Ancient Aerophones with Mirliton

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ZUSAMMENFASSUNG

In diesem Beitrag wird aufgezeigt, dass vorspanische Keramikflöten erhalten sind, die mit einem Mirliton versehen sein konnten. Aerophone mit Mirliton werden heute noch von zwei ethnischen Gruppen Nordwestmexikos verwendet, den Pame und Teenek, und sind in ländlichen Gebieten Mexikos auch in der Jagd als sog. gamitaderas *bekannt. Im Folgenden werden die organologischen und akustischen Charakteristika sowie der mögliche Gebrauch der archäologischen Instrumente diskutiert.*

1 INTRODUCTION

In the Hornbostel and Sachs systematic of musical instruments all devices, in which the sound is generated by oscillating air, are classified as aerophones; devices, in which the sound is generated by a vibrating membrane, are considered membranophones[1]. The mirliton, a membrane attached to the resonator of wind instruments, vibrates through the pressure of sound waves. Thus, it can be suggested that instruments with a mirliton can be classified as aerophones *and* membranophones. Nevertheless, the mirliton is not the primary generator of sound, which still is generated by an airstream directed against an edge (in flutes with an aperture), vibrating reeds (in oboes), or vibrating lips (in trumpets), but the device modifies the sound characteristics considerably. The specific timbre generated through the mirliton can be described as buzzing and reedy.

With the exception of publications on Asian flutes, the *dizi* from China and the Korean *taegŭm*[2], comprehensive studies on aerophones with mirliton are rare. This paper addresses prehispanic flutes with possible mirliton devices and some contemporary instruments played in rural Mexico, which may be successors of ancient acoustical designs. Unfortunately, information on the archaeological context of the discussed instruments is very limited, and their exact cultural meaning is mostly unknown. Nevertheless, experimental models can be made to study playing possibilities and acoustical features. Taking into account the contemporary use of aerophones with mirliton devices and experimental models of these as well as of ancient instruments, a proposal on the possible original uses of the ancient sound artifacts can be made.

2 PREHISPANIC FLUTES WITH MIRLITON

The hypothesis for the possible use of a mirliton in prehispanic flutes is supported by a characteristic organological feature, a small tubular device with a circular perforation attached to the flute's resonator. On hand of experimental models, it was verified that this device does not function as a fingerhole. On the other hand, it facilitates the vibration of the mirliton. As the original mirlitons, which were made of perishable material, are lost, their possible use has not been recognized.

2.1 CERAMIC TUBULAR DUCT FLUTES FROM COSTA RICA, HUETAR CULTURE (Late Classic and Early Post-Classic periods, ca. A.D. 800–1200)

Two tubular duct flutes of the Huetar culture were published by Samuel Martí (Fig. 1), who did not comment upon the possible attachment of a mirliton[3]. The instruments are 12 cm and 14 cm in length and show a short tubular airduct and a tubular resonator with a long tapered distal end. These flutes show zoomorphic attachments on their resonator. Other instruments of similar type show anthropomorphic attachments, such as two flutes published by Justin Kerr in his Precolumbian Port-

1 Hornbostel/Sachs 1914.
2 Tsai 2003; Heo 2003.
3 Martí 1970, 141, Fig. 119.

folio as "Costa Rica Whistles" K7875 and K7876 (Figs. 2–3)[4]. It is interesting to note that these flutes have two tubular mirliton devices at the distal end of the tube. An acoustical analysis still has to be undertaken on hand of the original artifacts or experimental models.

2.2 CERAMIC TRIPLE-GLOBULAR AEROPHONE FROM OAXACA, MEXICO

Gonzalo Sánchez recorded a triple globular aerophone from El Zapote, Ixtaltepec, a rural village located in the Isthmus of Tehuantepec, Oaxaca (Fig. 4)[5]. The instrument was found on the surface and donated by locals. Unfortunately, no data on the archaeological context exists. Closing the small tubular device with a finger does not change the pitch, indicating the use of a mirliton. The experimental model that was made and tested by Sánchez with an attached mirliton that produces buzzing sounds[6].

2.3 CERAMIC TUBULAR DUCT FLUTES FROM THE VALLEY OF MEXICO (Post-Classic Mesoamerica, A.D. 900–1521)

2.3.1 Tubular duct flute with an attached effigy representing a turkey

The beautiful flute represented in Figure 5 was excavated in a ritual deposit located in front of the west side of the Temple of the New Fire Ceremony at Cerro de la Estrella *(Huixachtecatl*), Iztapalapa, Mexico City. Currently, the instrument is exhibited in the *Museo Nacional de Antropología*, Mexico City. In this flute, like in other ones of the Late Post-Classic period, the small mirliton device is located between the first finger hole and the aperture. In his thesis, Miguel Pérez Negrete provides some basic archaeological and organological information[7]:

Object: 10–150344
Origin: Project 1974–1975
Context: Ritual Deposit 3, Late Colhua phase[8]
Description: Flute of clay with five perforations[9]. The body displays a shining red color. At the far end it shows the effigy head of a *guajolote* (turkey) with large earspools.
Dimensions: 20.5 cm length, 4.5 cm height
Temporality: Early Post-Classic (A.D. 950–1150)
Comments: A study by Doris Heyden exists on the *guajolote*, in which she resumes: "In Mexico, the *guajolote* occupied an important place in the economy, in feeding, in religion, and in symbolism. It was an offering to the gods and to the kings, the image of the dead king, and symbolized the ancestors. It represented the god *Tezcatlipoca* in one of his manifestations. The *guajolote* was one much estimated element in the native fauna of the Mesoamerican world in the prehispanic era."

According to Pérez Negrete[10], the following material was excavated in the ritual deposit: A matrix of clay, possibly from the shore of the ancient Lake of Texcoco; a fragmented *almena* (decorative architectural element); remains of young masculine individuals, mainly skulls (about 70 specimen); flutes of clay; vessels of clay; and figurines. Some objects may have been altered after the sacrifice or reused, as at least one cranium was painted with *chapopote*, a crude natural oil.

Considering the composition of the deposit and the decoration of some flutes with the effigy of divinities like *Tlaloc*, the god of rain, and possibly *Xochipilli*, the god of music, Pérez Negrete proposed that the sacrificial victims used the flutes in the course of the ceremony[11]: "The sacrificed boys who formed part of Ritual Deposit 3 may have represented the *tlaloques* (adjuncts of the god of rain, the author), who were accompanied with the flutes in a ritual unity that involved the *tlaloques* in the playing of these musical instruments." It should be pointed out that this hypothesis does not take into account the *guajolote* symbolism of the discussed flute.

2.3.1.1 Acoustical analysis of experimental model

The experimental model of the discussed instrument (Fig. 6) functions very well with a mirliton[12]. As shown in the spectrogram (Fig. 7), the model produces the typical musical scales of this type of flutes, but with a specific nasal timbre[13]. The pitch

4 Kerr n.d., Precolumbian Portfolio K7875 and K7876, <http://research.famsi.org/kerrportfolio.html>, retrieved March 1, 2008.
5 Gonzalo Sánchez included this aerophone in his poster presented at the 5th Symposium of the *International Study Group on Music Archeology*.
6 Gonzalo Sánchez, personal communication 2006.
7 Pérez Negrete 2005, Vol. 2, 687 (translation by the author).
8 Usually, such tubular duct flutes with a conic resonator are considered to be Aztec, but Ritual Deposit 3 was deposited before the Aztecs settled in the Valley of Mexico.
9 The possible use of a mirliton was not recognized, as the device was misinterpreted as the fifth finger hole.
10 Pérez Negrete 2005, Vol. 2, 603.
11 Pérez Negrete 2005, Vol. 2, 600 (translation by the author).
12 Used mirlitons were made from the intestine of a pig or a thin sheet of a plastic bag. Materials originally used, such as bat wings, could not be obtained.
13 See also Velázquez 2006c, <http://www.geocities.com/ehecatl92/pame/guajolote.html>, retrieved March 1, 2008. The spectrograms were obtained with the program "Gram" by Richard Horne (see <http://www.visualizationsoftware.com/gram.html>).

ranges from 840 Hz to 1610 Hz, but these values are less important, as the sounds were generated on an experimental model. In this case especially the timbre should be observed, as well as other acoustic characteristics when applying different playing techniques. Activated with vocalizations and gliding fingering positions, the instrument produces undulating sounds of great complexity showing many harmonics, noise and variations of intensity and pitch. When applying such playing techniques, it is possible to generate sounds which resemble bioacoustical sounds. Experimentally it has been tested that complex frequency components can be generated, which resemble turkey cries. The similarity is demonstrated in spectrograms (Fig. 8).

Models of a flute produce a sound pressure intensity of 100 dB when operated with and 95 dB when operated without a membrane[14]. The estimated maximum radiated acoustic power is 0.126 Watts and 0.04 Watts. Thus, the perceived power is greater when the flutes are operated with a mirliton, even if their estimated acoustic power is lower. The possible cause of this specific audible effect is the generation of harmonics in the frequency range of maximum hearing sensitivity, when the mirliton is used. The sounds of these flutes with a mirliton can be heard at a considerable distance, up to more than 300 m in an open field. Also, the strong harmonics generated in the range of maximum hearing sensitivity explain the perception at long distances. Thus, the flute could be heard very well in ritual events performed in open spaces, when a mirliton is attached.

If we recognize the possible use of a mirliton and the generation of turkey sounds and follow the interpretation by Negrete, a hypothesis for its use in an ancient rite to *Tlaloc* can be proposed, i.e., the flute could have been used as a symbolic offering to *Tlaloc*, in which the call of the turkey was incorporated, accompanying the sacrificial victims on their journey to the underworld.

2.3.2 Fragments of ceramic tubular duct flutes

The fragment of a similar flute with a small mirliton device is in exhibition in the *Museo Arqueológico de Xochimilco*, Mexico-City (Fig. 9). Unfortunately, no archaeological data exists on this find. The curator of the museum commented that many of the preserved objects were donated by local people, which may suggest that the fragment originates from the southern part of Mexico City[15].

Another fragment of a tubular duct flute from the collection of the *Instituto Tecnológico de Monterrey*, which shows the characteristic mirliton device, was published by Martí[16]. Martí noted that it probably originates from Colima, West Mexico, but its shape is clearly of the Late Post-Classic type, suggesting that the instrument originates from the Valley of Mexico.

Finds of similar clay flutes are frequently broken, indicating ritual fragmentation in the context of sacrificial ceremonies related to *Tezcatlipoca*, a god related to the night, the jaguar, and royal power.

3 CONTEMPORARY FLUTES WITH MIRLITON

In contemporary Mexico, flutes with a mirliton are still played among the Pame, San Luis Potosi, and among the Huaxtecs, Veracruz[17]. A specific type, the so-called *gamitaderas*, is used for hunting in rural areas of Mexico.

3.1 THE PAME MIRLITON FLUTE

The mirliton flute of the Pame (Fig. 10)[18] is still played in Santa Maria Acapulco, a rural community located in the mountain range north of the Sierra Gorda, in the southeastern part of the state of San Luis Potosi. Several flutes of the type were analyzed to examine their construction and morphology, but unfortunately none was in playable condition. However, it was possible to analyze their morphology and the materials used for their construction. Additionally, field recordings were analyzed[19].

The instruments are made of local natural materials. Their length is not standardized and varies between about 35–55 cm. The resonator consists of a tube of cane (*carrizo*) with four fingerholes. A small protuberance of *propoleo*[20] is attached over a perforation of the resonator, locat-

14 The dB levels were measured with a sonometer at 1 m and zero degrees.

15 Maria Teresa Herrera, personal communication 2005.

16 Martí 1968, 195.

17 Velázquez 2006b, <http://www.geocities.com/ehecatl92/pame/fpame.html>, retrieved March 1, 2008.

18 This Pame flute was given to the author by Carlos Garcia.

19 Vientos Sagrados: Música Ceremonial Pame. Conaculta-INAH 1998. Currently, this recording is not available for sale.

20 *Propoleo* (or *propolis*) is a wax-like resinous substance produced by honeybees, used as cement and to seal cracks or open spaces in the interior of the hive, as well as for protection against insects. Its color varies from green to brown and red, depending on its botanical source. In the Pame zone it is gray or black. *Propoleo* is widely known for its antibiotic properties. It is firm when in a cool state, but malleable when warmed up.

ed between the last finger hole and the aperture. The protuberance is covered by the mirliton, which is made of a thin sheet of an egg-sac of spider silk. Additionally, a leaf of maize is used to support the vibrations. The airduct of the flutes is made from the shaft of a turkey feather and is attached to the embouchure with *propoleo*. The internal structure of the embouchure is shown in Figure 11, after the removal of a segment of the lateral wall made of *propoleo*.

3.1.1 Acoustical analysis of the Pame mirliton flute

This exercise is to show that it is possible to analyze the signal of a musical instrument using the sounds of its recordings. In some cases the indirect analysis with recordings is the only one that can be realized, when the instruments are lost or unavailable for direct analysis, as in this case.

The sounds of the Pame flute can be analyzed with spectrograms. The spectrogram of the *Son de las Mariposas* ("Son of the Butterflies")[21] is shown in Figure 12, considering the frequencies of the complete audible range (up to 22 kHz). The graph shows the main acoustic characteristics of the flute like the variations in the intensity (dB) of the sounds and the effect on the frequency components, including the variations of intensity as well as tone range restriction, timbre changes or inhomogeneity and predominance of odd-numbered harmonics. Another important characteristics of the signal is the noise included between the harmonics, which is produced by the acoustic mechanism of this flute[22]. Weak even-numbered harmonics or predominance of odd-numbered harmonics of the nasal sound are shown in spectrogram of Figure 13, amplifying the graph of frequencies (up to 11 kHz) of the same sample. The details of the fundamental (F0) is shown in the spectrogram (Fig. 14) of a short segment. The main distinction of the sounds is the long duration of the notes (up to more that 5 seconds), but the pitch has small variations and noise around the F0. The five basic pitches of this flute are about 350 Hz, 480 Hz, 555 Hz, 625 Hz and 755 Hz, which are equivalent to (musical note +/- cents with A4= 440 Hz) F3+3.82, B4-49.35, C4+1.98, D4+7.62 and F4+34.77. The exact musical notes of these flutes are not important, because their dimension is not standard. Their intensity is between 70 dB and 72 dB and the quality acoustic factor are low, because the F0 varies +/- 30 Hz. The main distinction of the Pame flute is the timbre generated by its special embouchure and membrane. Pame flute sounds resemble laments of animals and other sounds of the natural environment. It is interesting that most of the names of Pame *sones* are of animals like *La Mariposa, La Víbora, El Tigre, El Sapo, El León, El Zopilote, La Mosca, La Ardilla*, *La Palomita, La Zorra, El Puerco,* etc. Some names are related with nature, as *Lucero de la Mañana*, *El Brillo*, etc. Other *sones* are related to the four cardinal points, as *Dos pasos para delante*, *Dos pasos para atrás*, etc. It is said about Pame music that it is composed of a mixture of the complex Mesoamerican concepts and the Spanish religion.

Maria Eugenia Jurado reported[23] that in the Pame region in 2003 three musicians made and played the flute with a mirliton: Rufino Medina, Juan Medina and Anastasio Rubio. In relation to the music, the two first performers commented that it is played at Catholic feasts, such as *Todos los Santos* and *Día de los Muertos*. For Rubio the Pame music was played in the sacred realm of high mountains and caves and considered as an offering to the gods. It was used in a ritual for the thunder god to ask for disgraces like thunderstorms, strong winds, or fire. Also, it was used to pray for rain, to let the corn grow and to stop rainstorms. Today, Santa Maria Acapulco is the only place where praying for rain is realized with *mitote* music. The Pame flute and its music were transmitted from fathers to sons in an oral tradition, but now these elements are in danger, because young Pames are more influenced by contemporary music and there are no important actions undertaken to preserve this extraordinary and singular tradition.

3.2 THE TUBULAR *GAMITADERA*

In several rural areas of Mexico a tubular *gamitadera*[24] with a mirliton was used to imitate sounds of animals to call or to hunt them, but its ancient name and history are lost. It was analyzed with experimental models in other paper[25]. Its open tubular design was very simple (Fig. 15). Usually, the body of the resonator was an open tube made from *carrizo* or from bone. An end hole was covered with the mirliton. A lateral hole was used to introduce the vocalizations. The mirliton

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21 Taken from *Vientos Sagrados: Música Ceremonial Pame*, Conaculta-INAH 1998.

22 The edge is not sharp, because it is made by a transverse cut of the cane. The embouchure has the windway covered with *propoleo*, that produces noisy sounds as with some clay flutes of Colima. An experimental model of this flute operated without a mirliton produces only the fundamental tone (F0) and one harmonics with noise.

23 Jurado 2005, 36–38.

24 In Spanish, *gamo* means deer. In Mexico the term *gamitadera* is used to designate instruments that call animals, usually for hunting.

25 Velázquez 2006a, <http://www.geocities.com/curinguri/gamitadera/gamitt.html>, retrieved March 1, 2008.

was made of several vegetal materials. In the state of Guerrero a dried bat wing was used as a mirliton[26]. A cord and/or bees wax was used to attach the mirliton at one end of the tube. Also, dried intestines of animals could be used. Bat wings break, if they are folded when they are dried[27].

It is possible that ancient tubular *gamitaderas* existed in other zones, because many photos of ancient drilled tubes of similar morphology were found in several museums, collections and publications. They are misidentified as bird bone flutes or whistles, but the possible use of a mirliton is not mentioned. Any open bone tube with a mirliton at one end can produce sounds of the natural environment, if the instrument is activated with vocalizations through the lateral perforation. Most of these instruments were made from the bones of large birds like eagles, turkeys, pelicans, etc.

Similar instruments without a lateral perforation function with a small hole in the mirliton, while the airstream is introduced at the opened end of the tube to produce whistling sounds with harmonics. One of those still is used in Mexico by balloon sellers. Usually, the short resonator tube is made from a plastic pen and the mirliton is made from a balloon. It is similar to the Mexican tubular *gamitadera*, but without the lateral hole. Also in Panama, a *gamitadera* with a hole in the mirliton was used[28]. In Spain, such an instrument is called "*membranofono soplado*" (blown membranophone), but it is made of cane and the mirliton is of cigarette paper or moistened onion skin[29]. It seems that similar instruments were and are used in Africa, such as the *kazoo* from Sierra Leone[30].

3.3 BUCCAL INSTRUMENTS WITH MIRLITON

Some special buccal instruments with a mirliton are still used by professional hunters to imitate animal voices. One of them with a mirliton made of latex is used to call turkeys[31] and another one to call deer[32]. A similar instrument made with a simple leaf has been used in Mexico to play melodies. Several vegetal mirlitons can produce buzzing sounds, when they are played in similar way. The generated sounds of those aerophones with a mirliton are very similar to those of animals, because their acoustic system is similar. The mirliton vibrates similarly to the vocal cords inside the larynx[33]. In the past, this acoustic system could be directly imitated from the analysis of the animal's voice system. Leonardo da Vinci examined the human voice system with larynx dissections of cadavers and represented it in drawings[34], but we do not know if he made physical models of that system.

The similarities between the sounds of a turkey and a turkey call are shown in spectrograms of Figures 16 and 17. Also, the similarities between the sounds of a tubular *gamitadera* and the deer stopper are shown in Figures 18 and 19. The main spectral characteristics of these sounds are their continuous variations in pitch with many harmonics and noise, as is also the case with some human voices and phonemes of our languages.

In Mexico, there was a similar instrument made from two pieces of cane with a mirliton inside a small wind pipe to produce sounds of deer, but now it is used as a toy, because there are very few regions in which deer hunting is still practiced. Similar designs may exist in other zones of the world.[35]

In Mesoamerica, we did not find specific evidence of the ancient use of these kinds of artifacts to call animals, but there are references of the use of instruments and sounds for hunting. Some ancient lithographies were published by Moun-

26 Jesús Mora 2008, personal communication. He informed me that his grandfather used this kind of *gamitadera* with a mirliton of a bat wing to hunt deer.

27 Similar mirlitons were used in xylophones of several regions in Africa and America. For example, in the *Balafan*, an ancient xylophone of Senegal used mirlitons in its resonators of gourd to produce its special timbre. Also, marimbas of Guatemala and Mexico still use dried intestines of pig to cover a lateral hole of the resonators. In the *marimba*, bees wax is used to glue the mirliton onto the resonators. In this case, the mirliton vibrates with the sound waves generated by the wood when it is hit.

28 Cortés n.d., <http://mensual.prensa.com/mensual/contenido/2002/07/28/hoy/nacionales/647417.html>, retrieved March 1, 2008.

29 Juanma n.d., <http://www.tamborileros.com/tradiberia/membran1.htm>, retrieved March 1, 2008.

30 See photo published in Anonymous a (see also Anonymous b; Romanowski n.d.).

31 See Primos Hunting Calls, <https://shop.primos.com/c-27-mouth-calls.aspx>, retrieved March 1, 2008.

32 See Deweys's Sporting Goods, <http://www.shopdeweys-online.com/index.php?product_details=on3szp1s0z>, retrieved March 1, 2008.

33 For example, the larynx of deer is a voice box with membranes (vocal cords) inside the trachea (wind pipe).

34 Drawings of the human voice system were shown in a exhibition "Leonardo da Vinci y la Música" of the Antiguo Colegio de San Idelfonso, Mexico City, in 2006. The accompanying text informed that the drawings are included in the *Cuadernos de Anatomía*, preserved in the Royal Library of Windsor Castle, United Kingdom (1508–1516. IV 134r., folio 114).

35 For example, Cajsa S. Lund showed me an interesting model of the "*Hökpipa*" hawk pipe and the "*Getskrika*" goat pipe in their local Livedish names in Liveden. It is the "*Loxkpipa för rådjur*" used to call deer in Scandinavia. The mirliton is of onion skin and located inside of a thin lateral aperture or wind pipe, made of a stick of wood that was longitudinally divided into two parts with a knife and then fastened with cords. Its mirliton vibrates in a similar way as the turkey call between the lips, but in this case in the aperture between the two parts of the stick. Some experimental models of this type were made and they work well.

tjoy[36] with "megaphones" used in rituals of deer hunting in the Cañon del Ocotillo, Mascota, Jalisco, Mexico (about 300 B.C.). During the Inquisition of Mexico, rituals of *invocaciones* and *conjuros* used for deer hunting, in which deer calls were imitated to call them, were reported by Hernando Ruiz de Alarcón in his *Tratado de idolatrias* from 1629[37]. Actually, in the Maya region the call used by a local guide is a common predator call (generated with a deer caller) and the broker deer (*Mazama gouazoubira*) responds aggressively[38].

4 CONCLUSIONS AND WORK FOR THE FUTURE

The main acoustical effect of the mirliton in all of the discussed aerophones is the extraordinary buzzing and nasal timbre.

All existing ancient flutes with a small pipe for a mirliton must be analyzed directly to get their exact dimensions to be able to reproduce their experimental models and to find their acoustical properties. It is recommendable to register all similar aerophones with a small pipe for a mirliton that are stored in explorations, collections and museums in order to complement the classification of this extraordinary organological family. We hope that the publication of this paper may help to identify other similar aerophones with the possible ancient use of a mirliton.

It is recommendable to analyze other acoustic properties of a Pame flute in operable conditions. It is necessary to study in detail its mirliton and to find the spider specie that produces the silk. We were able to make replicas of these flutes, but it is recommendable to register the original way of their construction, before their possible loss. In 2006, I also recommended that the complex symbolism of the Pame flutes and their sounds be analyzed, before the death of the last maker and performer. Actually, this is difficult to realize. Margarita Velasco[39] reported that the older Pame performer and maker Rubio has died. He cannot speak to us and his Pame flute does not sing any more.

It is interesting to have discovered aerophones with a mirliton in regions of several ancient cultures that are far away in the world, such as those of Africa, Asia, America and Europe. It means that there were more uses and similarities among these very special acoustic mechanisms than has been recognized yet.

It has been shown that it is possible to analyze wind instruments, even in an indirect way, using the little available information, as well as their experimental models or recordings, in order to find the characteristics of their sounds and to propose possible original uses.

It is possible that many ancient bone tubes with one perforation, such as those of the tubular *gamitadera* type, may exist in several museums and collections, because their construction could be achieved in a very easy way. Considering the simplicity of the design of this resonator, tubes with a lateral hole could be very old. Their use for hunting is probable, because they could help to call the animals, and the activity of obtaining proteins from animals was vital for ancient people. The possible ancient use of instruments to call animals was already reported in some papers, but the analysis of their sounds was not found.

However, the design of acoustic mechanisms for the production of sounds that resemble animal voices is not easy. At least, it is necessary to be able to imitate the complex animal sounds that are not well known in literature on music and archaeology and are more complex than the flat musical sounds. It is recommendable to register and study the sounds of animals of the Mesoamerican region, because many of them are in danger of extinction. Animals were very important for ancient people, who lived in nature. Many of them were believed sacred and they are mentioned in literature and represented in iconography. Instruments with a mirliton and other acoustical artifacts, that can resemble sounds of animals and nature, also could be necessary to enrich the ancient music to be used in rituals and ceremonies related to the representations of sounds of phenomena and animals of their mythology and natural environment.

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36 Mountjoy 2001, 62–63

37 Ruiz de Alarcón 1892, 84 (see <http://www.cervantesvirtual.com/servlet/SirveObras/03693951900225939732268/index.htm>). It is said that specific words like *tahui* were directed to the four cardinal directions to call animals.

38 Boddington 1999, 78.

39 Margarita Velasco, personal communication 2007.

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Fig. 1 Two tubular duct flutes of the Huetar culture (after Martí 1970, 141, Fig. 119).

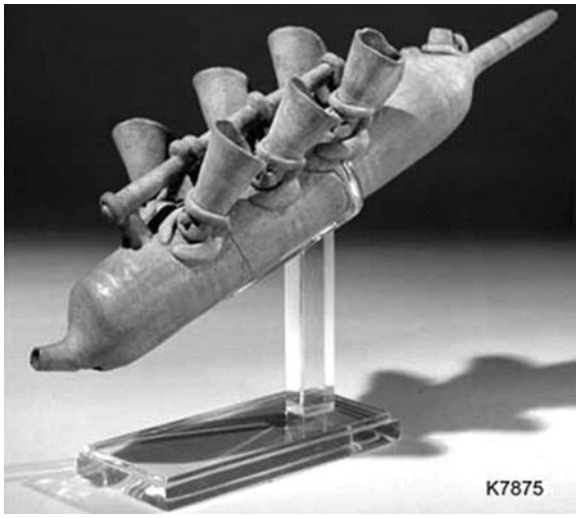

Fig. 2 Costa Rica Whistle K7875, published in Pre-columbian Portfolio by Justin Kerr.

Fig. 3 Costa Rica Whistle K7876, published in Pre-columbian Portfolio by Justin Kerr.

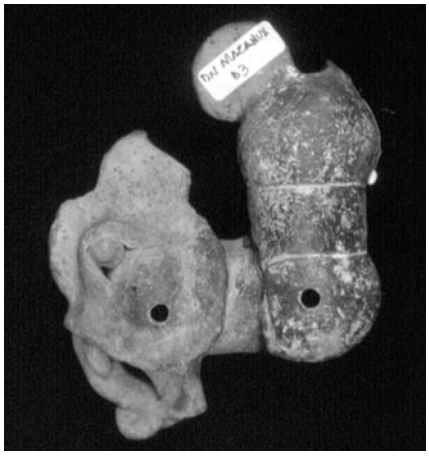

Fig. 4 Triple-globular aerophone from Oaxaca, Mexico, with an attached mirliton. Photo: G. Sánchez.

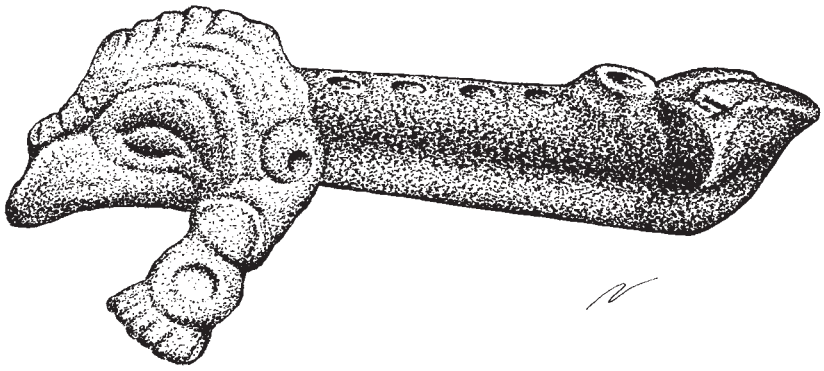

Fig. 5 Tubular duct flute with an attached effigy representing a turkey. Cerro de la Estrella, Ritual Deposit 3, Late Colhua phase (Early Post-Classic Mesoamerica, A.D. 950–1150). Drawing: R. Velázquez.

Fig. 6 Experimental model of the tubular duct flute with a mirliton.

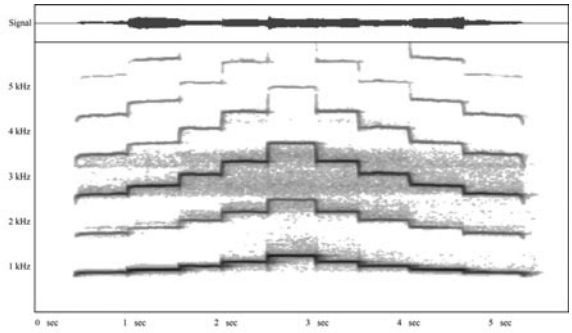

Fig. 7 Spectrogram of the musical scale produced by the experimental model.

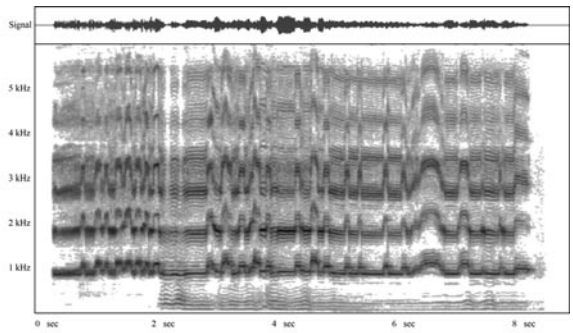

Fig. 8 Spectrogram of a turkey call on the experimental model.

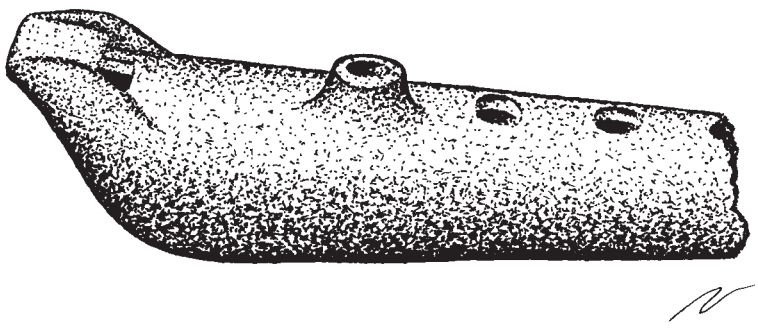

Fig. 9 Fragment of a similar flute with a small mirliton device. *Museo Arqueológico de Xochimilco*, Mexico-City. Drawing: R. Velázquez.

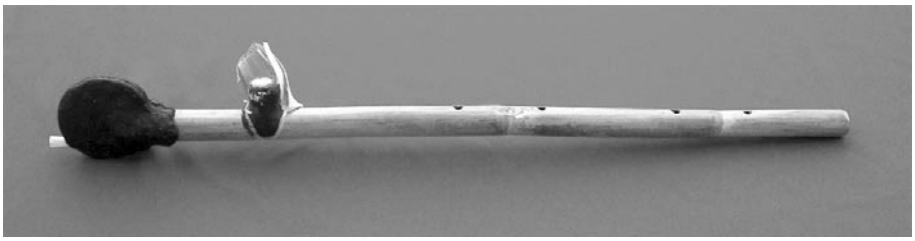

Fig. 10 The Pame mirliton flute.

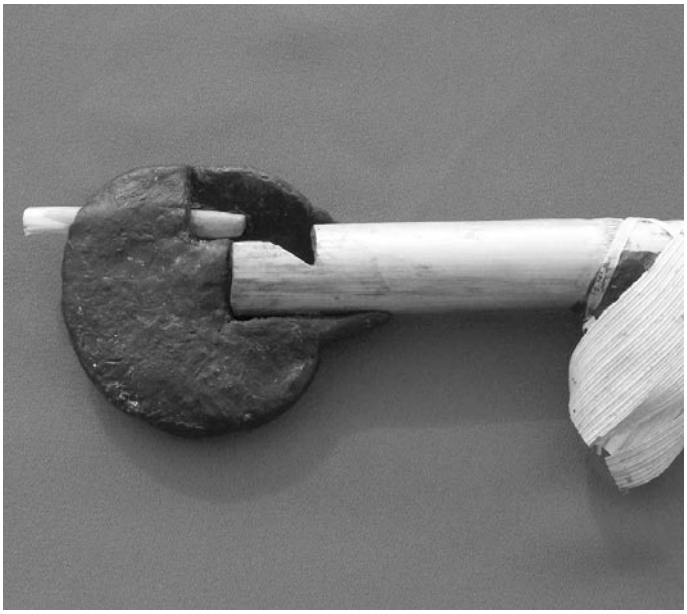

Fig. 11 The internal structure of the embouchure.

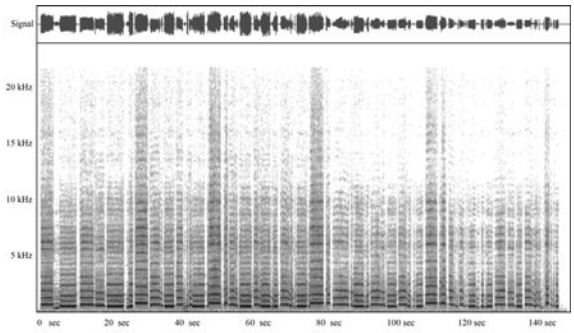

Fig. 12 Spectrogram of the *Son de las Mariposas*.

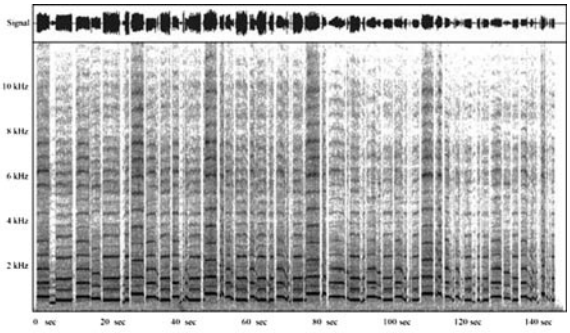

Fig. 13 Spectrogram of the *Son de las Mariposas* showing predominance of odd-numbered harmonics of the nasal sound.

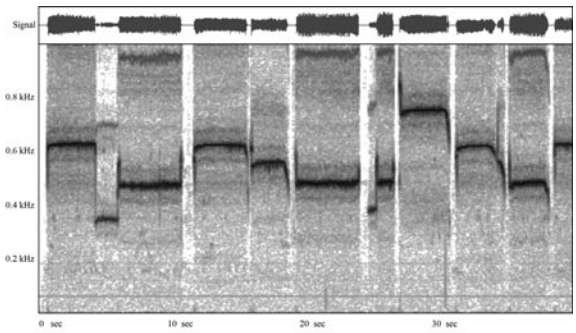

Fig. 14 Details of the fundamental (F0) of a short segment of the spectrogram of the *Son de las Mariposas*.

Fig. 15 Experimental models of tubular *gamitadera* made by the author.

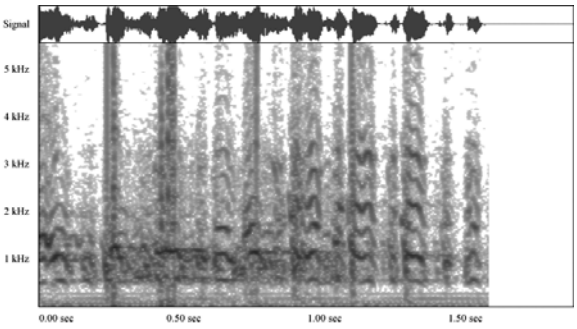

Fig. 16 Spectrogram of a turkey sound.

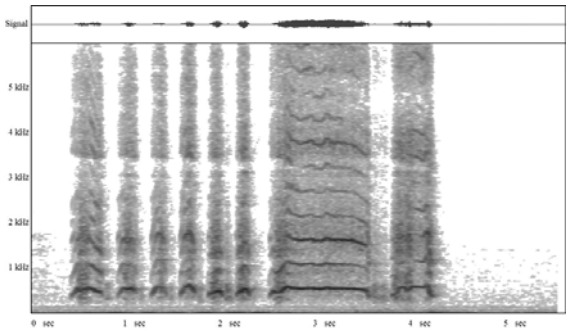

Fig. 17 Spectrogram of imitated turkey call produced on a buccal instrument with mirliton.

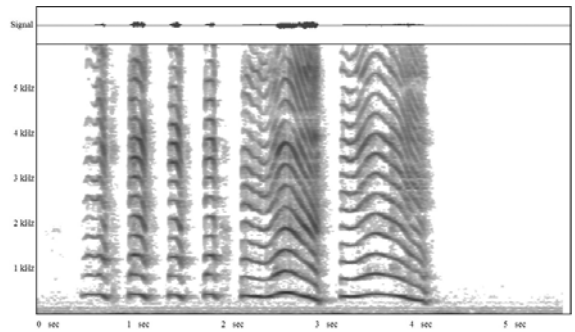

Fig. 18 Spectrogram of the sounds of a tubular *gamitadera*.

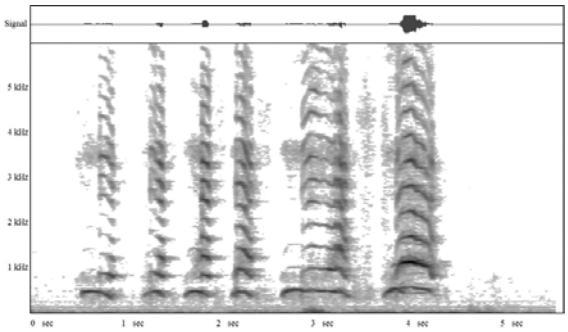

Fig. 19 Spectrogram of the sounds of a deer stopper.