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The potential of genetic resources and conservation of Gaga Chickens (*Gallus gallus domesticus*) in indonesia: a systematic review

Potensi sumber daya genetik dan pelestarian Ayam Gaga (Gallus gallus domesticus) di indonesia: a systematic review

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Abstrak. Penelitian ini bertujuan untuk menganalisis potensi, keragaman genetik, serta strategi pelestarian Ayam Gaga "Ketawa" (*Gallus gallus domesticus*), salah satu rumpun ayam lokal Indonesia dengan ciri khas bioakustik unik berupa kokok menyerupai tawa manusia. Kajian dilakukan melalui systematic review menggunakan metode PRISMA dengan menelaah 63 artikel dari database Science Direct, Google Scholar, dan PubMed, kemudian diseleksi berdasarkan kriteria inklusi-eksklusi sehingga diperoleh 12 literatur relevan untuk analisis mendalam. Hasil review menunjukkan adanya keragaman genetik tinggi antar populasi, dengan perbedaan signifikan pada karakter morfometrik, fenotipik, dan bioakustik, serta ditemukan indikasi penurunan heterozigositas akibat persilangan tidak terkendali. Bioakustik Ayam Gaga terbagi dalam tipe slow, dangdut, dan varian crystal dengan variasi durasi kokok dan jumlah suku kata yang mempertegas signifikansi nilai budaya dan ekonomi, terutama melalui kontes nasional. Meskipun telah diakui sebagai sumber daya genetik lokal yang dilindungi, ancaman erosi genetik dan keterbatasan data populasi menimbulkan risiko kepunahan. Kesimpulannya, pelestarian Ayam Gaga memerlukan strategi integratif yang menggabungkan program pemuliaan berbasis masyarakat (CBBP), insentif ekonomi, edukasi komunitas, serta langkah ex-situ melalui bank genetik dan kriopreservasi, guna menjaga keberlanjutan keragaman genetik, nilai sosio-kultural, serta kontribusinya pada keanekaragaman hayati Indonesia.

Kata kunci: *Conservation, genetic diversity, laughing chicken*

INTRODUCTION

Indonesia, as one of the countries with the highest biodiversity in the world, harbors a wealth of unique and valuable local livestock genetic resources (AnGR). Among these genetic assets, the Gaga “Ketawa” chicken (*Gallus gallus domesticus*) stands out as a prominent indigenous breed, primarily found in Sidendreng-Rappang (Sidrap) Regency, South Sulawesi, and Bangkalan Regency, Madura Island (Abinawanto, Zulistiana, Lestari, Dwiranti, & Bowolaksono, 2021). The principal uniqueness of the Gaga chicken lies in its distinctive crow, which resembles human laughter—a bioacoustic phenomenon that not only serves as a biological identifier but also holds profound cultural and socio-economic significance for local communities, especially in national contests and traditional ceremonies. The genetic resource potential of this breed renders Gaga chicken not merely a livestock commodity but a genetic heritage that requires systematic protection.

The significance of Gaga chicken conservation is closely linked to its high level of genetic diversity. Research based on bioacoustic, morphometric, and DNA barcoding analyses has revealed substantial genetic variation among Gaga chicken populations in different districts, both in terms of crowing duration and syllable patterns as well as morphological characteristics. The measured genetic distance, ranging from 0.025 to 1.872 based on gene barcoding analysis, indicates notable population structure and the presence of valuable local adaptation potential (Abinawanto et al., 2021). This genetic diversity serves as the foundation for the breed's resilience and adaptability to environmental changes, disease pressures, and future breeding needs. Loss of such diversity, or genetic erosion, poses a threat to the long-term survival and intrinsic value of Gaga chicken.

However, the considerable genetic resource potential of Gaga chicken currently faces serious threats. The main pressure arises from uncontrolled crossbreeding with other chicken breeds, which has the potential to dilute the unique genes responsible for the characteristic crow and adaptive traits (Ngeno, Vander Waaij, & Kahi, 2014). The poultry industry’s emphasis on uniform commercial breeds also indirectly marginalizes local breeds like Gaga chicken. Moreover, inadequate understanding and awareness at both community and policymaker levels regarding the importance of conserving local livestock genetic resources further exacerbate these challenges (Yulia, Jumadil Saputra, & Abdul Talib Bon, 2021). In the absence of strategic interventions, continual genetic erosion risks leading to genetic extinction of the superior and unique traits of Ketawa chicken.

In response to these challenges, the development and implementation of comprehensive conservation strategies is essential. These strategies must integrate both in-situ and ex-situ approaches. In-situ conservation strategies, such as the Community-Based Breeding Program (CBBP), have proven highly effective in managing local livestock genetic resources in Indonesia (Darmawan, Chang, & Wu, 2023). The CBBP approach leverages indigenous knowledge, actively involves farmers in selection and breeding processes, and assures sustainability through alignment with the economic and cultural interests of local communities. The provision of economic incentives, such as the development of market value based on unique crowing traits and participation in contests, serves as a key driver for community involvement in these in-situ strategies. Conversely, ex-situ conservation efforts, such as the establishment of gene banks for storing genetic materials (sperm, oocytes, DNA) or dedicated breeding centers, are crucial as backup resources and as sources of genetic material for future research and breeding programs.

In addition, enhancing awareness and capacity through education, training, and information dissemination to farmers, the broader public, and other stakeholders is an essential component in fostering a sense of ownership and collective commitment to conservation. Therefore, this review aims to conduct an in-depth analysis of the genetic resource potential of Gaga chicken and its conservation in Indonesia through a systematic approach, with consideration for its genetic uniqueness and cultural-economic value. The findings are expected to contribute to sustainable conservation efforts for Gaga chicken as an integral part of Indonesia’s biodiversity and national cultural heritage.

MATERIALS AND METHODS

The method employed in this literature review is the Systematic Review, which is used to map the literature and identify gaps in the research area explored in this study. The framework applied as a guideline in conducting the systematic review utilizes PRISMA For Systematic Review (Page et al., 2021), a methodology designed to enhance quality assurance related to the completeness of the structure and process of a systematic review. PRISMA For Systematic Review was chosen because it provides a detailed guideline for the preparation and implementation of systematic reviews. This review comprises several steps as follows:

1. Identification of article search results
2. Selection of articles based on titles and abstracts
3. Assessment of article eligibility based on full-text review

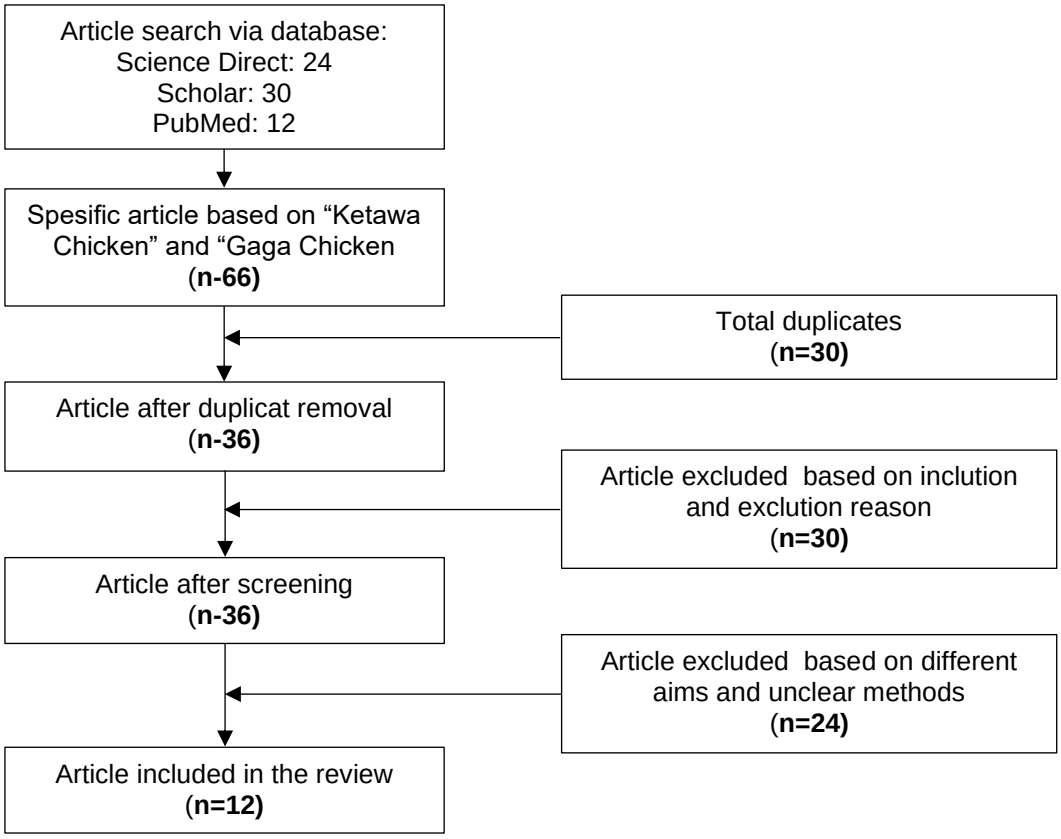


Figure 1. PRISMA Flowchart Diagram

Identification of Article Search Results (Step 1)

In this literature review, the search for articles involved the application of both inclusion and exclusion criteria. The inclusion criteria comprised original articles published in either English or Indonesian, discussing the Indonesian Gaga chicken, published in journals from 2013 to 2025, and available as free full-text. The exclusion criteria encompassed commentaries, opinion pieces, report documents, policy drafts/guidelines, and thesis reports. The article search was conducted using the Science Direct, Google Scholar, and PubMed databases. The keywords employed were (gaga chicken) AND (Indonesian indigenous chicken) OR (ketawa chicken).

Article Selection (Steps 2 and 3)

At this stage, the identified literature was further screened for duplicates, and the relevance of the studies was evaluated by considering the titles and abstracts in relation to the research objective; subsequently, full-text articles were analyzed against the inclusion and exclusion criteria.

Of the articles identified, 36 of 63 met the inclusion and exclusion criteria. The selected literature was then saved in BibTeX format and processed using the CADIMA web tool (CADIMA, 2023). After conducting a complete, duplicate-free analysis, a total of 12 full-text articles were ultimately included for final review.

RESULTS AND DISCUSSION

Population

The Gaga chicken (*Gallus gallus domesticus*), also known as the "laughing chicken," is a local ornamental breed originating from South Sulawesi, Indonesia. Initially, this chicken was developed by rulers in the ancient Ajatappareng region of South Sulawesi and was predominantly kept for its unique vocalization (Abinawanto & Effendi, 2017). During the 1940s, the chicken was primarily bred and maintained among the Bugis aristocracy as a symbol of social status. Its crow differs markedly from other ornamental chickens, characterized by a broken, staccato pattern resembling human laughter (Effendi & Abinawanto, 2016).

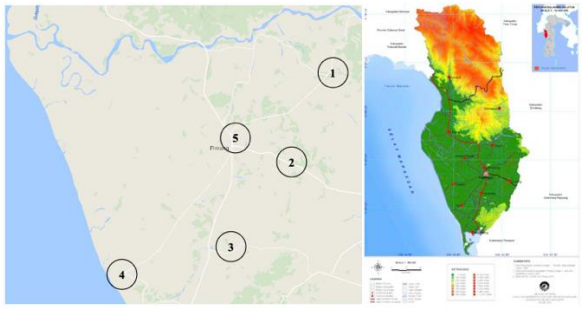


Figure 1. Study site in Pinrang District, South Sulawesi, Indonesia. A. Malimpung, B. Tiroan, C. Mattiro Bulu, D. Lamrisang, and E. Sawito (Wattang Sawito)

(a)

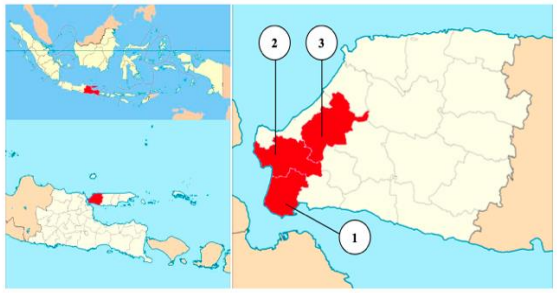
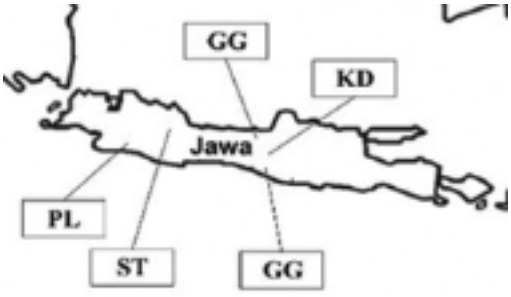


Figure 1. The map of research location in Bangkalan District, Madura Island, East Java Province, Indonesia. 1. Kamal, 2. Socah, 3. Bumeh

(b)



(c)

Figure 2. Distribution map of the Gaga chicken population; a: Pinrang-Sidrap Regency, b: Bangkalan Regency, c: Bantul and Kendal Regencies (Abinawanto & Effendi, 2017; Abinawanto et al., 2021; Maharani et al., 2021)

The initial distribution of Ketawa chicken was relatively limited. Toward the late 2000s, the number of cocks in its native region, Sidrap Regency, declined due to shifting trends among the Bugis nobility. Subsequently, this breed began to spread to communities outside Sidrap and eventually to other islands, primarily driven by human activity and the increasing number of crowing contests held elsewhere. Since then, Ketawa chicken has been kept throughout Indonesia, with farms developing in various regions, including Jakarta, Bogor, Yogyakarta, and Bangkalan. In Bangkalan Regency, Madura Island, the population of Ketawa chicken was estimated at 300 birds in 2017, nearly one third of the number of local Madura Gaok chickens in the area (Abinawanto et al., 2021; Asmara, Hilmia, & Garnida, 2023).

Gaga chicken has been designated as one of Indonesia's local breeds whose genetic resources require protection and conservation. This has been formalized through the Decree of the Minister of Agriculture No.2920/Kpts/OT.140/6/2011 (Bugiwati, Syakir, & Dagong, 2020). Evaluating the

genetic diversity of indigenous or local breeds is a critical step in identifying and conserving valuable genetic resources.

However, information on the population status of long-crowing chickens, including Gaga chicken, in Indonesia remains limited. Data on population size and distribution are crucial for assessing the extinction risk of these chickens. At present, all long-crowing chicken breeds in Indonesia are classified as having an unknown extinction risk level. Although experts believe that the population of Indonesian local chickens is declining, there is insufficient support for this assumption. Surveys on population size and dynamics are required to determine the risk level. Currently, conservation planning for long-crowing chickens generally remains at the hypothetical stage (Asmara et al., 2023).

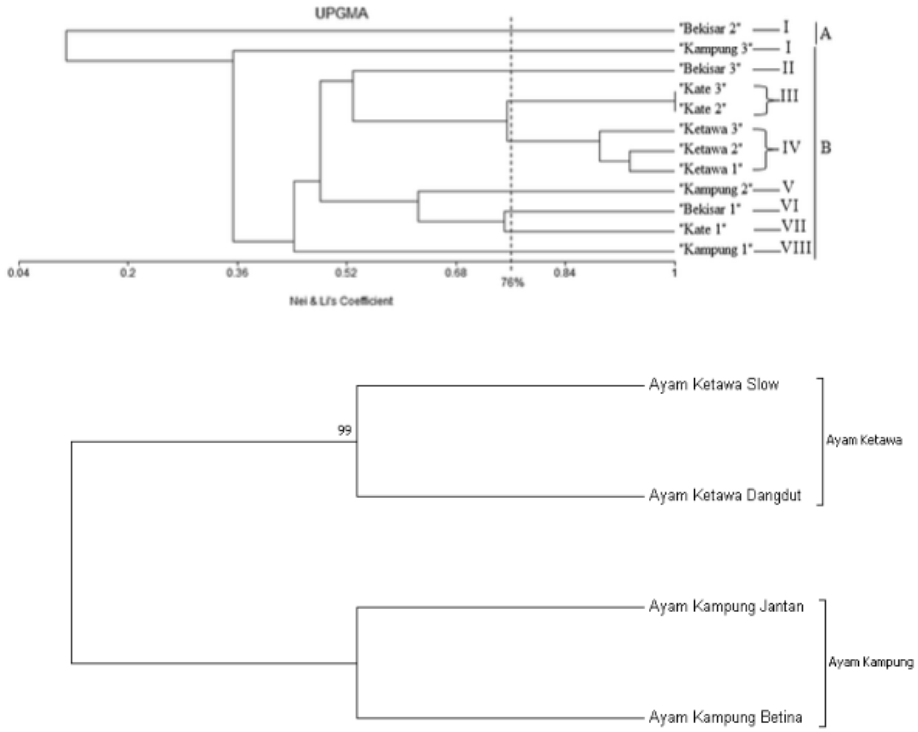


Figure 3. Phylogenetic tree of Gaga chicken (Abinawanto et al., 2019; Wintari, Pharmawati, & Wiratmini, 2019)

Regarding genetic diversity, studies using the microsatellite marker LEI0258 have revealed a significant degree of allelic variability among six Indonesian local chicken populations, including Gaga chicken. However, the Gaga chicken population exhibited the lowest observed heterozygosity (0.565) and the lowest number of effective alleles (3.503) among the breeds analyzed. A reduction in heterozygosity may indicate a decline in the genetic diversity of a population. The Gaga chicken population also showed a heterozygote deficiency, as evidenced by observed heterozygosity levels lower than those expected. These findings indicate a deviation from random mating, potentially influenced by factors such as null alleles, the Wahlund effect, scoring errors, or inbreeding. Significant deviations from Hardy-Weinberg equilibrium observed in Gaga chicken, where observed heterozygosity exceeded expected values, point to non-random mating, potentially through crossbreeding systems, especially since Gaga chicken is often maintained under backyard scavenging systems by smallholder farmers. Excess heterozygosity could result from the introduction of males from other breeds for crossbreeding purposes (Mustofa et al., 2022).

Although Gaga chicken has been recognized by the Indonesian government as a protected genetic resource due to its unique characteristics, comprehensive data on its total population size

and distribution throughout Indonesia remain very limited, and its current extinction risk status is unknown.

Characteristics

Morphometric characteristics of Gaga chicken reveal variation among types and populations from different locations. In a study conducted in Pinrang, South Sulawesi, the 'slow' type was found to be larger than the 'dangdut' type. However, overall differences in body weight among Gaga chickens from various rearing areas were not statistically significant. Comparisons with other Indonesian local chickens, such as native village chickens (ayam kampung), showed some similarities in body dimensions, but Gaga chickens tend to have larger shank circumference, femur length, wing length, and comb height.

Table 1. Morphometric Traits of Gaga Chicken

Location	Total Sample	Body Weight (kg)	Neck Bone Length (mm)	Femur Length (mm)	Tibia Length (mm)	Shank Length (mm)	Wings Length (mm)	Cestbone Length (mm)	Third Finger (mm)	Comb Length (mm)
Pinrang[1]	20	1,672	105.87	127.09	102.35	112.59	232.11	76.14	48.34	42.75
Bangkalan, Kamal[2]	9	1.96±0.65	72.07±12.95	103.98±11.37	122.64±24.77	94.68±8.85	239.56±24.40	72.07±12.95	52.53±2.45	34.97±16.96
Bangkalan, Burneh[2]	6	1.30±0.18	70.14±7.93	86.62±14.73	112.01±9.25	82.51±7.56	213.33±8.16	70.14±7.93	42.87±5.67	15.59±5.59
Bangkalan, Socah[2]	5	1.53±0.04	74.99±15.70	105.60±8.68	114.32±10.44	85.27±7.17	210.20±8.43	74.99±15.70	39.84±1.52	19.30±12.60
Bangkalan, Kamal[3]	3 (Dangdut type)	2.14±0.37	77.07±4.15	103.88±7.65	108.43±7.00	89.51±2.51	240.33±8.38	131.54±2.79	59.57±8.29	44.11±17.25
Bangkalan, Kamal[3]	7 (Slow type)	1.97±0.76	73.29±17.21	105.50±12.96	127.87±25.99	98.12±9.38	242.42±29.06	109.08±8.33	48.72±3.55	29.66±15.03
Kendari[4]	50	1.81±0.08	120.60±13.80	106.7±0.91	150.2±10.4	108.9±0.87	189.8±10.4	115.6±12.1	50.2±0.56	-
Unknown[5]	18	2.07±0.06	-	93.4±0.16	146.5±0.27	88.9±0.11	204.9±0.27	-	48.7±0.09	47.4±0.20
Bantul and Kendal[6]	18	2.071±2.64	-	93.4±0.66	146.5±1.15	88.9±0.48	204.9±1.15	-	48.7±0.38	-
Sidrap[7]	8	1.54±1.48	-	-	-	-	-	-	-	-
South Sulawesi[8]	-	1.6-18	-	-	-	-	-	-	-	-

[1](Abinawanto & Effendi, 2017), [2](Abinawanto et al., 2021), [3](Zulistiana & Abinawanto, 2018), [4](Andriyanto, Ba'a, & Rusdin, 2015), [5](Maharani et al., 2021), [6](Mustofa et al., 2022), [7](Bachmid, Purba, Apada, & Sari, 2019), [8](Asmara et al., 2023)

Body size traits are influenced by genetic, environmental, and management factors. Significant morphological differences have been observed among populations in Bangkalan, potentially related to habitat variation, human activity, and ambient temperature. For example, high stress levels due to environmental factors can reduce appetite and body weight. Morphometric traits such as body weight, neck bone length, femur length, tibia length, shank length, wing length, comb length, and third finger length have been measured in studies to assess diversity. Several quantitative traits including body weight, wing length, third finger length, and breastbone length showed significant differences among Gaga chicken populations in Bangkalan (Abinawanto et al., 2021; Zulistiana & Abinawanto, 2018).

The phenotypic appearance of Gaga chicken is characterized by traits such as plumage color, plumage pattern, comb shape, earlobe color, and eye color. Externally, Gaga chicken resemble general local chickens, but their unique crowing distinguishes them.

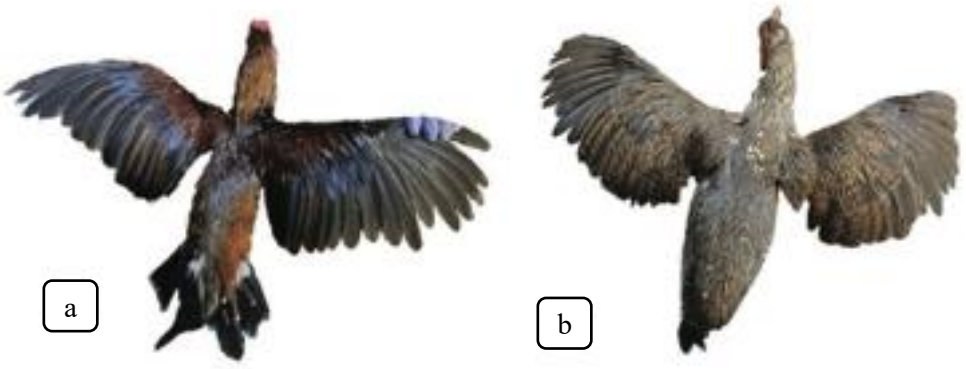


Figure 4. Variation in plumage color of Gaga chicken; a: male, b: female (Maharani et al., 2021)

Table 2. Fenotipe Traits of Gaga Chicken

Parameter	Location			
	Kendari Regency[1]		Sidrap Regency[2]	
	Male (n=50)	Female (n=25)	Male (n=65)	Female (n=30)
Plumage Color (%)				
Colored	94	84	93.85	76.66
White	6	16	6.15	23.34
Plumage Pattern (%)				
Black	68	60	32.31	83.34
Wild	32	40	67.69	16.66
Plumage Sheen (%)				
Silver	78	80	36.93	20.00
Gold	22	20	63.07	80.00
Bar Pattern (%)				
Bar	12	24	-	-
Non Bar	88	76	-	-
Shank Color (%)				
Yellow/White	38	56	83.07	73.34
Black/Grey	62	44	16.93	26.66
Comb Type (%)				
Rose	8	0	7.70	13.34
Walnut	6	72	6.15	26.66
Single	86	28	86.15	60.00

[1](Andriyanto et al., 2015), [2](Bugiwati, Syakir, et al., 2020)

Studies Bugiwati, Syakir, et al., (2020) indicated that colored plumage predominates in both male and female Gaga chickens, with only a few exhibiting white plumage. Wild plumage pattern was mostly observed in male Gaga chickens, while black plumage patterns were more common in females. Single comb shape and red earlobe color dominate Gaga chickens in Sidrap. Shank and eye colors display greater phenotypic variation. Research on male Gaga chickens in Kendari revealed a dominance of colored plumage, black coloration pattern, silver plumage sheen, and non-barred feather pattern. The shank color of males was predominantly black/gray, whereas females showed predominance of white/yellowish shank color. Single comb shape dominated males, and pea comb shape dominated females in Kendari (Andriyanto et al., 2015).

Gaga chicken is well-known for its distinctive crowing that resembles human laughter. This unique bioacoustic feature is a primary characteristic determining the breed and strongly influences its popularity among enthusiasts. Based on crowing patterns, Gaga chickens are generally categorized into two main types: the 'slow' type, characterized by a short and slow crowing song, and the 'dangdut' type, which has a long and fast crowing song. A third type, 'crystal,' is also recognized as a variant of the slow type with a clear and high-pitched sound of high value, although it is rare. These crowing sounds differ from other Indonesian ornamental chickens such as Kokok Balenggek, Pelung, Bekisar, and Gaok, which usually have longer crow durations; Gaga chicken's crow is described as broken and laugh-like. Bioacoustic analysis, often using software such as Cool Edit Pro, quantifies features such as crowing duration and the number of beats or syllables (Abinawanto & Effendi, 2017; Effendi & Abinawanto, 2016).

Studies across various locations demonstrate variation in specific metrics by crowing type. In Pinrang, the slow type exhibited 3–5 beats while the dangdut type had 4–7 beats. Another study in Pinrang reported a slightly different range: slow 3–5 beats and dangdut 5–7 beats. Conversely, a study in Bangkalan, Madura, showed a higher number of syllables for the slow type, reaching 10, and 9 for the dangdut type in Kamal District. A broader study on the South Sulawesi population categorized Gaga chicken into Slow, Short Dangdut, and Long Dangdut types, with average total crowing durations ranging from 3.65 seconds (Slow) to 30.52 seconds (Long Dangdut). Syllable counts also varied widely, from 8.27 (Slow) to 140.92 (Long Dangdut). These findings indicate that,

although basic classification exists, measurable traits such as duration and syllable number display considerable variation influenced by specific subtypes and geographical location.

Bioacoustic characteristics are influenced by a combination of morphological, physiological, circadian rhythms, and genetic factors. Morphological studies show that although syrinx size may not differ significantly among types, trachea length and tracheal muscle differ, with the dangdut type possessing longer tracheal muscles, which play a role in sound production and variation. Differences in sternum length have also been significantly recorded between dangdut and slow types in some populations, potentially affecting respiratory mechanics important for crowing. Environmental factors, management practices such as mucus suction, and training can also influence crowing ability and characteristics. Additionally, social status and dominance impact crowing frequency and timing (Zulistiana & Abinawanto, 2018).

Table 3. Bioacoustic Traits of Gaga Chicken

Type	Crowing Duration (s)	Crowing Beats	Crowing Syllable	References
Dangdut	30.83 ± 19.67	-	-	(Asmara et al., 2023)
Slow	3.68 ± 1.08	-	-	
Dangdut	longer	5-6 times	-	(Effendi & Abinawanto, 2016)
Slow	short	3-4 times	-	
Dangdut	7.67	-	9	(Zulistiana & Abinawanto, 2018)
Slow	6.71	-	10	
Dangdut	4.11±1.76	-	18.13±9.46	(Bugiwati, Dagong, & Tokunaga, 2020)
Slow	3.65±1.06	-	5.79±2.41	
Dangdut	-	4-7 times	-	(Abinawanto & Effendi, 2017)
Slow	-	3-5 times	-	

Development and Conservation Potential

The development potential to enhance the productivity of Gaga chicken, also known as the chicken with a unique crow and valued as an ornamental breed and genetic resource, is significant. Although local chickens generally serve as sources of meat and eggs, the primary economic value and development potential of Gaga chicken, as highlighted in various sources, center on its distinctive vocal characteristics.

The economic value of Gaga chicken as an ornamental/crowing breed is very high. Its unique crow, which sounds like human laughter, has made it popular among enthusiasts. This unique vocalization holds the highest potential economic value. Popular crowing contests contribute significantly to the economic value of Gaga chicken. Chickens that win contests can fetch very high prices, sometimes reaching hundreds of millions of Rupiah, making these strains potential candidates for development due to their strong economic value. Winners and their offspring are valued at higher prices. Different crowing types, such as "garetek" (slow) and "dangdut" (fast), along with specific traits including duration and syllable count, serve as key criteria in these contests and for selection (Bugiwati, Dagong, et al., 2020).

The potential for improvement through breeding and selection is also considerable. Gaga chickens possess unique physical forms and genetic compositions and have been recognized by the Indonesian government as a local chicken breed whose genetic resources need protection and conservation (Minister of Agriculture Decree No. 2920/Kpts/OT.140/6/2011). Understanding phenotypic characteristics (morphometric and bioacoustic) and genetic diversity is crucial for their utilization and conservation (Abinawanto & Effendi, 2017). Studies on morphometric traits show variation within populations, indicating the need for selection programs to develop elite strains. Phenotypic variation provides valuable information for designing selection and genetic improvement programs. Markers such as LEI0258 can be used for marker-assisted selection in breeding programs. Although typically smaller or comparable in size/weight to some other Indonesian local chickens, there is a general effort to selectively breed Indonesian local chickens, including Gaga, to enhance potential production traits for meat and eggs alongside their unique

characteristics. Enhancing productivity in this broad sense requires genetic quality improvement while maintaining desirable traits.

Improvement in husbandry and management is also a key aspect. Various sources note that differences in environmental factors and treatments (such as routine mucus suction in some farms) can influence chicken characteristics, especially their crowing ability. Crowing ability is not entirely genetically inherited but is also affected by training phases. The lack of information on husbandry techniques that specifically optimize crowing ability highlights the need for studies to establish standard rearing practices for this breed. Management adapted to environmental conditions can result in different phenotypic expressions (Zulistiana & Abinawanto, 2018).

Conservation efforts strongly support development. Formal recognition as a protected genetic resource mandates conservation efforts. Conservation methods, including in-situ (in the native environment) and ex-situ (such as cryopreservation), are relevant. Cryopreservation of Gaga chicken semen is being studied for genetic material preservation. Conservation is critical to prevent the loss of this unique genetic resource, especially as uncontrolled mating can reduce blood purity (Khaeruddin et al., 2022). Conservation efforts should also consider the socio-cultural values associated with this breed and ideally involve breeder and enthusiast associations. Providing incentives to these key actors is recommended to promote conservation.

CONCLUSION

The enhancement of productivity and development of Gaga chicken requires a genetically based, targeted selective breeding program to maintain superior crowing types (slow, dangdut, crystal) and prevent inbreeding, accompanied by standardized management (crowing training, nutrition, optimal environment), as well as active conservation (in-situ involving local farmers, enthusiast communities, and ex-situ such as cryopreservation) to ensure the sustainability of the genetic resource.

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