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Overview of H'Mong Cattle - A Valuable Livestock Genetic Resource in Vietnam

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Abstract

H'Mong cattle are considered to have several advantages over other local cattle in Vietnam, serving as a valuable livestock genetic resource. This breed is not only a primary livelihood but also a source of pride deeply tied to the cultural identity of the H'Mong people. Several research and development projects have been undertaken to utilize this cattle breed. This paper reviews available research findings to provide an overview of the breed's origins, actual strengths and weaknesses, and proposes sustainable solutions for its utilization.

Keywords

H'Mong cattle, genetic resource, meat productivity, beef quality

Introduction

H'Mong cattle are commonly raised by the H'Mong people and other ethnic minorities in the mountainous northern provinces of Vietnam. This breed is a crucial livelihood source and plays a significant role in shaping the unique cultural identity of the H'Mong people (Berthouly *et al*., 2010; Tran Hue Vien, 2016; Pham Van Gioi *et al.*, 2024). H'Mong cattle are considered superior to other local cattle breeds in Vietnam; particularly, their meat is known for being fragrant, tasty, tender, and finely textured (NIAS, 2004).

While no statistical figures for the nationwide population of H'Mong cattle are readily available, the breed has been officially listed in Vietnam's domestic cattle production and trade catalog under Circular No. 01/2018/TT-BNNPTNT of the Ministry of Agriculture and Rural Development - MARD (2018) and is prohibited from export under Decree No. 13/2020/ND-CP of the Government (2020). Several projects and enterprises have invested in developing H'Mong cattle production. However, to effectively utilize this breed, it is essential to understand its true advantages and limitations based on scientific evidence. This paper aims to provide a comprehensive overview of H'Mong cattle, encompassing their origin,

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physical traits, productivity, reproductive performance, and adaptability. It also examines traditional husbandry practices among the H'Mong people and proposes research and development strategies for sustainable utilization of this cattle breed.

Origin of H'mong cattle

Historical background

H'Mong cattle have been officially recognized as an indigenous breed in Vietnam (NIAS, 2004; MARD, 2018). According to FAO (2007), an indigenous breed is one that has evolved in a particular geographic area and adapted to its environmental conditions and cultural practices. Nonetheless, there is currently no conclusive evidence confirming that H'Mong cattle were developed by the H'Mong people after their migration into Vietnam.

Another possibility is that the H'Mong brought these cattle with them during their migration to Vietnam, selecting them based on their ability to adapt to harsh mountainous conditions. Historically, the H'Mong people have been well-known for their agricultural practices, valuing cattle for their economic benefits; moreover, they cherish their cattle as precious possessions and symbols of strength and wealth. For this reason, it is likely that they carried their characteristic cattle breed with them for livelihood and cultural preservation during their migration. Therefore, understanding the migration history of the H'Mong people may provide more insights into the origin of this breed.

The H'Mong people were displaced from their ancestral lands in the Yellow River Basin approximately 4,000-5,000 years ago due to conflicts with Chinese dynasties. They migrated southward to remote mountainous regions, settling in areas across Southwest China, Vietnam, Laos, Thailand, and Myanmar. Three major waves of migration into Vietnam occurred between the 17th and 19th centuries to escape persecution following their failed resistance against the Qing Dynasty's policies: the first in the late 17th to early 18th century, the second between 1796-1820, and the third between 1840-1868 (Vu Quoc Khanh & Hoang Thanh Lich, 2013). It is, therefore, likely that H'Mong cattle accompanied their owners during this migration.

The exact origin of H'Mong cattle remains uncertain based on current historical evidence. Two main hypotheses warrant further investigation: (1) H'Mong cattle were developed by the H'Mong people within the northern mountainous regions of Vietnam after their settlement, or (2) the breed was introduced from China during their migration. Genetic research findings may help clarify these possibilities.

Genetic and taxonomic status

There have been several studies to analyze the genetic makeup of H'Mong cattle. Pham Doan Lan *et al.* (2008) utilized 23 microsatellite loci to analyze 530 cattle samples from eight districts in Ha Giang province, which is well known for H'Mong cattle. The results showed that the observed heterozygosity (Ho) reached 0.67 and the expected heterozygosity (He) was 0.73, while the FST index among populations was very low (0.013), indicating a genetically homogeneous structure and a high level of genetic diversity within the H'Mong cattle population. In addition, the study revealed that the cattle population in the province was divided into two main groups (subpopulations).

Berthouly *et al*. (2010) analyzed single-nucleotide polymorphisms (SNPs) in the SRY gene and the mitochondrial DNA (mtDNA) D-Loop sequence to investigate the genetic origin of H'Mong cattle. Their study involved 408 animals sampled across eight districts in Ha Giang province. The observed heterozygosity ranged from 0.616 to 0.673, while the expected heterozygosity varied between 0.681 and 0.729, depending on the district. Genetic differentiation among districts was low (FST = 0.0076). A multivariate analysis of morphometric and genetic data also revealed two distinct subpopulations of H'Mong cattle, aligning with the southwestern and northeastern regions. This differentiation is likely due to geographical isolation and differences in farming practices. Notably, genetic analysis showed that all sampled animals possessed zebu-type Y chromosomes, whereas the mtDNA analysis

revealed a mix of taurine and zebu maternal lineages. Both subpopulations exhibited similar levels of taurine introgression.

It is important to know from a mitochondrial DNA analysis by Le Trung Thanh *et al*. (2013) that H'Mong cattle show a clear genetic distinction from other local breeds. This genetic separation indicates that H'Mong cattle possess a distinct genetic origin, reflecting their unique evolutionary lineage and limited introgression with local or imported breeds. The analysis also revealed a high level of genetic diversity of H'Mong cattle, with an observed heterozygosity (Ho) of 0.65 and an expected heterozygosity (He) of 0.68.

The presence of both taurine and zebu maternal lineages in the Ha Giang cattle population mirrors the genetic pattern observed in South Chinese cattle. According to Cai *et al*. (2006), these cattle possess zebu-type Y chromosomes, while Lei *et al*. (2006) reported that most of the Chinese cattle breeds sampled exhibited both taurine and zebu mtDNA, indicating maternal introgression from taurine cattle. This zebu-taurine admixture was confirmed by the intermediate position of the H'Mong population between the taurine and zebu clades in the neighbor-joining (NJ) tree based on microsatellite data (Berthouly *et al*., 2010).

These findings suggest that H'Mong cattle share genetic similarities with South Chinese cattle. This genetic affinity likely stems from historical hybridization events between zebu (*Bos indicus*) and taurine (*Bos taurus*) lineages (Zhang *et al*., 2007). Given the migratory history of the H'Mong people and their longstanding reliance on livestock for both their livelihood and cultural identity, it is plausible that such crossbreeding occurred prior to the stabilization of the breed's current genetic structure (Berthouly *et al*., 2010). Taken together, the genetic evidence and migratory history support the hypothesis that H'Mong cattle were brought into Vietnam by the H'Mong people during their southward migration from China, rather than being developed locally from other indigenous Vietnamese breeds after their settlement. However, their distinct genetic profile, long-standing adaptation to local highland ecosystems, and deep cultural integration justify their recognition as an indigenous Vietnamese cattle breed.

Physical Characteristics

Morphological characteristics

H'Mong cattle are characterized by a slightly concave back, long legs, a prominent or flat forehead, a relatively broad dewlap, small horizontally oriented ears, and short horns that curve upward and slightly forward together with a sloping rump (Nguyen Xuan Trach *et al*., 2021). Bulls tend to have elongated bodies, a relatively high shoulder hump, and a muscular, well-defined build, whereas cows display a smaller shoulder hump but a large udder (Tran Hue Vien, 2016).

The breed displays a wide range of coat colors, with light yellow being the most common, alongside variations such as chestnut, dark red, and jet black (Berthouly *et al*., 2010; Nguyen Xuan Trach *et al*., 2021). Their eyes and eyelashes often carry a yellowish tint, and the corners of their eyes are notably bright yellow (NIAS, 2004).

Overall, H'Mong cattle share several morphological traits with zebu cattle, such as the presence of a hump, a dewlap, and a sloping rump. However, these features are less pronounced in H'Mong cattle, as the hump and dewlap are modestly developed, the skin is less wrinkled, and the ears are neither large nor pendulous, unlike typical zebu cattle. In fact, H'Mong cattle exhibit a smaller, forward-sloping hump characteristic of Chinese cattle types (Berthouly *et al*., 2010). Although this feature points to zebu ancestry, it is important to recognize that many modern humped breeds, including Yunnan Yellow and Nayang Chinese cattle, resulted from historical crossbreeding between *Bos indicus* and *Bos taurus* cattle (Cai *et al*., 2006). Consequently, the general morphology of H'Mong cattle closely resembles that of the Southern Yellow cattle group, consistent with the aforementioned genetic findings and their intermediate characteristics between Indian zebu and European taurine breeds.

Body size

Table 1 summarizes the findings of various surveys on the body weights of H'Mong cattle across different age groups. As the data show, there is considerable variation among studies. This disparity may stem from differences in farming systems and environmental conditions across the surveyed locations. Additionally, the lack of standardized recording and measurement protocols, often relying on farmers' recollections of animal age, may contribute to inconsistent data. Furthermore, the observed variations could partially reflect the genetic diversity within the H'Mong cattle population, as previously discussed.

Male H'Mong cattle typically stand between 104 and 110.5cm tall, while females range from 102 to 104cm in height. This compact stature makes them well-adapted for draught work in mountainous regions (Berthouly *et al*., 2010).

The average body weights of H'Mong male and female cattle, calculated from the available data in **Table 1**, are approximately 16.9kg and 15.7kg at birth, 87.5kg and 78.3kg at 6 months, 134.8kg and 130.1kg at 12 months, 237.2kg and 220.5kg at 24 four months, and 398.3kg and 261.7kg at maturity, respectively. These figures suggest that H'Mong cattle are generally larger than the indigenous Yellow cattle, which typically reach 200-250kg for mature males and 180-200kg for mature females (Dinh Van Cai, 2007; Nguyen Xuan Trach *et al*., 2021). They are comparable to Sindhi crossbreds, which range from 350-450kg in males and 250-300kg in females at maturity (Dinh Van Cai, 2007; Nguyen Xuan Trach *et al*., 2021). Nonetheless, H'Mong cattle remain significantly smaller than most modern commercial breeds. For instance, Hanwoo cattle typically weigh between 600 and 800kg by 25-30 months of age (Jeong *et al*., 2013). Brahman bulls can range from 800 to 1,100kg, while cows weigh between 500 and 700kg (McGee *et al*., 2009). Mature Boran bulls in Kenya usually weigh 550-850kg, with cows between 400 and 550kg (Rege *et al*., 2001). Red Angus bulls average around 900kg, and cows approximately 635kg (Thrift & Thrift, 2004).

Table 1. Body weights (kg) of H'Mong cattle by age and sex

Age	Males	Females	Source
Birth	15-16	15-16	National Institute of Animal Sciences (2004)
	18.92	16.18	Trinh Quang Phong *et al.* (2006)
	17-18	14-16	Dao Lan Nhi (2012)
	17.34	16.87	Tran Van Thang *et al.* (2014); Tran Hue Vien (2016)
	16.25	15.72	Nguyen Thi Ngoan *et al.* (2015)
6 months	87.45	78.34	Tran Van Thang *et al.* (2014)
12 months	141.41	137.92	Nguyen Thi Ngoan *et al.* (2015)
	128.23	122.34	Trinh Quang Phong *et al.* (2006)
24 months	233-275	216-225	Dao Lan Nhi (2012)
	321.3	267.4	Tran Hue Vien (2016)
Mature	397.83	261.86	Nguyen Thi Ngoan *et al.* (2015)
	380-390	250-270	National Institute of Animal Science (2004)
	400-450	250-280	Nguyen Van Niem *et al.* (2001)
	382-388	250-270	Dao Lan Nhi (2012)

Meat Productivity

Growth rate and meat yields

The available research findings on the average daily gain (ADG) of H'Mong cattle by growth stage under traditional husbandry conditions are summarized in **Table 2**. While none of the studies encompassed all growth stages and each was conducted under varying, non-standardized conditions, the variable data collectively suggest that the growth rate of H'Mong cattle is very low. However, the ADG improved when cattle were fattened with a traditional diet (**Table 3**) or, especially, with an enriched diet (**Table 4**).

The fattening ADG of H'Mong cattle, varying widely depending on age (**Table 3**) and diet quality (**Table 4**), is generally comparable to that of the indigenous Yellow cattle and Sindhi crossbreds. For instance, Le Viet Ly *et al.* (1995) reported ADG values ranging from 0.51 to 0.58kg for Yellow cattle fattened on agricultural byproducts. Dung *et al.* (2013) observed ADG values between 0.43 and 0.69kg for Sindhi crossbreds fattened in Central Vietnam. In other regions, Sindhi crossbreds achieved 657.78g in Dak Lak (Pham The Hue *et al*., 2008) and up to 970g in Tuyen Quang (Dinh Van Tuyen *et al*., 2008). In contrast, the ADG of H'Mong cattle is significantly lower than that of Brahman and Red Angus crossbreds raised under Vietnamese conditions. Brahman cattle reached an ADG of 1,420g in Tuyen Quang (Dinh Van Tuyen *et al*., 2008). Crossbreeding Red Angus, Brahman, and Droght Master bulls with Sindhi crossbred cows yielded offspring with ADG values between 801.1 and 882.2g (Truong La *et al.*, 2017). In Kenya, the ADG was 1.07kg for improved Boran

Table 2. Growth rate of H'Mong cattle by growth stage

Growth stage	Average daily gain (g head^{-1} day^{-1})		Source
	Males	Females	
Birth-6 months	406.16	341.50	Tran Van Thang *et al.* (2014)
	300.61	291.50	Tran Hue Vien (2016)
6-12 months	267.89	240.11	Tran Hue Vien (2016)
12-24 months	197.50	168.11	Tran Hue Vien (2016)
18-24 months (unsexed)	294		Nguyen Dam Thuyen (2012)
24-36 months (unsexed)	135		Nguyen Dam Thuyen (2012)
24-36 months	148.50	108.42	Tran Hue Vien (2016)

Table 3. Meat yields of intact male H'Mong cattle fattened on a traditional diet at different ages

Parameters	Fattening age (years)		
	2	3	4
Initial weight (kg)	337.2	369.2	399.8
Slaughter weight (kg)	392.00	414.33	435.33
Carcass yield (kg)	213.48	226.27	237.01
Average daily gain (kg/head/day)	0.540	0.387	0.323
Feed conversion ratio (FCR)	12.41	17.38	20.89
Dressing percentage (%)	55.46	54.61	54.44

Source: Hoang Xuan Truong (2018).

x Sahiwal, 0.924kg for improved Boran, and 0.645kg for zebu cattle fattened on silage and grass-based rations (Tura *et al.*, 2024).

The FCR values reported in **Tables 3 and 4** are relatively high, especially when the H'Mong cattle were fattened on traditional diets and at older ages. However, enhancing the quality of the diet led to notable improvements in FCR, primarily due to increased ADG as shown in **Table 3**. In comparison, Sindhi crossbreds exhibit moderately better feed efficiency, with FCRs ranging from 8.5 to 10.0 according to Pham Van Gioi *et al.* (2023), and from 8.48 to 14.0 as reported by Dung *et al.* (2013). Comparatively, improved Boran and Boran x Sahiwal cattle finished on silage and grass-based rations in Kenya showed FCR averages of 12.87 and 12.23, respectively (Tura *et al.*, 2024).

According to Hoang Xuan Truong (2018), the average dressing percentage of H'Mong cattle fattened on a traditional diet was approximately 55% (**Table 3**), which is slightly higher than the 52.12% reported by Nguyen Van Niem *et al.* (2001) and the 50-52% noted by Dao Lan Nhi (2001) for H'Mong cattle. When compared to native Yellow cattle with an average dressing percentage of about 38-44% (Dinh Van Cai, 2007; Nguyen Xuan Ba *et al*., 2020), H'Mong cattle exhibit markedly higher values. Their dressing percentage is also comparable to that of Sindhi crossbreds, 48-55% (Dinh Van Cai, 2007; Nguyen Xuan Trach *et al*., 2021), and similar to Boran cattle managed under traditional conditions, reported at 50-55% (Ojango *et al*., 2006). However, H'Mong cattle fall short when compared to Hanwoo cattle, which typically achieve a dressing percentage of 58-62% (Park *et al*., 2014).

Meat quality

While H'Mong cattle are praised for their fragrant, flavorful, tender, and finely textured meat (NIAS, 2004), scientific data on the breed's meat quality remain limited. To date, Hoang Xuan Truong (2018) has provided the most comprehensive evaluation of H'Mong beef quality, based on animals fattened between 2-4 years of age (see **Table 5**). In addition, Tran Hue Vien (2016) reported that H'Mong beef contains an average dry matter content of 23.41%, protein content of 20.14%, total mineral content of 1.02%, and fat content of 0.73%. The meat also includes nearly all essential amino acids, with particularly high levels of phenylalanine, lysine, leucine, isoleucine, threonine, valine, and methionine.

Beef fat content typically ranges from around 0.6% to 23.3% of the meat's weight (Sakowski *et al*., 2022). Hanwoo ribeye beef generally contains between 15% and 25% fat (Moon *et al*., 2020). When compared to these benchmarks, H'Mong beef exhibits a notably low fat content, as indicated by the value of 0.73% reported by Tran Hue Vien (2016) and 7.18-7.96% (of DM) by Hoang Xuan Truong (2018).

The assessment of pH levels in the longissimus muscle of fattened H'Mong cattle by Hoang Xuan Truong (2018) revealed values (in

Table 4. Meat yields of intact H'Mong cattle fattened on a traditional and enriched diet

Parameters	Fattening diets		
	D1	D2	D3
Initial weight (kg)	322.4	325.2	324.4
Slaughter weight (kg)	356.4	370.2	370.4
Average daily gain (kg head^{-1} day^{-1})	0.567	0.750	0.767
Feed conversion ratio (FCR)	11.82	9.61	9.43

Note: D1: Traditional fattening diet with 10.6% CP and 9.3 MJ kg^{-1} DM; D2: D1 supplemented with corn meal and soybean meal to have 12.07% CP and 9.9 MJ kg^{-1} DM; D3: D1 supplemented with cassava and soybean meal to have 12.13% CP and 10.31 MJ kg^{-1} DM. Source: Hoang Xuan Truong (2018).

Table 5. Indicators of meat quality of H'Mong cattle fattened at different ages

Indicators	Fattening age (years)		
	2	3	4
Chemical composition			
Dry matter (%)	25.35	25.03	25.10
Protein (%DM)	77.48	77.24	77.12
Total minerals (%DM)	3.67	3.68	3.78
Fat (%DM)	7.18	7.55	7.96
pH			
After 45 minutes	6.62	6.87	6.82
After 24 hours	5.57	5.72	5.67
After 48 hours	5.61	5.59	5.56
Color (after 48h)			
Lightness (L*)	42.57	39.34	37.05
Redness (a*)	21.11	20.73	20.82
Yellowness (b*)	10.14	10.88	11.03
Storage/processing water loss (%)			
After 24 hours	1.92/37.03	1.78/32.62	1.40/31.18
After 48 hours	2.35/38.50	1.73/35.50	1.52/34.45
Toughness (N)			
After 24 hours	65.10	70.00	86.50
After 48 hours	64.21	69.04	84.31

Source: Hoang Xuan Truong (2018)

Table 5) similar to those observed in fattened Yellow cattle across various ages (Trinh Van Tuan *et al.*, 2013) and F1 Brahman × Sindhi crossbreds (Pham The Hue *et al.*, 2008). The pH values of H'Mong beef align with the standards established by the United States Department of Agriculture (USDA, 1997), which stipulate that muscle pH should be below 5.8 after 48 hours of postmortem storage.

In terms of coloration, H'Mong beef tends to exhibit higher brightness, redness, and yellowness (**Table 5**) compared to Thai cattle, F1 Brahman, and F1 Charolais, with respective L* values of 37.76, 35.01, and 38.76; a* values of 15.07, 16.05, and 16.35; and b* values of 4.27, 5.07, and 5.09 (Setthakul *et al.*, 2008). As noted by Honikel (1997), normal beef typically has an L* value ranging from 35 to 40, indicating that the color profile of H'Mong beef falls within the acceptable and desirable range for fresh beef.

The water loss percentage in H'Mong beef after 48 hours of storage is comparable to that observed in Sindhi crossbreds, F1 Brahman × Sindhi crossbreds, and F1 Charolais × Sindhi crossbreds, reported at 1.44%, 1.80%, and 2.34%, respectively (Pham The Hue *et al.*, 2008). Similarly, the cooking water loss after 48 hours in H'Mong beef aligns with the values found in Yellow and Sindhi crossbreds, at 37.57% and 36.68%, respectively (Do Duc Luc *et al.*, 2009).

Although H'Mong beef exhibits lower water loss during storage, it demonstrates a higher cooking water loss compared to local Thai cattle, which showed storage losses of 4.32-5.14% and cooking losses of 32.54-32.84% (Setthakul *et al.*, 2008).

Although the tenderness of H'Mong beef tends to decline with increasing fattening age (**Table 5**), it remains superior to that of several other cattle breeds. Specifically, its shear force values are lower than those recorded for Sindhi crossbreds, F1 Brahman × Sindhi crossbreds, and F1 Charolais × Sindhi crossbreds, which were measured at 100.61 N, 101.85 N, and 91.87 N, respectively (Pham The Hue *et al.*, 2008). H'Mong beef is also more tender than meat from Yellow cattle in Son La (115.12 N) and Thai cattle (113.34 N) according to Trinh Van Tuan *et al.* (2013). When fattened at 2-3 years of age, H'Mong beef exhibits tenderness levels comparable to tropical beef breeds such as Brahman (73 N) and Boran cattle (66 N) (Cundiff *et al.*, 1997). Based on the USDA (1997) beef tenderness classification system, H'Mong beef falls within the medium tenderness category.

Overall, H'Mong beef exhibits normal color characteristics, pH levels, and water retention properties. Notably, it is more tender than meat from local Yellow cattle and Sindhi crossbreeds, placing it on par with tropical beef breeds in terms of tenderness. However, the marbling fat content in H'Mong beef is very low, which may negatively impact its nutritional value, flavor, and juiciness. Unfortunately, there is a lack of available sensory evaluation data, taste panel results, and detailed fatty acid profiles. This highlights the need for more comprehensive and in-depth research to fully assess the meat quality of H'Mong cattle.

Reproductive Performance

Milk production

As shown in **Table 6**, H'Mong cows exhibit moderate to low reproductive performance, with first calving occurring at 33.0-36.8 months, calving intervals ranging from 12.8 to 17.2 months, and a conception rate at first insemination of only 45.3%. Compared to other tropical breeds, H'Mong cattle have slightly poorer fertility than Vietnamese Yellow cattle, which calve for the first time at 31.7-32.9 months and have shorter calving intervals of 12.8-13.0 months (Nguyen Minh Hoan, 2021). However, they perform better than Boran cattle, which calve first at around 41.2 months with a calving interval of 15.9 months (Gulelat *et al.*, 2015), and Brahman cows, which reach first calving at 53.3 months and have calving intervals of about 18.6 months (Osorio-Arce & Segura-Correa, 2010).

A summary of study results on the semen production capacity of H'Mong bulls (**Table 7**) shows a relatively high ejaculation volume with all biological semen parameters meeting the standards for frozen semen production.

The considerable variability in the reported data highlights the need for more rigorous and standardized studies to better understand the factors affecting reproductive performance in

Table 6. Reproductive performance of H'Mong cows

Parameters	Value	Source
Age at first calving (months)	33.44	Tran Xuan Vu (2012)
	33-35	Dao Lan Nhi (2012)
	36.78	Tran Hue Vien (2016)
Return to estrus after calving (months)	3.58	Tran Hue Vien (2016)
Conception rate at first insemination (%)	45.28	Tran Xuan Vu (2012)
Calving interval (months)	17.23	Tran Xuan Vu (2012)
	12.79	Tran Hue Vien (2016)

Table 7. Semen production capacity of H'Mong bulls

Parameters	Value	Source
Ejaculate volume (V, mL)	4.37	Tran Xuan Vu (2012)
	4.43	Trinh Xuan Binh (2013)
	4.50 (summer-autumn season) 6.10 (winter-spring season)	Trinh Quang Phong & Phan Van Kiem (2006)
Sperm activity (A, %)	67.98	Tran Xuan Vu (2012)
	68.97	Trinh Xuan Binh (2013)
	70 before freezing, 30 after freezing in summer-autumn season; 80 before freezing, 35 after freezing in winter-spring season	Trinh Quang Phong & Phan Van Kiem (2006)
Sperm concentration (C, billion/mL)	0.84	Tran Xuan Vu (2012)
	0.85	Trinh Xuan Binh (2013)
	0.85 (summer-autumn season) 0.98 (winter-spring season)	Trinh Quang Phong & Phan Van Kiem (2006)
Total progressive sperm count (billion)	2.5	Tran Xuan Vu (2012)
Abnormal morphology rate (%)	16.26	Tran Xuan Vu (2012)
	16.57	Trinh Xuan Binh (2013)
Post-thaw sperm survival rate (%)	83.47	Trinh Xuan Binh (2013)
Semen pH	6.74	Tran Xuan Vu (2012)

H'Mong cattle. Since fertility outcomes are highly influenced by nutrition, genetics, management practices, and environmental conditions, there remains strong potential for improvement. Enhancing these areas, particularly through targeted breeding, advanced reproductive technologies, and improved herd management, could significantly boost reproductive efficiency and overall productivity in this breed.

Adaptability

Along with the H'Mong people, H'Mong cattle have lived in semi-isolation at altitudes greater than 1000 meters above sea level (Berthouly *et al*., 2010). They are well adapted to the ecological conditions of high mountain regions, tolerant of cold, and capable of enduring harsh conditions. This makes them highly suitable for the traditional care and farming practices of the H'Mong people and other ethnic minorities who live in high, rugged mountainous areas and use the cattle for draught power (Berthouly *et al*., 2010; Tran Van Thang *et al*., 2014).

Traditional Husbandry Systems and Pratices

Husbandry systems

H'Mong cattle are integral to the traditional agropastoral systems of the H'Mong and other highland ethnic groups (Berthouly *et al.*, 2010). According to Hoang Xuan Truong (2018), a survey in Ha Quang district, Cao Bang province revealed that all H'Mong households (100%) kept this cattle breed. Cattle are typically raised as part of mixed crop-livestock systems, with most households keeping small herds of one to three animals. While reproduction remains the primary purpose of cattle rearing, some households also use the animals for draft power and meat production (Tran Hue Vien, 2016; Pham Van Gioi *et al.*, 2024).

According to Tran Hue Vien (2016), Hoang Xuan Truong *et al*. (2017), and Pham Van Gioi *et al*. (2024), the H'Mong people have two main cattle husbandry systems: semi-grazing and stall-feeding.

(i) *Semi-grazing:* This system is mainly applied to breeding cows. On warm, sunny days, cows and calves are grazed in forests, along roadsides, and in areas with forage plants. Farmers often combine grazing with their fieldwork. While working, they collect and carry back natural grass and agricultural by-products to feed their cattle. Newly calved cows are given additional concentrate feed.

(ii) *Stall-feeding:* This system is mainly used for bulls. Stall-fed bulls are typically allowed to exercise outside their pens for only 2-4 hours per week on sunny or dry days under supervision. During the winter months, both cows and calves are also stall-fed. Farmers cut and carry grass and fodder plants to the pens and supplement the cattle's diet with concentrate feed, salt, and warm water. Stall-fed bulls are fed twice daily with roughage and concentrate (cornmeal and bran). Concentrate feed is often cooked into porridge with sweet potato leaves, banana stems, taro, or certain chopped forest leaves and then fed in troughs. In the summer, some households mix cornmeal with water for additional feeding after grass consumption, along with salt-mixed drinking water.

Husbrandy and marketing practices

Based on the survey results from Tran Hue Vien (2016), Hoang Xuan Truong (2018), and Pham Van Gioi *et al.* (2024), the H'Mong cattle husbandry practices can be summarized as follows:

(i) Housing: Cattle pens are built separately from residential houses. The pens have sturdy raised wooden floors, often made of ironwood, ensuring cleanliness and preventing hoof diseases. They are well-ventilated in the summer, and during the winter, plastic sheets are used to retain warmth. The wooden pens are beneficial for cattle health, keeping hooves clean and dry while also facilitating waste management and manure collection.

(ii) Breeding: High-quality breeding bulls are kept and carefully managed. Households with cows in estrus bring them to those with superior bulls for natural mating. Bulls are rotated among villages to prevent inbreeding. A good bull is typically used for 2-3 years before being fattened for sale. Traditional breeding practices involve limited artificial insemination (AI).

(iii) Feeding: The H'Mong people primarily feed their cattle natural fodder supplemented with cultivated forage, agricultural by-products, and concentrate feed.

- *Natural fodder:* Households utilize available natural grasses and leaves as cattle feeds. Besides grass, farmers collect various forest leaves during the winter-spring season when natural grass growth is slow, cultivated forage is scarce, and corn stalks have been exhausted.

- *Cultivated fodder:* About one-third of H'Mong cattle farmers actively grow forage crops, mainly elephant grass (*Pennisetum purpureum*), VA06 grass (*Pennisetum purpureum x Pennisetum americanum*), Guatemala grass (*Tripsacum laxum*), cowpea (*Vigna unguiculata*), and banana (*Musa* spp.).

- *Agricultural by-products:* All households feed their cattle corn stalks, and a few also use peanut vines. Many households feed cattle with corn distillery residues, often mixed with chopped banana stems or sweet potato leaves.

- *Concentrate feed:* All cattle-raising households use cornmeal to some extent. Households raising cattle for multiple purposes supplement their cattle's diet with concentrate feed during the plowing, reproduction, and fattening phases. Those specializing in cattle fattening regularly provide 2-3kg of cornmeal per animal per day.

(iv) Marketing: When selling cattle, the H'Mong often take them to market fairs and consult experienced individuals for price estimates. They observe and negotiate with traders over multiple market sessions to determine a fair price. If the offer is unsatisfactory, they continue raising the cattle until they can secure a better price.

Despite their extensive experience in cattle farming, the H'Mong still face several limitations. Surveys by Pham Van Gioi *et al.* (2024) show that their cattle farming is largely based on traditional practices, relying on natural resources rather than scientific knowledge. Only a few households make silage (0.29%) or use mineral licking blocks (0.19%). Natural mating remains the dominant breeding method. Tran Hue Vien (2016) and Hoang Xuan Truong (2018) note that most households have not designated land for forage cultivation to ensure a stable roughage supply. Their ration formulation is based on experience rather than scientific nutritional principles.

Research and Developement Strategies

Genetic conservation

H'Mong cattle's adaptation to mountainous environments and their distinct genetic characteristics highlight the need for targeted conservation to safeguard their heritage and functional value. However, ongoing crossbreeding with other cattle breeds poses the threat of genetic dilution (Berthouly *et al*., 2010). To protect the breed's genetic integrity and adaptive traits, effective conservation strategies, both *in-situ* and *ex-situ* conservation, are crucial.

In-situ conservation

Maintaining H'Mong cattle within their native environment can help ensure the preservation of their unique adaptations to local ecological and cultural conditions as well as strengthen farmer engagement. The in-situ conservation of H'Mong cattle should focus on: (i) Traditional farming support to encourage the continuation of traditional husbandry systems that have preserved the breed's diversity; (ii) Farmer education programs to train local farmers in selective breeding techniques that emphasize desirable traits while minimizing inbreeding and preventing genetic dilution due to crossbreeding; and (iii) Community-based breeding programs to involve local communities in managing mating practices and selecting breeding bulls to maintain genetic integrity.

Ex-situ conservation

Ex-situ conservation involves the conservation of H'Mong cattle genetic material outside the cattle's natural habitat to safeguard its genetic material against disease outbreaks or population loss. Ex-situ conservation should be applied through: (i) Cryopreservation of semen, embryos, and DNA samples of representative individuals; (ii) Establishment of gene banks to store genetic material for future use in research or breed restoration; and (iii) Research herds to maintain small breeding populations at research institutions or universities for controlled studies and backup conservation.

Genetic characterization and protection

Given the limited number of genetic studies on H'Mong cattle, further research utilizing advanced genetic tools such as microsatellite markers, single nucleotide polymorphisms (SNPs), and mitochondrial DNA is crucial. Such studies should aim to: (i) evaluate genetic diversity in terms of heterozygosity and allelic richness; (ii) determine population structure and detect potential inbreeding; and (iii) monitor genetic changes over time resulting from selection pressures or admixture with other breeds.

To safeguard against genetic dilution, it is important to regulate crossbreeding with other breeds. Recommended strategies include: (i) establishing a registration and certification system for purebred H'Mong bulls; (ii) implementing AI programs using semen from genetically confirmed bulls; and (iii) developing designated breeding areas or "nucleus herds" exclusively for maintaining pure H'Mong cattle.

Genetic improvement for better beef production

H'Mong cattle exhibit substantial genetic variability, indicating strong potential for selective breeding aimed at enhancing beef production. Building on the breed's characteristics as previously discussed, a comprehensive breeding program should be developed with the following key objectives:

(i) Genetic improvement: Enhance traits related to meat production, including marbling, growth rate, carcass weight, and feed efficiency.

(ii) Conservation of native traits: Safeguard the breed's unique genetic identity and its adaptation to mountainous environments.

(iii) *Productivity enhancement*: Improve reproductive efficiency and overall farm profitability.

To achieve these goals, genetic selection should integrate traditional phenotypic approaches with modern genomic tools, including:

(i) *Estimated breeding values (EBVs)*: Selection based on traits such as growth rate, FCR, carcass quality, eye muscle area, intramuscular fat, and backfat thickness.

(ii) *Performance recording*: Systematic collection of phenotypic data through body measurements, ultrasound imaging, and carcass grading after slaughter.

(iii) *Genomic selection*: Application of SNP-based markers to predict performance and breeding value at an early stage.

Implementing such a program requires the development of robust infrastructure and a centralized genetic database. This database, ideally managed by a scientific institution, should integrate pedigree, performance, and genomic information to facilitate accurate breeding value estimations.

Moreover, reproductive technologies such as AI and embryo transfer should be employed to accelerate genetic progress. Establishing a national AI program would allow for the widespread dissemination of semen from elite, genetically superior bulls.

Through these coordinated efforts, the genetic quality and productivity of H'Mong cattle can be steadily and sustainably improved to make the breed better and better for beef production over time, while safeguarding the breed's unique genetic identity and its adaptation to local environments.

Nutritional improvement for better beef production

Improving the nutritional management of H'Mong cattle represents one of the most practical and impactful strategies for enhancing beef production. As previously discussed, H'Mong cattle typically feed in natural pastures, often low in protein, and on low-quality crop residues, with minimal supplementation. These limitations result in slow growth rates, high FCR, and delayed slaughter age. To address these challenges, nutritional interventions should be adapted to both the specific needs of the breed and the local environment, with the goal of optimizing meat yield, improving feed conversion efficiency, and enhancing beef quality, especially in terms of tenderness, marbling, unsaturated fatty acid content, and flavor. Therefore, the following strategies are recommended:

(i) Improved utilization of local forages

- Encourage the cultivation of nutrient-rich grasses for cattle feeding.
- Provide training for farmers on hay making, silage preparation, and treatment of byproducts to ensure adequate feed availability all year round.

(ii) Strategic supplementation

- Introduce feed supplements during critical growth and fattening stages.
- Supply mineral and vitamin blocks to address common micronutrient deficiencies.

(iii) Development of sustainable feeding systems

Further research is needed to:

- Develop feeding standards for different production stages (cow-calf, growth, and fattening).
- Identify the optimal ages for initiating fattening and for slaughter, based on growth curves, meat quality, and market demand.
- Formulate cost-effective rations using locally available feed resources, complemented by commercial feeds when necessary, to achieve better meat yield, meat quality, and economic returns.

Market integration and value chain development

Although H'Mong cattle have valuable traits, they are still underutilized due to: (1)

fragmented, small-scale production; (2) limited access to high-value markets; (3) lack of product differentiation and branding; and (4) poor infrastructure and weak linkages among producers, traders, processors, and consumers. Therefore, integrating H'Mong cattle into a structured, value-added beef value chain can: (1) enhance income and livelihood security for upland farmers; (2) incentivize genetic and nutritional improvements; (3) preserve the breed through economic relevance; and (4) meet growing domestic demand for high-quality, traceable beef. Therefore, the following key strategies for value chain development are recommended:

(i) Strengthening producer organizations

- Support the formation of producer groups or cooperatives to coordinate cattle production and marketing, strengthen bargaining power, and facilitate the sharing of breeding bulls, feed resources, and veterinary care.
- Implement capacity-building programs focusing on cooperative management, market engagement, and improved husbandry practices.

(ii) Enhancing market linkages and aggregation systems

- Develop village-level aggregation centers where cattle can be weighed, sorted by size or quality, and sold collectively to reduce transaction costs.
- Facilitate direct market linkages with slaughterhouses, supermarkets, and niche beef retailers.
- Encourage public-private partnerships (PPPs) involving local governments and agribusiness stakeholders to support logistics and investments.

(iii) Product differentiation and branding

- Create and promote a distinct regional brand, such as *"H'Mong Highland Beef"*, to emphasize the traditional mountain grazing practices, unique meat attributes, indigenous genetic heritage, and environmentally sustainable production.
- Explore options for geographical indication (GI) or eco-labeling to strengthen consumer recognition and market position.

(iv) Value-added processing and quality assurance

- Establish local-scale processing units equipped for pre-slaughter handling, chilling, and sanitation, as well as meat packaging for urban niche markets.
- Implement meat quality grading systems and ensure food safety certification.

(v) Access to market information and digital tools

- Provide real-time access to information on market prices, supply-demand trends, and service providers.
- Leverage mobile applications and rural communication channels to keep producers and traders informed and responsive to market signals.

Conclusions

Despite limited and sometimes inconsistent research, several key findings have emerged regarding H'Mong cattle:

(i) They likely originated outside Vietnam, accompanying the migration of H'Mong communities from southern China.

(ii) They exhibit superior body size and dressing percentage compared to native Yellow cattle, and are comparable to Sindhi crossbreds in these traits.

(iii) Their growth rates, feed conversion efficiency, and reproductive performance are generally low.

(iv) Their meat shows normal pH, color, and water-holding capacity, with tenderness superior to that of native Yellow cattle and zebu crossbreds, and comparable to tropical breeds like Brahman and Boran, though their intramuscular fat content remains limited.

(v) They are currently raised predominantly in smallholder systems that rely on traditional practices and locally available resources with minimal use of modern technologies or scientific inputs.

Given their unique genetic background and strong adaptation to mountainous environments, it is crucial to implement targeted conservation strategies to preserve the breed. Sustainable

utilization for beef production will require comprehensive genetic characterization, the development of scientifically guided breeding programs, and improved nutritional management to enhance growth, meat quality, and overall productivity. Simultaneously, integrating H'Mong cattle into a structured, value-added beef value chain, supported by branding and market development, will be essential for promoting both economic sustainability and cultural heritage conservation of this important indigenous resource.

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