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Farmer perspectives on desired catfish attributes in aquaculture systems in Nigeria. An exploratory focus group study

Timothy Manyise[a,*], Rose K. Basiita[b], Catherine M. Mwema[b], Olutokunbo Oyesola[f], Sunil Siriwardena[c], Bernadette Fregene[c], Steven M. Cole[e], Eric B. Dompreh[a], Rodolfo Dam Lam[a], Denise L. Lozano[a], Cristiano M. Rossignoli[a,d], John A.H. Benzie[a]

[a] WorldFish, Penang, Malaysia
[b] WorldFish, Zambia Office, Lusaka, Zambia
[c] WorldFish, Nigeria office, Ibadan, Nigeria
[d] Institute for Future Initiatives, University of Tokyo, Japan
[e] International Institute of Tropical Agriculture, Ibadan, Nigeria
[f] University of Ibadan, Ibadan, Nigeria

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ABSTRACT

As a first step to determine the focus of potential genetic improvement programs for African catfish in Nigeria, we conducted a study to identify the preferred attributes among catfish producers across three states renowned for aquaculture production, in December 2022. Employing a qualitative approach, data were collected through 11 focus group discussions involving 123 participants. The findings indicate that farmers prioritize a range of catfish attributes related to both consumption and production. The top five production-related attributes identified by farmers include stress tolerance, disease resistance, fast growth, robustness, and high survival rates. For consumption-related attributes, preferences were for large, long, heavy catfish, with abundant flesh and thickness. Notably, the prioritization of these attributes varied among catfish farmers both between and within states, reflecting diverse farming objectives and market dynamics. Future research is essential to define precise objectives and scope for selective breeding program design, considering the investment necessary for the success of such programs and how they can accommodate the diverse preferences identified.

1. Introduction

The growing demand for healthy and nutritious diets, driven by a fast-growing population, a rise in incomes, and the increasing appreciation for nutrition-benefits of fish consumption, calls for accelerated aquatic food system transformation and resilience (Béné et al., 2015; Cai and Leung, 2017; FAO, 2022; Rossignoli et al., 2023). This is particularly pertinent in sub–Saharan Africa (SSA) where the growth of aquaculture is severely threatened by the negative effects of climate change, such as the increasing rainfall variability, extreme temperature fluctuations, and other climatic-related shocks (Kobayashi et al., 2015; Tran et al., 2019). Production of farmed fish species in SSA accounts for <1% of global aquaculture production (Ragasa et al., 2022), yet about 200 million people in the region rely heavily on fish for the supply of vital nutrients (FAO, 2016), and the demand for fish and aquatic foods is projected to grow at a rate of 30% from 2020 to 2050 (Enahoro et al., 2021).This growing demand for fish requires investments in species that are not only productive and efficient (Henriksson et al., 2021) but also adaptable to the environment and affordable for farmers and consumers.

Nigeria stands as a prominent figure in Sub-Saharan Africa (SSA), making substantial contributions to the aquaculture sector (Subasinghe et al., 2021). The country is the largest aquaculture producer within SSA, ranking second in Africa after Egypt, with an annual production of approximately 260,000 metric tons (MT) of farmed fish (FAO, 2020). Remarkably, Nigeria distinguishes itself globally as the leading producer of catfish, which accounts about 64% of its total fish production (Yakubu et al., 2022). Research highlights *Clarias gariepinus*, *Heterobranchus bidorsalis*, the hybrid *Clarias* × *Heterobranchus* ('*Heteroclarias*'), and *Clarias nigrodigitatus* as key species within the Nigerian aquaculture subsector, with *Clarias gariepinus* and *Heterobranchus bidorsalis* emerging as the predominant farmed species (Adewumi and Olaleye, 2011).

Despite being the top producer of catfish, Nigeria is faces significant

* Corresponding author.
E-mail address: t.manyise@cgiar.org (T. Manyise).

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obstacles in bridging the demand-supply gap in its fishery market. The demand for catfish is particularly high, serving as a vital protein source for many low-income households (Dauda et al., 2018). The country's annual fish demand is estimated at 3.6 million metric tonnes, yet domestic production scarcely reaches about one million tonnes. To address this gap, Nigeria imports approximately 2.5 million tonnes of frozen fish each year. This heavy reliance on imports highlights the urgent need for aquaculture expansion and enhancement in the performance of commonly farmed species.

Genetic improvement of farmed fish species in other parts of the world demonstrates that the benefits from selective breeding in aquaculture are multiple (Dey et al., 2010; Nguyen, 2016). These improvements contribute significantly to the sustainability (social, economic, and environmental) of aquaculture systems (Rossignoli et al., 2023). For instance, the selective breeding of carp species across many Asian countries has shown substantially improved growth performance, ranging between 20 and 40%, along with higher benefit-to-cost ratios (Ponzoni et al., 2008). Selectively bred rohu (*Labeo rohita*) displayed 35 to 39% higher growth rate than the unimproved rohu in a range of farming environments in Bangladesh (Hamilton et al., 2022). Similarly, genetically improved tilapia strains demonstrated to be more productive and profitable than other strains under both monoculture and polyculture systems in Bangladesh (Tran et al., 2021). A study by Imron et al. (2020) in Indonesia suggests that the selective fish breeding programs yields greater gains for local catfish farmers. Improved catfish demonstrated better performance in terms of growth rate, feed efficiency, survival rate, productivity, and growing period. Additionally, Besson et al. (2016) highlighted the positive environmental and profitability impacts of genetic improvement in the growth rate and feed conversion ratio of African catfish. Growing evidence also suggests that selective breeding in aquaculture has the potential to alleviate poverty in many developing countries (Asian Development Bank., 2005; Yosef, 2010).

Despite the evidence highlighting selective breeding of farmed fish species as a key component of strategies to improve aquaculture sustainability and boost fish supply in developing countries, successful adoption will depend on the extent to which the improved breeds are valued by end users (Kumar et al., 2018; Mehar et al., 2022). Evidence shows that technologies that are user-oriented are better adopted (Obiero et al., 2019; Olaoye et al., 2016). Yet, detailed studies of fish trait preferences in SSA are still rare, particularly in relation to specific market segments (Mehar et al., 2022). Only a few studies have explored fish attributes preferences among fish farmers in SSA, including Nigeria. To maximize the gains from costly and often time-consuming selective breeding programs, it is therefore necessary to first understand existing practices and fish attributes preferences.

This paper reports the findings of a study undertaken to understand the preferences for catfish attributes in Nigeria, aiming to provide insights for designing future catfish genetic improvement programs. Employing an exploratory approach, this research utilized qualitative methods, specifically focus group discussions (FGDs), to investigate existing catfish farming practices, identify the attributes of catfish valued by producers, and understand the rationale behind these preferences.

2. Methods

2.1. Description of the study area

The study was conducted in three well-known aquaculture producing states in Nigeria: Oyo, Ogun, and Delta States (Kaleem and Bio Singou Sabi, 2021; Subasinghe et al., 2021) (Fig. 1). Ogun state covers an area of 16,980 km^2. The state is predominantly rainforest climate, receiving an annual rainfall between 1400 mm to 1500 mm, with relatively high temperatures averaging 30 °C (Oluwatimilehin and Ayanlade, 2021). Oyo is an inland state covering a total of 28,454 km^2. The climate in Oyo is largely equatorial, receiving annual rainfall of about 1050 mm to 1350 mm, with high average temperature of about 26 °C making it suitable for fish farming and crop cultivation activities

Fig. 1. Map of Nigeria showing location of the study (blue shaded region). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

(Awoyemi et al., 2003). Delta State covers about 16,842 km^2. The state experiences varying annual rainfall, ranging from approximately 4500 mm along the coast to about 1500 mm in the northern part. The average temperature in the region ranges between 24 °C and 34 °C (Balogun and Onokerhoraye, 2022). Additionally, the state heavily relies on agriculture and fisheries as its primary economic activities, engaging >60% of the working population (CPED), 2019).

3. Study design, participant selection and data collection

The FGD design in the form of a Nominal Group Technique (NGT) was considered appropriate to explore farming practices and the catfish attributes preferred by farmers due to the exploratory nature of our inquiry (Cyr, 2016). Given the limited structured knowledge pertaining to catfish attributes preferences in Nigeria, FGDs allowed to explore the subject in-depth, generating new insights about the predominant fish attribute preferences in the studied areas (Saidi et al., 2022). The social dimension of FGDs facilitates participant interactions and the exchange of thoughts and opinions, as compared to individual interviews providing a shared understanding of farmers' preferences and the underlying reasons (Barlagne et al., 2017).

The first step involved generating semi-structured questions for the focus group discussion. Following previous fish preference studies in other countries (Mehar et al., 2020), we organized the questions into two main categories: one on the catfish species farmed within the study regions, and another on the attributes valued by farmers and their reasons for these preferences. To address the potential influence of group dynamics in FGDs, where some participants might dominate the conversation while others may hesitate to share their opinions (Morgan, 2020), sessions also collected individual levels of agreement on each identified attribute (Cyr, 2016). After group discussion, participants individually rated their agreement on issues discussed. The discussion guide was validated by key informants within the study context and international aquaculture researchers. The FGD design process is summarised in Fig. 2.

3.1. Selection of participants

Participants in the FGDs were active catfish producers (grow-out, hatchery or both) and were selected from all the agricultural zones within each state. Selection of these participants was in consultation with representatives of fish farmer clusters (refer to Table 1 for a description of the selected participants). The number of FGDs conducted in each state was guided by the principle of data saturation; that is, FGDs were ceased when additional discussions no longer yielded new insights into the identified themes FGD (Hennink and Kaiser, 2022). In total, 11 FGDs were held (Ogun (4), Oyo (4), and Delta (3), involving 122 participants, with group sizes maintained at 8–12 participants to give room for all participants to share their perspectives. Ethics approval for this study was obtained from the National Health Research Committee of Nigeria with the approval code NHREC/01/01/2007–22/12/2022. The study ensured that participation was voluntarily, participants were adequately informed, and their responses were anonymized and treated with confidentiality.

3.2. Conducting focus group discussions

A pilot test was conducted with a group of 10 farmers to assess the practicality and feasibility of the FGD design and logistics. Feedback from pilot participants informed adjustments to the wording and structure of the discussion guide, enhancing its clarity and effectiveness in eliciting the required information from participants (Larson et al., 2023). Six facilitators received two days of training on the study's objectives and methodology prior to conducting the FGDs. These facilitators brought previous experience in leading FGDs on various aquaculture-related topics in comparable contexts. In the discussions, the lead facilitator served as the moderator, ensuring a consistent flow of the conversation, and reducing interviewer bias. A second facilitator was responsible for documenting the topics and participant views on flip charts. The third facilitator managed logistics and the material availability, tasks that included audio recording and providing scoring cards.

Prior to commencing each FGD, participants were briefed on the study's objectives and the conditions for participation, following which consent was obtained for recording the sessions. The discussions were guided by semi-structured questions, allowing for the exploration of identified themes while maintaining flexibility (Breen, 2006). The moderator ensured a consistent flow of the discussions across all FGDs, transitioning from the status of farmed catfish species to the catfish attributes valued by farmers. Upon discussing each topic and its subtopics, participants were presented with a summary of points discussed. They

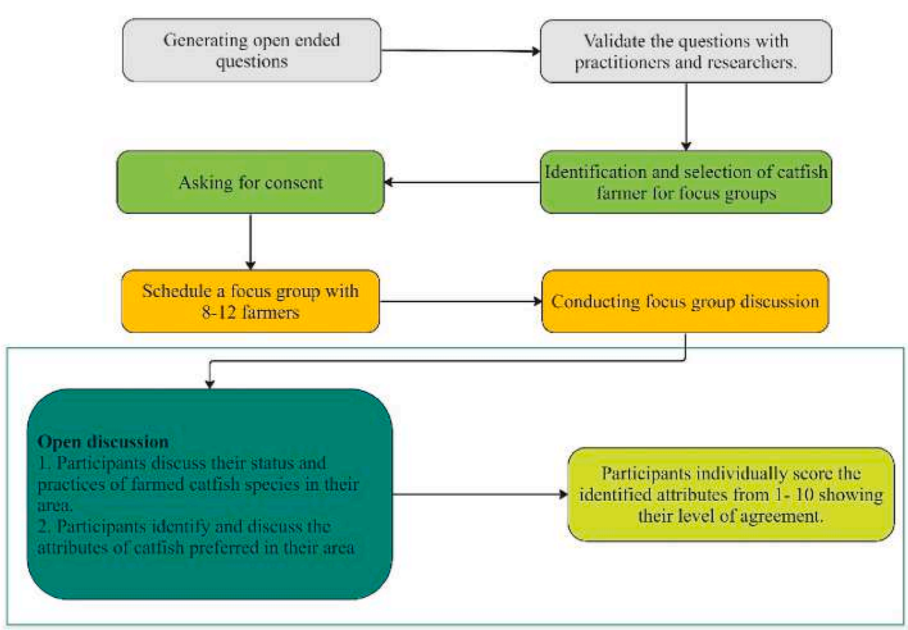

Fig. 2. The focus group design process.

Table 1
Characteristics of focus group discussion participants.

State	FGD	N	Sex		Age			Years of experience		Type of farmer		
			Male	Female	20–39	40–59	>60	<5 years	>5 years	Hatchery	Grow-out	Both
Oyo	1	11	54.5	45.5	36.4	54.5	9.1	18.2	81.8	27.3	63.6	9.1
	2	11	81.8	18.2	72.7	27.3	–	9.1	90.9	27.3	63.6	9.1
	3	12	100.0	–	16.7	50.0	33.3	–	100.0		100.0	–
	4	12	91.7	8.3	25.0	75.0	–	25.0	75.0	8.3	75.0	16.7-
Ogun	5	12	75.0	25	16.7	75.0	8.3	–	100.0	75.0	–	25.0
	6	10	80.0	20	50.0	50.0	–	30.0	70.0	–	–	100.0
	7	11	63.6	36.4	54.5	45.5	–	54.5	45.5	–	63.6	36.4
	8	9	77.8	22.2	55.6	44.4	–	33.3	66.7	–	100.0	–
Delta	9	12	83.3	16.7	66.7	33.3	–	25.0	75.0	41.7	58.3	–
	10	11	81.8	18.2	27.3	45.5	27.3	18.2	81.8	81.8	–	18.2
	11	12	66.7	33.3	33.3	50.0	16.7	8.3	91.7	41.7	33.3	25.0
Total count	11	123	96	27	50	62	11	24	99	35	62	26
Percentage		100	**78.0**	**22.0**	**40.7**	**50.4**	**8.9**	**19.5**	**80.5**	**30.1**	**50.4**	**19.5**

Values are percentages of total participants within FGD.

then used scorecards to express their personal agreement levels on a Likert scale, ranging from 1 (complete disagreement) to 10 (complete agreement) (Tastle and Wierman, 2007). Each FGD session lasted about 120 min.

3.3. Data analysis

To gain qualitative insights into catfish farming practices and the desired attributes of catfish as perceived by the participants, we conducted a thematic content analysis. FGD recordings were fully transcribed; for discussions in local languages, translations into English were provided by a language expert. We utilized the qualitative data analysis software, ATLAS.ti, for the systematic organization and analysis of the textual data. The data was uploaded into the software, and a theoretically informed code book was developed by consulting existing literature on farming practices and fish attribute preferences. Transcripts were thoroughly reviewed multiple times to ensure comprehensive understanding of the content. During the review process, codes were assigned to segments of the text corresponding to each category in the codebook. Additionally, new codes we inductively generated as new themes emerged from the data (Vila-Henninger et al., 2022). For instance, to grasp the reasons behind attribute preferences, we focused on the actual words used by the participants and formulated new codes accordingly. Through an iterative process of reviewing and refining, we identified four main themes: current practices and status in catfish farming, preferred production-related attributes, preferred consumption related attributes and the reasons behind attribute preferences. Subsequent to theme identification, we selected illustrative quotes from the discussions for each theme (Erlingsson and Brysiewicz, 2017).

To determine the ranking of preferred attributes, we computed the average scores for each catfish attribute from participants' Likert responses in each FGD (refer to Tables 1a-e, Tables 2a-c, in appendix). Subsequently, we aggregated the average scores within each state to determine the hierarchical ranking of attributes. Attributes receiving the highest total mean scores were assigned the first rank, followed in descending order by attributes with lower mean scores. Additionally, we calculated the consensus for each discussed attribute to gauge the extent of group agreement or disagreement on each attribute (detailed results presented in the appendix). Although various methodologies are available for consensus analysis, this study utilized the approach recommended by Tastle and Wierman (2007). This method involves taking a histogram or probability distribution over a discrete set of choices with ordinal values and producing a singular value on a scale ranging from 0 (indicating lack of consensus or disagreement) to 1 (indicating complete consensus). Consensus was calculated using the following formula in Microsoft Excel:

$$Cns(\mathrm{X}) = 1 + \sum\nolimits_{i=1}^{n} \rho_i log_2 \left(1 \frac{|X_i - \mu_x|}{d_x}\right)$$

Where ρ_i is the probability (relative frequency) of outcome Xi (which ranges from 1 to 10), μ_x is the mean score of X, and d_x is the width of X calculated as $X_{max} - X_{min}$ (Tastle and Wierman, 2007).

4. Results

4.1. Status and practices in catfish aquaculture

Farmers in the regions studied predominantly used earthen ponds for catfish farming, with a smaller proportion utilizing concrete tanks, plastic tanks, and tarpaulin ponds. The FGDs revealed variations in farming systems across regions, encompassing differences in the predominant catfish species farmed, levels of production intensity, and specific challenges, as detailed in Table 2.

African Catfish (*Clarias gariepinus*) was the predominant fish species cultured by farmers in all the three states. Notably, variations were observed: the majority of farmers in Ogun and Oyo specialized in producing hybrids of *Clarias gariepinus* and *Heterobranchus bidorsalis*,

Table 2
Current practices and status of farmed catfish species.

	Ogun	Oyo	Delta
Facilities			
Earthen ponds	√√√	√√√	√√√
Plastic tanks	√√	√√	√√
Tarpaulin	√√	√	√
Plastic tanks	√	√	√
Prevalence of farmed catfish species			
Heterobranchus bidorsalis	√√	√	√
Clarias gariepinus	√√√	√√√	√√√
Hybrid (*Heterobranchus* x *Clarias gariepinus*)	√√√	√√√	√
Prevalence of production systems			
Intensive production systems	√√	√√	√√√
Semi-intensive production systems	√√	√√	√
Extensive production systems	√	√	√
Farmed catfish challenges			
High mortality rate	√	√√	√√√
Prone to diseases	√√	√√√	√√
Taking time to grow	√	√	√√
Slow-growing fish	√	√	√√
Low fish weight	√	√	√
Small-sized fish	√	√	√

√√√ = High, √√ = medium, √ = low.

whereas the farming of hybrids among farmers in Delta was limited. Furthermore, a moderate proportion of farmers in Ogun state were reported to culture *Heterobranchus bidorsalis* in their fish farming, a practice less common in the other states.

Regarding production intensity, the majority of farmers in Delta employed intensive production systems, characterized by high stocking densities in ponds, typically in monoculture settings, accompanied by high input usage. Conversely, farmers in Ogun and Oyo utilized a mix of intensive and semi-intensive production systems. These systems included both polyculture and monoculture practices, with moderate stocking densities and moderate input usage. Additionally, a small subset of farmers across all three states engaged in extensive production, characterized by polyculture in earthen ponds, low stocking densities, and minimal application of inputs.

Major challenges reported by the discussants across the studied states were the high mortality rate, poor fish growth, low weight gain, disease outbreaks, extreme temperatures, floods, and pests. Common disease symptoms reported encompassed fin rot, mouth rot, skin peeling and swollen belly. The issue of mortality was universally noted by farmers in all states but was particularly emphasized in Delta, followed by Oyo, and was least pronounced in Ogun, as detailed in Table 2. Notably, *Heterobranchus bidorsalis* was reported to exhibit slower growth rates compared to *Clarias gariepinus* and their hybrids. Furthermore, across the investigated regions, farmers reported that the size and weight of their farmed catfish fell short of their ideal targets.

4.2. Preferred production-related catfish attributes

Farmers preferred catfish exhibiting high productivity, characterized by attributes such as stress tolerance, disease resistance, survival rate, growth rate, robustness (i.e., overall healthy, strength, and resilience), feed efficiency, growing period, and body ruggedness (less prone to injuries) (Table 3). In all three states, FGDs revealed that the top five attributes highly valued by farmers were high stress tolerance, high disease resistance, high survival rate, a robust body, and fast growth. Other attributes that were valued, albeit to a lesser extent, encompassed high feed efficiency, shorter growing period, body ruggedness, and large fingerlings. Nevertheless, the priority assigned to these attributes varied by state. For instance, in Ogun, attributes such as high stress tolerance, high disease resistance, high survival rate, and fast growth were deemed equally critical, receiving the highest average scores. Conversely, in Oyo and Delta, the highest ratings were given to high survival rate and rapid growth, respectively. The ranking of these top five attributes also differed between Oyo and Delta. Moreover, while Ogun and Oyo shared similar rankings for the secondary attributes, Delta showed a distinct preference, valuing body ruggedness over robustness.

Participants articulated several reasons for valuing both primary and secondary attributes in their catfish aquaculture. Key among these is the necessity to counteract the impacts of environmental stressors like extreme water temperatures and suboptimal water quality, leading farmers to prioritize catfish varieties with high stress tolerance and survival rates. These attributes consistently ranked among the top five in all three states, as depicted in Table 3. The FGDs revealed that the extreme environmental fluctuations, propelled by climate variability in Nigeria, expose fish to a range of stressors including variable water temperatures, poor water quality, and frequent disease outbreaks, underscoring the need for stress-tolerant catfish. One participant highlighted, "*Our challenge here involves fluctuating temperatures and floods, putting fish under significant stress. As farmers, cultivating catfish that exhibit higher stress tolerance is crucial for minimizing losses*" [FGD 7, Oyo]. Opting for species that can endure these stressors effectively reduces mortality risks. Farmers acknowledged that fish with the capacity to withstand and adapt to stressful conditions are more likely to survive and thrive under diverse environmental conditions. This aligns with the farmers' preference for catfish demonstrating a high survival rate. Participants indicated that high survival rate diminishes loss risks and guarantees a greater yield suitable for the market. This perspective was succinctly expressed in Ogun: "*We desire fish species that exhibit a high survival rate. If we, as farmers, can have fingerlings or catfish with low mortality rate, our operations would be more profitable. Currently, many farmers throughout Ogun* [State] *face substantial losses due to high mortality rates in their farming*" (FGD 3, Ogun).

Our findings also highlighted that farmers prioritize disease-resistant catfish to mitigate the risk of disease outbreaks and the associated economic losses stemming from treatment expenses and reduced productivity. As articulated by participants in an FGD from Ogun: "*In Nigeria, we experience too many fish diseases. These diseases cause fin rot, skin ulceration, swollen belly, and various other symptoms. Given these challenges, we prefer species that are resistant to diseases*" [FGD, 2]. This preference was consistently ranked among the top three attributes across all three states, as demonstrated in Table 3.

Additionally, participants across all the FGDs, unanimously highlighted the importance of selecting catfish strains with rapid growth rates to boost production efficiency and optimize resource utilization. A participant stated, "*We prefer fast-growing catfish, such as hybrids that mature quicker than other local species. These hybrids are more economical to raise, reaching market size in fewer months* [FGD 8, Oyo]." This shared perspective among farmers suggests that rapid growth not only accelerates returns on investment but also conserves resources, lowers production expenses, and enhances farm profitability.

Furthermore, while attributes such as feed efficiency, shorter growing period, rugged bodies, and large fingerling sizes have received rankings, they were still considered significant by farmers. For example, feed efficiency consistently emerged as the sixth most preferred catfish attribute in all three states, highlighting its importance to farmers. The value placed on feed efficiency is linked to its potential to reduce production costs. A participant from Ogun explained, "*We* [farmers in Ogun] *prefer catfish that are feed efficient; for example, Clarias gariepinus shows good response to feed, thereby boosting our productivity… As farmers, our aim is to be profitable, and as you are aware, feed represents one of the*

Table 3
Ranking of preferred production-related attributes of catfish by farmers.

State	Ogun		Oyo		Delta	
Preferred Attributes	Sum of averages scores	Rank	Sum of averages scores	Rank	Sum of averages scores	Rank
High survival rate	40.00	1	39.50	1	27.72	3
Stress tolerant	40.00	1	39.41	2	27.65	4
Disease resistant	40.00	1	38.67	3	28.19	2
Fast growing	40.00	1	37.34	4	28.28	1
Robustness	38.96	5	35.99	5	27.44	5
Feed efficiency	37.47	6	35.17	6	26.43	6
Early maturation	36.48	7	31.75	7	23.70	8
Rugged body	30.35	9	28.01	8	24.82	7
Fingerling size	34.12	8	25.14	9	23.37	9

The sum of average scores vales are the total of the average scores of from focus groups in each state. Rank is based on the descending order of the sum of average scores. Highlighted (grey) boxes show the top five attributes in each state.

biggest challenges in Nigerian aquaculture (FGD 1, Ogun)." These observations emphasize that since feed accounts for a major portion of catfish farming expenses, choosing feed-efficient catfish allows farmers to achieve more efficient results with lower feed input, directly contributing to improved overall farm profitability.

Similarly, the length of the growing period, although ranked lower, was underscored by participants for several reasons, including the aim for higher production efficiency, the preference for a shorter production cycle, and the need to satisfy market demand, highlighting its importance to farmers. Selecting fish with shorter growing periods enables farmers to decrease the time needed for fish to reach market size. A shorter growing period leads to reduced feed and resource consumption, thereby lowering production costs and enhancing the ability to quickly adapt to market demands and changes in consumer preferences. One participant from Oyo stated, "*We prefer to produce fish that mature in shorter periods. This reduces our production costs, and we can fulfil the increasing demand for fish in this region*" [FGD 7, Oyo]. Furthermore, by cultivating catfish that mature faster, farmers can optimize the use of pond facilities and undertake more production cycles, especially pertinent for those operating a limited number of ponds. As noted in Ogun, "*The majority of farmers here manage fewer than five ponds. If we cultivate catfish that require a year to reach harvest size, our production would be limited. By raising catfish with a shorter growing period, we can conduct more production cycles annually, thereby enhancing pond productivity*" [FGD 2, Ogun]. Additionally, a shortened production cycle affords farmers the benefit of mitigating exposure to various environmental and disease risks. This point was accentuated by a participant in Ogun, "*Growing catfish with a shorter growing period allows us to face fewer issues with diseases and avoid certain times of the year, like December, when we experience sudden temperature changes*" [FGD 3, Ogun]. All these multifaceted advantages explain why farmers preferred fast-growing catfish.

4.3. Preferred consumption-related catfish attributes

Farmers also value fish in alignment with consumer preferences within their regions. Consumption-related characteristics identified encompass body weight, shape, size, fleshiness, thickness, head size, body fat content, and skin colour. Although these attributes significantly influence farmers' selection of catfish, the findings presented in Appendix Table 2a-e reveal both shared preferences and distinct variations in the emphasis placed on these attributes across different states. In all three states farmers consistently identified catfish that are heavy, larger, elongated, flesh-rich, and thick-bodied as the top five desirable attributes. Nevertheless, the precise ranking order, based on the aggregated average scores, differed between states. In Ogun and Oyo, the attribute of body weight emerged as the foremost preference, whereas in Delta, the preference shifted towards larger body size as the primary attribute. Additionally, the rankings of other attributes exhibited variability. For example, in Ogun and Delta, FGDs accorded a higher preference to elongated bodies as the third most favoured attribute, in contrast to Oyo, where larger body size was ranked third. Likewise, preferences for attributes such as freshness and body thickness showed discrepancies between FGDs conducted in Ogun and those in Oyo and Delta.

Delving into the specifics of each attribute and the underlying reasons for their preference, FGDs consistently revealed farmers prefer catfish that attain higher weights. Regarding preferred harvest weight, it was found that these preferences vary based on market dynamics, consumer preferences, and specific farming objectives. In general, farmers aim to culture catfish that can achieve higher weights, with FGDs revealing that heavier catfish command higher prices in the market and are more sought after by consumers. By aligning with market preferences, farmers can enhance their profitability. As noted by participants in Delta, "*We aim to produce larger fish, typically ranging from 1 to 1.5 kg. Although it requires a longer time to reach harvest weight, there is a consistent market demand for them. We sell this size more frequently than others. However, we avoid producing excessively large fish as it escalates our production costs*" (FGD 10, Delta). While there is a general inclination towards cultivating heavier catfish, the preference for melange size catfish (weighing between 200 g to 500 g) was also noted, particularly in regions like Ogun and Delta, albeit ranked lower compared to other identified attributes. Participants in these FGDs mentioned that some farmers prefer melange size fish due to the reduced time required to reach marketable size, facilitating quicker returns on investment. An FGD participant in Ogun shared, "*We also have a preference for producing melange-size fish because they attain market size quicker*." Another added, "*This quicker turnaround is vital for our livelihoods, allowing us to realize our investment returns sooner*" [FGD 3, Ogun].

Table 4
Ranking of preferred consumption-related attributes of catfish by farmers.

State	Ogun		Oyo		Delta	
Attributes	Sum of averages scores	Rank	Sum of averages scores	Rank	Sum of averages scores	Rank
Heavy catfish	37.58	1	38.50	1	26.09	2
Large body	37.47	2	35.16	3	27.86	1
Long body	37.27	3	38.18	2	25.65	3
Fleshy	33.93	5	34.42	5	25.32	4
Thick catfish	36.27	4	35.22	4	24.82	5
Big head	33.82	6	32.58	6	24.34	6
Low-body fat	31.58	7	31.94	7	22.90	7
Dark skin colour	28.25	8	30.91	8	22.16	8
Small-size fish	24.21	9	10.34	9	20.62	9

The sum of average scores vales are the total of the average scores of from focus groups in each state. Rank is based on the descending order of the sum of average scores. Highlighted (grey) boxes show the top five attributes in each state.

Regarding body size and length, farmers exhibit a preference for cultivating catfish that attain large body sizes. This preference is underpinned by the perception, as consistently reported across the FGDs, that large-bodied catfish command higher market prices than their smaller counterparts. This sentiment was uniformly echoed in the discussions, as articulated by one participant: "*The majority of farmers in this region prefer catfish with a larger body. This size yields higher prices and is appealing to most of our customers*" [FGD 9, Delta]. Additionally, market demand influences farmers in the studied regions to favour the cultivation of catfish with elongated bodies. This preference was consistently highlighted across all FGDs. For instance, farmers in Ogun expressed their perspective: "*Farmers in this area prefer catfish that grow larger and longer…Our customers prefer long fish so that they can cut it into more pieces*" [FGD 3, Ogun].

In addition, the findings indicated that farmers value catfish with a fleshier body compared to lean-bodied catfish. As one participant expressed, "*We like to culture catfish that are fleshier. It is like soft meat*" [FGD 5, Oyo]. Concurrently, participants also highlighted a preference among farmers for catfish with thicker body as opposed to slim ones: *"Many farmers here like catfish that are thick-bodied. This thick-bodied catfish has more meat, and our customers are willing to pay more for it"* [FGD 7, Oyo].

Consistently, across all states, certain attributes were ranked lower: dark skin colour, low body fat, and a large head, in that specific order. It is important to note, however, that despite their lower rankings, these attributes are of significance to farmers, as evidenced by participants expressions (refer to Appendix, Table 2a). Across the regions studied, FGD participants underscored that dark skin colour in catfish attracts buyer attention and interest, potentially increasing demand, and marketability. Conversely, catfish with lighter skin tones were reported to be less favoured by farmers due to consumer preferences. In terms of head size, the discussions uniformly revealed a preference among farmers for culturing catfish with larger heads to meet market demands. The sentiments of these farmers were succinctly captured in the following statement: "*Farmers in this area prefer catfish with a big head, especially the hybrid of Clarias gariepinus and Heterobranchus…We grow for the market, and our customers prefer the big-headed catfish, especially pepper soup customers*" [FGD 9, Delta]. Additionally, the majority of FGDs emphasized that there is a consumer preference for catfish with lower fat content, attributed to health considerations. One participant from Ogun articulated this trend: "*We typically align our production with market demands. Our buyers specifically request fish with lower fat content. Several fish traders have also noted that their customers prefer low-fat fish, as it helps reduce their fat intake and is seen as beneficial for their overall health*" [FGD 1, Ogun].

5. Discussion

Limited research has been conducted on the preferences and expectations regarding fish products among farmers in sub-Saharan Africa (Darko et al., 2016). The present study investigated catfish farming practices, identifying prevalent challenges such as mortality, poor growth performance, and outbreaks of pests and diseases. These observations align with findings from previous research (Wisdom, 2013; Dimelu et al., 2018; Adah et al., 2023; Mukaila et al., 2023). Participants held a general view that the current farmed catfish in Nigeria need to be improved to increase the sustainability of the aquaculture sector. In line with prior research, this study identified attributes related to production and consumption that farmers valued, alongside the underlying reasons for their preferences (Mehar et al., 2020; Rossignoli et al., 2023). Through cross-case and within-case analyses, it was observed that while the prioritization of these attributes varied, the top five attributes remained constant across the regions examined.

First, this study demonstrated that farmers preferred catfish exhibiting superior performance in stress tolerance, survival rate, growth rate, disease resistance, and robustness. These findings are in concordance with prior research, such as the qualitative investigation by Belton et al. (2010) in Vietnam, which highlighted high growth rates, survival rates, and disease resistance as key attributes valued by producers. While existing studies have delved into similar production-related attributes across different fish species (Omasaki et al., 2016; Sae-Lim et al., 2012; Mehar et al., 2020; Mbokane et al., 2022; Manyise et al., 2024), the present research offers valuable insights specifically relevant to catfish farming in Nigeria and Sub-Saharan Africa (SSA), thereby enriching the body of knowledge and guiding future inquiries in this domain.

Expanding the existing body of literature (Mehar et al., 2020; Mbokane et al., 2022, this study corroborates the preference among farmers for catfish that are rapid-growing, disease-resistant, and stress-tolerant. The preference for fast-growing catfish is expected since fast-growing fish reach market size more rapidly, thereby shortening the production cycle and enabling farmers to generate revenue within a shorter period (Besson et al., 2016; Mehar et al., 2020; Mbokane et al., 2022). Similarly, the importance of disease resistance in catfish farming cannot be overstated, as diseases can significantly impact the efficiency and success of aquaculture operations (Kumar and Gaunt, 2020; Mukaila et al., 2023). Farmers recognize the value of selecting catfish that can withstand disease challenges, as it reduces the risk of losses and ensures a higher yield of marketable fish. Moreover, farmers value attributes such as stress tolerance and adaptability. These attributes are crucial in ensuring optimal productivity, especially in aquaculture systems facing extreme environmental fluctuations induced by climate change (Islam et al., 2022; Mugwanya et al., 2022). In Nigeria, as in numerous other countries in SSA, fluctuating climatic conditions subject fish to various stressors, including changes in water temperature and compromised water quality (Reverter et al., 2020). By choosing fast-growing, disease-resistant, and stress-tolerant catfish, farmers aim to lessen the adverse effects of these environmental stressors on fish health and overall farm productivity. Concurrently, these observations also imply that there may be opportunities to enhance management practices to mitigate the challenges identified in catfish aquaculture.

The preference for catfish with shorter growing periods and higher feed efficiency identified in this study aligns with findings from previous research (Ohen et al., 2014; Mehar et al., 2020; Hossain et al., 2022). For instance, the study by Ohen et al. (2014) demonstrated that a reduced growing period is a favoured trait among Nigerian fish farmers when it comes to catfish cultivation. High feed efficiency in fish is desirable as it enables farmers to optimize their feed utilization and reduce production costs (Tran et al., 2021). Drawing from these insights, we contend that attributes related to productivity efficiency are critical within catfish improvement programs, particularly in intensive aquaculture, where space, feed, and water resources need to be carefully managed.

Several investigations have delved into market preferences for fish attributes, yet studies specifically focusing on catfish remain scarce. For example, the research conducted by Ohen et al. (2014) revealed that Nigerian farmers prioritize size, weight, and colour as significant attributes in their catfish farming. Moreover, Russell et al. (2008) found that farmers in Malawi preferred to grow their local African Catfish because of its large size. These findings are important to improve catfish in response to market dynamics. This qualitative investigation enriches the existing literature by uncovering consumption-related attributes of farmed catfish as perceived by Nigerian farmers, thus offering valuable perspectives on the preferences shaping catfish aquaculture in response to market dynamics.

This study revealed that farmers' preferences for catfish attributes are influenced by market dynamics, consumer preferences, and specific farming objectives. Among the various attributes identified (Table 4, section 3.2 large, heavy, fleshy, thick, and long-bodied catfish fish emerged as the top five consumption-related attributes preferred by farmers. These findings align with previous research on fish attributes, which has shown that farmers prefer larger-sized fish. This preference is driven by the perception that larger fish fetch higher prices in the market, thereby enhancing profitability (Green and Engle, 2004; Mehar et al., 2020).

The preferred consumption-related preferences identified in this study corroborate the findings of ALCOM's (1994) which reported that consumers in Swaziland exhibited a preference for catfish with a greater meat yield. Consistent with the observations of Green and Engle (2004), the preference for fleshy catfish among farmers may be attributed to the perception of enhanced meat quality and flavour, as fleshy catfish are often associated with tender and succulent meat. Moreover, our results agree with other studies indicating that the body length of fish significantly influences consumer perceptions and preferences, with a longer body length suggesting a higher meat yield (Mehar et al., 2020).

In addition to the top-ranked attributes identified, this study also highlights the importance of other attributes such as head size, body fat composition, skin colour, and small size fish. Although research on these attributes within the context of catfish farming remains limited, literature pertaining to the broader field of aquaculture suggests that a well-proportioned body shape, characterized by a substantial head size and an appropriate body length, enhances the fish's visual appeal and may be preferred by consumers (Geng et al., 2016). The preference among farmers in the study regions for catfish with larger heads underscores the role of visual aesthetics in the marketability of aquaculture products. Furthermore, despite the recognized health benefits associated with the consumption of fatty fish (Trondsen et al., 2004; Tuomisto and Frøyland, 2008; Tørris, 2016), our findings indicate that some farmers opt to produce catfish with lower fat content to meet their market needs, a choice which is likely driven by the health-conscious preferences of their clientele. Extending the limited research on the significance of fish colour and texture in aquaculture (Mehar et al., 2022), our study demonstrates a preference for catfish with darker skin and a rougher texture over those with lighter skin and a smoother texture.

6. Implications for practice and future research

This study provides critical insights into the attributes of catfish preferred by Nigerian farmers, delineating both production-related and consumption-related attributes. By elucidating these attributes, the study establishes a foundation for more nuanced inquiries into the preferences of catfish producers. While many identified attributes corroborate findings from existing literature, this research underscores the efficacy of FGDs in refining the prioritization of these attributes, particularly in the context of future quantitative analyses. The employment of multiple FGDs across each state facilitated a thorough exploration of both common and divergent perspectives, thereby enhancing the methodological robustness of this approach. As a contribution to the scholarly discourse, this study not only identifies and prioritizes catfish attributes, but also validates a focus group methodology as an effective tool for identifying pertinent preferred attributes. The insights derived from this study are poised to significantly influence subsequent investigations into farmer preferences concerning catfish attributes. An anticipated follow-up study will explore the trade-offs made by farmers among these attributes, thereby deepening our understanding of their preferences.

While our study focused on catfish producers (farmers), we recommend further empirical research in this domain, involving different groups of value chain actors, including men and women, small farmers, and large farmers, etc. Employing alternative methods such as behavioural experimental models could deepen our understanding of catfish attribute preferences in Nigeria and beyond. This could entail conducting choice experiments and discussions on catfish preferences in major catfish-producing states in Nigeria. Moreover, it is important to note that not all catfish attributes identified in this study necessitate genetic improvement interventions. Considering that some preferred attributes and general observations from FGDs may relate to existing management practices, future research should discern which fish attributes could be optimized through enhanced management practices as opposed to genetic improvement. Undertaking such comprehensive studies could offer a more integrated view of the attributes valued by a diverse array of stakeholders within the catfish aquaculture sector. Consequently, this could guide the development of targeted interventions and strategies to boost the overall sustainability of the aquaculture sector in Nigeria and comparable regions across sub-Saharan Africa.

CRediT authorship contribution statement

Timothy Manyise: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Rose K. Basiita:** Conceptualization, Investigation, Project administration. **Catherine M. Mwema:** Conceptualization, Investigation, Validation. **Olutokunbo Oyesola:** Investigation, Project administration, Supervision, Writing – review & editing, Data curation. **Sunil Siriwardena:** Project administration, Resources, Supervision, Validation, Writing – review & editing. **Bernadette Fregene:** Project administration, Supervision, Validation. **Steven M. Cole:** Conceptualization, Funding acquisition, Investigation, Writing – review & editing. **Eric B. Dompreh:** Methodology, Validation, Writing – original draft, Writing – review & editing. **Rodolfo Dam Lam:** Methodology, Validation, Writing – original draft. **Denise L. Lozano:** Methodology, Validation, Writing – original draft. **Cristiano M. Rossignoli:** Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing. **John A.H. Benzie:** Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Declaration of competing 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.

Data availability

All authors have full access to the data reported in the manuscript.

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Appendix A. Appendix

Table 1a. Preferred production-related catfish attributes as perceived by aquaculture producers in Ogun.

	FGD 1		FGD 2		FGD 3		FGD 4		Exemplar quotes
Attributes	Mean (consensus)	Rank	Mean (consensus)	Rank	Mean (consensus)	Rank	Mean (consensus)	Rank	
Stress tolerance	10.00(1.00)	1	10.00(1.00)	1	10.00(1.00)	1	10.00 (1.00)	1	We prefer to produce species that are stress tolerant. Our farming is carried in earthen ponds… We experience temperature fluctuations here, and to reduce mortality and maximize productivity we need to have catfish that can withstand sudden weather changes (FGD 3).
Disease resistance	10.00(1.00)	1	10.00(1.00)	1	10.00(1.00)	1	10.00 (1.00)	1	In Nigeria, we experience too many fish diseases. Some of these [fish] diseases cause fin rot, skin ulceration, swollen belly, and many other symptoms. Because of these [disease] challenges, we prefer species that are resistant to diseases (FGD 2)
Survival rate	10.00(1.00)	1	10.00(1.00)	1	10.00(1.00)	1	10.00 (1.00)	1	We desire fish species that have a high survival rate. If we [farmers] can have fingerlings or catfish species that have low mortality rate, our businesses will be successful. As it is most of the farmers across Ogun [State] complain of high mortality rate in their farming (FGD 4)

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Attributes	FGD 1 Mean (consensus)	FGD 1 Rank	FGD 2 Mean (consensus)	FGD 2 Rank	FGD 3 Mean (consensus)	FGD 3 Rank	FGD 4 Mean (consensus)	FGD 4 Rank	Exemplar quotes
Fast growing	10.00(1.00)	1	10.00(1.00)	1	10.00(1.00)	1	10.00 (1.00)	1	Farmers in Ogun need species like the hybrid catfish which can grow fast. We require catfish with a better growth and performance (FGD 1)
Robustness	9.70(0.93)	5	9.75(0.94)	5	9.73(0.93)	5	9.78(0.94)	5	We need catfish fish that has a robust, hardy, and strong body, can swim fast and actively. We do not like fish with bodies that easily break or bruised (FGD 1).
Feed efficiency	9.10(0.78)	11	9.25(0.83)	7	9.45(0.86)	6	9.67(0.91)	6	We [farmers in Ogun] prefer catfish that are feed efficient, for example, Clarias *[C. grapienus]* respond well to feeding. As farmers we want to make profit, and as you know feed is one of the major challenges in Nigerian aquaculture (FGD 1).
Length of growing period	9.11(0.83)	7	9.25(0.85)	6	8.90(0.84)	7	9.22(0.85)	7	We also prefer catfish species that matures earlier than the once we have. For example, hybrid catfish grows quicker and mature early than the other species. This allows to meet the demands of the market and reduce the cost of production (FGD 3)
Rugged body	7.60(0.63)	9	7.33(0.74)	8	7.64(0.76)	9	7.78(0.77)	9	We like catfish with rugged skin because the tough skin reduces the risk of diseases and parasites attack. There are too many of these [diseases and parasites] problems here. Rugged skin will protect the fish from skin injuries during our routine farm management practices. We can also transport and process them without significant losses in quality (FGD 3).
Large fingerlings	8.40(0.92)	8	8.25(0.91)	9	8.36(0.78)	8	9.11(0.87)	8	Farmers in this area [Ogun] prefer to stock large size catfish fingerlings. We [farmers in Ogun] normally prefer to stock fingerlings above 9 cm long. Larger [catfish] fingerlings have low mortality rate; they respond well to feeding and grow faster compared to smaller -size fingerlings (FGD 4).

Values reported are Likert mean scores ranging from 1 to 10. Values in parentheses are consensus. Rank values are based on the average score of each attribute with lower values means more preferred and higher values means less valued.

Table 1b. Preferred production-related catfish attributes as perceived by aquaculture producers in Oyo.

Attributes	FGD 5 Mean (consensus)	FGD 5 Rank	FGD 6 Mean (consensus)	FGD 6 Rank	FGD 7 Mean (consensus)	FGD 7 Rank	FGD 8 Mean (consensus)	FGD 8 Rank	Exemplar quotes
Stress tolerance	9.75(0.94)	2	9.83(0.96)	4	10.00(1.00)	1	9.83(0.95)	2	Our problem here is fluctuation temperatures and floods which subjects fish to high levels of stress. Farmers need to grow species that can withstand these conditions (FGD 7)
Disease resistance	9.67(0.92)	3	9.83(0.95)	5	9.50(0.90)	3	9.67(0.90)	3	We prefer species which are disease resistant. Diseases destroy the business of many farmers here (FGD 6).
Survival rate	9.83(0.95)	1	10.00(1.00)	1	9.75(0.94)	2	9.92(0.97)	1	Farmers prefer catfish which has a better survival rate. Most of the farmers complaining of high mortality rates. We believe the problem of inbreeding in hatcheries is contributing to this because they continue to produce same fingerlings which are not adaptable to change in climate. (FGD 8).
Robustness	7.33(0.61)	6	10.00(1.00)	1	9.08(0.87)	5	9.58(0.91)	4	We face problems of pests and predators here. We need strong, active, and fast swimming fish, not the weak once (FGD 5).
Length of growing period	7.42(0.69)	5	7.75(0.76)	7	8.58(0.83)	6	8.00(0.92)	8	We like to produce species with shorter period to mature. This reduces the production costs, and we can meet the growing demand (FGD 7).
Feed efficiency	7.17(0.71)	7	10.00(1.00)	1	8.58(0.72)	7	9.42(0.85)	5	As farmers, we desire to grow fish species that respond well to feeding. We expect to get profit, and you know feed is one of the greatest challenges in fish farming (FGD 6.
Fast growing	9.17(0.82)	4	9.75(0.94)	6	9.17(0.82)	4	9.25(0.81)	6	We like fast growing catfish species the hybrid of Clarias and heterobranchus that grows faster compared to other local species (FGD 8).
Rugged body	6.00(0.76)	8	6.42(0.81)	8	6.92(0.74)	9	8.67(0.81)	7	We want catfish with a rugged skin because the skin protects it from the harsh weather and many predators and pests in this area (FGD 6).
Large fingerlings	5.17(0.81)	9	6.23(0.83)	9	7.26(0.84)	8	6.48(0.95)	9	Most farmers in this area desire larger size fingerlings like jumbo size because this size grow faster and respond well

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Attributes	FGD 5 Mean (consensus)	Rank	FGD 6 Mean (consensus)	Rank	FGD 7 Mean (consensus)	Rank	FGD 8 Mean (consensus)	Rank	Exemplar quotes
									to feeding (FGD 5). We desire post-fingerlings because they grow faster when they are well fed. We desire juvenile because it grows faster with the type of feed I am using (FGD 8).

Values reported are Likert mean scores ranging from 1 to 10. Values in parentheses are consensus. Rank values are based on the average score of each attribute with lower values means more preferred and higher values means less valued.

Table 1c. Preferred production-related catfish attributes as perceived by aquaculture producers in Delta.

Delta State	FGD 9		FGD 10		FGD 11		Exemplar quotes
Attributes	Mean (consensus)	Rank	Mean (consensus)	Rank	Mean (consensus)	Rank	
Stress tolerance	8.75(0.72)	4	9.45(0.83)	1	9.45(0.78)	2	Many of us prefer to grow species like *Clarias gariepinus* that tolerate the extreme changes in temperature. Sometimes we have floods here that pollute our water. If we have stress tolerant fish like the hybrid losses will be reduced (FGD 10). We are faced with problems of acid rain and sometimes oil spillage, so if you have species that are easily affected you will lose everything (FGD 11).
Disease resistance	9.58(0.85)	1	9.36(0.72)	3	9.25(0.86)	4	We have too many diseases and pests here. So as farmers we would like to have fish species that are disease resistant (FGD 11).
Survival rate	8.65(0.74)	6	9.24(0.76)	6	9.33(0.94)	3	More farmers are complaining of high mortality. You stock a lot of fingerlings, say per 100 fingerlings more than half of it will die (FGD 10).
Robustness	9.00(0.64)	3	9.27(0.85)	4	9.17(0.87)	5	We prefer to stock fish that are strong and active in swimming. They should be strong and not easily break or bruised (FGD 11).
Length of growing period	7.50(0.74)	8	9.10(0.76)	7	7.10(0.85)	9	We need fish that have early maturity. We cannot afford to grow fish for a loner period without sales. So, most of the farmers want early maturity catfish species (FGD 9).
Fast growing	9.25(0.81)	2	9.45(0.68)	1	9.58(0.94)	1	We prefer catfish that grow fast. Especially, the hybrid catfish is preferred by many farmers because if the faster writing characteristics compared to other local species (FGD 11).
Feed efficiency	9.00(0.83)	5	9.27(0.71)	4	8.16(0.84)	7	We prefer fish that respond well to feed. No farmer would want to keep feeding something that is not growing (FGD 11).
Rugged body	8.25(0.76	7	7.82(0.85)	8	8.75(0.69)	6	We like fish that has a rugged-looking skin, not the one that is too smooth. Our buyers say it has a visual appeal to their customers because it looks natural (FGD 10).
Small fingerlings	8.17(0.85)	9	7.74(0.82)	9	7.46(0.78)	8	Majority of farmers in this area prefer jumbo size fingerlings because it is easy it grow. We have low mortality rate, and this is important for our profitability (FGD 10).
Large fingerlings	8.75(0.84)	4	9.45(0.95)	1	9.45(0.76)	2	Of course, we sometimes buy small size fingerlings because that what is available in hatcheries, and we may not get the quality that we want, but farmers prefer larger size fingerlings above 5 cm to reduce mortality (FGD 10).

Values reported are Likert mean scores ranging from 1 to 10. Values in parentheses are consensus. Rank values are based on the average score of each attribute with lower values means more preferred and higher values means less valued.

Table 2a. Preferred consumption-related catfish attributes as perceived by aquaculture producers in Ogun.

	FGD 1		FGD 2		FGD 3		FGD 4		Exemplar quotes
Attributes	Mean (consensus)	Rank	Mean (consensus)	Rank	Mean (consensus)	Rank	Mean (consensus)	Rank	
Heavy catfish	9.50(0,86)	1	9.42(0.87)	1	9.10(0.69)	4	9.56(0.71)	2	We prefer to produce table size fish because it commands fair price, but customer preference cuts across, so we try to produce different fish sizes as well (FGD 1)
Fleshiness	8.56(0.81)	5	8.33(0.83)	5	8.60(0.86)	5	8.44(0.77)	5	We like to produce catfish which is fleshy. … It is like soft meat. … This type of fish does not have excess oil, and is preferred by many customers, including our local ones (FGD 4)
Thick catfish	9.10(0.78)	2	9.25(0.83)	2	9.45(0.86)	1	8.47(0.91)	4	As farmers, we desire to produce thick bodied catfish species. Our consumers demand more of this because they perceive them to have a better taste and texture. Because of this higher demand we can charge higher prices (FGD 2).
Big head	8.56(0.81)	6	8.33(0.73)	6	8.60(0.86)	5	8.33(0.77)	6	Majority of my customers prefer species with very large-sized heads which they find favourable for pepper soup (FGD 3). Big head is a desirable feature among our consumers. They like it for pepper soup. So, we need catfish species that have a larger head (FGD 1).
Large body	9.10(0.78)	2	9.25(0.83)	2	9.45(0.86)	1	9.67(0.91)	1	Farmers in this area prefer catfish which grows larger and longer. Many farmers prefer hybrid catfish because it grows
Long body	9.10(0.76)	4	9.25(0.78)	4	9.45(0.84)	3	9.47(0.84)	3	

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Attributes	FGD 1 Mean (consensus)	FGD 1 Rank	FGD 2 Mean (consensus)	FGD 2 Rank	FGD 3 Mean (consensus)	FGD 3 Rank	FGD 4 Mean (consensus)	FGD 4 Rank	Exemplar quotes
									larger than the other available species. In addition, our customers want long fish so that they can cut into more pieces (FGD 3).
Low-body fat	8.18(0.87)	7	7.69(0.91)	7	7.91(0.86)	7	7.78(0.91)	7	We like to produce to meet the demands of the market. Consumers prefer hybrid because they do not have a lot of body fat (FGD 1). We usually produce based on the demands of the market. Our buyers ask for fish will low fat content. Many of the fish aggregators also say that low-fat is preferred by many of their customers because it reduces their fat intake which is dangerous to their health (FGD 1)
Dark skin colour	6.80(0.86)	8	7.17(0.82)	8	7.08(0.81)	8	7.20(0.83)	8	Our consumers prefer dark-skinned catfish. They say it has a better taste. In addition, dark skinned catfish species allows catfish to blend with the earthen pond surrounds, camouflage themselves against predators. They also adapt better as they experience low mortality (FGD 4).
Small-size fish	6.00(0.86	9	6.17(0.82)	9	5.82(0.66)	9	6.22(0.60)	9	People also look for melange, but not as much as the table size fish (FGD 2).

Values reported are Likert mean scores ranging from 1 to 10. Values in parentheses are consensus. Rank values are based on the average score of each attribute with lower values means more preferred and higher values means less valued.

Table 2b. Preferred consumption-related catfish attributes as perceived by aquaculture producers in Oyo.

Attributes	FGD 5 Mean (consensus)	FGD 5 Rank	FGD 6 Mean (consensus)	FGD 6 Rank	FGD 7 Mean (consensus)	FGD 7 Rank	FGD 8 Mean (consensus)	FGD 8 Rank	Example quotes
Heavy catfish	9.50(0.84)	1	10.00(0.84)	1	9.42(0.84)	1	9.58(0.84)	2	We prefer 1 kg–2 kg, though it takes a longer period to mature but its sales are readily available. Some prefer 500 g–900 g because it does not really take time to mature, and its market is readily available in this area.
Fleshiness	8.75(0.64)	3	8.50(0.85)	4	7.67(0.82)	6	9.50(0.87)	3	Most farmers want to produce catfish species with a fleshy body. This will help us to increase our profitability since most customers want this [fleshy bodied catfish].
Thick catfish	8.50(0.87)	4	8.00(1.00)	6	9.38(0.84)	2	9.34(0.84)	5	Many farmers here like catfish which is thick. This [thick-bodied catfish] has more meat and our customers are willing to pay higher for it [thick bodied catfish] (FGD 7).
Big head	8.08(0.79)	8	7.67(0.78)	8	8.00(0.78)	5	8.83(0.74)	6	Farmer in Oyo desire catfish with big heard because many of our customers prefer catfish with big head (FGD 6).
Large body	8.17(0.79)	5	8.75(0.76)	3	8.57(0.72)	4	9.67(0.91)	1	The large size fish is also in high demand, especially 1.5 kg to 2 kg (FGD, 5).
Long body	9.17(0.64)	2	9.67(0.85)	2	9.38(0.82)	3	9.34(0.87)	4	We prefer catfish that grows long compared to short-bodied catfish species. The hybrid catfish is preferred because it grows long (FGD 8).
Low-body fat	8.00(0.82	6	8.36(0.82)	5	7.50(0.82)	7	8.08(0.82)	7	Our customers do not want fish which is fat. If we produce fatty species, we will make losses because there is extremely low demand for that (FGD 6)
Dark skin colour	8.08(0.82)	7	8.00(0.89)	7	7.25(0.86)	8	7.58(0.84)	8	We prefer dark skinned catfish. This is preferred by our customers (FGD 5)
Small-size fish	1.92(0.95	9	3.25(0.79)	9	3.25(0.79)	9	1.92(0.92)	9	Our customers desire the smoking size (FGD 7). The market for small size fish is readily available. They like it for smoking. In addition, we like melange size because it does not take a longer period to mature (FGD 8)

Values reported are Likert mean scores ranging from 1 to 10. Values in parentheses are consensus. Rank values are based on the average score of each attribute with lower values means more preferred and higher values means less valued.

Table 2c. Preferred consumption-related catfish attributes as perceived by aquaculture producers in Delta.

Attributes	FGD 9 Mean (consensus)	FGD 9 Rank	FGD 10 Mean (consensus)	FGD 10 Rank	FGD 11 Mean (consensus)	FGD 11 Rank	Example quotes
Heavy catfish	8.67(0.76)	2	8.64(0.85)	4	8.78(0.84)	3	We like to produce large fish of 1–1.5 kg, though it takes a longer period to mature but its market is readily available. We sell this size more than any other fish. We do not like extra big because it takes more production costs (FGD 10).
Fleshiness	8.25(0.84)	3	8.75(0.92)	2	8.32(0.86)	6	Good catfish should have a lot of meat. Our customers prefer fleshy fish, especially the hybrid one not fish with too many bones. This type [fleshy fish] of fish has good taste (FGD, 11.
Thick catfish	8.25(0.76)	3	7.82(0.84)	7	8.75(0.84)	4	We like to produce catfish which is thick. Many of our customers prefer thick bodied to lean fish (FGD 10).

(*continued on next page*)

(*continued*)

Attributes	FGD 9 Mean (consensus)	FGD 9 Rank	FGD 10 Mean (consensus)	FGD 10 Rank	FGD 11 Mean (consensus)	FGD 11 Rank	Example quotes
Big head	8.25(0.86)	3	8.09(0.78)	5	8.00(0.68)	5	Farmers in this area prefer catfish species with a big head, especially the hybrid of Clarias [*Clarias gariepinus*] and Heterobranchus. We grow for the market, and our customers prefer the big-headed catfish, especially pepper soup customers. (FGD 9).
Large body	9.17(0.94)	1	9.27(0.90)	1	9.42(0.94)	1	Most farmers in this region prefer catfish with a large body. This size fetches higher prices and are attractive to most of our customers (FGD 9).
Long body	7.92(0.92)	6	8.73(0.88)	3	9.00(0.94)	2	A good fish for the market should have a long body. Long fish is profitable that short-bodied fish. Our customers do not like short-bodied fish (FGD, 10).
Low-body fat	7.67(0.86)	7	7.73(0.84)	8	7.50(0.76)	7	Our barbeque customers like less fat catfish. Because we produce based on market needs, most of us prefer catfish species with less fat and less eggs (FGD 9).
Dark skin colour	7.00(0.78)	8	7.91(0.76)	6	7.25(0.74)	8	Our customers prefer the dark-skinned catfish. They find the colour more attractive (FGD, 10).
Small-size fish	6.75(0.82)	9	6.45(0.84)	9	7.42(0.84)	9	We also like to produce melange size fish because it takes short time to produce. This helps us to meet immediate financial needs since we rely on fish farming for our livelihoods (FGD 9).

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