Evaluation of genetic diversity of the Philippine native pigs and socio-cultural perspective of farmers towards conservation management and breeding

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SUMMARY

This study was conducted to characterize the native pigs in the Philippines with the ultimate goal of promoting its utilization in the achievement of national food security. Despite the local interest in the native pig, few studies have considered to explore the genetics of the pig from various provinces in Luzon and Visayas, Philippines. Moreover, few studies have examined farmer trait preferences at the multi-province level. We analyzed the genetics and morphology of the native pig and determined the production objectives and trait preferences of the farmers to inform interventions. The genetics of the Philippine native pig is complex, having originated from multiple domestication centers in Asia (Chapter 2) and having population structures at the province level (Chapter 3). This diversity can be observed physically between North Luzon lowland, South Luzon and Visayan pigs (Chapter 4). On the other hand, farmer typology revealed the existence of 3 types of native pig farmers that differed in demographics, production objective and trait preferences (Chapter 5). The findings of this study have several implications for an effective intervention program in the Philippines, in the aspects of genetic conservation, improvement and utilization.

Chapter 2. Multiple ancestry of the native pig

The native pigs are locally called native by virtue of their adaptation to Philippine conditions, however, various studies showed that the native pigs were introduced to the Philippines via human-mediated migrations (Inggico et al., 2017; Amano and Piper, 2013; Piper et al., 2009).

We analyzed the genetic lineage of the Philippine native pig, from the provinces of Benguet (B), Kalinga (K), Isabela (I), Nueva Vizcaya (N), Quezon (Q), Marinduque (M) and Eastern Samar (S), using the mitochondrial DNA (mtDNA) D-loop region. Combined phylogenetic and haplotype analysis showed that the Philippine native pigs belong to the Asian clade and clustered into 4 mtDNA signatures or haplogroups, i.e., the Cordillera cluster (CC), North Luzon cluster (NLC), South Luzon and Visayas cluster (SLVC) and Asian Mix cluster (AMC), which corresponds to domestication (D) centers in Cordillera/Lanyu clade, East Asia (D2) and Southeast Asia (D7). The CC constitutes a distinct node (with 98% bootstrap support) in the phylogenetic tree, which we refer to as the Cordillera clade. Further analysis showed that the Cordillera clade is sister to the Lanyu. The Cordillera clade is composed of pigs primarily from the Cordillera region (Kalinga, Benguet and Mountain Province), Nueva Vizcaya, Isabela and Batanes Island. On the other hand, pigs from NLC and AMC belong to the East Asian clade (D2), while pigs from SLVC belong to the Southeast Asian clade (D7). In summary, this study has shown that the native pigs in the Philippines have originated from multiple independent domestications of the Asian-type *Sus scrofa* wild ancestor. Furthermore, one pig from Kalinga clustered with the endemic wild pig *S. philippensis*. Although the current study is based on a maternally inherited region of the DNA, the findings suggest the existence of a highly diverse population of native pigs in the Philippines. There is, therefore, a definite need for careful management of pigs to conserve biodiversity.

Chapter 3. Population structure and conservation priorities

We further aimed to explore the population structure and genetic diversity of the native pig and to identify conservation priorities. Microsatellite analysis showed that the native pig exhibited a population structure with at least 7 distinct populations, roughly corresponding to the 7 provinces B, K, I, N, Q, M and S. Conservation priorities based on the effective population size

(*Ne*) suggest an immediate focus on the B, I, Q and S populations (*Ne* below 50). However, all native pig populations are below the ideal *Ne* of 500-5000, therefore, all native pig populations can benefit from conservation actions. In addition, our findings suggest a low admixture between native pigs and transboundary breeds, Duroc, Large White and Landrace, which are the major breeds of pigs farmed in the Philippines. This study has shown that the native pigs in the Philippines are highly diverse with distinct genetic groups in each province. Two possible applications of our results would be, (*i*) in harnessing the economic benefit of heterosis by crossbreeding of the native pigs (to B, to each other, or to transboundary breeds), and (*ii*) in the greater efforts needed to ensure the maintenance of between-breed diversity, both between native pig populations and between native and transboundary breeds.

Chapter 4. Physical characters of the native pig

This study set out to investigate the morphological differences between pigs at the province level and the island level. Our results show that the pigs of North Luzon lowland (K, I and N), South Luzon (M) and Visayas (S) can be discriminated based on physical parameters. The top 3 most discriminating variables are the ratio variables of tail length to body length, ear length to body length, and snout length to head length. North Luzon highland pigs of B, however, are not discriminated from North Luzon lowland and Visayan pigs. Pigs from B, which possess a unique mtDNA signature, may be discriminated by DNA analysis. This study has shown that physical parameters of the pig may discriminate between island populations. The findings suggest the possibility of assigning various populations based on morphometric data alone. The results of this study can guide future breeding and conservation efforts.

In addition, cluster analysis showed that pigs can be grouped into 2 clusters, referred to as medium-sized and small-sized pigs. The groupings did not correlate with geographic proximity, thus, suggesting that management may have played a significant role in their physical variation.

Medium-sized pigs were from M and I, while small-sized pigs were from B, K, N and S. The body weights of medium-sized pigs were 34 to 48 kg, and those small-sized were 13 to 31 kg. The medium-sized pigs have the advantage, in terms of *lechon*, of an earlier market offtake. Our findings show that the overall body size is not dependent on the mtDNA signature of the pig (i.e., M and S are both from SLVC, while I, N and K are from NLC). One implication of our findings is that despite a common genetic background native pigs can grow bigger through management.

On the other hand, we examined the reproductive traits of the native pig in terms of teat count and litter size. In general, higher teat counts were observed in medium-sized pigs (M and I) and lower teat counts in pigs from Cordillera (B and K), with a difference of 2 teats on each side (for a total of 4). On the other hand, litter sizes born alive range from 6.1 (K) to 8.6 (Q). Our results show that the native pigs are not only physically different, but their reproductive traits, i.e., teat count and litter size were also variable. This study shows that native pigs of various provinces in the Philippines differ in reproduction traits. This is consistent with the previous findings (Chapter 3) that the 7 populations are genetically distinct. Research is also needed to determine differences in the production performance of native pigs when raised in a similar environment.

Chapter 5. Farmer typology and the native pig production system

This study set out to examine farmer typology by incorporating demographics, trait preferences and production objectives. Understanding the trait preferences of farmers is important in the proper design of interventions, such as breeding programs. Cluster analysis showed that farmers can be grouped into 3 types. These are (*i*) the product-oriented farmer, who is relatively educated, predominantly female and aims to earn supplemental income from the pig (type 1, *n* = 108), (*ii*) the farmer with a classic mixed-farm system of crops, ruminants and poultry, who

is also predominantly female and aims to earn supplemental income from the pig (type 2, n = 229), and (*iii*) the income-driven farmer who is predominantly male and intends to earn major income from the pig (type 3, n = 59). These results provide a significant first step towards improving intervention programs by matching with the specific type of farmer and their needs.

We examined the production practices of the farmers to identify areas for improvement and interventions. Majority of farmers spend money on nutrition, but not on labor, housing and healthcare. Farmers give regular or supplemental feeding of plant-based feeds that are primarily carbohydrate-rich and fiber-rich, but low in protein. Major production challenges identified were feed cost, feed availability and price fluctuations. Our findings suggest a necessary improvement in the nutrition management of native pigs, especially in terms of providing more protein and lowering feed costs. A further study could assess feed formulation or mixes with balanced nutrition and affordable cost.

We further identified the various disposals (means of removal of the surplus meat) of the native pig. In addition to home consumption, all farmers sell piglets to derive income. Despite the increasing popularity of native pigs in the *lechon* industry, only the farmers in M, N, Q and S derive income from this market (B, K and I do not). For B and I, retail pork is the main form for selling adult native pigs. In K, the live pig is sold live for rituals and celebrations. On the other hand, the majority of farmers have shown willingness to undergo training on meat processing. In summary, farmers earn income from the pig by means other than *lechon*. They also earn income from selling of piglets, sale of pork, processed into meat products, and sale of live pigs for rituals and celebrations (in indigenous communities of Cordillera). These findings suggest several courses of action for promoting the sustainable use of native pigs for livelihood and food security in the Philippines. For example, in addition to promoting the native pig for *lechon*, it is also recommended to promote traditional meat products and conduct capacity-building activities for farmers on meat processing.

Economic reasons should not be at the cost of biodiversity. We show that native pig farmers in the Philippines are not all responsive to economic pressures, and when they do, there are various interventions that are proposed for the greatest impact. The information gathered in this study can be used to develop targeted interventions aimed at the conservation and utilization of the Philippine native pig. One key policy priority should be to plan for the long-term maintenance of between-population diversity among native pig populations and, at the same time, maximize economic benefit to the farmers.