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Knowledge of fish farmers on using artificial feed for catfish culture

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Abstract
Bangladesh's numerous inland lakes and river systems make capture fisheries and aquaculture here very promising. Bangladesh is producing more catfish since they are exceptionally resilient and can tolerate harsh weather conditions and unstable habitats. The aims of the research were to assess fish farmers' knowledge of using artificial feed for catfish culture and to identify the variables affecting their knowledge level. Thus, the research was conducted in three villages of Gauripur upazila (sub-district) of Mymensingh district. In-person interviews were conducted with 80 randomly chosen catfish farmers. According to the findings, the vast majority of respondents (63%) had medium-level and 32% had high and 5% of farmers found which have a low level of knowledge on using artificial feed for catfish culture. Formal education, fish farming experience, farm size, annual income, social mobility, communication exposure and training received were positively and significantly correlated with the knowledge of the respondents. Multiple linear regression analysis confirmed that formal education, communication exposure, and training received significantly influenced fish farmers' knowledge. High cost of fish feed, inaccessibility of good quality fish feed and lack of proper training were identified as the major problems faced by the fish farmers. In connection to these difficulties, development agencies such as Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh Fisheries Research Institute, relevant non-government and private organizations should take appropriate action like regular need based training, method demonstration, result demonstration, field day, other extension activities to increase the fish farmers' knowledge on using artificial feed for catfish culture.

Keywords: Knowledge, fish farmer, artificial feed, catfish, culture

1. Introduction
In the world, Bangladesh is regarded as one of the fisheries-friendly nations (Shamsuzzaman *et al*., 2017) [44]. It has a large number of freshwater and coastal water bodies (Ghose, 2014) [24]. Bangladesh's numerous inland lakes and river systems make capture fisheries and aquaculture here very promising. Bangladesh benefits from its favorable geographic location since it provides a wide range of aquatic species and resources to assist its expanding fishing industry (Shamsuzzaman *et al*., 2017; Sunny *et al*., 2020) [44, 48]. According to the FAO (2018) [20], Bangladesh is the fifth-largest aquaculture producer in the world, the third-largest producer of inland fish, and the eleventh-largest producer of marine fish. From 7.54 lakh metric ton in 1983–84 to 43.84 lakh metric ton in 2018–19, Bangladesh's total fish production has increased during the past three decades by approximately six times (DoF, 2019) [17]. According to BER (2019) [7], Bangladesh's fishing industry generates 3.50 percent of the nation's total GDP and 25.72 percent of the nation's agricultural GDP. Over 17 million people, including over 1.4 million women, depend on the fisheries sector for their livelihoods through fishing, farming, fish handling, and processing (BFTI, 2016) [8]. The rate of fish output, however, is lower than the rate of population growth (Uddin *et al*., 2022) [50]. The majority of ponds in the country are used for non-commercial reasons, with only 7.71 percent being used for commercial purposes (Hossain and Das, 2013) [29]. Increasing fish production is one of Bangladesh's most crucial endeavors to ensure that people are getting the essential amounts of protein and minerals.
Among different fishes, catfish culture is widely spreading in Bangladesh (Shamsuzzaman *et al*., 2020) [45], accounting for around 5.22 lakh MT catfish production (DoF, 2018) [16].

The commercially important catfish are *Clarias batrachus* (Magur), *Heteropneustes fossils* (Shing), *Mystus cavasius* (Gulsa), *Ompok bimaculatus* (Pabda). Bangladesh is producing more catfish since they are exceptionally resilient and can tolerate harsh weather conditions and unstable habitats (Warner, 2018) [52]. Furthermore, it is resistant to many diseases and consumes several kinds of bio-wastes and suitable for grow under natural conditions for their quick growth. Farmers cultivate catfish in natural inland freshwater bodies because of their carnivorous, cannibalistic, and voracious feeding habits (Kayode and Awoyemi, 2021) [32].

It is crucial to use improved procedures and management practices to increase fish production and produce a healthy, high-quality fish (Assefa and Abunna, 2018) [3] such as ensuring good nutrition (Elekwachi, 2018) [18]. Fish feeds supply nutrients for ideal fish growth and increase farmers' financial returns (Rahman, 2013; Dauda *et al*., 2019) [38, 14]. However, the natural food present in the water is insufficient for fish to grow and produce as much as possible. Even after applying fertilizers, there is still a lack of natural food in the pond (Verdegem, 2013) [51]. A study by Elekwachi (2018) [18] suggests that any aquaculture operation needs to have a consistent and sufficient supply of balanced artificial diets for the cultured fish in order for it to be successful and profitable. This is a result of the fact that the dissolved nutrients needed to support primary and secondary production in the natural environment are seasonal and may not be present in the necessary amounts to satisfy the nutritional needs of cultured fishes.

There is a growing body of literature that recognises the importance of using artificial feed to catfish culture to maximize fish growth and and increase the fish production (Filburn *et al*., 2013; Dauda *et al*., 2019) [23, 14]. Fish production is severely hampered by the lack of sufficient artificial feeds at the early stages of fish development (Kristanto *et al*., 2020) [33]. With the development of technology and rising demand, our nation is now utilizing a variety of upgraded cultural practices (Zaman *et al*., 2017) [54]. As a result, the demand of artificial feed is increasing to satisfy the increasing demand of cultured fish species for affordable, safe, high quality fish production (Kundu *et al*., 2017) [34]. According to Elekwachi (2018) [18], 'In order to grow healthily and vigorously, fish have a particular biological need for nutrients. These nutritional needs vary mostly based on the species, its size/life stage, and the environment'.

However, effective formulation and timely application of artificial feed is vital for the culture of any fish species. Due to difficulties such improper ingredient mixing, which leads to water pollution and deterioration of soil quality, etc., fish productivity is ultimately reduced. (Boyd and Tucker, 2012) [10]. Additionally, the unavailability of high-quality formulated fish feeds, high feed costs, and lack farmers' knowledge on-farm feed management procedures and rules are constraints that limit aquaculture production (FAO, 2021) [21]. In view of the above facts, It is now clear that research on the formulation, application, and acceptability of manufactured feeds for catfish production is crucial to the growth of Bangladesh's fisheries industry.

Therefore, knowledge of the fish farmers on feed management such as formulation, application and acceptability of synthesized feeds in fish farming may play great role to increase fish production of any fish species (FAO, 2021; Sakib *et al*., 2014) [21, 42]. The knowledge of fish farmers on using synthesized feed for catfish culture must be assessed in order to enhance the current state of catfish culture in this country.

Few research studies were conducted about knowledge on aquaculture practices, while Hashanuzzaman *et al.* (2020) [25] performed research on food safety and security knowledge, attitudes and practices of fish farmers. Besides, FAO (2021) [21] investigated the the lack of technical advice on fish feed manufacturing and on-farm feed management were identified as priority areas that needed to be addressed to improve production outcome. However, no available study found to asses the knowledge of fish farmers on using artificial feed for catfish culture.

The above mentioned facts were taken into consideration as the current investigation was conducted to 1) determine the knowledge of fish farmers on using artificial feed for catfish culture 2) explore the relationships between the knowledge of fish farmers and their selected characteristics, 3) identify the influential factors that may affect the fish farmers' knowledge on using using artificial feed for catfish culture and 4) To identify the problems faced by the fish farmers on using artificial feed for catfish culture.

2. Materials and Methods

Gauripur Upazila (sub-district) of Mymensingh district of Bangladesh (Figure 1) was considered as the study location. This area was selected purposively since it is one of the most notable upazilas (sub-district) and has a sizeable population of fish farmers engaged in catfish culture. The research area is very significant since it contains ideal soil for aquaculture, access to water, electricity, and marketing facilities. In Gauripur Upazila (sub-district), there were ten union parishads and due to the presence of catfish culture, the Douhakhola union was particularly chosen. The study was performed in the villages of Singhjani, Morichali, and Nandigram of the Douhakhola union.

2.1 Population and sample of the study

The purpose of the respondents' selection was to represent a representative sample of the catfish producers in the study area. An updated list of fish farmers was obtained from Upazila Fisheries Officer (UFO) and Local Extension Agent for Fisheries (LEAF). A total of 318 catfish farmers (target population) were found in the study area. The participants in the study were chosen from this list using it as a sampling frame. To choose a sample from the target population(318), a random sampling approach was used to choose 25% of the population. Consequently, 80 catfish farmers were chosen as the study's sample. It was arbitrary to select this sample size of 80 because the total population was large (Cochran, 1977) [12]. The sample size was determined after taking the research time, cost, and data quality into account. The distribution of the catfish farmer's sample size is shown in Table 1.

Table 1: Distribution of the sample size of the catfish farmers

Name of the upazila (sub-district)	Name of the union	Name of the village	Population	Number of fish farmer (sample size)
Gauripur	Douhakhola	Singhjani	44	11
		Morichali	132	33
		Nandigram	142	36
		Total	318	80

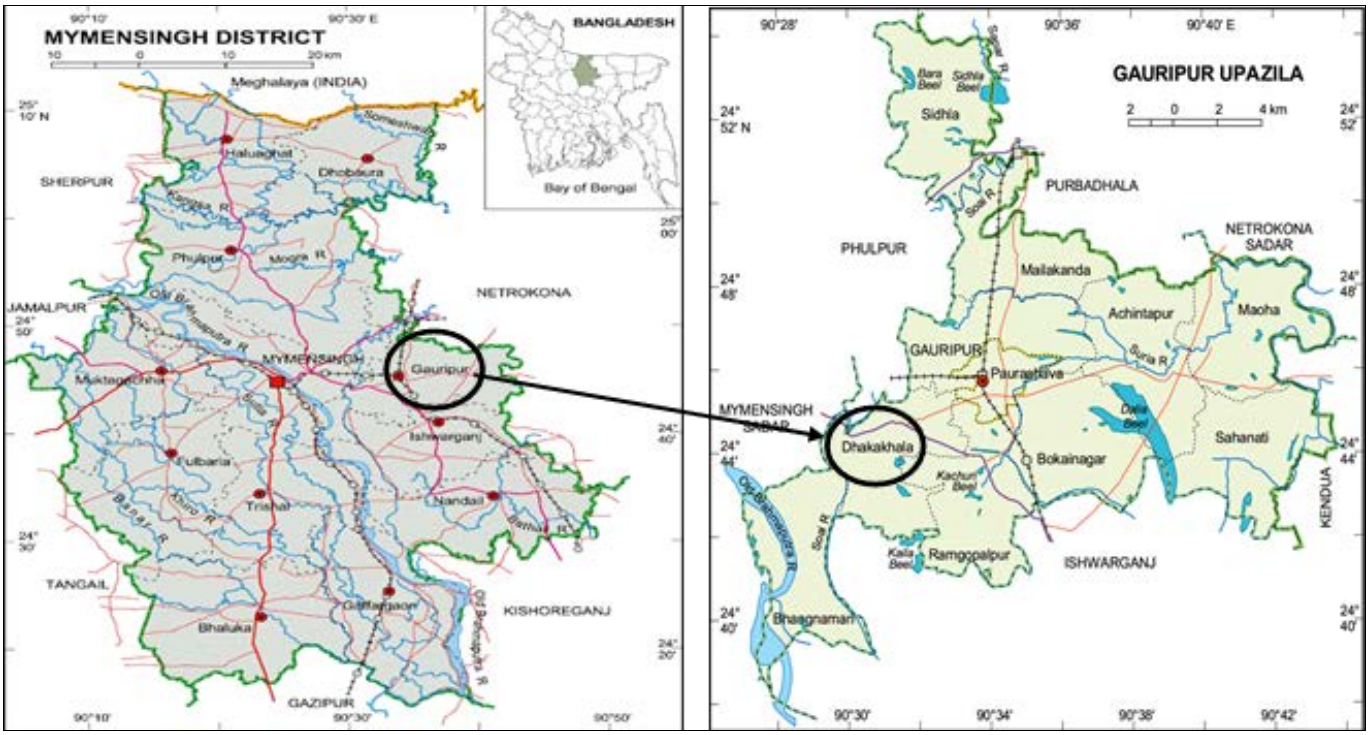

Fig 1: Map of Mymensingh district and Gauripur upazila (sub-district) showing the study union

2.2 Measurement of the variables and analysis of data

The dependent variable of the study was the 'knowledge of fish farmers on using artificial feed for catfish culture'. It was assessed by creating questions in line with Bloom's postulated six levels of the cognitive domain for measuring knowledge (1956) [9] and revised by Anderson and Krathwohl (2001) [2]. These six levels are: remembering, understanding, applying, analyzing, creating and evaluating. Each level had a number of close-type questions, and the importance, difficulty, and depth of understanding at each level were used to determine the score. A total of 18 questions were posed to each respondent. This procedure was followed by Roy (2014) [40], Dhali (2013) [15] and Shorif (2011) [46]. According to its significance, complexity, and depth, each question was given a different rating. The researcher gave marks to each of the questions according to the correctness of the responses of the respondents. The range of the overall knowledge score for all dimensions is from 0 to 48 where "0" indicated no knowledge and "48" indicated the highest knowledge on using artificial feed for catfish culture.

2.3 Factors affecting the knowledge of fish farmers on using artificial feed for catfish culture

The relationship between fish farmers' knowledge and their selected socioeconomic features was investigated using Pearson's Product Moment Correlation Coefficient (r). In addition, multiple regression analysis (both enter and stepwise methods) was used to identify factors affecting the knowledge of fish farmers on using artificial feed for catfish culture. Once insignificant variables have been eliminated from the model, stepwise regression analysis assists in quantifying the individual contributions of factor variables (Quddus and Kropp, 2020) [37]. The equation is as follows (Equation 1).

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \epsilon_i \quad (1)$$

Where, y_i =knowledge of fish farmers, β_0 = constant, X_1= age, X_2= formal education, X_3 = household size, X_4 = fish farming experience, X_5=farm size, X_6= annual income, X_7= credit received, X_8= social mobility, X_9= communication exposure, X_{10}= training received, ϵi= Error term

Using a 4-point rating scale, the problems experienced by the fish farmers were evaluated. In order to determine the ranking of the problems, the problem-facing index (PFI) was computed. The frequency counts of each cell on the scale for each problem were multiplied by the weights assigned to each cell, which ranged from 3 for high frequency to 2 for medium frequency to 1 for low frequency to 0 for not at all. PFI for each 8 selected problems was measured by using an equation. The equation is as follows (Equation 2).

Total score received = (Ph ×3) + (Pm×2) + (Pl ×1) + (Pn ×0) (2)

Where,
Ph = Number of respondents indicating high problem
Pm = Number of respondents indicating medium problem
Pl = Number of respondents indicating low problem
Pn = Number of respondents indicating problem not at all

$$PFI = \left(\frac{\text{Total score received}}{\text{Maximum total score}}\right) \times 100$$

The overall score for each problem issue for the 80 respondents might be between 0 and 240 (80×0 to 80×3), where zero 0 indicates no problem at all while 240 indicates the highest problem in each issue. The calculated PFI could range from 0 to 100 (0/240×100 to 240/240×100). Problems were then ranked ordered (RO) according to their problem-facing index (PFI) value.

3. Results and Discussion

3.1 Socio-economic characteristics of the fish farmers

Table 2 gives a brief breakdown of the respondents' socioeconomic characteristics. It demonstrates that the age range of the fish farmers was 25 to 65 years. Majority of the respondents (44%) were middle aged (36-50), compared to 38 percent being old aged (>50) and 18 percent being young (up to 35). The majority of participants (65%) had primary to secondary level education, according to data on their educational qualifications, 10% of the participants had higher secondary education, 8% had above higher secondary education and 17% had no education. The respondent's average household size was five people (5.14), which is higher than the national average of 4.06 (BBS, 2016) [5]. More specifically, (59%) of respondents had medium-sized households, (31%) had small households, and (10%) had large households. The fish farmers had an average of 13.48 years of experience, and the standard deviation was 6.67. With regard to farming experience, the majority of fish farmers (38%) had medium fish farming experience, followed by 35% by low experience, and 27% by high experience.

Table 2: Salient feature of the selected characteristics of the fish farmers (n=80)

Characteristics	Scoring system	Range	Categories	Respondent		Mean	SD*
		Observed (possible)		Number (n=80)	Percent (%)		
Age	Actual years	25-65 (Unknown)	Young (up to 35)	14	18	48.10	10.34
			Middle age (36-50)	35	44		
			Old (>50)	31	38		
Formal education	Years of schooling	0-17 (Unknown)	Illiterate (0)	14	17	7.06	4.46
			Primary (1-5)	23	29		
			Secondary (6-10)	29	36		
			Higher secondary (11-12)	8	10		
			Above higher secondary (>12)	6	8		
Household size	No. of members	3-12 (Unknown)	Small (up to 4)	25	31	5.14	1.46
			Medium (5-6)	47	59		
			Large (>6)	8	10		
Fish farming experience	Years of farming	3-27 (Unknown)	Low (up to 8)	28	35	13.48	6.67
			Medium (9-16)	30	38		
			High (>16)	22	27		
Farm size	Hectares	0.2-2.86 (Unknown)	Small (up to 1)	48	60	1.16	0.66
			Medium (1.01-2)	23	29		
			Large (>2)	9	11		
Annual income	Taka in (“000”)	90-370 (Unknown)	Low (up to 150)	23	29	215.56	81.36
			Medium (151-300)	41	51		
			High (>300)	16	20		
Credit received	Taka in (“000”)	0-150 (Unknown)	No credit (0)	50	63	23.15	38.61
			Low (1-50)	18	22		
			Medium (51-100)	7	9		
			High (>100)	5	6		
Social mobility	Score	0-7 (0-15)	Low (0-5)	57	71	3.49	2.16
			Medium (6-10)	23	29		
Communication exposure	Score	6-15 (0-36)	Low (up to 12)	43	54	10.92	2.64
			Medium (13-24)	37	46		
Training received	Days	0-10 (Unknown)	No training (0)	39	49	1.61	2.09
			Low (1-3)	34	4		
			Medium (4-7)	4	5		
			High (>7)	3	4		

Data showed that only 11% of fish farmers operated large farms, compared to 60% who operated small farms and 29% who operated medium-sized farms. The surveyed farmers' farms were 1.16 hectares in size on average. It was larger than the 0.6 hectares that made up the typical farm size in the country (Uddin *et al*., 2022) [50]. With a mean of 215.56 and a standard deviation of 81.36, the fish farmers' annual household income ranged from 90 to 370 thousand BDT. Of the 80 fish farmers, 29% were classified as having low income, 51% as having medium income, and 20% as having high income. With an average of 23.15 and a standard deviation of 38.61, the farmers' credit received ranged from 0 to 150 thousand BDT. The majority of fish farmers (63%) did not fall into any of the credit categories, while 22% were given small credit between 1,000 and 500,000 BDT. However, just 9% of farmers received medium-sized credit between 51,001 to 100,000 BDT, while 6% of farmers received large credit of more than 100,000 BDT.

The majority of farmers (71%) had low social mobility, compared to 29% who had medium social mobility. With an average of 10.92 and a standard deviation of 2.64, the farmers' communication exposure ranged from 6 to 15. Fish farmers made up of more than half (54%) had low communication exposure, while 46% had medium communication exposure.

The duration of the training for the farmers ranged from 0 to 10 days; the standard deviation was 2.09 days, and the average was 1.61 days. Only 4% of the fish farmers who were under investigation had high training experience, compared to 42% who had low, 5% who had medium, and 49% who had no training experience.

3.2 Knowledge of fish farmers on using artificial feed for catfish culture

The dependent variable of the study was fish farmers' knowledge on using artificial feed for catfish culture. The knowledge of the fish farmers was measured by using modified Bloom's Taxonomy of Cognitive Domain as explored by Ali (2012) [1] and Roy (2017) [41]. Different levels of knowledge of the fish farmers were presented in Table 3.

Table 3: Level of fish farmers' knowledge on using artificial feed for catfish culture (n=80)

Level of knowledge	Possible range	Observed range	Mean	Standard deviation
Remembering	0-10	3-8	4.64	1.16
Understanding	0-6	2-4	2.66	0.59
Applying	0-10	2-8	4.25	1.85
Analyzing	0-7	2-5	4.07	1.00
Evaluating	0-8	2-7	4.27	1.16
Creating	0-7	2-6	3.54	0.75

Data in Table 3 indicates that fish farmers had a higher level of remembering ability and a lower level of understanding ability across the six categories of measuring knowledge. Ali (2012) [1] reported a higher level of evaluation capability of the respondents in his study.

From 0 to 48, the fish farmers' total knowledge scores were assigned. Although the observed knowledge score of the fish farmers ranged from 13 to 38, with a mean of 31.47 and a standard deviation of 4.47.

Table 4: Distribution of the fish farmers based on their knowledge of using artificial feed for catfish culture (n=80)

Category	Fish Farmer		Mean	Standard deviation
	Number	Percent		
Poor knowledge (0-16)	4	5	31.47	4.47
Moderate knowledge (17-32)	50	63		
High knowledge (33-48)	26	32		
Total	80	100		

According to data in Table 4, roughly 63 percent of fish farmers had moderate knowledge of utilizing artificial feed for catfish culture, compared to 5 percent who had low knowledge and 32% who had a high level of knowledge. The majority of respondents (65%) had completed primary or secondary school, while 38% had medium farming experience, 29% had medium social mobility score, and 46% had medium communication exposure. As a result, they had a moderate knowledge level regarding the use of artificial feed in catfish culture. Similarly, Begum (2012) [6] and Shorif (2011) [46] found fish farmers had moderate knowledge of aquaculture and cage culture respectively.

3.3 Relationship between the selected characteristics of the fish farmers and their knowledge of using artificial feed for catfish culture

In order to investigate the relationships between the selected fish farmers' characteristics and their knowledge of using artificial feed for catfish culture, Pearson's Product Moment Coefficient of Correlation (r) was computed and the results are shown in Table 5.

Among the ten selected characteristics seven namely, formal education, fish farming experience, farm size, annual income, social mobility, communication exposure and training received of the respondents had significant positive relationship with their knowledge on using artificial feed for catfish culture. Therefore, farmers with more formal education, fish farming experience, large farm size, more annual income, more social mobility, more communication exposure and more training received for feed management will have more knowledge on using artificial feed for catfish culture. This is because farmers in the research area with higher levels of education used to frequently interact with extension agents, model farmers, and the media (TV), which allowed the knowledge of artificial feed for catfish culture to grow. This result is similar with findings of other studies who identified a significant and positive correlation between education and knowledge of fish farmers Sumon (2014) [47] and Yeasmin (2013) [53].

It is also evident from Table 5 that fish farming experience was positively correlated with their knowledge of using artificial feed for catfish culture. According to Dhali's (2013) [15] research, farmers' knowledge of semi-intensive aquaculture increased as they gained more experience, which is in line with this observation. It is also evident from Table 5 that farm size of the catfish farmers was positively correlated with their knowledge on using artificial feed for catfish culture, indicating that large farm size helps catfish farmers become more acquainted with the fish culture and different feed management practices which in turn makes them aware of broadening their level of knowledge of using artificial feed.

Table 5: Relationship between the selected characteristics of the fish farmers and their knowledge of using artificial feed for catfish culture (n=80)

Dependent variable	Selected characteristics (independent variables)	Computed 'r' values (78 DF)
Knowledge of fish farmers on using artificial feed for catfish culture	Age	0.117 NS
	Formal education	0.427**
	Household size	0.183 NS
	Fish farming experience	0.322**
	Farm size	0.443**
	Annual income	0.383**
	Credit received	0.218 NS
	Social mobility	0.450**
	Communication exposure	0.521**
	Training received	0.452**

**Correlation is significant at 0.01 level of probability (table value 0.287) with 78 DF.

*Correlation is significant at 0.05 level of probability (table value 0.220) with 78 DF, NS= Not Significant

The annual income of the fish farmers and their knowledge of using artificial feed for catfish culture were positively and significantly correlated, indicating that the farmers which had more annual income might have the option to spend money on for purchasing artificial feed for catfish culture. Therefore, compared to farmers with lower incomes, fish farmers with higher yearly incomes from fish farming had better knowledge on using artificial feed for catfish production. A positive relationship between annual income and knowledge was also discovered by Roy (2017) [41], Hossain (2008) [27], and Hossain (2000) [28] in their respective studies.

The relationship between fish farmers' knowledge of using artificial feed for catfish culture and their social mobility is also shown in Table 5, suggesting that social mobility helped fish farmers in becoming exposed to new sources of information and so increasing their knowledge. Additionally, Yeasmin (2013) [53] and Ali (2012) [1] found that respondents' social mobility had a positive effect on development of knowledge. The study's findings also revealed a positive significant relationship between fish farmers' knowledge and communication exposure. Thus, farmers with greater communication exposure are more knowledgeable about using artificial feed in catfish culture than farmers with less or no exposure to communication. This is due to the fact that farmers with greater communication exposure have more options to contact various information sources for efficiently managing a variety of farm activities (Odini, 2014; Hoque *et al*., 2021) [36, 26]. This finding is similar with a number of other studies that reported farmers having more commuination exposure usually plays a positive role in gaining knowldge Ali (2012) [1], Farhad (2003) [22], Sarker (2004) [43] and Hossen (2016) [30].

Farmers' knowledge on using artificial feed for catfish culture increases with the increase of training exposure, as indicated by the positive correlation coefficient. This means that the farmers who participate in more number of training, they are have more knowledge of catfish culture and feed management than those of farmers who didn't or participated less number of training. According to empirical data, training is a useful method for enhancing knowledge, especially when it comes to minimizing technology-related subjective uncertainty (Jackline *et al*., 2016; Nejadrezaei *et al*., 2018; Caffaro *et al*., 2020; Uddin *et.al*., 2022) [31, 35, 11, 50].

3.4 Factors affecting the knowledge of fish farmers on using artificial feed for catfish culture

Below is a discussion of the findings of several statistical techniques that explain the variables influencing fish farmers' knowledge of using artificial feed for catfish culture.

3.4.1 Multiple linear regression analysis

To identify the variables and their relevance in foretelling the focal variable, multiple linear regression analysis was performed. The results of the regression analysis (Table 6) revealed that all the explanatory variables, such as age, formal education, household size, fish farming experience, farm size, annual income, credit received, social mobility, communication exposure and training received significantly influence knowledge on using artificial feed for catfish culture (R^2 = 0.592). Among them, formal education (t=3.700; p< 0.01), communication exposure (t=2.559; p<0.01), and training received (t=4.079; p<0.01) had substantial impact on fish farmers' knowledge of using artificial feed for catfish culture.

The model's variables' multicollinearity was tested using the Variance Inflation Factor (VIF). Given that the maximum VIF value was 3.877 and the variable tolerance levels were all high, multicollinearity was not a problem. The model's F-test score was 10.0 with statistical significance at p<0.01 and an adjusted R-squared value of 0.533. The study's findings demonstrated that these three factors together could account for 53.3% of the variation (Adjusted R^2 = 0.533) of fish farmers' knowledge on using synthesized feed for catfish culture, which is statistically exceedingly significant (F = 10, p<0.01).

Results showed that farmers' knowledge of using artificial feed for catfish culture was significantly improved by their formal education, indicating that if formal education changes by 1 unit (one number), then knowledge of using artificial feed for catfish production changes by 0.348 units. In order to maintain a catfish farm, such as feed management, education is considered to be essential (Esau *et al*., 2022) [19]. Both Sumon (2014) [47] and Yeasmin (2013) [53] found similar results.

Table 6: Summaries of the linear multiple regression analysis

Explanatory variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	20.492	2.671		7.671	0.000		
Age (X_1)	-0.011	0.051	-0.026	-0.225	0.823	0.431	2.321
Formal education (X_2)	0.348	0.094	0.347	3.700	0.000***	0.673	1.487
Household size (X_3)	0.065	0.272	0.021	0.239	0.812	0.744	1.344
Fish farming experience (X_4)	0.160	0.088	0.238	1.806	0.075	0.342	2.925
Farm size (X_5)	0.567	1.027	0.084	0.552	0.583	0.258	3.877
Annual income (X_6)	0.002	0.008	0.045	0.311	0.757	0.278	3.595
Credit received (X_7)	-0.006	0.012	-0.055	-0.551	0.583	0.594	1.685
Social mobility (X_8)	-0.392	0.268	-0.190	-1.462	0.148	0.351	2.846
Communication exposure (X_9)	0.510	0.199	0.301	2.559	0.013**	0.428	2.336
Training received (X_{10})	0.837	0.205	0.391	4.079	0.000***	0.644	1.553
N= 80, R^2 = 0.592, Adjusted R^2 = 0.533, F value = 10.0							

Note. * = p< 0.10; ** = p< 0.05; *** = p< 0.01

The use of artificial feed in catfish culture is something that fish farmers who are exposed to a lot of communication sources are quite knowledgeable about, indicating that if communication exposure changes by 1 unit (one number) then the knowledge by 0.510. Farmers with communication exposure often have the chance to learn about utilizing artificial feed for catfish culture since this creates more opportunities to get in touch with the information sources. Ali (2012) [1] and Farhad (2003) [22] also found similarities. Results also indicated that farmers with more training are

more knowledgeable about using artificial feed in catfish culture, indicating that if training received score changes by 1 unit (one number) then the knowledge changes by 0.837. Findings showed that farmers' increased exposure to training had a substantial positive impact on the management of feed in catfish culture. Similar results were also discovered by Zinia (2010) [55], Hossain (2008) [27].

3.4.2 Step-wise multiple linear regression analysis

To investigate the contributions of each of the major variables in explaining variation in fish farmers' knowledge of using artificial feed for catfish culture, step-wise multiple linear regression analysis was conducted and presented in Table 7.

Table 7: Summary of the step-wise multiple regression analysis

Models	Multiple R	Multiple R^2	Variation explained (percent)	Significance level
Constant + X_9	0.606	0.367	36.7	0.000
Constant + X_9 + X_{10}	0.683	0.467	10.0	0.000
Constant + X_9 + X_{10} + X_2	0.721	0.520	5.3	0.005

As shown in Table 7, the findings of the multiple linear regression analysis revealed that three explanatory variables, such as communication exposure (X_9), training received (X_{10}), and formal education (X_2) were found as significant determinants in predicting their knowledge about using artificial feed in catfish culture.

As per multiple regressions analysis among the three variables, communication exposure contributed 36.7% in predicting their knowledgeable about using artificial feed in catfish culture, while training received and formal education of the fish farmers contributed 10%, and 5.3%, respectively.

The results revealed that communication exposure, training received, and formal education of the fish farmers' improve their knowledgeable about using artificial feed in catfish culture. This may be because these three elements give fish farmers a broader perspective on knowing about and developing their expertise in using artificial feed in catfish culture.

3.5 Problems with Artificial Feed Used in Catfish Culture as faced by Fish Farmers

Fish farmers faced different types of problems while using artificial feed for catfish culture. Figure 2 illustrates the problems respondents experienced while using artificial feed for catfish culture. According to the results, 56.3% of respondents had a medium level of problem, followed by 42.5% who had a low level, and 1.3% who had a high level problem. The problems were ranked according to the problem-facing index (PFI), and they were then listed in Table 8.

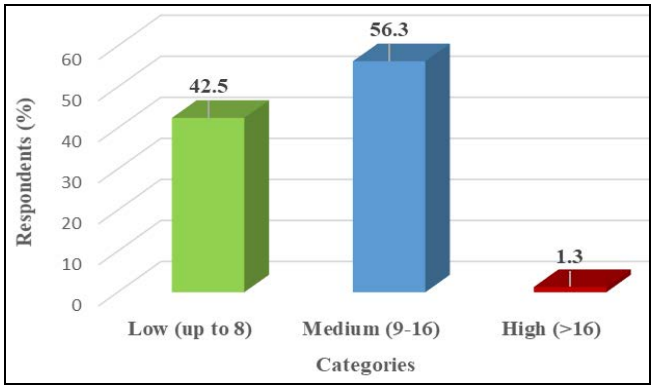

Fig 2: Distribution of catfish farmers based on their respective problems (n = 80)

According to Table 8's findings, the respondents rated the high cost of artificial fish feed as the greatest problem, scoring it at 90 on the problem-facing index (PFI). Similar conclusions were reached by Bak and Yücel (2017) [4], Das *et al.* (2018) [13], and Uddin *et al.* (2022) [50]. There were 56 respondents who faced this problem to a high extent out of 80 respondents and 24 respondents faced the same problem to a medium extent.

Table 8: Problem facing index of the fish farmers on using artificial feed

Problems	Extent of problem				PFI	RO
	High (3)	Medium (2)	Low (1)	Not at all (0)		
High cost of artificial fish feed	56	24	0	0	90	1
Inaccessibility of good quality fish feed	0	30	40	10	41.67	2
Poor access to market	0	2	27	51	12.92	8
Inaccessibility of feed industries	0	7	25	48	16.25	7
Artificial fish feed causes of environmental pollution in water body	2	17	50	11	37.50	4
Artificial feed degrades the quality of the soil	0	20	34	26	30.83	6
Lack of technical knowledge on feed application method	2	16	44	18	34.17	5
Lack of proper training	2	27	37	14	40.42	3

The inaccessibility of good-quality fish feed was the respondents' second major problem, receiving a PFI score of 41.67. The study's findings showed that 30 had a medium level of problem, 40 had a low level of trouble and 10 respondents had no problem at all. This finding supports Syeead *et al.* (2018) [49] findings, which revealed that Farmers occasionally use subpar feed produced by certain feed manufacturers. Third-ranked problem with a PFI score of 40.42 was lack of proper training. Due to inadequate training, farmers may have had little knowledge of using artificial feed for catfish culture. Rana *et al.* (2022) [39] and Uddin *et al.* (2022) [50] also found similar findings.

There were also various problems associated with knowledge of using artificial feed for catfish culture, such as lack of technical knowledge on feed application method, artificial feed degrades the quality of the soil, inaccessibility of feed industries, and poor access to market.

4. Conclusion

One of the most significant economic sectors in Bangladesh today is fisheries. Because of Bangladesh's ever-growing population, the need for fish is rising daily. Knowing on using artificial feed for catfish culture plays a crucial part in enhancing catfish production by guiding farmers in choosing the right artificial feed to use. The study's analyses showed that most fish farmers had medium to high levels of knowledge and that very few had low levels of knowledge about using artificial feed for catfish culture. Formal education, fish farming experience, farm size, annual income, social mobility, communication exposure and training received of the respondents all significantly correlated positively with their knowledge on using artificial feed for catfish culture. Among the correlated variables, formal education, communication exposure, and training received were the best predictors to the total explained variation of 53 percent. Additionally, it was determined that the main problems faced by the fish farmers were the high cost of fish feed, inaccessibility of good quality fish feed, and lack of proper training. Therefore, it can be said that the aforementioned issues may be the causes of farmers' lack of knowledge regarding the use of artificial feed in catfish culture. As a result, the current study provides the relevant authority with a window of opportunity to act on the issues that have been discovered. In connection to these issues, development agencies such as Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, Bangladesh Fisheries Research Institute (BFRI), relevant NGOs and other private organizations, should take necessary action like regular need based training, method demonstration, result demonstration, field day and other extension activities to increase the fish farmers' knowledge. Alongside each other, relevant organizations should take the required actions to educate fish farmers about the use of artificial feed through the media, group discussions, and individual approaches. Additionally, the government needs to assure that quality fish feed and fertilizer subsidies are accessible and available locally. The market for feed and fertilizer must be regularly monitored by the relevant government.

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