



Research in

AGRICULTURE, LIVESTOCK and FISHERIES

ISSN : P-2409-0603, E-2409-9325

An Open Access Peer-Reviewed International Journal

Article Code: 531/2026/RALF
Article Type: Research Article

Res. Agric. Livest. Fish.
Vol. 13, No. 1, April 2026: 165-181.

Antimicrobial Use (AMU) in Polyculture Aquafarms of Mymensingh Sadar: Category, Quantity and Surveillance

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ARTICLE INFO

ABSTRACT

Received
14 January 2026

Revised
18 February 2026

Accepted
20 February 2026

Key words:
Antimicrobial use
Polyculture
AMR
Aquaculture
Surveillance
Bangladesh

Aquaculture has become one of the fastest-growing food production sectors, playing a critical role in nutritional security and rural livelihoods in Bangladesh. However, disease outbreaks in farming systems have increased reliance on antimicrobials, raising concerns about antimicrobial resistance (AMR) and environmental contamination. This study assessed the categories, quantity, and determinants of antimicrobial use (AMU) in polyculture aquafarms of Mymensingh Sadar Upazila (sub-district). The survey-based study was conducted among 100 randomly selected polyculture fish farmers using a structured questionnaire. Data were collected on farm characteristics, antimicrobial types, dosage, duration, route of administration, and advisory sources. AMU was quantified using a weight-based method (mg/kg biomass), and statistical analyses, including correlation and multiple regression, were performed to identify the influential factors. Findings revealed widespread antibiotic use, primarily for therapeutic purposes (91%), with the fluoroquinolone group, including enrofloxacin, levofloxacin, and ciprofloxacin, being the most frequently used agents. These drugs were classified as critically important for human medicine, heightening public health concerns. Most antimicrobials were administered as medicated feed, though a significant proportion was applied directly to pond water. Stocking density emerged as the strongest predictor of AMU, followed by pond size and farming experience. While withdrawal periods were commonly practiced, the provision of professional guidance was inconsistent, leading some farmers to depend on drug vendors or their own decisions. Overall, the study highlighted the urgent need for improved antimicrobial stewardship, farmer training, strengthened regulatory oversight, and systematic AMU surveillance to ensure sustainable aquaculture and mitigate the risk of antimicrobial resistance.

To cite this article: Akter M. F., L. T. Mim, I. Islam, M. M. Hasan, T. Rahman and M. A. Reza Faruk, 2026. Antimicrobial Use (AMU) in Polyculture Aquafarms of Mymensingh Sadar: Category, Quantity and Surveillance. Res. Agric. Livest. Fish. 13(1): 165-181.

DOI: <https://doi.org/10.3329/ralf.v13i1.88074>



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Introduction

Aquaculture is one of the fastest-growing food sectors worldwide (Tacon, 2020). It has expanded steadily over the past three decades and contributes significantly to food security, income, and trade (Bjørndal et al., 2024). This growth in aquaculture industry is mainly concentrated in Asian countries whereas other regions are lagging behind (Verdegem et al., 2023). Though global production reached 130.9 million tons in 2024, showing its strong potential to meet rising food demand, more than 89.8% of production comes from only 11 countries (FAO, 2024). However, increasing concerns about food security, population growth, and climate change highlight the need for sustainable aquaculture (Costello et al., 2020).

Bangladesh is one of the leading fish-producing countries due to its rich water resources (Shamsuzzaman et al., 2020). Total fish production reached 49.15 lakh MT in FY 2022–23, of which 58.03% was from aquaculture (DoF, 2023). The country exceeded its production target and ranked third in inland open-water capture and fifth in global aquaculture production (Azad & Azad, 2022; FAO, 2018). The fisheries sector recorded 2.43% GDP growth and contributed 22.14% to agricultural GDP in FY 2022–23 (DoF, 2023). It also contributed 0.80% to export earnings and supplied about 60% of animal protein intake (BBS, 2017). Despite strong potential, the aquaculture sector faces different challenges (Ghose, 2014) which include pressure on land and water resources, limited input, weak research and extension services, and inadequate credit support (Mitra et al., 2024). The focus is shifting from quantity to quality and in that case sustainable production that balances environmental, economic, and social aspects is essential for future growth (Costello et al., 2020).

Antibiotics are naturally produced substances from microorganisms, such as bacteria and fungi, that inhibit or kill other microbes (Chandra & Kumar, 2017). Today, the term “antimicrobials” encompasses natural, semisynthetic, and synthetic agents that inhibit microbial growth (Konstantopoulou et al., 2016). Antibiotics can be bacteriostatic, limiting bacterial growth, or bactericidal, killing bacteria (Nemeth et al., 2015). They are essential for treating bacterial infections in medicine (Patil & Patel, 2021). Today, antimicrobials are widely used in medicine, agriculture, livestock, and fish farming as therapeutic or growth-promoting agents (Kourkouta et al., 2019). As antimicrobials were widely adopted in agriculture and animal production, their use in aquaculture also increased to address rising disease challenges. With the growth of aquaculture, diseases have become a major constraint, leading farmers to use antimicrobials for disease control and prevention (Ibrahim et al., 2020). Intensified farming creates conditions that favor infections, so chemicals such as antibiotics, hormones, pesticides, and vitamins are used depending on the species and farm type (Salma et al., 2022). Global antimicrobial use in food animals was about 63,151 tons in 2010 and is projected to reach 105,596 tons by 2030 (Fatima et al., 2023), mainly due to more animals being farmed and the rise of intensive systems, especially in Asia (Ibrahim et al., 2020). In aquaculture, increasing production and disease incidence similarly drive antimicrobial use. Unlike terrestrial farming, aquaculture exposes the environment directly to these drugs via water. Antimicrobials are primarily used to prevent and treat bacterial infections rather than to promote growth (Okocha et al., 2018). Bacterial diseases can sometimes be managed through eradication, vaccination, maintaining healthy stock, and good hygiene, but antimicrobials remain essential for treatment and prevention (Jansen et al., 2018). Proper use helps cure sick animals, speeds recovery, improves welfare, and reduces disease spread, including zoonotic transmission to humans. However, overuse contributes to antimicrobial resistance (AMR), as antibiotics in animal feed can promote the spread of resistant bacteria in the environment (Irfan et al., 2022). Responsible use requires proper diagnostics, monitoring programs, and good aquaculture practices to reduce the risk of AMR (Zrnčić, 2020). In developed countries, antimicrobial use is restricted to avoid selecting for human-pathogen resistance (Cabello et al., 2013), whereas limited diagnostic capacity in low- and middle-income countries often leads to misuse among small-scale farmers (Henriksson et al., 2018).

In Bangladesh, about 1,338 veterinary drugs are licensed, of which 818 (61%) are antimicrobials (DGDA, 2021). There are 73 unique generic antimicrobials, 85% of which are antibiotics, mainly fluoroquinolones, tetracyclines, penicillin, and sulfonamides (Orubu et al., 2021). By law, antibiotics, growth hormones, and insecticides are banned in animal and fish feed. Although national data on antibiotic use in inland aquaculture are limited, the government has approved a National Action Plan for Antimicrobial Resistance Containment to guide responsible antibiotic use (Fish Feed and Animal Feed Act, 2010). Given the high availability of antimicrobial products and the existing regulatory framework, systematic monitoring of antibiotic use in aquaculture is essential to ensure compliance and promote responsible usage practices. Monitoring antibiotic use in aquaculture is important for understanding current antibiotic use practices and their associated factors. Understanding current antibiotic use patterns and related issues will be easier with antibiotic use monitoring in aquaculture. This study would alert policymakers and fish producers to the problems of irrational antibiotic use. Additionally, by implementing focused treatments, it will assist aquafarm in lowering the use of antibiotics. Keeping these issues in mind, this study aims to determine the types, dose and dosage forms of antibiotic application and to assess the quantitative antimicrobial use (AMU) in the polyculture aquafarms located in Mymensingh Sadar upazila (sub-district); and to investigate the influential factors that may affect the amount of antimicrobial use (AMU).

Materials and Methods

This study used a survey-based approach to assess the quantity, categories, and usage practices of antimicrobials in polyculture farms. A structured questionnaire was used to collect data from farm owners and managers. Information on the types, dosages, and frequencies of antimicrobial use was recorded. The data were compiled and analyzed to meet the study objectives.

Study area

This research was carried out in five selected areas within Mymensingh Sadar Upazila (sub-district) viz., Shambhuganj, Charhariপুর, Anandipur, Rahmatpur, and Dapunia where polyculture is actively practiced. All these areas are major producers and contributors to Mymensingh Sadar's aquaculture (Figure 1).

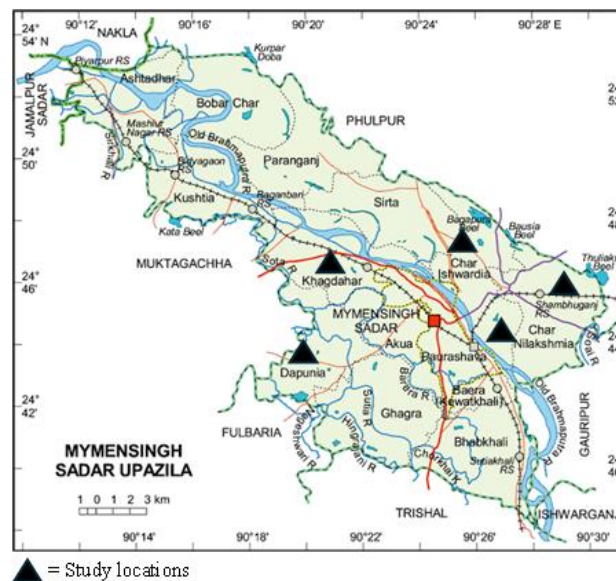


Figure 1. Map of Mymensingh Sadar Upazila (sub-district) showing the study locations

Study design and sampling

A total of 100 polyculture farms were randomly selected for the survey. Farm owners were approached for participation, and informed consent was obtained. Participation was voluntary, and anonymity was maintained to ensure confidentiality.

Data Collection

A structured questionnaire was developed with three sections: (i) farm and farmer background information, (ii) antimicrobial usage details including types, dosage, frequency, and routes of administration, and (iii) farmers' knowledge, practices, and sources of advice regarding antimicrobial use and withdrawal periods. Data were collected through multiple field visits over a defined period.

Calculation of AMU (Antimicrobial Use)

The weight-based method was used to quantify antimicrobial use (AMU) following the Food and Agriculture Organization and the World Organization for Animal Health (2023). The amount of antimicrobial products used and its active ingredient concentration were recorded.

$AMU \text{ (mg/kg biomass)} = \text{Total amount of active antimicrobial (mg)} / \text{Biomass of fish treated (kg)}$.

Here, the total amount of active antimicrobial used is the total mass of the antimicrobial (mg) administered to the fish. For this, the amount of antimicrobial product used and the concentration of the active ingredient (as listed on the label) were considered. The total active antimicrobial (mg) was calculated as:

$\text{Total active ingredient (mg)} = \text{Amount of product used (g)} \times \text{Concentration of active ingredient (mg/g)}$.

On the other hand, the biomass was estimated by the number of fish treated and their average body weight.

$\text{Biomass (kg)} = \text{Number of fish treated} \times \text{Average weight of fish (kg)}$.

Statistical analysis

The Statistical Package for Social Sciences (SPSS, V21) was used for data analysis. Descriptive statistics, such as range, count, percentage, mean, and standard deviation, were used to address the study's objectives. The relationship between the selected characteristics of fish farmers and the amount of antimicrobial use (AMU) was ascertained using inferential statistics, such as Pearson's Product Moment Correlation Co-efficient.

To identify key variables that could significantly affect antimicrobial use (AMU), a multiple linear regression analysis was employed (Jambari et al. 2020). The important independent variables influencing the dependent variable were found using this technique. It displays the adjusted R² value, which indicates the extent to which the independent variables explain the dependent variable. The following is the multiple regression equation:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e$$

Here,

$y = \hat{y} + e$ = Amount of antimicrobial use (AMU) by the fish farmers

β_0 = Intercept

X_1 = Age

X_2 = Farming experience

X_3 = Pond size

X_4 = Stocking density

Results

Demographic information of the farmers

The age distribution of respondents involved in polyculture revealed a notable trend toward middle- to older-age groups (Table 1). A significant proportion (43%) of participants were within the 36 to 55 years age bracket, indicating that middle-aged individuals constitute the largest share of fish farmers. Those aged 55 and above accounted for 33% of the respondents, further underscoring the dominance of older age groups in the sector. In contrast, youth farmers, defined as individuals aged 18 to 35, had the lowest participation rate at 24%. On the other hand, in case of the farming experiences of the respondents, the majority of the farmers (72%) had moderate experience between 6 to 10 years (Table 1). Additionally, 16% of the participants had high experience, which was over 10 years, while 12% had low experience which was less than 6 years.

The findings from Table 1 also revealed a significant disparity in pond sizes among the surveyed farmers. A majority (64%) possess ponds with an area of less than 100 decimals, indicating a prevalence of small-scale aquaculture operations. Meanwhile, 20% of the farmers have ponds ranging from 100 to 200 decimals, representing a moderate scale of fish farming. Only 16% of the farmers own ponds larger than 200 decimals, highlighting the limited presence of large-scale pond owners within the study population. This distribution suggested that smallholder aquaculture is the dominant practice in the region. Lastly, regarding stocking density, Table 1 shows an average density of 12.5 fish per square meter. Regarding the source of fry, majority of respondents relied on local commercial hatcheries, and sometimes obtained fry from mobile traders or from their own on-farm breeding or nearby farms.

Table 1. Demographic information of the farmers (n=100)

| Characteristics (Measuring units) | Score range | | Categories | Farmers | | Mean | SD |
|--|-------------|----------|--------------------------|---------|----|-------|-------|
| | Possible | Observed | | No. | % | | |
| Age (Years) | Unknown | 29-78 | Young (18-35) | 24 | 24 | 49.31 | 12.72 |
| | | | Middle age (36-55) | 43 | 43 | | |
| | | | Old (>55) | 33 | 33 | | |
| Farming Experience (Years) | Unknown | 3-19 | Low (Up to 5) | 12 | 12 | 7.91 | 5.01 |
| | | | Medium (6-10) | 72 | 72 | | |
| | | | High (>10) | 16 | 16 | | |
| Pond size (Decimal) | Unknown | 43-257 | Small (<100 decimal) | 64 | 64 | 75.51 | 53.28 |
| | | | Medium (100-200 decimal) | 20 | 20 | | |
| | | | Large (>200 decimal) | 16 | 16 | | |
| Stocking density (Fish/m ²) | Unknown | 4-18 | Low (up to 6) | 12 | 12 | 12.5 | 3.70 |
| | | | Medium (7-12) | 64 | 64 | | |
| | | | High (>12) | 24 | 24 | | |

Species in polyculture

In the polyculture system practiced in the study area, a distinct species composition was observed, with different cultured fish exhibiting distinct stocking proportions (Figure 2). The culture system was predominantly composed of pabda (Ompok pabda), which accounted for 69% of the total fish population. This reflected the species' commercial value, market demand, and compatibility with polyculture environments. The second most prominent species were Indian Major Carps (*Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*), representing 12% of the cultured population. Following this, Tengra (*Mystus sp.*) accounted for 8%, suggesting its suitability in co-culture with Pabda due to their complementary feeding habits and habitat preferences. Tilapia

(*Oreochromis spp.*) made up 7% followed by Koi (*Anabas testudineus*) and magur (*Clarias batrachus*) were stocked at equal proportions of 2% each (Figure 2).

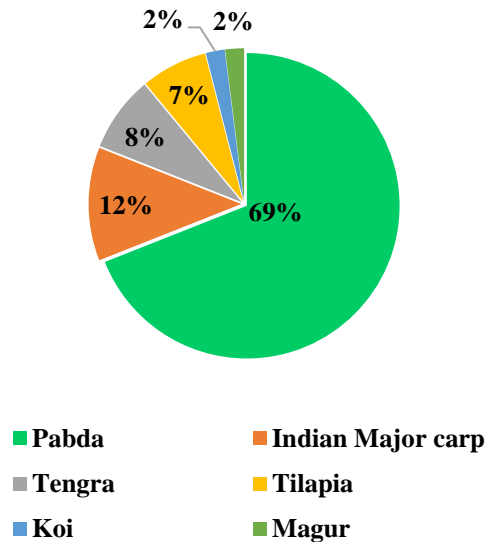


Figure 2. Species used in polyculture in the study area

Antibiotic usage

Purpose of using antibiotics

The study revealed widespread antibiotic use among fish farmers in the study area. About 91% of respondents used antibiotics primarily for therapeutic purposes, particularly to treat fish disease outbreaks (Figure 3). In contrast, only 8.6% of farmers reported using antibiotics as a prophylactic measure to prevent disease before it occurs. A marginal 0.4% of responses were categorized as 'others', which included uncertain or non-specific uses of antibiotics.

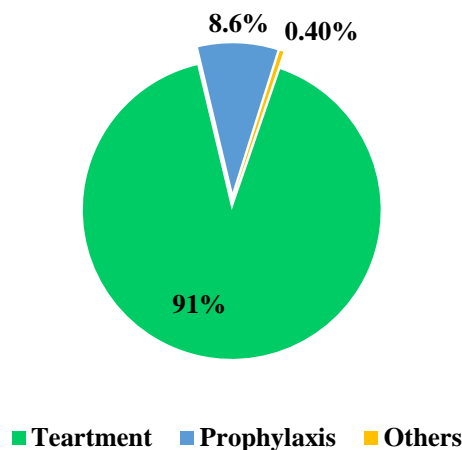


Figure 3. Purpose of using antibiotics

Commonly used antibiotics

The investigation revealed the use of approximately 10 to 12 branded antibiotics used by the fish farmers during the study period. They are marketed under various trade names, as shown in Table 2. Despite the diversity of brand names, the primary active pharmaceutical ingredients used were oxytetracycline, enrofloxacin, levofloxacin, and ciprofloxacin. Table 2 showed these antibiotics were frequently administered for disease prevention and treatment in aquaculture operations, indicating a reliance on a limited range of antimicrobial agents.

Table 2. List of commonly used antibiotics by the farmers in the study area

| Antibiotic Name | Active ingredients | Dose used by Farmers (g/kg feed) |
|-----------------|---|----------------------------------|
| Enroflox | Enrofloxacin BP 100mg | 20 |
| Enroflox DS | Enrofloxacin BP 200mg | 10 |
| Enrocin | Enrofloxacin 100mg | 5 |
| Renamycin | Oxytetracycline 200mg | 5 |
| Tetravet | | 5 |
| Levo-AL | Levofloxacin Hemihydrate 10% (each gram contains 100 mg) | 20 |
| Levo-max | Levofloxacin 100 mg | 10 |
| Levoxin | | 10 |
| Aci-LEVO | | 10 |
| Levocolixin Kz+ | | 10 |
| Cipro-A vet | Ciprofloxacin 100 mg | 5 |
| Ciprocin Vet | | 5 |

Categorization of used antibiotics

A categorization of the used antibiotics by group and generic name is shown in the following flowchart (Figure 4). The antibiotics are primarily categorized into two major groups: Fluoroquinolones and Tetracyclines.

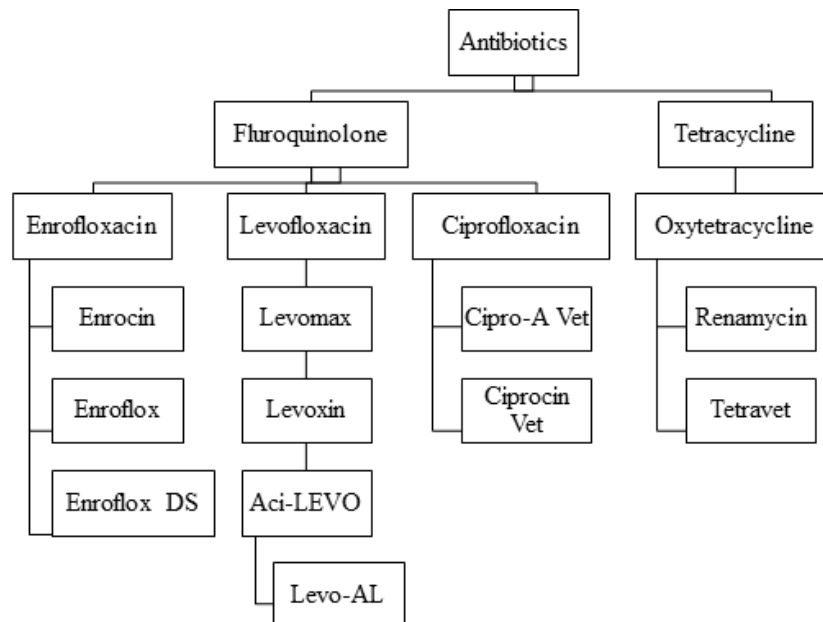


Figure 4. Categorization of the used antibiotics

Classification of identified antimicrobials according to WHO priority and use

A total of two groups of antimicrobial agents were identified in use across the surveyed polyculture farms under the generic names Enrofloxacin, Levofloxacin, Ciprofloxacin, and Oxytetracycline. Among these, three antibiotics, such as Enrofloxacin, Levofloxacin, and Ciprofloxacin, belong to the fluoroquinolone class, which are listed as Critically Important Antimicrobials (CIAs) by the World Health Organization (WHO), shown in Table 3.

Table 3. Classification of identified antimicrobials according to WHO priority and use

| Antimicrobials | Class | WHO Category |
|-----------------|-----------------|----------------------|
| Enrofloxacin | Fluoroquinolone | Critically important |
| Levofloxacin | Fluoroquinolone | Critically important |
| Ciprofloxacin | Fluoroquinolone | Critically important |
| Oxytetracycline | Tetracycline | Highly important |

[Source: WHO List of Critically Important Antimicrobials for Human Medicine, 6th Revision (2019)]

Distribution of antibiotics according to different companies

In the study area, various pharmaceutical companies were in operation. Eskayef was found to lead with the highest usage at 63%, followed by Acme (51%) and Renata (49%). Incepta and ACI contributed 38% and 37%, respectively, while Square accounted for 27%. Antibiotics from other companies constituted only 7% of the total usage (Figure 5).

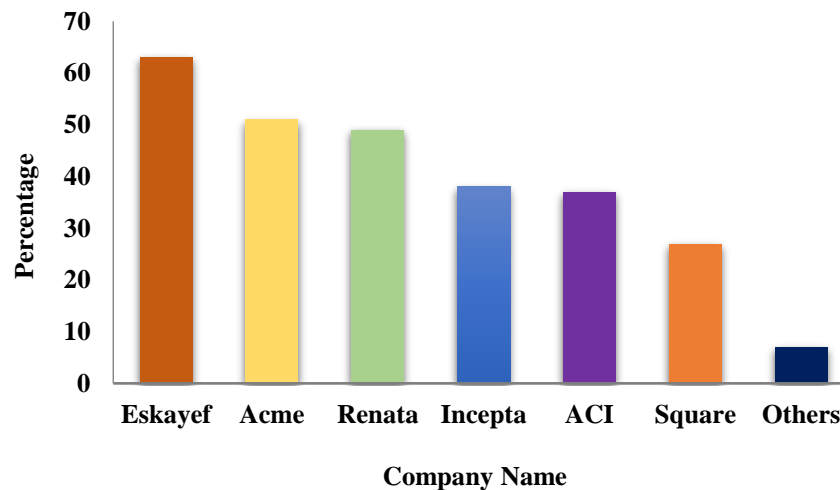


Figure 5. Distribution of antibiotics by different company

Quantity of antimicrobial use (AMU) in the study area

The quantity of antibiotics used by farmers was calculated per kg of fish biomass (Figure 6). Among the fluoroquinolone group, Enrofloxacin was the most widely used, with three commercial formulations reported. The highest dosage was recorded for Enroflox DS (74 mg/kg), followed by Enroflox (59.4 mg/kg), while Enrocin was administered at a considerably lower dose of 10 mg/kg. For Levofloxacin, also a fluoroquinolone, several formulations were observed among which Levo-AL was most heavily used at a dosage of 29.86 mg/kg

followed by Levoxin (14.33 mg/kg) and Levo-max (11.73 mg/kg). Additionally, another notable product ACI-Levo was calculated at 47.23 mg/kg and Levocolixin KZ+ at 21.66 mg/kg.

Within the tetracycline group, Oxytetracycline usage was found through two main trade names and that are Renamycin at 22.34 mg/kg biomass and Tetravat at 20.73 mg/kg biomass, indicating a relatively consistent application rate among the farmers using tetracyclines. Among Ciprofloxacin-based products use of Cipro-A Vet was calculated at 18.3 mg/kg and Ciprocin Vet at 16.93 mg/kg, reflecting moderate usage levels (Figure 6).

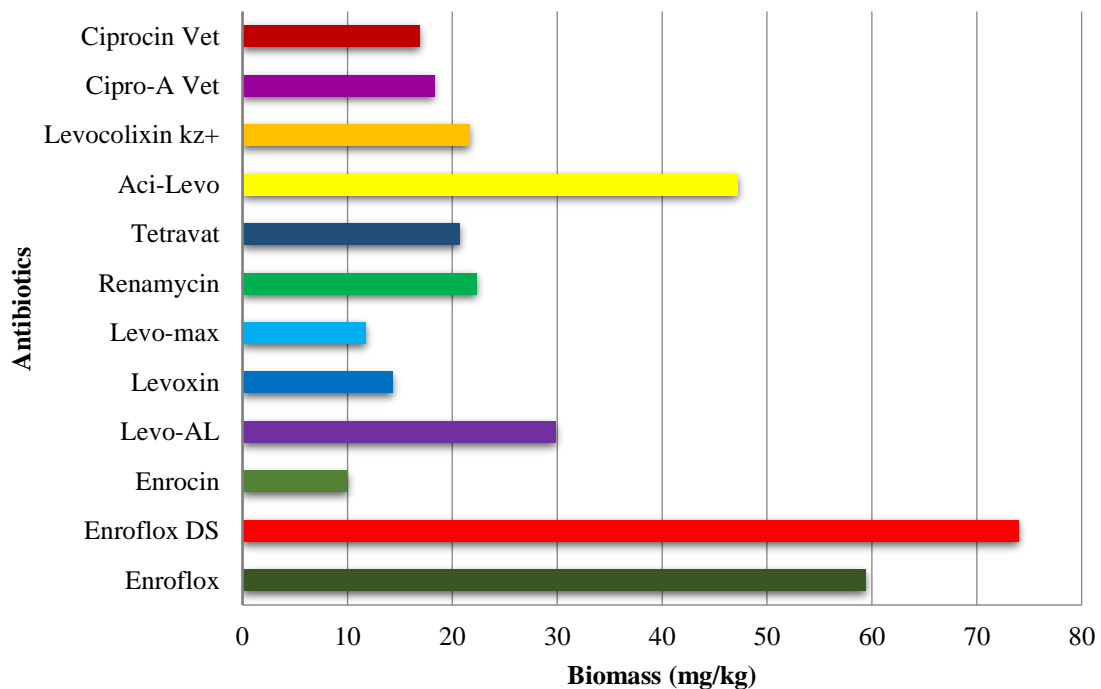


Figure 6. Quantity of antimicrobial use (AMU) in the study area

Percentage of AMU by generic name

Among the respondents, Enrofloxacin was identified as the most commonly used antibiotic, reported by 64% of the farmers (Figure 7). This was followed by Levofloxacin, which was used by 50% of the respondents. The use rate of Ciprofloxacin was also high, with 52% of farmers reporting its use. In contrast, Oxytetracycline was the least frequently used among the four antibiotics, with 41% of the farmers reporting its application which is shown in Figure 7. These findings suggest that fluoroquinolone antibiotics namely Enrofloxacin, Levofloxacin, and Ciprofloxacin are widely used in farming practices in the region. The high proportion of farmers relying on multiple antibiotics raises concerns about misuse and the risk of antimicrobial resistance (AMR).

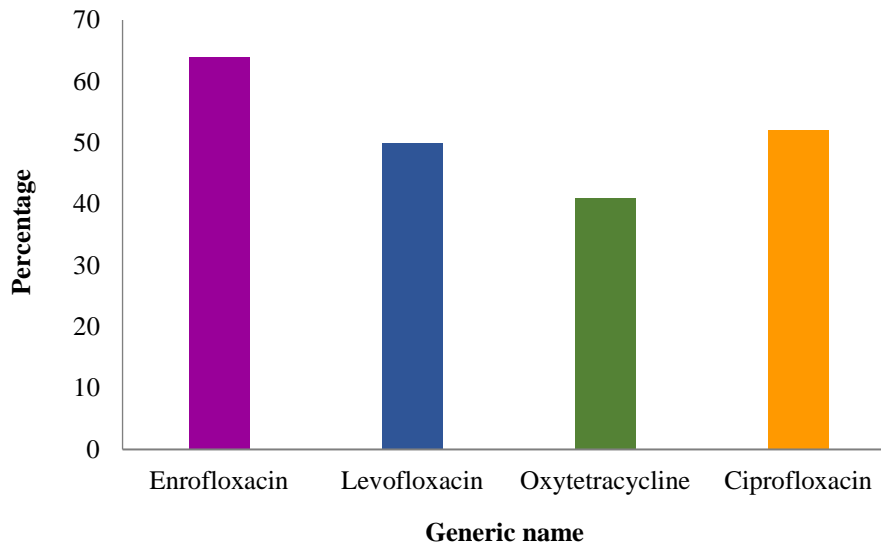


Figure 7. Percentage of antimicrobial use (AMU) by generic name

Duration of antimicrobial use (AMU)

The surveyed farmers reported administering antimicrobials through medicated feed once daily. Figure 8 shows that treatment duration varied slightly, with most farmers continuing the application for 3 to 5 consecutive days, depending on the perceived severity of the fish health condition. Majority of farmers (58%) continued the treatment for 3 days, while 33% treated for 5 days, and a smaller proportion (9%) continued for 4 days (Figure 8).

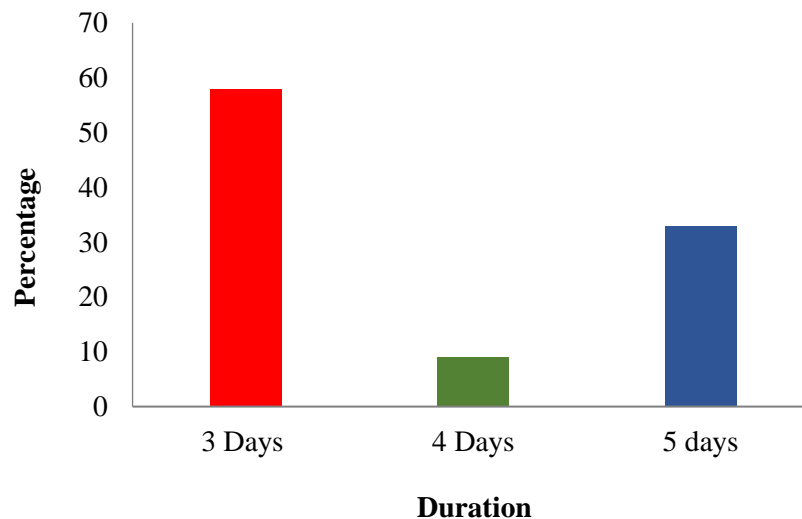


Figure 8. Duration of antimicrobial use (AMU)

Route of administration of antibiotics

The study identified two main routes of antibiotic administration among the surveyed polyculture farms. One was a feed-mixed method, and another was a water-mixed method. It was found that about 75% of the antibiotics were administered through feed-mixing, while only 25% were administered by mixing the antibiotics into the pond water (Figure 9). No evidence of direct administration (such as direct injection into fish or direct application onto the fish surface) was found during the survey.

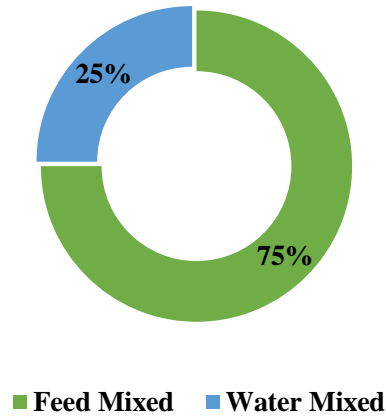


Figure 9. Route of administration of antibiotics

Sources of advice for antimicrobial use

The sources of advice regarding antimicrobial use among the surveyed farmers in the study area varied considerably (Figure 10). It was observed that majority proportion of farmers (45%) reported relying primarily on veterinarians for recommendations regarding the selection and application of antimicrobials. About 30% of the farmers stated that they sought guidance from drug dealers. Notably, 25% of the farmers made antimicrobial usage decisions independently, without consulting any professional advisors.

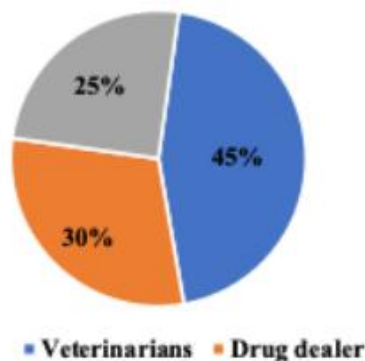


Figure 10. Sources of advice for antimicrobial use

Resting period maintained by farmers

The study revealed that a significant majority of respondents (87.14%) adhered to a minimum resting period of about 7 to 15 days before harvesting the stock after administering medications or treatments (Figure 11). A smaller proportion (8.57%) reported not maintaining the resting period, while 4.29% indicated they were unaware of what the resting period entails, which is illustrated in Figure 11.

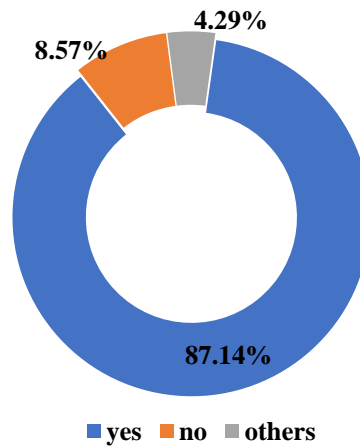


Figure 11. Resting period maintained by the farmers

Factors influencing antimicrobial use (AMU) of farmers

Relationship between selected demographic characteristics of farmers and their antimicrobial use (AMU)

The coefficient of correlation (r) between the selected demographic characteristics of the farmers is presented in Table 4. Among four characteristics of the selected farmers, three characteristics (farming experience, pond size, and stocking density) had showed a positive and significant relationship with their amount of antimicrobial use.

The results in Table 4 indicate that antimicrobial use (AMU) was strongly associated with stocking density ($r = 0.756$) and moderately associated with pond size ($r = 0.431$). On the other hand, farming experience showed a weak association ($r = 0.198$).

Table 4. Coefficient of correlation (r) showing the relationship between selected demographic characteristics of farmers and their antimicrobial use ($n = 100$)

| Selected characteristics | Value of coefficient of correlation (r) with 98 df | Tabulated values of (r) with 98 df | |
|---|--|--|-------|
| | | 0.05 | 0.01 |
| Age (years) | 0.126 | | |
| Farming experience (years) | 0.198* | 0.195 | 0.254 |
| Pond size (decimal) | 0.431** | | |
| Stocking density (fish/m ²) | 0.756** | | |

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

Table 5. Summary of multiple linear regression analysis explaining the focus variable (n= 100)

| Explanatory variables | Unstandardized Coefficients | | Standardized Coefficients | t-value | Sig. | Collinearity Statistics | |
|---|-----------------------------|------------|---------------------------|---------|-------|-------------------------|-------|
| | B | Std. Error | | | | Tolerance | VIF |
| (Constant) | 5.626 | 5.197 | - | 1.083 | 0.000 | - | - |
| Age (years) | -0.153 | 0.149 | -0.133 | -1.030 | 0.306 | 0.759 | 1.270 |
| Farming experience (years) | 0.087 | 0.042 | 0.133 | 2.094 | 0.037 | 0.594 | 1.683 |
| Pond size (decimal) | 0.636 | 0.243 | 0.114 | 2.618 | 0.001 | 0.398 | 2.510 |
| Stocking density (fish/m ²) | 0.536 | 0.043 | 0.645 | 12.406 | 0.000 | 0.389 | 2.568 |
| R = 0.882, R ² = 0.838, Adj. R ² = 0.831, F-value = 122.423 | | | | | | | |

Multiple linear regression analysis

The summary of the linear regression analysis for the farmers is provided in Table 5. To test the multicollinearity among variables in the model, the Variance Inflation Factor (VIF) was used. In addition to the variables' high tolerance levels, multicollinearity was not an issue because the maximum VIF value was 2.568. The adjusted R-squared value for the model was 0.831, and the F-test statistic value was 122.423 with a statistical significance of $p < 0.01$. This shows that none of the parameters have meaningful zero significance, and the predicted model fitted the data well.

With an F value of 122.423 and an R² of 0.838, the results indicate that three of the four variables were significant. Table 5 shows that farming experience ($t = 2.094$; $p = 0.05$), pond size ($t = 2.618$; $p = 0.05$), and stocking density ($t = 12.406$; $p = 0.05$) all significantly influenced the prediction of the amount of antimicrobial use by the farmers in the study area.

Discussion

This study provides important insights into antimicrobial use (AMU) practices in polyculture fish farms in Mymensingh Sadar. The demographic profile indicates that aquaculture in the study area is largely dominated by middle-aged and older farmers with moderate farming experiences. It is also reported that most of the farmers were operating smallholder ponds (<100 decimal). Such small-scale systems often function with limited biosecurity and technical support, increasing vulnerability to disease outbreaks (FAO, 2024; Henriksson et al., 2018). The relatively medium to high stocking densities observed suggest production intensification, a known driver of infectious disease and antimicrobial dependence in aquaculture systems (Schar et al., 2020).

Antibiotics were used predominantly for therapeutic purposes, indicating that disease outbreaks remain the principal trigger for AMU. This pattern aligns with findings that antimicrobials in aquaculture are mainly applied to treat bacterial infections rather than for growth promotion (Okocha et al., 2018). However, therapeutic use without laboratory diagnosis, as commonly reported in developing-country contexts, raises concerns about empirical treatment and inappropriate drug selection (Henriksson et al., 2018). A notable finding was the heavy reliance on fluoroquinolones such as Enrofloxacin, Levofloxacin, and Ciprofloxacin as these are classified as Critically Important Antimicrobials (CIAs) for human medicine. The use of CIAs in aquaculture is concerning because of their importance in treating serious human infections and the potential for resistance transfer (Cabello et al., 2013). The repeated use of a limited number of antimicrobial classes further increases the risk of antimicrobial resistance (AMR) development (Preena et al., 2020).

Dosage variation across commercial formulations suggests inconsistent understanding of appropriate therapeutic levels. In aquaculture, antimicrobials are introduced directly into aquatic environments, increasing the risk of environmental dissemination and selection of resistant bacteria (Pepi & Focardi, 2021). Although most farmers administered antibiotics through medicated feed, a considerable proportion applied them directly into pond water, a practice that may amplify environmental exposure. While nearly half of the farmers sought advice from veterinarians, a substantial number relied on drug sellers or made independent decisions. Similar advisory patterns have been documented in low and middle-income countries where informal pharmaceutical supply chains influence antimicrobial use (Orubu et al., 2021), often under weak regulatory oversight. Although most farmers reported maintaining a resting period before harvest, incomplete awareness among some respondents suggests gaps in stewardship practices (Gaikwad et al., 2026).

The findings indicate that stocking density was the strongest determinant of AMU, followed by pond size and farming experience. Intensified production systems inherently elevate disease transmission risks, thereby increasing antimicrobial dependency (Henriksson et al., 2018). Larger pond operations may involve greater biomass and financial investment, motivating farmers to use antimicrobials to minimize economic losses (Tran et al., 2025). The positive association between farming experience and AMU may reflect increased familiarity with pharmaceutical interventions rather than improved preventive health management. Previous studies suggest that without structured training on antimicrobial stewardship, experience alone does not necessarily reduce inappropriate use (Farías et al., 2024).

Conclusion and recommendation

This study provides a detailed assessment of antimicrobial use (AMU) in polyculture fish farms in Mymensingh Sadar, Bangladesh. The findings reveal widespread reliance on antibiotics, primarily for therapeutic purposes during disease outbreaks. Fluoroquinolones which are classified as Critically Important Antimicrobials (CIAs) for human medicine, were the most frequently used class, raising concerns regarding antimicrobial resistance (AMR) and public health risks. Antibiotics were administered mainly through medicated feed, although a considerable proportion of farmers still applied them directly to pond water. Variations in dosage and duration, combined with partial dependence on informal advisory sources, indicate gaps in antimicrobial stewardship. While most farmers reported maintaining a resting period before harvest, inconsistent awareness suggests that compliance may not always be guided by scientific understanding. Stocking density, pond size, and farming experience significantly influenced AMU, highlighting the structural role of production intensification in driving antimicrobial reliance. Overall, the findings underscore the urgent need to strengthen responsible antimicrobial use practices in smallholder aquaculture systems to safeguard environmental sustainability and food safety.

Therefore, to promote responsible antimicrobial stewardship in polyculture aquaculture systems, coordinated efforts are required at farm, institutional, and policy levels. Strengthening extension and farmer training programs is essential to improve awareness of appropriate dosages, compliance with withdrawal periods, and biosecurity practices. Improved access to diagnostic facilities and qualified veterinary services would help reduce empirical antibiotic use and encourage evidence-based treatment decisions. Regulatory authorities should enhance monitoring and enforcement mechanisms, particularly concerning the use of fluoroquinolones and other critically important antimicrobials in aquaculture. Greater emphasis should also be placed on preventive health management strategies, including optimized stocking densities, improved water quality management, and adoption of good aquaculture practices (GAP) to reduce disease occurrence. Finally, establishing systematic antimicrobial use (AMU) surveillance systems at farm and national levels would support data-driven policymaking and long-term mitigation of antimicrobial resistance risks.

Statements and declarations

Competing interest

No potential conflict of interest was reported by the authors.

Acknowledgement

The authors wish to express their sincere gratitude to the Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, for providing the necessary facilities and support for this research. We are especially thankful to the respondent fish farmers for their invaluable time and cooperation during data collection.

Ethics approval

It should be mentioned in the text that there was no chance to apply for the Study Ethics Board permission because there was no institutional ethical board to approve social science research. Because of this academic constraint, the study was exempt from needing ethics approval.

Consent to participate

All study participants provided informed consent before their data were used in a scholarly publication. This research did not involve any minors.

Funding

There was no funding provided for this work by any source.

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