrimp (<i>Penaeus vannamei</i> Boone, 1931) | 353.75 (13,671.21) | 69,084.10 (1,002,463.00) | 48,284.18 (1,018,405.69) | 35,148.65 (781,266.76) | 38,376.83 (1,009,482.72) | 39,557.84 (1,098,067.71) |
| | Grouper (<i>Ephinephelus fuscoguttatus</i> (Forsskål, 1775)) | 1,217.56 (32,204.73) | 4,569.63 (220,197.25) | 7,956.07 (285,244.99) | 3,750.75 (207,090.48) | 2,625.15 (118,153.42) | 3,956 (180,391.94) |
| | Red snapper (<i>Lutjanus argentimaculatus</i> (Forsskål, 1775)) | 132.93 (2,104.97) | 4,956.29 (88,403.47) | 10,400.61 (230,949.63) | 7,256.48 (192,182.88) | 47.03 (174,695.15) | 5,243.98 (195,351.99) |
| | Asian seabass (<i>Lates calcarifer</i> (Bloch, 1790)) | 3,428.43 (54,202.79) | 20,021.52 (333,181.12) | 29,132.37 (435,860.40) | 23,033.83 (327,447.89) | 34,186.73 (600,456.00) | 43,734.54 (767,644.93) |
| | | | | | | | |

MYR 1.0 = USD 0.24 (November 2025).

Bacterial diseases

Bacterial infections are frequently detected in both marine and freshwater fish and occur as secondary infections in most cases. The most common bacterial infections in freshwater fish are triggered by *Aeromonas hydrophila*, *Flexibacter*, *Pseudomonas*, and/or *Edwardsiella* sp. (Siti-Zahrah, 1992). Motile *Aeromonas* septicemia (MAS) is commonly reported as a major cause of mortality in farmed fish (Amal et al., 2018; Laith and Najjah, 2013). Starting from the year 2000 onwards, Malaysia experienced notable disease outbreaks caused by *Streptococcus* spp. in Tilapia (*Oreochromis* sp.), which resulted in more than 60 % mortality (Siti-Zahrah et al., 2008; Rahmatullah et al., 2017; Mohamad Ali et al., 2020). In Malaysia, farmers tend to use erythromycin and oxytetracycline to treat streptococcosis in tilapia as well as a prophylactic agent in healthy fish. These antibiotics are usually sprayed onto fish pellets and given orally to fish (Zamri-Saad et al., 2014). However, antibiotics are deemed ineffective compared to vaccinations. Although there are no official *Edwardsiella* outbreaks in Malaysia, *Edwardsiella tarda* is commonly isolated from diseased freshwater fish in Malaysia. (Lee and Musa, 2008; Lee and Wendy, 2017).

Infections with *Vibrio* sp., or vibriosis, are most common in marine fish and crustaceans (Leong, 1989; Leong and Wong, 1992; Chuah, 2001). *Vibrio* spp. are the major cause of bacterial diseases such as necrosis and septicemia (Palanisamy, 1990). Vibriosis has caused high mortality rates in cultured grouper since the 1960s (Wong et al., 1979) and commonly occurs throughout the hatchery and grow-out phases and coincides with parasitic infections (Chuah, 2001). The use of antibiotics has been attempted in hatcheries, but it has not been tested in ponds. Vibriosis in Asian seabass was also reported in Sabah (Ransangan and Mustafa, 2009). According to Sayuthi (1993), most hatcheries use antibiotics to control bacterial diseases.

Bacterial disease is also a serious problem for the ornamental fish industry, with *Aeromonas hydrophila* being the most dominant bacteria involved (Anjur et al., 2021). According to Stratev and Odeyemi (2017), *A. hydrophila* infection is mainly controlled by antibiotics such as tetracycline, sulfadimethoxine, and ormetoprim.

Viral diseases

The main viral disease in freshwater fish is channel catfish virus (CCV), also known as ictalurid herpesvirus 1 (IcHV-1), a cytopathic herpesvirus that mainly infects catfish and causes severe haemorrhage, especially in young fingerlings. The detection of CCV in Malaysian catfish was reported by Siti-Zahrah et al. (2013) in cultured striped catfish, which resulted in 30–40 % mortality rates. Recently, global tilapia cultures were threatened by a deadly disease caused by a virus

named tilapia lake virus (TiLV), an orthomyxo-like virus belonging to the Orthomyxoviridae family, whose presence was confirmed in the wild (Abdullah et al., 2018) and cultured tilapia (Amal et al., 2018) in Malaysia.

The most common viral disease in marine fish (Asian sea bass, grouper, and golden pompanos) is viral nervous necrosis (VNN). Viral nervous necrosis in marine finfish is considered endemic (Ransangan and Manin, 2010; Zainathan et al., 2016). Disease outbreaks caused by iridovirus were first reported in 2009, which resulted in a cumulative mortality rate of 100 % and a loss of approximately MYR50,000 (Network of Aquaculture Centres in Asia-Pacific [NACA], 2018).

Meanwhile, white spot syndrome (WSS) is the main disease in farmed shrimp in Malaysia. In addition, infectious hypodermal and hematopoietic necrosis virus (IHHNV) and a relatively new shrimp disease, acute hepatopancreatic necrosis disease (AHPND), are other frequently occurring diseases in shrimp since 2011, and later in 2015 in tiger shrimp (Manan et al., 2015; Kua et al., 2016). Besides that, new emerging diseases such as infection with infectious myonecrosis virus (IMNV) and a parasitic infection called hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) were also reported in white shrimp in Malaysia from 2014 onwards.

Koi herpesvirus (KHV) is a major economic threat to the common carp (*Cyprinus carpio*) and koi rearing industries worldwide. Up to date, KHV has been persistently detected in koi and common carp farms located in Perak, Negeri Sembilan, and Selangor (Network of Aquaculture Centres in Asia-Pacific [NACA], 2018).

Antimicrobial Use (AMU) Survey

As mentioned in the introduction, the information on AMU in the local aquaculture industry is lacking and dates back about 20 years (Shariff et al., 2000; Choo, 2002; Ibrahim, 2003). Shariff et al. (2000) stated that several antibiotics applied for fish and shrimp treatment in Malaysia were mostly generic imports from China and Thailand. The types of antibiotics used were listed, but there was no information on the quantity used. The method of obtaining the information was also not specified. Choo (2002) on the other hand, went into greater detail about antibiotic environmental and regulatory issues in Malaysia. According to Choo (2002), at that time, farmers were free to use all types of antibiotics except nitrofurans and chloramphenicol, oxytetracycline, oxolinic acid, and furazolidone were most frequently used before 1996. Because of this, several studies were carried out to determine the withdrawal period of antibiotics in farmed fish (Choo, 1995, Choo, 1997) and the degradation of antibiotics in fresh and seawater (Choo, 1998). Likewise, Ibrahim (2003) highlighted antibiotic residue problems in farmed shrimp in the Southeast Asian Fisheries Development Centre (SEAFDEC)

member countries. The information was derived from the questionnaire responses that were distributed to member countries regarding the antibiotic residue issue. From the information gathered, antibiotic residue in farmed shrimp is a common problem faced by countries in Southeast Asia, particularly Thailand and Vietnam. Although Indonesia, Myanmar, and Malaysia also encounter similar problems, they are not as serious. According to Ibrahim (2003), about 10 % of shrimp farmers in Malaysia use antibiotics.

Since then, the information on the use of antimicrobials in aquaculture has not been updated. In 2017, FAO initiated the FMM/RAS/298 project, which aims to assist in strengthening capacities, policies, and national action plans on prudent and responsible use of antimicrobials in fisheries through providing technical assistance to selected countries (China, Malaysia, the Philippines, and Vietnam). The technical assistance includes: (i) documentation of AMU in aquaculture and possibly antimicrobial resistance (AMR) surveillance and other relevant informal surveys; (ii) enhancing capacities of prudent use of antimicrobials and good biosecurity and husbandry best practices; and (iii) promoting advocacy, communication, and education activities. After a long gap of reports on AMU in Malaysia, this paper presents the AMU survey carried out under the FMM/RAS/298 project and provides additional information on AMU in fisheries in Malaysia.

AMU survey

Under FAO FMM/RAS/298, an AMU survey in Malaysia was executed in August 2017. The first survey was carried out during the AMR Awareness and Stakeholders Consultation session organised together with the Malaysian Aquaculture Development Association (MADA). The session consisted of an awareness talk on AMR followed by an AMU survey. The survey aims to understand the current status of the use of antimicrobials and other chemicals in the aquaculture industry in Malaysia. Although the FMM/RAS/298 project ended in December 2017, the AMU survey was continued using other affordable means and scheduled DOF events and functions (Table 3). Figure 1 illustrates the localities covered by the AMU surveys, which covered almost all states in Malaysia.

Ethical statement

This survey was initiated in July 2017 with FAO FMM/RAS/298 funding. While no formal ethical clearance was obtained, all participants were informed about the purpose and nature of the survey, and participation was voluntary. Out of over 600 distributed forms, 297 meaningful responses were received, reflecting respondents' consent and comfort in providing information.

Investigative tools

An AMU questionnaire from the NACA was initially used

with some modifications. During the first exercise, many respondents were discouraged by the lengthy and complex questionnaire. Thus, the questionnaire was simplified to only four sections: 1. Respondent profile (name, position, farm or company's name, address, and contact number); 2. Farm information (cultured species, type of operation, operating system based on stocking density, length of production cycle, number of production cycles per year, common disease encountered); 3. Awareness of rules and regulations pertaining to AMU (national regulations, recommended practices, prescriptions, banned drugs); 4. AMU details (type of antimicrobials and other chemicals used, mode of application, purpose of use, source of antimicrobial, veterinary prescription required). A slightly different set of questionnaires was prepared for fish feed suppliers, ornamental fish exporters, aquatic animal health professionals, researchers, veterinarians from private animal clinics, zoos, and aquatic theme park managers.

The surveys managed to gather a meaningful response from a total of 297 respondents, consisting of farmers (230), fish exporters (who are also farmers) (22), feed suppliers (8), veterinary clinics (16), aquatic animal health professionals (4), zoo and aquatic theme park managers (7), government hatchery managers (6), and researchers (4). Aquatic animal health professionals are researchers from the National Fish Health Research Division, Fisheries Research Institute (FRI), Batu Maung, Penang, FRI Tg Demong, and FRI Glami Lemi. The other group of FRI researchers interviewed were those involved in fish and shrimp broodstock development and ornamental fish R&D. Table 4 summarises the farmer's information obtained from the AMU survey.

Results of AMU survey (farmers)

The survey had a total of 230 fish and shrimp farmers that answered the questionnaires meaningfully. They were composed of 94 freshwater fish farmers, 60 marine/brackish water farmers, 63 shrimp hatchery and grow-out farmers, and 11 ornamental fish producers. Only 18 farmers, or 7.5 %, confessed to using antibiotics. For shrimp, early mortality syndrome (EMS) / Acute Hepatopancreatic Necrosis Disease (APHND), white spot and *Enterocytozoon hepatopenaei* (EHP) were the main diseases faced by the respondent, while pop eye, scale drops, fin/tail rot, skin ulceration/haemorrhage white/black spots, vibriosis, and parasitic infection were common in fish. Most of the farmers (about 70 %) used more chemicals (anti-helminthic and anti-parasitic) in their operations. The use of banned drugs such as chloramphenicol and nitrofurans was not reported. Similarly, Devadas et al. (2025) also reported that high percentage (95.0%) of shrimp farmers interviewed have never used antibiotics on farmed shrimp during the knowledge, attitudes and practices survey in Malaysia.

Figure 2 details the types and purposes of antibiotics

Table 3. List of antimicrobial use (AMU) surveys carried out from 2017–2022.

| Activities | No of respondents | Date | Venue |
|---|-------------------|----------------|--|
| 1. AMR Awareness and Stakeholders Consultation | 46 | 04 Aug 2017 | Malaysia External Trade Development Corporation (MATRADE), Kuala Lumpur |
| 2. Aquaculture Industry Consultation Forum | 21 | 10 Jul 2018 | Fisheries Biosecurity Centre, Department of Fisheries, Sepang, Selangor |
| 3. Interview with Aquatic Animal Health Professionals | 4 | 13–20 Jul 2018 | Fisheries Research Institute (FRI), Batu Maung, Penang; FRI Tg Demong, Terengganu; FRI Glami Lemi, Jelebu, Negeri Sembilan; FRI Pulau Sayak, Kedah |
| 4. Aquaculture Industry Consultation Forum | 7 | 17 Jul 2018 | FRI, Batu Maung, Penang |
| 5. Marine Aquaculture Industry Consultation Forum | 28 | 29 Jul 2018 | FRI Tg. Demong Terengganu |
| 6. Aquaculture Industry Consultation Forum | 23 | 07 Aug 2018 | Department of Fisheries, Putrajaya |
| 7. Aquaculture Industry Consultation Forum | 30 | 20 Sep 2018 | Department of Fisheries, Tawau, Sabah |
| 8. Meet the Clients Day, FRI Glami Lemi | 22 | 26–27 Jun 2019 | FRI Glami Lemi, Jelebu, Negeri Sembilan |
| 9. Phone interview | 5 | 09–10 Jul 2019 | Veterinary clinics in Penang |
| 10. Phone interview | 5 | 24–25 Jul 2019 | Veterinary clinics in Perak |
| 11. Phone interview | 6 | 10–11 Mar 2020 | Veterinary clinics in Kuala Lumpur |
| 12. Verification activity | 2 | 10 Mar 2021 | Zoo Taiping, Perak |
| 13. Verification activity | 2 | 17 Mar 2021 | SeaLife, Legoland, Johor |
| 14. Verification activity | 3 | 08 Apr 2021 | Underwater World, Langkawi, Kedah |
| 15. Aquaculture Awareness Talk–Biosecurity | 26 | 16 Apr 2021 | Fisheries Biosecurity Centre, Department of Fisheries, Tunjung, Kedah |
| 16. Phone interview | 4 | 22–25 May 2021 | Fisheries Research Institute (FRI), Tg Demong, Terengganu, FRI Pulau Sayak, Kedah, FRI Glami Lemi, Negeri Sembilan, FRI Gelang Patah, Johor |
| 17. Phone interview | 4 | 25 Jul 2023 | Aquaculture Extension Centre (PPA) Bukit Tinggi, Pahang; PPA Perlok, Pahang; PPA Jitra, Kedah; PPA Enggor, Perak |
| 18. Phone interview | 1 | 10 Aug 2023 | Pusat Ikan Hiasan, Department of Fisheries Malaysia, Port Dickson, Negeri Sembilan |
| 19. Face to face interview | 1 | 03 Nov 2021 | Aquarium Tunku Abdul Rahman, FRI Batu Maung, Penang |
| 20. Farmers Day: 11 th Diseases in Asian Aquaculture Symposium | 57 | 23 Aug 2022 | Borneo Convention Centre Kuching, Sarawak |
| Total | 297 | | |

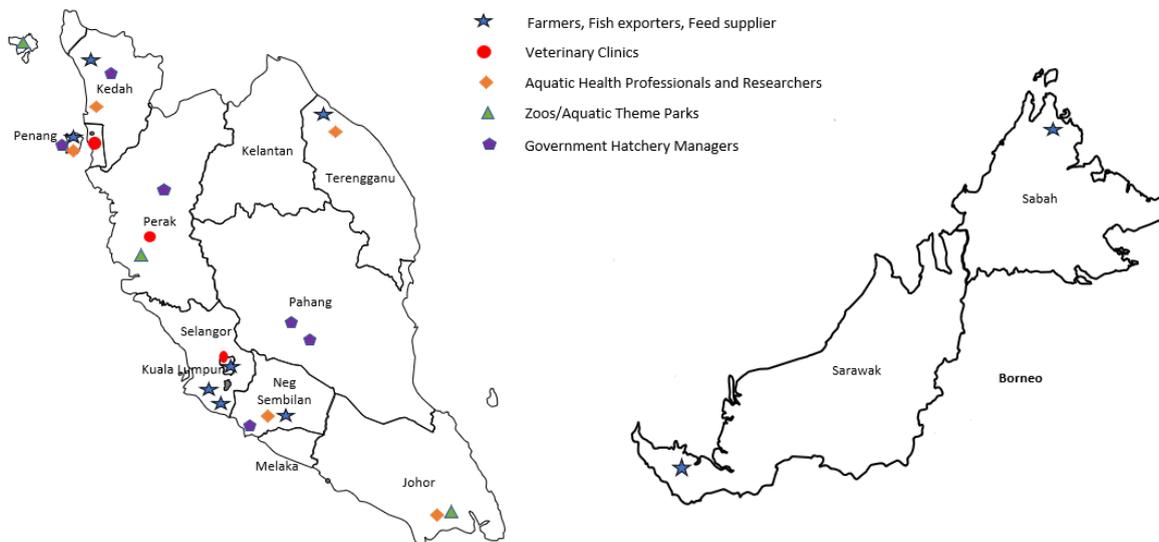


Fig. 1. Locations of antimicrobial use (AMU) surveys implemented in the present study.

Table 4: The details of the farmers that joined the antimicrobial use (AMU) survey.

| Survey's location | No of respondents | Culture species (No. of respondents) |
|-------------------|-------------------|--|
| Kuala Lumpur | 28 | Freshwater fish (9)(red tilapia, gift tilapia, black tilapia, catfish); shrimps (11); marine fish (6)(hybrid grouper); ornamental fish (2) |
| Selangor | 13 | Freshwater fish (1)(catfish), marine fish (2); shrimps (8); ornamental fish (2) |
| Penang | 7 | Freshwater fish (2); marine fish (2)(red snapper, mangrove snapper, golden pomfret, Asian sea bass); shrimps (2); ornamental fish (1) |
| Terengganu | 28 | Marine fish (26); shrimps (2) |
| Putrajaya | 21 | Ornamental fish (4); shrimps (2); freshwater fish (10); marine fish (5) |
| Sabah | 28 | Freshwater fish (2); marine fish (9)(grouper, red snapper, brown-marble grouper, humpback grouper); mollusc (1); ornamental fish (2); seaweed (1); echinoderm (sea cucumber sandfish)(1); shrimps (12) |
| Negeri Sembilan | 22 | Freshwater fish (12); Freshwater prawns (10) |
| Kedah | 26 | Freshwater fish (21)(red tilapia, gift tilapia, climbing perch, catfish, gourami); marine fish (3)(hybrid grouper, red snapper, Asian sea bass); marine shrimps (1)(tiger shrimp, white shrimp); freshwater shrimp (red claw)(1) |
| Sarawak | 57 | Shrimps (10)(tiger shrimp, white shrimp); freshwater lobster/crayfish (4); freshwater fish (37)(tilapia, Hoven's carp, mahseer, carp, tinfoil barb, river catfish); marine/brackishwater (6)(snapper, grouper) |
| Total | 230 | |

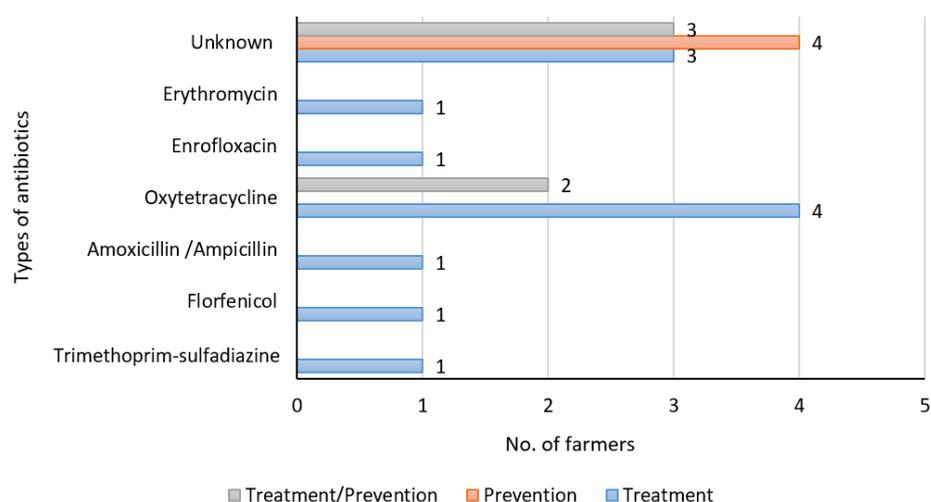


Fig. 2. The types and purposes of antibiotics used by the farmers in this survey.

used by farmers. Oxytetracycline was the most common antibiotic used by farmers (6 out of 18, 33 %). Erythromycin, amoxicillin, ampicillin, enrofloxacin, trimethoprim-sulfadiazine, and florfenicol were also applied. Slightly more than half of the farmers (10 out of 18, 55.5 %) did not state the name, brand, or type of antibiotics they used. This could probably be due to the fact that they used off-label antimicrobials and do not wish to disclose more information. Most of the farmers (72 %) used antibiotics for treatment purposes only. About 28 % of farmers use for both treatment and prevention. The amount of usage was only disclosed by several farmers. The amount used for treatment ranged from 1-40 kg (oxytetracycline), 1 kg (florfenicol) and 0.2 kg (enrofloxacin) in a year.

Figure 3 illustrates the sources of antibiotics used at

the farm. Most of the farmers (10 respondents) who admitted to using antibiotics in their operations obtained antibiotics from the veterinary doctor. This is logical as antibiotics are not cheap and therefore the correct recommendations from authorised individuals were sought before treatment. Other significant sources were through aquaculture chemical suppliers or agents (9 respondents) or bought over the counter (5 respondents). Online purchases were also reported (4 respondents). About 20 years ago, Ibrahim (2003) also recorded that most of the antibiotics used by shrimp farmers in Malaysia were mainly procured through aquaculture chemical suppliers. Nevertheless, this has not only happened in Malaysia but also in Bangladesh and Vietnam (Luu et al., 2021; Chowdhury et al., 2022). One farmer obtained antibiotics from Thailand. Generally, antibiotics are incorporated into

feed or via other routes such as bathing, dipping, or parenteral injection. The surveys show that most respondents (14 out of 18) use antibiotics administered through feed. The bath or immersion technique is also common (Fig. 4).

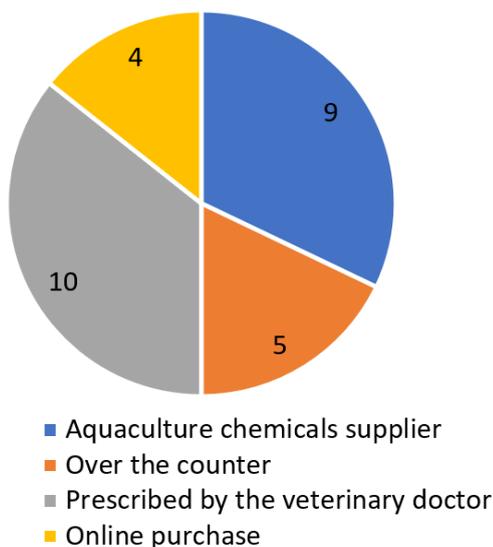


Fig. 3. Sources of antimicrobials used in farms based on respondent numbers.

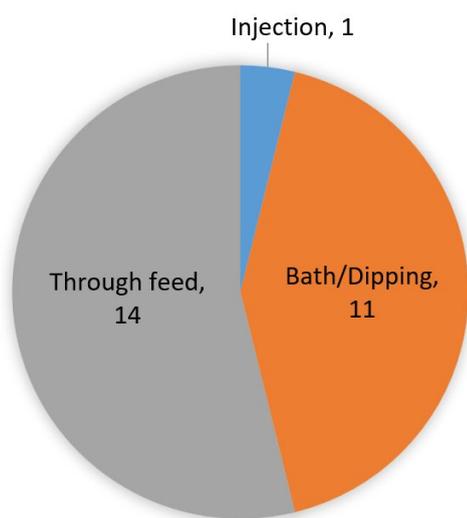


Fig. 4. Routes of antibiotics administration in aquaculture operations by number of respondents.

About 59 % of the farmers were aware of the national regulations on the use of antimicrobials in aquaculture including banned drugs, guidelines for AMU and inspection by DOF auditors on this matter. However, awareness of the proper use of antibiotics was very low among the farmers. The other 39 % of the farmers were uninformed about all these regulations while 2 % provided no response to this question. Our findings are in line with Devadas et al. (2025) who stated that vast majority (88.1 %) of shrimp farmers who participated in the knowledge-and attitude-related KAP survey had inadequate knowledge of AMU and AMR.

Table 5 compares the AMU information from three prior reports with the present survey. The present survey covers more respondents from 9 out of 13 states in Malaysia. At this point, it is possible to say that AMU in aquaculture in Malaysia is not extensive. This observation is logical, as antibiotics are expensive and pose an additional burden to the already high operating costs of aquaculture.

The regular antibiotics used by the farmers in the present survey are slightly different from those listed by Shariff et al. (2000) and Choo (2002). Oxytetracycline (class: tetracyclines besides doxycycline, chlortetracycline, and lymecycline) was the most frequently used, in line with previous reports. This is understandable, as tetracyclines are quite low in cost, high in efficacy, and possess broad-spectrum properties for treatment and prevention of various infectious diseases in aquaculture farms (Hazrat et al., 2016; Mo et al., 2017). Owing to its long-time application in fish farms, oxytetracycline was banned in EU member states (Suzuki and Hoa, 2012) and later restricted for veterinary use by the WHO (Shamsuzzaman et al., 2012, Hassali et al., 2018).

The use of erythromycin (class macrolides C14), enrofloxacin (class quinolone second generation), and trimethoprim-sulfadiazine (class sulphonamide) was likewise mentioned in the previous AMU reports. On the other hand, florfenicol (class: amphenicols) and amoxicillin/ampicillin (class: aminopenicillin) were first mentioned in the present survey. Enrofloxacin is extensively consumed because its chemical molecules are stable in water and sediment (Romero et al., 2012), thus making it simple to manage (Kümmerer, 2004). According to Lulijwa et al. (2020), 55 % of major aquaculture-producing countries have used enrofloxacin. However, countries like Vietnam have banned the use of enrofloxacin in aquaculture (Luu et al., 2021). Likewise, the use of sulphonamides in finfish farms is substantial. This antibiotic class represents the third most prevalent antibiotic used in aquaculture after tetracyclines and quinolones (Thiang et al., 2021). They are mainly used due to their low-price, high-water solubility, and high floating characteristics that allow easy movement and dissemination in aquatic environments and are easily adsorbed by finfish through the gills (Liu et al., 2017).

All the antibiotics reported in this survey were classified as Veterinary Critically Important Antimicrobial Agents (VCIA) for food-producing animals, as indicated in the Malaysia Veterinary Antimicrobial Guidelines (Department of Veterinary Services [DVS], 2021).

Despite being more extensive than previous efforts, the current AMU survey was not able to capture precise estimates of the quantities of antibiotics used in Malaysian aquaculture. This limitation stems from the questionnaire's broad focus, which was designed primarily to screen for antibiotic use. Our intention was

Table 5. Comparison of antimicrobial use (AMU) information from the present and previous reports.

| Antimicrobial use (AMU) information | Shariff et al. (2000) | Choo (2002) | Ibrahim (2003) | Present survey |
|-------------------------------------|--|--|---|--|
| Location | Not mentioned | Not mentioned | Not mentioned | 9 out of 12 states in Malaysia |
| Percentage of use among farmers | Not mentioned | Not mentioned | 10 % of respondents (shrimp farmers) | 7.7 % (18 out of 233 farmers) |
| Antibiotics used | Sulphonamides, Tetracycline, Nitrofurans, Chloramphenicol, Oxolinic acid, Virginiamycin, Dimetridazole/Metronidazole, Erythromycin phosphate, Neomycin, Terramycin | Terramycin (fish), Sulphonamides (fish), Tetracycline (fish), Nitrofurans (fish), Chloramphenicol (fish, shrimps), Furazolidone (shrimps), Oxytetracycline (shrimps), Oxolinic acid, Erythromycin, Neomycin, Norfloxacin, Flumequine | Sulphonamides, Tetracycline, Chlotetracycline, Oxytetracycline, Nitrofurans, Chloramphenicol, Oxolinic acid, Sulfamonomethoxine, Enrofloxacin, Norfloxacin, Ciprofloxacin | Oxytetracycline, Erythromycin, Amoxicillin, Ampicillin, Enrofloxacin, Trimethoprim-sulfadiazine, Florfenicol |
| Purpose of use | Treatment, Prophylaxis | Majority for treatment, Less for prophylactic or growth promoter | Treatment, Prophylaxis | Treatment, Prophylaxis |
| Sources of antibiotics | Selected stores licensed under the Poisons Act, 1984 to retail veterinary pharmaceuticals | Official channels by licenced pharmacist, Bought from neighbouring countries | Not mentioned | Chemical suppliers, over the counter, direct selling, online purchase and vet clinics |

to first identify farmers who reported using antibiotics and then conduct a more targeted follow-up survey with this group to collect detailed data on quantities used, sources of supply, administration procedures, and compliance with withdrawal periods. At this point, it is only possible to say that the usage is not extensive. This observation is understandable, as antibiotics are expensive and pose an additional burden to the already high operating costs in aquaculture. Thus, unnecessary costs will be evaded by the farmers. Our findings are in line with previous reports. According to Choo (2002), seven types of antibiotics were approved for incorporation into animal feed by the MOH. Much later, based on the list of permitted antibiotics to be used in food-producing animals for treatment and disease prevention/metaphylaxis by the National Pharmaceutical Regulatory Agency (NPRA), under the Ministry of Health (MOH) in 2017, only three antibiotic classes are allowed to be used in fish: i.e., beta-lactams (amoxicillin), quinolones (flumequine), and amphenicols (florfenicol) (Hassali et al., 2018). According to the list of registered veterinary products (updated January 2019), there was only one antibiotic registered for specific use in aquaculture out of 774 registered antibiotics (Rachel Fong Wai Jing, personal communication, December, 2020), and similarly, the current list of approved and re-registered veterinary products showed no evidence of

specific entry of antibiotics exclusively for fish (National Pharmaceutical Regulatory Agency [NPRA], 2023). From the data, we could say that the legitimate entry of specific antibiotics to be used for fish is very minimal compared to livestock, poultry, equine and companion animals.

Results of AMU survey (other respondents)

The fish feed suppliers interviewed disclosed that they did not use antibiotics in their operations. The aquatic animal health professionals and veterinary clinics that participated in this survey also confessed that they had never prescribed any antibiotics to local fish farmers for treatment purposes. The interview with the state zoo indicated that antibiotics were not used to treat fish in the zoo. This could probably be because the aquatic exhibit is not so extensive and involves low- and medium-value fish. On the other hand, the commercial aquatic theme parks did use antibiotics in their operations with proper records and monitoring (Table 6).

The other quantitative AMU data was obtained from the FRI Tanjung Demong with a minimal amount of about one kg per year of tetracycline. This is used to treat grouper and Asian sea bass broodstock at the FRI

Table 6. Type of antibiotics used by the commercial aquatic theme park and their purposes.

| Antibiotics | Purposes |
|-----------------------------------|---|
| Oxytetracycline | To stop fin rot, a bacterial disease that attacks the fins of aquarium fish. Once the bacteria are killed, most fish will heal and regrow their fins in a clean aquarium. To control diseases caused by Gram-positive and Gram-negative organisms that adversely affect salmonids, catfish and lobsters. |
| Enrofloxacin | To treat bacterial infections. Its use in dogs to treat certain specific infections and its use in small mammals, birds, and reptiles is 'off label' or 'extra label'. It has a high tolerance level for ornamental fishes and high efficacy against important bacterial diseases and recommended for the treatment of ornamental fishes. |
| Chloramphenicol | To promote health, but its use for short periods. |
| Betamethasone and neomycin creams | To reduces skin inflammation, and the neomycin is an antibiotic that treats bacterial infection. |

Tanjung Demong hatchery. Use of antibiotics in this premise has been testified to, earlier on when tetracycline was used to treat injured Asian sea bass broodstock at the rate of 20 mg kg⁻¹ body weight during quarantine until the fish totally recovered from their injuries sustained during transportation and also for disease treatment in the hatchery later (Hussin, 1987).

AMU-Related Evidence Obtained Through Non-primary Data Sources

Import alert

Malaysia has encountered the total ban of seafood by the EU in 2008 (Alavi, 2009) and the detention of all cultured shrimp products from Peninsular Malaysia by the US Food and Drug Administration in 2016 (USFDA Import Alert 16-136) without physical examination due to the presence of banned antibiotics (FDA, 2022). From October 1, 2014, to September 30, 2015, the FDA tested 138 samples of shrimp and prawns from Peninsular Malaysia and discovered residues of chloramphenicol and/or nitrofurans in 45 samples (32 %). For that cause, the FDA placed companies processing and/or shipping shrimp and prawns from Peninsular Malaysia on Import Alert. Malaysia's states of Sabah and Sarawak, however, were not subjected to this. The most recent cases include notifications by Thailand in February, March, and June 2025 regarding residue levels of enrofloxacin and norfloxacin exceeding the maximum residue limits (MRLs) in frozen and chilled sea bass imported from Malaysia, as reported in the ASEAN Rapid Alert System for Food and Feed (ARASFF, 2025). Additionally, during the first quarter of 2025, shrimp shipments from five different exporters in (one of them is Malaysia) were refused entry owing to the presence of veterinary drug residues, as documented by the U.S. Food and Drug Administration (FDA, 2025).

Antibiotic residue monitoring program (ARMP)

Monitoring of veterinary drug residues, including

antibiotics in fish, has been implemented by the DOF under the Antibiotic Residue Monitoring Programme (ARMP) since 2008, when there was an issue with the EU banning shrimps from Malaysia due to unapproved antibiotic residues. The ARMP programme covers the examination of main aquaculture species, including shrimp, sea bass, river catfish, grouper, tilapia, milkfish, and fishmeal, for nitrofurans, chloramphenicol, nitroimidazole, stilbenes, steroids, malachite green, melamine, and substances with MRLs. To support the ARMP, the DOF established a dedicated Standard Operating Procedure, SOP-DOF-BP1-1BA1B in 2021. Under this protocol, the Fisheries Biosecurity Unit collected samples from fish and shrimp farms, as well as feed millers, across all states (Table 7) for analysis of banned antibiotics. The results from ARMP showed that nitrofurans and chloramphenicol were not detected in any of the samples examined from 2008 until 2013 and even until 2022 (Zarina Zainuddin, August 2024). This suggests that farmers have not used the banned drugs in their operations, as the impact of the ban was quite huge on farmers and the seafood industry in general.

AMU information from farm audit records

The DOF executes a yearly audit of the registered farms under the Malaysia Farm Certification Programme (My-GAP: Malaysia Good Aquaculture Practices) for compliance or renewal purposes. This is also one avenue to acquire additional information on antibiotic use. The DOF's 2020 audit reports of registered farms, hatcheries, and ornamental fish suppliers in Malaysia were examined specifically for non-compliance or observations on the use of antibiotics. Based on these reports, only two (2) out of 73 (2.7 %) farmers used antibiotics in their operation, and all records of usage were in place (Fig. 5).

Antibiotic residues in seafood from published literature

From the literature search, not many articles have reported on antibiotic residue studies in local seafood. Ibrahim et al. (2010) examined 240 fish samples (Red

Table 7. Number of shrimps and finfish samples analysed for various veterinary drugs under antibiotic residue monitoring program (ARMP)(Karunasagar, 2020).

| | Years | | | | | |
|-----------------|-------|------|------|------|------|------|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Antibiotics | | | | | | |
| Shrimps | | | | | | |
| Chloramphenicol | 79 | 45 | 60 | 80 | 100 | 70 |
| Nitrofurantoin | 67 | 45 | 55 | 80 | 100 | 80 |
| Finfish | | | | | | |
| Chloramphenicol | 40 | 20 | 15 | 25 | 30 | 25 |
| Nitrofurantoin | 30 | 17 | 20 | 25 | 30 | 30 |

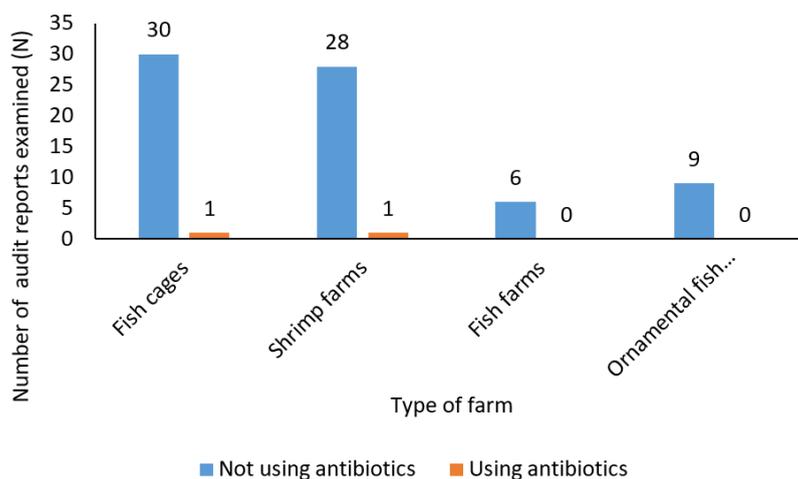


Fig. 5. Evidence of antibiotics used from the Department of Fisheries audit reports examined in 2020.

tilapia (*Oreochromis* sp.), Catfish (*Clarias* sp.), and *Pangasius* sp.) randomly collected from fish farms (earth ponds, floating net cages, and ex-mining pools) and qualitatively detected antibiotic residues in 5.8 % of farm fish samples. The results of the recent study were alarming: a total of 23 antibiotics were detected in the surface water samples of the main aquaculture sites in Perak, Selangor, Pahang, Kelantan, Penang, Malacca, and Johor (Thiang et al., 2021). Tetracycline (83 %), the most frequent antibiotic detected, was followed by sulphonamides (72 %), and quinolones (69 %), indicating wide consumption of antibiotics in aquaculture farms. Oxytetracycline, tetracycline, minocycline, sulfamerazine, sulfathiazole, enrofloxacin, nalidixic acid, and ofloxacin were the most abundant antibiotics detected. Minocycline was detected for the first time in aquaculture. The distinct observations from the two studies could be attributed to the more sensitive quantitative equipment used in the latter study. Moreover, the class of antibiotics reported by Thiang et al. (2021) is in agreement with the present survey.

Regulations on Antibiotics Employment in Aquaculture in Malaysia

The developing countries such as Europe, North America, and Japan have already executed strict

regulations on AMU. In 2001, the European Veterinary Medicinal Products Directive eliminated the prophylactic usage of antimicrobials for aquaculture (Watts et al., 2017). Norway, one of the principal world fish producers, also adopted stringent AMU regulations starting in 1987 and accomplished a 99 % reduction by 2013 in combination with improved vaccinations (Watts et al., 2017). Similarly, in Vietnam, enrofloxacin, ciprofloxacin, and 22 more chemicals and antibiotics were banned for aquaculture use starting in 2016 (Ministry of Agriculture and Rural Development [MARD], 2016).

In Malaysia, all antibiotics designated for human and animal use are under the purview of the NPRA, MOH in compliance with several pieces of legislation, such as the Poisons Act 1952, the Dangerous Drugs Act 1952, the Medicine (Advertisement and Sales) Act 1956, and other related acts. The Poisons Act, 1984, requires all drugs to be registered with the NPRA, including trade and distribution. The Animal Act (1952) has provisions to control the use of antibiotics in animal farming, but the provisions are rarely applied and do not pertain to fish. The allocation for overseeing the consumption of antibiotics in the aquaculture sector is not clearly spelled out in the Fisheries Act of 1985.

Efforts towards mitigating overuse and encouraging prudent use of antibiotics in animals have been geared

up. Starting August 1, 2007, all veterinary products containing scheduled and non-scheduled poisons intended to be administered to animals for medicinal purposes should be registered. Regulations on feed (prohibited antibiotics, hormones, and other chemicals) were gazetted in August 2012 and implemented in April 2013 (Aziah, 2019). Avoparcin was prohibited in feed and feed additives for the purposes of treatment, prevention, and growth promotion for all animals. In addition, the use of chloramphenicol, vancomycin, carbadox, olaquinox, nitrofurazone, nitrofurantoin, furazolidone, furaltadone, and teicoplanin for the purposes of treatment, prevention, and growth promoter was barred in food-producing animals feed and feed additives. Every premix to be imported, manufactured, and sold will be checked for raw material content, used antibiotics, and dosage before approval by the NPRA. Starting from 1st January 2015, medicated feed for animals was put under the control of the DVS in accordance with the Feed Act 2009, and later premixes (antibiotics for prevention and growth promotion) started on July 2015.

However, the Feed Act (2009) applies only to Peninsular Malaysia and the Federal Territory of Labuan. The use of antibiotics in feed as growth promoters (AGP) is still allowed, but alternatives such as herbs, probiotics and organic acid are an option for farmers. The use of AGP will be phased out in stages. On 1st January 2019, Colistin (polymyxin E) was banned as a growth promoter and prophylaxis, and five more (erythromycin, ticomycin, tylosin, neomycin, and phosphomycin) are in the pipeline (Aziah, 2019). The DVS has also come up with the Malaysian Veterinary Antimicrobials Guidelines (MVAG) in 2021 in order to curb or minimise the incidence of AMR, but these guidelines are specific to livestock and not aquaculture.

At present, there are no specific regulations, an official list of approved or banned antibiotics, or guidelines on the employment of antibiotics in aquaculture in Malaysia. The DOF has been using the Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals (ASEAN Secretariat, 2013) developed by the ASEAN Secretariat as a reference regarding this matter. To address these gaps, work is underway to strengthen the regulatory landscape for aquaculture sector. The Inland Fisheries Aquaculture Regulations (Federal Territory of Kuala Lumpur and Federal Territory of Labuan), introduced by the DOF in 2017, aim to regulate the use of chemicals, including veterinary drugs, in aquaculture operations. However, enforcement remains limited to the Federal Territories, with ongoing initiatives to adapt the framework for broader state-level application. In parallel, the DOF has developed a dedicated Standard Operating Procedure (SOP-DOF-BP1-1CA1: Antibiotics Usage in Aquaculture Farm), which provides operational guidance for selected species, namely shrimp from brackish water ponds, finfish from marine and brackish water ponds and finfish in marine and freshwater cages.

This SOP incorporates both the List of Pharmacologically Active Substances with established MRLs and the List of Prohibited Substances under the Feed (Prohibited Antibiotics, Hormones and Other Chemicals) Regulation 2012. While these existing instruments establish a foundation by outlining approved and banned antimicrobials, there remains an urgent need for more holistic and aquaculture-specific AMU frameworks, ones capable of guiding responsible practices across a wider range of farming systems and ecological contexts.

Way Forward

To be able to comprehend AMU in aquaculture and formulate the necessary regulations and guidelines, we need to obtain the most recent scenarios of AMU first. This is achieved through the present survey, which is able to gather the contacts of farmers using antibiotics. The next step will be the farm-level interview to gain more information on the amount and frequency of consumption. At the same time, the qualitative AMU survey will continue to cover more stakeholders, especially hatcheries, nurseries, grow-outs, and ornamental fish farms and shops. More farm audit reports could be scrutinised to identify farmers that consume antibiotics in their operations. Apart from that, legit and spot-on information could also be obtained by adding an extra requirement, which is to declare AMU for the new application or renewal of My-GAP.

Besides direct information on AMU, indirect proof of AMU, such as screening antibiotic residues in locally produced shrimp and fish tissue at intervals along with the banned antibiotics may also offer some indication of whether antibiotics are commonly used, prove withdrawal time was adhered to, and ascertain the present survey findings, which point to minimal use of antibiotics in aquaculture in Malaysia.

Given the growing significance of aquatic food production and its unique AMU dynamics, there is a pressing need for aquaculture-specific guidance to ensure responsible antimicrobial practices within the sector. The aquaculture industry in Malaysia should have its own Aquaculture Antimicrobial Guideline, similar to the MVAG developed for the livestock sector by the DVS. Such a guideline could specifically address key elements, including prudent antibiotic use, a clear list of permitted and banned antibiotics in Malaysia, and appropriate disposal practices. Last but not least, more awareness programmes on prudent use of antimicrobials should be conducted for farmers to make them understand that antibiotics must be used with the correct dosage and prescription; otherwise, they will only be wasting their money and aggravating AMR.

Conclusion

The present AMU survey provided information on the common antimicrobials applied by fish farmers. It could be deduced that antibiotics are not extensively

used in the aquaculture industry in Malaysia. Only 18 (7.5 %) of the farmers interviewed applied antibiotics in their operation. Oxytetracycline was the most common antibiotic used (6 out of 18, 33 %) together with erythromycin, amoxicillin, ampicillin, enrofloxacin, trimethoprim-sulfadiazine and florfenicol to some extent. More than half of the farmers (59 %) are aware of the national regulations on banned drugs and the importance of proper use of antibiotics, including the withdrawal time. The key purpose of AMU was for treatment (72 %) with no indication of its use to promote growth. The odds for professional consultation when using antibiotics are quite high. The relatively low level of antibiotic use observed in the current survey is encouraging and presents a timely strategic opportunity to implement proactive stewardship measures. Establishing clear guidelines and targeted interventions at this early stage can help prevent misuse from becoming entrenched, safeguarding both aquaculture productivity and broader public health outcomes.

There is a critical need for comprehensive mechanisms to quantify antibiotic usage in aquaculture, alongside clear guidance for farmers on prudent use, proper record-keeping, and safe disposal practices. While sector-specific guidelines for antimicrobial use (AMU) in aquaculture are still in their infancy, ongoing efforts aim to strengthen the surrounding regulatory landscape. The insights gained from this survey serve as a foundational step toward establishing a robust legislative framework to guide industry practices. Moreover, targeted awareness programs are essential to enhance understanding of AMU and AMR, fostering rational and responsible antibiotic use within the aquaculture sector.

Acknowledgements

The authors would like to thank the Food and Agriculture Organization (FAO) for funding the first survey under the FMM/RAS/298 project. We gratefully acknowledge the Department of Fisheries, Malaysia, for facilitating interviews through their event platforms. Our sincere appreciation is extended to Madam Khairul Ediana Mohd Tahir of the Strategic Planning Division and Dr. Noor Affizah Bujang Saili of the Biosecurity Division, Department of Fisheries, for their valuable assistance, including support in obtaining clearance for the publication of this paper. We also thank all staff who generously supported us throughout this exercise.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions: Wan Norhana Md Noordin: Conceptualisation, data curation, writing, reviewing and editing. Rozana Johari: Data curation, writing, original draft preparation, editing. Eleanor Daniella

Lokman: Data curation, reviewing and editing.

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