Sonic Heritage and Acoustic Profiling of the Gendang Kecapi: A Bamboo-Based Instrument from Kelantan, Malaysia

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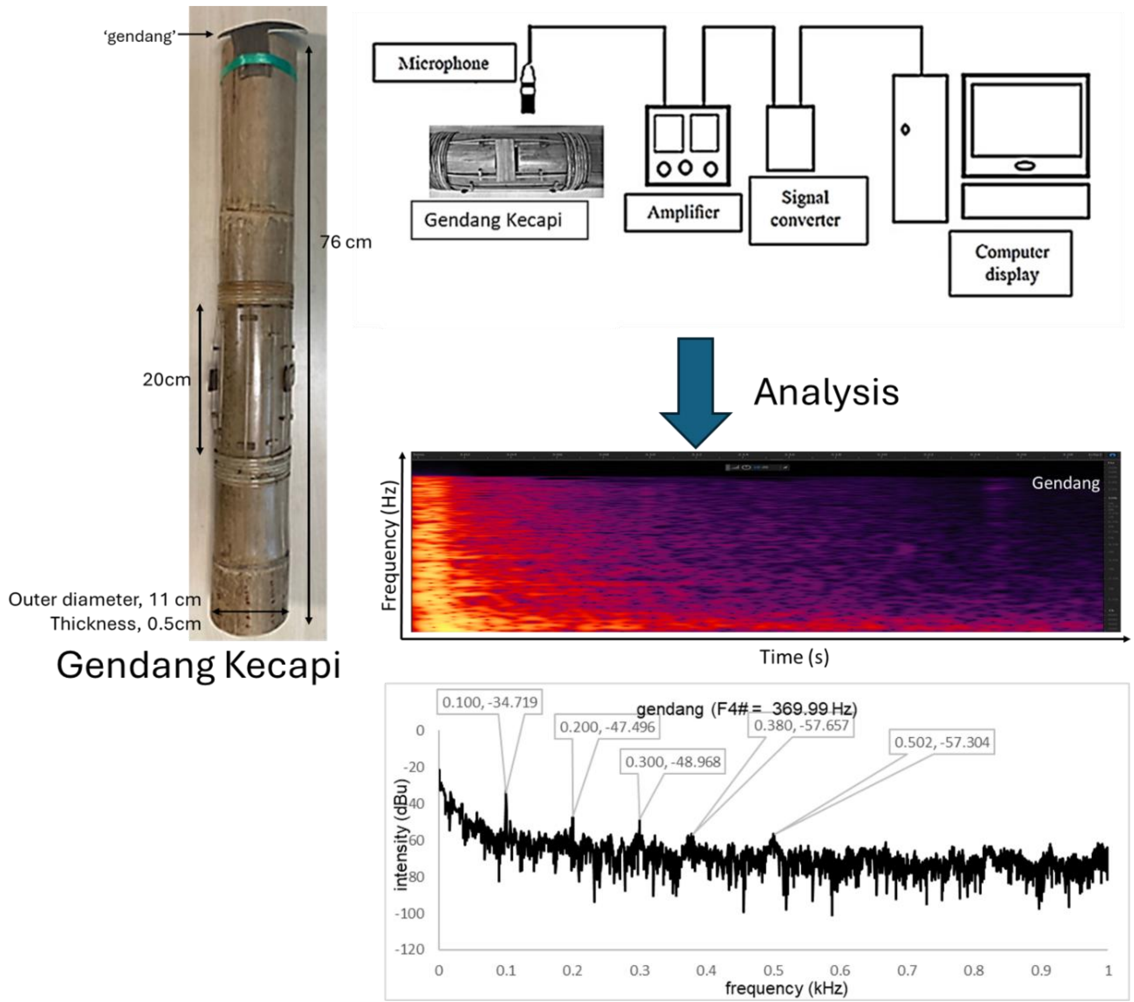
GRAPHICAL ABSTRACT



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This study considered the 'Gendang Kecapi' (GK) musical instrument, the sounds of which were recorded in an anechoic chamber. The Fast Fourier Transform (FFT) data was obtained using a Picoscope oscilloscope. The GK is an idiochord bamboo tube zither from Kelantan, Malaysia. The GK have two strings (called *canang*), two gongs, and a *gendang* (drum). The instrument produced unique and innovative sounds. The time frequency analysis (TFA) used Adobe Audition to produce the spectrograms. The fundamental frequency (f0) of string 1 (*canang ibu*) and string 2 (*canang anak*) are 0.888 kHz (A5) and 1.054 kHz (C6), respectively. The f0 of gong 1 (*gong ibu*) and gong 2 (*gong anak*) are 0.230 kHz (A3#) and 0.246 kHz (B3), respectively. The f0 of *gendang* is 0.380 kHz (F4#). The frequency spectrum showed less distinct fundamental frequency with several lower partial frequencies at 0.017, 0.100, and 0.200 kHz.

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Keywords: Gendang Kecapi; Fast Fourier transform (FFT); Time frequency analysis (TFA); Canang; Gong; Gendang

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INTRODUCTION

Traditional Malay performing arts, such as *Dikir Barat*, *Wayang Kulit*, *Tarian Zapin*, and *Main Puteri*, incorporate various musical instruments that hold deep cultural significance. However, these instruments are increasingly overshadowed by other musical traditions. Compared to Chinese and Indian traditional music, Iban folk culture from Sarawak has gained more influence, while Malay traditional instruments face a decline in recognition (Hamdan *et al.* 2023). This underscores the urgent need for research, documentation, and preservation to sustain these instruments for future generations. The Gendang Kecapi (GK) is a bamboo-based idiochord tube zither from Kelantan, Malaysia, consisting of two strings (*Canang Ibu* and *Canang Anak*), two gongs (*Gong Ibu* and *Gong Anak*), and a drum (*Gendang*). It produces a distinctive sound that has been integral to various cultural performances, including *Silat*, *Wayang Kulit*, *Dikir Barat*, *Main Puteri*, *Makyong*, and *Muay Thai*. Historically, Abdullah Bin Majid introduced the GK to an international audience through a performance in the United States (Isa *et al.* 2021).

Traditional Malay instruments such as the GK are not merely musical artifacts but also symbols of unity, cultural identity, and artistic heritage. They also play a vital role in folklore and nature-inspired sound imitation. The GK, for instance, is known to replicate the calls of local wildlife, such as deer, white-breasted waterhen (*burung wak-wak*), sitar bird, mouse deer, and partridge (*ayam hutan*).

Similar bamboo-based instruments exist across Malaysia. Hamdan *et al.* (2024) studied the *Pratuonkg*, a Borneo bamboo zither of the Bidayuh people in Sarawak, Malaysia, featuring five strings carved from the bamboo trunk. Two strings are divided by a middle bridge into 2 parts and make the total count come to 7 strings (the 2 strings called as string no 3 and string no 4 are divided by the middle bridge into strings 3A and 3B, and string 4a and 4b, respectively). The strings are played by striking with a small piece of wood. Meanwhile, Hamdan *et al.* (2025) analyzed the *Tongkungon*, a KadazanDusun plucked instrument from Sabah, Malaysia, with 6 strings and the bamboo tube split to form a resonating chamber. Two strings are on the left side and 4 strings are on the right side. Both instruments share structural similarities with the GK but differ in playing techniques.

The GK's unique design integrates percussion and string elements. The strings (*Canang Ibu* and *Canang Anak*) are plucked using the index finger. The gongs (*Gong Ibu* and *Gong Anak*) are struck with the palms of both hands. The *Gendang* (drum) is played by beating the bamboo cavity covered with a frond from areca nut branches with the palm of the right hand alternately with *gong ibu*. The GK's design and acoustic properties resemble those of the *Gendang Melayu Sarawak* (Sinin *et al.* 2024a) and *Sarawak Tar* (Sinin *et al.* 2024b). The strings are supported by bridges that determine tension, affecting pitch and tonal quality. By analyzing the GK's acoustic structure and performance technique, this study contributes to the preservation of Malaysia's sonic heritage. The findings will serve as a foundation for future research, instrument conservation, and digital sound archiving, ensuring the GK's cultural legacy endures. Figure 1 shows the *pratuonkg tongkungon* and *gendang kecapi.*

Fig. 1. The *pratuonkg* (left), *tongkungon* (middle) and *gendang kecapi* (right)

The dimensions of the GK instrument are shown in Fig. 2. Its design is unique, as it integrates a drum, gongs, and strings. The drum produces a sound like a leather-based musical instrument such as the *Gendang Melayu Sarawak* (Sinin *et al.* 2024a) and the *Sarawak tar* (Sinin *et al.* 2024b). The GK uses 2 strings of raised fiber from the bamboo tube (see Fig. 3a). The string at the front (on the right and left side of the middle string) are raised by 2 bridges. The distance between the bridges for *canang ibu* and *canang anak* are 13.5 cm and 13.7 cm respectively. The thickness of both strings is 0.8 mm and the width are 2.0 mm. The middle string is for positioning both thumbs. The bridges are placed toward the end of the bamboo tube. The strings are played by plucking with the index finger. On the right side (see Fig. 3b), a hole (35.5 mm × 40.7 mm) is made between two strings and covered with a piece of flat bamboo (29 mm width x 66.6 mm length x 8 mm thickness). On the left side (see Fig. 3c), a hole (35 mm x 37.8 mm) is made in the center of 2 strings and covered with a piece of flat bamboo (30 mm width x 64 mm length x 5.7 mm thickness). A frond is measured slighter bigger than the surface of the bamboo cavity. The middle part of the frond of areca nut branches bone is very suitable as this part is resistant to fractures. Figures 3a, 3b, and 3c shows the front, right and left sides, respectively.

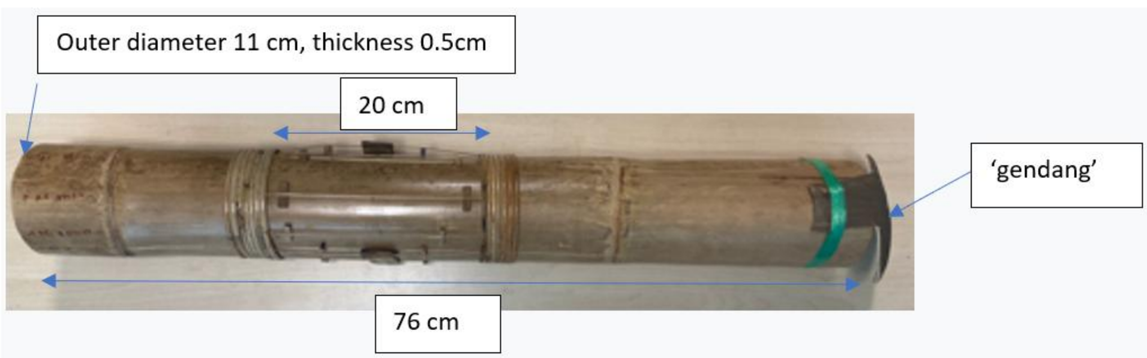


Fig. 2. *Gendang Kecapi* (GK) dimension with the *gendang, gongs* and strings

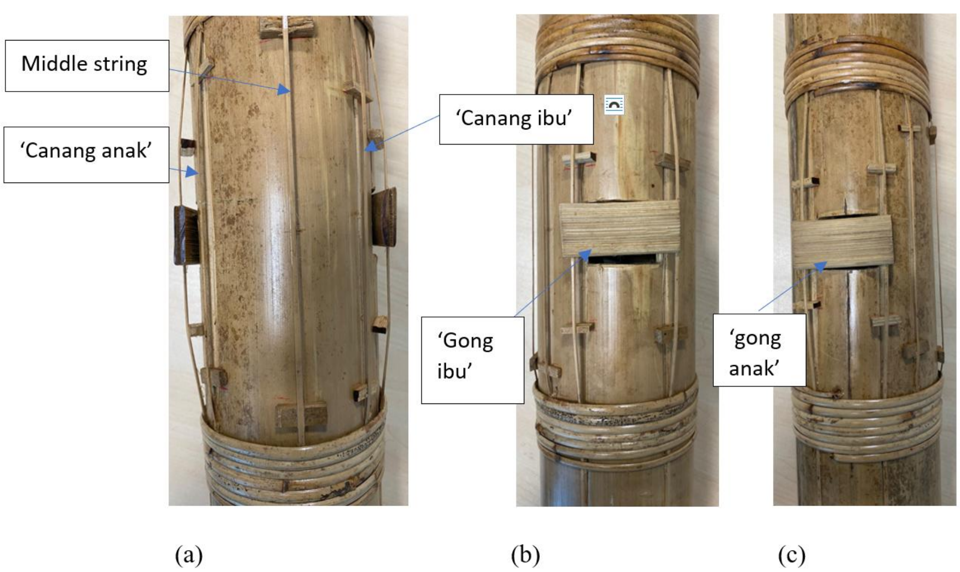


Fig. 3. (a) Front part (the right string *canang ibu* and left string *canang anak* are separated by the middle string and raised by 2 bridges), (b) Right side (a piece of flat bamboo act as *gong ibu*), and (c) left side (a piece of flat bamboo act as *gong anak*)

EXPERIMENTAL

PicoScope software was utilized to visualize and analyze time signals from PicoScope oscilloscopes and data recorders for real-time signal capture. The PicoScope software facilitates analysis using Fast Fourier transform (FFT), a spectrum analyzer, voltage-based triggers, and the capability to store and load waveforms to a disk. Figure 4 illustrates the schematic diagram of the experimental apparatus. The GK was positioned to record sound with little interference. The Behringer Powerplay Pro XL amplifier guaranteed that the sound capture was sufficiently loud for detection by the signal converter. The sound spectra are derived from PicoScope readings. Subsequent to the acquisition and recording of the data sound, the FFT was evaluated utilizing Adobe Audition to ascertain the dominant frequency for each tone at designated intervals. The Fourier transformation identifies fundamentals, harmonics, and subharmonics.

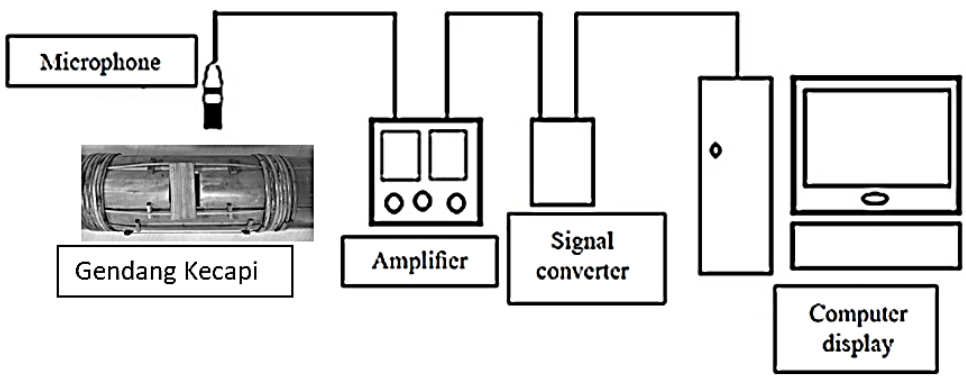


Fig. 4. Schematic diagram for recording using signal converter (PicoScope)

The frequency was measured at the studio hall of Universiti Malaysia Sarawak (UNIMAS). The audio signal was recorded in mono, at 24-bit resolution, and 48 kHz sampling rate. The signal was calibrated using a 1 kHz sine wave. The signal was recorded using the Steinberg UR22mkII (audio interface), Audio-Technica AT4050 (microphone) and XLR cable (balance). Using an oscilloscope from Pico Technology's 3000 series, the Fast Fourier transform (FFT) was performed. The resulting digital time record was mathematically transformed into an FFT spectrum using the FFT technique. The FFT is a straightforward set of operations that implements the Fourier's theorem. The resulting FFT spectrum shows the input signal's frequency components. PicoScope software (version 6) was then used to examine the findings, with an emphasis on FFT, voltage-based triggers, and spectrum analysis. To reduce inconsistencies, the precise plucking motions were thoroughly trained using the Pico Scope software before the recordings. By lessening the impact of human variability, this methodological rigor improves the experimental results' reproducibility and dependability.

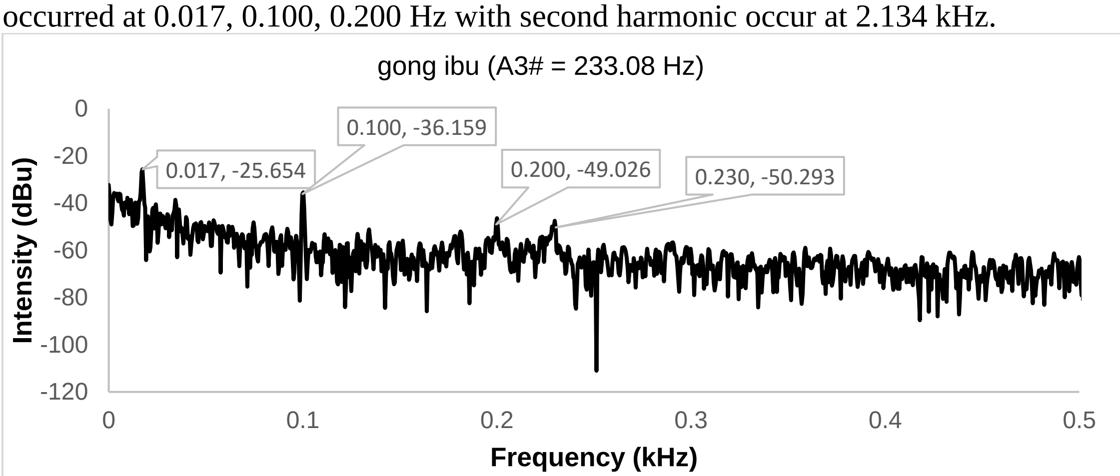
The Time Frequency Analysis (TFA) was performed in Adobe Audition using measurements in seconds, focusing on the exact intensity in hertz to differentiate the power of partial frequencies. Partial frequencies, or partials, are the frequency components that combine to create a complex sound, such as a vibrating musical instrument. The numerous different frequencies or pitches that combine to create a complex sound are known as partials. The group of partials is known as the harmonic series or overtone series. The fundamental frequency is the first subpart and is typically the strongest to the ear. It establishes the sound's pitch. Overtones are the partials that are above the fundamental. The relative strength of the overtones determines the sound's tone, color, and timbre. Tone systems are commonly studied using this technique in sound analysis and re-synthesis (Hamdan *et al.* 2020). Previous studies had been done using FFT and TFA methodologies in *Nirai* guitar (Duin *et al.* 2025), *Hasapi* (Sinin *et al.* 2025), *Pratuonkg* (Hamdan *et al.* 2024) and *Tongkungan* (Hamdan *et al.* 2025) musical instruments.

An omnidirectional microphone was used to measure the radiated sound in an anechoic setting. To ensure a fair comparison, the GK was played in the conventional seated position. In order to capture the true acoustic qualities of the sound, this posture is most indicative of normal playing settings and promotes natural sound output and resonance throughout the recording process. This arrangement guarantees that the recordings accurately capture the tonal qualities of the sound without adding bias or distortion from different microphone positions.

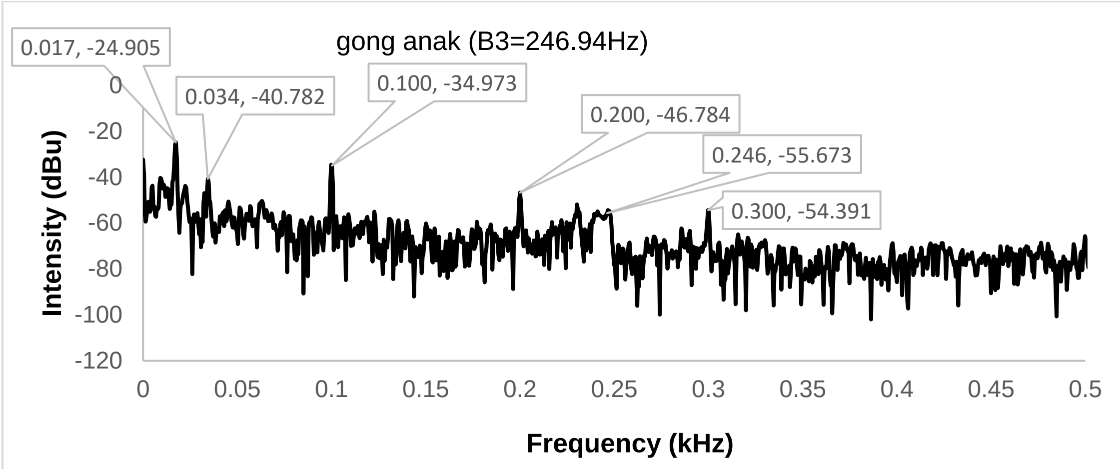
The microphone was positioned 20 cm from the string, as shown in Figure 4. This 20 cm microphone position promotes natural sound generation and resonance and is most realistic of normal playing situations. To capture the authentic acoustic qualities, the microphone was positioned in front at a constant distance and angle during the recording process. With this setup, distortion is avoided and the recordings are guaranteed to accurately capture the tonal qualities. The instrument was played and recorded under identical circumstances to minimize any anomalies or variations. The microphones were positioned above them at the same height and angle to guarantee that the recordings accurately captured the acoustic qualities of the instrument without adding any bias.

RESULTS AND DISCUSSION

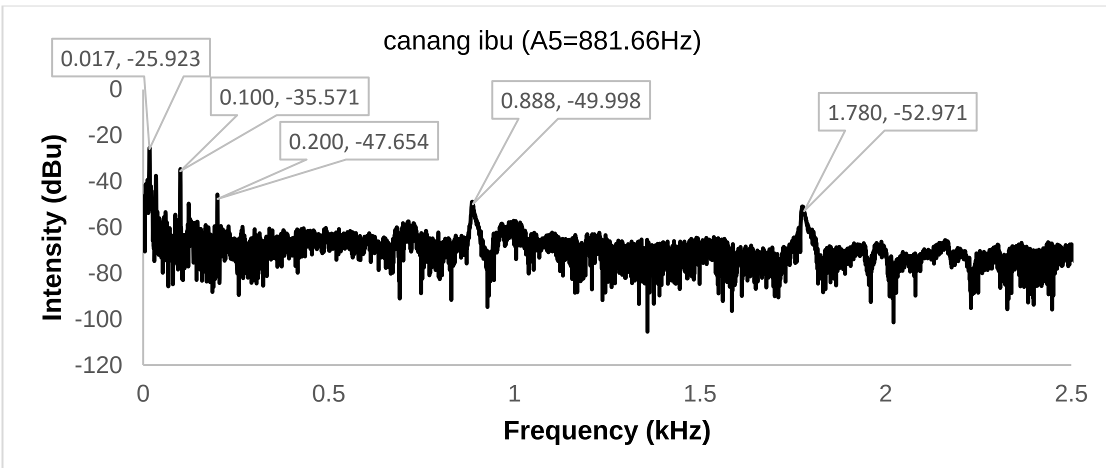
Figure 5 shows the frequency spectrum of *gong ibu* (0.230 kHz (A3#)), *gong anak* (0.246 kHz (B3)), *canang ibu* (0.888 kHz (A5)), *canang anak* (C6 = 1.054 kHz (C6)), and *gendang* (0.380 kHz (F4#)). Several subharmonics lower than the fundamental frequency (f0) of *gong ibu* occur at 0.017, 0.100, 0.200 kHz, and several subharmonics below f0 of *gong anak* occur at 0.017, 0.034, 0.100, 0.200 kHz and above f0 at 0.300 kHz. Several subharmonics lower than f0 of *canang ibu* at 0.017, 0.100, 0.200 kHz with second harmonic occurred at 1.780 kHz. Several subharmonics lower than f0 of *canang anak* occurred at 0.017, 0.100, 0.200 Hz with second harmonic occur at 2.134 kHz.



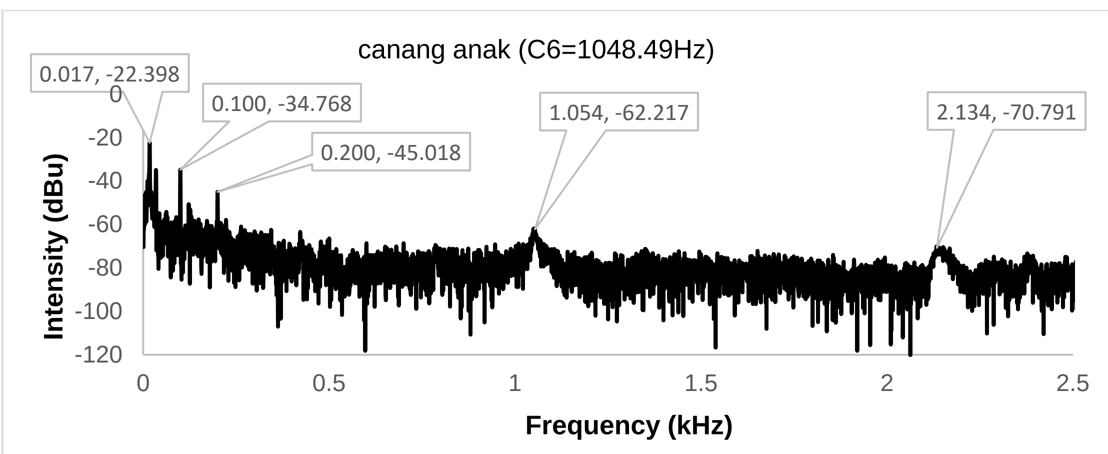
(a) *gong ibu*



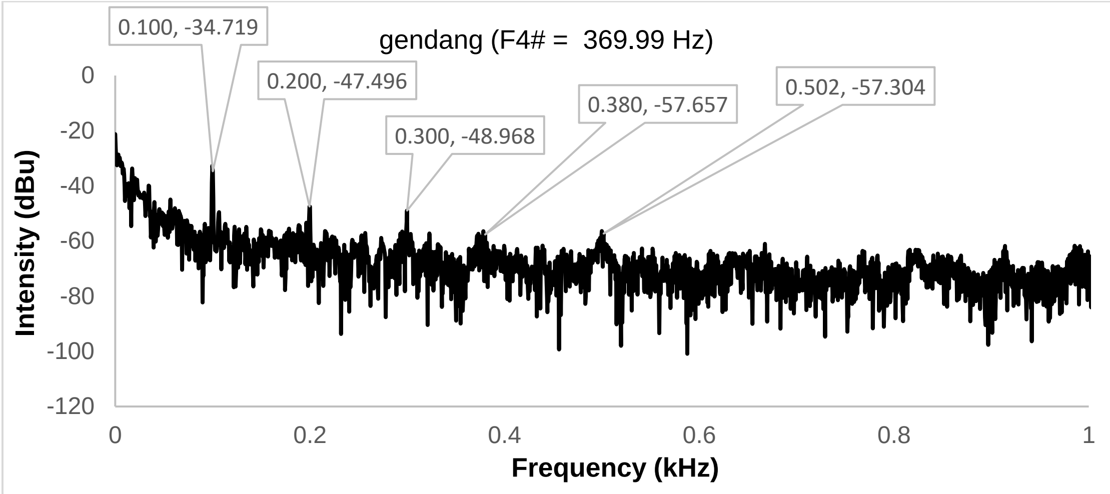
(b) *gong anak*



(c) *canang ibu*



(d) *canang anak*



(e) *gendang*

Fig. 5. The frequency spectrum of *gong ibu, gong anak, canang ibu, canang anak, and gendang*

The fundamental frequency, often referred to simply as the fundamental (abbreviated as f0), is defined as the lowest frequency of a periodic waveform. A sub harmonic is a component of a periodic wave having a frequency that is an integral submultiple of the fundamental frequency. The subharmonic having half the fundamental frequency is the second subharmonic.

Table 1 shows the respective fundamental and higher frequency (and notes) for the gongs, strings, and drum from *Gendang Kecapi*. Table 2 shows the fundamental (f0), first (f1), and second (f2) partial for string 1 through 5 and the drum from *Pratuonkg* (Hamdan *et al*. 2024). Table 3 shows the fundamental frequency f0 (bold) and partials frequency for strings 1 to 6 for *Tongkungon* (Hamdan *et al.* 2025). Frequency f_H is the pitches as heard. From Table 1 the fundamental frequency for *gong ibu*, *gong anak*, *canang ibu*, *canang anak*, and the *gendang* were 230, 246, 888, 1054, and 380 Hz, respectively. From Table 2 the fundamental frequency for string 1, 2, 3A, 3B, 4A, 4B, 5 and drum were 320, 300, 350, 410, 490, 470, 500 and 210 Hz respectively. From Table 3 the fundamental frequency for string 1, 2, 3, 4, 5, 6 were 260, 330, 250, 200, 180, 200 Hz respectively.

From Table 1, only the strings *canang ibu* and *canang anak* displayed second harmonic partials at 1.780 and 2.134 kHz, respectively, whereas *gendang* displayed higher partials at 0.505 kHz. Based on the observations on the results, it is concluded that this bamboo GK yield 5 pitches namely A3#, B3, A5, C6 and F4#. The TFA showed the distinct partial frequencies from the strings 1 (*canang ibu*) and string 2 (*canang anak*). The *pratuonkg* strings yield 7 pitches namely E, D, F, Ab, B, A# and B and the drum was A3. The *tongkungon* strings yield 6 pitches namely C, E, B, A, F and A.

Table 1. Gongs, Strings, and Drum with the Respective Fundamental and Higher Frequency (and Notes) for *Gendang Kecapi*

Gongs, Strings and Drum	Fundamental and Higher Partial Frequency (kHz)
Gong 1 (*gong ibu*-low pitch)	0.230 (A3#)
Gong 2 (*gong anak*-high pitch)	0.246 (B3)
String 1 (*canang ibu*-low pitch)	0.888 (A5), 1.780
String 2 (*canang anak*-high pitch)	1.054 (C6), 2.134
Drum (*gendang*)	0.380 (F4#), 0.502

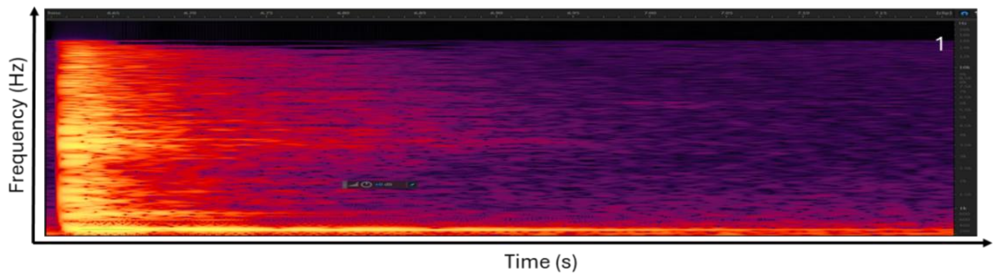
Table 2. The Fundamental (f0), First (f1), and Second (f2) Partial (in hertz) for String 1 Through 5 and the Drum for *Pratuonkg* (Hamdan *et al.* 2024)

	f0	f1	f1/f0	f2	f2/f0	Pitches From FFT
String 1	320(E4)	640	2			E4
String 2	300(D4)	630	2.1	770	2.56	D4
String 3A	350(F4)	710	2.02	840	2.4	F4
String 3B	410(Ab4)	840	2.04			Ab4
String 4A	490(B4)	950	1.93			B4
String 4B	470(A#4)	520				A#4
String 5	500(B4)	530				B4
Drum	210(A3)	400	1.85	500	2.38	A3

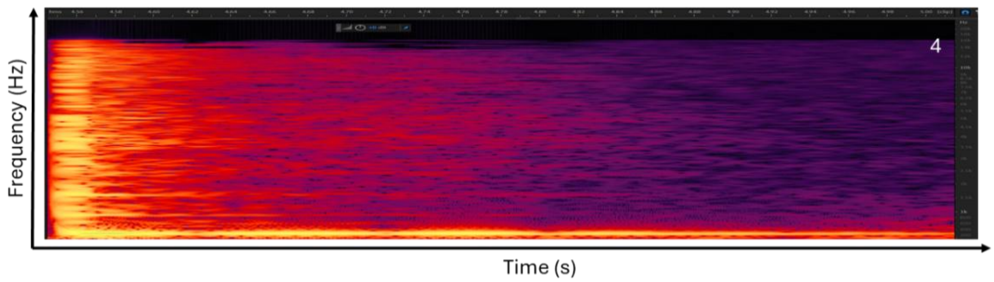
Table 3. Fundamental Frequency f0 (bold) and Partials Frequency (in hertz) for Strings 1 to 6 for *Tongkungon* (Hamdan *et al.* 2025); Frequency f_H is the pitch as heard.

String No.	1st Peak	2nd Peak	3rd Peak	4th Peak	5th Peak	6th Peak	7th Peak	8th Peak	Pitches as Heard f_H	Difference Between f_H and f_o
1	20	100	120	200	**260**	530 ($2f_o$)	810	1200	C4 (261)	261 – 260 = 1
2	20	100	200	**330**	360	500	660 ($2f_o$)	-	E4 (329)	330 – 329 = 1
3	20	100	**250**	500 ($2f_o$)	760	930	1050	-	B3 (246)	250 – 246 = 4
4	20	100	**200**	440 ($2f_o$)	600	880	1100	-	A3 (220)	220 – 200 = 20
5	20	100	**180**	360 ($2f_o$)	620	800	-	-	F3 (174)	180 – 174 = 6
6	20	100 ($0.5f_o$)	**200**	500	670	890	-	-	A3 (220)	220 – 200 = 20

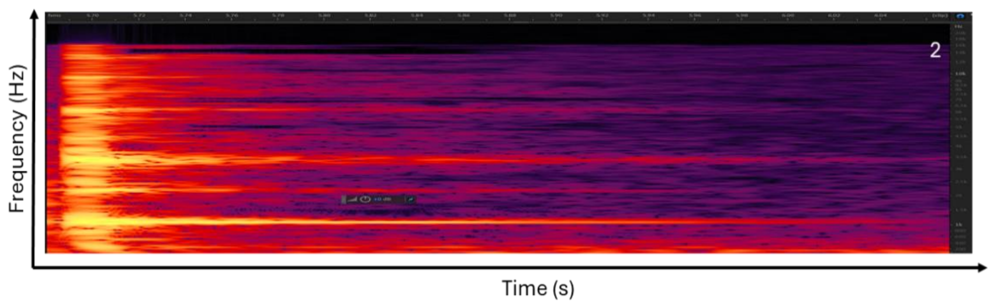
Figure 6 shows the time frequency analysis (TFA) from *gong ibu, gong anak, canang ibu, canang anak*, and the *gendang*. *Gong anak* is brighter than *gong ibu*. *Canang anak* is brighter than *canang ibu*. In Table 1 *gong ibu* is a low pitch gong (0.230 kHz) compared to *gong anak* (0.246 kHz), and *canang ibu* is a low pitch string (0.888 kHz) compared to *canang anak* (1.054 kHz). Both strings display second harmonic partials.



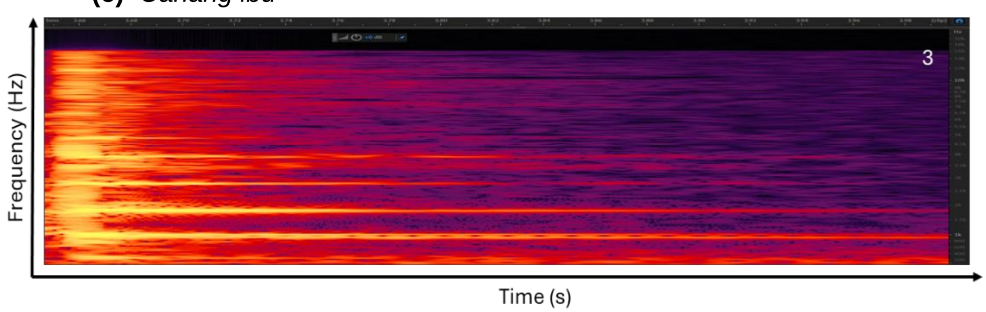
(a) *Gong ibu*



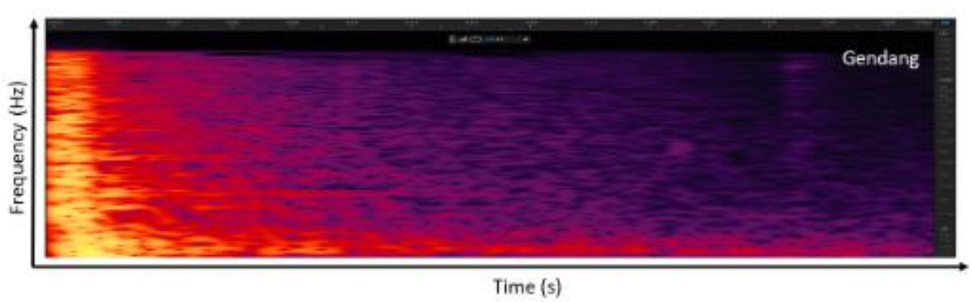
(b) *Gong anak*



(c) *Canang ibu*



(d) *Canang anak*



(e) *Gendang*

Fig. 6. Time frequency analysis (TFA) of *gong ibu, gong anak, canang ibu, canang anak, gendang*

CONCLUSIONS

1. Fundamental frequencies (f0) of *gong ibu*, *gong anak, canang ibu, canang anak*, and *gendang* were 0.230 kHz (A3#), 0.246 kHz (B3), 0.888 kHz (A5), 1.054 kHz (C6), and 0.380 kHz (F4#).
2. Only the strings *canang ibu* and *canang anak* displayed second harmonic partials at 1.780 and 2.134 kHz, whereas *gendang* displayed higher partials at 0.505 kHz.
3. Based on the observations on the results, it is concluded that this bamboo GK yielded 5 pitches, namely A3#, B3, A5, C6, and F4#.
4. The TFA showed the distinct partial frequencies from the strings 1 (*canang ibu*) and string 2 (*canang anak*).
5. This study highlights the potential for sonic heritage preservation through meticulous sound analysis and documentation. By capturing the instrument's unique acoustic properties using FFT analysis and time-frequency spectrograms, this research offers a foundation for creating a digital sound library that preserves the cultural identity embedded within the instrument's sonic characteristics.

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REFERENCES CITED

Hamdan, S., Said, K.A.M., Rahman, M. R., Sawawi, M. and Sinin, A. E. (2023). "Borneo Lute 'Sape': The frequency spectrum and time frequency analysis (TFA)," *BioResources* 18(4), 6761-6771). DOI: 10.15376/biores.18.4.6761-6771

Hamdan, S., Said, K. A. M., Musib, A. F., Rahman, M. R., Sawawi, M., and Sinin, A. E. (2024). "Pratuokng: The Borneo Bamboo Zither of Bidayuh Sarawak," *BioResources* 19(1), 1305–1315. DOI: 10.15376/biores.19.1.1305-1315

Hamdan, S., Said, K. A. M., Kipli, K., Duin, E. A. M. and Sinin, A. E. (2025) "The Tongkungon: A Traditional Kadazan Dusun Plucked Musical Instrument from Sabah, Malaysia," *BioResources* 20(1), 357-367. DOI: 10.15376/biores.20.1.357-367

Isa, M. A., Daud, K. A. M., Harun, M. H., Ishak, W. M. F. W., Muhammad, S., Berahim, M. H., Ghani, R. D. A., Apandi, S. N. A. M., Kiffli, S., and Saari, F. A. (2021). "The designing and development of gendang kecapi as bamboo-based musical instruments on eco-tourism activities," *AIP Conference Proceedings* 2347(1), 020035.

Sinin, A. E., Hamdan, S., Said, K. A. M., Abdullah, S., and Musib, A. F. (2024a). "Gendang Melayu Sarawak (GMS)-Sarawak Malay drum, the dying and forgotten tradition," *BioResources* 19(2), 2065-2076. DOI:10.15376/biores.19.2.2065-2076

Sinin, A. E., Hamdan, S., Said, K. A. M., Sawawi, M., Jia, G. T. J., and Hipni, M. J. (2024b). "The Sarawak 'Tar' for Hadrah performance," *BioResources* 19(3), 5288-5299. DOI: 10.15376/biores.19.3.5288-5299

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