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Commodification of Death: Morphological and Chemical Analysis of Two Shrunken Heads

by

Shanda Lin Putnam

A thesis

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The members of the committee appointed to examine the thesis of Shanda Lin Putnam find it satisfactory and recommend that it be accepted.

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Dedication

I dedicate this thesis to my nephews (and hopefully eventual nieces).

Your smiles brighten even the darkest moments.

Acknowledgments

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Commodification of Death:

Morphological and Chemical Analysis of Two Shrunken Heads

Thesis Abstract—Idaho State University (2019)

This project analyzed two shrunken heads curated by the Idaho Museum of Natural History to determine 1) if they are human and 2) if they are of commercial or ceremonial origin. The purpose is to assess the possibility of repatriation and examine curation issues regarding dark tourism (visiting places associated with death and tragedy) artifacts in museums. Both heads were analyzed using metric, morphological, microscopic, and chemical analyses of skin, hair, and fiber samples associated with the specimens. A wide range of analytical tools were used, including solution based inductively coupled plasma mass spectroscopy (ICP-MS), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy and energy dispersive x-ray spectroscopy (SEM/EDS). Results of the analyses ultimately revealed that the specimens are probable human, commercial shrunken heads. This has implications for their future curation and highlights the investigative role of anthropology for addressing ethical consumerism and dark tourism collections.

Key words: shrunken heads, chemical analysis, morphological analysis, dark tourism, *tsantsas*, museum collections.

Chapter 1 - Introduction

1.1 The Problem

It is estimated that nearly three-fourths of shrunken heads found in museums and private collections are not authentic *tsantsa*, trophy heads of the Shuar from South America. It is not always clear if shrunken heads are made from human materials, yet this is essential for museums to document in order to determine curation and repatriation needs. In particular, minimally invasive analyses are needed to establish the future of curated shrunken heads. Recent findings from anthropological and ethnographic studies have established that morphological characteristics can be used to distinguish commercial shrunken heads from ceremonial *tsantsas* (Houlton & Wilkinson, 2018, 2019). However, few studies have attempted to discriminate between the two, nor have protocols for determining if the shrunken heads are indeed human been established. This thesis investigates and utilizes morphological and morphometric methods that have previously been developed (Houlton and Wilkinson 2016, 2018; Houlton 2017) and then applies other methods such as microscopic and chemical analyses to examine two shrunken heads from the Idaho Museum of Natural history (IMNH). The goal is to determine their authenticity for the purposes of repatriation and/or modification of curation techniques to those appropriate for human remains.

1.2 Research Questions

This thesis focuses on two main research questions:

1) Are the shrunken heads human and do they exhibit the morphological and chemical discriminators identified as human?

2) Are the shrunken heads ceremonial or commercial in origin and do they exhibit morphological, decorative, and chemical discriminators to determine this?

This study further brings to light the ethical nature of the curation and repatriation of shrunken heads and the impact of dark tourism in the creation of museum collections. Dark tourism's role in anthropology is also explored (Rubenstein, 2004). The nature of the commoditization of human remains in the instance of shrunken heads is also addressed in this study. Correspondingly, the connection between the commoditization of human remains and dark tourism (Lennon & Foley, 2005) leads to a discussion on the potential for repatriation to the culture of the shrunken heads' origin (Rubenstein, 2007). It is necessary to analyze the remains (specimens 5195 and 5196) to determine if they are human or non-human (e.g. monkey, sloth, or otherwise) in order to discern whether returning the two heads to their country and culture of origin (repatriation) is necessary and possible (Harner, 1973; Houlton, 2012).

1.3 Outline of Thesis

Chapter 2 consists of a literature review regarding shrunken heads and the Shuar. First, terminology concerning the Shuar is defined and is followed by a description of Shuar territory. Next, the history of the Shuar and the reliability of the ethnographic material regarding them is examined. Spirituality, social structure, and warfare practices involved in the creation of shrunken heads for both a ceremonial and commercial level are presented. Following this is a description of *tsantsas* as trophies, how they were typically made, the rituals related to them, and their eventual commercialization. Finally, Chapter 2 ends with a brief outline of research that has been performed on shrunken heads prior to this study.

Chapter 3 describes the materials and methods employed to answer the research questions. First, the specimens are described. This is followed by an explanation of sampling process. Next, the methods involving the multi-factorial analyses are described. These analyses include nondestructive methods such as morphological and morphometric analyses. The other methods used were destructive (whether by the nature of sampling or via the analysis itself) and included light microscopy, scanning electron microscopy and energy dispersive x-ray spectroscopy (SEM/EDS), Fourier Transform Infrared Spectroscopy (FTIR) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS). All methods are discussed in terms of their function, abilities, and the protocols followed for this project.

Next, the results are provided in Chapter 4. First, the morphological and morphometric results are displayed and this is followed by an outline of all the results for the destructive analyses performed each sample type: skin, hair, and fiber in turn. This chapter comparatively applies these results to studies from which various methods were derived.

Finally, discussion and interpretation of results are provided in Chapter 5. First, the research questions will be addressed, followed by a discussion of sampling and methodological limitations. This discussion will lead into a consideration of research that might be performed in the future. Following this consideration will be a description of dark tourism and how it relates to the shrunken head trade. Next, the potential for repatriation will be discussed. A summation of the conclusions reached in this thesis will end this chapter.

Chapter 2 - Literature Review

This chapter provides background about the Shuar that is most relevant to their trophy taking practices and the origins and construction of shrunken heads. Specific details about the shrunken heads (or *tsantsas*) that were traditionally created as war trophies will be discussed as well (Harner, 1973; Jandial et al., 2004). The focus of this thesis are two shrunken heads that are believed to have originated from the Shuar. Ethnographic information most relevant to the belief systems and processing of shrunken heads will be covered as well as facts about how the ethnographic research was carried out. The Shuar's contact with Europeans will be briefly described. Then, after covering how the spirituality and warfare practices of the Shuar led to the creation of and ceremonies involving shrunken heads, how shrunken heads became part of the global trade market will be summarized. Previous scientific research examining shrunken heads will be reviewed. Finally, the chapter is summed up by briefly discussing current beliefs that the Shuar currently have about shrunken heads and tsantsas.

2.1 Notes on Terminology

In order to understand and analyze the two shrunken head specimens donated to the Idaho Museum of Natural History, there must be an understanding of the culture of "head shrinking" originating in eastern Ecuador and northwestern Peru. This cultural group are henceforth discussed here using the term "*Shuar*," though they refer to themselves as the "*untsuri šuarä*" (Harner, 1973). The group is occasionally called the Jívaro, though this term has been used in a derogatory manner or is used to reference the language group or people of all five groups indigenous to the area (Harner, 1973; Stirling, 1938). Thus, the term Jívaro will not be used in this thesis in reference to the Shuar.

This thesis will focus on what the Shuar call *tsantsas* and most other aspects of Shuar culture will only briefly be touched upon in this chapter. Although these heads are the remains of humans, this paper will occasionally refer to them as objects. This terminology is not meant to disrespect the victims of this or any other type of trophy taking practices, but rather used for the convenience of context. The label of shrunken heads will be given to both ceremonially and commercially made shrunken heads. However, the words *tsantsa* or *tsantsas* will only refer to the heads made for ceremonial purposes as shrunken head trophies. The Shuar produce *tsantsas* (human or sloth) for ritualistic purposes related to trophy-taking. In contrast, the Shuar or others produce commercial shrunken heads (from human, nonhuman, or other material) as a commodities to sell; therefore, they hold no ritualistic value.

2.2 Shuar Territory

The Shuar inhabit the dense tropical rainforests between the upper mountains of the Andes, and the tropical rainforests and savannas of the Amazonian lowlands in northeastern Peru and western Ecuador. There are several tribes documented in the region. This area consists of a large group known as the Jívaro and is composed of five tribes that are dialectically different. Aside from the Shuar (known best for their *tsantsas*), there are the Achuara, the Huambisa, the Aguaruna, and the Mayna in the region (Figure 2.1) (Harner, 1973). These tribes are discussed because they were commonly targets of headhunting raids. The Shuar have some natural physical barriers from the surrounding landscape that discourage attacks. This includes a river full of rapids that prevent infiltration from the Achuara in the east. In addition, the Andes act as an obstruction for those who wished to colonize or conquer the Shuar from the west (Figure 2.1 & 2.2) (Harner, 1973).

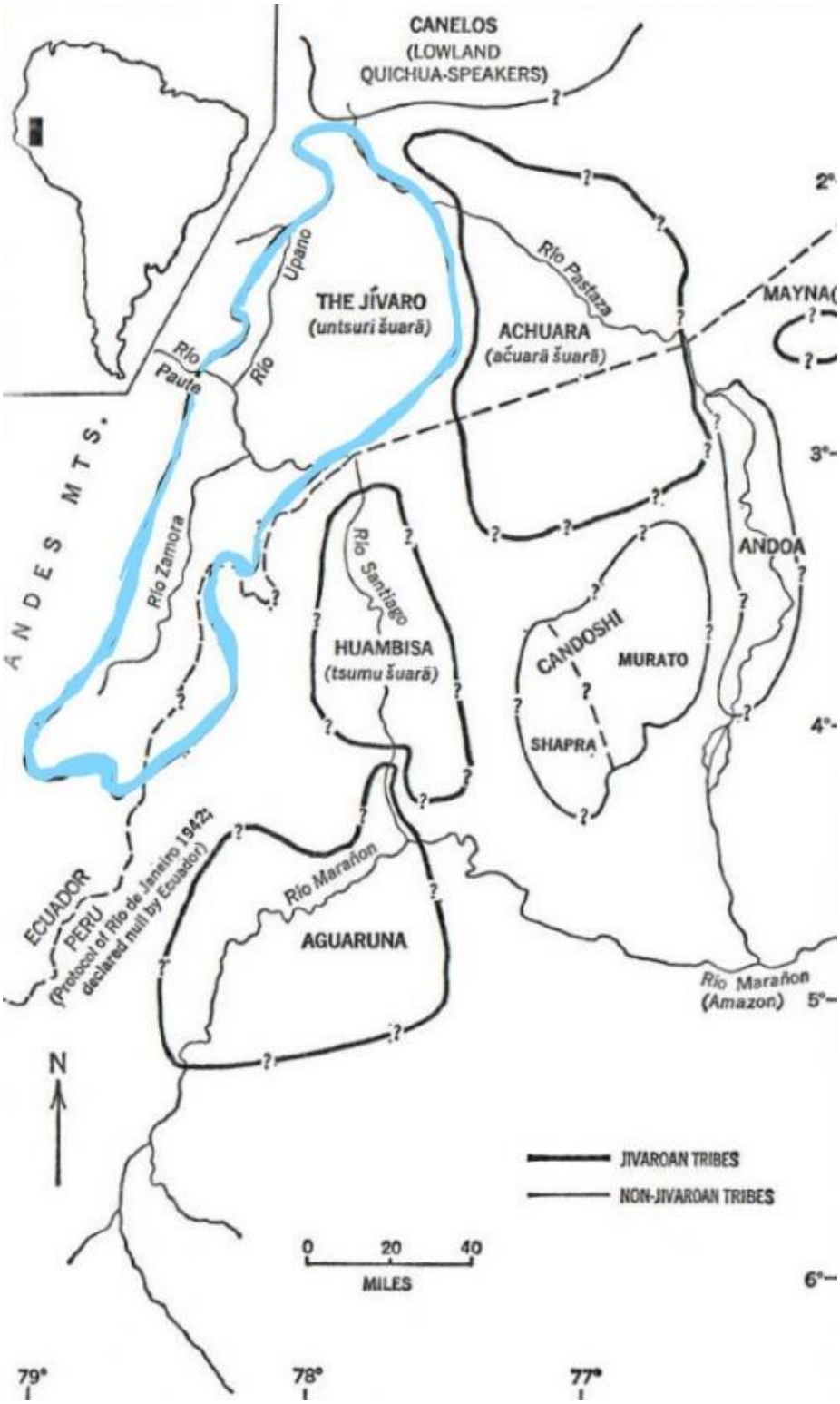


Figure 2.1. The Shuar (known as the Jívaro in this figure and outlined in blue) and tribes in neighboring territories. Adapted from *The Jívaro: People of the Sacred Waterfall*. (p 11) M. Harner, 1973, Garden City, NJ: Doubleday. Copyright 1973 by Doubleday.

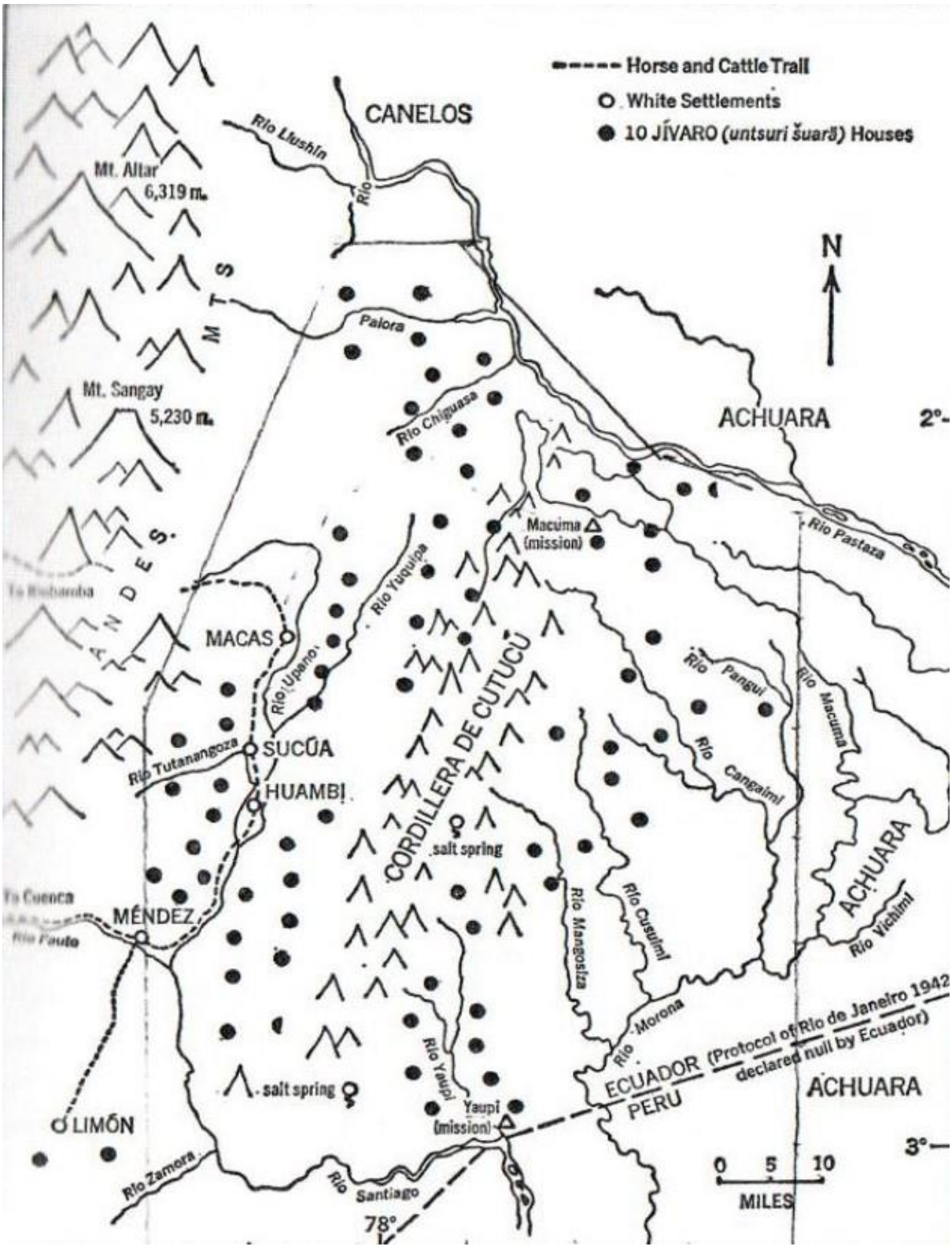


Figure 2.2. Distribution of the Shuar. Reprinted from *The Jívaro: People of the Sacred Waterfall*. (p 15) M. Harner, 1973, Garden City, NJ: Doubleday. Copyright 1973 by Doubleday.

2.3 History and European Contact

Few ethnographic sources exist regarding the Shuar. In fact, Harner's (1973) 14 months of fieldwork is the most consistently cited work in subsequent ethnographic reporting of the Shuar. Harner was a cultural anthropologist that started his ethnographic research in the late 1950's. The lack of ethnographic sources as well as the age of the sources likely biases and certainly limits ethnographic accounting for the Shuar. The biases in Harner's (1973) work could derive from his inexperience with the Shuar language, the absence of sophisticated technology to document his findings, or the unavailability of multiple sources, among other limitations (Harner, 1973; LeCompte 1987). Nonetheless, Harner's (1973) accounts are an integral source for this thesis. This ethnographic information is supplemented with work done by Karsten (1923), Stirling (1938) Rubenstein (2004, 2007), and Redmond (1994). Redmond's (1994) and Rubenstein's (2004, 2007) ethnographic research was narrowly focused on warfare practices or modern Shuar culture and modern laws, but both ethnographers provide some relevant information for this thesis. According to Harner (1973), Karsten's work from 1935 and Stirling's 1938 work were the main available sources during his fieldwork. Harner (1973) claimed that they had their limitations and he attributed these to their lack of linguistic knowledge and their use of interpreters. Stirling agreed and contacted Harner to tell him how glad he was that someone could do a proper study on the Shuar and he agreed he relied too heavily on his interpreter (Harner, 1973). Harner's (1973) hope was to remedy this problem by using multiple interpreters, gaining his own knowledge of the language, using multiple informants, and double-checking all of his reports. The interpreters he chose were mostly Shuar men who had learned Spanish at the nearby missions. By paying his informants and giving them

money or supplies, Harner (1973) believed that he had ensured his own safety as well as the reliability of the information the Shuar were giving him.

No artifacts have been found that provide an isolated date on the arrival of Shuar ancestors into the jungle they inhabit today. Some pottery has been discovered, but aside from that, little to no material culture has been found in the region associated with the Shuar (Harner, 1973). This could be due to a lack of excavations performed in the area or the nature of poor preservation in a wet, tropical environment. The pottery fragments dating to approximately 2,500 years ago are the oldest recovered artifacts in the region. Two types of pottery were found in two different test pits in the middle of the Río Upano Valley. Carbon dating of pottery revealed date ranges from 1049 B.C.E. to 169 C.E. and 881-1201 C.E. However, this pottery is inconsistent in style from known Shuar pottery complexes, and therefore Harner (1973) believed there was not adequate support for a cultural connection between the humans who lived in the area around that time and the Shuar who lived in the area during his (1973) fieldwork in the 1950s.

2.4 Social Structure, Warfare, and Spirituality

Harner (1973) proposed that the Shuar's lack of an organized system in which to punish non-normative behavior resulted in personal revenge acts. Revenge was considered the only socially acceptable form of murder among the Shuar. However, most killings occurred through war with peoples outside of the Shuar. The Achuar were typically the cultural group attacked by the Shuar through raids carried out to procure large quantities of *tsantsas*. Such ceremonial *tsantsas* were only made with the skinned heads of men. Women and children were only killed for revenge or their deaths were the result of collateral damage (Redmond, 1994). Children rarely have their heads taken for *tsantsa* raids (Harner, 1973). The number of people participating in these raids changed throughout time, becoming smaller and smaller as contact with outsiders

grew. The oldest reports numbered up to 400 Shuar participants and had later dwindled to 20 or so. In addition, the time between raids increased immensely with European contact. At the time of Redmond's (1994) research, raids were occurring at most, once a year, when they had previously occurred about once a month (Redmond, 1994). Now head-taking raids are unheard of because murder is considered illegal by the Ecuadorian government. Later, the government would occasionally infringe on the rights of the Shuar (Harner, 1973). Catholicism did not factor as much into the legal aspect of head-taking raids as the government; however, the Salesian Order of the Catholic Church did aid the Shuar in regaining rights from the government, specifically land rights. The influence of outside contact via trade and because of globalization also factored into less raids. Outside influence as well as Catholic influence provided the Shuar with new perspectives and rituals in dealing with death, revenge, and violence (Harner, 1973; Rubenstein, 2004).

Religion and spirituality are relevant to the Shuar's manufacturing of *tsantsas* and the processes performed during that process. This ritualistic belief system and processing in turn helps differentiate ceremonial and commercial shrunken heads. The Shuar believe in three souls, two of which are relevant to *tsanstas*. The *arutam* soul, typically obtained by men, was found through rituals involving hallucinogenic drugs. Women sometimes obtain an *arutam*, though this occured less frequently. The process began when a man was about 6 years of age. The purpose of obtaining an *arutam* soul was to make him stronger and he was then taught how to make *tsantsas* using the heads of sloths or non-human primates. Men could accumulate multiple *arutam* souls and the amount they possess correlated with how strong they were considered to be. When a man died, *arutam* souls were created for others to take into their bodies, with the

number of souls created being the same as the number of *arutam* souls the man had throughout his lifetime (Harner, 1973).

The other soul relevant to *tsantsas* was the *muisak* soul. This soul was that of a vengeful spirit of a murdered person who had obtained at least one *arutam* soul in his lifetime. The purpose of the *muisak* was to exact revenge on the person who took their life. The *muisak* soul was of great importance with regard to shrunken heads because it was only referred to as such while it is in a *tsantsa*. If the soul was accidentally released from the *tsansta* it became one of three types of demons. These demons came in the form of a dangerous and poisonous snake, a large water boa constrictor, or a large falling tree. In order to prevent these demons arising, shrunken heads were made (Harner, 1973).

2.5 Shrunken Heads (Tsantsas) as War Trophies

The head usually takes significance over the rest of the body and tends to be the part of a corpse that is decorated or taken as a trophy and displayed in some fashion. The focus on the head was likely due to the presence of features that could be easily identifiable as human. The head also holds features that are distinctive to each person. Trophy heads in particular, are representative of the enemy from whom the head was taken. Particular to the Shuar, heads that were shrunken and made into *tsanstas* held features that were somewhat immortalized in that form (Bonogofsky, 2011).

2.5.1 Tsantsa creation methods.

To create ceremonial *tsantsas* the head was typically cut off as close to the clavicle as possible and either the headband of the killer or a section of vine was woven through the neck and mouth to carry the head while making an escape after a successful raid. During a series of

stops on the retreat home, steps of the head shrinking process were performed. The head-takers usually had a cache of ceramic pots (similar to Figure 2.3) and cooking materials set aside somewhere near the raid location for the beginning of this procedure. The first procedure was to peel the skin from the skull by making an incision from the back of the neck up toward the crown of the head. Everything else, including the skull and brain, was discarded in the river, as a tribute to the anaconda that they believe inhabits the river (the source does not specify if this is a spirit or just the animal itself, Harner, 1973).

Figure 2.3. Example of ceramic pot used to prepare *tsantsas*. Reprinted from "Tribal and Chiefly Warfare in South America." by E.M. Redmond 1994. *Studies in Latin American Ethnohistory & Archaeology 5*, 3-15. Copyright (1994) by University of Michigan Museum of Anthropology and Archaeology.

The shrinking process started with a submersion in boiling water that lasted about half an hour. Harner (1973) stated that this would halve the size of the head while keeping the hair intact. Stirling (1938) suggested that juice from an un-named parasitic vine, that the Shuar referred to as *chipichipi*, could be put in the water that would keep the hair from falling out and

they would then boil the head for up to two hours. Once this was done, the skin was lifted out with a stick and put in the earth, this would be done to dry the head (Stirling, 1938).

Next, the head was turned inside out and any remaining flesh and fat was removed with a knife. After turning the head right side out, the slit that was made to remove the skull was sewn up to the neck. There, a vine was attached to make the head into a sort of sack. Harner (1973) suggests that the lips were tied with string at this time as well. However, he (Harner, 1973) also later mentions that three wooden pins were threaded through the lips and lashed together with string made from bark and this is supported by Stirling (1938).

To shrink the head further, round stones were heated in a fire and put inside the head. The head was then rolled around to distribute the heat throughout. When the head became too small to fit stones, heated pebbles were used in the stones place and eventually, the head was filled with hot sand, replacing the pebbles. The process with the sand was done repeatedly until the raiders made it back to their own territory (Harner, 1973) but sources do not distinctly explain exactly when each step was performed along their journey home (Harner, 1973; Karsten, 1923; Stirling, 1938).

The skin would also be massaged with charcoal and balsa wood periodically to help the drying process and retain the general shape of facial features (Harner, 1973). However, these features were not always formed to portray the exact depiction of the person killed (Houlton & Wilkinson, 2016). Next, sealing of the lips and sewing up or blocking the eyes was believed to prevent the *muisak* soul from seeing outside of the head or escaping through the mouth. A hole would be made in the head for a string to allow the head-taker to wear the head around their neck for celebrations (Harner, 1973) and to hang the heads over fires to preserve them further via

smoke (Stirling, 1938). After nearly six days of preparation, the heads were ready as ornaments for the feasts that would be held in the head-taker's honor (Harner, 1973).

If a warrior was unable to take the head of the man he killed, a faux head was made by sculpting beeswax onto a tree gourd and adorning it with lip spikes and then attaching the hair of the victim (Harner, 1973). *Tsantsas* were occasionally made out of sloths to represent fallen enemies from which heads could not be obtained (Harner, 1973; Karsten, 1923; Stirling, 1938). Additionally, trophies were not always made from enemies, but occasionally made from animals the Shuar respected (Karsten, 1923). Karsten (1923) reported heads of jaguars and sloths being taken and turned into trophies and treated with similar respect. These trophies were also celebrated (Karsten, 1923).

2.5.2 Tsantsa celebrations.

Celebrations held for *tsantsas* were very important in Shuar culture in the past and they came in the form of multiple feasts. The first feast was immediately held upon the return of the raid party. This lasted about two days and was held in each respective head-taker's house, if there were multiple. After these feasts, the men from the raiding party returned home and prepared for the two subsequent celebrations that would take place (Harner, 1973; Karsten, 1923; Stirling, 1938).

At least a year after the raids were held and the *tsantsas* were made, the second feast would be held once the family had prepared and harvested enough food and manioc beer for the 125 to 150 possible guests. In addition, a large new house might be built to hold guests more comfortably. This celebration typically lasted about five days. Then, about a month later, a third feast was held. Hosts of these feasts gained prestige. All of the host's close relatives would

gather game to supply fresh meat for the guests. Furthermore, most of the food stores saved for a year, by the family, was used for this feast. The household would thereafter subsist off meager diets until they could replenish their stock. This lack of food could sometimes result in the third and final feast not being held. On the other hand, if they had gathered enough to hold the third feast, it would be the greatest of them all. Only at this third feast, that lasted about six days, could the *muisak* soul be released completely. After the third feast, the pins holding the mouth shut were removed and replaced by cotton strings. The strings were usually as long as the hair on the *tsantsas*. The ears were frequently decorated with red and yellow toucan feathers (Harner, 1973).

To utilize the *muisak* spirit and its power, the man who made the shrunken head lifted it above his head. While he did this, two women that he wanted to bestow strength and success upon, held onto each of his respective arms. They would perform a ritual dance and the power of the *muisak* spirit would filter into the women, making them stronger and better at cultivating crops. This dance would occur during each feast until they fully released the *muisak*. The *tsantsa* celebrations were intended to be peaceful to prevent the *muisak* in the head from taking possession of vulnerable people to do damage to their killer or his kin. If there was violence and someone was killed as a result, the *muisak* was assumed to have escaped after causing this havoc. If the feasts were successful and the *muisak* soul was released at the end of the last feast, it would return to its original homeland (Harner, 1973; Karsten, 1923; Stirling, 1938).

2.5.3 Shrunken head trade.

The heads were typically kept as decorations within the households or worn by the killer at smaller parties and celebrations. Sometimes the *tsantsas* were buried with the head-taker after their death. With further contact with outsiders, however, these heads were eventually sold or

traded after the release of the *muisak* (Harner, 1973). Europeans were fascinated by shrunken heads and their interest perpetuated the growth of their trade in the curio-markets in the mid 1800's and their value as trade goods perpetuated the creation of commercialized shrunken heads. (Houlton, 2017; Steel, 1999). Houlton and Wilkinson (2016) state that on average, 80% of shrunken heads in collections around the world are commercial.

Once the Shuar realized outsiders valued a shrunken head, shrunken heads were made and sold with more frequency (Steel, 1999). Steel (1999) suggested that the change in frequency of head-hunting raids against outside tribes and a periodical increase in intra-tribal conflict that occurred from the 1850s to the late 1950s, respectively, occurred due to the commoditization of shrunken heads. Because the heads could be traded for manufactured goods, Steel (1999) suggested that the Shuar began making the heads in order to trade them rather than for ceremonial purposes alone. Steel (1999, p 755) called this type of trade the "heads-for-guns" trade. Trading partners were considered to be off limits for revenge attacks or killings because they provided an essential connection to the outside world (Harner, 1973). This limited the access to heads that would otherwise be taken from outsiders when many of the Achuar, previously major enemies, became trading partners with the Shuar. Intra-tribal feuding, in turn, increased and heads were taken from those enemies or some stranger that was randomly happened upon. The market for shrunken heads remained open and the demands of the market kept being filled until about the middle of the 1950s (Steel, 1999).

Steel (1999) describes a raid in which the leader ordered the heads of all but young women to be taken to supply enough heads to trade. This is unusual in the context of ceremonial *tsantsas* that were only taken from men. This suggests the heads women and children would only be taken to fulfill a need for a currency of shrunken heads (Steel, 1999). The shrunken heads

would accumulate with the Shuar until they eventually became commodities that were circulated in the market. Later, the heads were taken off the market and have now begun to accumulate once again in museums (Rubenstein, 2007).

2.6 Biological and Chemical Analyses of Shrunken Heads

There have been multiple studies done on shrunken heads and they vary widely. These studies often used forensic methods to determine authenticity. There are some studies that include DNA analyses (Hermon et al., 2011; Reichenpfader, Buzina, & Roll, 2009; Piniewska, Sanak, Wojtas, & Polanska, 2017) and more that discuss the morphology of shrunken heads (Charlier, Huynh-Charlier, Brun, Hervé, Lorin de la Grandmaison, 2012; Hermon et al., 2011; Houlton, 2017; Houlton & Wilkinson, 2016, 2018; Mutter, 1975; Piniewska et al., 2017). Houlton (2011, 2012) also used experimental techniques, based on ethnographic descriptions, (Harner, 1973; Karsten, 1923; Stirling, 1938) on pig heads to examine the shrinking process.

In 1975, Mutter described the first criteria of traits that could be used to distinguish authentic heads from ceremonial *tsantsas*. His study used only two human shrunken heads (one authentic and the other commercial) from the College of Physicians' Mütter Museum in Philadelphia, Pennsylvania. His criteria for an authentic shrunken head included sealed eyes, long strings attached hanging from the mouth, polished and dark skin, lateral compression (result of processing), a string through the scalp for hanging, and long hair. The lack half or all of these traits was used to categorize it as commercial (Mutter, 1975).

In 2009, Sauvageau, Kremer, Brochu, Julien and Racette, S. modified Mutter's (1975) technique in an attempt to decipher the authenticity of a shrunken head brought to them by a hairdresser. Approximately half of Mutter's (1975) traits were not apparent on the head so the

authors (Sauvageau et al., 2009) additionally examined hair microscopically and performed DNA analysis. Results showed that both the hair and DNA were not consistent with being human. They, (Sauvageau et al., 2009) determined that the head was a forged, commercial shrunken head and suggested the forensic techniques be applied to the identification of other specimens.

The same year, Reichenpfader, et al. (2009), used several methods to identify a shrunken head with an unknown origin. These methods included histological analysis of a skin sample, a DNA analysis, and a microscopic analysis of larvae connected to the hair. The results of the DNA analysis confirmed that the skin likely belonged to a human female. The human identification was supported by the identification of the larvae as human head lice (Reichenpfader et al. 2009). The method used by Reichenpfader et al. (2009) supports the idea that forensic techniques can be applied to the identification and authentication of shrunken heads.

In 2011 a study similar to that of Sauvageau et al. (2009), was performed by Hermon et al. The study combined morphological observations of a specimen from the Eretz Israel Museum in Tel Aviv with DNA extraction from a skin sample and microscopically examined hair. As with the specimen examined by Sauvageau et al. (2009), this specimen only exhibited half the traits Mutter (1975) suggested were consistently found in authentic shrunken heads. In this case, however, the DNA and hair were consistent with the DNA of a human and human hair (Hermon et al., 2011). Additionally, Hermon et al. (2011) estimated ancestry using DNA and proposed the skin belonged to someone of both recent African and South American ancestry. In other words, this shrunken head could have been an authentic *tsantsa* (Hermon et al., 2011).

In 2017, Piniewska and colleagues published another DNA analysis on shrunken heads. The analysis was performed on four shrunken heads from the State Ethnographic Museum in

Warsaw, Poland, and the Museum of the Department of Forensic Medicine at Jagiellonian University Medical College in Krakow, Poland. Along with trying to identify the species, ancestry, and ultimately the authenticity of these specimens, the researchers attempted to discover sex and kinship as well. All specimens were identified as human (which was additionally confirmed through microscopic examination of the hair). Three specimens were consistent with South American ancestry. The remaining specimen was determined to be of Southeastern European descent, qualifying it as a commercial shrunken head. Sex was only determined for two specimens (both male) and kinship was understood to be possible through a paternal line, though this was not conclusive. Overall, Piniewska et al. (2017) suggested that DNA analyses would be helpful in determining authenticity of shrunken heads, but that other methods used in conjunction would be optimal.

In 2011, Houlton experimented using two pig heads to observe how the shrinking process changed the face and at what rates they changed features would change based on the cartilage in any particular area. He based his study on the ethnographic accounts from Harner (1973). Houlton marked all craniofacial landmarks on the heads in permanent ink and measured them according to Farkas, Munro, and Vanderby (1976). He (Houlton, 2011) did this before and after he shrunk the heads. He also digitally scanned the heads before and after the shrinking process. Houlton (2011) procured these heads from a butcher, shaved the hair off, and skinned the face from the skull. Next, the subcutaneous fat and muscle tissue were removed, the lips were pierced and the eyeballs sutured shut. The first head was put in cold water and brought up to 80°C and simmered at that temperature for an hour. This process made the first head extremely fragile and the skin had to be dried out using salt (which was not a practice of the Shuar). The second head was placed in a pot that was already simmering at 90°C for two hours. Next, the excess tissue

and fat were removed before the incisions made to remove the skull were sutured shut. The process of using hot rocks and sand discussed in various ethnographies (Harner, 1973; Karsten, 1923; Stirling, 1938) was performed and the heads shrunk further and further. Houlton (2011) did not perform the final process of smoking the head over the fire, but rather the heads were dried at 150°C in a domestic oven for an hour. This study resulted in two pig heads shrunk to approximately half the size of the original heads; the author concluded that skin around cartilaginous areas shrunk slower than other areas of the face and that this may explain why *tsantsas* had upturned noses (Houlton 2011).

A year later, Houlton (2012) published his analysis of one shrunken head (referred to as the McManus *tsantsa*) from the McManus Museum in Dundee compared to three authentic *tsantsas* located at the Blythe House in London. Analyses included morphological and morphometric comparisons between the heads (Houlton, 2012).

The McManus head had blackened skin and shared various other features with the three authentic *tsantsas.* However, it lacked temporal depressions and was less weighty and much more damaged than the Blythe House *tsantsas.* Houlton (2012) states that authentic heads vary widely in their measurements as well as in their appearance but that the McManus head had multiple similar measurements and was slightly larger. Next, the McManus head was compared to a known shrunken nonhuman primate head presented by Jamieson (2010). The ears, nose, and mouth differed morphologically, as the McManus head had more human-like features. With this and a general comparison to photos of the ears, nose, and mouths of various types of nonhuman primates, it was evident that the McManus head shared few if any similarities with any known nonhuman primate species in South America (Houlton, 2012).

Following this, Houlton (2012) performed microscopic analysis on a hair sample taken from the McManus head and it was then determined it to be consistent with human. This information as well as a "mongoloid" ancestry estimation could reasonably suggest that the McManus head originated from Ecuador or Peru and was likely human. However, this does not mean that this information signifies that the head came from the Shuar. This is because "mongoloid" is too broad an ancestry estimation, as it could also indicate that the hair was from a human of Asian ancestry (Houlton, 2012). The term mongoloid refers to an "Anthropological term designating one of the major groups of human beings from Asia; includes the Inuit peoples and Amerindians," according to Petraco and Kubic (2004, p 58). This term is no longer used in anthropological literature due to the implications of race that are related to it and terms like it. However, the term is still used as a classifier along with terms like Caucasoid and Negroid in other disciplines, like forensic microscopy (Ousley, Jantz, & Hefner, 2018; Petraco & Kubic, 2004).

In the vein of Mutter (1975), Charlier and colleagues (2012) used 20 heads, assumed to be *tsantsas*, from various collections to develop a list of 14 diagnostic characteristics and compared them to their trait list (developed through studying relevant literature) to understand the percentage of each trait's presence. These characteristic traits include anatomical features, coloration, materials associated, and various other items. All but three of the characteristics were present 100% of the time. The three inconsistent traits were the presence of a vine and/or hole associated with stringing it through the heads in order to hang them (65%); sewn or sealed eyes and a lack of down on the face (90%); and holes, fibers, or wooden pegs associated with closing the mouth (70%). The authors suggest that if the aforementioned traits are not easily visible on

the external portion of the heads, CT scans or a fiberscope can be helpful to identify the presence or absence of the traits (Charlier et al., 2012).

Houlton and Wilkinson's (2016) used perhaps the largest sample of heads assessed by any researcher. Their 2016 study examined 65 shrunken heads from the museums in the United Kingdom (the Science Museum in London and the Elgin Museum in Elgin) and the United States of America (the Smithsonian in Washington DC). The authors intended to discover morphological design and preparation variables using various methods in order to create criteria other researchers could use to identify shrunken heads as commercial or ceremonial. Using descriptions provided by ethnographers, they assembled a list of 16 identifying characteristics (Table 3.2) (Harner,1973; Mutter 1975; Stirling, 1938). Next, they viewed each head under infrared reflectography (IRR) to identify skin textures and hair follicles, utilized computerized tomography (CT) to understand skin thickness, and did a microscopic analysis of hair in the attempt to understand the condition of the hair.

Within their sample, Houlton and Wilkinson (2016) identified 9% as commercial, 56% as commercial, and 35% as ambiguous. Computed tomography scans confirmed that there were temporal compression patterns (indentations at the temples where the head was held during manipulation) in authentic *tsantsas*. The IRR revealed more damage to the epidermis in ceremonial shrunken heads when down was removed using hot rocks also. Discoloration was more visible when skin was more thoroughly desiccated (common in commercially made shrunken heads). Microscopically, hair nits (lice eggs) were more commonly observable in commercial heads while black piedra (a hair fungus) was more commonly observed in ceremonial heads, indicative of the environment they previously existed in (Houlton & Wilkinson, 2016).

In 2017, Houlton performed a morphometric investigation of the aforementioned sample (Houlton & Wilkinson, 2016) of shrunken heads. The method involved 32 measurements (Table 3.3 and Figure 3.3) that were not ultimately telling. He suggested that ceremonial heads were consistently smaller but that using morphological analysis combined with morphometrics would provide more consistent and accurate results (Houlton, 2017).

In 2018, Houlton and Wilkinson discussed previously performed research and proposed other methods of identification geared more toward understanding how mummification changes a facial appearance. They (Houlton & Wilkinson, 2018) also discussed how various technologies and methods could be used to determine age, sex, and ancestry. Houlton and Wilkinson (2018) used IRR to determine if there was a large amount of facial hair at some point to determine sex and used microscopy on the hairs to determine if the hair belonged to an adult or a juvenile and to estimate ancestry. Ultimately, Houlton and Wilkinson (2018) suggest that DNA analysis would provide the most reliable results, albeit destructive and cost prohibitive.

Despite the various methods used by previous authors when examining shrunken heads, the values of analytical chemistry to identify the origins of shrunken heads has not been explored. Pollard et al. (2007) define analytical chemistry as a "branch of chemistry which deals with the qualitative or quantitative determination of one or more constituents in an unknown material." Archaeological and forensic materials are frequently studied using techniques and technologies associated with analytical chemistry. These techniques and technologies include analyses used in this thesis: Energy Dispersive X-Ray Spectroscopy (EDS), Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS), and Fourier Transform Infrared Spectroscopy (FTIR).

Materials similar to shrunken heads have been analyzed using methods in analytical chemistry. For example, FTIR analyses have been performed on pig skin, healthy human skin,

cancerous human skin, and mummified human skin (Greve, Anderson, and Nielsen, 2008; Guidi et al. 2012; Kyriakidou, Anastassopoulou, Tsakiris, Koui, & Theophanides, 2017; Stani, Baraldi, Boano, Cinquetti, & Bridelli, 2014). However, nothing has been published using analytical chemistry to test skin modified via the exact processes involved in creating a shrunken head (as the process is not entirely known).

2.7 Summary

This literature review initially covered ethnographic information that was most relevant to this thesis. Then, a description of shrunken heads and the processes involved in the manufacturing was reviewed. Finally, there was a discussion of various analyses that have been performed on or in conjunction with shrunken heads. *Tsantsas* remain important to the Shuar and their culture (Rubenstein, 2007). The only frustration felt by the Shuar when seeing the *tsantsas* in museums is due to the lack of context provided about the practice and the rest of Shuar culture (Rubenstein, 2004). Head-taking raids are no longer performed by the Shuar. The trade of the heads, along with various other items, ended up connecting the Shuar with the outside world and put them on a path to become who they are today. The Shuar are proud of their history and this pride might facilitate repatriation (Rubenstein, 2007).

Chapter 3 - Materials and Methods

This chapter will present the materials and methods of this research. First, the specimens, their origins, and objects or information associated with them are introduced. This includes brief descriptions of and purposes for methods used. Second, the protocols used for sampling the two specimens are discussed along with description of samples taken using said protocols. Third, non-destructive methods such as morphological and morphometric analyses are described. Finally, minimally invasive and destructive methods (destructive by nature of sampling) such as Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Spectroscopy (EDS), Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS), Fourier Transform Infrared Spectroscopy (FTIR), and Light Microscopy, which were performed on samples taken from the specimens, are also described. All destructive methods were performed at the Center for Archaeology, Materials and Applied Spectroscopy (CAMAS) laboratory and done under the supervision of John Dudgeon Ph.D. All procedures were performed according to the CAMAS protocols.

3.1 Materials

This study analyzes two shrunken heads, catalog numbers 5195 and 5196, shown in Figure 3.1 (accession number 1033), which are curated at the Idaho Museum of Natural History (IMNH) in Pocatello, Idaho. Donated with these specimens were artifacts from South America and a letter describing how the specimens came to be curated at IMNH. The artifacts originated from different places or are unrelated to shrunken heads but are listed and described in Appendix A. Mrs. A.J. Bell and her husband donated all of these artifacts to IMNH in 1962. These artifacts and the specimens 5195 and 5196 are currently secured in dry storage in the anthropology collections at the IMNH.

Figure 3. 2. Specimens 5195 (left) and 5196 (right) from the Idaho Museum of Natural History.

3.1.1 Acquisition of materials. Mrs. Bell wrote a letter accompanying the specimens. It described how honeymooners, Jacques Bardonnet and his wife, Francie, purchased and later sold two shrunken heads, which they obtained in Ecuador between 1951-1954 (Figure 3.1, Appendix A). The specimens were purchased through a third party from tribes near the Pastaza River, near known Shuar territory (Figures 2.1 and 2.2) (Harner, 1973). The couple later sold the shrunken heads to Mrs. A.J. Bell and her husband due to personal financial hardship. Mrs. Bell's letter is currently at the IMNH (both a typed version and a scan of the original are in Appendix A).

When creating the sampling protocols in this thesis, it was assumed that the skin would be leathery and pliable. However, the skin of specimens 5195 and 5196 was dryer than expected, which made it more brittle and fragile to handle. Specimen 5195 did not appear to be damaged prior to handling for this project, while specimen 5196 had a large crack across the face (Figure

3.1). This crack runs from below the left ear, through the left eye and up into the scalp through the middle of the forehead. There is also a small hole on the cheek below this crack. There are several associated artifacts with 5195 and none associated with 5196 (aside from the fibers hanging from the mouth). Specimen 5195 has a bright decorative headband around the head, small feathers in the ears, and unidentified painted beans strung around the neck with some type of adhesive or string (as if they were a necklace) (see Figure 3.1).

3.2 Methods

3.2.1 Sampling protocols. To prevent cross-contamination, nitril gloves, hairnets, and facemasks were used to handle the specimens and were not shared between specimens. Each specimen was photographed using a digital camera from six views (anterior, posterior, superior, inferior, lateral [right and left]) before samples were collected. The Idaho Virtualization Lab, within the IMNH, performed 3D scans on each specimen to document them and preserve them further after samples were obtained.

Equipment used to collect samples was sterilized before use. Surgical scissors and tweezers were wrapped in aluminum foil, placed on a baking pan, and partially sterilized through dry heat at 400°F in a conventional oven for four hours. After cooling, each tool remained in aluminum foil and then was placed in 99.9% isopropyl for 30 minutes to complete sterilization before sampling began. Between sampling of specimens, tools, including the tips of the sliding and spreading calipers, were sterilized in the isopropyl for another 30 minutes. Each sample was placed in a piece of dry heat sterilized aluminum foil (heated at 400°C for four hours), labeled, and bagged separately (Samantha Blatt Ph.D., personal communication, 2018; John Dudgeon Ph.D., personal communications, 2018, 2019).

3.2.2 Skin, hair, and fiber samples. Samples of each specimen were taken with permission from the IMNH and in accordance with their protocols. The samples were taken with care and with the intent to prevent and limit damage as much as possible. Samples of the skin, hair, and fibers (from around the mouth) were cut from both specimens. Table 3.1 describes the weight and condition of the samples. For each specimen, a skin sample of 5x5 mm was taken using sterilized scissors, tweezers, and a disposable scalpel (not reused between specimens) (Blatt, personal communication, 2018; Tews, personal communication, 2018). Some difficulties, related to the dry and brittle nature of the skin, resulted in the sample being removed in several smaller pieces. These smaller skin pieces measured at most 2mm by 4mm and often crumbled. This sampling process resulted in small, hard and fatty tissue samples. Weight of the skin samples were 31.7mg (5195) and 20.5mg (5196).

Hair from each specimen was thin, yet anchored firmly in the scalp. As a result, hair had to be cut from as close to the scalp as possible rather than pulled with a root intact. Due to this development, it was difficult to isolate individual hairs, so small groupings were removed in a fashion that would be least obvious to the naked eye (Blatt, personal communication, 2018; Tews, personal communication, 2018). Sampling of specimen 5195 resulted in approximately 12 hairs while specimen 5196 sampling resulted in approximately 25 hairs, 4-6 cm long.

Fibers used to sew the mouths closed were also sampled. Since the heads had been handled for several years, the fibers had become unfurled and began to fray at the ends. As a result, the manufactured twisting of the fibers were not intact enough for analysis. Three, 1 cm fibers were cut from a single string hanging from the mouth of each specimen, labeled F1, F2, and F3 for each specimen. (Blatt, personal communication, 2018; Tews, personal

communication, 2018). The strings of F1 and F2 were unfurled while the F3 string was partially intact in the case of specimen 5195 and completely intact in the case of specimen 5196.

Table 3.1

Description of and details about samples taken for analyses.

Sample Type	Specimen 5195 Amount/Weight (mg)		Specimen 5196 Amount/Weight (mg)		Methods Used
Skin		31.70 mg Subsample: 4.072 mg		20.50 mg Subsample: 4.319 mg	Subsample used for ICP-MS and another subsample (not weighed but because it was not destroyed) was analyzed in the FTIR.
Hair		~12.0		~25.0	Subsamples made into slides for light microscopy and put into SEM/EDS.
Fibers	F1	~21.0	F1	~14.0	Subsamples of F1 made into slides and put into SEM/EDS. Also, sample F2 was used for the ICP-MS.
	F2	1.229 mg	F2	3.465mg	
	F3	1.0	F3	~1.0	

3.2.3 Nondestructive methods.

3.2.3.1 Morphological analysis. Morphological traits associated with commercial versus ceremonial shrunken heads from Houlton (2012, 2017) and Houlton and Wilkinson (2016, 2018) were utilized in this analysis. Definitions and explanations of these traits are shown in Table 3.2. Houlton's (2012) method comparing ear shape, hair distribution and thickness, and nostril shape of human and South American primates will also be used to determine the similarities specimen 5195 and 5196 might share with either group.

Methods from Houlton and Wilkinson (2016, 2018) were used to score both specimens. Sixteen morphological characteristics were scored as present, absent, or ambiguous by the author and a second observer (original table of each observer's results can be found in Appendix B). Houlton and Wilkinson's (2016, 2018) list of characteristics was originally constructed to aid

museum curators in identifying the authenticity of shrunken heads coming into their possession as well as ones they may already have. A test of this method being used on smaller sample sizes has not yet been published.

The author and one other observer tested the method to assess its repeatability by observers who are inexperienced with *tsantsas* and shrunken heads. Explanations of how these traits were scored were vague or lacked clarity so the two specimens were scored as follows. If the observers agreed that all characteristics described were observable in a specimen the trait was considered present. If the observers agreed that none of the characteristics described were present, the trait was considered absent. If parts of a trait description were present while other parts were absent, altogether the trait would be considered ambiguous. Other reasons a trait would be marked as ambiguous included if the presence or absence of a trait was unclear or if the observers disagreed on presence or absence. The goal of this method was to identify the specimens as ceremonial or commercial based on traits commonly associated with these categories.

Table 3.2

Characteristics that distinguish Ceremonial Tsantsas *from Commercial Shrunken Heads.*

Ceremonial *tsantsa*		Commercial shrunken head	
1	Long narrow face, often presenting a 'pinched' impression at the temples, a forcibly upturned and spread nose, and intentionally distended lips, creating an elongated profile with a sloping brow and receding chin	1	More convincingly proportioned face and an upright profile. Rounded to domed shaped scalp. Nostrils retain rounded shape.
2	Size approximately a fifth of a full scale head, equal to a clenched human fist	2	Variable scale
3	Skull-removal incision located at posterior median of head	3	Variable skull-removal incision locations

4	Sutures are often wide and uneven – performed using a thick and inflexible flat bamboo needle with coarse chambira fibre	4	Stitches are usually more precise, discrete and consistent – due to access to finer, sharper, metal needles and thinner suture threads
5	Sutures are typically made using 'over and over' stitches	5	Sutures are typically made using 'baseball' stitches
6	Loop of flexible vine is sewn into the neck – if absent, traces of suturing can be evident. Neck ring could be removed, but the inferior margin of neck will be smooth.	6	No supporting vine at the neck structure. Uneven or irregular base of neck edge (may be flayed)
7	Eyelids are tightly drawn into the head and sutured shut	7	Variable, but the eyelids are often carefully sutured to retain their visible form; often with the upper lid positioned over the lower lid
8	Three mouth perforations from chonta pin application – sometimes retained and lashed together with chambira	8	No, or a variable number of perforations mark the mouth. If pins are present, they are not always chonta wood
9	The mouth pins are classically replaced with intricately woven string tassels applied to the mouth at a length equal to the scalp hair. Several horizontal red bands of achiote are painted, but these can fade over time	9	Mouth tassels are often not attached. If present, atypical colorants, materials and knots for securing them may be present
10	Skin browned using carbon staining	10	Skin sometimes remains unstained, presenting as a grey or yellow color
11	Vellus downy hair removed. If present, then active attempts at removing are identifiable.	11	Vellus downy hair is sometimes maintained, or shaved/trimmed to a stubble
12	Skin is polished	12	Skin can sometimes present a dull, rough texture
13	Skin tends to be dense and of considerable weight	13	Skin can vary; it can sometimes be thin, fragile and very light in weight
14	Typically long scalp hair is present, with no facial hair. Scalp hair cut into 3 tiers (fringe, temples, posterior).	14	Scalp hair can vary in length. Facial hair is often maintained. No particular style scalp hair.
15	One or two perforations mark the crown, with one fitting a vegetable fibre string suspension cord (woven into a five-loop braid) that is secured within the head by a small wooden pin. The cord is long enough for adornment about a person's neck	15	Heads are not always perforated to fit a cord. If cords are fitted, they can be produced from a variety of different materials, woven differently, overly decorated, and of an inappropriate length for personal adornment around someone's neck
16	Piercings that would typically present at the earlobes were not always	16	Headbands, necklaces and any ornamentation comprising beads, seeds, or

	decorated. Toucan feather ear danglers and/or wooden tubes/pins are however common	portions of seeds are atypical to ceremonial *tsantsa*

Note. Reprinted from "Recently Identified Features that Help to Distinguish Ceremonial *tsantsa* from Commercial Shrunken Heads." By T.M.R. Houlton, & C. Wilkinson, 2016. *Journal of Cultural Heritage 20*, 660-670. Copyright (2018) by Elsevier, Inc.

3.2.3.2 Morphometrics. Additionally, 31 of 32 anthroposcopic metrics (Table 3.3 and Figure 3.2) from Houlton (2017) were observed and recorded using Neiko Tools Model 01407A Electronic Digital Caliper and GPM Model 106 spreading calipers. The 32nd measurement, tissue depth of the skin samples, was not measurable for specimens 5195 and 5196 (considering the condition of the skin samples). Only the left side of lateral metrics was recorded to be consistent with Houlton's (2017) method. These measurements were performed twice on each specimen and then averaged to obtain the final results. These were then compared to those of Houlton's box and whisker plots (2017).

Table 3.3

Morphometric measurements modified from Houlton, 2017 (Measurement numbers correspond with Figure 3.2).

No.	Points	Description
1	Max. cranial breadth (eurion-eurion)	Distance between the most lateral points on the side of the head
2	Cranial base width (tragus-tragus)	Distance between the highest points on the tragus of the ear
3	Max. head length I (opithsocranion-stomion)	Distance between the most posterior point of the scalp (from the most prominent midline point between the eyebrows), to the midpoint of the lips
4	Max. head length 2 (opithsocranion-glabella)	Distance between the most posterior point of the scalp to the most prominent midline point between the eyebrows
5	Forehead height (trichion-glabella)	Midpoint of the hairline to the midline point between the eyebrows
6	Auricular head height (vertex-porion)	The highest point of the head (when rested to view full facial features in the anterior position), to the highest point on the upper margin of the external auditory meatus

7	Upper face height (vertex-subnasale)	The highest point of the head to the midpoint of the columella base
8	Craniofacial height (vertex-gnathion)	The highest point of the head to the lowest medial landmark beneath the chin
9	Jaw width (gonion-gonion)	Distance between the most lateral points of the inferior jaw line
10	Supraorbital depth (glabella-tragus)	The most prominent midline point between the eyebrows to the highest point on the tragus of the ear. Taken from the left side
11	Orbital-tragial depth (exochanthion-tragus)	The outer corner of the eyelid to the highest point of the tragus of the ear. Taken from the left side
12	Upper jaw depth (subnasal-tragus)	Midpoint of the columella base to the highest point on the tragus of the ear. Taken from the left side
13	Lower jaw depth (gnathion-tragus)	The lowest medial landmark beneath the chin to the highest point on the tragus of the ear. Taken from the left side
14	Face height I (trichion-gnathion)	Midpoint of the hairline to the lowest medial landmark beneath the chin. Taken from the left side
15	Lower face height (subnasale-gnathion)	Midpoint of the columella base to the lowest medial landmark beneath the chin
16	Anterior lower jaw height (stomion-gnathion)	Midpoint line of the lips to the lowest medial landmark beneath the chin
17	Chin height (sublabiale-gnathion)	Midpoint of the labiomental groove to the lowest medial landmark beneath the chin
18	Intercanthal width (endocanthion-endocanthion)	Distance between the inner corners of the eyelids
19	Biocular width (exocanthion-exocanthion)	Distance between the outer corner of the eyelids
20	Eye fissure length (endocanthion-exocanthion)	Distance between the inner and outer corners of the eyelid. Taken from the left side
21	Nose width (alare-alare)	Distance between the most lateral point of each alar contour. Taken from left side
22	Alar thickness	Refer to Figure 3.2
23	Columella thickness	Refer to Figure 3.2
24	Nasal tip protrusion (subnasale-pronasal)	Midpoint of the columella base to the most protruding point at the tip of the nose
25	Mouth width (chelion-chelion)	Distance between the corners of the mouth fissure
26	Upper lip height (stomion-upper lip border)	Midpoint line of the lips to the midpoint of the upper vermillion line
27	Lower lip height (stomion-lower lip border)	Midpoint line of the lips to the midpoint of the lower vermillion line
28	Ear length (superaurale-subaurale)	Distance between the most superior point on the helix of the ear to the most inferior point on the helix of the ear

29	Ear width	Distance between the point anterior to the tragus to the medial point on the outer helix border of the ear
30	Neck circumference	Refer to Figure 3.2
31	Tissue depth taken at neck opening	Visible thickness of tissue lining the neck/head opening
32	Min and Max tissue depth from skin samples	*Not able to take because samples were too degraded.*

Note. Adapted from "A Morphometric Investigation into Shrunken Heads." by T.M.R. Houlton 2017. *Journal of Cultural Heritage 32*, 238-247. Copyright (2018) by Elsevier Masson SAS.

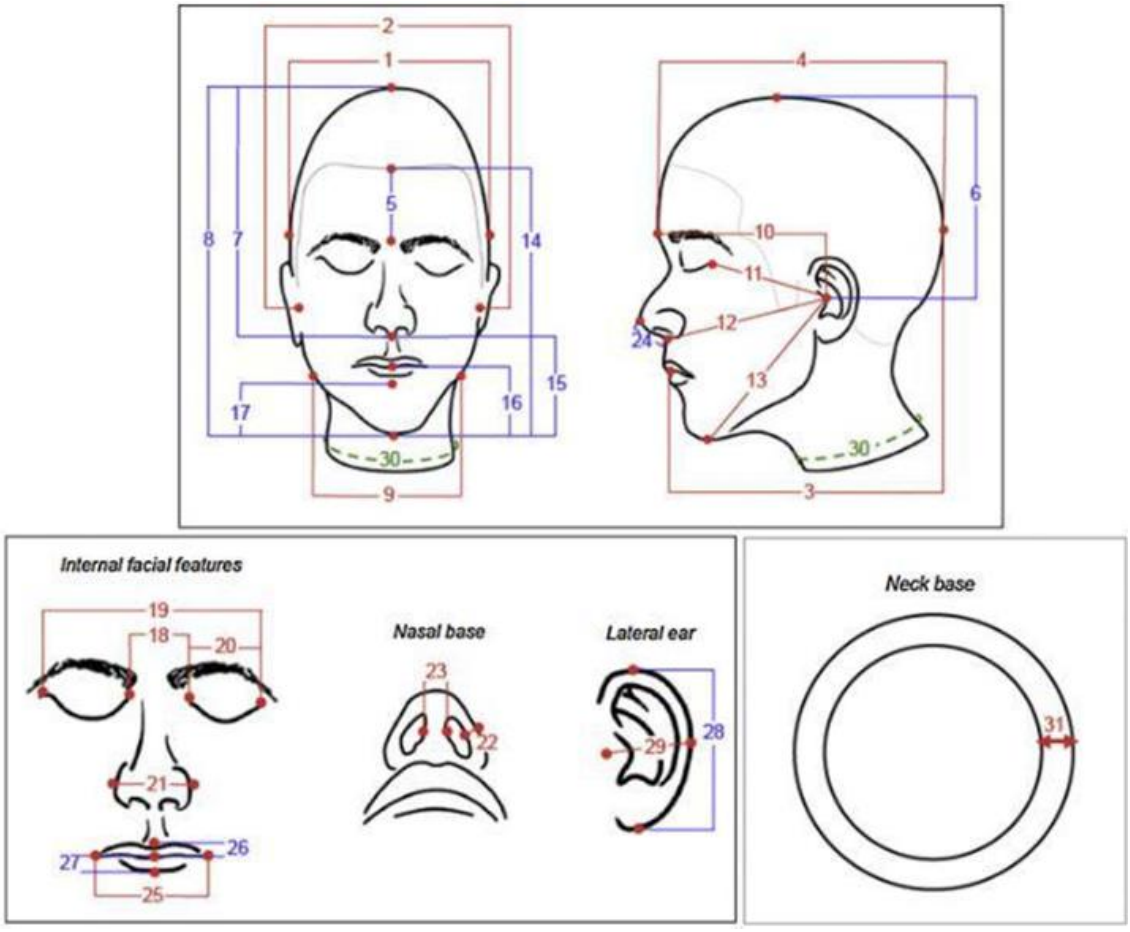


Figure 3.2 Morphometric measurements from Houlton, 2017 (Numbers correspond with measurement descriptions Table 3.3). Reprinted from "A Morphometric Investigation into Shrunken Heads." by T.M.R. Houlton 2017. *Journal of Cultural Heritage 32*, 238-247. Copyright (2018) by Elsevier Masson SAS.

3.2.4 Destructive methods.

3.2.4.1 Light microscopy. Three hair subsamples and three fiber subsamples from each specimen were wet-mounted using n_e = 1,518 (23°C) Immersion Oil 518C. This created one hair slide and one fiber slide with two samples on each for both 5195 and 5196. Hair and fiber samples from each head were also dry-mounted using double-stick tape to secure them to the slide (Dudgeon, personal communications, 2018, 2019). Each sample was viewed, imaged, and measured under a Leica DM 2500 M light microscope with polarization.

Important features for identification include hair width and the calculation of the medullary index. The medullary index is the ratio of the cortex to the medulla (structures shown in Figure 3.3), or the width of the cortex divided by the width of the medulla. Color distribution and cuticle pattern were also used as criteria to classify the hairs as human or nonhuman. Color or pigment distribution is defined as the density and dissemination of pigment across and throughout the hair. Cuticle pattern refers to how the scales on the external portion of the hair grows and lays across the surface. Imbricate patterns (Figure 3.3), where scales are overlapping on adjacent sides, are indicative of human hair (Petraco & Kubic, 2004). Trauma, which is an area on the hair that has been altered, includes being crushed, frayed, destroyed, and evidence of pathology (due to disease or an infestation of lice or other kinds of organisms) were also documented if present (Figure 3.4). An example of one of one of these conditions is "Trichorrhexis nodosa - Disease or condition in which the hair breaks off at node-like structures formed primarily by over-bleaching and/or mechanical damage" (Petraco & Kubic, 2004). These conditions can indicate where the hair was from and what might have happened to it after it was removed from the head (Houlton, 2017; Petraco & Kubic 2004).

Microscopy images were analyzed for these features and sent to hair-analysis experts for verification of results. This was in the form of email communications in January of 2019 with Sandra Koch Ph.D. (personal communication, January 25, 2019) a Senior Research Microscopist at McCrone Associates, Inc and Kimberly Rumrill (personal communication, January 29, 2019) a criminalist from New Hampshire State Police Forensic Laboratory. Human hair typically measures between 30 and 80 micrometers (μm), and has a medullary index that falls between 0.25 and 0.44 (Goyal, A., Goyal, N., Goyal, R., Vij, & Sethi, 2016). If a medulla is not clearly defined or visible, a uniform color distribution can be used to indicate whether the hair belongs to a human (Petraco & Kubic, 2004).

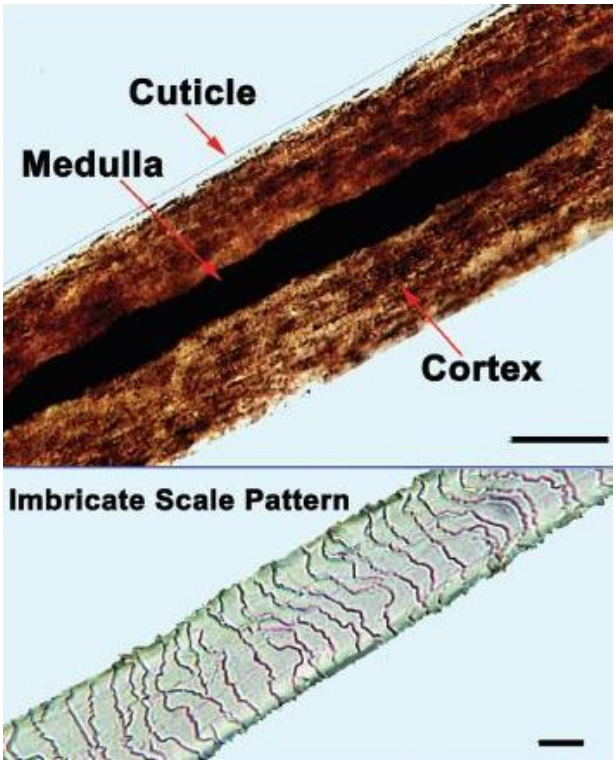


Figure 3.3. The three primary anatomical regions of hair used in species identification: the cuticle, the medulla, and the cortex (top) and typical imbricated scale pattern (bottom). The black scale is equal to 40 μm. Reprinted from *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators.* (p 63) by N. Petraco and T. Kubic, 2004, Boca Raton, FL: CRC Press. Copyright (2004) by CRC Press LLC.

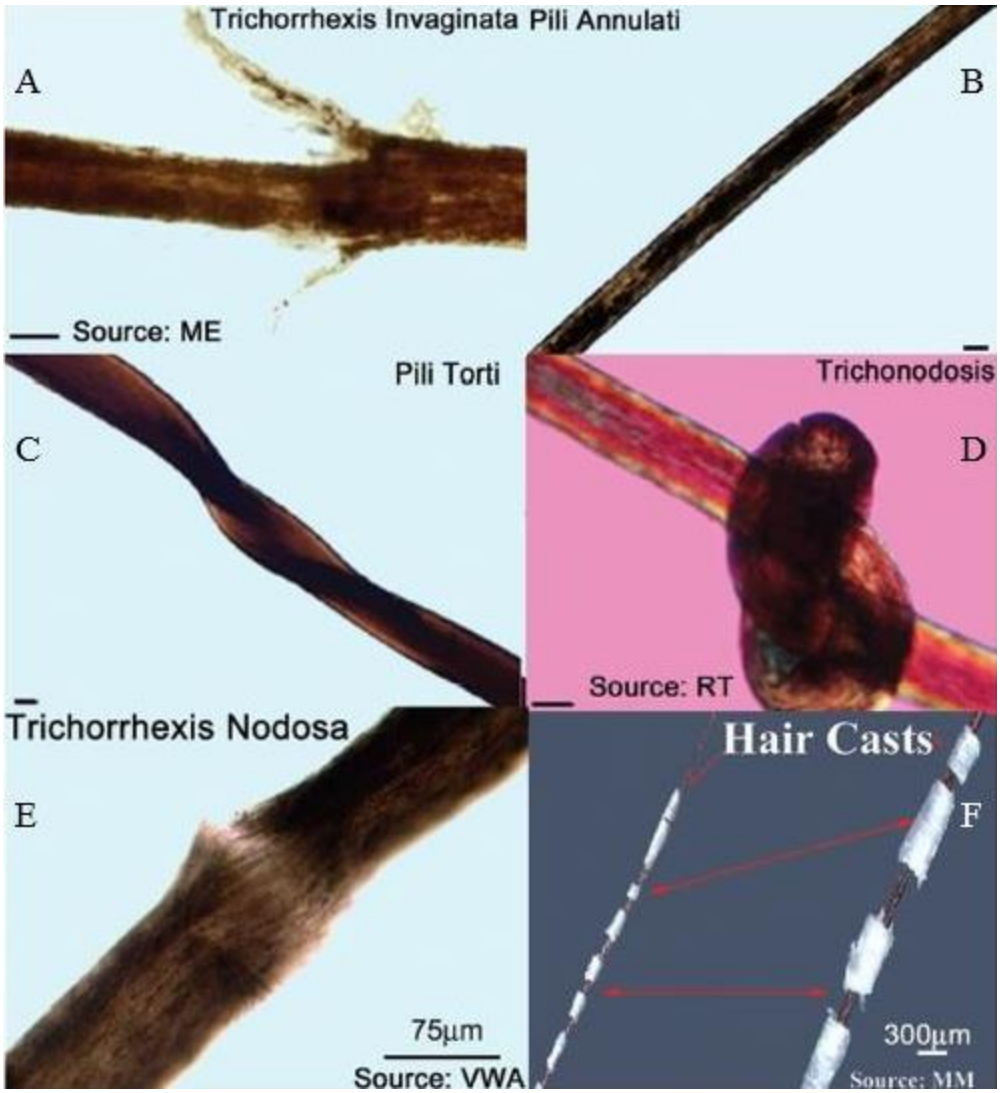


Figure 3.4. Examples of six hair conditions (pathologies and trauma) the black scale is equal to 40 µm, unless otherwise noted. In order: [A] Tichorrhexis Invaginata, [B] Pili Annulati, [C] Pili Torti, [D] Trichonodosis, [E] Trichorrhexis Nodosa, and [F] Hair Casts. Adapted from *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators.* (p 67) by N. Petraco and T. Kubic, 2004, Boca Raton, FL: CRC Press. Copyright (2004) by CRC Press LLC.

The fibers were also inspected to determine whether they were synthetic or natural, as signified by the presence or absence of spirals, crystals, and other naturally occurring structures (Petraco & Kubic, 2004). If the fibers are made of synthetic materials, the likelihood that they are commercial shrunken heads is increased.

3.2.4.2 SEM/EDS. Scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS) were used to produce topographic and chemical maps of subsamples taken from the hair and F1 samples. As some shrunken heads are forged from non-human animal skins with animal hair or fur in place of human hair (Sauvageau et al. 2009), distinguishing cuticle patterns on the hairs is necessary to classify species (Petraco & Kubic, 2004). Identifying the fibers as natural or synthetic would provide additional evidence as to their nature (ceremonial, commercial, or ambiguous). Similarly, EDS can reconstruct the chemical makeup of fibers and hairs, of which, chemical anomalies outside the materials known to be used to process *tsanstas* may provide evidence of the specimen's authenticity.

Carbon conductive double stick PELCO Tabs (12 mm OD) were placed on aluminum specimen mounts (½ inch slotted head, ⅛ inch pin). One hair and one small fiber from both 5195 and 5196 were taken from the full samples, placed on the carbon tape, and labeled. Ultimately there were two specimen mounts, one for the fibers and one for hairs (Dudgeon, personal communications, 2018, 2019).

The samples were then coated in gold using a SPI-Module Sputter Coater. The plasma current was kept at 15 to 16 milliamperes (mA) for two-minute intervals. This was done twice for uniform, but thin coats and the mA levels were kept low to ensure the samples were not burned (Dudgeon, personal communications, 2018, 2019). Scanning electron microscopy uses concentrated beams of electrons to produce extremely detailed images. However, biological material is not conductive and without the metal coating, secondary electrons may not be produced at a high enough rate to create a detailed image (Flegler, Heckman, & Klomparens, 1993). The samples were imaged and analyzed using a SEM-FEI Quanta 200F at multiple levels

of magnification set at 30 kV (accelerating voltage). Micrographs of notable features and anomalies were taken and the width of each hair was measured.

X-ray signals are generated by the electron beam and the EDS has the capability of measuring the energy and intensity distribution of these x-rays. Any elements with an atomic number above four can be detected through identification of their characteristic x-rays (Goldstein et al., 2003). Using this technique, the mounted hair and fiber samples were scanned by the Bruker Quantax 200 EDS software and the chemical makeup of the samples, as well as particles adhering to samples, was recorded. Distributions of elements in and around the sample at different points on the fiber were produced.

3.2.4.3 ICP-MS. The purpose of inductively coupled plasma mass spectroscopy (ICP-MS) analysis was to assess the chemical modification of samples through preservation techniques used upon the two specimens. Because the traditional method of shrinking heads in the Shuar culture requires only water and charcoal and occasionally botanical additives, the detection of other elements unrelated to those materials may suggest that non-traditional (non-ceremonial) methods were used in the shrinking process (Harner, 1973; Stirling, 1938).

Fiber sample two (F2) and subsamples of the skin, which were taken from the original skin samples, were weighed (Table 3.1). These samples were then dissolved in trace element grade concentrated nitric acid that was diluted with 18 MΩ deionized water to a resultant 2% nitric acid solution. While diluting the acid, the samples were sonicated in a FS30 Ultrasonic Cleaner to complete the digestion of the samples into the aqueous phase. This process was continued until the dilution was brought up to 100%. A solution-based approach is optimal for samples such as these because the acid fully digests the skin and fiber and the sample becomes homogenous and can be measured at low limits of detection (LOD), generally at low nanograms

per milliliter of solution (parts per billion, ppb) (Dudgeon, personal communications, 2018, 2019). There are limitations to this analysis because chemicals on the surface of the samples would dissolve in the acid and be analyzed as part of the sample itself. However, the EDS analysis balances these problems out in the case of the fibers because it can pinpoint certain chemicals on a sample versus those inside the sample.

The digested samples were then introduced via liquid sample aspiration to an X-Series 2 ICP-MS using a Cetac ASC-520 autosampler. Several washes occurred between sampling and two reagent blanks of 2% nitric acid solution were tested to assert the validity of the experiment and establish a LOD for each element. Reagent Blank 2 was selected for the control (Dudgeon, personal communications, 2018, 2019). The sample was introduced to a plasma torch and the dissolved elements were ionized before being submitted to a mass spectrometer for elemental analyses (Pollard, Batt, Stern, & Young, 2007).

Plasma ionization mass spectrometry has a theoretical sensitivity range over nine orders of magnitude (i.e., parts per trillion [ppt] to parts per million [ppm]). Instrumental intensity counts are converted to concentration data (ppb, ng/mg, ng/mL, etc.) via a linear calibration based on graded sets of calibrating standards containing elements of interest for the analysis. Data can be calibrated manually or via the PlasmaLab software suite. The data was converted to parts per million and the corrected concentration for mass and the dilution factor was calculated. The data were reduced to a form that more accurately represented each sample while simultaneously simplifying the data for interpretations (Dudgeon, personal communications, 2019). Software would typically be used to aid in interpretation but was not accessible and thus these interpretations were made by comparing the chemical composition of these samples to similar organic substances.

3.2.4.4 FTIR. A subsample of the skin sample from each specimen was analyzed using the Fourier transform infrared spectroscopy (FTIR). The purpose was not only to compare the organic signature of the two specimens, but also to pinpoint anomalies if any were present. Such anomalies would be signified by peaks in wavenumbers that were not consistent between specimens and other known samples of similar composition. The primary function of this analysis was to understand how the specimens may have been preserved (Harner, 1973; Stirling, 1938). In an FTIR analysis, an infrared beam passes through the samples, and the energy thus transmitted is measured and a spectrum is generated. The spectrum can then be analyzed and interpreted by viewing wavenumbers and their peaks (Pollard et al., 2007; Weiner, 2010). Considering the aforementioned methods of preparation, elements associated with various peaks should be similar to those seen in other skin samples.

The Bruker's Alpha Platinum – ATR machine, through OPUS – Alpha Advance software, was used to generate data to later be interpreted. First, a background test was run to ensure the machine was calibrated and to provide a control background to compare the spectra of the skin subsamples. Subsamples of the skin samples of 5195 and 5196 were placed on the machine and the infrared beam was engaged three times on each sample. Each time it was engaged, 24 scans were collected, lasting approximately once second per scan. This was done according to CAMAS lab protocol. A baseline correct was performed to remove the background and each peak was pinpointed using the aforementioned online open source OPUS (Online Publikationsverbund der Universität Stuttgart) software (Dudgeon, personal communications, 2018, 2019).

As with the ICP-MS data, the software used to identify peaks was unavailable. Comparing results in other literature with similar properties would be particularly useful.

However, in order to interpret these results further, an experiment will be performed on multiple skin samples (pig skin) that were altered in a variety of ways to compare multiple preservation methods (Dudgeon, personal communications, 2018, 2019). This will be described further when future research is discussed, but results are not addressed in this thesis specifically.

3.4 Conclusion. In summary, various methods were performed on two shrunken heads from the IMNH in order to determine their nature: human versus non-human and ceremonial versus commercial. These methods include two nondestructive methods including morphological analyses and morphometrics. Also performed were light microscopy, SEM/EDS, ICP-MS, and FTIR, all of which are destructive methods. In each section, the method itself is explained along with its applicability to this study. The next chapter will describe the results of each method. These data will be presented as they coincide with methods performed on the full specimens then data from methods performed on each sample type is discussed.

Chapter 4 - Results

The results of all procedures are presented and described here. First, the results from the morphological and morphometric analyses are provided. Then, results of destructive methods outlined in Chapter 3 will be organized by sample type. Findings of the hair and fiber analyses include those generated by light microscopy and scanning electron microscopy (SEM). Additionally, inductively coupled plasma mass spectroscopy (ICP-MS) results are presented for fibers. The final portion of the chapter will be devoted to the results of the analyses performed on the skin samples, including ICP-MS and the Fourier transform infrared spectroscopy (FTIR).

4.1 Morphological Analysis

Using methods from Houlton (2012), the morphology of specimens 5195 and 5196 were determined to be inconsistent with South American nonhuman primates. The ears, facial and head hair, and nostrils are distinctly human. The ears of both specimens exhibited traits most like those of humans. The ears were helical in shape and the skin was thick. Specimen 5195 and 5196 faces were absent of evidence of thick animal hair. In addition, South American nonhuman primate nostrils are lateral facing and specimens 5195 and 5196 have inferior facing nostrils (Houlton, 2012).

After considering the possibility of human hair being threaded through the skin of another animal, the head was observed for punctures or other methods of attaching the hair to skin that it did not originate from. No evidence of threading was found and no adhesive was apparent at the roots of the hair on either specimen (Davie, 1900).

Table 4.1.

Traits identified from modified table in Houlton and Wilkinson (2016, 2018) distinguishing ceremonial tsantsas. *(Traits correspond with those in Table 3.2).*

Ceremonial *tsantsa*		Specimen 5195	Specimen 5196
1	Long narrow face, often presenting a 'pinched' impression at the temples, a forcibly upturned and spread nose, and intentionally distended lips, creating an elongated profile with a sloping brow and receding chin	Ambiguous	Ambiguous
2	Size approximately a fifth of a full scale head, equal to a clenched human fist	Present	Present
3	Skull-removal incision located at posterior median of head	Present	Present
4	Sutures are often wide and uneven – performed using a thick and inflexible flat bamboo needle with coarse chambira fibre	Ambiguous	Ambiguous
5	Sutures are typically made using 'over and over' stitches	Ambiguous	Ambiguous
6	Loop of flexible vine is sewn into the neck – if absent, traces of suturing can be evident. Neck ring could be removed, but the inferior margin of neck will be smooth.	Ambiguous	Ambiguous
7	Eyelids are tightly drawn into the head and sutured shut	Ambiguous	Ambiguous
8	Three mouth perforations from chonta pin application – sometimes retained and lashed together with chambira	Present	Present
9	The mouth pins are classically replaced with intricately woven string tassels applied to the mouth at a length equal to the scalp hair. Several horizontal red bands of achiote are painted, but these can fade over time	Ambiguous	Ambiguous
10	Skin browned using carbon staining	Present	Ambiguous
11	Vellus downy hair removed. If present, then active attempts at removing are identifiable.	Ambiguous	Ambiguous
12	Skin is polished	Present	Absent
13	Skin tends to be dense and of considerable weight	Ambiguous	Ambiguous
14	Typically long scalp hair is present, with no facial hair. Scalp hair cut into 3 tiers (fringe, temples, posterior).	Ambiguous	Ambiguous
15	One or two perforations mark the crown, with one fitting a vegetable fibre string suspension cord (woven into a five-loop braid) that is secured within the head by a small wooden pin. The cord is long enough for adornment about a person's neck	Absent	Absent
16	Piercings that would typically present at the earlobes were not always decorated. Toucan feather ear danglers and/or wooden tubes/pins are however common	Ambiguous	Ambiguous

Note. Reprinted from "Recently Identified Features that Help to Distinguish Ceremonial *tsantsa* from Commercial Shrunken Heads." By T.M.R. Houlton, & C. Wilkinson, 2016. *Journal of Cultural Heritage 20*, 660-670. Copyright (2018) by Elsevier, Inc.

Table 4.2.

Traits identified from modified table in Houlton and Wilkinson (2016, 2018) distinguishing commercial shrunken heads. (Traits correspond with those in Table 3.2).

	Commercial shrunken head	Specimen 5195	Specimen 5196
1	More convincingly proportioned face and an upright profile. Rounded to domed shaped scalp. Nostrils retain rounded shape.	Ambiguous	Present
2	Variable scale	Ambiguous	Ambiguous
3	Variable skull-removal incision locations	Absent	Absent
4	Stitches are usually more precise, discrete and consistent – due to access to finer, sharper, metal needles and thinner suture threads	Ambiguous	Ambiguous
5	Sutures are typically made using ‘baseball’ stitches	Ambiguous	Ambiguous
6	No supporting vine at the neck structure. Uneven or irregular base of neck edge (may be flayed)	Ambiguous	Absent
7	Variable, but the eyelids are often carefully sutured to retain their visible form; often with the upper lid positioned over the lower lid	Ambiguous	Ambiguous
8	No, or a variable number of perforations mark the mouth. If pins are present, they are not always chonta wood	Absent	Absent
9	Mouth tassels are often not attached. If present, atypical colorants, materials and knots for securing them may be present	Ambiguous	Ambiguous
10	Skin sometimes remains unstained, presenting as a grey or yellow color	Ambiguous	Present
11	Vellus downy hair is sometimes maintained, or shaved/trimmed to a stubble	Ambiguous	Present
12	Skin can sometimes present a dull, rough texture	Absent	Present
13	Skin can vary; it can sometimes be thin, fragile and very light in weight	Ambiguous	Ambiguous
14	Scalp hair can vary in length. Facial hair is often maintained. No particular style scalp hair.	Absent	Absent
15	Heads are not always perforated to fit a cord. If cords are fitted, they can be produced from a variety of different materials, woven differently, overly decorated, and of an inappropriate length for personal adornment around someone’s neck	Present	Present
16	Headbands, necklaces and any ornamentation comprising beads, seeds, or portions of seeds are atypical to ceremonial *tsantsa*	Present	Absent

Note. Reprinted from "Recently Identified Features that Help to Distinguish Ceremonial *tsantsa* from Commercial Shrunken Heads." By T.M.R. Houlton, & C. Wilkinson, 2016. *Journal of Cultural Heritage 20*, 660-670. Copyright (2018) by Elsevier, Inc.

Using the method of Houlton and Wilkinson (2016, 2018), both specimens exhibited primarily ambiguous traits rather than either typical ceremonial *tsantsas* or typical commercial shrunken heads (Tables 4.1 and 4.2). Specimen 5195 had two more traits in common with *tsantsas* than specimen 5196 with a total of five of the sixteen ceremonial traits present. Specimen 5196 had four more traits that were representative of a commercial shrunken head with a total of total of five of the sixteen commercial traits present.

4.2 Morphometric Analysis

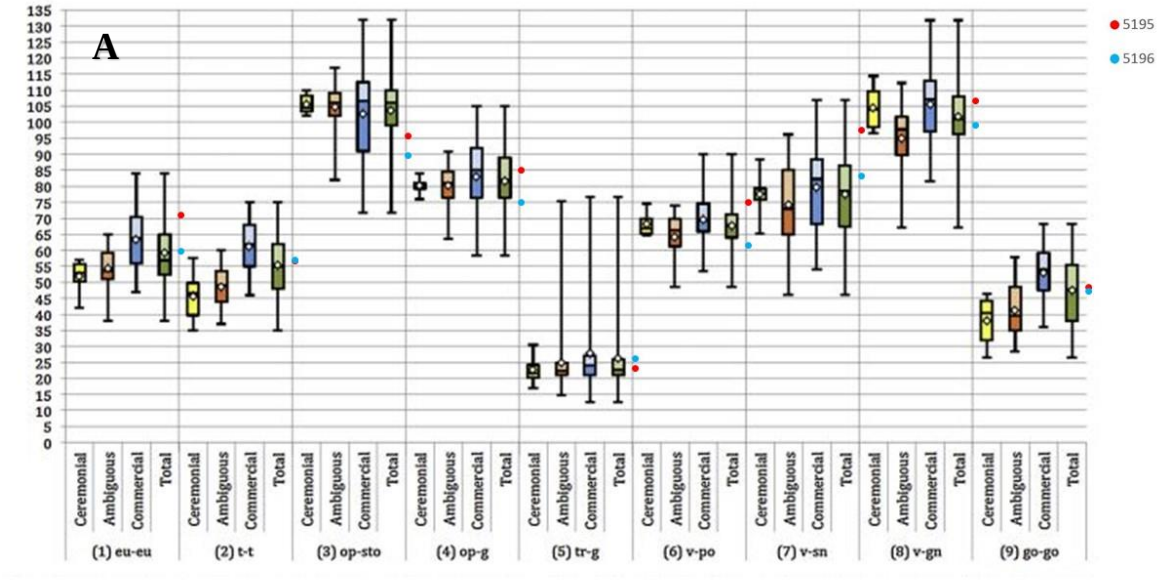
All the measurements that were taken are represented in Table 4.3. Measurements were entered into the box and whisker plots created by Houlton (2017) which includes his sample of 65 heads (Figure 4.1). All of Houlton's (2017) ranges were approximated using his box and whisker plots. As shown in Figure 4.1 and Table 4.3, the means of all but three measurements from this study fell within the ranges taken by Houlton (2017). Columella thickness (1.80-2.05 mm), protrusion of the tip of the nose (4.7-7.5 mm) (numbered 23 and 24 in Figure 4.1 and Table 4.3), and ear width (12.2-16.5 mm) (number 29 in Figure 4.1 and Table 4.3) fell slightly out of the ranges from Houlton (2017). For specimen 5195, columella thickness (1.80 mm) was thinner and ear width (12.2 mm) (measure number 23 and 29 in Figure 4.1 and Table 4.3) was smaller than the any specimens in Houlton's (2017) sample (range was 2-6.4 mm for measurement 23 and 12.4-29.5 mm) (Figure 4.1 and Table 4.3). Similarly, nasal tip protrusion (4.70 mm) (measurement number 24 in Figure 4.1 and Table 4.3) was smaller for specimen 5196 than results in Houlton's (2017) sample, which range from 6.1-19.8 mm.

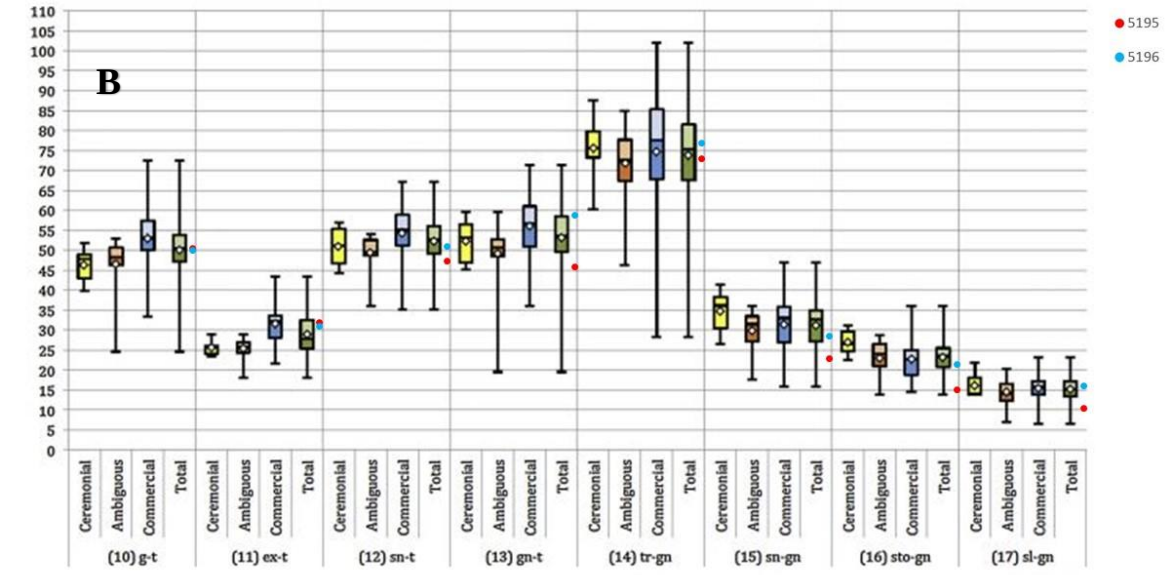
Table 4.3.

Mean measurements taken from specimen 5195 and 5196. Measurements correspond with descriptions on Table 3.3 and Figure 3.2 from Houlton (2018).

Measurement		Specimen 5195 (mm)	Specimen 5196 (mm)
1	Max. cranial breadth (eurion-eurion)	71.50	60.00
2	Cranial base width (tragus-tragus)	57.00	57.50
3	Max. head length I (opithsocranion-stomion)	96.00	90.00
4	Max. head length 2 (opithsocranion-glabella)	85.50	75.50
5	Forehead height (trichion-glabella)	23.50	26.50
6	Auricular head height (vertex-porion)	75.50	62.00
7	Upper face height (vertex-subnasale)	98.00	83.50
8	Craniofacial height (vertex-gnathion)	107.00	99.50
9	Jaw width (gonion-gonion)	49.00	47.50
10	Supraorbital depth (glabella-tragus)	50.50	50.00
11	Orbital-tragial depth (exochanthion-tragus)	32.00	31.00
12	Upper jaw depth (subnasal-tragus)	47.50	51.00
13	Lower jaw depth (gnathion-tragus)	46.00	59.00
14	Face height I (trichion-gnathion)	73.00	77.00
15	Lower face height (subnasale-gnathion)	23.00	28.50
16	Anterior lower jaw height (stomion-gnathion)	15.00	21.50
17	Chin height (sublabiale-gnathion)	10.50	16.00
18	Intercanthal width (endocanthion-endocanthion)	11.00	21.50
19	Biocular width (exocanthion-exocanthion)	41.00	44.00
20	Eye fissure length (endocanthion-exocanthion)	18.00	14.00
21	Nose width (alare-alare)	15.00	15.00
22	Alar thickness	1.40	1.65
23	Columella thickness	1.80	2.05
24	Nasal tip protrusion (subnasale-pronasal)	7.50	4.70
25	Mouth width (chelion-chelion)	27.00	24.50
26	Upper lip height (stomion- upper lip border)	2.80	4.45
27	Lower lip height (stomion-lower lip border)	3.25	3.65
28	Ear length (superaurale-subaurale)	26.00	21.20
29	Ear width	16.50	12.20
30	Neck circumference	93.50	122.50
31	Tissue depth taken at neck opening	2.55	1.89

Note. Adapted from "A Morphometric Investigation into Shrunken Heads." by T.M.R. Houlton 2017. *Journal of Cultural Heritage 32*, 238-247. Copyright (2018) by Elsevier Masson SAS.


A
5195
5196
Ceremonial
Ambiguous
Commercial
Total
(1) eu-eu
(2) t-t
(3) op-sto
(4) op-g
(5) tr-g
(6) v-po
(7) v-sn
(8) v-gn
(9) go-go


B
5195
5196
Ceremonial
Ambiguous
Commercial
Total
(10) g-t
(11) ex-t
(12) sn-t
(13) gn-t
(14) tr-gn
(15) sn-gn
(16) sto-gn
(17) sl-gn

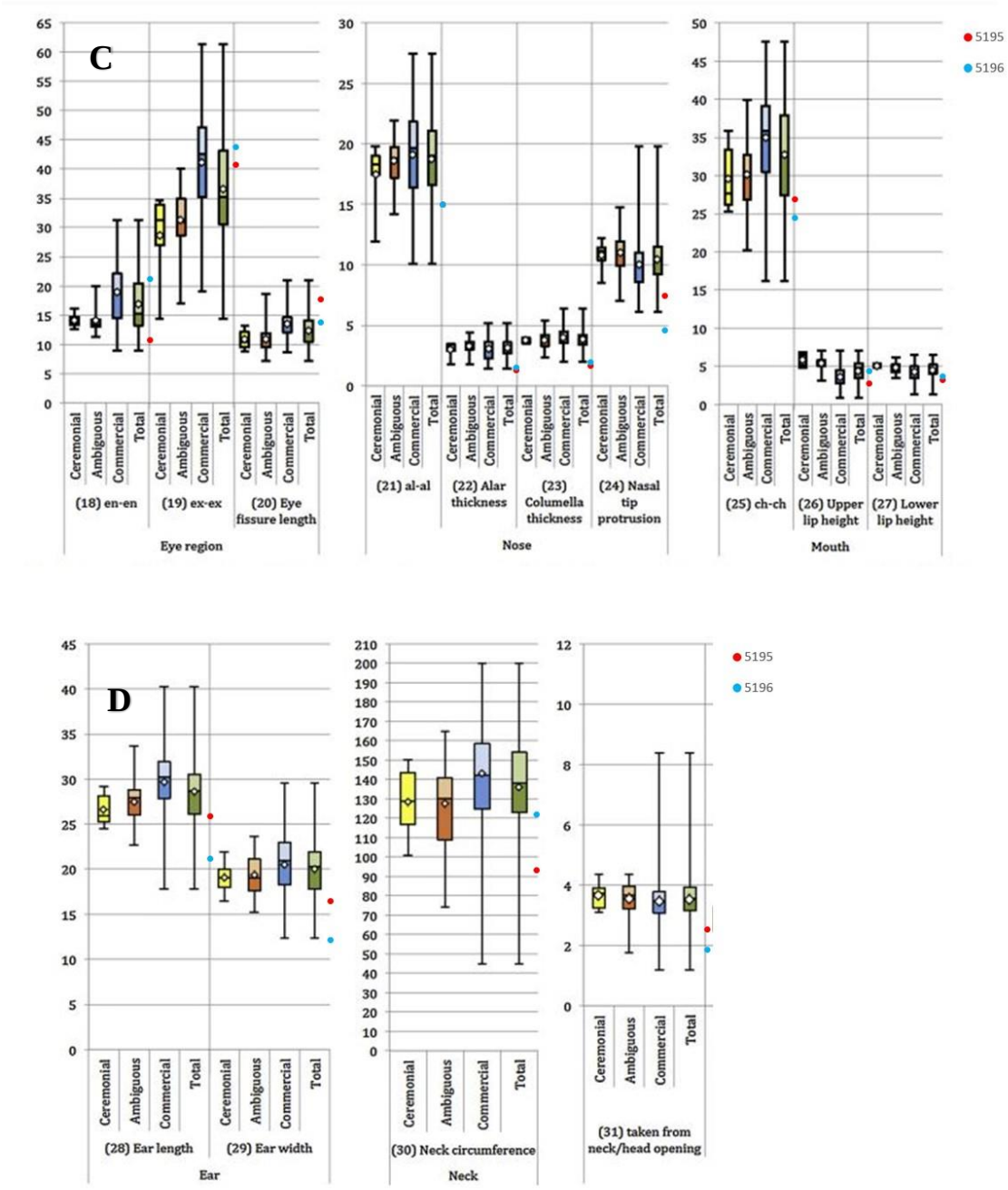


Figure 4.1. Houlton's (2017) box and whisker plots with data (Table 4.3) from specimens 5195 (red) and 5196 (blue) overlaid on top. [A] Measurements 1-9, [B] measurements 10-17, [C] measurements 18-27, and [D] measurements 28-29. Adapted from "A Morphometric Investigation into Shrunken Heads." by T.M.R. Houlton 2017. *Journal of Cultural Heritage 32*, 238-247. Copyright (2018) by Elsevier Masson SAS.

4.3 Hair

The hair samples from both specimens (Table 3.1) share many characteristics. The hairs have an imbricate scale (overlapping like roof tiles) pattern as viewed using light microscopy (Figure 4.3) and SEM (visible in Figure 4.4 - 4.5). The hair width of specimen 5195 ranged from 34.73 - 47.80μm while specimen 5196 ranged from 41.90 - 48.45μm (Figure 4.4). In addition, the pigmentation of each hair from each specimen appeared to be spread evenly across the hair (Figure 4.2). These traits from both specimens are consistent with human hair (Petraco and Kubic, 2004). Because the medullas of both hair samples were not explicitly visible, a second opinion in the blind was sought to determine if the hairs were of human origin. Specialists in forensic hair identification Dr. Sandra Koch (personal communication, January 25, 2019) and Kimberly Rumrill (personal communication, January 29, 2019) reaffirmed that all hair samples were of probable human origin. Aside from damage from the tweezers and hemostats used to handle the hair, trauma and pathological conditions were absent.

The hair samples of the specimens differed only in that those from specimen 5196 had slightly darker pigmentation (though not quantified) and it's samples were thinner at 34.73 μm (versus 44.14 μm from specimen 5195) (Figures 4.2, 4.4, and 4.5). There was also more observable debris from decomposing organic material, detritus, on the surface of samples from 5196 (Figures 4.2 and 4.5).

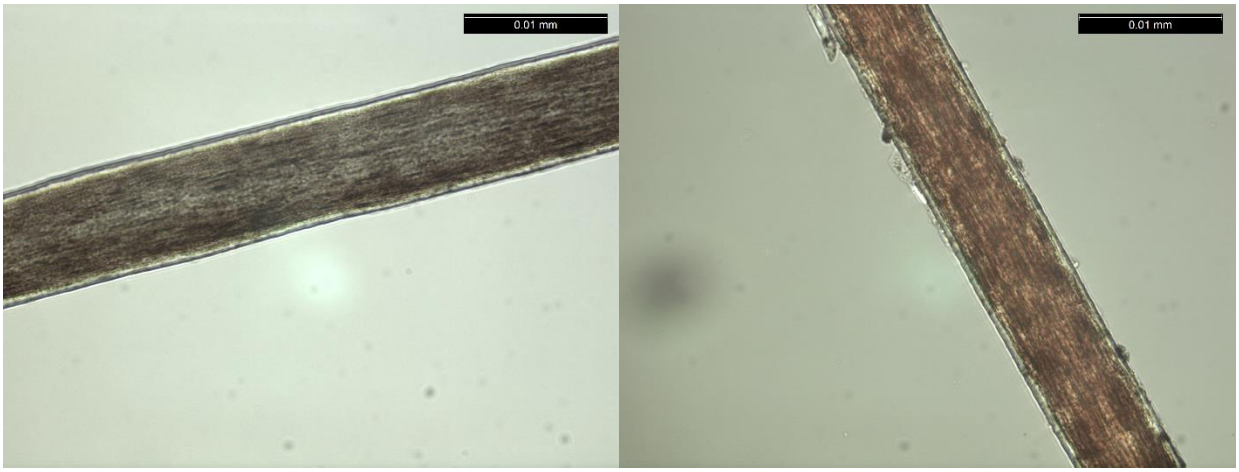


Figure 4.2. Images of wet mounted hair samples in the light microscope at 50X. Specimen 5195 (left) and specimen 5196 (right).

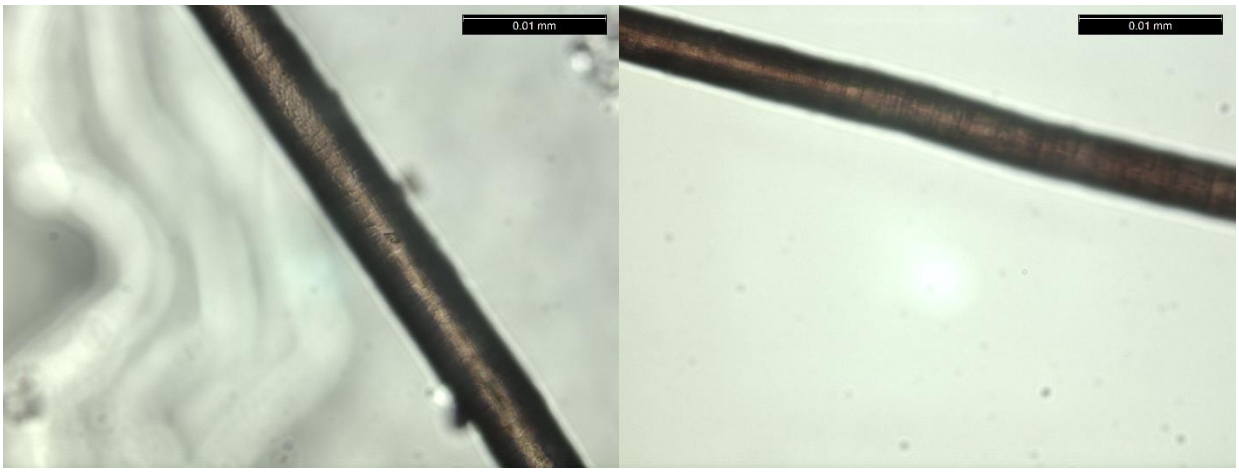


Figure 4.3. Images showing scale pattern on dry mounted hair samples in the light microscope at 50X. Specimen 5195 (left) and specimen 5196 (right).

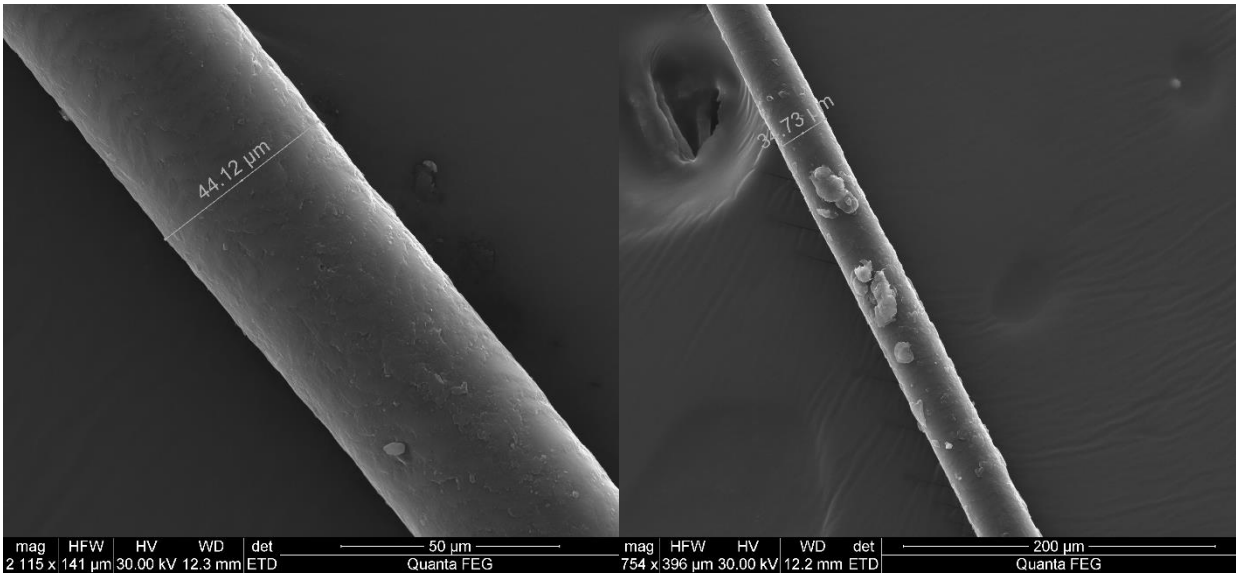


Figure 4.4. SEM micrographs of 5195 measured hair sample (left) and 5196 measured hair sample (right).

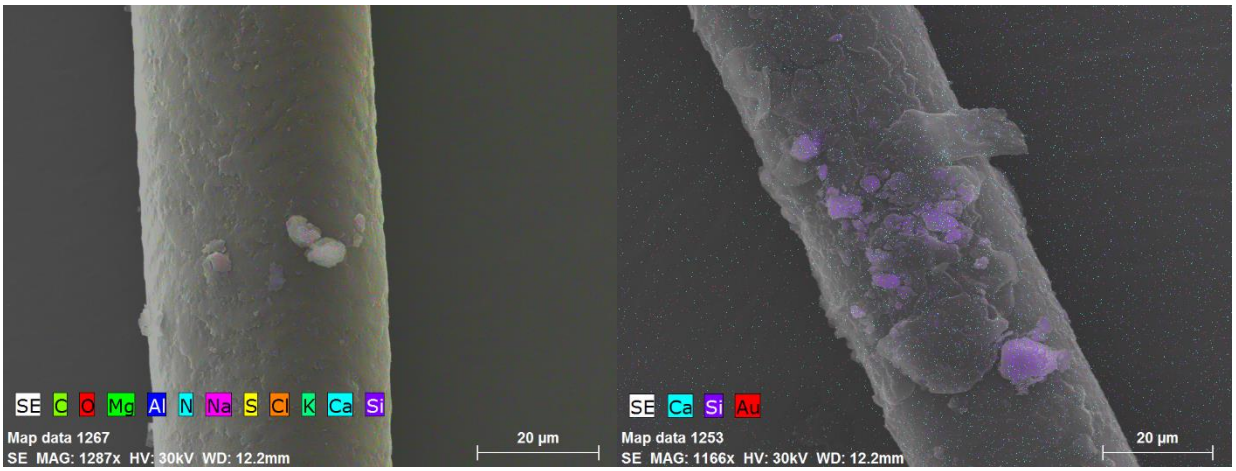


Figure 4.5. EDS scan over micrograph of 5195 hair sample (left) and 5196 hair sample (right). Element colors signified by the legend in bottom left corner of each photo. Sample 5195, in particular, showed silicon (Si) signatures in the debris coating the hair.

4.4 Fibers

When viewed with light microscopy, the structures in the fibers appear similar to sisal spirals (pictured in the 5196 fiber sample in Figure 4.6). Sisal spirals are structures found in sisal

fibers which are natural plant fibers that can be sourced to *Agave sisalana* (Petraco & Kubic 2004; Ashby, 2013). The SEM and EDS analyses reveal that specimen 5196 has more detritus on the surface and EDS analysis identified the material consisting of silicon (Si), nitrogen (N), and calcium (Ca) (Figure 4.8). The external particles are mostly silicates while the internal portion of the fibers are primarily composed of carbon (C).

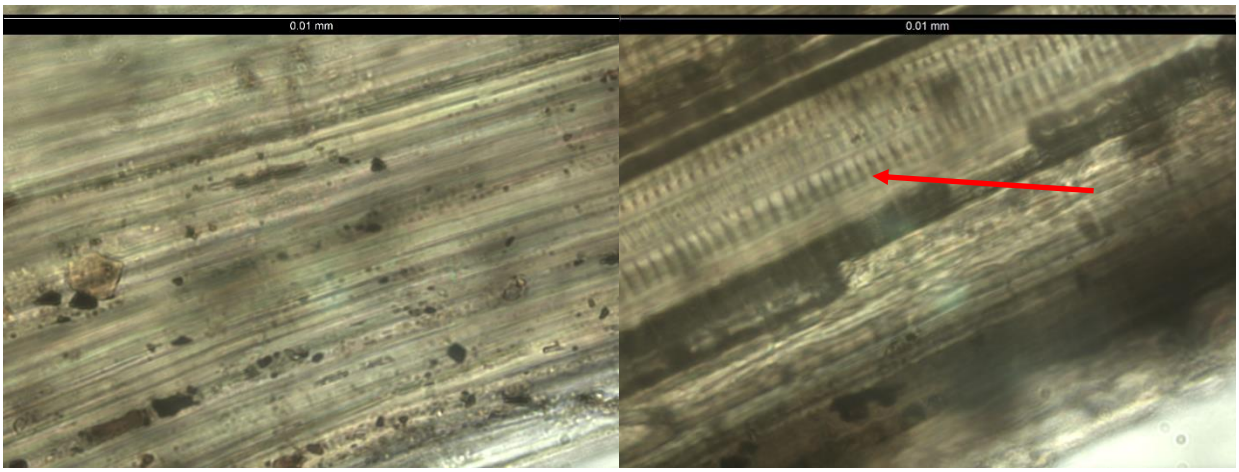


Figure 4.6. Images of wet mounted fiber samples in the light microscope at 100X of specimen 5195 (left) and specimen 5196 with red arrow pointing out an example of a sisal spiral (right).

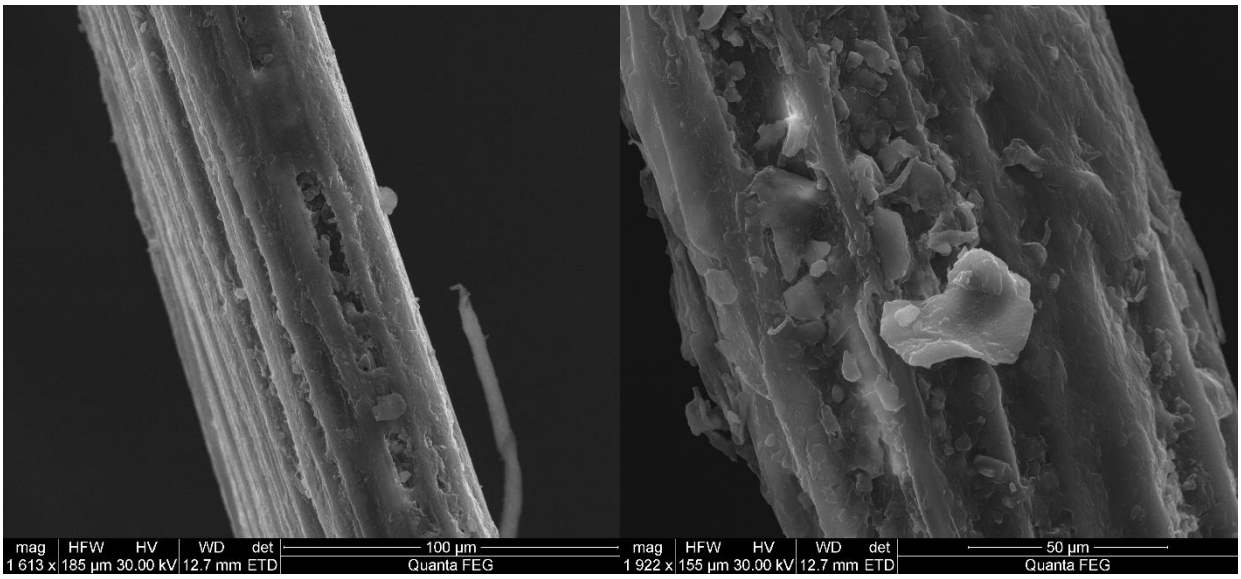


Figure 4.7. SEM micrographs of 5195 fiber sample (left) and 5196 fiber sample (right) exhibiting difference in detritus.

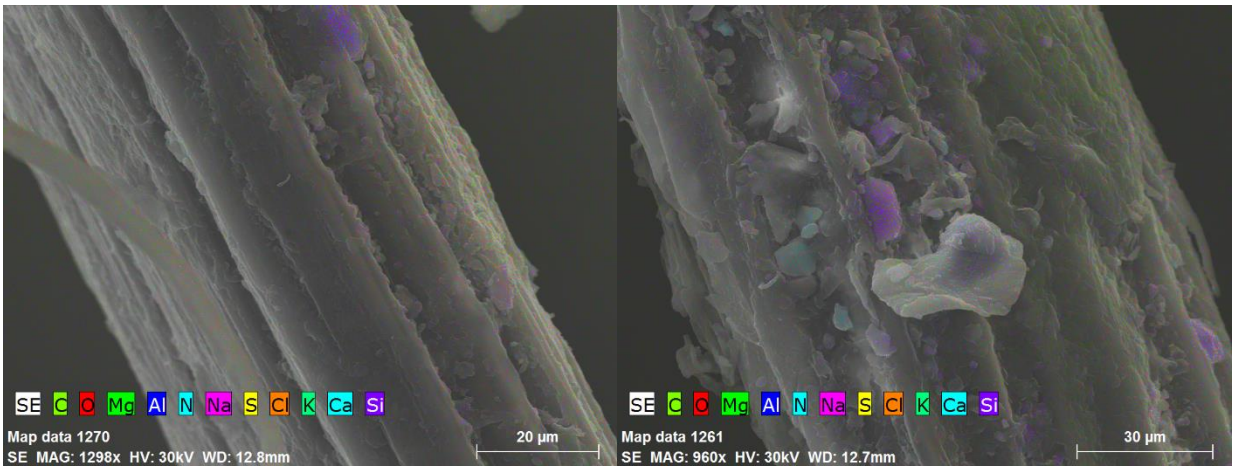


Figure 4.8. EDS scan over micrograph of 5195 fiber sample (left) and 5196 fiber sample (right). Element colors signified by legend in bottom left corner of each photo.

Raw data from the solution-based ICP-MS experiment on both the hair and fiber are presented in Table 4.4 and the fiber data is summarized in Figure 4.9. The fiber samples from both specimens have similar chemical compositions. However, there is a nearly 4500 ppm count difference in Ca between the two samples. The fiber sample from specimen 5195 had much more Ca (8894.49 ppm) than the fiber sample from 5196 (4045.80 ppm). The only other major difference between the two samples was the 1500 ppm count difference of magnesium (Mg) (5195 at 2752.67 ppm and 5196 at 1220.45 ppm). The fiber sample from 5196 (190.75 ppm) had twice as much manganese (Mn) as the fiber sample from 5195 (85.27 ppm). In both specimens, the chemical composition consisted primarily of sodium (Na) (5195 at 2640.15 and 5196 at 2963.44), potassium (K) (5195 at 3773.92 and 5196 at 3216.08), and Ca; moderate amounts of Mg (5195 at 2752.67 ppm and 5196 at 1220.45 ppm), aluminum (Al) (5195 at 491.78 ppm and 5195 at 350.94 ppm), iron (Fe) (5195 at 516.46 ppm and 5196 at 337.55 ppm), zinc (Zn) (5195 at

322.81 ppm and 5196 at 284.67 ppm), and phosphorus (P) (5195 at 557.30 ppm and 5196 at 350.94 ppm) with smaller amounts of boron (B) (5195 at 65.38 ppm and 5196 at 104.50 ppm) and Mn (5195 at 85.27 ppm and 5196 at 190.75 ppm) (Table 4.4 and Figure 4.9).

Table 4.4.

Raw ICP-MS data for the skin and fiber samples from 5195 and 5196 accompanied by data from Reagent Blank 2, the control.

Element (w/atomic mass)	Control –Reagent Blank (RB2)	5195 Fiber (F2_5195)	5196 Fiber (F2_5196)	5195 Skin (skin_5195)	5196 Skin (skin_5196)
7Li	0.00	0.58	0.47	0.09	0.07
9Be	0.00	0.01	0.00	0.03	0.02
11B	0.00	65.38	104.50	19.43	37.71
23Na	0.00	2640.15	2963.44	4061.82	1978.68
24Mg	0.00	2752.67	1220.45	969.38	1008.73
27Al	0.00	491.78	350.94	555.65	766.43
31P	0.01	557.30	420.97	2706.55	1810.68
39K	0.00	3773.92	3216.08	3858.96	1894.36
44Ca	0.07	8894.49	4045.80	3015.64	3309.62
45Sc	0.00	0.35	0.30	0.14	0.10
47Ti	0.00	23.45	19.03	14.41	8.53
51V	0.00	0.99	1.04	0.44	0.25
52Cr	0.00	9.42	6.96	2.86	2.80
55Mn	0.00	85.27	190.75	13.95	15.82
57Fe	0.01	516.46	337.55	320.58	233.45
59Co	0.00	0.39	0.43	0.14	0.09
60Ni	0.00	18.03	11.05	2.72	2.09
65Cu	0.00	95.80	85.46	12.20	15.70
66Zn	0.00	322.81	284.67	113.17	63.08
69Ga	0.00	4.37	3.63	0.81	0.81

75As	0.00	2.67	1.55	1.55	0.26
82Se	0.00	0.33	0.56	0.46	0.29
85Rb	0.00	8.90	5.76	8.46	5.24
88Sr	0.00	36.76	18.51	7.59	8.23
89Y	0.00	0.19	0.21	0.07	0.05
90Zr	0.00	0.54	0.46	0.29	0.50
93Nb	0.00	0.00	1.13	0.58	1.04
95Mo	0.00	1.02	0.64	0.60	0.43
107Ag	0.00	9.08	10.35	0.69	0.54
111Cd	0.00	3.87	5.98	0.22	0.53
118Sn	0.00	7.41	3.19	4.07	2.51
121Sb	0.00	1.06	0.90	0.12	0.21
133Cs	0.00	0.03	0.04	0.03	0.01
137Ba	0.00	65.69	55.69	12.11	12.00
139La	0.00	0.35	0.38	0.09	0.07
140Ce	0.00	0.58	0.74	0.17	0.14
141Pr	0.00	0.08	0.09	0.03	0.02
146Nd	0.00	0.31	0.33	0.09	0.06
147Sm	0.00	0.06	0.06	0.03	0.01
153Eu	0.00	0.02	0.02	0.01	0.00
157Gd	0.00	0.05	0.06	0.02	0.01
163Dy	0.00	0.04	0.04	0.02	0.01
165Ho	0.00	0.01	0.01	0.01	0.00
166Er	0.00	0.02	0.02	0.01	0.00
169Tm	0.00	0.01	0.00	0.01	0.00
172Yb	0.00	0.01	0.01	0.01	0.00
175Lu	0.00	0.01	0.00	0.01	0.00
205Tl	0.00	0.00	0.03	0.05	0.06
208Pb	0.00	66.45	55.05	5.94	6.00

232Th	0.00	0.00	0.06	0.02	0.04
238U	0.00	0.04	0.04	0.02	0.01

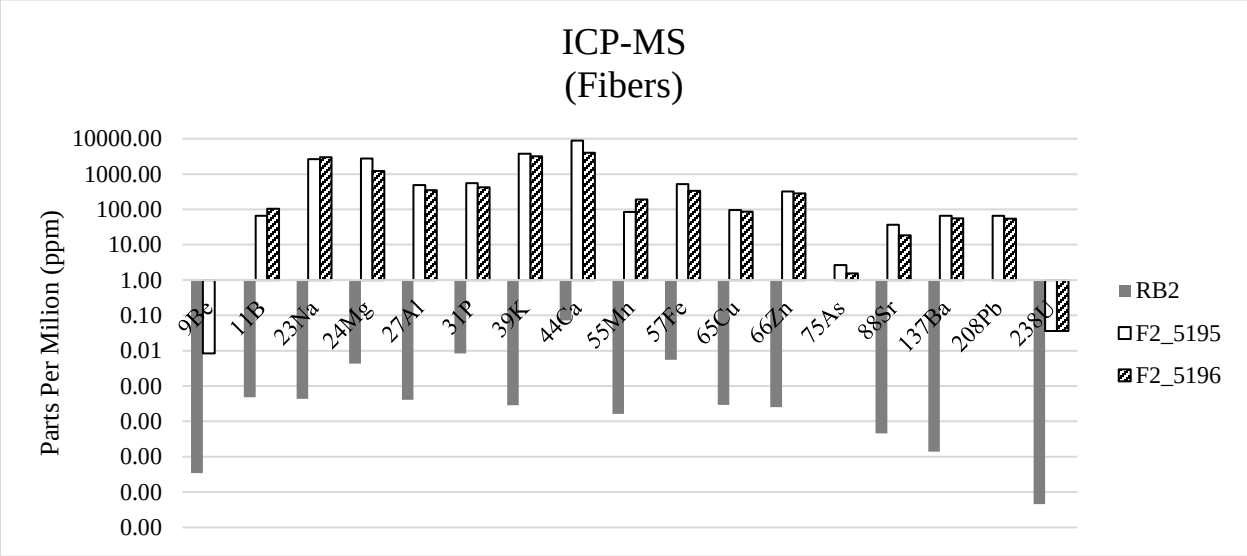


Figure 4.9. Bar graph for ICP-MS analysis of fiber samples from specimens 5195 and 5196. RB2 = second reagent blank. F2_5195 and F2_5196 = fiber samples from each respective specimen.

4.5 Skin

Data from the solution-based ICP-MS experiment on the subsamples of skin from 5195 and 5196 are summarized in Figure 4.10 and refer back to Table 4.4 for the compilation of the ICP-MS data. Both specimens are very similar regarding the elements detected. However, the counts differ significantly with Na and K counts, with a difference in counts at with 5195 having 2000 parts per million (ppm) more than 5196. The count difference for P is smaller, with a 5195 having roughly 1000 ppm counts more than specimen 5196. In each case, the skin sample for specimen 5195 is the sample that contained higher ppm of Na (5195 at 4061.82 ppm and 5196 at 1978.68 ppm), K (5195 at 3858.96 ppm and 5196 at 1894.36 ppm), and P (5195 at 2706.55 ppm

and 5196 at 1810.68 ppm). For both samples, the ICP-MS detected large amounts of Na, P, K, and Ca (5195 at 3015.64 ppm and 5196 at 3309.62 ppm) in respect to the reagent blank that was set as the control. There were also lower amounts of Mg (5195 at 969.38 ppm and 5196 at 1008.73 ppm) and Al (5195 at 555.65 ppm and 5196 at 766.43 ppm). Very little B (5195 at 19.43 ppm and 5196 at 37.71 ppm), Fe (5195 at 320.58 ppm and 5196 at 233.45 ppm), and Zn (5195 at 113.17 ppm and 5196 at 63.08 ppm) were found in both skin samples (Table 4.4 and Figure 4.10).

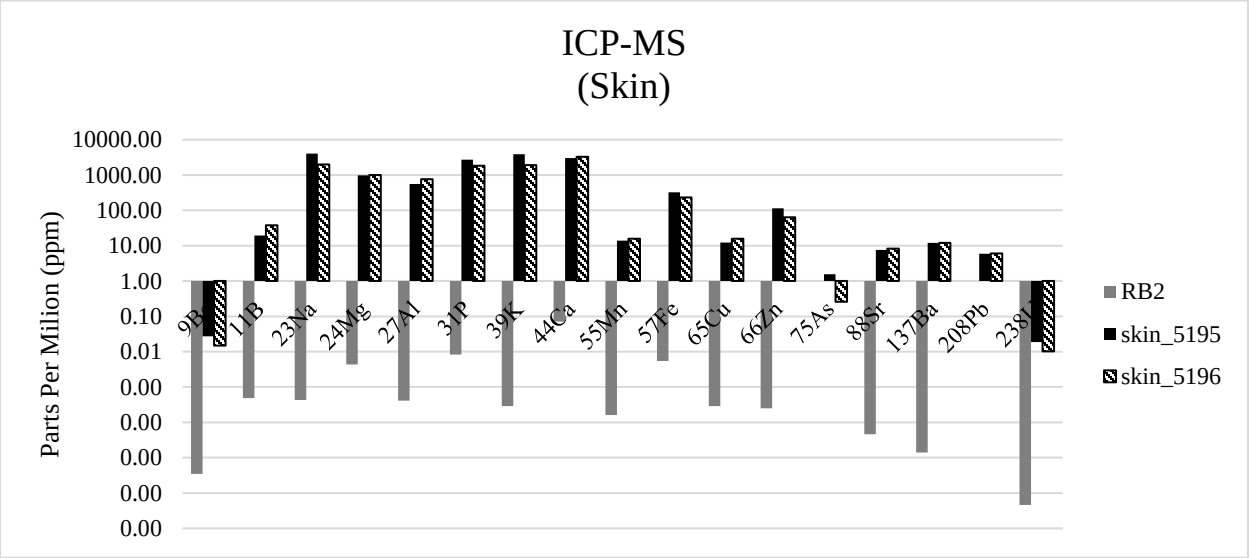


Figure 4.10. Bar graph for ICP-MS analysis of skin samples from specimens 5195 and 5196. RB2 = second reagent blank. Skin_5195 and Skin_5196 = skin samples from each specimen.

The FTIR analysis on the skin supports the results for ICPMS as both specimens are very similar with wavenumber peaks at 3288, 2918, 2851, 1649-1634, 1536, 1460-1464, 1176-1146, 665-655 and 589 cm^{-1} (Figure 4.11 and Figure 4.12). Some peaks are slightly dissimilar and

specimen 5196 has two peaks at 1733 and 1708 cm $^{-1}$ that do not appear in specimen 5195.

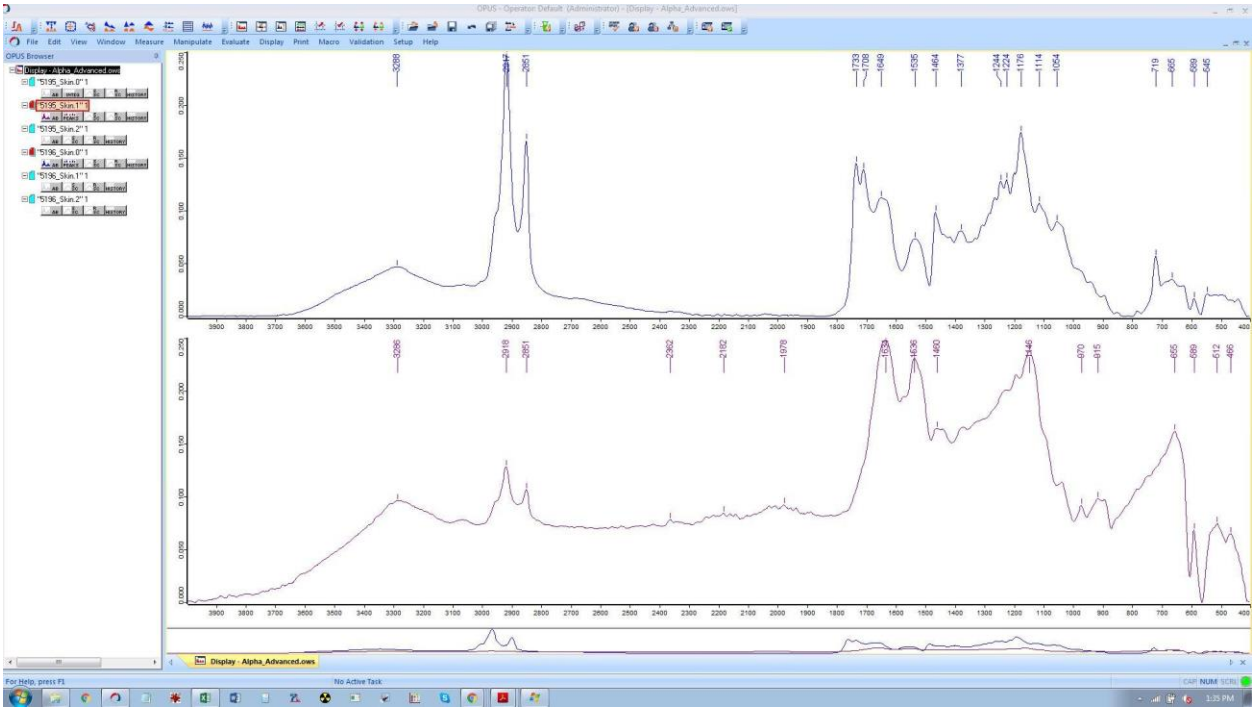


Figure 4.11. Screenshot of stacked FTIR graph of skin from specimen 5195 (bottom) and specimen 5196 (top).

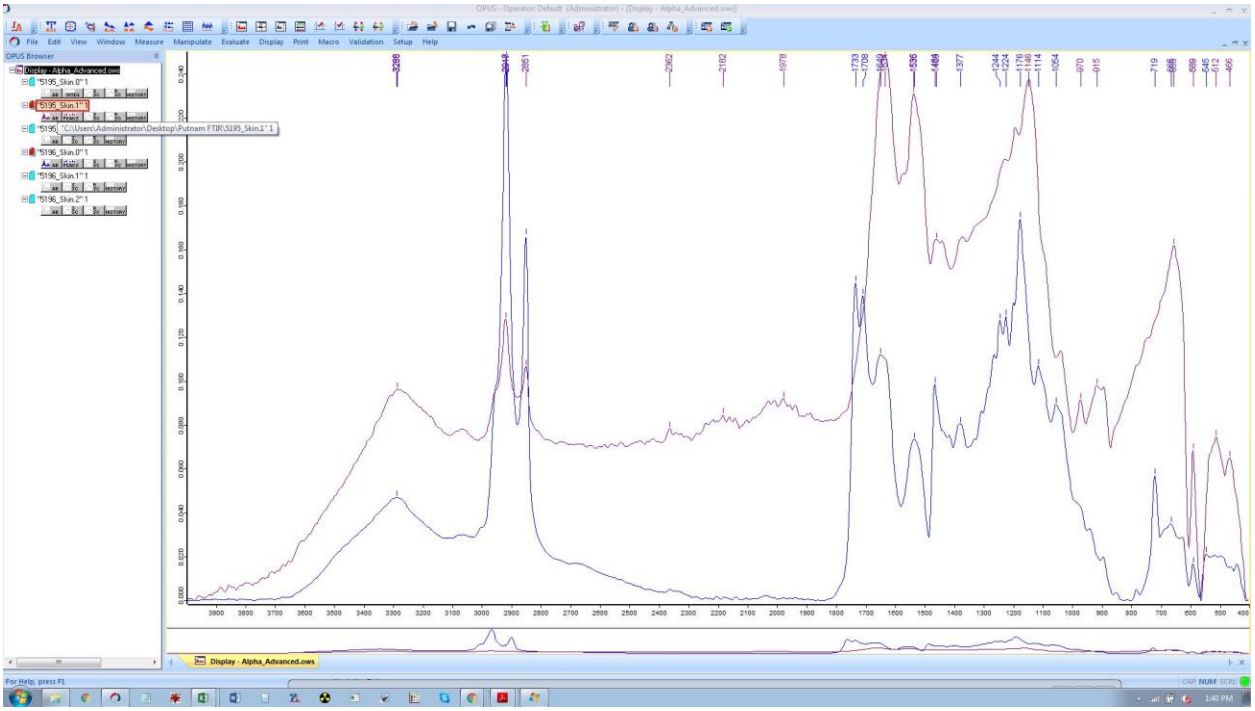


Figure 4.12. Screenshot of overlaid FTIR graph of skin from specimen 5195 (top) and specimen 5196 (bottom).

4.6 Summary

The specimens both looked more human than primate morphologically. In addition, they both had more ambiguous traits than ceremonial or commercial. Overall, samples from both specimens show similar results. The hair samples are consistent with human hairs. In addition, the fibers are most consistent with sisal plant fibers. Furthermore, there is no evidence of chemical preparation of skin, fiber, or hair. Chemical composition of fibers and skin varied slightly by parts per million between specimens, but in general the same natural chemical signatures appear in both.

Chapter 5 - Discussion and Conclusion

In this chapter, the research questions outlined in Chapter 1 will be addressed through the interpretation of the results presented in Chapter 4. Next, the limitations of this thesis will be outlined, followed by a discussion about ongoing research as well as possibilities for future research. Subsequently, this topic will lead to a discussion about dark tourism and how its existence perpetuated the role of shrunken heads in a curio-trade market. A consideration of the repatriation of human remains at an international level will follow.

5.1 Discussion

5.1.1 Are the specimens human? Morphology and light microscopy were key elements in determining if the specimens were human or nonhuman. Comparing morphological features of the two specimens to features of humans and other animals was valuable in this case. The ear and hair morphology of both specimens were consistent with those of a human. If shrunken heads were made using an animal skin with animal hair attached, the skin would have evidence, such as large visible follicles, from the thick hair being burnt off. In addition, the lack of lateral facing nostrils suggested that neither species was nonhuman South American primate (Houlton, 2012).

The most significant evidence that the specimens are likely human, however, is the microscopic hair identification. Hair samples from both specimens were within the normal range of human hair width (Goyal et al. 2016). Both hair samples had a medulla that were not explicitly present, continuous pigment distribution across the hair, and an imbricate cuticle pattern (Figures 4.1-4.3). All of these characteristics align most closely with a human

identification and were confirmed via blind tests (Rumrill, personal communication, January 25, 2019; Koch, personal communication, January 25, 2019).

Methods to perform species identification via microscopic hair analysis have been used by forensic scientists for approximately a century. The presence of a culmination of all of the aforementioned traits, which would be attributed to a human hair, is what leads to the probable human identification. In other words, some animals may have an imbricate pattern similar to humans but might not have continuous pigment distribution, or the hair could have a medulla that would measure outside of the human range (Goyal et al. 2016; Petraco & Kubic, 2004). Less pertinent to this thesis is the more concerning venture towards identifying an individual based on microscopic hair comparison. These endeavors have been less successful. The difficulty of accurate individualizations derive from the fact that an individual's hair varies. Therefore, identifying a hair as belonging to a specific individual is extremely difficulty through microscopy alone (Miller, 1987).

5.1.2 Are the specimens commercial or ceremonial? If the hair from specimens 5195 or 5196 was not human, the heads would not have automatically been considered commercial shrunken heads. However, if the species were determined to be something other than a sloth (which were commonly shrunken by the Shuar), their creation for commercial purposes would have been much more likely (Harner, 1973; Karsten, 1923; Stirling, 1938).

Little to no deformation is visible in either specimen. Both specimens 5195 and 5196 had evidence of little to no facial distortion; however, specimen 5196 had more facial features that resemble those of an average human head. The nose is slightly pointed on 5195, but other aspects appears to remain in their original states (this is typical of commercial shrunken heads). Specimen 5195 and 5196 had proportions attributed to ceremonial *tsantsas* at about a fifth the

size of the human head after the shrinking process as commercial head sizes varied greatly from each other (Houlton & Wilkinson, 2016, 2018). Both specimens also shared other ceremonial traits, such as the incision for skull removal present in the middle of the back of the head. Another example of a ceremonial trait the two specimens share is the three puncture locations where the mouth was sewn shut. The presence of ceremonial traits between the specimens differs mainly in the skin samples. Specimen 5195 is polished and appears to be darkened (though this has not been absolutely confirmed) and this darkening could have been done using carbon staining (typical in ceremonial preparations), while specimen 5196 has no evidence of darkening (Houlton & Wilkinson, 2016, 2018). The presence of downy hair on 5196 suggests that the face was not polished. That fact and the rough texture and grayish yellow color are traits that are indicative of specimen 5196 being a commercial shrunken head (Houlton & Wilkinson 2016, 2018). Neither head had a perforation at any point in the scalp that would have ceremonially been used to hang the heads for show or ornamentation. Specimen 5195 was decorated with a headband, feathers, and a bean necklace which is a commercial trait. All other traits appeared ambiguous: either they were missing multiple aspects or those aspects' presence or absence could not be determined by both observers (Houlton & Wilkinson, 2016, 2018).

Specimen 5195 exhibited more traits that are considered ceremonial, while specimen 5196 displayed more commercial traits. Because so many attributes that would belong to either commercial shrunken heads and ceremonial *tsantsas* appear in both specimens, it is unclear what category they fit into most according to the method created by Houlton and Wilkinson (2016, 2018). Thus, to use their terminology, 5195 and 5196 would be considered ambiguous (Houlton & Wilkinson, 2016, 2018).

When compared to the 65 specimens in the literature, the specimens from IMNH fell within the metric ranges from Houlton's (2017) box and whisker plot. Those metrics from specimen 5196 that fell outside the Houlton's (2017) range may be attributable to the fact that specimen 5196 appears to be a juvenile both from current observations and from statements in the acquisition letter (Bell, 1954).

Through light microscopy and SEM analysis, the hairs from both specimens were shown to be covered in detritus. When viewed using the EDS, the detritus consisted of silicates and other organic materials (Figures 4.2-4.5). The lack of elements used in synthetic preservation suggests that there was no synthetic preserver applied to the external portion of the specimens (Davie 1900). The higher quantity of detritus material on specimen 5196, may simply be a matter of curation and transport, rather than original preservation methods

The fibers showed similar results to the hairs using SEM/EDS in their lack of additives and the fact that their primary composition consisted of C (Figures 4.6, 4.7, and 4.8). The fibers were identified as the leaf plant similar to the *Agave sisalana* because of the sisal spirals that were visible throughout the fibers (sisal spirals being a structure typical of that species). This natural fiber can be found in northern South America, as well as parts of Asia and Africa (Ashby, 2013). It is typically found in tropical and subtropical areas of the world, notably in northern South America up through the Yucatan Peninsula. This plant is commonly used for medicinal and ornamental purposes as well as to make fibers. These fibers were traditionally used for rope and twine (Debnath, Padney, Sharma, Thakur, & Lal, 2010). It is probable that this fiber was traditionally used by the Shuar.

Nearly all organic matter primarily consists of oxygen (O), hydrogen (H), C, and N (Kabata-Pendias, 2011). As was previously mentioned, the presence of Mg, P, Na, K, and Ca

were detected in the fiber samples and these are elements that are typically found in plants. Nonetheless, the presence of various other trace elements depends on a multitude of variables unique to plants. One variable is uptake of various trace elements from things like soil, fertilizers, and pesticides. Elements that are essential to the growth of plants include Al, B, bromine (Br), chlorine (Cl), cobalt (Co), copper (Cu), fluorine (F), Fe, iodine (I), Mn, molybdenum (Mo), nickle (Ni), rubidium (Rb), Si, titanium (Ti),vanadium (V), and Zn. Of these elements, the ICP-MS detected Al, B, Fe, Mn, and Zn in trace amounts or quantities dependent on the soil in which each plant fiber came from. The difference in Ca counts for each specimen is likely an idiosyncrasy of preservation or there was variation in the soil from which the plant fibers were taken (Kabata-Pendias, 2011). There is no evidence that chemicals were present which would suggest that the fibers were exposed to a preservative. In addition, there were no foreign chemicals detected in either of the fiber samples. These results are consistent with the identification of the fibers as natural, minimally processed, plant-based fibers. Boron and lead (Pb) levels may be slightly high, but as with the skin samples, there are currently no baseline ICP-MS studies done for plant fibers related to shrunken heads, either ceremonial or commercial.

The chemical makeup of plants is quite similar to that of the human body with N, C, H and O being the most common elements (Kropp & Halasey, 2007) Elements that commonly appear in smaller quantities include K, P, Ca, Mg, Sulfur (S), Na, and Cl. However, the concentration of these elements varies depending on the organisms (Kabata-Pendias, 2011). The human body is no exception to this rule (Shyamala, 2009). These are among the lighter elements that are not detectable by an ICP-MS (Pollard et al. 2007). Elements found in the skin samples include detectable elements such as Ca, P, K, Na, and Mg. These elements are also found in the human body in smaller quantities than O, H, C, and N. The ICP-MS can also detect the trace

elements B, Fe, Mn, and Zn that also appear in the human body. Trace amounts such as these were found in the skin samples. Aluminum is found in the human body as well, but the quantities found in the skin samples were larger than expected. Aluminum is a trace element in the human body at less than .01% and it appears at around .05-.06% (Pollard et al., 2007; Shyamala, 2009). Therefore, while many elements were detected in the skin, none are foreign to the human body.

Additionally, the difference between the amounts of Na, P, and K in the skin samples could suggest there is a difference in the level of diagenesis. Specimen 5195 may have been more well-preserved. Ceremonial shrunken heads were preserved using only heat, water, and, in some cases, botanical additives (Harner, 1973; Charlier et al., 2012). These additives would be very difficult to distinguish from other naturally occurring elements that are typically found in most living organisms. It is unclear how commercial heads were preserved compared to ceremonial *tsantsas* (Harner, 1973; Rubenstein, 2007). However, if the preservation techniques were much different (or in any way similar to modern techniques), it is likely that there would be detectable chemical additives. An excess of B, arsenic (As), or Na and Al, for example, would suggest something typically used in taxidermy was used to clean or preserve the heads (Davie, 1900). Arsenic does not appear in either skin sample. Boron is an integral part of the body (Pizzorno, 2015) and does appear in trace amounts, specifically in an amount less than .01% (Shyamala, 2009), in this sample. However, this quantity may not be a significant enough amount to suggest the use of a preservative like borax. Nevertheless, the presence of Al may signify that a salt and alum mixture or something similar was used to tan the heads (Davie, 1900). If there are any additives, the likelihood that the two specimens were made for commercial purposes is far greater. However, there is no baseline to compare to these results or to confirm this interpretation of the ICP-MS data. Additionally, the similarities between numbers

of both sample types from both specimens are important to note because it suggests they may have been stored in similar places or had similar production processes.

Research on the skin samples using FTIR is ongoing and will be described further in the future research section. However, comparing the FTIR results from specimen 5195 and 5196 to a control skin sample absorption spectrum (Figure 5.2) provided by Guidi et al. (2012) suggests that specimens 5195 and 5196 are very similar to the control. However, the shrinking process may have altered them in some fashion. Access to the software used to identify peaks would increase our understanding of FTIR results; however, there is still no comparable research that has been performed on other shrunken heads to aid in the interpretation of this data. Thus, the peaks at 1733 and 1708 cm^{-1} found in specimen 5196 remain unidentified.

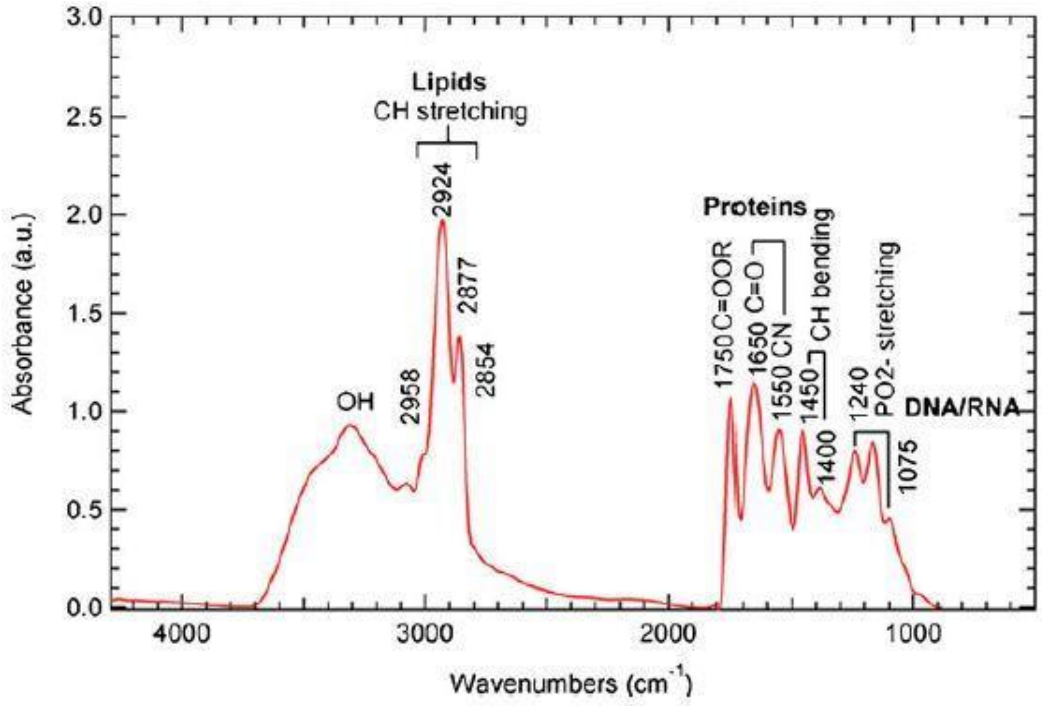


Figure 5.1. Control skin sample. Reprinted from "In Vivo Skin Leptin Modulation after 14 MeV Neutron Irradiation: A Molecular and FT-IR Spectroscopic Study." By M.C. Guidi, et al., 2012, *Analytical and Bioanalytical Chemistry 404*(5), 1317-1326. Copyright (2012) by Springer-Verlag.

The morphological and morphometric analyses suggest that specimen 5195 and 5196 are human, commercially made shrunken heads. The lack of chemical additives to skin, hair, and fibers and the use of natural, locally occurring fibers is most consistent with the preparation similar to ceremonial *tsantsas*.

If the letter written about the acquisition of the specimens (Bell, 1954) is accurate, both specimens are potentially commercial shrunken heads made by the Shuar. The locations and conditions described in the letter are consistent with the area the Shuar were known to live during that time (Bell, 1954; Harner, 1973; Stirling, 1938). However, if specimen 5195 was an old woman and specimen 5196 was a young boy (Bell, 1954) this is inconsistent with the ideas that *tsantsas* are typically made from the heads of male warriors (Steel, 1999). Redmond's (1994) work suggests women and children never had their heads taken to create ceremonial *tsantsas*, which would indicate that the two heads at the IMNH were made with commercial purposes in mind. Though the sex cannot be confirmed through the methods preformed in this thesis, specimen 5196 did have thinner hair than specimen 5195. The difference in thickness and the fact that 5196 was smaller than 5195, could be an indicator that specimen 5196 was a juvenile (Houlton, 2017). Steel (1999) proposed that the Shuar began to trade old *tsantsas* (usually ones in which the *muisak* was released) and made new ones, specifically to trade to European travelers, when they realized that they could be turned into commodities. This information would be consistent with Bell's (1954) descriptions in the letter provided to the IMNH.

5.1.3. Limitations. This research has multiple limitations. First, there were difficulties with sampling due to the condition of the two specimens (dry and brittle skin), which also limited the amount of data that could be gathered on the skin and hair. Second, Houlton and

Wilkinson's (2016, 2018) morphological analysis method, though useful, lacked the distinct definitions necessary for an accurate characterization of traits. For example, when the authors say "variable size" they do not define what they mean by this. Similarly, the trait describing ceremonial heads as "weighty" compared to commercial heads, is not defined or easy to interpret (Houlton & Wilkinson, 2016, 2018). Therefore, the method needs improvement if it is to be used by inexperienced observers with small sample sizes. Additionally, Houlton (2017) added a caveat at the end of his article about how his morphometric method was not as useful for identifying shrunken head authenticity as the morphological method from Houlton and Wilkinson (2016). Houlton (2017) agreed that having a more representative sample of ceremonial *tsantsas* would be helpful when using the metrics method.

Another limitation was encountered based on the amount of ethnographic data and other research data that is available for the Shuar. Many researchers studied the Shuar because of how resistant they were to outside influence. Yet, this may also have led to difficulties in getting ethnographic data as an outsider (Harner, 1973; Stirling, 1938). On the other hand, rumors of cannibalism and misconceptions about shrunken heads may have been a source of trepidation for outsiders looking to gain knowledge about the Shuar and shrunken heads (Bell, 1954; Harner, 1973). As for modern research, a representative sample of shrunken heads is likely nonexistent (Komar & Grivas, 2008) and if it were it would be almost inaccessible due to the protocols involved in getting approval to do research and rules concerning repatriation and the destruction of human remains (King, 2013). In part, this is because other specimens are part of museum curation or private collections (Houlton & Wilkinson, 2016). The sample at the IMNH is not a representative sample.

Finally, perhaps the most limiting aspect of this study is the lack of background research done on shrunken heads in regards to their chemistry and use of ICP-MS, FTIR, and SEM analyses. If more research were eventually performed on other specimens, the data gathered in this experiment would have more context. Correspondingly, if access to software used to interpret the data from the ICP-MS and FTIR was available for the research in question, increasingly informed interpretations could be made about the samples. The hope is that this research will inspired other researchers to analyze the chemistry of commercial and ceremonial shrunken heads in order to broaden comparability.

5.1.4 Future research. Research with the FTIR and the development of a new way to use Houlton's (2017) morphometric method are ongoing. Further FTIR research on pig skin and preservation will be done. Moreover, using the morphometric method and Houlton's (2017) data to place the heads still requires approval from Houlton (personal communication, May 1, 2019) to move forward. Moreover, several other research possibilities remain for the samples taken from specimen 5195 and 5196. Many of these experiments were not performed because they did not reflect the research questions of this thesis. In addition, given the identification of these remains as human, the analyses could be considered unnecessary considering their destructive nature.

Samples of pig skin will be put through the FTIR using methods described in Chapter 3. The samples will include a control test of regular pig skin and the results will be compared to those of skin that has been boiled and/or treated with various types of preservatives. Examples of preservatives that will be used include iodized salt, borax, and botanical additives that may be similar to the parasitic vine juice referenced in Stirling (1938). This research will potentially tell us how proteins in skin change based on what was done to preserve it (Pollard et al. 2007).

Another test that could be performed with the FTIR would be to run the fiber samples and look for the cellulose wavenumber peak. This test would confirm the organic nature of the fiber (Rumrill, personal communication, January 29, 2019; Pollard et al. 2007).

After gaining access to Houlton's 2017 morphometric data, it may be possible to create a discriminate function analysis and use it to classify specimens 5195 and 5196 in known categories. The measurements would be separated into the categories *commercial*, *ambiguous,* and *ceremonial*.

Another possible analysis includes genetic barcoding would be useful in confirming species because it allows short genetic markers to be viewed through a taxonomic scope to identify species. In other words, this would confirm that the specimens are human (Savolainen, Cowan, Vogler, Roderick, & Lane, 2005). This would be decided on an exclusionary basis through the presence or absence of DNA that belongs to other animals. Specimens have likely been contaminated with human DNA through years of handling in both the original owner's and the museum's possession.

For more information about the specimens, hair samples could be subjected to isotopic analysis and the ratios would be measured through mass spectroscopy. This separates the various isotopes of an element and this signature can reveal things about diet and geographical origin (via strontium [Sr] ratios). If comparative samples cannot be found for this analysis, this method will still give us data to suggest whether each specimen was an omnivore or an herbivore, had a more traditional or modern diet, or whether their diet changed closer to the end of their life. Another possibility from this analysis is that it would reveal the isotopic signature of each sample and that could then be compared to isotopic signatures of animals and humans from the suspected origin in South America on the Ecuador and Peru border (Pollard et al., 2007).

Yet another possible analysis would be the laser ablation ICPMS (LA-ICPMS).In LA-ICPMS a laser beam is focused on a sample and generates fine particles. These fine particles are ionized and digested by a plasma torch and then introduced to a mass spectrometer for elemental analyses. This could be performed on the surface of the hair samples to determine the chemical signature of the hair (Pollard et al., 2007). This would be done in order to obtain ICPMS results for all sample types.

5.1.5 Dark tourism and repatriation. Trophy taking may coincide with a morbid fascination with death. This fascination may take form through the action of trophy-taking itself, but it could be fulfilled via the purchase of a trophy or another strange curio related to death. The trade in shrunken heads could fit this description. However, most levels of morbid curiosity are satisfied by a simple visitation of sites where bodies are displayed or where tragedies have occurred. This could be in the form of tombs or even visiting the concentration or work camps associated with the Holocaust. Visiting places such as these is considered as "dark tourism" (Young & Light, 2016).

Massive amounts of the revenue gained from the tourist industry comes from cites that could be considered "dark tourism" sites. The abundance of these sites and their success in the tourism market suggests that dark tourism plays a role in society as a whole. Some people go to satisfy academic interests while others go to mourn the dead. Other visitors suggest their interest is in finding another way to understand the unknown that is death (Young & Light, 2016). Another possible reason for the popularity of dark tourism sites is that they solidify people's ideas of where they or whichever group they belong to stand in society. Through the commemoration of some of the darkest moments of the past, the present becomes far more comprehensible in comparison (Tinson, Saren, & Roth, 2015). If sites of death and tragedy can

be made into commodities, then death itself is being commoditized (Lennon & Foley, 2000). We can consider the commoditization of the human body as a form of dark tourism, in which someone is collecting morbid curios or souvenirs that reflect these sites but come in the form of human remains. This commoditization could have prompted the death of more individuals because of another individual's pursuit of economic success (Steel, 1999).

Commercialization has led shrunken heads to accumulate in museums and private collections across the world. This created a problem for curators and museums both in determining authenticity and in eventually trying to repatriate shrunken heads (Rubenstein, 2007). The IMNH wanted to determine the authenticity of specimens 5195 and 5196. It will be their decision whether to repatriate the specimens because the Shuar do not reside in the United States and thus the specimens would not fall under the Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 (Rubenstein, 2007).

There have been cases of repatriation, as described by Rubenstein (2007). This was not a requirement by law, but rather a decision made by the National Museum of the American Indian (NMAI). Their repatriation effort resulted in the repatriation of 12 *tsantsas* to the Shuar-Achuar Federation because they are viewed as great reminders of the past and are pieces of Shuar cultural heritage (Rubenstein, 2007). Whether the Shuar decide to agree to the repatriation from the IMNH may also depend on their opinion of commercial versus ceremonial shrunken heads as commercial heads may have originated from various places in Central and South America (Houlton & Wilkinson, 2016). Whether repatriation of these remains should be attempted is unclear, considering these human remains might not belong to the Shuar of the past, it may be unethical to return remains to the people that orchestrated these people's deaths. If repatriation does not occur and the heads are displayed again in the IMNH, proper descriptions of the Shuar

culture and of the probable origins of specimen 5195 and 5196 should be provided. The unethical commodification of human remains needs to be investigated and addressed before any changes can be made concerning the trade of human remains (Halling & Seidemann, 2016).

Although several laws prohibit sales of human remains, Halling and Seidemann (2016) documented the sale of 454 human remains on eBay and other internet auction over the span of seven months, noting that these laws did not seem to act as much of a deterrent. These and other authors (Huxley & Finnegan, 2004; Seidemann, Stojanowski, & Rich, 2009) noted than many of these remains appeared to be prehistoric and Native American. After such sales were reported, Ebay announced, in brief, that its policy forbids the sale of "human bodies, body parts, or products made from the human body," with the exception of human scalp hair for wigs. Upon a current perusal of eBay now, over 1,200 search results with prices listed as high as $349.00 are found when using the keyword "shrunken head." There are no clearly human shrunken heads for sale, but there is a large market for shrunken heads that look like human heads. Many are listed as replicas made of real leather and hair, while some are listed as dolls, oddities, and props (eBay, June 13, 2019). Even if they are not authentic (neither in origin or materials), there is still an obvious morbid fascination with the practice of head shrinking and display of human remains.

5.2 Conclusion

Specimens 5195 and 5196 from the Idaho Museum of Natural History were analyzed through various means. Morphological and morphometric analyses were used to determine that both specimens were probable human yet, likely commercially-produced shrunken heads. Furthermore, microscopic hair analysis identified the hairs sampled from the specimen as probable human hair. Moreover, microscopic analysis on the fibers aided in identification of the plant species. The fibers were made from the *Agave sisalana* plant that is known to be found in

tropical locations like Ecuador and Peru. Chemical analyses were inconclusive but data suggested the fibers were not synthetic and there is no substantial evidence of preservatives. This implies that the Shuar could have produced the heads at the IMNH for commercial purposes. These conclusions were made with knowledge obtained via primary sources, ethnographic studies, and previous research. In accordance with the decision of the IMNH, specimens 5195 and 5196 have the potential to be repatriated to the Shuar with the cooperation of the Shuar Federation.

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Appendix A

Idaho Museum of Natural History Documents: Bell's letter typed, Bell's original letter, and list of items from the Bell collection donated in 1962 to IMNH accession number 1033. Specimens 5195 and 5196 are bolded.

Museum: Idaho Museum of Natural History · Accession #: 1033

Author: Mrs. A.J. Bell

*Letter will be quoted verbatim, without corrections or clarification.

Jacques Bardonnet – A Frenchman & his Colombian wife Francie were in Quito the Capital of Ecuador. They were trying to find some of the shrunken heads they had heard so much about. The government of Ecuador had prohibited the sale of the heads & Jacques & Francie knew if they located some of the heads, they would have to purchase them under cover! They soon discovered the heads were very scarce, in fact it was weeks before they found any one that could give them any information concerning the heads.

One day quite by chance Jacques found an old Indian (Indias they are called in S.A) woman. She was very old & very ugly but she told them if they would give her the money she would get them some heads but she would have to travel very far and it would take her quite some time. Also the deal must be kept very quiet as she would get in serious trouble with the govt. if it learned of the transaction. Jacques & Francie talked it over & decided they would not trust her with the money so ask her if they could go with her. She said they could so they all left Quito & went to Ambato by train. From Ambato they traveled over terrible roads till they came to a small petroleum camp, run by Americans.

This was as far as they were allowed to go. The old woman took the money & went on alone. She had to cross a high mountain range. The Andes mountains. The other side of the mountain she came in to the jungle. It is called La Jungla. It is so dense she had to cut her way thru with a machete. The jungle grows so rapidly, in less than 2 months her path would be all grown over.

She finally came out into a valley formed by two rivers. The Pastaza & the Napa. The Jibaro Indians live on the Pastaza river while the Zaparos live on the Napa. These two tribes are bitter enemies & are constantly fighting each other with poisoned arrows. They are presumed to the cannibals but no one white person has ever returned who has ever returned who has gone in there, to tell for sure.

They are black Indians with very fine hair. It was to the Jibaros Tribe the old lady went to for heads. In about a week she returned to the oil camp but had only one head for Jacques & Francie. The head of an old Indian woman. She told Jacques & Francis they must wait a couple of weeks for the other head. She told them to go back to Ambato to wait. She would not go with them as she didn't want to be with them if the head was discovered.

A couple of weeks later they made the trip to the oil field again & again Jacques & Francie waited while the old woman went into the tribe. When she came out the second time she had the head of a 15 yr old boy. It was still very fresh. So fresh the neck & the incision in the back of the head still looked raw even tho processed. Again she would not return to Ambato with them for fear of punishment by the govt. if they ever found out about the heads.

Jacques & Francie then returned to Quito the Capital of Ecuador. From Quito they smuggled the heads into Colombia. The strange thing about the whole deal was the fact that the

Indians would not sell the heads for anything but American dollars. They would not accept any other money.

From Quito Francie & Jacques went to Bogota, where Jacques with a degree in engineering obtained work. They had only been married a few months before going to Bogota. Their marriage was a civil marriage, not performed by a catholic priest. After they were settled in Bogota & Jacques had started on his new job, they were visited by a Catholic priest who informed them they would have to be married by a priest or their marriage would not be recognized in Bogota. They refused & the priest broadcast that they were living in sin. They still refused to be married in the Catholic Church so they were persecuted & hounded out of Bogota. They came to Bucaramanga & he obtained work here. In a few weeks (as quickly as the priest in Bogota found out where they had gone, the persecutions started again. He lost his job again & wasn't able to obtain another. The priest had said he would drive them out of S.A. They began to sell their few possessions to obtain money to live on. They kept the Indian heads till they became desperate for pesos. Thru a mutual friend we heard about the heads and the friend made it possible for us to see them. Later we made an offer for the heads but Jacques had heard of another job & wouldn't sell till he found out about it. The job was a good one but vanished when the party found and talked with the priest. Shortly after Jacques sent word he would except our offer as he wanted to leave Bucaramanga & go to Baranquilla to try & find work.

We then met at our apartment & Jacques gave us the history of the heads & the map. Francie cried when she left the heads with us. They were her prized possessions & they had had a lot of trouble getting them.

They also told us the Rockyfeller Foundation had sent an expedition to Ecuador to find out and study how the shrinking was done, hoping the method would help in their research

on cancer. However the expedition failed as they were stopped at Ambato. They were not allowed to go into the tribes. There is a tale of one white man getting into the tribe but of never being heard of again. Later his wife went to Ecuador looking for him & recognized his head in a museum. However this may or may not be true.

We have the heads but will we be able to get them out of South America. I hope so as I want to show them to all of my people.

Story of the Shrunken Heads as told by Acc # 1033
Jacques Bardonnet and Wife Francie.

Jacques Bardonnet - A Frenchman & his Columbian wife Francie were in Quito the Capital of Ecuador. They were trying to find some of the shrunken heads they had heard so much about. The government of Ecuador had prohibited the sale of the heads & Jacques & Francie knew if they located some of the heads, they would have to purchase them under cover. They soon discovered the heads were very scarce, in fact it was weeks before they found any one that could give them any information Concerning the heads.

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We have the heads but will we be able to get them out of South America. I hope so as I want to show them to all of my people.

Catalog #	Place Name	Description
5187	Ecuador, South American	Skin Painting, A dog skin 36.0 cm wide; 35.0 cm long and depicting a man proposing to a woman. The woman is kneeling with her arms to her sides. She wears a green head dress that drops down her back to the ground. She wears a blue dress, white blouse, red, yellow, and blue beads which hang from her ears to her chest. A belt of yellow, blue, and red has a decor of opposing triangles. The man has one knee on the ground while the elbow of his arm rest son the other. The right hand is extended to her ear while the left hand is holding his hat. His hair is black as are his eyes and lashes. The man has a red and orange colored cap dropped over his hat hand. His shirt and pants are white. The ground they're on is a muddy green. Collected between 1951-1954
5186	Ecuador, South American	Skin Painting, 74.9 cm long; 44.2 cm wide and is made from goat hide. The painting is of an Ecuadorian? Indian holding what appears to be a broom. The figure is wearing a hat. Greyish white for the sleeves and skirt. Brown for the hat, bundle and poncho. Blood color for the neckerchief. The figure itself is 58.8 cm tall. Collected between 1951-1954
5178	Bucaramanga, Colombia, South America	A Solingen Machete with etched design (Trademark Head of the Horse). The knife is 72.9 cm long and 5 cm wide. This is typical of the knives used by the South American natives. A sheath is included with this object. It is made of leather and has human figures etched vertically upon it. Braided leather straps are wrapped around the upper third of the sheath and at the lower end also. It is a simple braid. The sheath has a leather loop attached to it. The handle has 5 brass holding pegs and is made of plastic. The handle is 12.1 cm long 4.3 cm wide. The etching on the knife blade depicts four Indians attempting to lasso several of the six buffalo that are running away from them.
5184	Colombia, South America	"Estribas" (Woman's stirrups) 2-A type of stirrup brought to South America by early Spaniards. Measuring 19.1 cm in length by 9.2 cm in width by 7.4 cm in height and having a blunt toe measuring 4.5 cm by 1.5 cm. A brass peg on both sides of the toe piece hold a brass "U" shape which at the nadir has two projections with a bar bracing both of them. A horse head decorates the toe piece.

		Collected 1951-1954.
5183	Colombia, South America	Estribes, woman's stirrups. Two measuring 22.4 cm length, 9.0 cm in width. It is a type brought to South America by early Spaniards. It has a slightly upturned toe, but with no decor except for cut out triangle on the bottom. Two pieces of wrought copper project on both sides of the toe piece and bar braces them. Collected 1951-1954.
5185	Colombia, South America	Estribes, woman's stirrups. Two measuring 22.4 cm length, 9.0 cm in width. It is a type brought to South America by early Spaniards. It has a slightly upturned toe, but with no decor except for cut out triangle on the bottom. Two pieces of wrought copper project on both sides of the toe piece and bar braces them. Collected 1951-1954.
5196	**Colombia, South America**	**Jivaro shrunken head of an old woman.** **Original card missing.**
5195	**Colombia, South America**	**Jivaro shrunken head said to be that of a boy about fifteen years old.** **Original card missing.**
5194	Bucaramanga, Colombia, South America	Ladies bag, hand woven from native grass (fique), with a yarn design. 35 cm in diameter with lid open. Made from 2 circles. The sides and bottom are 4 cm thick. The bag is plaited. The center is 19.5 cm in diameter and is plaited in an over one, under one pattern. There is a double strand used throughout the bag. There is a 5 cm band of open work. A plaiting of over one, under one forming hexagon holes. The border is 3 cm wide. The edge is finished off by bringing the strands back and re-plaiting them into the bag. A portion of the front of the bag has been turned inside of the bag. On the lid is a little hat decorated with red and yellow thread. The sides and bottom are plaited using 5 to 7 strands to a stitch and is plaited in an one over and one under pattern. The sides are fastened to the front and back with purple yarn using a whip stitch.

		Has a long handle. A red button in the center of the bag. The yard design consists of flowers and leaves. Collected between 1951-1954
5182	Bucaramanga, Colombia	The purse is made out of crocodile leather. It has two draw thongs for opening and closing the purse. It is not lined with any material. At every other section of which there is 8, a pair of crocodile feet may be found. Each section is sewn by plastic straps with a simple over and under stitch. The purse has a small base measuring 9.7 cm in diameter. The purse itself is like a 8 petal tulip that is blossoming. With it's largest diameter measuring 17.7 cm.
5189	Colombia, South America	Ceramic Figure, Made by the Tolemi Indians. The figure being 22.8 cm high supports a beard and hair reaching down to his knees. It wears a head band with a design painted gold and a swirl. He wears a cloak and its edges have a design similar to the headband and is colored gold. On the rest of this cloak vague but similar designs may be found; however, these are brown as is the general color of the figure. The man is holding in his right hand what looks like the end of a walking staff. The tip is light brown. Collected between 1951-1954
5180	Quito, Ecuador, South America	Inlaid wooden picture, A picture of a woman cradling a jar. The woman has an ear ring on her right ear. A knot hole is to be found in the proximity of her hip. The picture is 16.7 cm by 25 cm. A gouged out from of 2 cm surrounds the actual picture which is 12.9 by 21 cms. The difference in width is accounted for by a slight warping in the board.
5181	Quito, Ecuador, South America	Inlaid wooden picture, A picture of a woman cradling a jar. The woman has an ear ring on her right ear. A knot hole is to be found in the proximity of her hip. The picture is 16.7 cm by 25 cm. A gouged out from of 2 cm surrounds the actual picture which is 12.9 by 21 cms. The difference in width is accounted for by a slight warping in the board., A picture of a woman with a child on her back. A cloth slung around her shoulders and the cloth supports the child. She carries also a small jar with a handle on it. The gouged out frame measures 2.3 cm while the actual picture is 31.4 by 20.9 cm.
5179	Quito, Ecuador, South America	Inlaid wooden picture, A picture of a woman with a jar on her back is supporting this by a cloth which is slung around her shoulders and then around the jar. The dimensions are 16.5 cm by 25 cm. A gouged out frame of 2 cm surrounds the actual picture which is 12.8 cm by 21 cm. The difference in width is accounted by a slight

		warping in the board.
5190a	Bucaramanga, North Colombia, South America	Togue Nut Vase, This pair of vases the smaller being 9.7 cm high, are made from togue nut. Both have circular openings measuring 2.4 cm in diameter while the base diameter is 2.3 cm. Each vase has a decor on the rim with a line looking like a string with open triangles. Below this are 4 black dots painted at intervals measuring from 0.8 to 1.1 cm on the smaller and 0.9 to 1.2 cm on the larger. Each vase has a similar depiction. Several black birds may be found in the sky, two houses on opposite sides of the vases with colors white, orange, and black, green field separated with yellow fields, several trees near the houses and purple mountains in the distance. A set of orange stairs leading to t he house with a figure painted black, white, and red. Collected between 1951-1954
5190b	Bucaramanga, North Colombia, South America	Togue Nut Vase, This pair of vases the smaller being 9.7 cm high, are made from togue nut. Both have circular openings measuring 2.4 cm in diameter while the base diameter is 2.3 cm. Each vase has a decor on the rim with a line looking like a string with open triangles. Below this are 4 black dots painted at intervals measuring from 0.8 to 1.1 cm on the smaller and 0.9 to 1.2 cm on the larger. Each vase has a similar depiction. Several black birds may be found in the sky, two houses on opposite sides of the vases with colors white, orange, and black, green field separated with yellow fields, several trees near the houses and purple mountains in the distance. A set of orange stairs leading to t he house with a figure painted black, white, and red. Collected between 1951-1954
5192	Bucaramanga, Colombia, South America	Togue Nut Vase, A small jar measuring 3.6 cm in height, the opening being 1.3 cm and the base 1.6 cm. A light pastel orange in color with green trees, a red house, and togue color mountains in the distance. Collected between 1951-1954
5191	Bucaramanga, Colombia, South America	This togue nut vase at the opening measures 2.1 cm in diameter, the widest point of the vase measures 4 cm and the base is 2.1 cm in diameter. The lid measures 2.7 cm in diameter. The difference in the lid and opening being accounted for by a edge slant inward fro the lid, outward for the opening. A green shading is found around the base while on the side a red house and five trees of darker green complete the decor. The lid is tooled and raised to a point in the middle. The tip of this point is painted black. Collected between 1951-1954

5177	Bucaramanga, Colombia, South America	A mounted specimen of a young (Crocodylus Americanus). The skin was tanned before mounting and a few segments of the tail are missing. A particularly interesting specimen in that it is 83.1 cm long and 28 cm around at the widest point. The mouth is 12.6 cm long on the left and 12.2 cm on the right as you are looking down the nose. The eyes are separated by 3.3 cm of skull and the ears by 4.2 cm of skull. A hole is to be found in each of the legs. There are 40 teeth showing on the lower jaw and 42 teeth showing on the upper jaw. The eyes are not real. Almost the whole length of the bottom side of the specimen is sewn up with thread. The skull is 11.9 cm long and 6.5 cm wide.
5188	Colombia, South America	Ceramic Figure, Made by the Tolemi Indians. The figure is 24.9 cm high, is colored brown and gold, and has hair down to its knees. It also has a helmet on with horns curving upwards near each ear. Two imposed triangles may be found on each design which embraces the helmet. The upper part of the left horn is missing. A ring may be found in the nose and left ear. Four necklaces are to be found in the front. The last coming down almost to the feet. An imposed design of a swirl is to be found in quantity on each of the necklaces. A robe embraces him and on the front edges a design of a swirl is to be found. The back is covered partially with hair, a plain surface and with numerous cylindrical shaped grooves. Collected between 1951-1954
5193	Bucaramanga, North Colombia, South America	A cylindrical-shaped bag made from fique grass by the inmates of the Federal Prison. The variety of weaving is limited to a grass-coil foundation and coiled at each end and while the purse uses a back and forth technique. The individual coils are joined by a simple wrapped border technique. At one end of the purse a depiction of a butterfly may be found. Its colors are turquoise, purple, red, and yellow. At the other end a star having 8 points may be found. Its colors are red, yellow, purple, and turquoise. The sides of the purse are decorated too. On one side a large pot of flowers can be found. The handles are red, the rim is purple, the middle is yellow. The flowers number 5 with 3 leaves. The colors used are green, purple, red, orange, and yellow. On the other side is a house with blue windows, red door, and red roof, one yellow side, one red and the chimney is blue with purple smoke. Two trees stand beside the house and the sun beside the furthest tree. It is 39.7 cm long, 17.2 cm wide and 29.3 cm high. Collected between 1951-1954

Appendix B

Four tables with the results of the morphological analysis done by the author (SLP) and observer (HBD). P stands for Present and A stands for Absent. Notes were made on many of the traits. Tables represent what the observers used for study.

Specimen 5195 (SLP)			
Ceremonial		**Commercial**	
Trait	**Present (P)/ Absent (A)**	**Trait**	**Present (P)/ Absent (A)**
Long narrow face, often presenting a 'pinched' impression at the temples, a forcibly upturned and spread nose, and intentionally distended lips, creating an elongated profile with a sloping brow and receding chin	Short round, not really pinched. P - Sloping forehead A - Chin not receding	More convincingly proportioned face and an upright profile. Rounded to domed shaped scalp. Nostrils retain rounded shape.	P - nostrils were slightly oval
Size approximately a fifth of a full scale head, equal to a clenched human fist	P	Variable scale	individual variation between 5195 and 5196
Skull-removal incision located at posterior median of head	P - Starts in the middle then goes to right	Variable skull-removal incision locations	A
Sutures are often wide and uneven – performed using a thick and inflexible flat bamboo needle with coarse chambira fibre	A	Stitches are usually more precise, discrete and consistent – due to access to finer, sharper, metal needles and thinner suture threads	P
Sutures are typically made using 'over and over' stitches	A	Sutures are typically made using 'baseball' stitches	P
Loop of flexible vine is sewn into the neck – if absent, traces of suturing can be evident. Neck ring could be removed, but the inferior margin of neck will be smooth.	Not visible due to decoration	No supporting vine at the neck structure. Uneven or irregular base of neck edge (may be flayed)	P
Eyelids are tightly drawn into the head and sutured shut	A	Variable, but the eyelids are often carefully sutured to retain their visible form; often with the upper lid positioned over the lower lid	Not Uniform P
Three mouth perforations from chonta pin application – sometimes retained and lashed together with chambira	P	No, or a variable number of perforations mark the mouth. If pins are present, they are not always chonta wood	A
The mouth pins are classically replaced with intricately woven string tassels applied to the mouth at a length equal to the scalp hair. Several horizontal red bands of	String looks twisted/ is simple	Mouth tassels are often not attached. If present, atypical colorants, materials and knots for securing them may be present	Knots near lips present

achiote are painted, but these can fade over time			
Skin browned using carbon staining	P	Skin sometimes remains unstained, presenting as a grey or yellow color	Some yellow
Vellus downy hair removed. If present, then active attempts at removing are identifiable.	P	Vellus downy hair is sometimes maintained, or shaved/trimmed to a stubble	A
Skin is polished	P	Skin can sometimes present a dull, rough texture	A
Skin tends to be dense and of considerable weight	A	Skin can vary; it can sometimes be thin, fragile and very light in weight	P
Typically long scalp hair is present, with no facial hair. Scalp hair cut into 3 tiers (fringe, temples, posterior).	Not clear/ Possibly tiered Not explicitly clear	Scalp hair can vary in length. Facial hair is often maintained. No particular style scalp hair.	A
One or two perforations mark the crown, with one fitting a vegetable fibre string suspension cord (woven into a five-loop braid) that is secured within the head by a small wooden pin. The cord is long enough for adornment about a person's neck	A	Heads are not always perforated to fit a cord. If cords are fitted, they can be produced from a variety of different materials, woven differently, overly decorated, and of an inappropriate length for personal adornment around someone's neck	P A
Piercings that would typically present at the earlobes were not always decorated. Toucan feather ear danglers and/or wooden tubes/pins are however common	P	Headbands, necklaces and any ornamentation comprising beads, seeds, or portions of seeds are atypical to ceremonial *tsantsa*	P

Specimen 5195 (HBD)			
Ceremonial		**Commercial**	
Trait	**Present (P)/ Absent (A)**	**Trait**	**Present (P)/ Absent (A)**
Long narrow face, often presenting a 'pinched' impression at the temples, a forcibly upturned and spread nose, and intentionally distended lips, creating an elongated profile with a sloping brow and receding chin	P P P P P	More convincingly proportioned face and an upright profile. Rounded to domed shaped scalp. Nostrils retain rounded shape.	A A A
Size approximately a fifth of a full scale head, equal to a clenched human fist	P	Variable scale	
Skull-removal incision located at posterior median of head	P	Variable skull-removal incision locations	A
Sutures are often wide and uneven – performed using a thick and	P A	Stitches are usually more precise, discrete and consistent – due to	A

inflexible flat bamboo needle with coarse chambira fibre		access to finer, sharper, metal needles and thinner suture threads	
Sutures are typically made using 'over and over' stitches	P	Sutures are typically made using 'baseball' stitches	A
Loop of flexible vine is sewn into the neck – if absent, traces of suturing can be evident. Neck ring could be removed, but the inferior margin of neck will be smooth.	P A	No supporting vine at the neck structure. Uneven or irregular base of neck edge (may be flayed)	A P
Eyelids are tightly drawn into the head and sutured shut	P P	Variable, but the eyelids are often carefully sutured to retain their visible form; often with the upper lid positioned over the lower lid	A P
Three mouth perforations from chonta pin application – sometimes retained and lashed together with chambira	P	No, or a variable number of perforations mark the mouth. If pins are present, they are not always chonta wood	A
The mouth pins are classically replaced with intricately woven string tassels applied to the mouth at a length equal to the scalp hair. Several horizontal red bands of achiote are painted, but these can fade over time	P ?	Mouth tassels are often not attached. If present, atypical colorants, materials and knots for securing them may be present	A
Skin browned using carbon staining	P	Skin sometimes remains unstained, presenting as a grey or yellow color	A
Vellus downy hair removed. If present, then active attempts at removing are identifiable.	A A	Vellus downy hair is sometimes maintained, or shaved/trimmed to a stubble	P
Skin is polished	P	Skin can sometimes present a dull, rough texture	A
Skin tends to be dense and of considerable weight	P ?	Skin can vary; it can sometimes be thin, fragile and very light in weight	?
Typically long scalp hair is present, with no facial hair. Scalp hair cut into 3 tiers (fringe, temples, posterior).	P P	Scalp hair can vary in length. Facial hair is often maintained. No particular style scalp hair.	A
One or two perforations mark the crown, with one fitting a vegetable fibre string suspension cord (woven into a five-loop braid) that is secured within the head by a small wooden pin. The cord is long enough for adornment about a person's neck	A	Heads are not always perforated to fit a cord. If cords are fitted, they can be produced from a variety of different materials, woven differently, overly decorated, and of an inappropriate length for personal adornment around someone's neck	P
Piercings that would typically present at the earlobes were not always decorated. Toucan feather ear danglers and/or wooden tubes/pins are however common	? P	Headbands, necklaces and any ornamentation comprising beads, seeds, or portions of seeds are atypical to ceremonial *tsantsa*	P

Specimen 5196 (SLP)

Ceremonial		Commercial	
Trait	**Present (P)/ Absent (A)**	**Trait**	**Present (P)/ Absent (A)**
Long narrow face, often presenting a 'pinched' impression at the temples, a forcibly upturned and spread nose, and intentionally distended lips, creating an elongated profile with a sloping brow and receding chin	A	More convincingly proportioned face and an upright profile. Rounded to domed shaped scalp. Nostrils retain rounded shape.	P Thicker and rounder than 5195
Size approximately a fifth of a full scale head, equal to a clenched human fist	P	Variable scale	Smaller than 5195
Skull-removal incision located at posterior median of head	P	Variable skull-removal incision locations	A
Sutures are often wide and uneven – performed using a thick and inflexible flat bamboo needle with coarse chambira fibre	P	Stitches are usually more precise, discrete and consistent – due to access to finer, sharper, metal needles and thinner suture threads	A
Sutures are typically made using 'over and over' stitches	More like this	Sutures are typically made using 'baseball' stitches	Kind of?
Loop of flexible vine is sewn into the neck – if absent, traces of suturing can be evident. Neck ring could be removed, but the inferior margin of neck will be smooth.	No vine or trace of sutures but margin of neck is smooth (No neck)	No supporting vine at the neck structure. Uneven or irregular base of neck edge (may be flayed)	A
Eyelids are tightly drawn into the head and sutured shut	No sutures visible	Variable, but the eyelids are often carefully sutured to retain their visible form; often with the upper lid positioned over the lower lid	No sutures visible
Three mouth perforations from chonta pin application – sometimes retained and lashed together with chambira	P	No, or a variable number of perforations mark the mouth. If pins are present, they are not always chonta wood	A
The mouth pins are classically replaced with intricately woven string tassels applied to the mouth at a length equal to the scalp hair. Several horizontal red bands of achiote are painted, but these can fade over time	String looks twisted/ is simple	Mouth tassels are often not attached. If present, atypical colorants, materials and knots for securing them may be present	knots near lips present
Skin browned using carbon staining	P	Skin sometimes remains unstained, presenting as a grey or yellow color	little grey and yellow
Vellus downy hair removed. If present, then active attempts at removing are identifiable.	More downy hair but attempts to remove?	Vellus downy hair is sometimes maintained, or shaved/trimmed to a stubble	P
Skin is polished	A	Skin can sometimes present a dull, rough texture	P
Skin tends to be dense and of considerable weight	A	Skin can vary; it can sometimes be thin, fragile and very light in weight	P

Typically long scalp hair is present, with no facial hair. Scalp hair cut into 3 tiers (fringe, temples, posterior).	Not clear? Possible tiers but not explicit	Scalp hair can vary in length. Facial hair is often maintained. No particular style scalp hair.	P
One or two perforations mark the crown, with one fitting a vegetable fibre string suspension cord (woven into a five-loop braid) that is secured within the head by a small wooden pin. The cord is long enough for adornment about a person's neck	A	Heads are not always perforated to fit a cord. If cords are fitted, they can be produced from a variety of different materials, woven differently, overly decorated, and of an inappropriate length for personal adornment around someone's neck	P
Piercings that would typically present at the earlobes were not always decorated. Toucan feather ear danglers and/or wooden tubes/pins are however common	A (Nothing)	Headbands, necklaces and any ornamentation comprising beads, seeds, or portions of seeds are atypical to ceremonial *tsantsa*	A

Specimen 5196 (HBD)			
Ceremonial		**Commercial**	
Trait	**Present (P)/ Absent (A)**	**Trait**	**Present (P)/ Absent (A)**
Long narrow face, often presenting a 'pinched' impression at the temples, a forcibly upturned and spread nose, and intentionally distended lips, creating an elongated profile with a sloping brow and receding chin	A A A P P	More convincingly proportioned face and an upright profile. Rounded to domed shaped scalp. Nostrils retain rounded shape.	P P P
Size approximately a fifth of a full scale head, equal to a clenched human fist	P	Variable scale	A
Skull-removal incision located at posterior median of head	P	Variable skull-removal incision locations	A
Sutures are often wide and uneven – performed using a thick and inflexible flat bamboo needle with coarse chambira fibre	A P	Stitches are usually more precise, discrete and consistent – due to access to finer, sharper, metal needles and thinner suture threads	P A
Sutures are typically made using 'over and over' stitches	A	Sutures are typically made using 'baseball' stitches	P
Loop of flexible vine is sewn into the neck – if absent, traces of suturing can be evident. Neck ring could be removed, but the inferior margin of neck will be smooth.	P	No supporting vine at the neck structure. Uneven or irregular base of neck edge (may be flayed)	A

Eyelids are tightly drawn into the head and sutured shut	P A	Variable, but the eyelids are often carefully sutured to retain their visible form; often with the upper lid positioned over the lower lid	P
Three mouth perforations from chonta pin application – sometimes retained and lashed together with chambira	P ?	No, or a variable number of perforations mark the mouth. If pins are present, they are not always chonta wood	A
The mouth pins are classically replaced with intricately woven string tassels applied to the mouth at a length equal to the scalp hair. Several horizontal red bands of achiote are painted, but these can fade over time	A A A	Mouth tassels are often not attached. If present, atypical colorants, materials and knots for securing them may be present	P A
Skin browned using carbon staining	? Brownish	Skin sometimes remains unstained, presenting as a grey or yellow color	Grayish Yellow
Vellus downy hair removed. If present, then active attempts at removing are identifiable.	A P	Vellus downy hair is sometimes maintained, or shaved/trimmed to a stubble	P
Skin is polished	A	Skin can sometimes present a dull, rough texture	P
Skin tends to be dense and of considerable weight	P (what does considerable weight mean?)	Skin can vary; it can sometimes be thin, fragile and very light in weight	?
Typically long scalp hair is present, with no facial hair. Scalp hair cut into 3 tiers (fringe, temples, posterior).	P P	Scalp hair can vary in length. Facial hair is often maintained. No particular style scalp hair.	A
One or two perforations mark the crown, with one fitting a vegetable fibre string suspension cord (woven into a five-loop braid) that is secured within the head by a small wooden pin. The cord is long enough for adornment about a person's neck	A A	Heads are not always perforated to fit a cord. If cords are fitted, they can be produced from a variety of different materials, woven differently, overly decorated, and of an inappropriate length for personal adornment around someone's neck	P
Piercings that would typically present at the earlobes were not always decorated. Toucan feather ear danglers and/or wooden tubes/pins are however common	P A	Headbands, necklaces and any ornamentation comprising beads, seeds, or portions of seeds are atypical to ceremonial *tsantsa*	A - no ornamentation

Note. Adapted from "Recently Identified Features that Help to Distinguish Ceremonial *tsantsa* from Commercial Shrunken Heads." By T.M.R. Houlton, & C. Wilkinson, 2016. *Journal of Cultural Heritage 20*, 660-670. Copyright (2018) by Elsevier, Inc.