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Production Objectives and Trait Preferences of Smallholder Farmers in the Philippines: Implications for Designing Breeding Schemes Utilizing Indigenous Swine Genetics

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Profit maximization is not the only production objective in farming. For smallholder farms worldwide, family sustenance often takes priority, with production being viewed more as savings-oriented than market-oriented. Furthermore, market pressures can lead to the mismanagement of indigenous livestock resources, increasing their risk of genetic erosion. To ensure the long-term conservation of the Philippine native pig, this study aimed to determine the various types of native pig farmers and define the intervention strategies for each type. A total of 432 native pig farmers representing seven provinces in the Philippines (Benguet, Kalinga, Isabela, Nueva Vizcaya, Quezon, Marinduque, and Eastern Samar; *n* = 52 – 76) were interviewed using a structured questionnaire that covered sociodemographic information, production objectives, herd-level data, breed choice and trait preferences, market preferences for specific traits, breeding and selection practices, production and management practices, and challenges encountered. The data obtained was then used to make specific recommendations for each type of farmer to meet their production objective and ensure the long-term genetic conservation of the native pig. Three farmer types were identified, each requiring unique interventions to increase farm productivity. These were: (i) the 'income-driven' farmer (Type 3) (*n* = 58), (ii) the farmer in a 'classic mixed farm' who raises native pigs for supplemental income (Type 2) (*n* = 217), and (iii) the 'product-oriented' farmer (Type 1) who traditionally produces niche products as part of their regular diet (*n* = 119). Based on farmer trait preference, it is therefore recommended to increase the growth and reproduction traits of the native pig to maintain its relevance to smallholder livestock farmers and ensure its long-term genetic conservation. Breed development strategies may include crossbreeding or participatory breeding approach, depending on the farmer type.

Keywords: native pig farmers, survey, demographics, trait preference, breeding objective

INTRODUCTION

Indigenous pig breeds generally have lower productivity compared to transboundary commercial breeds, making them a minority in many countries (Xayalath et al. 2021; Kasprzyk and Walenia 2023). Furthermore, crossbreeding with commercial breeds has led to the decline of indigenous breeds such as the Bamei pigs of China, the Livni pigs of Russia, and the H'mong black pigs of Vietnam (Berthouly-Salazar et al. 2012; Zhang et al. 2018; Abdelmanova et al. 2024). However, despite their lower productivity, indigenous breeds often have superior meat quality and possess unique

adaptive traits (Amoako Antwi 2022). Some breeds serve as vital sources of niche products, such as the dry-cured Jamón Ibérico from Iberian pigs, which is renowned for its exceptional meat quality in the Iberian Peninsula (Ventanas et al. 2005). Similarly, the Greek black pig is widely used in the Greek organic production system for its high-quality meat, resistance to diseases, and adaptability (Michailidou et al. 2014; Papakonstantinou et al. 2023). Indigenous breeds in Asia also serve as a valuable genetic resource for improving European breeds (Giuffra et al. 2000). For example, the Meishan pig of China was instrumental in enhancing the litter size of the Large White breed in the 1980s (Elstein 2002).

In the Philippines, the native pig has remained the breed of choice in certain regions. The actual proportion of native pigs is not known, pending a national inventory, but it is estimated to be a minority, ranging from 1.4 to 4.0% (Bondoc and Ramos 1998; Armenia et al. 2016; Barnes et al. 2020). However, in the Cordillera region, it was reported at 74%, though this is in decline (Maddul 1991). A recent study on the Philippine native pig showed a generally low effective population size (*Ne*), suggesting a genetic risk to this breed, which necessitates immediate conservation actions (Banayo et al. 2023). This requires greater participation in native pig farming.

Native pig farmers prefer native pigs over commercial breeds due to their adaptability to unfavorable environmental conditions, resistance to diseases, ability to thrive on diverse and readily available feed sources, and reduced dependence on expensive commercial feed (Monleon 2005; Santiago 2010; Aggalao 2011; Mesia et al. 2018; Brion 2019; Quintua et al. 2019; Dacules and Afable 2020; Logronio et al. 2022). Furthermore, their superior meat quality led ethnic communities in the Cordillera region to develop various niche products, such as *etag*, *kiniing*, and *kinuday* (Maddul et al. 2015; Alabado 2017; Molintas 2017; Garambas et al. 2022). More importantly, native pigs hold cultural significance as an essential part of ethnic rituals (Voss 1987; Maddul 1991; Ma 2010; Lapeña and Acabado 2017). When breeding, some farmers select their breeder pigs based on abundance of teats, good body conformation, and prolific breeding capabilities (Dacules and Afable 2020). However, some place emphasis on color uniformity, with black as the primary criterion to classify pigs as native (Geromo et al. 2020). On the other hand, other raisers prioritize body conformation and size when purchasing pigs (Villanueva and Sulabo 2018).

To date, formal literature documenting native pig farmer preferences is lacking. Understanding farmer preferences is critical in the effective design of intervention programs toward conservation and animal breeding. Evaluation of farm-household economics, production systems, breeding practices, production objectives, and trait preferences are all important considerations in designing intervention programs (McConnell and Dillon 1997; Sölkner et al. 1998). Furthermore, the incorporation of farmers' knowledge and preferences is essential to ensure the acceptance and successful implementation of such programs (Abigaba et al. 2022). By aligning breeding objectives with the practical needs of farmers, interventions such as conservation and improvement of desired traits and long-term production sustainability can result in better outcomes. Hence, this study aimed to determine the various types of native pig farmers and define the intervention strategies for each type to ensure the long-term conservation of the Philippine native pig.

MATERIALS AND METHODS

Data Collection

The survey used a structured questionnaire that covered information on the respondents' sociodemographic characteristics, their production objectives, herd-level data, breed choice and trait preferences, market preferences for specific traits, breeding and selection practices, production and management practices, challenges encountered in raising native pigs, and the support they require. Only native pig farmers with at least 1 yr of experience in native pig raising were allowed to participate in the survey. The interviews were conducted in 2021 by visiting farmers in their houses or meeting them as a group per *barangay* (village).

Description of Study Sites

Only provinces with native pigs and with local collaborating researchers from state universities and colleges (SUCs) or government research institutions were included. These were the provinces of Benguet, Kalinga, Isabela, Nueva Vizcaya, Quezon, Marinduque, and Eastern Samar. Purposive sampling was employed so that at least three municipalities in each province and at least three barangays in each municipality were represented. Sampling considerations included logistics for reaching the barangays, the cooperation of farmers and local officials, and the exclusion of the area from African Swine Fever red zones as classified by the Bureau of Animal Industry (DA 2019). The following municipalities were represented: Benguet (B), Sablan (n = 19), Itogon (n = 33), and Buguias (n = 8); Eastern Samar (S), Maydolong (n = 20), San Julian (n = 20), and Borrongan (n = 20); Kalinga (K), Tabuk City (n = 14), Tinglayan (n = 15), and Balbalan (n = 32); Marinduque (M), Buenavista (n = 21), Sta. Cruz (n = 21), and Torrijos (n = 21); Nueva Vizcaya (N), Diadi (n = 13), Bagabag (n = 26), Solano (n = 20), and Bayombong (n = 1); Quezon (Q), San Francisco (n = 20), Mulanay (n = 35), and Lopez (n = 21); Isabela (I), Jones (n = 21), Echague (n = 19), and San Agustin (n = 12). Each province was independently surveyed by the counterpart local team, and each respondent voluntarily joined the study.

Data Analysis

Data quality checks are detailed in the Supplementary Information. The final data (n = 393) were analyzed by multiple correspondence analysis (MCA), followed by agglomerative hierarchical clustering (AHC) using default settings in XLSTAT (Addinsoft, USA). Twelve variables were included in the MCA, namely: sex, highest educational attainment of the husband or wife, sustainability (perception of population growth), profitability (perception of profitability), diversity (having ruminants, poultry, or crops), flexibility (secondary processing), time dispersion (frequency of income; monthly and quarterly were assigned as frequent), and trait preferences (priority trait for an ideal pig, trait they want to improve in the pig, trait considered in pricing). The production objective (non-income, supplemental income, major income) was added as a supplementary variable in the MCA. For descriptive statistics, the frequency means were compared using the t-test or ANOVA at α = 5% in XLSTAT. The least significant difference (LSD) test was used for multiple means comparisons.

Three questions were constructed to assess trait preference (involving four traits: growth, reproduction, adaptation, and color and appearance) as follows: priority traits in an ideal pig were ranked from 1 to 4 (1 being the highest), with missing ranks assigned tied values; traits to improve in the pig and traits considered in pricing both allowed for multiple answers. Overall differences in the ranking of priority traits were tested for significance using the Friedman test for paired samples and compared using the Nemenyi method (1963) in XLSTAT (Addinsoft, USA), with n = 432 respondents. The scale was reversed from 4 to 1, with 4 being the most preferred. Among provinces, differences in priority traits were tested for significance using the Friedman test for paired samples and compared using the Wilcoxon signed rank test using SPSS.

RESULTS

Sociodemographics

The majority of respondents (83%) were married women (68%) aged 45 – 48 yr with an average of 12 yr (ranging from 3 to 21 yr) of experience in raising native pigs (Table 1). Most of the farmers had high school education (n = 168), while most of their children had a college education (n = 166). Family income comes primarily from raising native pigs, growing crops, and other sources (such as employment) at a quarterly, semiannual, or annual frequency (Table 1).

Reason for Native Pig Production

The main reason for raising native pigs was primarily for supplemental income, except for farmers in Nueva Vizcaya who intended to earn major income (Table 2). However, farmers in Kalinga had non-income reasons which highlight the

Table 1. Sociodemographics of native pig farmers from selected provinces in the Philippines.

Variables	B	K	I	N	Q	M	S	Total	Average	*P*-value
Average age (yr)	47.5	45.0	48.0	44.5	48.0	48.0	45.0	-	46.6	0.7061
Average length of farming (yr)	6.7^{de}	7.3^{de}	14.8^{bc}	3.3^{e}	20.8^{a}	19.7^{ab}	11.5^{cd}	-	12.1	< 0.0001
					Number of farmers (*n*)					
Sex										
Male	18	15	22	23	35	12	13	138	20^{b}	0.0028
Female	42	46	30	37	41	51	47	294	42^{a}	
Civil Status										
Married	44	45	49	48	65	54	44	349	50^{a}	
Unmarried	12	10	2	6	8	2	11	51	8^{b}	< 0.0001
Widowed	4	3	1	0	2	7	5	22	3^{b}	
Educational Level										
Farmer/In-charge										
College[1]	14	29	2	5	7	11	12	80	11^{a}	
High School	36	22	25	2	40	26	17	168	24^{a}	0.0812
Elementary[2]	10	10	24	53	29	25	30	128	26^{a}	
Spouse										
College	3	2	2	0	3	0	5	15	2^{a}	
High School	5	6	10	1	9	6	7	44	6^{a}	0.1105
Elementary	3	4	3	0	24	9	17	60	9^{a}	
Children										
College	29	26	4	28	32	29	18	166	10^{b}	
High School	8	14	8	17	33	20	17	117	17^{ab}	0.0325
Elementary	4	9	5	7	26	10	12	73	24^{a}	
In-charge of native pig raising										
Female/mother	34	34	24	22	21	44	20	199	28^{a}	
Male/father	15	5	17	33	17	13	12	112	16^{b}	0.0030
Parents	7	17	10	2	3	0	26	65	9^{b}	
Sources of family income from all sources										
Native pig raising	18	2	51	45	68	32	22	238	34^{a}	
Own farm crops	20	28	31	12	29	11	28	159	23^{ab}	
Farm laborer	16	9	16	4	25	3	1	74	11^{b}	0.0164
Raising other animals	3	2	15	2	47	2	3	74	11^{b}	
Others[3]	6	11	4	15	31	16	5	88	13^{ab}	
Range of monthly income (Php)	4 000–15 000^{ab}	3 000–20 000^{ab}	500–6 000^{b}	10 000–15 000^{a}	1 000–30 000^{ab}	1 500–15 000^{ab}	200–60 000^{b}	200–60 000	-	0.0087
Average income										
Frequency of income from native pig raising										
Monthly	0	0	0	0	6	0	0	6	1^{b}	
Quarterly	1	0	0	52	28	3		86	12^{ab}	
Semiannually	17	11	41	5	49	36	32	191	27^{a}	0.0008
Annually	41	31	11	0	4	19	25	131	19^{ab}	
Seasonal	0	3	0	0	0	0	1	4	1^{b}	
Not selling[4]	0	16	0	0	0	0	0	16	2^{b}	
Annual income range (Php)	20 000 – 140 000^{a}	2 000–15 000^{c}	2 000–28 000^{c}	1 000 – 50 000^{c}	1 000–250 000^{b}	1 000–60 000^{c}	3 000–84 000^{c}	1 000–250 000	-	< 0.0001

[1]Includes college, vocational, and post-graduate studies; [2]at most elementary; [3]others include full-time employment, part-time employment, fishing, copra production, vendor, sari-sari store, washing clothes, government employee, and remittance; [4]personal consumption or savings. Number of respondents per province: B-Benguet n = 60, K-Kalinga n = 61, I-Isabela n = 52, N-Nueva Vizcaya n = 60, Q-Quezon n = 76, M-Marinduque n = 63, S-Eastern Samar n = 60.

sociocultural importance of the native pig. In general, most farmers derive income from selling piglets and slaughter pigs for *lechon* (Table 3). However, only farmers in Marinduque, Nueva Vizcaya, Quezon, and Eastern Samar derive income from the *lechon* market, which may be explained by their proximity to major cities (i.e., markets in Metro Manila for farmers in Marinduque, Nueva Vizcaya, and Quezon, and markets in Cebu City for farmers in Eastern Samar). In Benguet and Isabela, retail pork is the main form of selling native pigs, while in Kalinga, pigs are primarily sold for rituals or celebrations (S.D. Codiam, personal communication, Kalinga State University, 2023 Jan 12).

Native Pig Production and Management

The native pig production system is generally classified as low-input. Most farmers (71%) have one to five animals in the herd (Table 4). The majority (71%–79%) also raise poultry (Table 13). In general, most farmers provide housing (n = 327), pay for the nutrition of the pig (n = 330), and provide regular feeding (n = 282) (Tables 5 and 6). However, most farmers provide only carbohydrate-rich or fiber-rich feeds, while only a few provide protein-rich feeds such as *Tricanthera* (Table 5), suggesting that native pigs may have a low protein intake. On the other hand, this also shows the native pig's adaptive characteristic of utilizing alternative feed sources, which is advantageous given concerns about feed-food competition (Makkar 2018; Lassaletta et al. 2019). Furthermore, locally available feeds can be nutritionally complete and affordable (FAO and IFIF 2010). However, most farmers do not spend on animal health (n = 298), do not consult veterinarians (n = 253), and do not administer vaccines (n = 307), but do give some form of medication (n = 300) such as herbal medicines. In general, the results show that a low-input production system predominates in the Philippines, which is supported by previous studies (Maddul 1991; Monleon 2005; Manipol et al. 2014; Ayomen and Kingan 2019;

Table 2. Production objectives of Philippine native pig farmers.

Production objective	Number of farmers (n)									P-value
	B	K	I	N	Q	M	S	Total	Average	
Supplemental income	53	27	43	18	69	42	51	303	43[a]	
Savings*	0	49	9	13	31	31	23	156	22[ab]	
Major income	7	2	6	58	5	10	10	98	14[b]	< 0.0001
Cultural / ritual*	2	23	0	0	2	0	1	28	4[b]	
Want / hobby*	0	10	0	1	6	10	9	36	5[b]	

*Identified as non-income objective for multivariate analysis; multiple answers given; P-value < 0.0001. Number of respondents per province: B-Benguet n = 60, K-Kalinga n = 61, I-Isabela n = 52, N-Nueva Vizcaya n = 60, Q-Quezon n = 76, M-Marinduque n = 63, S-Eastern Samar n = 60.

Table 3. Various native pig products sold by Philippine native pig farmers.

Province	Number of famers (n)									P-value
	B	K	I	N	Q	M	S	Total	Average	
Products										
Piglets	26	40	27	32	49	43	44	261	37[a]	
Slaughter pig for *lechon*	4	2	4	33	64	42	43	235	27[a]	
Pork *(kinilo)*	47	11	37	28	31	3	20	134	25[ab]	< 0.0001
Sow	1	14	2	1	10	0	3	31	4[bc]	
Boar service	0	0	3	1	12	1	0	17	2[c]	

Number of respondents per province: B-Benguet n = 60, K-Kalinga n = 61, I-Isabela n = 52, N-Nueva Vizcaya n = 60, Q-Quezon n = 76, M-Marinduque n = 63, S-Eastern Samar n = 60.

Table 4. Pig inventory by breed of Philippine native pig farmers.

Breed	Number of farmers (n)								P-value
	B	K	I	N	Q	M	S	Total	
A. Native									
1-5	47[a]	33[a]	40[b]	47[b]	33[ab]	42[ab]	35[ab]	277	< 0.0001
6-10	12	10	5	7	18	11	9	72	0.2575
≥ 11	0	2	2	4	14	8	10	40	0.3799
Average number of pigs	4 ± 2[bc]	4 ± 3[bc]	3 ± 4[c]	3 ± 4[c]	8 ± 8[a]	5 ± 5[bc]	6 ± 7[ab]	5 ± 5	< 0.0001
Range	1 – 10	1 – 12	1 – 20	1 – 15	1 – 40	1 – 22	1 – 37	1 – 40	
***B. Mestiso* (crossbreed)**									
1-5	18	3	9	3	15	3	23	74	0.3353
6-10	1[ab]	0	0	1[b]	4[ab]	1[a]	1[a]	8	0.0339
≥ 11	0	0	0	0	11	1	0	12	0.6079
Average number of pigs	2 ± 1	2 ± 0	2 ± 1	4 ± 2	14 ± 28	5 ± 5	3 ± 2	2 ± 1	0.1151
Range	1 – 5	2	1 – 3	1 – 6	1 – 151	1 – 11	1 – 10	1 – 151	
C. Exotic breed									
1-5	3	1	0	3	2	3	2	14	0.5083
≥ 11	0	0	0	1	0	1	0	2	-
Average number of pigs	2 ± 1	3	0	4 ± 5	2 ± 1	6 ± 8	2 ± 1	3 ± 1	0.8942
Range	1 – 3	3	0	1 – 11	1 – 2	1 – 18	1 – 2	1 – 8	

Number of respondents per province: B-Benguet n = 60, K-Kalinga n = 61, I-Isabela n = 52, N-Nueva Vizcaya n = 60, Q-Quezon n = 76, M-Marinduque n = 63, S-Eastern Samar n = 60.

Table 5. Production practices in Philippine native pig farming in terms of nutrition, healthcare, and housing.

Province	Number of farmers (*n*)									*P*-value
	B	K	I	N	Q	M	S	Total	Average	
Nutritional management										
Regular feeding	58	0	33	55	27	53	56	282	40[a]	
Scavenging	1	38	3	2	1	0	2	47	7[b]	< 0.0001
Supplemental feeding	1	20	16	1	42	10	2	92	13[b]	
Types of feeds										
Kitchen-scrap	16	17	3	4	35	30	44	149	21[bc]	
Commercial feeds	49	11	42	57	58	40	27	284	41[bc]	
Carbohydrate-rich[1]	52	201	75	81	196	75	114	794	113[a]	
Fiber-rich[2]	60	209	42	40	102	23	55	531	76[ab]	< 0.0001
Protein-rich[3]	0	8	0	4	1	2	0	15	2[c]	
Salt	3	54	0	2	10	4	36	109	16[bc]	
Vitamins	6	1	1	55	52	0	26	141	20[bc]	
Housing Type of housing										
Housed[4]	58	61	40	36	60	20	52	327	47[a]	< 0.0001
Not housed[5]	2	0	12	23	16	41	7	101	14[b]	
Healthcare Vaccinations										
Yes	12	11	6	2	46	12	36	125	18[b]	< 0.0001
No	48	50	46	58	30	51	24	307	44[a]	
Vet Consultation										
Yes	27	51	4	22	19	19	37	179	26[b]	< 0.0001
No	33	10	48	38	57	44	23	253	36[a]	
Use of medicine										
Yes	47	47	3	59	40	49	55	300	43[a]	< 0.0001
No	13	14	49	1	36	14	5	132	19[b]	
Herbal	0	3	0	0	13	0	53	69	10[a]	< 0.0001
Non-Herbal	0	0	0	0	20	0	1	21	3[b]	

[1]Carbohydrate-rich: rice bran, corn bran, coconut, tubers-camote, potato, gabi, cassava, carrot, banana fruit, papaya, *pungapong*, sugar, molasses, paliat; [2]Fiber-rich: leaves of camote, *gabi*, weeds, *kangkong*, banana pseudostem, rice bran, corn bran, coconut; [3]Protein-rich: *Trichanthera*, beans, *ipil-ipil, lima-lima*, dried fish (*tuyo*); [4]Housed: A-frame, granary, pen, semi-range; [5]Not housed: tethered, free-range. Number of respondents per province: B-Benguet *n* = 60, K-Kalinga *n* = 61, I-Isabela *n* = 52, N-Nueva Vizcaya *n* = 60, Q-Quezon *n* = 76, M-Marinduque *n* = 63, S-Eastern Samar *n* = 60.

Table 6. Expense inputs of Philippine native pig farmers in terms of nutrition, labor, housing, and healthcare.

Province	Number of farmers (*n*)									*P*-value
	B	K	I	N	Q	M	S	Total	Average	
Nutrition										
No expense	2	12	33	45	5	5	0	102	15[b]	< 0.0001
With expense	58	49	19	15	71	58	60	330	47[a]	
Labor										
No expense	60	57	52	56	49	61	55	390	56[a]	< 0.0001
With expense	0	4	0	4	27	2	5	42	6[b]	
Housing										
No expense	60	23	52	0	33	52	49	269	38[a]	< 0.0001
With expense	0	38	0	0	43	11	11	103	15[b]	
Healthcare										
No expense	13	59	52	57	35	38	44	298	43[a]	< 0.0001
With expense	47	2	0	3	41	25	16	134	19[b]	

Number of respondents per province: B-Benguet *n* = 60, K-Kalinga *n* = 61, I-Isabela *n* = 52, N-Nueva Vizcaya *n* = 60, Q-Quezon *n* = 76, M-Marinduque *n* = 63, S-Eastern Samar *n* = 60.

Quintua et al. 2019; Falculan 2021). As a response to this issue, a local research project was implemented in the Philippines in 2015–2019 to develop strategies for improving native pig farm productivity (Baguio 2017; Codiam 2020).

Willingness for Improvement

Consequently, most farmers showed willingness to improve their production system (*n* = 374) and increase their herd size (*n* = 421) (Table 7). If given sufficient achievable income, most farmers were willing to shift to full-time raising of native pigs (*n* = 370). They identified the need for training on improved production practices as the top priority for assistance (*n* = 280), followed by support for improving animal health and product marketing (Table 7). When asked about production-related challenges, they identified feed costs and input price fluctuations as their major concerns (Table 8). The estimated monthly expenditure for nutrition ranged from Php 100.00 to Php 35 000.00 (Table 9). The majority (*n* = 387) also reported a lack of access to slaughterhouses, which may impact their access to retail markets (Table 7). Previous studies reported similar problems faced by native pig farmers (Manipol et al. 2014; Villanueva and Sulabo 2018).

Table 7. Willingness of Philippine native pig farmers to improve their production system.

Province	Number of farmers (*n*)									*P*-value
	B	K	I	N	Q	M	S	Total	Average	
Attended seminars										
Yes	19	3	0	56	18	13	3	112	16[b]	< 0.0001
No	41	58	52	4	58	50	57	320	46[a]	
Willingness to participate in seminars										
Yes	59	45	52	59	76	61	59	411	59[a]	< 0.0001
No	1	16	0	1	0	2	1	21	3[b]	
Needs assistance										
Yes	58	57	52	1	72	42	60	342[a]	49[a]	< 0.0001
No	2	4	0	59	4	21	0	90[b]	13[b]	
Specific assistance needed										
Improved production	47	46	52	0	66	39	30	280	40[a]	0.0034
Marketing	12	1	25	0	36	0	22	96	14[ab]	
Secondary processing	7	1	2	0	35	0	50	95	14[b]	
Animal health	7	50	24	1	48	14	23	167	24[ab]	
Source of stocks	5	1	19	0	34	1	18	78	11[b]	
Others*	14	1	2	0	1	0	2	20	3[b]	
Access to Slaughterhouse										
Yes	3	0	19	0	10	1	6	39	6	
No	57	58	33	60	64	61	54	387	55	
Profitability										
Yes	57	51	52	59	76	58	60	413	59[a]	< 0.0001
No	3	10	0	1	0	5	0	19	3[b]	
Increase Herd Size										
Yes	60	56	52	59	74	60	60	421	60[a]	< 0.0001
No	0	5	0	1	2	3	0	11	2[b]	
Shift to full-time native pig raising										
Yes	60	20	47	59	71	55	58	370	53[a]	< 0.0001
No	0	41	5	1	5	8	2	62	9[b]	
Improve production practices										
Yes	60	20	50	57	75	52	60	374	53[a]	< 0.0001
No	0	41	2	3	1	0	0	47	7[b]	

*Others: financial support, feeds, free sow/gilt, any available assistance, guide. Number of respondents per province: B-Benguet *n* = 60, K-Kalinga *n* = 61, I-Isabela *n* = 52, N-Nueva Vizcaya *n* = 60, Q-Quezon *n* = 76, M-Marinduque *n* = 63, S-Eastern Samar *n* = 60.

Table 8. Challenges identified by Philippine native pig farmers.

Factors	Number of farmers (*n*)							
	B	K	I	N	Q	M	S	Average
Trait-related								
Slow growth rate	50	37	24	58	47	20	25	37[a]
Low litter size	6	30	20	56	39	9	28	27[a]
Smaller than exotic breeds	21	14	0	35	42	0	22	19[ab]
High mortality in young animals	1	5	1	0	17	1	32	8[bc]
Disease susceptibility	0	7	0	0	17	3	7	5[bc]
Poor meat quality	0	1	1	0	5	0	13	3[bc]
High litter size	0	0	1	0	10	1	3	2[bc]
Others	0	2	0	0	2	1	1	1[c]
Production-related								
Feed cost	38	9	31	57	48	51	49	40[a]
Input price fluctuation	7	0	1	56	52	0	32	21[ab]
Feed availability	3	12	24	0	20	45	7	16[b]
Expensive inputs	2	0	3	0	29	1	20	8[b]
Lack of veterinary services	0	0	8	0	22	0	24	8[b]
Lack of loan sources	2	0	2	0	16	0	33	8[b]
Cost of medicine	2	0	1	0	19	0	20	6[b]
Housing expense	1	4	0	0	8	4	19	5[b]
Source of stocks	9	4	4	0	9	0	6	5[b]
Lack of marketing of animals/products	3	0	5	1	11	2	8	4[b]
Lack of access to slaughterhouse	2	0	0	0	16	0	9	4[b]
Laborious	1	0	0	0	7	3	15	4[b]
Lack of castration services	0	0	3	0	9	0	7	3[b]
Lack of artificial insemination services	0	0	0	0	0	0	15	2[b]
Lack of semen source	0	0	0	0	2	0	6	1[b]

This table shows the positive responses (yes); a lower value is preferred. Number of respondents per province: B-Benguet *n* = 60, I-Isabela *n* = 52, K-Kalinga *n* = 61, M-Marinduque *n* = 63, N-Nueva Vizcaya *n* = 60, Q-Quezon *n* = 76, and S-Eastern Samar *n* = 60. *P*-value < 0.0001.

Table 9. Farmer-estimated monthly production costs of Philippine native pig farming in terms of nutrition, healthcare, and housing.

Province	*Cost (Php)								*P*-value
	B	K	I	N	Q	M	S	Average	
Nutrition									
Cost per farm	3 501 ± 2 186^{ab}	1 878 ± 1 034^{bc}	590 ± 320^{c}	3 900 ± 6 332^{ab}	4 658 ± 5 833^{a}	1 756 ± 2 714^{bc}	1 956 ± 1 476^{bc}	2 775 ± 3 621	< 0.0001
Range	500 – 10 000	500 – 5 000	400 – 1 500	244 – 25 000	100 – 35 000	160 – 19 500	500 – 9000	100 – 35 000	
Labor									
Cost	0	2 625 ± 1 601	0	4 250 ± 1 500	2 481 ± 2 056	1 750 ± 353	2 300 ± 2 745	2 624 ± 2 017	0.5443
Range	0	1 500 – 5 000	0	2 000 – 5 000	300 – 7 500	1 500 – 2 000	300 – 6 000	300 – 7 500	
Housing									
Cost	0	9 658 ± 12 268	0	0	7 354 ± 9 411	2 292 ± 2 040	2 567 ± 2 420	7 156 ± 9 960	0.0584
Range	0	2 000 – 72 000	0	0	270 – 50 000	100 – 5 000	340 – 6 000	100 – 72 000	
Healthcare									
Cost	609 ± 794^{b}	225 ± 269^{b}	0	3 433 ± 2 713^{a}	536 ± 536^{b}	673 ± 2 986^{b}	227 ± 162^{b}	611 ± 1 493	0.0309
Range	60 – 4 000	35 – 415	0	300 – 5 000	100 – 3 150	5 – 15 000	40 – 500	60 – 4 000	

*Cost estimates provided by Philippine native pig farmers. Number of respondents per province: B-Benguet *n* = 60, K-Kalinga *n* = 61, I-Isabela *n* = 52, N-Nueva Vizcaya *n* = 60, Q-Quezon *n* = 76, M-Marinduque *n* = 63, S-Eastern Samar *n* = 60.

Breeding Practices

Farmers were asked about their breeding practices to inform future genetic improvement programs. Most farmers purchase new stocks when the herd size is low and when there is extra money (Table 10). In addition, farmers in Nueva Vizcaya and Quezon also purchase new stocks to prepare for peak seasons. Most farmers source their breeding stocks on-farm or from their neighbors (family or friends), except in Nueva Vizcaya, where they mostly source their stocks from more distant locations (Table 11). The current sources of breeding stocks will be a key consideration in designing a participatory breeding program for native pigs. On the other hand, the movement of pigs from one location to another has implications for their genetic population structure. In particular, sourcing breeding stocks from distant locations could explain the observed admixture among Nueva Vizcaya native pigs (Banayo et al. 2023).

Trait Preferences

Native pigs are known for their slow growth rate and smaller size compared to exotic breeds. Despite this, farmers identified these traits, along with low litter size, as major challenges (Table 8). The farmers were then asked to rank their priority traits for improvement. In general, most farmers wanted to improve the growth and reproduction traits of the native pig (Fig. 1). This was followed by adaptation traits and color and appearance. Farmers in Benguet and Isabela identified growth as their priority trait for improvement; those in Nueva Vizcaya and Eastern Samar identified reproduction; and those in Kalinga and Marinduque identified both traits as equally important (Table 12). Although adaptation is important for the current production system, it was not identified as a priority trait for improvement, except for Quezon farmers who identified both growth and adaptation. This highlights the already recognized

Table 10. Reasons of Philippine native pig farmers for purchasing new breeding stocks.

Reason for purchase of stocks	Number of farmers (*n*)								*P*-value
	B	K	I	N	Q	M	S	Average	
When stocks are low	27	0	32	40	24	20	4	21^{a}	
When there is extra money	26	22	17	3	15	13	33	18^{ab}	0.0287
For peak season	3	0	3	24	30	2	12	11^{ab}	
Does not buy	1	3	0	0	13	0	2	3^{b}	

Table 11. Various sources of breeding stocks for Philippine native pig farmers.

Source of stocks	Number of famers (*n*)								*P*-value
	B	K	I	N	Q	M	S	Average	
Neighbor	53	44	39	6	52	32	39	38^{a}	
Distant locations	1	10	4	50	3	3	4	11^{b}	0.0110
Own farm	3	1	7	4	17	9	14	8^{b}	
Livestock market			2		1	1		1^{b}	

Table 12. Ranking of Philippine farmers' preferences for improvement on native pig traits at the province level.

Province	Traits			
	Growth	Reproduction	Adaptation	Color and Appearance
Benguet	3.35[a]	2.92[b]	2.03[c]	1.71[d]
Isabela	3.81[a]	2.96[b]	1.88[c]	1.36[d]
Kalinga	3.13[a]	2.96[a]	1.84[c]	2.07[b]
Marinduque	2.98[a]	3.21[a]	2.25[b]	1.56[c]
Nueva Vizcaya	2.67[b]	3.60[a]	2.44[b]	1.29[c]
Quezon	3.06[a]	2.34[b]	2.94[a]	1.66[c]
Eastern Samar	2.84[b]	3.16[a]	2.69[b]	1.31[c]
Average	**3.10[a]**	**3.00[a]**	**2.33[b]**	**1.57[c]**

*Ranking scale of 1 to 4 (4 being the highest priority). Mean ranks with the same letter are not significantly different based on the results of the Wilcoxon signed rank test.

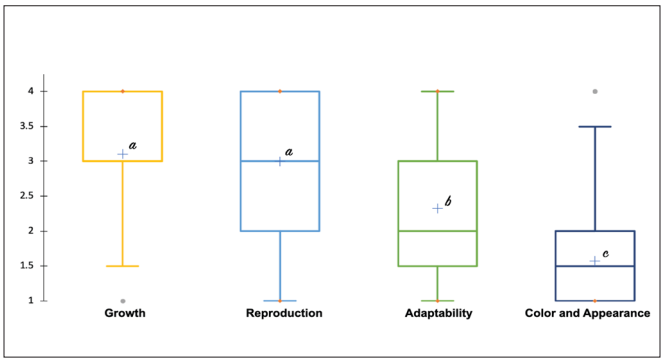

Fig. 1. Ranking of Philippine native pig farmers' preferences for improvement of native pig traits. Boxplots represent the mean (plus sign), median (solid lines), first and third quartiles (contained in the boxes), and dispersion (line outside the box). The data were tested using the Friedman test for paired samples and compared using the Nemenyi method (1963), with n = 432 respondents, and a ranking scale of 1 to 4 (4 being most preferred).

adaptability of the native pig as a default breed characteristic in general, but also points to possible adaptation issues in the Quezon native pig. Quezon farmers also identified both mortality and disease susceptibility as trait-related challenges (Table 8). In addition, results show that farmers' preferences for growth and reproduction traits are correlated with these traits being considered in the selling or buying price of the pig (pricing_GR_yes) (Fig. 2).

The involvement of farmers in defining breeding objectives is essential for their long-term cooperation. In future genetic improvement efforts, it is recommended that growth and reproduction traits be enhanced in the realistic production system of the native pig, while maintaining traits related to adaptation and color and appearance. A participatory approach in the genetic improvement of the native pig could be effective, since farmers have a long history of raising this breed.

Farmer Types

Sociodemographics, production objectives, and trait preferences highly varied among native pig farmers in the seven provinces. Hence, the farmers were grouped by combining these variables, resulting in three farmer clusters or types in unequal proportions (Fig. 3). These were the: (i) product-oriented farmers (Type 1, n = 119), (ii) those with classic mixed farm systems (Type 2, n = 217), and (iii) the income-driven farmers (Type 3, n = 58) (Table 13). These clusters have common features, such as their practice of raising poultry in addition to the native pig (71% – 79%), their perception of native pig raising as profitable (89% – 100%), and their priority for improving growth and reproduction traits over adaptation and color and appearance traits (94% – 100%).

Income-driven (Type 3). These farmers are income-driven (76%), male (59%), and mostly with elementary education (98%) (Table 13). On the farm, they have no crops (81%) nor ruminants (97%). Most observed an increasing native pig population size since childhood (93%); they have a perception of profitability and earn relatively frequent income (monthly or quarterly, as opposed to annually). They rated growth and reproduction as priority traits for improvement in the native pig (81%).

Classic mixed farms (Type 2). These farmers have a production objective for supplemental income (68%), are not male (identified as females, or both husband and wife) (76%), and have reported earning infrequent income (92%) (Table 13). Type 2 has a higher proportion of farmers with crops (46%) and ruminants (51%).

Product-oriented (Type 1). These are farmers with the objective of supplemental income (75%), not male (identified as females, or both husband and wife) (78%), and have reported earning infrequent income (96%) (Table 13). Type 1 has a higher proportion of farmers with at least a high school education (82%) and the highest proportion of farmers who perform secondary processing (45%).

DISCUSSION

Conservation of livestock genetics is dependent on their relevance to the community. Indigenous livestock may be relevant for various reasons such as having superior traits related to adaptation to the current environment, as a source of niche products, and cultural integration to the society (Köhler-Rollefson 2001). To assess the relevance of the native pig, native pig farmers from seven provinces in the Philippines were interviewed, and it was determined that the native pig is raised for either income or non-income reasons, depending on the type of farmer (Tables 2 and 13). Farmers were classified into three distinct types: the income-driven farmers, the farmers in

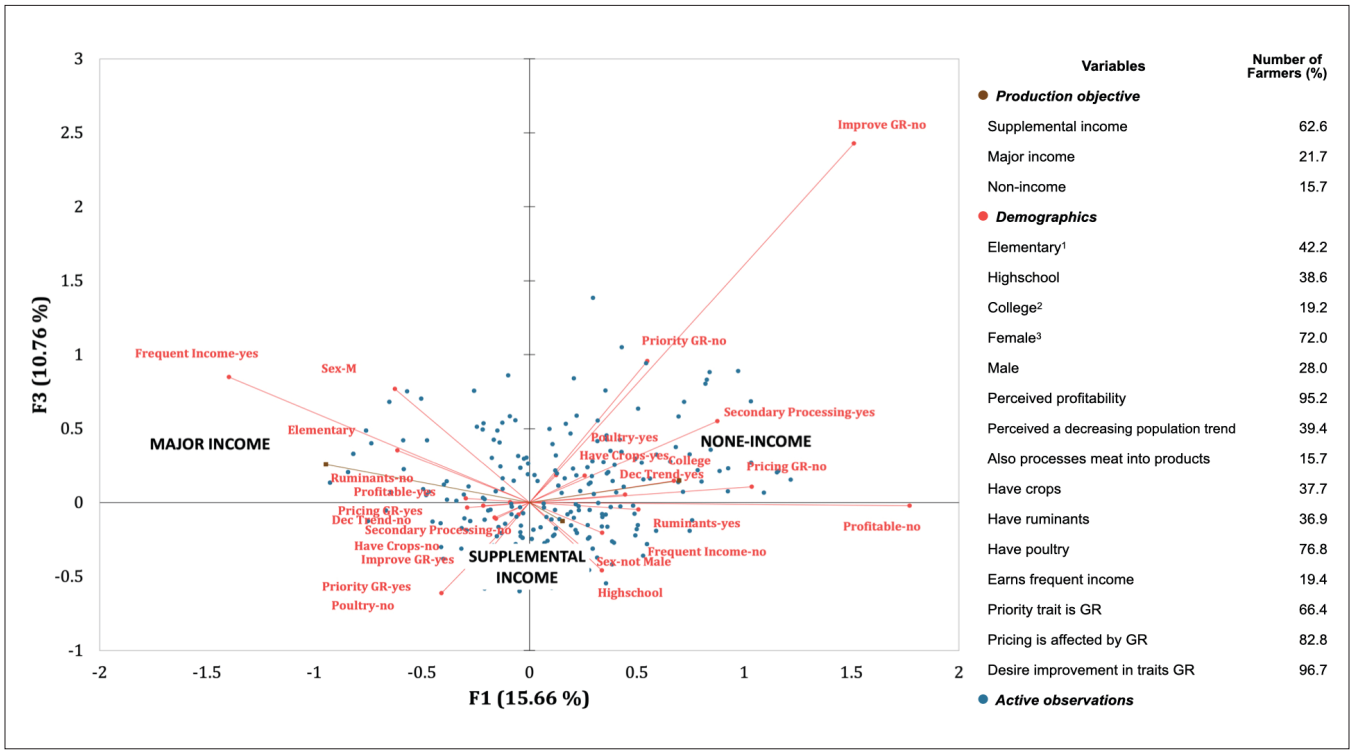

Fig. 2. Multiple correspondence analysis symmetric plot showing the correlation of farmer production objective with sociodemographics and trait preferences on the F1 and F3 axes. The most discriminating variables were: desire to improve growth and reproduction traits, sex, frequency of income, secondary processing, and perception of profitability. Percentages shown are the variations explained by each of the principal coordinates. F3 showed the highest factor loading for sex and priority trait. GR – growth and reproduction traits. Number of farmers is the relative proportion (%) of *n* = 396 who answered 'yes' to the binary question answerable by 'yes' or 'no'.[1]At most elementary education; [2]college, vocational, or graduate studies; [3]females or when both parents were identified.

classic mixed-farm systems, and the product-oriented farmers (Table 13). Across all groups, the priority support needs were (i) improved production, (ii) animal health, and (iii) product marketing. They also identified the need to improve the growth and reproduction traits of the native pig. Specific intervention measures are recommended for each farmer type to address their production objective and ensure the long-term genetic conservation of the native pig.

Income-driven Farmers (Type 3)

There are many ways to increase the income of native pig farmers, but the beneficiary must be receptive to these interventions. The results show that this cluster of farmers, who are mostly from Nueva Vizcaya and who earn majority of their income (albeit low) from native pigs, could be the most receptive to interventions (Table 1). They may benefit from various recommendations for increasing income and overall farm profitability such as consolidating farmers into cooperatives or farmer organizations, eliminating middlemen (if possible), increasing the scale of operations, raising additional livestock, and securing organic certification (DA-BAR n.d.; Dumont et al. 2014; Manipol et al. 2014; Muth et al. 2020; Quintua et al. 2019). They may also substitute native pigs with more productive exotic breeds, but this can be ineffective, as previously experienced by dairy farmers in Africa (Karugia et al. 2001). Substituting with exotic breeds also compromises the goal of conserving native pig genetics for the long-term sustainability of local food systems. Where production can be intensified or improved to a profitable level, the high productivity potential of crossbred pigs may be suitable for income-driven farmers. Further research can also focus on the development of a new diet for the crossbred native pig. Farmers will also benefit from trainings and seminars for production support as well as the provision of capital incentives and access to loans to increase herd size and scale of operations. It must be noted that Nueva Vizcaya had the highest proportion of farmers who have previously participated in seminars; however, they are also the only group of farmers who claimed not to need any external support (Table 7). Hence, extension support initiatives must carefully consider this apprehension toward trainings.

Income-driven farmers also had the highest proportion (81%) who prioritize growth and reproduction traits in the native pig (Table 13). Despite the negative connotation of crossbreds in terms of genetic diversity, when properly

Table 13. Sociodemographics and trait preferences of the three farmer clusters.

Variables		[1]Frequency of farmers (%)		
		Type 1 *(product-oriented)*	Type 2 *(classic mixed farms)*	Type 3 *(income-driven)*
Production objective	Objective is major income?	8	15	76
	Objective is supplemental income?	75	68	21
	Objective is none-income?	18	17	3
Sociodemographics	Is male?	22	24	59
	Had high school or higher?	82	59	2
	Have poultry?	79	77	71
	Have crops?	31	46	19
	Have ruminants?	28	51	3
	Doing secondary processing?	45	3	2
	Observed increasing population size?	61	52	93
	Profitable?	89	98	100
Trait preferences	Frequent income?	4	8	95
	Priority trait is GR[2]?	54	70	81
	Trait to improve is GR[2]?	99	94	100
	Pricing consideration is affected by GR[2]?	76	82	100

[1]answered 'yes' to the question, [2]growth and reproduction; automatic color scaling white to blue (blue being the highest). Number of farmers having positive responses shown as relative frequency distribution (%) per farmer type. Type 1 *n* = 119, Type 2 *n*= 217, Type 3 *n* = 58.

executed, crossbreeding is a way to safeguard a breed (FAO 2007). Crossbreeding allows for heterosis, or hybrid vigor, in offspring produced from a cross of native pigs and exotic breeds. Animal breeders can leverage this heterosis by mating native pigs with any exotic breed. A previous study on population structure revealed a high genetic distance between the Philippine native pig and the exotic breeds Duroc, Large White, Landrace, or Berkshire (Banayo et al. 2023). In addition, crossbreeding between native pig populations is also reasonable since there is a high genetic distance between some populations such as those in Kalinga and Quezon. However, to prevent genetic admixture, all crossbreds must be raised as a terminal breeds (i.e., slaughter pigs or fatteners) and must not be used as parents for the next generation.

Farmers in Classic Mixed farms (Type 2)

The majority of farmers (*n* = 217) fall under the cluster of having a classic mixed-farm system aiming to gain only supplemental income from raising native pigs (Table 13). This result is supported by several previous studies (Monleon 2005; Manipol et al. 2014; Petilos and Pelesco 2014; Quintua et al. 2019). Since the 1990s, smallholder farmers in Asia have been shifting from purely subsistence-based to income-driven motivations (McConnell and Dillon 1997). In this study, farmers in a classic mixed-farm system are mostly women who are able to raise poultry (77%) and ruminants (51%) in addition to the native pig. They also grow crops, which are their major source of income, managed by the husband (Table 13). These farmers can be best supported by on-farm trainings to improve their production. As the majority of them are women, they may be unable to attend trainings that are

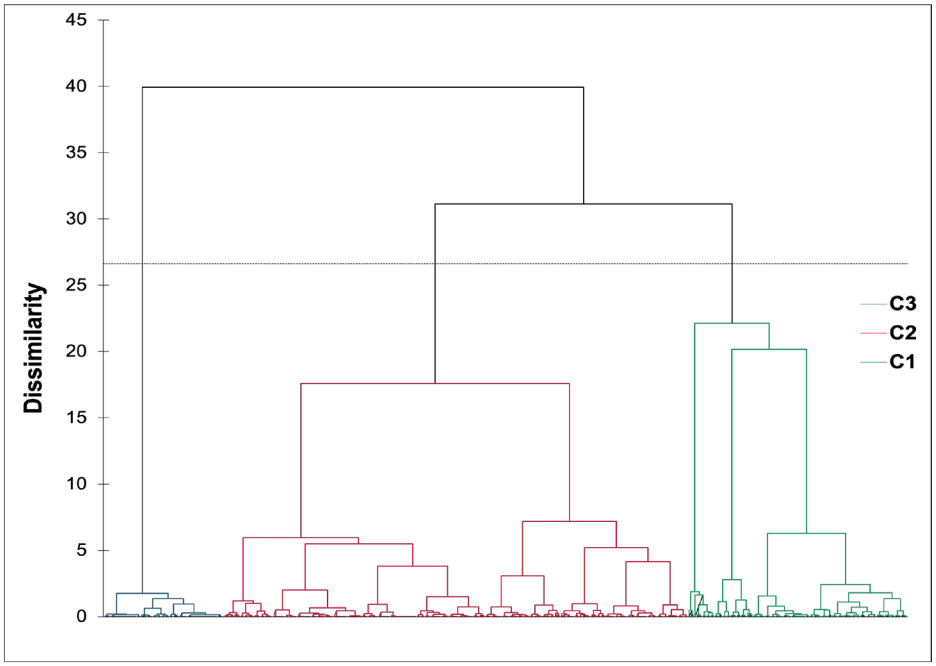

Fig. 3. Three clusters of Philippine native pig farmers. This dendrogram is based on *n* = 394 respondents (41–63 per province). Clusters were constructed using the first five principal coordinates with a cumulative inertia of 54.87%. Automatic cutoff was based on the Hartigan index. Number of respondents belonging to Cluster 1 (C1) *n* = 119, Cluster 2 (C2) *n* = 217, and Cluster 3 (C3) *n* = 58. C1: product-oriented farmers, C2: classic mixed farms, and C3: income-driven farmers.

typically organized in universities or training institutions due to their domestic responsibilities. Therefore, extension support must be provided directly at their homes. They may also benefit from external support in marketing and transporting their animals to *lechoneros*. The elimination of middlemen is not recommended as these farmers do not do the marketing themselves. However, consistent and reasonable pricing may incentivize them to continue raising native pigs. Those without access to *lechoneros* may also benefit from some sort of low-volume supply agreement with meat processors for the production of niche products.

Type 2 farmers are also interested in improving the growth and reproduction of native pigs (Tables 12 and 13). They can benefit from breeding programs aimed at increasing the growth and reproduction traits of the pigs in a realistic production system while maintaining adaptability and color and appearance. In predominantly low-input production system, FAO (2007) recommends improving feed efficiency as a breeding objective so the pig can grow faster despite low-quality feed. Furthermore, genetic selection to reduce the residual feed intake (RFI) can result in animals that eat less without sacrificing growth and production performance (FAO 2007). Although the benefits of developing an improved breed take time, these farmers can tolerate this delay due to their diverse income source.

Product-oriented Farmers (Type 1)

The last type is the product-oriented farmer, the only cluster with farmers performing secondary processing (45%) (Table 13). Like the farmers in classic mixed farms, they also raise poultry (79%) and ruminants (28%) and grow crops (31%). Most of them had a high school education (89%) and are therefore receptive to trainings. These farmers can benefit from access to slaughterhouses and meat processing facilities to upscale their meat production. Although these farmers are mostly from the Cordillera region (Kalinga and Benguet) and have already developed traditional niche products as part of their regular diet, they can still benefit from marketing support in selling these niche products. This support can be provided by the One Town, One Product (OTOP) program of the Philippines' Department of Trade and Industry. Partnerships with other entrepreneurs to establish an online marketplace as well as warehousing and trading of the farmers' niche products are also encouraged. In addition, meat science research can focus on improved processing techniques and further product development. Lastly, because these farmers are educated, they are more likely to actively engage in record-keeping the production performance of their animals, which is crucial for the success of a participatory breeding program (FAO 2007).

These farmers may be amenable to village-based or participatory breeding approaches for the genetic improvement of the native pig. For instance, the village-based breeding approach has been successfully implemented in smallholder sheep farms in Ethiopia (Gizaw et al. 2009). In the participatory breeding approach, the farmer—often referred to as the 'farmer-breeder'—owns the animals and also makes the final selection decisions, while receiving guidance from experts. Furthermore, the native pig farming community can be divided into those focusing on breeder production, led by the farmer-breeder, while the remaining segments (Types 1 and 2) focus on the production of slaughter pigs and fattener pigs. The distribution of superior genetics can be achieved by loaning out the boars. Through this arrangement, the farmer-breeder may also receive payment in the form of piglets. The payment scheme can follow a model similar to the existing *Paiwi* or *Dos por Cinco* systems commonly practiced in the Philippines (The Philippine Star 2013). Finally, a local breeders society can be established to pool experts who can provide guidance and support for these farmers and farmer-breeders.

CONCLUSION

The native pig continues to be relevant to smallholder livestock farmers in the Philippines, playing crucial roles in household economics, women farmer empowerment, and cultural preservation. Based on analyses of Philippine native pig farmers' sociodemographics, production objectives, herd-level data, breed choice and trait preferences, market preferences for specific traits, breeding and selection practices, production and management practices, and challenges encountered, this study identified three distinct farmer types: the 'income-driven' farmer, the farmer in a 'classic mixed farm' system, and the 'product-oriented' farmer. Tailored recommendations and intervention strategies have been provided for each farmer type, which are necessary to meet their specific needs and ensure the long-term genetic conservation of the Philippine native pig.

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Supplementary Information

Data Quality Assessment and Transformations

When both the mother (female) and the father (male) were identified as in-charge in native pig farming, the value 'female' was used to highlight the participation of the female in native pig farming. For educational attainment, the highest educational attainment obtained between the mother and the father, and among children was used. In income questions answerable by 'yes' or 'no', a lack of answer was assigned as 'no'. For production objective, cultural, savings, and others were grouped as 'non-income', and when both 'major income' and 'added income' were identified, only the 'major income' was retained for analysis. For selling price, the prices of 'ready-to-breed animals' and 'slaughter pigs' and *lechon* were considered as the selling price for *lechon* pigs. Although respondents were asked for both prices, only one was provided. When the prices were provided at minimum and maximum amounts, the average was used. Adult pigs for *lechon* were identified as *lechon* or slaughter pigs. The selling prices in Nueva Vizcaya, which were relatively higher than average, were based on market prices during the African Swine Fever (ASF) outbreak, as the survey was conducted at that time. Prices in all other locations were based on pre-ASF rates, as specified during the interviews. In Marinduque, prices identified per kilogram were converted to price per head by multiplying by 30 kg for adult pigs and 10 kg for piglets. For Marinduque and Benguet, selling points were categorized as trader, processor, personal consumer (if not among the provided options), or 'farm' if left blank. This adjustment affected n = 54 and n = 61 respondents, respectively. When 'no derived income' was declared, details of the selling price and selling place were not considered, which affected n = 3 respondents. Furthermore, for questions on 'income from' (piglets, *lechon*, kinilo, sow or boar) and 'income derived' (yes or no), those who answered 'no' to 'income from' were also assigned 'no' to 'income derived', which affected n = 14 from Kalinga and n = 1 from Marinduque. For those with 'non-income' production objectives, income earned was allowed since buyers were available, which affected n = 60 respondents (n = 4 in Isabela, n = 31 in Kalinga, n = 15 in Marinduque, n = 4 in Quezon, n = 5 in Eastern Samar and n = 1 in Nueva Vizcaya).

For the production expense, blanks on the amount were considered as having 'no expense'. Nutrition expenses (Php) per day converted to monthly expenses by multiplying with 30. Housing expenses categorized as 'with expense' and those provided with a cost were both classified as 'with expense'. If no amount was provided, they were reassigned to 'no expense' (n = 1, Quezon). Responses indicating 'no expense', left blank, or missing an amount were all assigned as 'no expense'.

For the frequency of income question, when two answers were given, only the most frequent one was considered (e.g., monthly and quarterly were reassigned to monthly), Both 'monthly' and 'quarterly' were then categorized as 'frequent'. The final dataset included complete information for n = 396 respondents for multivariate analysis and n = 432 for univariate analysis (with missing data).

List of Challenges

For the question on challenges faced by farmers, respondents were provided with a set of options grouped into production-related and trait-related challenges. The production-related challenges included feed cost, feed availability, cost of medicines, housing issues, lack of medicines, susceptibility to disease, marketing of animals and products, sources of stocks, access to loans and capital, access to slaughterhouses, labor intensiveness, input price fluctuation, high expenses, lack of veterinary services, boar semen availability, artificial insemination (AI) service, castration services, and none. The trait-related options included low litter size, high litter size, poor meat quality, high mortality in young animals, piglet mortality, slow growth rate, being smaller than white breeds, disease susceptibility, and none (absence of pig trait-related challenges).