

# Research on the Acoustic Characteristics and Digital Inheritance Pathways of Liangshan Yi Ethnic Folk Songs

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**Abstract:** This study focuses on the important intangible cultural heritage of Liangshan Yi folk songs, which faces severe challenges such as shrinking transmission fields and a shortage of inheritors in the process of modernization. To scientifically protect and revitalize this cultural heritage, the research adopts an interdisciplinary perspective combining ethnomusicology and music acoustics, systematically conducting acoustic characteristic analysis and exploring digital transmission pathways. Through fieldwork, experimental ethnomusicological analysis, and literature review, professional audio analysis tools are employed to quantitatively measure and qualitatively analyze core acoustic parameters—pitch, loudness, timbre, and formants—of four representative folk song genres: mountain songs, wedding songs, sacrificial songs, and festival ritual songs. The findings reveal significant differences in acoustic dimensions such as energy, fundamental frequency, and formants across different genres, closely related to their social functions, emotional expressions, and cultural contexts. Specifically, mountain songs exhibit high-pitched, free-flowing acoustic characteristics; wedding songs feature intense emotional contrasts and pronounced pitch fluctuations; sacrificial songs are solemn and steady with unified timbre; while festival ritual songs are bright, cheerful, and rhythmically dynamic. Building on these insights, the study proposes digital transmission pathways including the construction of a multi-modal database, acoustic feature modeling, development of virtual singing systems, and new media dissemination, providing theoretical foundations and technical support for the scientific protection, living transmission, and contemporary dissemination of Yi folk songs.

**Keywords:** Yi Ethnic Folk Songs, Acoustic Analysis, Digital Inheritance, Path Thinking.

## 1. Introduction

Liangshan Yi Autonomous Prefecture (hereinafter referred to as Liangshan Prefecture) is located in the southwest of Sichuan Province, China, at the northeast edge of the Hengduan Mountains, the transitional zone between the the Yunnan-Guizhou Plateau and the Sichuan Basin. It is the largest Yi inhabited area in China, and one of the most complete and representative areas of Yi culture preservation. [1]

Yi ethnic folk songs, as an important intangible cultural heritage in southwestern China, carry the historical memory, life wisdom, and aesthetic taste of the Yi people, and are treasures in the diverse cultural treasure trove of the Chinese nation. Yi ethnic folk songs, with their unique scale structure, rhythm patterns, and singing techniques, have formed distinct regional characteristics and ethnic styles, and have important value in linguistics, musicology, and anthropological research. [2] However, with the acceleration of modernization and changes in lifestyle, Liangshan Yi folk songs are facing severe challenges such as aging inheritors, reduced audience, and disappearance of native contexts. The traditional oral transmission method is no longer suitable for the needs of contemporary cultural dissemination.

Liangshan Prefecture is the largest Yi ethnic settlement in China, preserving the oldest and most primitive Yi culture. As a unique oral culture of the Yi ethnic group, Yi folk songs have become excellent representative works of Yi culture with their beautiful melodies, simple language, realistic life scenes, vivid and touching artistic images, and artistic charm of pursuing truth, goodness, and beauty. Any kind of music originates from language, which is the mother body of music. The expressions, tones, and rhythms of language determine

the melody and rhythm of music, as well as the beginning, interval, and ending of the melody. Especially the emergence of folk singing forms is the result of the mutual breeding of local language, culture, and customs. The research on Liangshan Yi folk songs can be roughly divided into the following aspects:

Firstly, from the perspective of musicology research, Yang Liu (2015) analyzed the artistic expression forms of Liangshan Yi folk songs and focused on exploring the singing techniques of Yi folk songs. [3] Xu Ning (2020) conducted research on the musical characteristics of Yi ethnic folk songs, which not only showcases the charm of Yi ethnic folk songs, but also calls on more people to pay attention to the current situation of Yi ethnic folk songs, truly realize the urgency of protecting and inheriting them, and thus achieve the goal of promoting traditional ethnic culture. [4]

Secondly, the cultural connotation of Liangshan Yi folk songs is studied from the perspective of ethnic cultural inheritance. Yan Huafeng (2021) explores the current situation and characteristics of the dissemination of Liangshan Yi music culture in the context of new media, analyzes and studies the impact of new media on the dissemination of Yi music culture, and proposes strategies for the development of Yi music culture in the context of new media, aiming to lay a solid foundation for the sustainable development of Yi music culture. [5] Cheng Fuwen (2023) analyzed and summarized the ecology of Yi folk songs in Liangshan, discovered their historical context and current survival status, and analyzed their dissemination attributes to understand the evolution and transformation of Yi traditional culture in Liangshan Prefecture. [6]

Finally, from the perspective of textual connotation, research has been conducted on the folk songs of the Yi

people in Liangshan. Ye Jiangling (2022) studied the text types of traditional Liangshan Yi folk songs and, based on oral poetics theory, divided them into four categories: oral texts, written texts derived from oral sources, tradition-oriented texts, and performance-oriented texts, and conducted connotation analysis for each type of text. Tang Jin (2024), through field investigations, interpreted the cultural meaning of the 'Rheda' marriage wailing songs from the perspective of ethnic memory, deconstructed and analyzed their intrinsic content from a researcher's viewpoint, and further identified issues and constraints in their inheritance, proposing relevant strategies for their continuation in contemporary society.[7]

In the context of the rapid development of digital technology, exploring modern methods for the protection and transmission of Yi folk songs has become particularly urgent. This study approaches the topic from the perspective of acoustic analysis, utilizing modern audio processing techniques, spectrogram analysis methods, and digital signal processing theory to systematically investigate the acoustic parameters of Liangshan Yi folk songs, including fundamental frequency characteristics, formant structures, time-domain features, and timbre composition. It aims to establish a scientific acoustic feature database, providing new technical approaches and methodological support for the preservation of intangible cultural heritage.[8]

This study not only helps deepen the scientific understanding of Yi musical culture but also provides a practical model for the digital preservation and living transmission of minority oral traditions. It holds significant practical importance for maintaining cultural diversity and promoting ethnic unity and progress. Through the interdisciplinary integration of technology and humanities, we hope to open up new possibilities for the sustainable transmission of the precious cultural heritage of Liangshan Yi folk songs.

## 2. Introduction to Research Theories and Methods

### 2.1. Theoretical Foundation

Ethnomusicology emphasizes examining music within its specific cultural and social context. Its core perspective holds that music is not only an aesthetic art form but also a carrier and expression of a particular group's historical memory, social structure, religious beliefs, and emotional patterns.[9] In the case of the Liangshan Yi folk songs, their various genres—mountain songs, wedding songs, sacrificial songs, and festival ritual songs—have developed and evolved precisely within the unique context of Yi mountainous agricultural culture, clan system, ancestor worship, and festival customs. Alan P. Merriam proposed the 'Concept-Behavior-Sound' threefold analytical model, which indicates that the production of musical sound stems from musical behavior governed by specific cultural concepts (such as understandings of nature, marriage, and deities). Therefore, the analysis of the acoustic characteristics of folk songs in this study is not merely an isolated measurement of physical parameters; it attempts to explore the underlying cultural concepts (such as the longing for freedom in mountain songs, the complex emotions concerning family relationships in wedding songs, and reverence for deities in sacrificial songs) and specific performing behaviors (such as high-pitched outdoor singing, ritual chanting, and collective song-and-dance) that shape their unique acoustic features. This

contextualized interpretation helps avoid the 'deculturation' tendency in acoustic data analysis, ensuring that the data interpretation retains cultural depth and humanistic sensitivity.

### 2.2. Pronunciation Materials

The corpus for this experiment was selected from the most representative traditional Yi folk songs. According to the social function, performance occasion, and musical forms of the songs, they can be roughly classified into the following categories:

**Folk Songs of the Hills:** Mainly sung in the mountains, fields during labor, or while traveling, the content involves love, life, nature, and so on. Their melodies have wide undulations, free rhythms, and broad vocal ranges, making them the genre that best embodies the characteristics of Yi folk songs for acoustic analysis. Examples include "A Re Niu" (a love song) and "Zhuo He" (a labor song).

**Wedding Songs:** Permeate the entire wedding process, such as "Crying Wedding Song," "Sending off the Bride Song," and "Welcoming the Bride Song." Their emotional expression is rich, featuring both plaintive, mournful tones and festive, lively rhythms.

**Sacrificial Songs:** Compared with the Yi hill songs, which have wide melodic ranges and significant ups and downs, Bimo music has relatively gentle melodies and narrower ranges, focusing more on the rhythm and prosody of the language. Its musical form closely follows the tonal, rhythmic, and intonational patterns of the Yi language, serving as a kind of "musicalization of language".

**Festival and Ritual Songs:** Such as songs sung during Torch Festival or the Yi New Year, often combined with dance, featuring distinct rhythms and structured arrangements. Different genres of folk songs exhibit significant acoustic differences.

This study will focus on representative examples such as the hill song "Troubled Leisure," the wedding song "Crying Wedding Song," the sacrificial song "Bimo Music," and the festival and ritual songs "A Du Gao Qiang" and "Duo Le He" for the main acoustic analysis, to ensure both the typicality and depth of the research.

### 2.3. Recording Equipment and Methods

The hardware equipment for this experiment mainly includes a mixing console, external sound card, lavalier microphone, camera, and laptop. In a quiet recording studio, using the Adobe Audition CC recording software without accompaniment, the speaker's voice and vocal signals are simultaneously collected at a sampling frequency of 22050Hz with a resolution of 16 bits. After the recording is completed, it is saved as WAV format.

## 3. Acoustic Analysis

Voice acoustic signals mainly include intensity, which represents the level of volume, airflow, and vibration amplitude of a singer during singing.[10] Pitch: Represents the range and pitch variation of a singer's vocal range when speaking. Formant: a region of the sound spectrum where energy is relatively concentrated, which can reflect the resonance characteristics of a singer during the singing process.[11]

### 3.1. Energy Analysis of Different Genre Songs

In phonetics, energy is a physical quantity that reflects the changes in sound intensity and dynamics. In vocal acoustics

research, energy is an important physical parameter that characterizes the intensity and dynamic changes of sound, directly reflecting the height, strength, and temporal distribution characteristics of sound during singing. The sound effects of songs perceived by the human ear, including the fluctuation of pitch and the contrast of intensity, are closely related to the distribution of sound energy. There are significant differences in energy utilization in music expression across different cultural backgrounds. For example, various types of Yi folk songs have different requirements for singing energy, reflecting the deep influence of ethnic culture and aesthetic concepts on sound expression.

In vocal performance, good energy control is one of the core elements of singing technique, which is closely related to techniques such as breathing support, resonance regulation, and articulation clarity, jointly constraining the expressive power and artistic level of singing. Through quantitative analysis of singing energy, the technical characteristics of singers in respiratory management, range utilization, and dynamic hierarchical arrangement can be effectively revealed. In addition, energy distribution directly affects the emotional communication of a song: high-energy segments often convey strong emotions such as passion or tension, while low-energy segments are often used to express soft, introverted, or sad emotions, thereby guiding the audience to resonate.

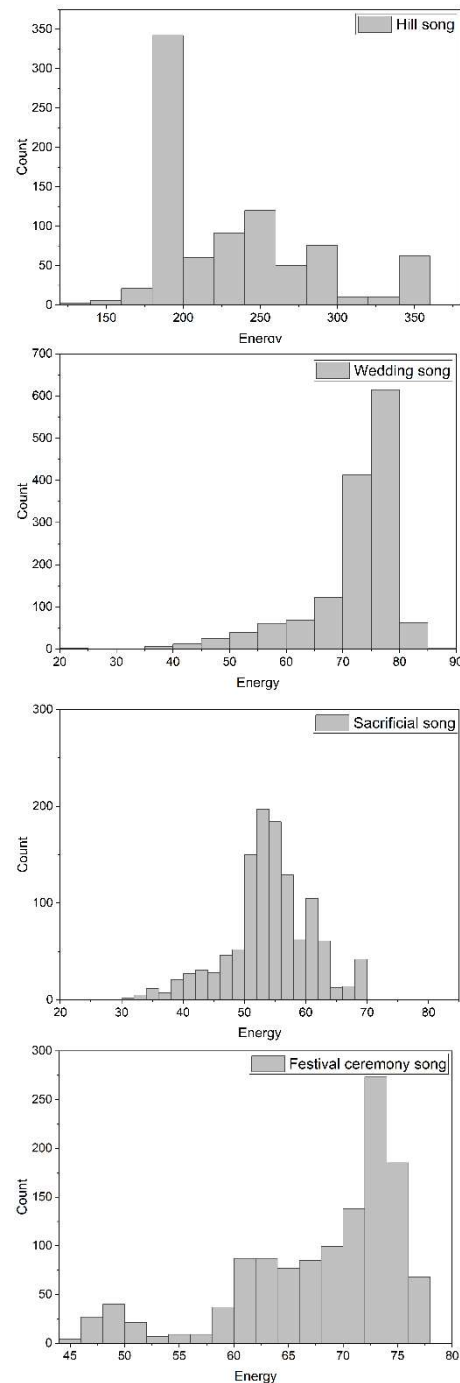
Table 1 shows the mean and standard deviation of energy in different Yi ethnic folk songs, and the statistical measures can reflect the dynamic range and distribution characteristics of energy in each song. The maximum and minimum values indicate the maximum range of volume, with larger mean and standard deviation indicating richer emotional fluctuations, and smaller mean and standard deviation indicating more stable singing.

**Table 1.** Energy Data of Yi Ethnic Folk Songs

Type	Energy(dB)			
	Max	Min	Avg	SD
Hill song	91.67	33.72	81.15	8.74
Wedding song	86.86	21.34	71.96	8.42
Sacrificial song	69.15	31.06	54.14	6.83
Festival Ceremony Song	77.76	45.20	67.98	7.52

This study quantitatively analyzed the acoustic energy data of four typical types of Yi folk songs (mountain songs, wedding songs, sacrificial songs, and festival ritual songs), and the results showed that there were significant differences in energy levels, stability, and dynamic ranges among the four types, each with distinct acoustic characteristics.

In terms of the overall distribution of energy intensity in different types of folk songs, descriptive statistics show that there are differences in the singing styles of various types of folk songs. The average energy of mountain songs is the highest (81.15 dB), reflecting their high pitched and open vocal characteristics; Wedding songs come in second place (71.96 dB), with moderate energy levels, reflecting the diversity of their content and form; The festival ceremony song is slightly lower than the wedding song (67.98 dB), with concentrated and stable energy, which is in line with its lyrical characteristics; The sacrificial song has the lowest energy (54.14 dB), which is highly consistent with its ceremonial and recitative style.



**Fig. 1** Histogram of energy distribution for four types of songs

From the energy histogram of mountain songs, their distribution shows a certain regularity. There may be a more obvious peak area, indicating a relatively common intensity range in mountain song singing. For example, the intensity value corresponding to this peak may reflect the typical volume size used by mountain songs in general singing situations to convey emotions and information in open environments. The characteristic of relatively large standard deviation (SD=8.75) may be reflected in the histogram as a wide distribution width, indicating a significant variation in the singing intensity of mountain songs. This may be due to the diverse occasions for singing mountain songs, such as working in the mountains, festivals and celebrations, where singers adjust the volume according to the environment and their own emotional expression needs, resulting in significant differences in intensity.

The intensity histogram distribution of wedding songs also

has its unique features. The energy distribution histogram presents a multi peak structure, with severe fluctuations in the time curve and multiple sudden peaks. This reveals the distinct rhythm, strong contrast, dramatic and expressive sound effects of folk songs.

The intensity histogram of sacrificial songs is significantly different from other types of folk songs. Due to its lowest average intensity (54.14 dB), the histogram overall leans towards the lower intensity range. The distribution is relatively concentrated, reflecting that the intensity of sacrificial songs changes relatively little under the requirement of solemn singing atmosphere (SD=6.83), indicating that in sacrificial occasions, singers will follow certain norms and maintain a relatively stable volume to reflect the solemnity of sacrificial activities.

The energy histogram of festival ritual songs presents a relatively regular shape. Its average intensity is 67.98 dB, which is at an intermediate level and has a wide range of energy distribution. This is because although festival ceremonies have a certain degree of flexibility, there are also some established procedures and norms that limit the excessive variation of singing intensity, causing it to fluctuate within a certain range.

The energy characteristics of the four types of folk songs of the Yi ethnic group are highly related to their social and cultural functions: mountain songs are characterized by their high and sustained intensity, wedding songs are characterized by their contrast of ups and downs, sacrificial songs are marked by their low and steady tone, and festival ritual songs are centered around rhythm and melody. This energy analysis provides objective and quantitative data support for the acoustic classification and inheritance protection of Yi ethnic folk songs.

### 3.2. Fundamental Frequency Analysis of Different Genre Songs

Pitch, as one of the core attributes of sound (together with sound intensity, length, and timbre to form the four basic characteristics of sound), is directly determined by the fundamental frequency (F0) of sound in its physical essence. This correlation is a fundamental understanding in the field of acoustic analysis. From the perspective of acoustic characteristics of speech, vowels and voiced consonants naturally carry detectable fundamental frequency signals due to the periodic vibration of the vocal cords during vocalization; And voiceless consonants usually do not have independent fundamental frequencies because the vocal cords are in a non vibrating state. However, it should be noted that the adjacent vowel signals before and after them often continue the fundamental frequency characteristics, forming a coherent acoustic spectrum. The application value of fundamental frequency in acoustic analysis is particularly prominent: in the field of speech processing, it is a key parameter for extracting tones, analyzing rhythms, and recognizing emotions. There are significant differences in the fundamental frequency fluctuation patterns under different emotional states (such as joy and sadness); In the field of music analysis, fundamental frequency is the core element in constructing melodies - the ordered combination of different fundamental frequencies forms intervals and harmonic structures, directly affecting the aesthetic transmission and artistic expression of music. For Yi ethnic folk songs, their unique melodic style, emotional expression, and cultural connotations all require precise analysis of fundamental

frequency data to be quantitatively presented. Table 2 shows the fundamental frequency data of four types of Yi ethnic folk songs.

**Table 2.** Fundamental frequency Data of Yi Ethnic Folk Songs

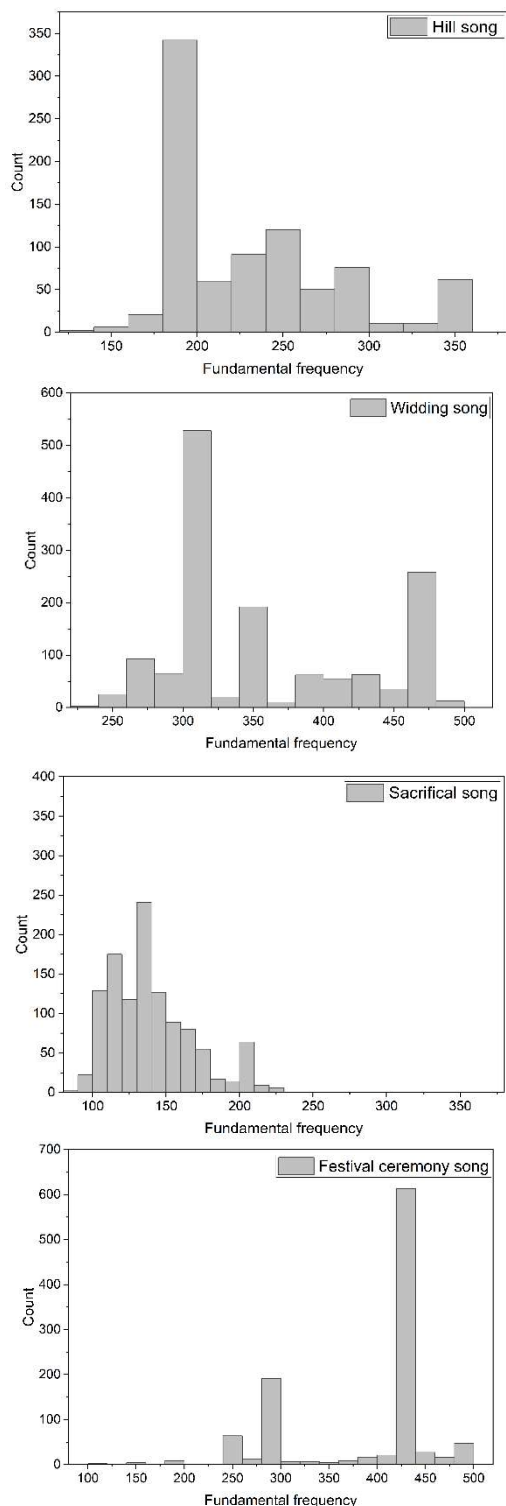
Type	Fundamental frequency (Hz)			
	Max	Min	Avg	SD
Hill song	358.64	134.17	232.83	50.44
Wedding song	498.75	233.71	357.45	69.5
Sacrificial song	226.11	86.4	139.74	28.26
Festival Ceremony Song	499.55	117.05	388.18	73.73

As show in Table 2, it can be seen that the fundamental frequency mean of the "Crying Marriage Song" is the highest (about 385.6 Hz), with a large standard deviation (85.4 Hz), indicating that its overall pitch is high and the amplitude of variation is significant. The emotional expression is extremely rich, often accompanied by large interval jumps and strong emotional fluctuations, which is in line with the expression characteristics of combining "crying" and singing. Festival ritual songs also exhibit a higher fundamental frequency level, but their distribution is more concentrated, overall high and fluctuating frequently, reflecting a cheerful and enthusiastic festival atmosphere and characteristics of collective participation.

In contrast, the fundamental frequency of sacrificial songs is the lowest (average 142.8 Hz), with the smallest degree of variation, demonstrating a high degree of consistency and stability. Its pitch variation is limited, and the melody is smooth and solemn, which meets the solemn and standardized ceremonial requirements in sacrificial occasions. Mountain songs fall between the above three categories, with a natural distribution of fundamental frequencies and moderate fluctuations, presenting a fluidity between language tone and singing melody, closely related to their narrative and lyrical functions.

By analyzing the histograms drawn from the fundamental frequency data of four types of Yi ethnic folk songs, significant features and differences in pitch distribution can be clearly observed for each type of folk song. The fundamental frequency distribution of mountain songs is relatively flat and has a moderate span, showing an approximate normal distribution shape without obvious extreme peaks, reflecting that their pitch usage is more natural and free, between linguistic tones and singing melodies, closely related to their narrative and lyrical functions. The fundamental frequency distribution of wedding cry songs shows a clear bimodal pattern, indicating the existence of two relatively stable pitch ranges in their singing, corresponding to low pitched narration and high pitched crying in emotional expression, reflecting the dramatic and rich emotional transformation of this type of folk song. The fundamental frequency distribution of sacrificial songs exhibits highly concentrated and low characteristics, with the vast majority of data points concentrated in the low-frequency region. The distribution curve is steep and the peak value is significant, indicating that the pitch is extremely uniform and stable, which meets the requirements of solemn, dignified, and standardized music expression in sacrificial occasions. The fundamental frequency of festival ritual songs is mainly concentrated in the mid to high frequency range, with a relatively wide overall distribution but still in a unimodal

shape, indicating that although their pitch usage has certain fluctuations, it still revolves around a main pitch interval, reflecting the cheerful and enthusiastic collective musical characteristics.



**Fig. 2** Histogram of fundamental frequency distribution for four types of songs

These distribution characteristics not only reveal the preferences and patterns of pitch usage in the four types of folk songs from a statistical perspective, but also reflect their different social functions, emotional attributes, and cultural contexts behind them. The bimodal structure of wedding cry songs reflects the binary opposition of emotional expression. The concentrated distribution of sacrificial songs reflects the

standardization of ritual music, while the broad distribution of festival ritual songs echoes the openness and inclusiveness of their celebrations. The natural distribution of mountain songs is highly consistent with their life and narrative functions. This histogram analysis provides a visual and powerful basis for distinguishing and understanding the types of Yi folk songs from an acoustic perspective.

### 3.3. Formant analysis of Different Genre Songs

**Table 3.** Formant Data of Yi Ethnic Folk Songs

Type	F1(Hz)		F2(Hz)		F3(Hz)	
	Avg	SD	Avg	SD	Avg	SD
Hill song	667	134	1523	269	2815	331
Wedding song	429	170	1566	492	2964	419
Sacrificial song	680	203	1549	379	2885	530
Festival Ceremony Song	625	249	1520	408	3020	583

By analyzing the formant data (F1, F2, F3) of four types of Yi ethnic folk songs, as shown in Table 3 that there are significant differences in their timbre characteristics, which are closely related to the social functions, singing occasions, and emotional expression of various types of folk songs.

Firstly, from the perspective of the first formant (F1), the mean F1 of wedding songs is significantly lower than the other three categories (429 Hz), indicating that singers have a tighter vocal tract and higher vowel pronunciation when singing wedding songs, which is usually associated with tense, suppressed, or high effort vocal states. This is highly consistent with the emotional expression of sadness and sobbing in the custom of "crying for marriage". On the contrary, the F1 mean of mountain songs and sacrificial songs is relatively high (667 Hz and 680 Hz, respectively), reflecting a more open and natural vowel pronunciation and relaxed singing state, which is in line with the lyrical and solemn characteristics of mountain songs and sacrificial songs. The F1 mean of festival ritual songs is between the two (625 Hz), but has the largest standard deviation (249 Hz), indicating that their timbre is diverse and may incorporate multiple vocalizations such as joy and calling.

The mean of the second formant (F2) shows little difference among different types (1520-1566 Hz), indicating that the overall pronunciation positions of the four types of folk songs are relatively close in the front and back dimensions of vowels. However, the F2 standard deviation of wedding songs is extremely large (492 Hz), much higher than other genres, suggesting that there are significant vocal variations and uncertainties during singing, which may be due to the unstable tone and vowel variations caused by strong emotional fluctuations during the crying wedding process.

The third formant (F3) is related to the brightness of the timbre and the tightness of the front of the channel. The F3 mean of festival ceremony songs is the highest (3020 Hz), usually associated with bright and penetrating tones, making them very suitable for outdoor celebration occasions to attract attention and create atmosphere. The F3 of the wedding song is also relatively high (2964 Hz), combined with its extremely high F2 standard deviation, further supporting its characteristics of vocal tension and emotional excitement. The F3 of mountain songs and sacrificial songs is relatively low, and the tone may be softer and richer.

## 4. Conclusion

Through a systematic analysis of four types of Yi ethnic folk songs (Hill songs, Wedding songs, Sacrificial songs, and Festival ritual songs) in terms of energy, fundamental frequency, and formant, this study reveals the differences in acoustic performance of different genres of folk songs from the perspective of physical parameters and their inherent connections with cultural functions and emotional expression. The results indicate that Yi ethnic folk songs exhibit significant typological differentiation in acoustic characteristics, with strong genre recognition and socio-cultural adaptability in terms of energy distribution, pitch structure, and timbre attributes.

Energy analysis shows that mountain songs, with their high mean and large standard deviation energy characteristics, embody a high pitched and free emotional expression, suitable for outdoor and long-distance singing scenes; The energy of wedding songs fluctuates dramatically and is distributed in multiple peaks, reflecting their strong dramatic and emotionally contrasting folk performance characteristics; The sacrificial song has the lowest energy and concentrated distribution, which meets the aesthetic requirements of solemnity and solemnity in ritual activities; Festival ritual songs have moderate energy and stable distribution, reflecting the musical function of balancing coordination and lyricism in collective activities.

Fundamental frequency analysis further supports the above classification from the pitch dimension: wedding songs and festival ritual songs have higher fundamental frequencies and rich variations, corresponding to intense or cheerful emotional expressions; The low and stable fundamental frequency of sacrificial songs reflects the standardization and consistency of ritual music; The fundamental frequency distribution of mountain songs is natural, with moderate fluctuations, and combines linguistic and melodic features, which is highly compatible with their narrative function.

Formant analysis deepens the understanding of the vocal mechanisms of various folk songs from the perspective of timbre: the abnormal fluctuations of wedding songs on F1, F2, and F3 correspond to their strong emotional tension and large vowel variation in singing state; The concentrated distribution of formants in sacrificial songs reflects their stable vocalization and unified timbre; The festival ceremony song F3 is relatively high and has a bright tone, suitable for creating a festive atmosphere; The formant characteristics of mountain songs show an open and natural way of vocalization.

The digital inheritance of Yi folk songs is a systematic cultural project, and its path construction should be based on a multi-level and multi-media integration strategy grounded in acoustic analysis. The acoustic characteristics of Yi folk songs are not accidental phenomena, but rather the specific

manifestations of their cultural context, social function, and aesthetic orientation in sound form. Energy, fundamental frequency, and formant together constitute a multi-dimensional acoustic identification system, which can not only be used for the objective differentiation of folk song types but also provide empirical evidence for understanding the cultural connotation and performance practices of ethnic music.

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## References

- [1] Cheng Fuwen. Research on the Ecology and Dissemination of Yi Folk Songs in Liangshan Prefecture [J]. *Art Research*, 2023, (03): 68-71
- [2] Su Lianke. *Basic Theory of Yi People's Audible Language and Its Digitization Method Research* [M]. Beijing: Ethnic Publishing House, 2017
- [3] Yang Liu. An Analysis of the Artistic Forms and Singing Techniques of Liangshan Yi Folk Songs [J]. *Music Research*, 2015(3): 45-50
- [4] Xu Ning. Research on the Musical Characteristics, Inheritance, and Protection of Yi Folk Songs [J]. *Chinese Music*, 2020(2): 78-83
- [5] Yan Huafeng. Research on the dissemination of Liangshan Yi music culture in the context of new media [J]. *Journal of Journalism and Communication Research*, 2021(5): 112-120
- [6] Ye Jiangling. A Study on the Text Types of Traditional Folk Songs of the Yi People in Liangshan [J]. *Forum on Folk Culture*, 2022(4): 56-64
- [7] Tang Jin. A Study on the Cultural Implications of the "Reda" Wedding Songs of the Liangshan Yi People in Ethnic Memory [J]. *Folklore Studies*, 2024(1): 88-95
- [8] Song A'yim, Liu Haiqing. Promoting the Development of Spiritual Civilization in Liangshan Region through Yi Folk Song Culture [J]. *Journal of Ethnology*, 2023, (6)
- [9] Luo Qin. *Culture in Music and Music in Culture* [M]. Shanghai: Shanghai Conservatory of Music Press, 2010
- [10] Gao Shan. Digital Research on Mongolian Long and Short Tunes Based on Physiological Acoustics [D]. Lanzhou: Northwest Minzu University, 2012
- [11] Zhang Chunlian. Experimental phonetics research on the singing style of Hanteng Dagu [D]. Peking University. 2015: Chapter 6 Long-term average spectrum analysis of text and track.