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Crowing sound and inbreeding coefficient analysis of *Pelung* chicken (*Gallus gallus domesticus*)

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Abstract. *Daryono BS, Mushlih M, Perdamaian ABI. 2021. Crowing sound and inbreeding coefficient analysis of Pelung chicken (*Gallus gallus domesticus*). Biodiversitas 22: 2451-2457. Pelung* is one of the crowing-typed chickens from Indonesia. The bioacoustics characters of Indonesian crowing-typed chicken especially *Pelung* chicken were less documented. This study aimed to characterize crowing sound and to study the inbreeding coefficient of the *Pelung* chicken. In this study, crowing voice of 77 male *Pelung* chicken was recorded. Bioacoustics analyses of crowing voice were done using Adobe Audition CS5.5 and PRAAT 5.3.66 software. The results showed that chicken crowing consisted of front sound (first syllable), middle sound (second syllable) and end sound (third syllable). Each section of *Pelung* crowing had specific characteristics compared to other chicken breeds and varied among champions and non-champions. Champion chicken had slowed and clear first and second syllable, sound energy was lower in first syllable then decrease at second syllable and has *bitu gantung* third syllable. Crowing duration and fundamental frequency (F0) of champion and non-champion were not statically different. The inbreeding coefficient reached 0.53 in several *Pelung* champions. Based on the research findings, bioacoustics software was applicable to assist the chicken show.

Keywords: Bioacoustics, crowing characteristic, Indonesian crowing-typed chicken, *Pelung* chicken

INTRODUCTION

In Indonesia, 28 local chicken breeds had identified and documented. Each breed has a morphological identifier and different potentials (Ulfah et al. 2016). Among Indonesian chicken breeds, four breeds have the ability in producing a distinctive crowing sound so-called a singer chicken. Singer chicken can produce a melodious sound, as well as rhythm but varying in character (Ulfah et al. 2017). These four breeds categorized as singer chicken were *Kokok balenggek* chicken from West Sumatra, *Bekisar* chicken from East Java, Gaga chicken from southern Sulawesi, and *Pelung* chicken from Cianjur District, West Java Province (Daryono et al. 2020). Three of them (Gaga, *Kokok balenggek*, *Pelung*, respectively) have been patented as genetic treasurer of Indonesia in 2011 by Indonesian Ministry of Agriculture. In this research, the authors attempt to describe these four chicken breeds.

In this research, the authors deeply concentrate on *Pelung* chicken. At glance, *Pelung* chicken has a large body compared with the other local Indonesian chickens. Adult females have an average weight of 4,500 gr while the male has 5.400 gr (Asmara1 et al. 2020; Asmara2 et al. 2020). The other local chicken breed weight was just approximately 1,500 to 1,800 gr for adult males and 1,000 to1,400 gr for females. However, for *Pelung* chicken enthusiasts, *Pelung* chicken usually maintained if it has a good voice or has potential for competition, while *Pelung* chicken with regular voice is usually sold to a market or used as a source of food. *Pelung* chicken mating usually well documented so the pedigree was clear. Chicken with the same predecessor grouped as the same clan (trah) which determines the chicken price. For example, trah *Lembayung* and trah *Gerandong* which had approximately eight times winning records were expensive than the others. Closely related mating makes the inbreeding coefficient arguably high.

Pelung has a distinctive crowing voice (called: melung) with a characteristic sound that long, undulating, loud and rhythmic. For beginner readers, the sound of *Pelung* chicken crowing was like common chicken but much longer with a prolonged end. *Pelung* chicken singing competition often held by several agencies. One of them by the district government held regularly to preserve the existence of *Pelung* chicken. The winner of each chicken show was determined by a group of judges which consisted of three to four persons with one leader. Subjectivity might occur during the examination. On this occasion, the authors were compiling the chicken voice recordings from different champions to make a standardization.

Vocalization was important character for identification which had been studied in Toad (Wang et al. 2019) and Liocichla (Kong et al. 2020). This research aimed to study the bioacoustics character and study the inbreeding coefficient of *Pelung* chicken.

MATERIALS AND METHODS

The study was done in 2018 in Cianjur, West Java, Indonesia as the central development of *Pelung* chicken. 77 male *Pelung* chicken were used in this research.

Bioacoustics analysis

Pelung chicken crowing sound data retrieval by purpose ve sampling method using a voice recorder, by using a set of digital voice recording (SONY ICD-UX533F). The crowing of each chicken was done by 1 to 5 repetitions (minimum) or to obtain an optimal sound. Form these repetitions, the crowing voice used in this research was based on the opinions of the expert. The crowing voice used in this research was the best that can be produced by the sample. The distance of recording approximately 500 cm from the object. Recorded sound stored in the ".wav" form, then analyzed with Adobe Audition CS5.5 and PRAAT 5.3.66 software. The parameters used in this study are presented in Table 1. Voice was transformed into a waveform and spectrogram to show the voice pattern. The waveform can be a representation of the voice graph. Formant is a spectrum of peak waves to another peak wave. To at least three formants (F1, F2, F3) (Jenny 2013). Statistical analysis was done by the T-independent test and ANOVA.

Champion sound analysis

In this research, the authors attempt to analyze the champion sound characters. *Pelung* chicken divided into two bioacoustics analyses, chicken with winning record were grouped as champion while others grouped as non-champion.

Inbreeding coefficient analysis

Pedigree construction was done by interview at least two reliable breeders. inbreeding coefficient calculated using the standard formula (Frankham et al. 2002).

$$F = \sum \left(\frac{1}{2}\right)^n$$

Where; F was the Inbreeding Coefficient (IC) and n was the number of lines of mating.

RESULTS AND DISCUSSION

Chicken crowing bioacoustics

Indonesia has three natural chicken breeds (*Kokok balenggek*, *Gaga*, *Pelung*, respectively) and one hybrid chicken breed (*Bekisar*) which especially breed to sing (Rusfidra and Arlina 2014). In this research, we managed to describe them. The different chicken breeds might produce various sound characters in each part. Dwarf chicken (*Ayam Kate*) and Crested chicken *Ayam Mahkota*) have the same crowing voice parts compared to *Pelung* chicken but different in duration (Figure 1).

Pelung chicken crowing duration reached 8.435 ± 1.647 seconds while Crested and Dwarf chicken only 1.975 ± 0.2252 seconds and 1.772 ± 0.2698 seconds. *Pelung* chicken crowing duration more than four times longer than a dwarf and a crested chicken.

Table 1. *Pelung* chicken crowing sound parameters

Parameter	Definition
Crowing duration	Entire crowing vocalization
F0 syllable (Pitch)	Average F0 at first syllable
Min. F0 syllable	F0 (*pitch*)* minimum at first syllable
Max. F0 syllable	F0 (*pitch*)* maximum at first syllable
First syllable duration	Entire first syllable
Element duration	First syllable element duration
Silent interval	Silent duration between element and first syllable
Second syllable duration	Entire second syllable vocalization
Third syllable duration	Entire third syllable vocalization
F0 mean	The average of F0 (*pitch*) at entire crowing vocalization
F0 min	F0 (*pitch*) minimal at entire crowing vocalization
F0 max	F0 (pitch) maximal at entire crowing vocalization
F0 second wave	The average of F0 (Pitch) at second syllable
F1 mean	The average of *Formant* -1 at entire crowing vocalization
F1 second syllable	The average of *Formant* -1 at second syllable
F2 mean	The average of *Formant* -2 at entire crowing vocalization
F2 second syllable	The average of *Formant* -2 at second syllable
F3 mean	The average of *Formant* -3 at entire crowing vocalization
F3 second syllable	The average of *Formant* -3 at second syllable
The amplitude of element	Amplitude/energy element at first syllable
The amplitude of first syllable	Amplitude/energy at first wave/syllable
The amplitude of second syllable	Amplitude/energy at second wave/syllable
The amplitude of third syllable	Amplitude/energy at third wave/syllable

Crowing sound consists of 1.104 ± 0.210 seconds first syllable, 5.532 ± 1.274 seconds second syllable, and 1.858 ± 0.969 third syllable. The first syllable (first wave) is the sound that started the sequence of crow. The first element consists of one element and first syllable which joined in the beginning of crowing sound. Between element and syllable separated with silent interval. At the beginning of *Pelung* chicken crow, the element is a short wave bite that has a length of 0.1973 ± 0.059 sec. Element and early sound syllables separated by a pause of about 0.1213 ± 0.038 seconds.

Based on the analysis, the first syllable has an F0 (fundamental frequency) around 243.875 ± 64.260 Hz, the minimum F0 188.43 ± 66.119 Hz, and a maximum F0 295.37 ± 81.972 Hz. The crowing style followed a pattern similar to syllable earlier, namely forming sound "*ku - ku*" and then followed down the volume rises with the style called initial syllable. First syllable length 0.7924 ± 0.20 seconds. The length of the initial syllable around 1.1128 ± 0.218 seconds.

In terms of amplitude, significant difference was noticed among the syllables. The average of energy produced by *Pelung* chicken is 83.237 ± 1.780 dB. *Pelung* chicken will emit a loud sound at the beginning syllable that the syllable "*ku*" (element component). The results showed that "*ku*" voice has 84.849 ± 1.758 dB amplitude then decreases to 83.648 ± 1.061 dB when reaching the initial syllable early after the silent syllable. When it reaches the middle syllable, amplitude decreased again to 83.174 ± 0.754 dB. However, the decrease was significantly different at P>0.01. off all observed *Pelung* crowing, the Standard deviation (SD) of the amplitude of the middle voice has the lowest value compared to other voice parts, this means that the sound is constant in this section. The second syllable was the beautiful part of the *Pelung* crowing.

In the end, syllable decreased to 81 279 ± 1,152 dB. Sound energy at the end tends to have higher than syllable beginning and middle, but not higher when compared with the element at the first syllable. The Standard deviation value demonstrated a high-end control syllable was very different in individuals.

The bioacoustics of the *Pelung* champion

To analyze the champion characters, the authors investigate the crowing sound structure of 1st winner (champion) from several chicken shows. The limitation of this study was high variability of crowing sound (Figure 2). In different city, most of the chicken show contestant and champion was different. The subjectivity of judgment might occur. Five components were used to select a champion consisted of first syllable, second syllable, third syllable, rhythm, and harmony.

Based on voice visualization, each champion produces a similar crowing pattern. The first syllable must be slow rhythmic and clearly heard. "*Ku-ku*" and followed by "*ellu*" sound must be harmonic. The second syllable must be slow, "*ke-ke…ellu..*" then form an increasing sound (*bitu gantung*) along with "ell" sound. the L sound at *bitu* should be clearly heard at "*elllLLLUuuu*". Decrease F0 but increase the amplitude. However, the type of *bitu* will be described in another paper (Daryono et al. 2020). Based on our analysis, the crowing duration does not determine the quality of crowing. Crowing duration of champion and non-champion were not statically different.

The comparison of crowing energy between champion (having win record) to non-champion attempts to analyze the sound hardness (Figure 3). In terms of sound energy, in this occasion, the authors use "*kekelur*" typed crowing for example as champion and "*kukulir*" typed crowing for example as non-champion. "*Kululir*" was a very ordinary *Pelung* crowing type, and always not selected to follow a chicken show.

The champion (*kekelur*) produced lower sound energy than the common *Pelung* chicken (*kukulir*) at the first syllable's element. Then sound energy was noticed decreased at second syllable in both groups, this downstream was significant at the champion but not at common *Pelung*. At the third syllable, the champion produces lower sound energy than the common *Pelung*. At the third syllable, the ability to control the sound energy to produce long and decreasing crowing was the champion criteria.

Fundamental frequency (F0) and formant are important factors in bioacoustics (Figure 4). The result of the calculation cannot be used before transformed into In or log10 function (Flynn and Foulkes 2011). Based on our analysis, the fundamental frequency was not different between champion and non-champion ($p > 0.01$). Whereas among champions in Semarang chicken show, the fundamental frequency was not uniform.

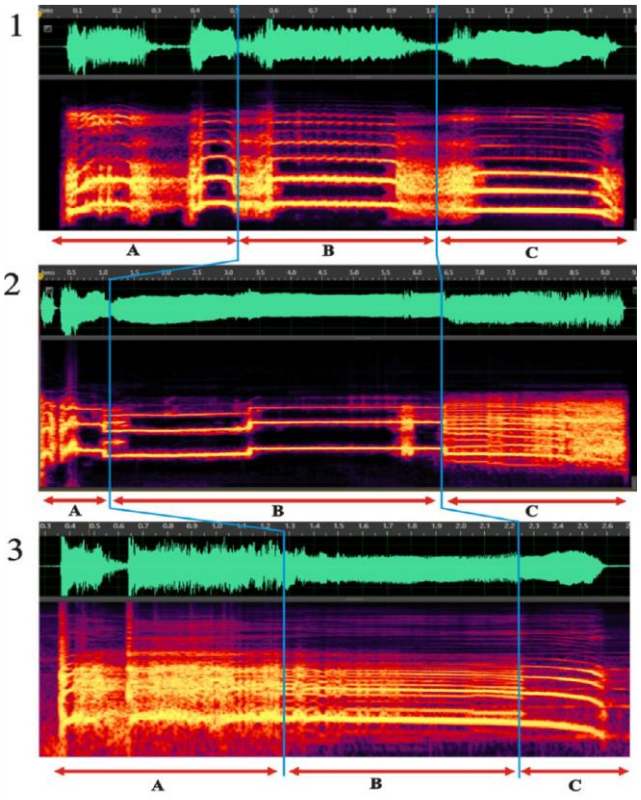

Figure 1. The comparison of first syllable (A), second syllable (B), and end syllable (C) divided by vertical blue lines crowing voice parts duration of Dwarf chicken (1), *Pelung* (2), and Crested chicken (3)

Based on our visualization, F0 were highly polymorphic. F0 cannot used as a bioacoustics marker. Contrary, the value of Formant 2 (F2), F2-F1, F3, F5 were statistically different at P<0.05 while pitch (F0), F1, F3-F2, F4 + F2, and F4 at P<0.01. F1, F2, F3, F4, total formant and F4+F1 at vowel "i" and "u" used in this research to estimate the difference between champion crowing and usual crowing voice. The F1 and F2 of "*kukulir*" and "*kekelur*" were different positions in the sound sequence (Figure 5).

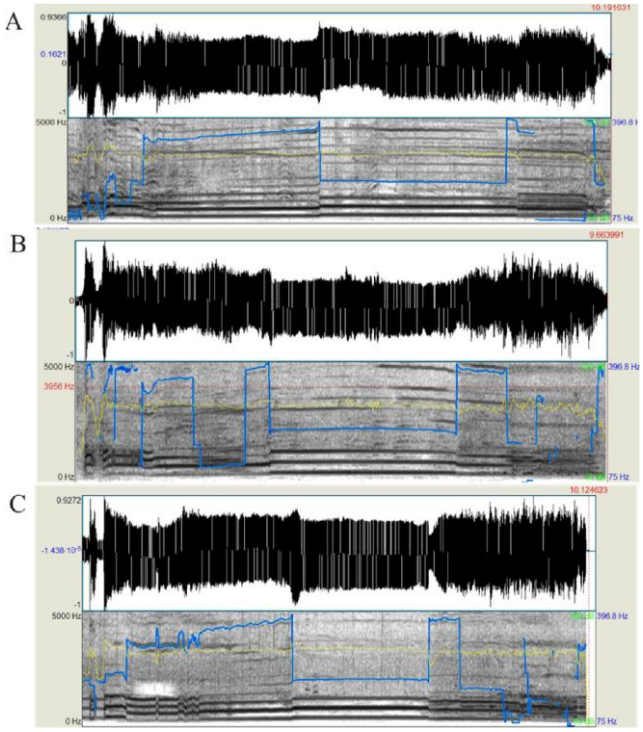

Figure 2. The crowing bioacoustics visualization of 1st winner *Pelung* chicken in Jakarta and Bandung chicken show (A), Surabaya chicken show (B) and Semarang chicken show (C). Blue line indicated the bitu (intonation dynamic) sequence.

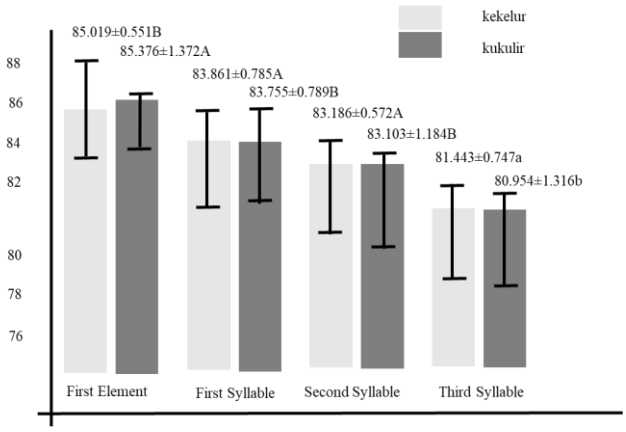

Figure 3. Energy (dB) comparison of 1st winner chicken crowing (blue box) to typical *Pelung* crowing voice (red box). Superscript AB and ab indicate statistical difference at >5% and >1%.

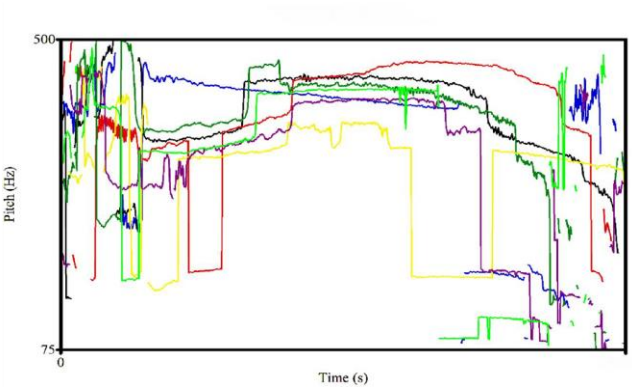

Figure 4. The comparison of the fundamental frequency (F0) of 1st winner (dark blue line) at Semarang chicken show compared to 1st winner (violet line) at Jakarta and Bandung chicken show, runner up (yellow), 10th winner (green), 17th position (red), qualified (light blue and black).

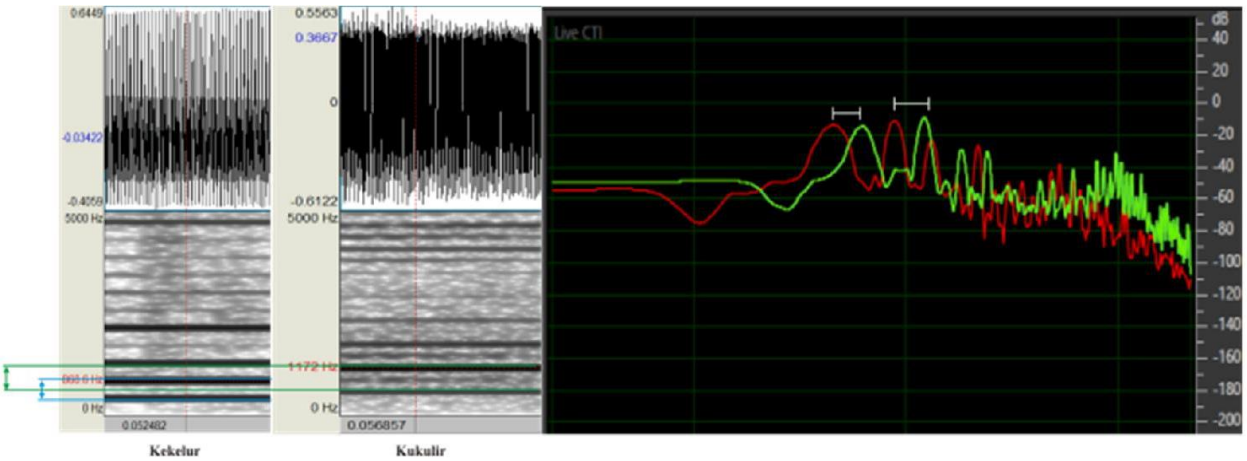

Figure 5. The visualization of "*kekelur*" and "*kukulir*" typed sound at Formant 1 (F1) and formant 2 (F2) position. Green box and blue box indicate the formant frequency difference (left panel). The sound sequence of "*kekelur*" (red line) and "*kukulir*" (green line) and white dash indicate the Formant 1 (F1) and Formant 2 (F2) position (right panel)

The inbreeding coefficient of champion *Pelung* chicken

Based on our calculation, the Inbreeding Coefficient (IC) reached 0.53 at one champion named *Khayangan*. However, *Khayangan* brothers were not exhibited excellent crowing sound. Although high IC value was bad, but no physical deterioration was commonly noticed. For example, there was no statistical difference between champion and non-champion body weight. When the authors attempt to outbreed *Pelung* to broiler into the first Backcrossed (BC_1) population, all siblings were non-singer. Chicken enthusiasts remember the pedigree of *Pelung* chicken. In the beginning, champion *Pelung* chicken named Rengket was descendent of Si Kaget which also had ^{first} place record. Rengket mating to female which had bloodline was produced champion chicken named Lembayung. Lembayung was the predecessor of many champions including Khayangan (Figure 6).

Lembayung mating to female named Rengge which not had bloodline was produced champion chicken named Lodaya. Kencana and Kemuning, Lodaya's offspring also had champion record. Having big name, Lembayung descendent was mated to other bloodlines, i.e. Grandong, Simega and Sidolar (pers. comm. Agus Abdurrahman). Sibling mating was regularly practiced until produce Khayangan. From many Khayangan offspring, only Samhiyang (not showed in Figure 6.) had champion criteria. Samhiyang in the learning phase (juvenile age) ever participating in chicken contest and even selected to the grand final.

Discussions

Chicken crowing bioacoustics

Indonesia has three natural chicken breeds (*Kokok balenggek*, *Gaga*, *Pelung*, respectively) and one hybrid chicken breed (*Bekisar*) which especially breed to sing (Rusfidra and Arlina 2014). In this research, we managed to describe them.

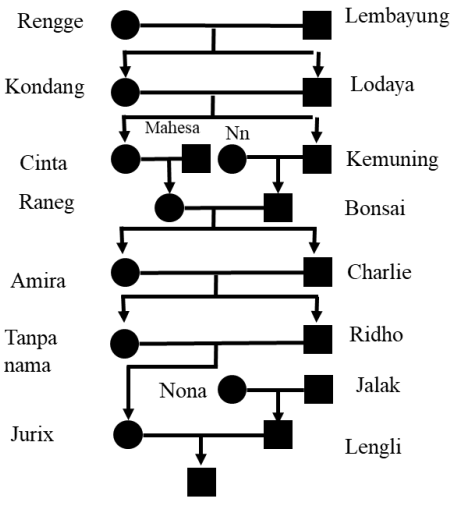

Figure 6. The detailed *Pelung* chicken pedigree shows individual *Pelung* names and mating scheme

Bekisar chicken was famous in Madura Island and the eastern part of Java Island. This hybrid chicken originated from the mating of the female domestic chicken (*Gallus gallus domesticus*) which mostly black-feathered kampung chicken breed with male green junglefowl (*Gallus varius*) (Ulfah et al. 2017). *Bekicem* (*Bekisar cemani*) was all black-colored *Bekisar* produced by crossing female *cemani* chicken breeds (fibromelanosis phenotype) with male green junglefowl. Although had low fertility, crossing male *Bekisar* to female domestic chicken able to produce the first Backcrossed line (BC_1) called *Bekikuk*. This male BC_1 chicken has a similar appearance and crowing sound to male *Bekisar*.

Kokok balenggek chicken breed was originated from the Western part of Sumatra Island. Among singer-typed chicken in Indonesia, this chicken has the highest number of syllables which reached 24. Typical of this breed has a 5.07 syllable each crowing. Crowing consisted of front sound, middle sound, and end sound. The uniqueness of these breeds laid on their end voice. *Kokok balenggek* chicken crowing sound has a frequency of around 8.08 times/10 minutes. The crowing duration approximately 2.03 to 4.43 seconds.

The last list of the crowing typed chicken breed, *Gaga* chicken, is crowing type chicken that originated from the south part of Sulawesi Island (Zulistiana and Abinawantoa 2018). *Gaga* chicken has a crowing voice reminiscent of human laughing voice so often called as laughing chicken (*Ayam Ketawa*) (Abinawanto and Effendi 2017) *Gaga* chicken crowing voice consisted of three main parts, front voice with high intonation, middle voice laughing like a human, and sort end voice. The ending voice is the uniqueness and determines the quality and price of *Gaga* chicken (Bugiwati and Ashari 2013). Crowing duration around 3.68 ± 1.08 seconds.

Gaga chicken can be divided into two types based on the crowing rhythm and the amount of syllables (Effendi and Abinawanto 2016, Abinawanto and Effendi 2018). First, dangdut (fast rhythm typed) and common (slow rhythm typed). Based on the amount of syllables, dangdut can be divided again into two types, long dangdut, and short dangdut. Long dangdut type crowing duration reaches 30.8 seconds whereas short dangdut only 4.2 seconds while the common (slow type) around 7 seconds. The syllable recorded from long dangdut was 143 while short dangdut was only 21, whereas the common-typed *gaga* chicken was only 8. Most various parts of *Kokok balenggek*, *Gaga*, and *Pelung* chicken crowing voice occurred in the middle voice.

Pelung chicken was originated from Cianjur, West Java province (Asmara et al. 2020). The different chicken breeds might produce various sound characters in each part. Dwarf chicken (*Ayam Kate*) and Crested chicken (*Ayam Mahkota*) have the same crowing voice parts compared to *Pelung* chicken but different in duration (Figure 1).

The bioacoustics of the *Pelung* champion

Based on voice visualization, each champion produces a similar crowing pattern. Crowing duration of champion and non-champion were not statically different. The

comparison of crowing energy between champion (having win record) to non-champion attempts to analyze the sound hardness (Figure 3). the ability to control the sound energy to produce long and decreasing crowing was the champion criteria.

Fundamental frequency (F0) and formant are important factors in bioacoustics (Figure 4). The result of the calculation cannot be used before transformed into In or log10 function (Flynn and Foulkes 2011). Based on our analysis, the fundamental frequency was not different between champion and non-champion ($p > 0.01$). Whereas among champions in Semarang chicken show, the fundamental frequency was not uniform.

The inbreeding coefficient of champion *Pelung* chicken

The folklore about *Pelung* chicken origin believed by people, today *Pelung* chicken breed was derived from a single male ancestor. The story said that the very first *Pelung* chicken breed was male chick hatched from common local chicken (*Ayam Kampung*). This chick had bigger body appearance and late covered by feathers which when adult produces distinctive crowing sounds. In 1850s, *Pelung* chicken breed begins famous.

This study shows the breeding scheme of the making of satisfying *Pelung* chicken. As described earlier, clan (*trah*) and pedigree was determining the *Pelung* chicken price. Believed by breeder, a clan with winning record prominent for *Pelung* chicken breeding. Contrary, *Kokok balenggek* breeder not precisely made pedigree for the breeding scheme. Usually, breeder keeps their chicken free-range. That made the inbreeding coefficient remain low. (Rusfidra et al. 2014, Rusfidra et al. 2015).

Based on our calculation, the Inbreeding Coefficient (IC) reached 0.88 at one champion named *Khayangan*. However, *Khayangan* brothers were not exhibited excellent crowing sound. Although high IC value was bad, but no physical deterioration was commonly noticed. For example, there was no statistical difference between champion and non-champion body weight. Many *Pelung* chicken breeders use non-commercial produced feed which mainly comprised of paddy bran to minimize the detrimental effect of feed additives. This decision has consisted of other reports that evaluated the impact of chicken commercial feed on animal and human health (Ahmad et al. 2020).

Winning a chicken show would raise his price as well as his progeny. Champion male mating with a female (had closest as possible bloodline with the champion male) to producing chicken for highly competing in the chicken show. Chick was intensively reared for participating in chicken show.

When the authors attempt to outbreed *Pelung* to broiler into the first Backcrossed (BC_1) population, all siblings were non-singer (Utama et al. 2018). The results indicate the recessive autosomal as the inheritance mode of long-crowing sound traits. However, this theory was not linier to other singer chicken breeds. *Gaga* and *Kokok balenggek* chicken crowing ability were believed to be acquired by learning (genetics imprinting) (Bugiwati and Asyari 2013; Rusfidra 2007).

Each section of *Pelung* crowing has specific bioacoustics characters and vary among champions and non-champions. The inbreeding coefficient reached 0.88 in several *Pelung* champions. Bioacoustics software was applicable to assist the chicken show. Amplitude was different among *Pelung* chicken. Supported by outbreeding data, the authors propose multiple gene works responsible for *Pelung* crowing trait.

Inbreeding Coefficient (IC) and bioacoustics do not have direct correlation. However, Inbreeding mating in *Pelung* farm was carried out and maintained through generation to accumulate and preserve the ample genes responsible for crowing. This led to higher IC at *Pelung* champion clan which also increase the possibility to had deleterious traits.

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