CRANIOMETRIC ANALYSIS OF SOUTH AMERICAN SAMPLES TO AID IN MIGRANT IDENTIFICATION

by

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DEDICATION

Para mis padres quienes siempre me han apoyado, gracias Feos.

Para los migrantes desaparecidos y sus familiares quienes continúan esperar respuestas. Nunca serán olvidados.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CBP	US Customs and Border Patrol
DFA	Discriminant Function Analysis
FACTS	Forensic Anthropology Center at Texas State
ILDs	Interlandmark Distances
OpID	Operation Identification
OTM	“Other Than Mexico”
PTD	Prevention Through Deterrence
PCOME	Pima County Office of the Medical Examiner
US	United States

ABSTRACT

The ongoing humanitarian aid crisis at the US-Mexico border has experienced an increase of individuals “Other Than Mexico” apprehended in the past couple of years. In 2019, Mexico was surpassed as the nationality with the most apprehended individuals reported by the CBP (US Customs and Border Patrol, 2019a). Despite the increase of Central and South American individuals reported as apprehended, current craniometric data does not have reference samples of these reported countries. Craniometric analysis can aid in the identification of presumed migrant remains by estimating the geographic origin of an individual. Currently, the only reference data available for comparison when conducting anthropological analysis on migrant includes a “Hispanic” and a Guatemalan Mayan group. Grouping Latin American individuals under the term “Hispanic” is problematic as the term does not include all Latin American countries. Therefore, this project aims to address these problems by looking at craniometric variation from South American samples in comparison to current Central American reference data. This research looks at archaeological and modern samples from Colombia, Brazil, Peru, Guatemala, and Mexico using thirteen ILDs as described by Howells (1973). Results further demonstrate the need of modern reference samples and further analysis between country samples and within country samples. Incorporating reference samples of the CBP reported apprehension can aid in the identification of presumed migrants found in South Texas and allow for further anthropological, DNA, and isotopic analysis to further provide a positive identification.

I. INTRODUCTION

In 1994 the United States Government enacted a Customs and Border Patrol (CBP) strategy known as “Prevention through Deterrence” (PTD) to deter undocumented migration through the country’s southern border. This strategy increased security in certain locations along the US-Mexico border causing migration to move towards the Sonoran Desert in Arizona (Spradley et al., 2018). The goal for this strategy was to decrease undocumented migration but has ultimately created an international migrant crisis. Although the number of migrants crossing into the US was variable from year-to-year, overall, it remained relatively high since the implementation of PTD (US Customs and Border Patrol, 2019c). In addition, deaths along the border increased due to the hazardous routes made available to migrants (Martinez et al., 2014). This can be seen through CBP apprehensions, where a total of 14,827,600 apprehensions (2000-2019) and 7,805 deaths (1998-2019) have been reported along the Southwest Border (US Customs and Border Patrol, 2019b; 2019c).

While most of the reported apprehensions were Mexican citizens, there has been a recent increase in Central and South American individuals, whom are among the individuals referred to as being from countries “Other Than Mexico” (OTM) in CBP reports (US Customs and Border Patrol, 2018a). Based on the data reported by CBP, two percent of the individuals apprehended in 2000 were of countries OTM, eight percent in 2009, 62% in 2018, and in 2019 Guatemala and Honduras alone accounted for 61% of all individuals apprehended (US Customs and Border Patrol, 2019a). This is the first time in CBP reported apprehensions in which Mexico is surpassed as the nationality with the most apprehended individuals in a fiscal year.

Yet, few anthropological research studies specifically focus on lower Central and South American samples, as individuals from these countries are often classified under the umbrella term “Hispanic” (Spradley et al., 2018; Tise, Kimmerle, & Spradley, 2014). Grouping Indigenous, Spanish, and Portuguese-speaking individuals from North, Central, and South America is problematic as populations have different biological ancestries (Tise, Kimmerle, & Spradley, 2014). The US census describes people who identify as “Hispanic or Latino” as someone of Cuban, Mexican, Puerto Rican, South or Central American, and other Spanish culture or origin regardless of race (UC Census, 2020). The US Latinx community defines “Hispanic” as individuals of Spanish-speaking origins, while Latinx is a gender-neutral or nonbinary alternative to Latino/Latina and includes those from Latin American countries.

By definition, “Hispanic” does not include all Latin American countries, such as Brazil whose main language is Portuguese, not Spanish. As the present research aims to analyze morphological variation between Latin American populations, specifically Colombia, Brazil, and Peru, the term Latinx will be used to describe the population samples used in this research. It should also be noted that the use of ‘Latinx’ to describe the countries used in this project is also not ideal as US terminology is being imposed on populations that more commonly identify based on their nationalities. This further demonstrates the problem in attempting to classify “Hispanic” countries into one category.

In 2012 Texas surpassed Arizona in the number of migrant deaths reported by CBP (US Customs and Border Patrol, 2018b). Due to the border crisis discussed above, the Forensic Anthropology Center at Texas State (FACTS) started the project Operation

Identification (OpID) in 2013 under the direction of Dr. Kate Spradley with a goal to facilitate identification and repatriation of unidentified human remains that are found near the South Texas-Mexico border (Gocha, Spradley, & Strand, 2018). Since it was founded, OpID has either recovered or received more than 300 unidentified decedents and 39 individuals have been positively identified. Approximately eighty-six percent of the cases are still pending identification due to data limitations of Latin American reference samples needed for the application of geographic origin estimate methodologies.

This project aims to assist in the improvement of migrant identification by examining craniometric variation in samples derived from South American countries. The acquired data will be compared to previously collected data from North and Central American individuals to better assess craniometric variation. A discriminant function analysis will be conducted to analyze the variation between the samples used.

II. BACKGROUND

Latin America Population History

Population history research conducted through genetic and genomic studies has shown that genetic variation throughout Latin America varies between regions and admixture experienced in different populations. Research has shown that Latin American admixture varies predominantly between Indigenous, European, and African descent (Sans, 2000; Salzano & Sans, 2014; Ruiz-Linares et al, 2014; Cabana et al, 2014). As colonization and slavery began to expand into the Americas, colonizers, African slaves, and Indigenous people intermixed and therefore account for the variation observed. Admixture composed of Indigenous, European, and African descent presents differently based on the country's region and population (Figure 1). The difference can be observed due to country and community constructed social categories that presented limitations on certain individuals based on racist and classist perspectives and foundations. Additionally, although these are three main ancestries found within Latin American, recent data suggest that Asian populations have migrated to these regions and can account for additional admixture between the countries used for this project (Salzano & Sans, 2014).

Colombia

Colombian population history also varies between the six natural regions found in the country. The natural regions consist of Pacifica, Caribe, Andina, Orinoquía, Amazonía, and Insular. Research shows that European ancestry is higher in the central regions which are characterized by a combination of the Andina (highlands), Orinoquía (plains), and Amazonía (Amazonian basin) regions. A higher range of Indigenous ancestry is found near the southern region of the country which is mainly an Amazonía environment. African ancestry in Colombia is highest in the west coastal Pacifica region and extends towards the Caribe northwest coast (Ruiz-Linares, 2014).

Brazil

The population history in Brazil also varies between regions and environmental areas. Brazil is characterized into five regional zones (north, northeast, center-west, south, and southeast) with six environmental biomes (Amazônia, Caatinga, Cerrado, Pantanal, Pampa, and Mata Atlântica). European descent is most predominant in the south/southeast which consist of a combination of the Pampa, Mata Atlântica, and Cerrado biomes. These regions consist of flatlands, tropical rainforest, and savannah environments. African ancestry is higher in the northeast region that is made up of Caatinga and Cerrado regions which are thorny shrub and savannah environments. Indigenous ancestry is most prominent in the northwest region towards the Amazônia tropical rain forest and Amazon basin (Sans, 2000; Salzano & Sans, 2014; Ruiz-Linares et al., 2014).

Peru

Research shows that admixture in Peru varies between regional areas. Peru is typically characterized into three ecological zones, coastal, highlands, and lowlands that can then be divided by north, central, and southern regions (Cabana et al., 2014). The highland Andean region demonstrates a mix of both Indigenous and Spanish genetic variation. The southern region, which is mostly a combination of all three ecological zones, demonstrates more Indigenous ancestry, with the northern and central regions having more European ancestry. African ancestry is shown to have the least variation in this country but can be observed in the northern coast (Ruiz-Linares et al., 2014; Homburger et al., 2015).

Guatemala

Guatemala is divided into three main geographic regions that have varying ancestral admixture. The three regions are made up of the central-western highlands (Sierra Madre Mountains), low northern plateau (Petén, mostly jungle), and the tropical coastal lowlands. Guatemalan population history is most commonly split between Ladino (admixture of European, Indigenous, and some African ancestry) and Indigenous Mayan (Söchtig et al. 2015). The regions with the most Ladino ancestry are the urban areas, which typically falls along the central-western highlands of the Sierra Madre Mountains. Additionally, the Indigenous Mayan population expresses mainly Indigenous ancestry with a small mix of European ancestry. The Indigenous Mayan population is also found along the Sierra Madre Mountains and in the Petén low northern plateau. These regions were more difficult to access when the Spanish began colonizing Guatemala, which is why researchers believe there is less admixture within the Indigenous Mayan population (Söchtig et al. 2015).

Mexico

Mexican population history is more clearly split up according to regional areas. Within these regions there are 5 main geographic regions, which are made up of the chaparral, desert, forest, low rainforest, and tropical rainforest. The northern region, which borders the US, is made up of the chaparral (shrubland/woodlands) which is found along the western coast, desert, and forest environments. This norther region is shown to express the highest European ancestry. The central region is made up of a combination of all three forest types with a bit of the desert environment. The central region experiences more Indigenous and European descent, with some African ancestry along the central-eastern coast. The southern region, which borders Guatemala, is made up of low and tropical rainforests. This southern region experiences the most Indigenous with minimal African ancestry along the coastal region. (Ruiz-Linares et al. 2014; Humphries et al., 2015).

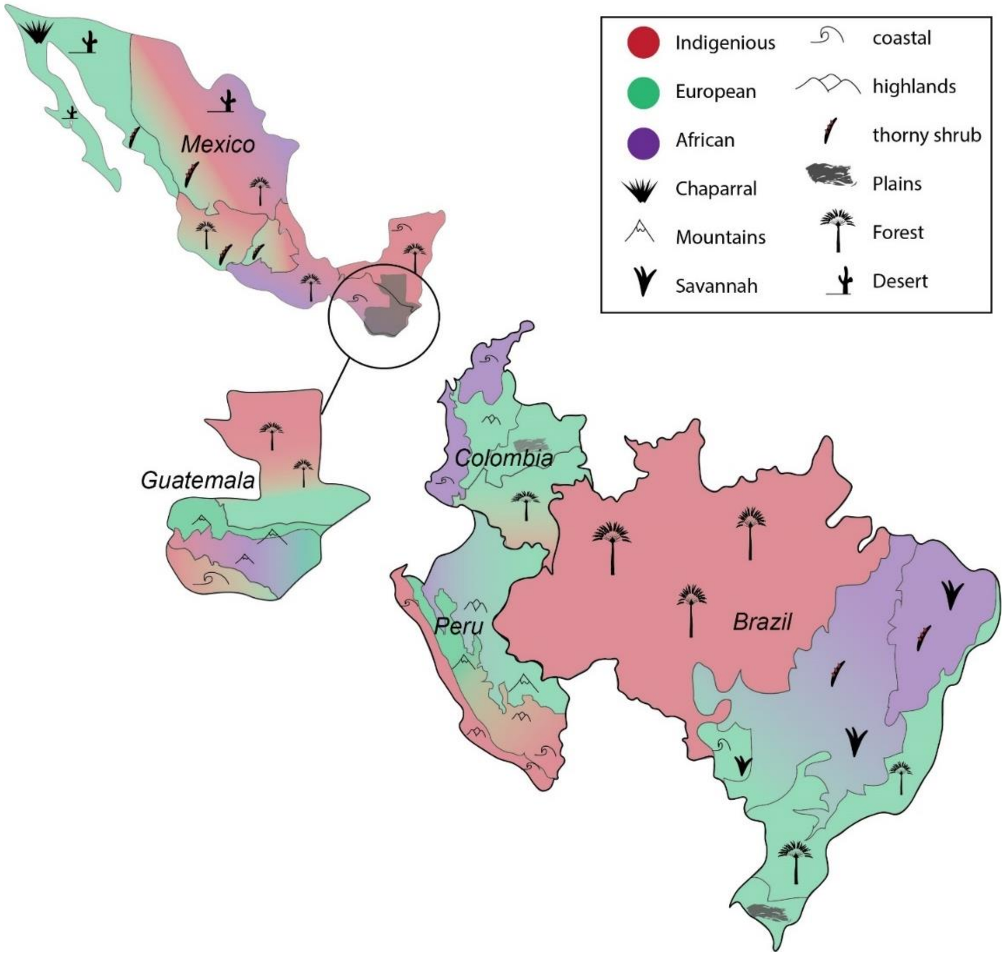


Figure 1. Genetic ancestry and environmental regions for the countries used in this research. (Cabana et al., 2014; Ruiz-Linares et al., 2014; Sans, 2000; Salzano & Sans, 2014; Söchtig et al. 2015)

Craniometric History

Assessment of craniometric variation has long been used in scientific research to examine evolutionary and population history (Relethford, 1994; Hughes et al., 2019) as a well as a means of estimating regional origin of human remains (Spradley, 2021). It has previously been stated that there is limited morphological variation among humans

(Relethford, 1994), but further studies show that there is significant craniometric variation among population samples of different geographical regions, especially among Latinx populations in the Americas (Bedoya et al., 2006; Herrera & Tallman, 2019; Ross, Ubelaker, & Falsetti, 2002; Ross, Juarez, & Urbanová, 2016; Spradley, 2016; Spradley & Jantz, 2016; Strauss et al., 2010; Tise, Kimmerle, & Spradley, 2014). Additionally, numerous studies have shown that genetic and morphological admixture due to migration and colonization can impact cranial morphology and produce significant variation among different geographical regions (Ross, Ubelaker, & Falsetti, 2002; Ruiz-Linares et al., 2014). As the Americas are not as homogenous as once previously thought (Relethford, 2004; Ross, Ubelaker, & Falsetti, 2002; Ruiz-Linares et al., 2014), the heterogeneity of admixture among populations can still be observed through cranial analysis.

Several factors account for craniometric variation and result in shape and size differences of the skull within and between populations. Most factors are associated with intrinsic, caused by genetic factors, and extrinsic, caused by environmental factors, conditions which, in turn, affect heritability and ultimately establish a measure of variation that can be quantified through biological distance analysis (Spradley, 2016; Hefner et al., 2016). These factors can be studied within or between populations (Lopez-Capp et al., 2018; Hefner et al., 2016). Conditions such as altitude, nutritional factors, stress, and bone growth evolution are unique to each population (Lopez-Capp et al., 2016). Understanding the geographic and genetic relationships of reference groups can assist in providing a good classification of the regional origin of unidentified remains.

Howells (1973) created a composite of previously defined craniometric interlandmark distances (ILDs) and measurements, to which he assigned a three-letter variable names facilitating the use of these measures in computer applications (Hefner et al., 2016). Currently, craniometric measurements and observations are available from various sources, such as Howells (1973) and the Forensic Anthropology Databank (FDB) (Jantz, 1986). Both databases are focused on 2D ILDs, but additional 3D digitizing techniques can be applied to obtain more detailed craniometric landmark measurements (Spradley & Jantz, 2016). Recently, research has been conducted on craniometric landmarks and measurements obtained from CT scans have been positively compared to other Latino samples (Tise et al, 2014; Herrera & Tallman, 2019). This research will use 2D ILDs collected from multiple researchers on individual crania from Peru, Brazil, Colombia, Guatemala, and Mexico.

The goal of this project is to assess the level of craniometric variation within and between a diverse Latinx sample of South American individuals derived from Peru, Brazil, and Colombia in addition to extant data from Guatemalan and Mexico. This research aims to add to the knowledge of anthropology by providing robust reference data for scholars to use for both forensic research and identification purposes. Findings from this research can lead to better understanding of craniometric variation within Latin American populations and elucidate geographic origin of presumed migrant remains.

Research Questions

1. Is statistically significant craniometric variation present between the Peruvian, Brazilian, Colombian, Guatemalan, and Mexican samples?
2. Does the additional craniometric data from South America increase the accuracy of the country-of-origin prediction/classification of the previously identified OpID individuals?
3. If so, how confident can we be in the classifications of the unidentified OpID individuals using this combined reference dataset?
4. If it does not improve the country-of-origin predictions, how does the addition of these South American groups impact our understanding of the craniometric variation of the unidentified OpID individuals?

III. MATERIALS AND METHODS

Reference Groups

This research focused on craniometric samples from Colombia (provided by Drs. Hefner and Bethard), Brazil (Hubbe et al., 2015), and Peru (Howells, 1973). The South American data is combined with existing Mexican Mayan, Mexican and Guatemalan data which are derived from various sources including identified OpID individuals, identified cases from PCOME in Arizona, and known individuals from the modern skeletal collection at Universidad Autónoma de Yucatán. These data have been provided by Dr. Kate Spradley (Spradley, 2021).

Colombia

The Colombian data consists of two samples. The first and larger sample is housed at the Universidad de Antioquia in Medellín, Colombia and the craniometric data was provided by Dr. Joe Hefner (Hefner and Monsalve, 2016). This sample consists of a total of 242 identified individuals from the Cementerio Universal in Medellín who are now housed at the Universidad for curation purposes and for use in academic and scientific research (Monsalve and Isaza, 2014). Demographic data for this sample includes age at death, sex, and birthplace.

The second sample is from the Antioquia Modern Skeletal Reference Collection in Medellín and was collected by Dr. Jonathan Bethard. This modern sample provides sex and age-at-death demographic data for almost all of the individuals used and consists of a total of 56 individuals. The individuals in this sample are from the Antioquia region and are predominantly from near or around Medellín, with some individuals from the

Atlántico, Boyacá, Caldas, Chocó, Cundinamarca, Quindío, and Risaralda departments. Both of these samples are from the Antioquia region which encompasses the Andina region.

Brazil

The Brazilian data was provided by Hubbe et al. (2015) and consists of four archaeological samples from hunter-gatherers dated to 11.5-7.5 kyr BP and encompass four different regions of Brazil. Raw data were accessed through the Hubbe et al. (2015) publication and provides demographic data including sex and age for the total 121 individuals in this sample. The age provided for all data samples consists only of 'Adult' individuals. The samples used were collected from the Universidad Nacional de Colombia in Bogotá, Colombia, the Museu do Homem do Sambaqui "Pe. João Alfredo Rohr" in Florianópolis, Brazil, The Museu Nacional, Universidade Federal do Rio de Janeiro, Brazil, and the Museu de Etnologia e Arqueologia, Universidade de São Paulo, Brazil, these are referred to as the first, second, third, and fourth sample, respectively.

The first sample consists of Tupi-Guarani individuals which includes a total of 23 individuals and encompasses the Amazônia towards the Mata Atlântica biomes. The second sample consists of Botocudo individuals which has a total of 32 individuals and is found in the east-central region which surrounds the Cerrado and Caatinga biomes. The third sample consist of Tapera individuals and has a total of 47 individuals and is found in the southern region of the Pampa and Mata Atlântica biomes. The final sample consists of Cabeçuda individuals and consists of a total of 19 individuals and covers the southeast part of Brazil and is also made up of the Pampa and Mata Atlântica biomes.

Peru

The Peruvian sample used in this project is from a collection purchased from the National Museum of Anthropology and Archaeology in Lima, Peru in 1911 by the Warren Anatomical Museum of the Harvard Medical School and was later transferred to the Peabody Museum. The sample consists of archaeological material dated to AD 900-1300 and is estimated to be from the Yauyos central highland region in Peru (see Figure 2). The measurements used for this project were collected by W.W. Howells (1973) and the raw data was accessed through The William W. Howells Craniometric Data Set website provided by Dr. Benjamin M. Auerbach (2014). The known demographic data includes sex and country of origin. Sex estimation for this sample was also conducted by W.W. Howells. The craniometric data for this sample consists of a total of 110 individuals. The Yauyos region is located approximately southeast of Lima and on the western slopes of the Andes and encompasses the highland ecological zone.

Mexican Mayan

The Mexican Mayan data was collected by Dr. Kate Spradley from a curated skeletal reference sample collection from the Xoclán cemetery which is located at the Universidad Autónoma de Yucatán in Mérida. The collection was obtained as part of an agreement between the municipality and the University with the purpose of restoring, inventorying, and curating the remains for use in academic and educational purposes (Chi-Keb et al., 2013). This collection consists of individuals of Mayan descent from the Yucatán peninsula with known demographic data consisting of sex, age, and socioeconomic status (Chi-Keb et al., 2013). The sample size used in this project includes

57 individuals. The Yucatán peninsula is located in the Southeast region of the country and encompasses the coastal and tropical rainforest biomes.

OpID

The OpID data provided includes various individuals from Guatemala, Mexico, and other Central American countries. The data was provided by Dr. Kate Spradley and was collected from presumed migrant individuals that died in the border region of south Texas. These individuals were exhumed from county cemeteries throughout south Texas and later identified through a collaboration of forensic anthropological analysis, DNA analysis, community outreach and work with governmental agencies and humanitarian aid organizations (Gocha, Spradley, & Strand, 2018). Craniometric data was collected by Dr. Spradley and the OpID team and the demographic data available consists of nationality, sex, and county in which the remains were found or buried. This sample is made up of a total of 21 individuals, 10 individuals from Guatemala, 8 individuals from Mexico, and the remaining three individuals are from other Central American countries. The three Central American individuals were included in the analysis to better understand classification patterns within the used samples.

PCOME

The PCOME data was also provided by Dr. Spradley and consists of identified undocumented border crossers. The PCOME is located in Tucson, Arizona and collaborates with humanitarian aid organizations to provide information that can assist in facilitating positive identifications of migrants found in the Sonoran Desert and surrounding areas. The demographic data provided for this sample also consists of nationality and sex. As identification of these individuals is not shared, no exact geographic information is provided for this sample. The sample consists of a total of 193 individuals. Of the PCOME data, 34 individuals account for the Guatemalan samples, while the remaining 159 individuals make up the Mexican sample, respectively.

Table 1. Reference Group Table

Country	Sample Size	Demographic Data	Sample Period	Reference
Colombia-UAM	241	Sex, geographic origin	Modern	Dr. Hefner
Colombia-AMSRC	56	Sex, geographic origin	Modern	Dr. Bethard (Eck et al., 2019)
Archaic Colombia	33	Sex, geographic origin	Archaeological (11.0-7.5 kyr BP)	Hubbe et al. (2015)
Paleo Colombia	14	Sex, geographic origin	Archaeological (11.0-7.5 kyr BP)	Hubbe et al. (2015)
Lagoa Santa	29	Sex, geographic origin	Archaeological (11.0-7.5 kyr BP)	Hubbe et al. (2015)
Brazil-Tupi-Guarani	23	Sex, geographic origin	Archaeological (450 BP)	Hubbe et al. (2015)
Brazil-Botocudo	32	Sex, geographic origin	Archaeological (1500-1900)	Hubbe et al. (2015)
Brazil-Tapera	47	Sex, geographic origin	Archaeological (1140-550 BP)	Hubbe et al. (2015)
Brazil-Cabeçuda	19	Sex, geographic origin	Archaeological (2500-1700 BP)	Hubbe et al. (2015)
Peru	110	Sex, geographic origin	Archaeological (1050-1450 BP)	W.W. Howells (1973)
Mexican Mayan	44	Sex, geographic origin	Modern	Dr. Spradley (Spradley, 2014)
Guatemala	57	Sex, nationality	Modern	PCOME and OpID (Dr. Spradley)
Mexico	167	Sex, nationality	Modern	PCOME and OpID (Dr. Spradley)

Figure 2. Map of geographical location of reference samples used.

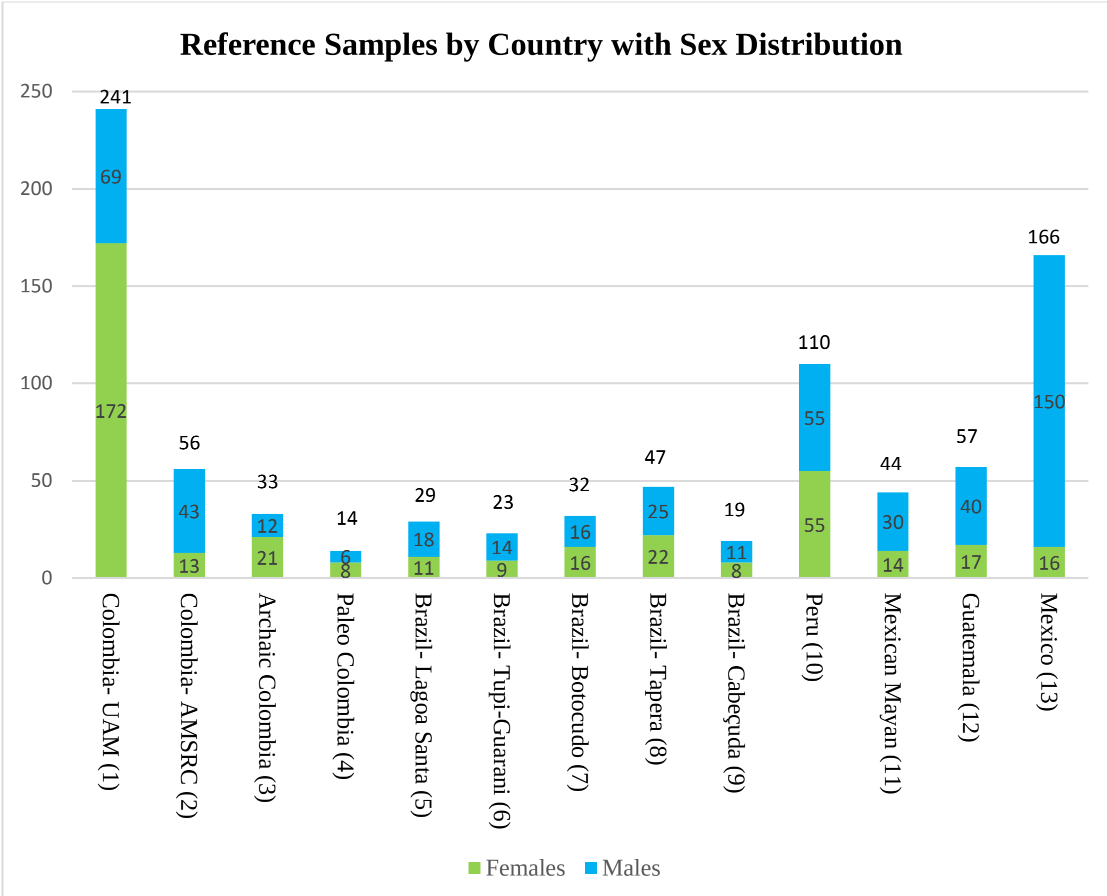


Figure 3. Sample Size of Reference Samples by Country with Sex Distribution.

Methods

The measurements used in this project are based on 2D interlandmark distances (ILDs) as defined by Howells (1973). Traditional 2D ILDs are measured from one anatomical landmark on the cranium to a secondary landmark using a specific osteometric instrument (sliding caliper, coordinate caliper, radiometer, or mandibulometer) as recommended by Howells (1973). Recent craniometric data collection incorporates the recording of three-dimensional coordinates for each anatomical landmark using a digitizer and a computer program, like *3Skull* (Ousley, 2004). A total of 89 cranial landmarks and arcs are collected and various ILDs are computed by *3Skull*. *3Skull* then stores the measurements and coordinates collected digitally in two separate databases, one with the Howells traditional 2D ILDs and another with the 3D coordinates.

While multiple ILD measurements were provided per sample, based on the availability of data for this research, only 13 ILDs described by Howells (1973) were identified for use in this project. This selection was made due to the availability of the same ILDs included in each sample and were limited as measures were not consistent across all studies (Appendix A), possibly due to interobserver error in measurement definition or description. Therefore, to ensure these ILDs were identified as being present across all samples and there were no missing values throughout the individuals used per sample. The archaeological samples used for this research were taken using traditional caliper 2D measurements, while the modern samples were collected using 3D coordinates. The 2D ILDs were then calculated from the coordinates in *3Skull*. The ILD definitions used in this project can be seen in Table 2, and Howells (1973) landmark definitions used in the ILDs selected can be seen in Appendix B.

Statistical Analysis

Once the data was compiled and the ILDs were selected, the data was standardized in Excel by sex across all samples. Preliminary data analysis was conducted in RMET to better understand the biological distance measures between the samples with the Archaic and Paleo Colombian and Brazilian samples provided through Hubbe et al. (2015). Based on the biological distance measure results produced in RMET, it was decided to not include these samples in this project to ensure a more accurate representation of data from samples that can closely relate to present admixture in the country samples used.

Table 2. Definitions of Interlandmark Distances Used

Howells (1973) ILD Definitions		
Abbreviation	**ILD Name**	**Description**
GOL	Glabello-occipital length	Greatest length, from the glabellar region, in the median sagittal plane
XCB	Maximum cranial breadth	The maximum cranial breadth perpendicular to the median sagittal plane (above the supramastoid crests)
BBH	Basion-bregma height	Distance from bregma to nasion, as defined.
AUB	Biauricular breadth	The least exterior breadth across the roots of the zygomatic processes, wherever found.
NPH	Nasion-prosthion height	Upper facial heigh from nasion to prosthion, as defined.
NLH	Nasal height	The average height from nasion to the lowest point on the border of the nasal aperture on either side.
NLB	Nasal breadth	The distance between the anterior edges of the nasal aperture at its widest extent.
OBB	Orbit breadth, left	Breadth from ectoconchion to dacryon, as defined approximating the longitudinal axis which bisects the orbit into equal upper and lower parts.
OBH	Orbital height, left	The height between the upper and lower borders of the left orbit, perpendicular to the long axis of the orbit and bisecting it.
EKB	Biorbital breadth	The breadth across the orbits from ectoconchion to ectoconchion.
FRC	Nasion-bregma chord (frontal chord)	The frontal chord, or direct distance from nasion to bregma, taken in the midplane and at the external surface.
PAC	Bregma-lambda chord (parietal chord)	The external chord, or direct distance from bregma to lambda, taken in the midplane and at the external surface.
OCC	Lambda-opisthion chord (occipital chord)	The external chord, or direct distance from lamda to opisthion, taken in the midplane and at the external surface.

Comparison of All Country Samples

To assess the classification rates of the country samples provided, a discriminant function analysis (DFA) was performed in SPSS version 26. The individuals were separated into their respective groups out of the ten samples described above. Prior to the

DFA, data screening was performed to assess for outliers and to ensure normal distribution throughout and one case with an extreme outlier was removed and resulted in a total of seven hundred and ninety-five individuals used for this analysis. The DFA was conducted on the above mentioned thirteen ILDs selected for analysis to classify the individuals into the respective Colombian, Brazilian, Peruvian, Guatemalan, Mexican Mayan, and Mexican groups. The DFA calculated canonical discriminant function coefficients and cross-validated classifications.

A secondary DFA was conducted with the multiple samples provided for specific countries combined to further assess the classification rates provided in the initial DFA. The samples combined included the two Colombian samples which were incorporated into one modern Colombian sample and the four archaeological Brazilian samples were combined to produce on archaeological Brazilian sample that was then compared to the Peruvian, Guatemalan, Mexican Mayan, and Mexican samples. The Mexican Mayan and Mexican samples were not combined to evaluate variation across all samples provided.

Comparison of All Country Samples with Identified OpID Individuals

A DFA was also ran with all the sample groups and with seventeen identified OpID individuals from Guatemala and Mexico and with three individuals from Central American countries not included in the reference data. Data screening was also conducted prior to the DFA, and the same case was removed due to the extreme outlier, producing an analysis of seven hundred and ninety-eight individuals. The DFA also calculated canonical discriminant function coefficients and cross-validated classifications. An additional DFA was conducted with the previously mentioned combine country samples to further compare the results to those from the country samples without the identified OpID individuals.

Comparison of Modern Country Samples

To better assess the cross-validated classification rates from the previous DFA analysis, another DFA was conducted with just the modern sample data which consisted of the combined Colombian sample, the Guatemalan sample, the Mexican Mayan sample, and the Mexican sample. Data screening conducted prior to the DFA found two extreme outliers and these individuals were removed from the analysis, resulting in a total sample of five hundred and sixty-three individuals. The DFA was then conducted with the same thirteen ILDs and calculated canonical discriminant function coefficients and cross-validated classifications.

IV. RESULTS

Prior to standardizing the data, the mean and standard deviation was calculated by sex for each sample according to the landmarks selected based on the raw data provided (Table 3).

RMET Results

The RMET preliminary data analysis provided results that separated all of the samples into their individual groups when plotted according to the first two eigenvectors (Figure 4). There are approximately seven observed groupings based on the classifications. The Archaic Colombia, Paleo Colombia, and Lagoa Santa archaic Brazilian sample were also grouped individually but appear to be focused closed to each other. The two Colombian samples are grouped closely together, with the Botocudo sample classifying closer to the Colombian samples than the other archaic or archaeological material. The Tapera and Cabeçuda samples are another close grouping, as well as the Guatemalan and Mexico samples. The Peruvian samples is classifying closer to the Guatemalan and Mexican samples but still appears to be its own distinct group. Additionally, the Tupi-Guarani and Mexican Mayan are grouping individually away from the rest of the samples.

Table 3. Mean and standard deviations of samples by sex

Males														
Sample		**GOL**	**XCB**	**BBH**	**AUB**	**UFHT**	**NLH**	**NLB**	**OBB**	**OBH**	**EKB**	**FRC**	**PAC**	**OCC**
1	**Mean**	170.31	134.91	130.59	114.68	60.68	47.59	24.62	38.20	33.56	93.55	107.23	109.47	93.08
	StDev	7.54	5.21	4.72	5.27	5.29	3.15	2.20	1.83	1.92	4.78	5.20	8.06	5.89
2	**Mean**	175.77	136.77	136.00	119.74	66.42	50.79	24.63	39.81	33.74	95.56	111.05	108.40	99.07
	StDev	6.79	5.86	4.49	4.61	4.99	2.87	2.10	2.18	2.36	3.86	4.62	5.63	6.87
3	**Mean**	186.58	133.17	138.12	121.62	72.08	52.51	26.00	38.07	34.45	96.50	110.97	119.93	98.83
	StDev	6.10	7.13	4.44	6.01	3.45	1.63	0.97	1.53	1.50	2.94	3.66	8.10	6.38
4	**Mean**	186.50	129.50	134.54	122.00	68.83	50.17	25.25	38.67	32.92	96.83	110.25	115.75	99.27
	StDev	7.94	5.13	3.06	4.38	3.87	1.69	2.19	2.64	1.86	4.07	2.96	8.20	5.25
5	**Mean**	183.72	128.72	134.56	122.28	64.86	48.53	25.06	39.72	33.00	98.35	110.44	116.04	96.45
	StDev	4.62	4.13	3.86	4.46	5.72	3.96	2.18	1.71	1.97	2.74	2.82	5.73	4.99
6	**Mean**	175.14	136.93	123.57	118.29	67.28	50.50	25.36	39.07	35.14	94.14	105.50	109.07	91.93
	StDev	6.20	4.55	5.96	5.38	4.25	2.85	1.98	2.16	1.79	4.96	4.26	4.68	5.93
7	**Mean**	184.44	136.38	140.31	125.58	70.38	52.25	25.13	42.19	34.13	101.31	115.75	114.44	95.25
	StDev	5.03	3.34	5.75	3.23	3.79	2.24	1.54	1.80	1.89	3.74	4.40	7.16	5.57
8	**Mean**	180.64	140.33	138.99	124.96	74.31	54.76	25.20	40.16	35.96	99.60	113.33	110.54	102.96
	StDev	4.70	4.88	4.23	3.62	3.71	2.47	2.42	1.34	2.32	2.96	4.65	4.06	6.10
9	**Mean**	184.82	142.55	137.75	125.80	72.92	51.66	25.48	40.00	36.27	101.90	114.73	113.91	100.68
	StDev	6.26	6.64	3.75	6.88	2.90	3.51	2.62	1.67	1.79	2.98	4.45	8.47	5.78
10	**Mean**	177.96	137.95	130.53	123.51	67.78	50.35	25.24	38.25	34.27	95.45	109.73	108.98	98.11
	StDev	5.22	3.98	5.22	4.33	3.59	2.24	1.78	1.42	1.47	3.04	4.42	6.01	6.25
11	**Mean**	176.03	137.13	133.93	123.57	69.70	52.37	25.03	39.77	35.63	95.70	110.43	110.80	95.73
	StDev	7.86	4.75	4.86	3.99	3.75	2.57	1.63	1.63	2.14	3.56	4.42	6.54	5.13
12	**Mean**	175.68	143.48	125.98	127.03	69.90	52.70	25.63	39.83	34.90	97.93	106.83	108.13	94.43
	StDev	7.07	5.51	7.17	4.47	4.22	3.25	1.76	1.74	1.89	3.15	5.43	7.86	5.25
13	**Mean**	177.63	139.72	136.22	125.21	70.75	52.59	25.19	40.29	35.31	97.17	111.19	110.97	97.38
	StDev	6.72	5.47	4.95	5.12	3.80	2.82	2.01	2.12	2.15	3.98	4.13	6.75	5.51
Females														
Sample		**GOL**	**XCB**	**BBH**	**AUB**	**UFHT**	**NLH**	**NLB**	**OBB**	**OBH**	**EKB**	**FRC**	**PAC**	**OCC**
1	**Mean**	177.36	138.76	137.42	120.03	66.54	51.25	24.90	39.52	34.34	96.37	111.98	112.38	95.65
	StDev	7.35	5.41	5.84	5.03	6.13	2.85	2.35	1.78	1.94	3.70	5.18	7.44	6.37
2	**Mean**	171.00	133.38	128.85	114.69	62.38	48.85	24.69	39.23	34.69	94.85	106.92	108.38	94.92
	StDev	7.26	5.90	7.57	4.92	6.08	3.69	2.06	1.83	1.75	3.89	3.86	7.11	3.93
3	**Mean**	183.28	127.45	133.23	113.20	64.79	48.59	25.34	37.21	33.92	93.62	111.42	115.32	97.34
	StDev	7.16	4.04	4.76	4.61	4.90	3.01	1.96	1.86	1.56	3.83	5.09	6.82	2.42
4	**Mean**	179.88	130.13	129.96	115.13	65.75	49.00	24.13	38.50	34.50	95.16	107.25	109.50	99.00
	StDev	6.27	3.14	3.20	6.96	4.23	3.41	2.17	1.20	2.07	2.70	2.05	8.38	4.81
5	**Mean**	179.00	128.20	133.19	116.11	60.21	46.14	24.80	37.32	32.36	95.25	107.82	113.00	97.24
	StDev	4.52	4.93	3.75	5.13	4.17	2.56	1.90	1.55	1.69	2.22	3.34	4.98	5.10
6	**Mean**	174.67	137.33	124.78	119.11	63.10	47.22	24.67	37.89	34.56	92.84	105.67	109.56	91.33
	StDev	4.61	6.02	4.27	5.49	3.74	3.35	1.58	1.96	1.01	3.58	3.57	5.81	3.16
7	**Mean**	172.44	130.25	130.75	117.31	66.14	48.97	23.74	40.00	32.94	95.66	107.56	107.63	90.19
	StDev	4.53	3.77	2.77	3.44	5.02	3.23	1.63	2.03	1.61	3.43	3.79	3.77	4.31
8	**Mean**	171.95	134.50	132.00	119.27	69.75	51.46	24.86	39.59	37.32	98.02	108.05	108.27	98.25
	StDev	3.62	4.26	2.86	3.11	3.68	2.39	1.64	1.92	1.99	3.02	4.85	4.51	5.37
9	**Mean**	175.13	139.25	135.51	122.13	69.13	48.88	23.25	38.38	35.13	97.65	111.38	103.75	102.75
	StDev	3.83	3.15	3.73	3.87	4.02	3.87	1.75	1.51	2.03	1.66	4.00	4.33	6.25
10	**Mean**	169.00	128.75	124.91	117.56	63.65	47.65	23.96	36.82	34.15	90.78	105.07	104.07	95.53
	StDev	5.20	3.82	4.05	4.24	3.67	2.50	1.60	1.29	1.39	2.85	3.99	6.08	6.18
11	**Mean**	169.79	133.86	127.36	118.79	67.07	48.71	24.50	39.21	35.86	93.57	104.64	107.21	95.93
	StDev	6.49	6.49	3.52	6.02	5.68	2.87	2.47	2.52	2.11	3.98	5.06	6.64	5.54
12	**Mean**	166.59	137.76	122.12	120.29	65.29	49.35	24.53	38.12	34.47	93.24	103.47	105.18	90.53
	StDev	8.37	5.73	9.10	5.22	4.36	3.08	1.94	1.54	1.91	2.82	4.43	8.97	6.09
13	**Mean**	168.82	134.06	130.82	120.06	66.59	49.24	24.29	38.88	34.88	93.00	105.53	106.88	94.35
	StDev	7.58	5.90	3.84	4.49	5.15	3.21	1.79	1.22	1.90	3.24	5.21	6.55	5.77

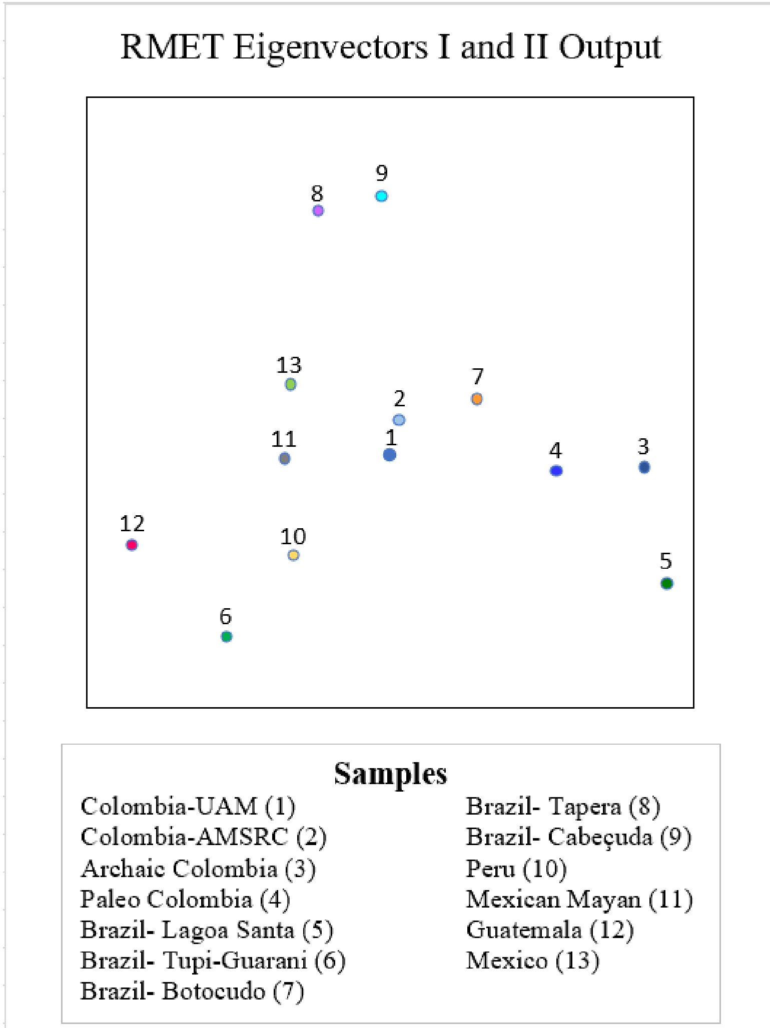


Figure 4. RMET Preliminary Analysis Results

Comparison of All Country Samples

The cross-validated summary from the discriminant function analysis conducted demonstrated that 52.1% of the cross-validated grouped cases were correctly classified (Appendix C). The breakdown of each sample can be seen in Table 3 and the canonical discriminant functions plot can be seen in Figure 5. The Colombian sample 1 provided by Dr. Hefner has an 73.4% cross-validated classification rate which is the highest classification rate across all of the samples. While the Guatemalan sample has the least correctly classified results with 47.7% of individuals classifying as Mexican and 22.7% classifying as Colombian, sample 1. The cross-validated classification result indicates that the classification rates throughout are not clearly distinguishable for all of the samples (Table 3 and Figure 4). This demonstrates that of the ILDs used in this project, there is no clear distinction between the samples, with the exception of the Colombian samples which demonstrate the highest classification rates within both Colombian samples.

To attempt to understand the classification rates of the samples by country, the samples were combined into their respective countries. The cross-validated classification rate remained similar at 53.8% for grouped cases that were correctly classified (Appendix D). The cross-validated classification rate for each country is shown in Table 4. The highest classification rate was 74.4% for Colombia, followed by a 62.7% for the Peruvian sample, and 59.6% for the Mexican Mayan sample. The Brazilian samples demonstrate classifications split 28.9% as Brazil, 34.7% as Colombian, and 21.5% as Mexican. The Guatemalan sample continued to demonstrate classification rates of 40.9% Mexican and 29.5% Colombian. Additionally, the Mexico sample continued to have classification rates across all 6 country samples.

Table 4. Cross-Validated Classification Results for All Samples

Classification Results													
Samples			**Predicted Group Membership**										**Total**
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Original	**Count**	**Colombia-UAM (1)**	181	5	1	2	5	2	11	0	2	32	241
		Colombia-AMSRC (2)	31	5	2	3	1	1	1	0	3	9	56
		Brazil- Tupi-Guarani (3)	3	0	11	0	0	0	2	0	5	2	23
		Brazil- Botocudo (4)	8	0	0	14	0	0	1	0	0	9	32
		Brazil- Tapera (5)	11	0	0	0	20	1	2	0	1	12	47
		Brazil- Cabeçuda (6)	2	0	0	0	2	8	1	0	0	6	19
		Peru (7)	13	1	1	0	1	0	75	1	4	14	110
		Guatemala (8)	10	0	0	1	2	1	8	2	1	19	44
		Mexican Mayan (9)	5	0	1	0	2	0	6	0	35	8	57
		Mexico (10)	42	1	0	4	7	1	16	2	7	86	166
	%	**Colombia (1)**	75.1	2.1	0.4	0.8	2.1	0.8	4.6	0.0	0.8	13.3	100.0
		Colombia (2)	55.4	8.9	3.6	5.4	1.8	1.8	1.8	0.0	5.4	16.1	100.0
		Brazil- Tupi-Guarani (3)	13.0	0.0	47.8	0.0	0.0	0.0	8.7	0.0	21.7	8.7	100.0
		Brazil- Botocudo (4)	25.0	0.0	0.0	43.8	0.0	0.0	3.1	0.0	0.0	28.1	100.0
		Brazil- Tapera (5)	23.4	0.0	0.0	0.0	42.6	2.1	4.3	0.0	2.1	25.5	100.0
		Brazil- Cabeçuda (6)	10.5	0.0	0.0	0.0	10.5	42.1	5.3	0.0	0.0	31.6	100.0
		Peru (7)	11.8	0.9	0.9	0.0	0.9	0.0	68.2	0.9	3.6	12.7	100.0
		Guatemala (8)	22.7	0.0	0.0	2.3	4.5	2.3	18.2	4.5	2.3	43.2	100.0
		Mexican Mayan (9)	8.8	0.0	1.8	0.0	3.5	0.0	10.5	0.0	61.4	14.0	100.0
		Mexico (10)	25.3	0.6	0.0	2.4	4.2	0.6	9.6	1.2	4.2	51.8	100.0
Cross-validated	**Count**	**Colombia-UAM (1)**	177	5	1	2	6	2	13	0	3	32	241
		Colombia-AMSRC (2)	32	4	2	3	1	1	1	0	3	9	56
		Brazil- Tupi-Guarani (3)	4	0	7	0	0	0	3	0	6	3	23
		Brazil- Botocudo (4)	9	0	0	13	0	0	1	0	0	9	32
		Brazil- Tapera (5)	11	0	0	0	15	1	2	1	2	15	47
		Brazil- Cabeçuda (6)	2	0	0	0	2	8	1	0	0	6	19
		Peru (7)	15	1	1	0	1	0	72	1	6	13	110
		Guatemala (8)	10	0	0	1	2	1	8	0	1	21	44
		Mexican Mayan (9)	6	0	1	0	2	0	6	0	34	8	57
		Mexico (10)	41	1	0	4	10	1	16	2	7	84	166
	%	**Colombia (1)**	73.4	2.1	0.4	0.8	2.5	0.8	5.4	0.0	1.2	13.3	100.0
		Colombia (2)	57.1	7.1	3.6	5.4	1.8	1.8	1.8	0.0	5.4	16.1	100.0
		Brazil- Tupi-Guarani (3)	17.4	0.0	30.4	0.0	0.0	0.0	13.0	0.0	26.1	13.0	100.0
		Brazil- Botocudo (4)	28.1	0.0	0.0	40.6	0.0	0.0	3.1	0.0	0.0	28.1	100.0
		Brazil- Tapera (5)	23.4	0.0	0.0	0.0	31.9	2.1	4.3	2.1	4.3	31.9	100.0
		Brazil- Cabeçuda (6)	10.5	0.0	0.0	0.0	10.5	42.1	5.3	0.0	0.0	31.6	100.0
		Peru (7)	13.6	0.9	0.9	0.0	0.9	0.0	65.5	0.9	5.5	11.8	100.0
		Guatemala (8)	22.7	0.0	0.0	2.3	4.5	2.3	18.2	0.0	2.3	47.7	100.0
		Mexican Mayan (9)	10.5	0.0	1.8	0.0	3.5	0.0	10.5	0.0	59.6	14.0	100.0
		Mexico (10)	24.7	0.6	0.0	2.4	6.0	0.6	9.6	1.2	4.2	50.6	100.0

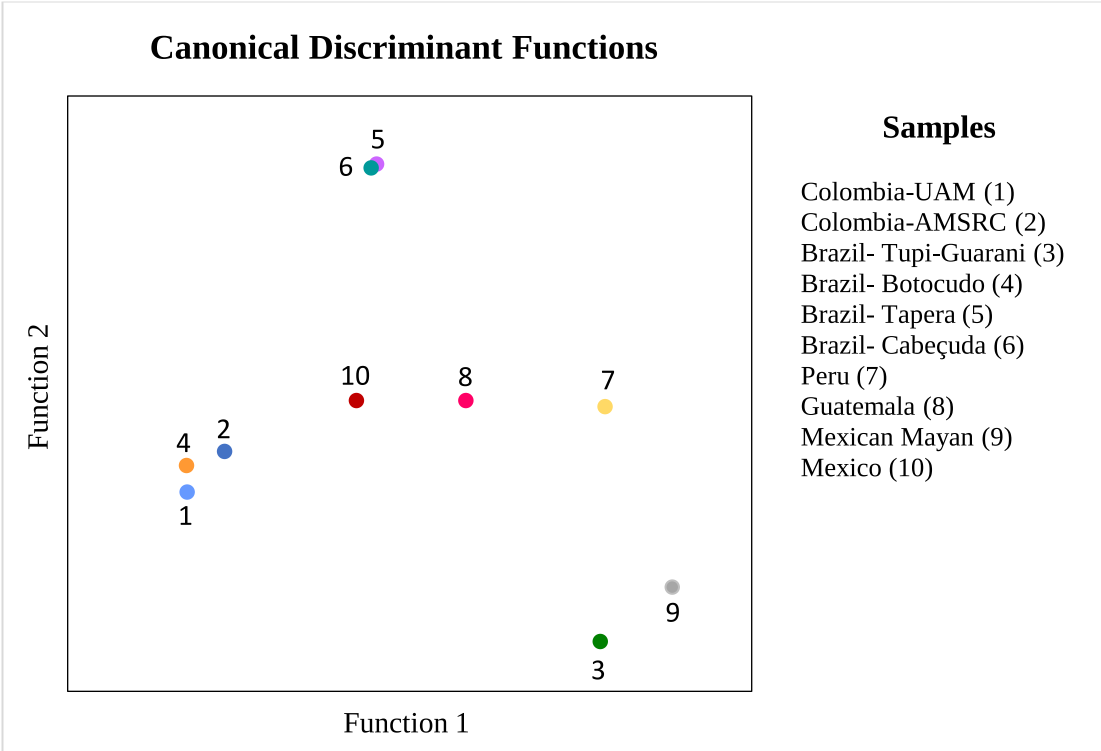


Figure 5. Canonical Discriminant Functions Graph for Functions 1 and 2 for All Samples.

Table 5. Cross-validated Classification Results for Combined Country Samples.

Classification Results									
Samples			**Predicted Group Membership**						**Total**
			1	**2**	**3**	**4**	**5**	**6**	
Original	**Count**	**Colombia (1)**	225	22	13	0	4	33	297
		Brazil (2)	39	41	8	1	8	24	121
		Peru (3)	17	9	71	1	1	11	110
		Guatemala (4)	13	2	8	3	1	17	44
		Mexican Mayan (5)	5	4	4	0	36	8	57
		Mexico (6)	57	12	13	2	7	75	166
	%	**Colombia (1)**	75.8	7.4	4.4	0.0	1.3	11.1	100.0
		Brazil (2)	32.2	33.9	6.6	0.8	6.6	19.8	100.0
		Peru (3)	15.5	8.2	64.5	0.9	0.9	10.0	100.0
		Guatemala (4)	29.5	4.5	18.2	6.8	2.3	38.6	100.0
		Mexican Mayan (5)	8.8	7.0	7.0	0.0	63.2	14.0	100.0
		Mexico (6)	34.3	7.2	7.8	1.2	4.2	45.2	100.0
Cross-validated	**Count**	**Colombia (1)**	221	24	14	0	5	33	297
		Brazil (2)	42	35	9	1	8	26	121
		Peru (3)	18	9	69	1	2	11	110
		Guatemala (4)	13	3	9	0	1	18	44
		Mexican Mayan (5)	5	4	5	1	34	8	57
		Mexico (6)	62	13	13	2	7	69	166
	%	**Colombia (1)**	74.4	8.1	4.7	0.0	1.7	11.1	100.0
		Brazil (2)	34.7	28.9	7.4	0.8	6.6	21.5	100.0
		Peru (3)	16.4	8.2	62.7	0.9	1.8	10.0	100.0
		Guatemala (4)	29.5	6.8	20.5	0.0	2.3	40.9	100.0
		Mexican Mayan (5)	8.8	7.0	8.8	1.8	59.6	14.0	100.0
		Mexico (6)	37.3	7.8	7.8	1.2	4.2	41.6	100.0

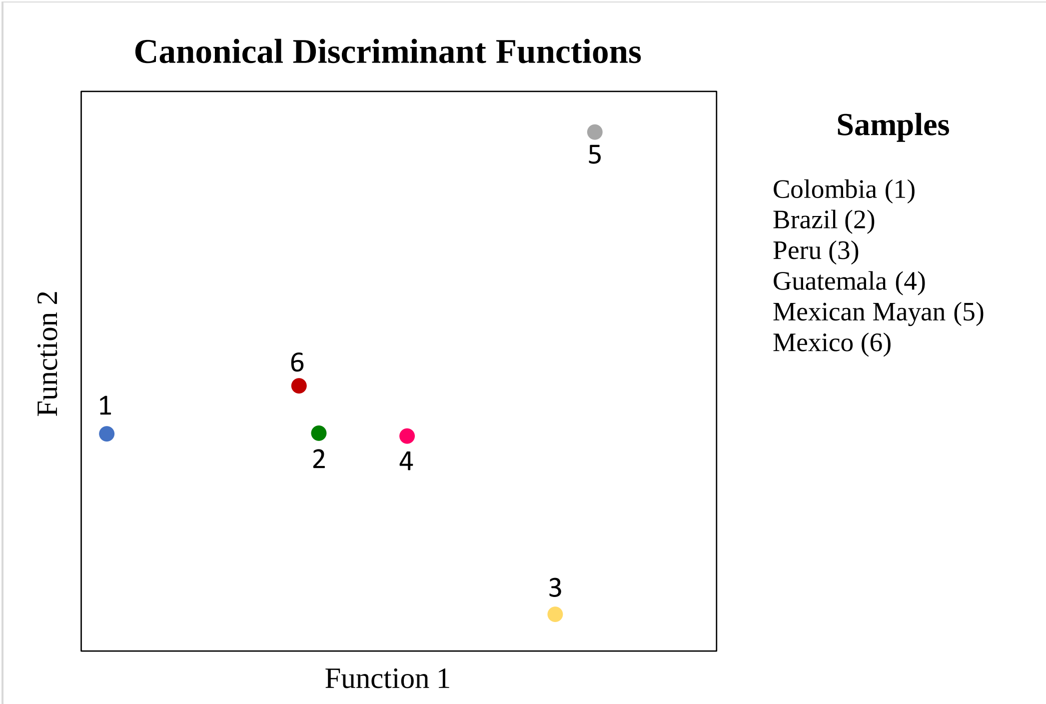


Figure 6. Canonical Discriminant Functions Graph for Functions 1 and 2 for Combined Country Samples.

Comparison of All Country Samples with Identified OpID Individuals

The cross-validated summary from the discriminant function analysis conducted on all the combined country samples with the twenty known OpID individuals introduced demonstrates that 54.6% of the cross-validated grouped cases were correctly classified (Appendix E). The breakdown of each country sample can be seen in Table 5. The country samples analyzed in the DFA classified differently than the prior DFA conducted above. In the cross-validated classifications, the Colombian samples is classifying best at 74.7% followed by the Peruvian and Mexican Mayan samples with a 62.7% and 59.6% classification rate, respectively. There variation observed classifies at least one case for each country across all samples, with the exception of the Mexican Mayan group in which only one Mexican case is classifying as Mexican Mayan. The majority of the ungrouped identified OpID individuals are classifying as Colombian, followed by Mexican, Peruvian, and then Brazilian. The Guatemalan and Mexican samples have zero OpID cases in their classifications. The canonical discriminant functions graph for functions 1 and 2 can be seen in Figure 7.

Table 6. Cross-validated Classification Results for Combined Country Samples and Identified OpID Individuals.

Classification Results									
Samples			**Predicted Group Membership**						**Total**
			1	2	3	4	5	6	
Original	**Count**	**Colombia (1)**	225	23	13	0	5	31	297
		Brazil (2)	40	46	7	0	8	20	121
		Peru (3)	18	9	71	0	1	11	110
		Guatemala (4)	12	2	6	0	1	13	34
		Mexican Mayan (5)	6	4	4	0	36	7	57
		Mexico (6)	56	13	12	1	7	70	159
		Ungrouped ID OpID (7)	9	1	3	0	0	7	20
	%	**Colombia (1)**	75.8	7.7	4.4	0.0	1.7	10.4	100.0
		Brazil (2)	33.1	38.0	5.8	0.0	6.6	16.5	100.0
		Peru (3)	16.4	8.2	64.5	0.0	0.9	10.0	100.0
		Guatemala (4)	35.3	5.9	17.6	0.0	2.9	38.2	100.0
		Mexican Mayan (5)	10.5	7.0	7.0	0.0	63.2	12.3	100.0
		Mexico (6)	35.2	8.2	7.5	0.6	4.4	44.0	100.0
		Ungrouped ID OpID (7)	45.0	5.0	15.0	0.0	0.0	35.0	100.0
Cross-validated	**Count**	**Colombia (1)**	222	23	14	0	7	31	297
		Brazil (2)	43	36	9	0	8	25	121
		Peru (3)	18	10	69	0	2	11	110
		Guatemala (4)	13	2	6	0	1	12	34
		Mexican Mayan (5)	6	4	5	0	34	8	57
		Mexico (6)	60	14	13	1	7	64	159
	%	**Colombia (1)**	74.7	7.7	4.7	0.0	2.4	10.4	100.0
		Brazil (2)	35.5	29.8	7.4	0.0	6.6	20.7	100.0
		Peru (3)	16.4	9.1	62.7	0.0	1.8	10.0	100.0
		Guatemala (4)	38.2	5.9	17.6	0.0	2.9	35.3	100.0
		Mexican Mayan (5)	10.5	7.0	8.8	0.0	59.6	14.0	100.0
		Mexico (6)	37.7	8.8	8.2	0.6	4.4	40.3	100.0

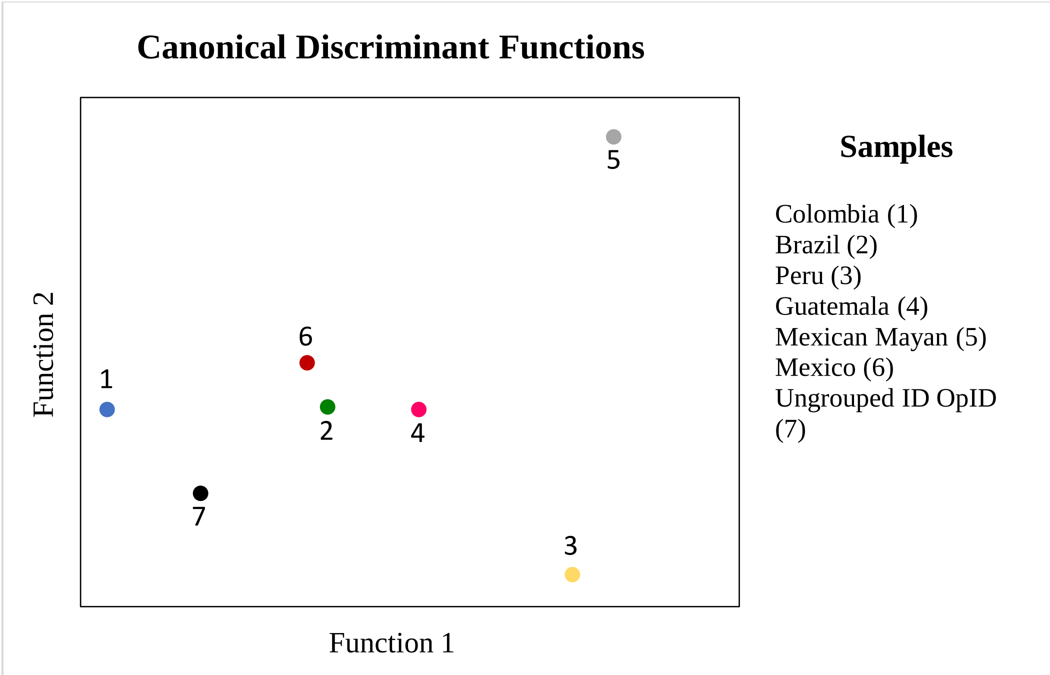


Figure 7. Canonical Discriminant Functions Graph for Functions 1 and 2 for Combined Country Samples and Identified OpID Individuals.

Comparison of Modern Country Samples and Identified OpID Individuals

The cross-validated summary from the discriminant function analysis conducted on all the modern country samples with the identified OpID individuals demonstrates that 65.8 % of the cross-validated grouped cases were correctly classified (Appendix F). The breakdown of each country sample can be seen in Table 6. The country samples analyzed in the DFA above continue to be classifying similarly as the ones ran above. The combined Colombian sample continues to classify the best with a classification of 83.2%, followed by the Mexican Mayan sample with a rate of 66.7%. The Guatemalan sample continues to be split between Colombia and Mexico, and the Mexico sample continues to be classifying throughout all samples. The Ungrouped OpID individuals are classifying

50% as Colombian, 40% as Mexican, and 10% as Guatemalan. The canonical discriminant functions graph for functions 1 and 2 can be seen in Figure 8.

Table 7. Cross-validated Classification Results for Modern Country Samples and Identified OpID Individuals.

Classification Results							
Samples		**Predicted Group Membership**					**Total**
			1	**2**	**3**	**4**	
Original	**Count**	**Colombia (1)**	251	0	5	41	297
		Guatemala (2)	17	4	1	22	44
		Mexican Mayan (3)	8	0	38	11	57
		Mexico (4)	67	3	6	90	166
		Ungrouped ID OpID	10	2	0	8	20
	%	**Colombia (1)**	84.5	0.0	1.7	13.8	100.0
		Guatemala (2)	38.6	9.1	2.3	50.0	100.0
		Mexican Mayan (3)	14.0	0.0	66.7	19.3	100.0
		Mexico (4)	40.4	1.8	3.6	54.2	100.0
		Ungrouped ID OpID	50.0	10.0	0.0	40.0	100.0
Cross-validated	**Count**	**Colombia (1)**	247	0	5	45	297
		Guatemala (2)	17	1	1	25	44
		Mexican Mayan (3)	8	0	38	11	57
		Mexico (4)	71	3	7	85	166
	%	**Colombia (1)**	83.2	0.0	1.7	15.2	100.0
		Guatemala (2)	38.6	2.3	2.3	56.8	100.0
		Mexican Mayan (3)	14.0	0.0	66.7	19.3	100.0
		Mexico (4)	42.8	1.8	4.2	51.2	100.0

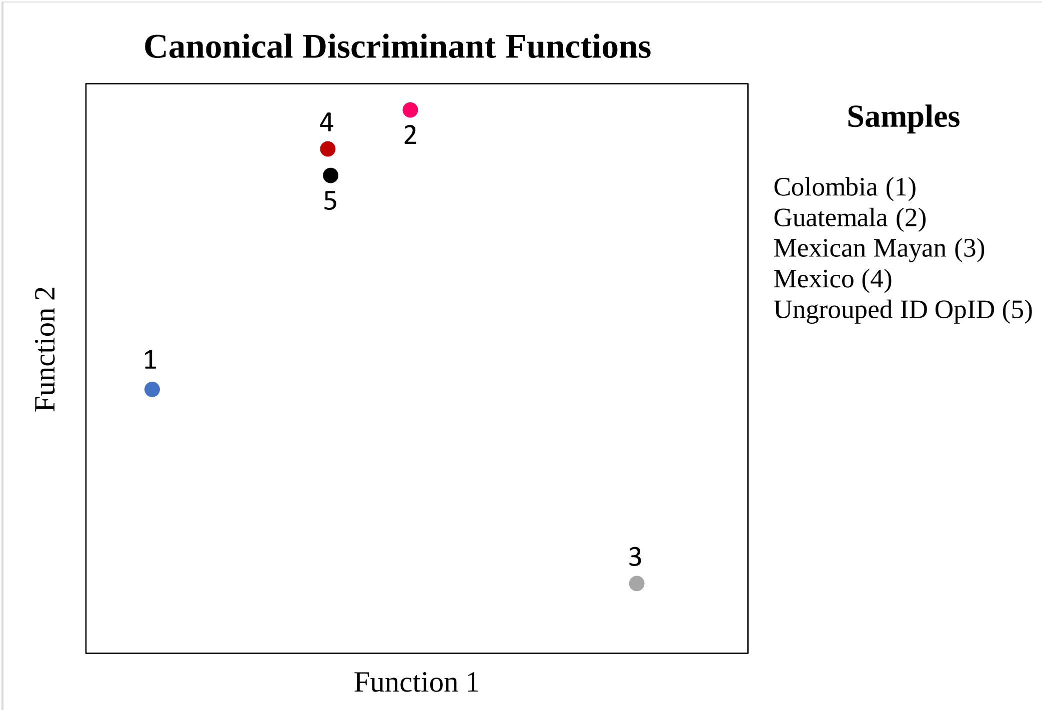


Figure 8. Canonical Discriminant Functions Graph for Functions 1 and 2 for Modern Country Samples and Identified OpID Individuals.

V. DISCUSSION

Current CBP data reports demonstrate an increase in South and Central American apprehensions (US Customs and Border Patrol, 2019b). These data reports illustrate the need for further reference samples from the reported apprehended nationalities. This project addresses this need by looking at craniometric variation within thirteen selected ILDs in archaeological and modern samples from South and Central American countries that are part of the top 15 countries in the CBP apprehension reports.

Comparison of All Country Samples

Based on population history and variation in environmental biomes for the countries used in this project, a clearer distinction between the samples used was anticipated. When the multiple country samples were combined, a clearer distinction was observed.

Colombia

Population history of Colombia suggest that the two samples used would demonstrate more Indigenous and European descent (Ruiz-Linares, 2014; Sans, 2000, Ossa et al., 2016). The genetic admixture experienced in Medellin, the tropical highland Andina region, can elucidate the variation expressed among the samples. As research has shown that this tropical highland region is predominantly of European descent, the use of these modern samples in comparison to the different genetic admixture, environmental climates, and altitude regions can account for the clear distinctions observed when the Colombian samples are compared to the other country samples.

Brazil

The location of the Brazilian hunter-gatherer groups utilized largely encompasses Indigenous and European descent. Research shows that it is probable that the Tapera and Cabeçuda samples experience an increase of European descent as opposed to the more prominent Indigenous descent found in the Tupi-Guarani and Botocudo samples region (Ruiz-Linares, 2014; Salzano and Sans, 2014; Hubbe et al., 2015; Lopez-Capp, 2018).

The classification patterns observed when comparing the four samples demonstrates the effect extrinsic factors play on the cranial morphology. This can be observed more clearly when looking at the close classifications of the Tapera and Cabeçuda samples, both of which are in the Pampa and Mata Atlântica regions, as opposed to the Tupi-Guarani and Botocudo samples which are classifying more distinctly. Of the two samples said to demonstrate more Indigenous descent, the Tupi-Guarani sample appears to be grouping closer to the Mexican Mayan sample which appears to agree with current literature, while the Botocudo sample appears to be grouping closer to the modern Colombian samples which are predominantly of more European descent.

Additionally, as these data are from archaeological material, it is possible that the admixture experienced now in these regions may not be observed within these samples. While the samples experience variation in biomes and genetic makeup, a temporal change is also observed. The Tupi-Guarani sample is the oldest of the four archaeological sample used, while the Botocudo sample is the most modern archaeological sample used while the Tapera and Cabeçuda samples are of a more similar temporal range. This difference can also account for the classification patterns observed within the samples.

The differentiation within classification patterns demonstrates the impact both the genetic variation and environmental regions have between the samples.

Peru

The location of the Peruvian sample collected by Howells (1973) also demonstrates more Indigenous descent (Cabana et al., 2014; Ruiz-Linares, 2014). The classification patterns of this sample do not appear to be grouping directly with any other country sample, although the classification rates span across the Peruvian, Colombian, and Mexican samples, in that order. This observation can be due to multiple factors, such as the genetic admixture of the sample, the conditions of a higher altitude environment, or the temporal space amongst the other archaeological samples used.

But when looking at the time rages between the archaeological samples, this sample was from a time frame similar to the Brazilian Tapera and Cabeçuda samples yet demonstrates a clear distinction between the samples. This demonstrates that the environmental conditions experienced by this sample potentially had a greater influence on the cranial morphology of these individuals.

Guatemala and Mexico

The Guatemalan and Mexican samples obtained from PCOME and OpID have shown to have a clear distinction from the Mexican Mayan sample as the data is obtained from recent Guatemalan and Mexican migrants (Spradley, 2021). The distinction could be attributed to the population admixture experienced in areas throughout Guatemala and Mexico that might not have a large Indigenous population. As Spradley (2021) demonstrates, the migrant samples tend to classify closer to each other as opposed to their country's Mayan sample. This demonstrates that the genetic admixture of these modern migrant individuals is significantly different than those of more Indigenous areas and populations. This can possibly be due to a more European descent, general variation of European and Indigenous admixture, environmental conditions, such as possible influence of past migration and dietary changes due to these conditions.

Mexican Mayan

The Mexican Mayan sample consistently groups individually from the rest of the samples. As this sample is known to be of predominantly Indigenous descent, it demonstrates the difference in genetic admixture possibly experienced by the other country samples. While the environmental conditions of this sample vary when compared to the other samples, and the Mexican migrant sample especially, it appears that this sample is most influenced by their genetic makeup.

When looking at the overall sample comparisons, the Brazilian- Tupi-Guarani sample appears to be in a grouping with the Mexican Mayan sample. This can indicate a more Indigenous genetic makeup within the Tupi-Guarani sample that is possibly influencing the close grouping in relation to the rest of the samples used. As none of the samples experience a grouping pattern with the Mexican Mayan sample when the country samples are combined, it further demonstrates the impact the intrinsic factors have on the cranial morphology of this sample.

Country Summary

Overall, the results demonstrate that the archaeological samples have a significant split between their own correct classifications and between the Colombian and Mexican samples. The Brazilian Tupi-Guarani sample exhibits an even split between correctly classifying as Tupi-Guarani and the second highest classification being six individuals grouped as Mexican Mayan, followed by an even split between Colombia, Peruvian, and Mexican. The Botocudo sample is the highest Brazilian sample that is correctly classified, with thirteen cases being correctly classified, nine cases being classified as Mexican, another nine as Colombian, and one as Peruvian. The Tapera sample demonstrates correct classification on fifteen cases tied with another fifteen being classified as Mexican, followed by eleven classifying as Colombian. The fourth Brazilian sample, Cabeçuda, is the smallest sample of the four, and is correctly classified in eight cases, followed by six classifying as Mexican, two as part of the Tapera sample, two as Colombian, and one as Peruvian.

The Peruvian archaeological sample experiences a correct classification on seventy-two individuals, followed by fifteen of the cases classifying as Mexican and another fourteen as Colombian. Additional individuals from the Peruvian sample have classifications throughout the rest of the samples, with the exception of the Botocudo and Cabeçuda samples.

While the Guatemalan sample is smaller than the other modern samples used, the majority of the cases are classifying as Mexican. This observation can be seen in Spradley's (2021) article which demonstrates a clear grouping of Mexican and Guatemala migrant data when compared to Mexican and Guatemalan Mayan data. Based on the 2021 study, and previous population history research on the admixture of Indigenous, European, and African descent in Mexico, it was decided to keep the Mexican Mayan and Mexico samples separate to evaluate the classification rates of these samples when looking at the selected ILDs.

Comparison of All Country Samples with Identified OpID Individuals

As no clear distinction was observed throughout all of the samples, the identified OpID individuals were introduced to assess their classification when compared to the additional archaeological and modern Latin American data. The country breakdown of the known OpID individuals includes ten individuals from Guatemala, seven individuals from Mexico, one individual from Honduras, one individual from Nicaragua, and one identified individual from an unknown country. When grouped individually, seven cases classify as Guatemalan, four cases as Colombian, another four as Brazilian, three as Mexican, and two as Peruvian. This classification provides interesting results that demonstrate that the genetic history is possibly impacting the results as the samples from areas with low genetic admixture, of more Indigenous ancestry, are grouping a bit more distinctly than the samples from high admixture areas. Incorporating reference data from the known countries of these individuals would provide crucial information on craniometric variation across Latin American samples that can then be compared to their genetic history to better interpretate the variation observed.

Comparison of Modern Samples with Identified OpID Individuals

Although the cross-validated classification rates increased when looking at the identified OpID individuals with only the modern samples, no additional information was obtained from this analysis aside from the benefit of using modern samples for comparison. An interesting pattern observed in both the overall sample analysis and the modern sample comparison is that the second greatest classification in the Mexican cases continues to be Colombian as opposed to Guatemalan.

Based on the previously mentioned study conducted by Dr. Spradley (2021), it was expected that since both the Guatemalan and Mexican data were obtained from migrant individuals found in Arizona and Texas, the classifications would continue to group both samples closely. The introduction of the Colombian sample and the classification of the majority of cases classifying as Colombian further demonstrates the incorporation of additional reference data to better understand the patterns observed in current and past research. Looking specifically at the geography of the samples used, it can be said that the classification of Colombian for the identified Central American OpID individuals is understandable, yet it also adds to the argument of the need for further reference samples from Central and South America.

ILD Selection

The selection of the thirteen ILDs was established based on the availability of ILDs across all samples and those that had measurements on the majority of individuals present. Additionally, the ILDs were selected based on having complete measurements throughout all samples so as to not have to impute missing data. This was decided as the data for this project already varied due to the mix of archaeological and modern data. The ILDs used focused on a mix of cranial and facial features.

Across all canonical discriminant functions ran, BBH, FRC, and PAC continue to be the largest absolute correlation between the variables and any discriminant function. Low BBH, FRC, and PAC make up the first function, while low BBH and FRC with a high PAC make up the second function. Based on the statistics, it appears that the cranial vault shape is what is affecting the classification rates the most. When looking at the comparison across all ten samples used, BBH, FRC, and OCC present the largest absolute correlation between the variables. While PAC does not present to have a large correlation in this comparison, OCC still contributes to the observation that the cranial vault is influencing the classification patterns the most. The variation in cranial vault shape can be attributed to the intrinsic and extrinsic factors mentioned previously that vary between the samples and overall countries. Utilizing modern samples with known genetic makeup and environmental lifestyles of the individuals would be beneficial to further assess which factors are affecting the ILDs that demonstrate the largest absolute correlation between discriminant function variables.

When compared to Spradley (2021), none of the Howells (1973) measurements used in this project correlate with the ones used in Spradley (2021). The Howells (1973) ILDs used in Spradley (2021) were not included in this project due to the lack of availability of these ILDs being provided across all samples. This further demonstrates the need for complete craniometric data from modern collections that include both Howells (1973) ILDs and standards (1994) measurements to ensure that additional measurements can be used in different analyzes for a better understanding of the cranial morphology of these country samples.

VI. CONCLUSION

Based on the cross-validated classifications of the Central and South American data used, statistically significant variation was not observed among the samples used. As mentioned above, the combination of archaeological and modern data could account for this, but further analysis on modern data should be conducted to better assess the craniometric variation between the samples.

The classification rates of the data used was not as accurate as expected, therefore the accuracy rate of the previously identified OpID individuals could not be assessed entirely. Additionally, based on the ILDs selected for this project, not all of the previously identified OpID individuals could be included. Further analysis should be conducted including a higher number of ILDs to get a better understanding of overall cranial and facial morphology of the country samples used, and for comparison analysis including known OpID individuals.

Due to the low classification rates, the unknown OpID individuals could not be confidently assessed in comparison to the combined reference samples used. Had classification rates been more suitable, the unknown OpID individuals would have been assessed using the reference samples compiled.

As the country-of-origin prediction of the unknown OpID individuals could not be assessed due to lack of improvement in the predictions, the addition of the country samples used demonstrate that the use of additional modern Central and South American reference data could aid in the estimation of country of origin of the unidentified OpID individuals. Further analysis needs to be conducted with modern country samples to facilitate a better understanding of craniometric variation between and within Latin American countries to better assess the questions addressed in this research project.

Future Directions

Further research is needed that addresses the inconsistencies in the samples used. Future directions for this project include the use of modern samples for all of the countries used as well as a Procrustes analysis comparing the data used in this project and the data used in Spradley (2021) to better understand the variation between the countries. When using modern samples, it will be ensured that the data is collected by the same individual as certain definitions and the method used can affect the data and therefore affect the classification rates observed. The use of 2D measurements used in the archaeological data compared to the use of 3D coordinates in the modern samples can also attest to the lower classification patterns observed. The collection of the most ILDs and landmark measurements possible per country sample can ensure that the samples have the same measurements and coordinates to further enable an overall better understanding of the intrinsic and extrinsic factors that affect the cranial and facial shape variation of the countries.

Additionally, use of ethically acquired collections from Latin American individuals is crucial, as recent publications have demonstrated that one of the Colombian samples used in this project initially included data from unknown individuals whose relatives had not consciously approved of their use in scientific research and for academic purposes. The unknown individuals were immediately removed from the sample upon notice and only known individuals who were initially part of the city and university agreement were included in the sample used. The incorporation of the unknown individuals in the Colombian sample attest to the larger problem of violence experienced in Latin American countries due to governmental, gang, and cartel violence that is currently pushing Latin American individuals to come to the US in pursuit of a better life, and in which some individuals will ultimately lose their lives trying to achieve. Ultimately further affecting the humanitarian aid crisis we are trying to address.

Overall, the addition of these South American and Central American samples further proves the need of international collaboration and incorporation of further methods to better understand the variation between these countries. The incorporation of craniometric data with DNA and isotopic analysis can further aid in the identification of migrant individuals by providing a better understanding of the intrinsic (DNA analysis) and extrinsic (isotopic analysis) factors that affect the variation between the countries. Having craniometric reference data from the countries demonstrating the most apprehensions in CBP reports would help narrow the pool of possible identifications for both OpID and PCOME cases. Possibly narrowing down the country of origin based on craniometric data can then facilitate the DNA and isotopic comparison to better ascertain the identification of migrant individuals.

Collaboration with Latin American colleagues can provide better results for both US and Latin American researchers to work together to address the needs of all. This collaboration will not only aid in the identification of migrant remains found in the US but can potentially benefit the Latin American countries with the ongoing missing and unidentified cases experienced due to feminicide and cartel violence.

APPENDIX SECTION

APPENDIX A: Craniometric Availability Matrix

Sample	**GOL**	**XCB**	**BBH**	**AUB**	**NPH**	**NLH**	**NLB**	**OBB**	**OBH**	**EKB**	**FRC**	**PAC**	**OCC**
Colombia-UAM	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Colombia-AMSRC	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Brazil	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Peru	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mexican Mayan	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Guatemala	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mexico	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sample	**FMB**	**MAB**	**ZYB**	**NOL**	**BNL**	**XFB**	**WFB**	**ASB**	**BPL**	**JUB**	**MAL**	**MDH**	**DKB**
Colombia-UAM	N	Y	Y	N	Y	N	Y	N	Y	N	Y	Y	Y
Colombia-AMSRC	N	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y
Brazil	N	N	N	Y	N	Y	N	Y	N	Y	N	N	N
Peru	N	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y
Mexican Mayan	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Guatemala	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mexico	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sample	**NDS**	**WNB**	**SIS**	**ZMB**	**SSS**	**NAS**	**DKS**	**IML**	**XML**	**MLS**	**WMH**	**GLS**	**STB**
Colombia-UAM	N	N	N	N	N	N	N	N	N	N	N	N	N
Colombia-AMSRC	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Brazil	N	N	N	Y	N	Y	N	Y	Y	N	Y	N	N
Peru	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mexican Mayan	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Guatemala	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mexico	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sample	**FRS**	**FRF**	**PAS**	**PAF**	**OCS**	**OCF**	**FOL**	**FOB**	**NAR**	**SSR**	**PRR**	**DKR**	**ZOR**
Colombia-UAM	N	N	N	N	N	N	Y	Y	N	N	N	N	N
Colombia-AMSRC	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
Brazil	Y	N	Y	N	N	N	N	N	Y	N	N	N	N
Peru	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Mexican Mayan	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Guatemala	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mexico	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sample	**FMR**	**EKR**	**ZMR**	**AVR**	**BRR**	**VRR**	**LAR**	**OSR**	**BAR**				
Colombia-UAM	N	N	N	N	N	N	N	N	N				
Colombia-AMSRC	Y	Y	Y	N	Y	N	Y	Y	Y				
Brazil	Y	N	N	N	N	N	N	N	N				
Peru	Y	Y	Y	Y	Y	Y	Y	Y	Y				
Mexican Mayan	Y	Y	Y	Y	Y	Y	Y	Y	Y				
Guatemala	Y	Y	Y	Y	Y	Y	Y	Y	Y				
Mexico	Y	Y	Y	Y	Y	Y	Y	Y	Y				

APPENDIX B: Howells (1973) Landmark Definitions Used in the Selected ILDs

Landmark	**Abbreviation**	**Definition**
Basion	ba	On the anterior border of the foramen magnum, in the midline, at the position pointed to by the apex of the triangular surface at the base of either condyle, i.e., the average position from the crests bordering this area. Mark carefully with a pencil.
Bregma	br	The posterior border of the frontal bone in the median plane.
Dacryon	dk	The apex of the lacrimal fossa, as it impinges on the frontal bone. Mark with a pencil point on both sides.
Ectoconchion	ek	The intersection of the most anterior surface of the lateral border of the orbit and a line bisecting the orbit along its long axis. Mark both sides with a pencil.
Lambda	la	The apex of the occipital bone at its junction with the parietals, in the midline.
Nasion	na	The intersection of the fronto-nasal suture and the median plane. Mark with a pencil.
Opisthion	os	The inferior edge of the posterior border of the foramen magnum in the midline.
Prosthion	pr	The most anteriorly prominent point, in the midline, on the alveolar border, above the septum between the central incisors. Mark with a pencil.

APPENDIX C: Discriminant Function Analysis Output of All Samples

Analysis Case Processing Summary

Unweighted Cases		N	Percent
Valid		795	100.0
Excluded	Missing or out-of-range group codes	0	.0
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	0	.0
Total		795	100.0

Group Statistics

GROUP		Mean	Std. Deviation	Valid N (listwise) Unweighted	Weighted
1	GOL	.085680384372859	1.144380523189039	241	241.000
	XCB	.142671404243315	.998268974061172	241	241.000
	BBH	.413638112031159	1.027165762569263	241	241.000
	AUB	-.254505567010354	1.178333458839541	241	241.000
	UFHT	-.334559704850300	1.251228588475746	241	241.000
	NLH	-.049420807280069	1.123721201508585	241	241.000
	NLB	.045666237247241	1.116491818144906	241	241.000
	OBB	.020926901449741	.989211909742142	241	241.000
	OBH	-.242662653516554	.968808241001851	241	241.000
	EKB	.043936642965075	1.071379376829311	241	241.000
	FRC	.207717769961848	1.060593557634934	241	241.000
	PAC	.244720753019125	1.023916711374126	241	241.000
	OCC	-.122095816237780	1.031170742673094	241	241.000
2	GOL	-.169367727346714	.920985163979101	56	56.000
	XCB	-.324279243063605	1.000962125321182	56	56.000
	BBH	.153888148741560	.912588316616438	56	56.000
	AUB	-.577922609574822	.822079812995824	56	56.000
	UFHT	-.423495405464844	.937749303006012	56	56.000
	NLH	-.219178589022238	.915052993736557	56	56.000
	NLB	-.164981322958384	1.029926119270402	56	56.000
	OBB	.109648434546042	1.001107323638801	56	56.000
	OBH	-.347842743706696	1.063840343236261	56	56.000
	EKB	-.177738049107692	.898770748721268	56	56.000
	FRC	.051945532233885	.881044143716309	56	56.000
	PAC	-.220163219917568	.844024780975483	56	56.000
	OCC	.272057522617543	1.010221586595965	56	56.000
3	GOL	-.073468671942934	.755105413552485	23	23.000
	XCB	-.074683346337840	.879622242013875	23	23.000
	BBH	-1.402751345938703	.821346133812597	23	23.000
	AUB	-.440191845546672	1.006537315660785	23	23.000
	UFHT	-.327201726657899	.727704244275356	23	23.000
	NLH	-.499299478985809	.949279828957256	23	23.000
	NLB	.098569675656247	.883944619909484	23	23.000
	OBB	-.357441911535072	.995213255074812	23	23.000
	OBH	.104797588103000	.712724586267061	23	23.000
	EKB	-.537500036305233	1.024807790219363	23	23.000
	FRC	-.779850359563750	.760001344724298	23	23.000
	PAC	-.078421582754171	.706914217749434	23	23.000
	OCC	-.706092189202717	.786095773946915	23	23.000
4	GOL	.443107258631381	.886100326975485	32	32.000
	XCB	-.622074479424876	.631360712562707	32	32.000
	BBH	.376619652141754	.953754150178731	32	32.000
	AUB	.037282807888424	.745422490362297	32	32.000
	UFHT	.185390000613672	.801718297669661	32	32.000

	NLH	-.037487585262206	.885194135550237	32	32.000
	NLB	-.187193325648833	.783681995948054	32	32.000
	OBB	.881715246608230	.985096685151469	32	32.000
	OBH	-.554718741669754	.868630557518744	32	32.000
	EKB	.637715471720254	.961051830143376	32	32.000
	FRC	.423787352963825	1.019265003382260	32	32.000
	PAC	.205966014750195	.913705799722795	32	32.000
	OCC	-.518219189339428	.827433383345977	32	32.000
5	GOL	.180117265954102	.684043020652429	47	47.000
	XCB	.077056067678115	.811718208724308	47	47.000
	BBH	.402440932419475	.723317644206148	47	47.000
	AUB	.198094453697502	.625898821897701	47	47.000
	UFHT	.871868070531707	.681736718830920	47	47.000
	NLH	.737022061663737	.777778759023349	47	47.000
	NLB	.094316590441165	1.015419710835228	47	47.000
	OBB	.296593820816104	.797444606686280	47	47.000
	OBH	.938231530796209	1.105294536156478	47	47.000
	EKB	.726181141078905	.701300294548280	47	47.000
	FRC	.254350652469884	.957554961877154	47	47.000
	PAC	-.029519477952604	.595858837293934	47	47.000
	OCC	.747815667731646	.940498565784968	47	47.000
6	GOL	.717755396313268	.847975686384654	19	19.000
	XCB	.640845534159319	.928742199636449	19	19.000
	BBH	.568865869534995	.568417257177724	19	19.000
	AUB	.537491771477505	.960660093211406	19	19.000
	UFHT	.700211076548882	.605834076179617	19	19.000
	NLH	-.104509406561607	1.097992873750353	19	19.000
	NLB	-.149761966692874	1.174306456897890	19	19.000
	OBB	-.007913253713112	.789498133560641	19	19.000
	OBH	.522095855139511	.910520979380375	19	19.000
	EKB	.994506830058309	.644010724973494	19	19.000
	FRC	.694281671362412	.818561653449448	19	19.000
	PAC	.012570394623471	1.183873551346675	19	19.000
	OCC	.863456339145114	.964723375290576	19	19.000
7	GOL	-.218214387294861	.799351410900441	110	110.000
	XCB	-.601748799676683	.821146716361437	110	110.000
	BBH	-.828589128543221	.807352409435658	110	110.000
	AUB	-.103353991174767	.815673279619786	110	110.000
	UFHT	-.268838602018484	.665725110286412	110	110.000
	NLH	-.521401043856810	.749277978544970	110	110.000
	NLB	-.105687655036580	.838601865602806	110	110.000
	OBB	-.847297507562008	.687778658360295	110	110.000
	OBH	-.218765416606019	.685646390787299	110	110.000
	EKB	-.633467886302656	.795458820794382	110	110.000
	FRC	-.382494568901219	.838580601838667	110	110.000
	PAC	-.427149132009913	.878443865435078	110	110.000
	OCC	.131593993471086	.984922358626440	110	110.000
8	GOL	-.216709961558230	1.010651391559265	44	44.000
	XCB	-.262233712947100	.886907584823269	44	44.000
	BBH	-.217730940488190	.795117810415777	44	44.000
	AUB	.067537001470609	.861533914443297	44	44.000
	UFHT	.216970436011609	.784767852664821	44	44.000
	NLH	.067444473728260	.855814610234563	44	44.000
	NLB	-.030578258641393	.924272658038057	44	44.000
	OBB	.097312398961703	.941585230930289	44	44.000
	OBH	.479783211483848	1.005508936070764	44	44.000
	EKB	-.237685298686205	.863184388020095	44	44.000
	FRC	-.202667945813926	.942554583074191	44	44.000
	PAC	-.018748702764735	.936823810129703	44	44.000
	OCC	-.073716174450188	.833819099862998	44	44.000
9	GOL	-.366122812319439	1.056127935829469	57	57.000
	XCB	.706186238929775	.977503837185195	57	57.000
	BBH	-1.298061380258967	1.211081528854625	57	57.000

	AUB	.553867607378451	.855337373201923	57	57.000
	UFHT	.147796211153862	.776769403434642	57	57.000
	NLH	.209351852739443	.987687762934914	57	57.000
	NLB	.180450763477050	.890654864408820	57	57.000
	OBB	-.048950644333609	.833120010690647	57	57.000
	OBH	.030059035458995	.892568015078486	57	57.000
	EKB	.101074653960879	.787974057750278	57	57.000
	FRC	-.742764069879303	.989396280293260	57	57.000
	PAC	-.365691155748802	1.153987042109636	57	57.000
	OCC	-.479860035999165	.883031202033645	57	57.000
10	GOL	.077394328921294	.922036685674825	166	166.000
	XCB	.165896434055851	.969993263768986	166	166.000
	BBH	.344579999474525	.768062293249877	166	166.000
	AUB	.378265297237364	.834442551684660	166	166.000
	UFHT	.386905136654311	.711390201982483	166	166.000
	NLH	.294869082166699	.867259793062360	166	166.000
	NLB	.023844139104442	.986368679037189	166	166.000
	OBB	.288742886672355	.978728556391175	166	166.000
	OBH	.253895625326961	.984074400137080	166	166.000
	EKB	.082010140294591	.926384256985070	166	166.000
	FRC	.137461560198358	.833606460674306	166	166.000
	PAC	.085726835813227	.979595333910492	166	166.000
	OCC	.085328369475684	.873685510889262	166	166.000
Total	GOL	.005278659297465	.994713700978903	795	795.000
	XCB	.000576783863862	.999247064043639	795	795.000
	BBH	.000379950066212	1.093332506330522	795	795.000
	AUB	.003593829683626	.999745115005902	795	795.000
	UFHT	.001219004004823	1.002191580980338	795	795.000
	NLH	.002869455540042	1.001260085537211	795	795.000
	NLB	.001136682728429	.998596793946935	795	795.000
	OBB	.001493244592477	1.000640093187446	795	795.000
	OBH	.002039571254101	1.001303705492038	795	795.000
	EKB	.001183969554193	.999316274074645	795	795.000
	FRC	.004061228462402	.998168922116532	795	795.000
	PAC	-.005204892214422	.985786516188666	795	795.000
	OCC	.003250713027572	.999716862412422	795	795.000

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
GOL	.953	4.312	9	785	.000
XCB	.865	13.644	9	785	.000
BBH	.684	40.208	9	785	.000
AUB	.888	10.983	9	785	.000
UFHT	.847	15.713	9	785	.000
NLH	.897	9.993	9	785	.000
NLB	.991	.827	9	785	.591
OBB	.841	16.441	9	785	.000
OBH	.870	13.072	9	785	.000
EKB	.856	14.615	9	785	.000
FRC	.880	11.897	9	785	.000
PAC	.938	5.734	9	785	.000
OCC	.893	10.424	9	785	.000

Analysis 1

Box's Test of Equality of Covariance Matrices

Log Determinants

GROUP	Rank	Log Determinant
1	13	-5.036
2	13	-7.517
3	13	-15.776
4	13	-15.033
5	13	-11.429
6	13	-14.664
7	13	-12.358
8	13	-11.699
9	13	-9.133
10	13	-8.548
Pooled within-groups	13	-6.988

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Test Results

Box's M		1511.381
F	Approx.	1.608
	df1	819
	df2	61828.081
	Sig.	.000

Tests null hypothesis of equal population covariance matrices.

Summary of Canonical Discriminant Functions

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.772[a]	41.9	41.9	.660
2	.364[a]	19.8	61.6	.517
3	.244[a]	13.2	74.9	.443
4	.198[a]	10.7	85.6	.406
5	.130[a]	7.0	92.6	.339
6	.068[a]	3.7	96.3	.252
7	.045[a]	2.4	98.7	.207
8	.020[a]	1.1	99.8	.139
9	.004[a]	.2	100.0	.062

a. First 9 canonical discriminant functions were used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 9	.215	1202.454	117	.000
2 through 9	.381	754.601	96	.000
3 through 9	.520	511.500	77	.000
4 through 9	.647	340.527	60	.000
5 through 9	.775	199.266	45	.000
6 through 9	.876	103.876	32	.000
7 through 9	.935	52.483	21	.000
8 through 9	.977	18.250	12	.108
9	.996	3.006	5	.699

Standardized Canonical Discriminant Function Coefficients

	Function								
	1	2	3	4	5	6	7	8	9
GOL	-.123	-.576	-.197	-.022	-.463	.792	.542	-.217	1.094
XCB	-.152	-.583	.805	-.585	.193	.296	-.041	-.534	.103
BBH	-1.063	.211	.022	.184	.310	.606	-.050	-.012	.254
AUB	.705	.136	-.263	.725	.016	.431	-.671	.262	-.295
UFHT	.448	.481	.253	.383	-.226	.303	.246	-.330	.236
NLH	-.206	-.213	.241	-.211	.206	-.814	-.401	.739	.441
NLB	.106	-.162	-.006	.140	.487	.037	.126	.114	.284
OBB	-.216	-.602	.076	1.075	.135	-.446	.114	-.675	-.049
OBH	.147	.414	.216	-.077	.447	.262	.663	.038	-.300
EKB	-.249	.732	.245	-.961	-1.068	-.309	-.024	.475	-.380
FRC	.022	.240	-.406	-.115	-.093	-.269	-.203	.087	-.577
PAC	.252	.145	.172	.042	.326	-.216	.102	.426	-.600
OCC	.365	.644	-.165	-.255	.335	-.590	-.365	-.329	-.046

Structure Matrix

	Function								
	1	2	3	4	5	6	7	8	9
BBH	-.691*	.424	.158	.195	.132	.352	-.248	.024	.138
FRC	-.358*	.281	.027	.056	-.133	.278	-.111	-.036	.019
OCC	-.024	.523*	-.052	-.181	.178	-.101	-.230	-.492	.349
XCB	-.047	-.087	.728*	-.202	.016	.325	-.361	-.270	-.025
NLH	-.075	.225	.547*	.229	.057	-.218	-.155	.377	.469
UFHT	.102	.474	.486*	.370	-.179	.085	.028	.017	.413
OBB	-.291	.082	.466	.504*	-.302	-.245	.090	-.266	-.041
EKB	-.205	.287	.510	.036	-.562*	-.028	-.034	.068	-.031
AUB	.176	.184	.432	.300	-.162	.390	-.528*	.111	-.029
OBH	.125	.427	.457	.116	.242	.013	.468*	-.013	-.110
PAC	-.248	-.022	.152	.075	.023	.303	.227	.358*	-.075
NLB	.010	-.044	.161	-.039	.067	.015	.021	.256*	.229
GOL	-.158	.156	.063	.023	-.271	.350	.177	-.008	.480*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions

Variables ordered by absolute size of correlation within function.

*. Largest absolute correlation between each variable and any discriminant function

Canonical Discriminant Function Coefficients

	Function								
	1	2	3	4	5	6	7	8	9
GOL	-.126	-.590	-.201	-.022	-.474	.811	.555	-.222	1.120
XCB	-.163	-.623	.861	-.626	.207	.317	-.044	-.572	.110
BBH	-1.168	.231	.024	.202	.340	.666	-.055	-.014	.279
AUB	.743	.143	-.278	.765	.017	.455	-.708	.277	-.311
UFHT	.483	.519	.273	.413	-.244	.326	.265	-.356	.254
NLH	-.216	-.224	.253	-.221	.216	-.854	-.420	.775	.463
NLB	.106	-.162	-.006	.140	.487	.037	.126	.114	.285
OBB	-.234	-.652	.083	1.164	.146	-.484	.124	-.731	-.054
OBH	.157	.441	.230	-.082	.476	.279	.705	.040	-.319
EKB	-.268	.787	.263	-1.034	-1.149	-.332	-.026	.511	-.409
FRC	.024	.255	-.431	-.122	-.099	-.286	-.215	.093	-.613
PAC	.262	.151	.179	.044	.340	-.225	.107	.443	-.624
OCC	.384	.678	-.174	-.268	.353	-.621	-.385	-.347	-.049
(Constant)	-.001	.000	.003	-.001	.003	-.002	.001	.002	-.006

Unstandardized coefficients

Functions at Group Centroids

GROUP	Function 1	2	3	4	5	6	7	8	9
1	-.886	-.329	.018	-.307	.078	.077	-.003	.079	-.011
2	-.696	-.090	-.474	-.104	.105	-.584	-.085	-.347	.005
3	1.225	-1.205	.123	-.172	-.027	.163	.964	-.172	.129
4	-.890	-.176	-.523	1.051	-1.375	-.125	.100	.117	-.002
5	.082	1.598	.598	-.325	-.050	-.468	.202	.182	.057
6	.053	1.578	.374	-.996	-.924	.801	.031	-.425	-.102
7	1.250	.176	-.889	-.198	.038	.068	-.096	.073	.013
8	.538	.209	.026	.609	.428	-.089	.309	.018	-.204
9	1.595	-.890	.958	-.194	-.342	-.221	-.261	.005	-.029
10	-.025	.209	.259	.545	.219	.183	-.109	-.054	.047

Unstandardized canonical discriminant functions evaluated at group means

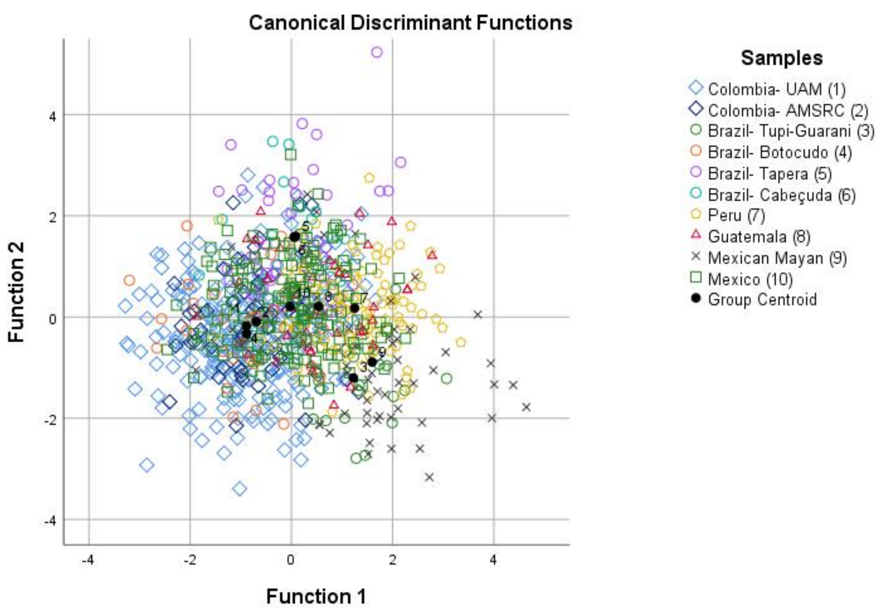
Classification Statistics

Classification Processing Summary

Processed		795
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	0
Used in Output		795

Prior Probabilities for Groups

GROUP	Prior	Cases Used in Analysis: Unweighted	Weighted
1	.303	241	241.000
2	.070	56	56.000
3	.029	23	23.000
4	.040	32	32.000
5	.059	47	47.000
6	.024	19	19.000
7	.138	110	110.000
8	.055	44	44.000
9	.072	57	57.000
10	.209	166	166.000
Total	1.000	795	795.000



Classification Results[a,c]

		GROUP	Predicted Group Membership 1	2	3	4	5	6	7	8	9	10	Total
Original	Count	1	181	5	1	2	5	2	11	0	2	32	241
		2	31	5	2	3	1	1	1	0	3	9	56
		3	3	0	11	0	0	0	2	0	5	2	23
		4	8	0	0	14	0	0	1	0	0	9	32
		5	11	0	0	0	20	1	2	0	1	12	47
		6	2	0	0	0	2	8	1	0	0	6	19
		7	13	1	1	0	1	0	75	1	4	14	110
		8	10	0	0	1	2	1	8	2	1	19	44
		9	5	0	1	0	2	0	6	0	35	8	57
		10	42	1	0	4	7	1	16	2	7	86	166
	%	1	75.1	2.1	.4	.8	2.1	.8	4.6	.0	.8	13.3	100.0
		2	55.4	8.9	3.6	5.4	1.8	1.8	1.8	.0	5.4	16.1	100.0
		3	13.0	.0	47.8	.0	.0	.0	8.7	.0	21.7	8.7	100.0
		4	25.0	.0	.0	43.8	.0	.0	3.1	.0	.0	28.1	100.0
		5	23.4	.0	.0	.0	42.6	2.1	4.3	.0	2.1	25.5	100.0
		6	10.5	.0	.0	.0	10.5	42.1	5.3	.0	.0	31.6	100.0
		7	11.8	.9	.9	.0	.9	.0	68.2	.9	3.6	12.7	100.0
		8	22.7	.0	.0	2.3	4.5	2.3	18.2	4.5	2.3	43.2	100.0
		9	8.8	.0	1.8	.0	3.5	.0	10.5	.0	61.4	14.0	100.0
		10	25.3	.6	.0	2.4	4.2	.6	9.6	1.2	4.2	51.8	100.0
Cross-validated[b]	Count	1	177	5	1	2	6	2	13	0	3	32	241
		2	32	4	2	3	1	1	1	0	3	9	56
		3	4	0	7	0	0	0	3	0	6	3	23
		4	9	0	0	13	0	0	1	0	0	9	32
		5	11	0	0	0	15	1	2	1	2	15	47
		6	2	0	0	0	2	8	1	0	0	6	19
		7	15	1	1	0	1	0	72	1	6	13	110
		8	10	0	0	1	2	1	8	0	1	21	44
		9	6	0	1	0	2	0	6	0	34	8	57
		10	41	1	0	4	10	1	16	2	7	84	166
	%	1	73.4	2.1	.4	.8	2.5	.8	5.4	.0	1.2	13.3	100.0
		2	57.1	7.1	3.6	5.4	1.8	1.8	1.8	.0	5.4	16.1	100.0
		3	17.4	.0	30.4	.0	.0	.0	13.0	.0	26.1	13.0	100.0
		4	28.1	.0	.0	40.6	.0	.0	3.1	.0	.0	28.1	100.0
		5	23.4	.0	.0	.0	31.9	2.1	4.3	2.1	4.3	31.9	100.0
		6	10.5	.0	.0	.0	10.5	42.1	5.3	.0	.0	31.6	100.0
		7	13.6	.9	.9	.0	.9	.0	65.5	.9	5.5	11.8	100.0
		8	22.7	.0	.0	2.3	4.5	2.3	18.2	.0	2.3	47.7	100.0
		9	10.5	.0	1.8	.0	3.5	.0	10.5	.0	59.6	14.0	100.0
		10	24.7	.6	.0	2.4	6.0	.6	9.6	1.2	4.2	50.6	100.0

a. 55.0% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 52.1% of cross-validated grouped cases correctly classified.

APPENDIX D: Discriminant Function Analysis Output of Combined Country Samples

Analysis Case Processing Summary

Unweighted Cases		N	Percent
Valid		795	99.9
Excluded	Missing or out-of-range group codes	0	.0
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	1	.1
	Total	1	.1
Total		796	100.0

Group Statistics

GROUP		Mean	Std. Deviation	Valid N (listwise) Unweighted	Weighted
1	GOL	.037590504722030	1.108799723545067	297	297.000
	XCB	.054626837747734	1.013729760385414	297	297.000
	BBH	.364661687976555	1.010230692376298	297	297.000
	AUB	-.315486558200961	1.125796485352505	297	297.000
	UFHT	-.351328725841595	1.197495261466337	297	297.000
	NLH	-.081429008551320	1.088052527868880	297	297.000
	NLB	.005948178757291	1.102102435259154	297	297.000
	OBB	.037655540686754	.990374641651846	297	297.000
	OBH	-.262494589714022	.986412351656611	297	297.000
	EKB	.002139394628122	1.043231484449991	297	297.000
	FRC	.178346573622569	1.029566044515583	297	297.000
	PAC	.157065862499075	1.007771622887045	297	297.000
	OCC	-.047777341571457	1.037123178002949	297	297.000
2	GOL	.285888569019104	.812312905850752	121	121.000
	XCB	-.048152065929487	.892221982227679	121	121.000
	BBH	.078609283114266	1.063532337288680	121	121.000
	AUB	.087532399890176	.841889918678357	121	121.000
	UFHT	.435443389057230	.842730990499465	121	121.000
	NLH	.165048491144305	1.007736982722688	121	121.000
	NLB	-.017650260306602	.960171710420208	121	121.000
	OBB	.279200675074087	.978365870584559	121	121.000
	OBH	.319636760231483	1.117940237540505	121	121.000
	EKB	.504715187287969	.975699802269654	121	121.000
	FRC	.171656772287988	1.030859404570689	121	121.000
	PAC	.030071389278792	.815824346260628	121	121.000
	OCC	.154792334021656	1.117552183503929	121	121.000
3	GOL	-.218214387294861	.799351410900441	110	110.000
	XCB	-.601748799676683	.821146716361437	110	110.000
	BBH	-.828589128543221	.807352409435658	110	110.000
	AUB	-.103353991174767	.815673279619786	110	110.000
	UFHT	-.268838602018484	.665725110286412	110	110.000
	NLH	-.521401043856810	.749277978544970	110	110.000
	NLB	-.105687655036580	.838601865602806	110	110.000
	OBB	-.847297507562008	.687778658360295	110	110.000
	OBH	-.218765416606019	.685646390787299	110	110.000
	EKB	-.633467886302656	.795458820794382	110	110.000
	FRC	-.382494568901219	.838580601838667	110	110.000
	PAC	-.427149132009913	.878443865435078	110	110.000
	OCC	.131593993471086	.984922358626440	110	110.000
4	GOL	-.216709961558230	1.010651391559265	44	44.000
	XCB	-.262233712947100	.886907584823269	44	44.000
	BBH	-.217730940488190	.795117810415777	44	44.000
	AUB	.067537001470609	.861533914443297	44	44.000
	UFHT	.216970436011609	.784767852664821	44	44.000

	NLH	.067444473728260	.855814610234563	44	44.000
	NLB	-.030578258641393	.924272658038057	44	44.000
	OBB	.097312398961703	.941585230930289	44	44.000
	OBH	.479783211483848	1.005508936070764	44	44.000
	EKB	-.237685298686205	.863184388020095	44	44.000
	FRC	-.202667945813926	.942554583074191	44	44.000
	PAC	-.018748702764735	.936823810129703	44	44.000
	OCC	-.073716174450188	.833819099862998	44	44.000
5	GOL	-.366122812319439	1.056127935829469	57	57.000
	XCB	.706186238929775	.977503837185195	57	57.000
	BBH	-1.298061380258967	1.211081528854625	57	57.000
	AUB	.553867607378451	.855337373201923	57	57.000
	UFHT	.147796211153862	.776769403434642	57	57.000
	NLH	.209351852739443	.987687762934914	57	57.000
	NLB	.180450763477050	.890654864408820	57	57.000
	OBB	-.048950644333609	.833120010690647	57	57.000
	OBH	.030059035458995	.892568015078486	57	57.000
	EKB	.101074653960879	.787974057750278	57	57.000
	FRC	-.742764069879303	.989396280293260	57	57.000
	PAC	-.365691155748802	1.153987042109636	57	57.000
	OCC	-.479860035999165	.883031202033645	57	57.000
6	GOL	.077394328921294	.922036685674825	166	166.000
	XCB	.165896434055851	.969993263768986	166	166.000
	BBH	.344579999474525	.768062293249877	166	166.000
	AUB	.378265297237364	.834442551684660	166	166.000
	UFHT	.386905136654311	.711390201982483	166	166.000
	NLH	.294869082166699	.867259793062360	166	166.000
	NLB	.023844139104442	.986368679037189	166	166.000
	OBB	.288742886672355	.978728556391175	166	166.000
	OBH	.253895625326961	.984074400137080	166	166.000
	EKB	.082010140294591	.926384256985070	166	166.000
	FRC	.137461560198358	.833606460674306	166	166.000
	PAC	.085726835813227	.979595333910492	166	166.000
	OCC	.085328369475684	.873685510889262	166	166.000
Total	GOL	.005278659297465	.994713700978903	795	795.000
	XCB	.000576783863862	.999247064043639	795	795.000
	BBH	.000379950066212	1.093332506330522	795	795.000
	AUB	.003593829683626	.999745115005902	795	795.000
	UFHT	.001219004004823	1.002191580980338	795	795.000
	NLH	.002869455540042	1.001260085537210	795	795.000
	NLB	.001136682728429	.998596793946935	795	795.000
	OBB	.001493244592477	1.000640093187446	795	795.000
	OBH	.002039571254101	1.001303705492038	795	795.000
	EKB	.001183969554193	.999316274074645	795	795.000
	FRC	.004061228462402	.998168922116532	795	795.000
	PAC	-.005204892214422	.985786516188666	795	795.000
	OCC	.003250713027572	.999716862412422	795	795.000

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
GOL	.967	5.450	5	789	.000
XCB	.903	16.979	5	789	.000
BBH	.754	51.518	5	789	.000
AUB	.908	16.008	5	789	.000
UFHT	.880	21.523	5	789	.000
NLH	.934	11.096	5	789	.000
NLB	.996	.654	5	789	.659
OBB	.870	23.543	5	789	.000
OBH	.926	12.624	5	789	.000
EKB	.900	17.498	5	789	.000
FRC	.917	14.241	5	789	.000
PAC	.953	7.800	5	789	.000
OCC	.975	4.090	5	789	.001

Analysis 1

Box's Test of Equality of Covariance Matrices

Log Determinants

GROUP	Rank	Log Determinant
1	13	-4.936
2	13	-7.842
3	13	-12.358
4	13	-11.699
5	13	-9.133
6	13	-8.548
Pooled within-groups	13	-6.547

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Test Results

Box's M		1008.431
F	Approx.	2.078
	df1	455
	df2	164167.807
	Sig.	.000

Tests null hypothesis of equal population covariance matrices.

Summary of Canonical Discriminant Functions

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.670[a]	54.3	54.3	.634
2	.230[a]	18.7	73.0	.433
3	.199[a]	16.2	89.1	.408
4	.117[a]	9.5	98.6	.324
5	.017[a]	1.4	100.0	.130

a. First 5 canonical discriminant functions were used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 5	.357	808.023	65	.000
2 through 5	.596	405.519	48	.000
3 through 5	.734	242.847	33	.000
4 through 5	.880	100.163	20	.000
5	.983	13.307	9	.149

Standardized Canonical Discriminant Function Coefficients

	Function				
	1	2	3	4	5
GOL	-.155	-.032	-.173	-.218	.522
XCB	-.352	.859	-.436	.098	.182
BBH	-1.059	-.206	.482	.286	.428
AUB	.841	-.175	.393	.587	.474
UFHT	.515	.075	.685	-.264	.179
NLH	-.242	.333	-.425	.087	-.043
NLB	.041	-.017	.064	.423	-.122
OBB	-.193	.468	.438	.609	-.401
OBH	.080	-.140	.441	-.042	-.551
EKB	-.154	-.019	-.352	-1.514	.101
FRC	.081	-.403	-.155	-.095	-.180
PAC	.228	.061	.118	.139	-.539
OCC	.372	-.351	.009	-.004	-.033

Structure Matrix

	Function 1	2	3	4	5
BBH	-.628*	-.095	.532	.039	.456
PAC	-.252*	.070	.169	-.012	-.066
XCB	-.089	.656*	.012	.024	.426
NLH	-.054	.401*	.390	-.066	.176
NLB	-.004	.133*	-.012	.012	.040
UFHT	.161	.266	.681*	-.277	.286
OBH	.114	.158	.549*	-.160	-.373
OBB	-.246	.466	.518*	-.209	-.074
EKB	-.152	.381	.307	-.601*	.216
AUB	.233	.362	.376	.077	.592*
GOL	-.135	-.039	.215	-.302	.353*
FRC	-.317	-.112	.279	-.150	.328*
OCC	-.015	-.258	.191	-.107	.324*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
Variables ordered by absolute size of correlation within function.
*. Largest absolute correlation between each variable and any discriminant function

Canonical Discriminant Function Coefficients

	Function 1	2	3	4	5
GOL	-.158	-.033	-.177	-.222	.532
XCB	-.370	.902	-.458	.102	.191
BBH	-1.112	-.216	.506	.300	.450
AUB	.880	-.183	.411	.614	.496
UFHT	.546	.080	.726	-.280	.190
NLH	-.249	.343	-.438	.089	-.045
NLB	.041	-.017	.064	.424	-.122
OBB	-.206	.499	.467	.651	-.428
OBH	.082	-.144	.456	-.043	-.570
EKB	-.161	-.020	-.370	-1.592	.107
FRC	.084	-.420	-.162	-.099	-.188
PAC	.236	.063	.122	.144	-.558
OCC	.376	-.355	.010	-.004	-.033
(Constant)	-.002	.002	.000	.001	-.005

Unstandardized coefficients

Functions at Group Centroids

GROUP	Function 1	2	3	4	5
1	-.878	-.018	-.309	.045	-.017
2	.124	-.034	.357	-.754	-.008
3	1.239	-.826	-.371	.102	.051
4	.540	-.057	.584	.369	-.483
5	1.429	1.339	-.636	-.012	-.003
6	.025	.160	.603	.309	.132

Unstandardized canonical discriminant functions evaluated at group means

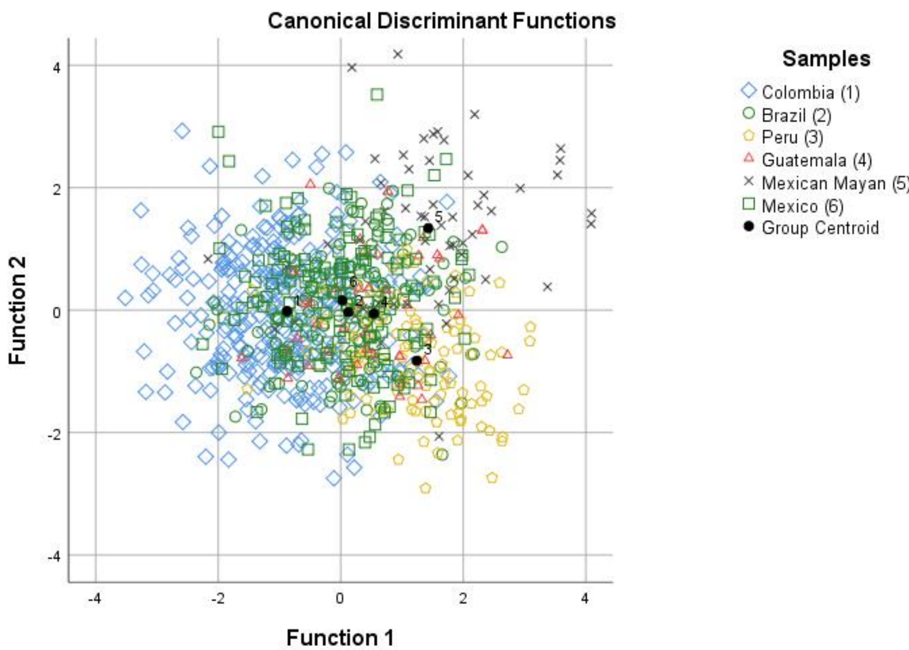
Classification Statistics

Classification Processing Summary

Processed		796
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	1
Used in Output		795

Prior Probabilities for Groups

GROUP	Prior	Cases Used in Analysis	
		Unweighted	Weighted
1	.374	297	297.000
2	.152	121	121.000
3	.138	110	110.000
4	.055	44	44.000
5	.072	57	57.000
6	.209	166	166.000
Total	1.000	795	795.000



Classification Results[a,c]

		GROUP	Predicted Group Membership 1	2	3	4	5	6	7	8	9	10	Total
Original	Count	1	181	5	1	2	5	2	11	0	2	32	241
		2	31	5	2	3	1	1	1	0	3	9	56
		3	3	0	11	0	0	0	2	0	5	2	23
		4	8	0	0	14	0	0	1	0	0	9	32
		5	11	0	0	0	20	1	2	0	1	12	47
		6	2	0	0	0	2	8	1	0	0	6	19
		7	13	1	1	0	1	0	75	1	4	14	110
		8	10	0	0	1	2	1	8	2	1	19	44
		9	5	0	1	0	2	0	6	0	35	8	57
		10	42	1	0	4	7	1	16	2	7	86	166
	%	1	75.1	2.1	.4	.8	2.1	.8	4.6	.0	.8	13.3	100.0
		2	55.4	8.9	3.6	5.4	1.8	1.8	1.8	.0	5.4	16.1	100.0
		3	13.0	.0	47.8	.0	.0	.0	8.7	.0	21.7	8.7	100.0
		4	25.0	.0	.0	43.8	.0	.0	3.1	.0	.0	28.1	100.0
		5	23.4	.0	.0	.0	42.6	2.1	4.3	.0	2.1	25.5	100.0
		6	10.5	.0	.0	.0	10.5	42.1	5.3	.0	.0	31.6	100.0
		7	11.8	.9	.9	.0	.9	.0	68.2	.9	3.6	12.7	100.0
		8	22.7	.0	.0	2.3	4.5	2.3	18.2	4.5	2.3	43.2	100.0
		9	8.8	.0	1.8	.0	3.5	.0	10.5	.0	61.4	14.0	100.0
		10	25.3	.6	.0	2.4	4.2	.6	9.6	1.2	4.2	51.8	100.0
Cross-validated[b]	Count	1	177	5	1	2	6	2	13	0	3	32	241
		2	32	4	2	3	1	1	1	0	3	9	56
		3	4	0	7	0	0	0	3	0	6	3	23
		4	9	0	0	13	0	0	1	0	0	9	32
		5	11	0	0	0	15	1	2	1	2	15	47
		6	2	0	0	0	2	8	1	0	0	6	19
		7	15	1	1	0	1	0	72	1	6	13	110
		8	10	0	0	1	2	1	8	0	1	21	44
		9	6	0	1	0	2	0	6	0	34	8	57
		10	41	1	0	4	10	1	16	2	7	84	166
	%	1	73.4	2.1	.4	.8	2.5	.8	5.4	.0	1.2	13.3	100.0
		2	57.1	7.1	3.6	5.4	1.8	1.8	1.8	.0	5.4	16.1	100.0
		3	17.4	.0	30.4	.0	.0	.0	13.0	.0	26.1	13.0	100.0
		4	28.1	.0	.0	40.6	.0	.0	3.1	.0	.0	28.1	100.0
		5	23.4	.0	.0	.0	31.9	2.1	4.3	2.1	4.3	31.9	100.0
		6	10.5	.0	.0	.0	10.5	42.1	5.3	.0	.0	31.6	100.0
		7	13.6	.9	.9	.0	.9	.0	65.5	.9	5.5	11.8	100.0
		8	22.7	.0	.0	2.3	4.5	2.3	18.2	.0	2.3	47.7	100.0
		9	10.5	.0	1.8	.0	3.5	.0	10.5	.0	59.6	14.0	100.0
		10	24.7	.6	.0	2.4	6.0	.6	9.6	1.2	4.2	50.6	100.0

a. 55.0% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 52.1% of cross-validated grouped cases correctly classified.

APPENDIX E: Discriminant Function Analysis Output of Combined Country Samples and Identified OpID Individuals

Analysis Case Processing Summary

Unweighted Cases		N	Percent
Valid		778	97.5
Excluded	Missing or out-of-range group codes	20	2.5
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	20	2.5
Total		798	100.0

Group Statistics

GROUP		Mean	Std. Deviation	Valid N (listwise) Unweighted	Weighted
1	GOL	.037590504722030	1.108799723545067	297	297.000
	XCB	.054626837747734	1.013729760385414	297	297.000
	BBH	.364661687976555	1.010230692376298	297	297.000
	AUB	-.315486558200961	1.125796485352505	297	297.000
	UFHT	-.351328725841595	1.197495261466337	297	297.000
	NLH	-.081429008551320	1.088052527868880	297	297.000
	NLB	.005948178757291	1.102102435259154	297	297.000
	OBB	.037655540686754	.990374641651846	297	297.000
	OBH	-.262494589714022	.986412351656611	297	297.000
	EKB	.002139394628122	1.043231484449991	297	297.000
	FRC	.178346573622569	1.029566044515583	297	297.000
	PAC	.157065862499075	1.007771622887045	297	297.000
	OCC	-.047777341571457	1.037123178002949	297	297.000
2	GOL	.285888569019104	.812312905850752	121	121.000
	XCB	-.048152065929487	.892221982227679	121	121.000
	BBH	.078609283114266	1.063532337288680	121	121.000
	AUB	.087532399890176	.841889918678357	121	121.000
	UFHT	.435443389057230	.842730990499465	121	121.000
	NLH	.165048491144305	1.007736982722688	121	121.000
	NLB	-.017650260306602	.960171710420208	121	121.000
	OBB	.279200675074087	.978365870584559	121	121.000
	OBH	.319636760231483	1.117940237540505	121	121.000
	EKB	.504715187287969	.975699802269654	121	121.000
	FRC	.171656772287988	1.030859404570689	121	121.000
	PAC	.030071389278792	.815824346260628	121	121.000
	OCC	.154792334021656	1.117552183503929	121	121.000
3	GOL	-.218214387294861	.799351410900441	110	110.000
	XCB	-.601748799676683	.821146716361437	110	110.000
	BBH	-.828589128543221	.807352409435658	110	110.000
	AUB	-.103353991174767	.815673279619786	110	110.000
	UFHT	-.268838602018484	.665725110286412	110	110.000
	NLH	-.521401043856810	.749277978544970	110	110.000
	NLB	-.105687655036580	.838601865602806	110	110.000
	OBB	-.847297507562008	.687778658360295	110	110.000
	OBH	-.218765416606019	.685646390787299	110	110.000
	EKB	-.633467886302656	.795458820794382	110	110.000
	FRC	-.382494568901219	.838580601838667	110	110.000
	PAC	-.427149132009913	.878443865435078	110	110.000
	OCC	.131593993471086	.984922358626440	110	110.000
4	GOL	-.233102447089533	1.020704075210664	34	34.000
	XCB	-.295310673694310	.859637757075308	34	34.000
	BBH	-.229037072054854	.840820689467393	34	34.000

	AUB	.074271257582985	.878082523531120	34	34.000
	UFHT	.149337780489298	.769503209991315	34	34.000
	NLH	.044431388141842	.873481917896598	34	34.000
	NLB	-.190424453134143	.865875240355135	34	34.000
	OBB	-.014650443397567	.946437097388038	34	34.000
	OBH	.400044957903574	1.088548089671243	34	34.000
	EKB	-.357732966213636	.844922817249257	34	34.000
	FRC	-.248101980821571	.989924951635081	34	34.000
	PAC	-.045717956359450	.947342989916217	34	34.000
	OCC	-.175188954666654	.861529340001685	34	34.000
5	GOL	-.366122812319439	1.056127935829469	57	57.000
	XCB	.706186238929775	.977503837185195	57	57.000
	BBH	-1.298061380258967	1.211081528854625	57	57.000
	AUB	.553867607378451	.855337373201923	57	57.000
	UFHT	.147796211153862	.776769403434642	57	57.000
	NLH	.209351852739443	.987687762934914	57	57.000
	NLB	.180450763477050	.890654864408820	57	57.000
	OBB	-.048950644333609	.833120010690647	57	57.000
	OBH	.030059035458995	.892568015078486	57	57.000
	EKB	.101074653960879	.787974057750278	57	57.000
	FRC	-.742764069879303	.989396280293260	57	57.000
	PAC	-.365691155748802	1.153987042109636	57	57.000
	OCC	-.479860035999165	.883031202033645	57	57.000
6	GOL	.098304823064035	.897222029916280	159	159.000
	XCB	.167023023015221	.973256034440599	159	159.000
	BBH	.340415213823610	.768624101933583	159	159.000
	AUB	.389887521869471	.842247926438603	159	159.000
	UFHT	.398377915827393	.720165938440979	159	159.000
	NLH	.298451361699049	.883766125188675	159	159.000
	NLB	.039655506761936	.991136263896687	159	159.000
	OBB	.295339342643026	.993349886338761	159	159.000
	OBH	.271244510686537	.989761796162319	159	159.000
	EKB	.080605218731042	.935142952409789	159	159.000
	FRC	.162627787660152	.810004204694320	159	159.000
	PAC	.092645326063344	.991209006391549	159	159.000
	OCC	.090254833381990	.875676862851751	159	159.000
Total	GOL	.011040228168701	.991114985762660	778	778.000
	XCB	.001252077431857	1.000378288501956	778	778.000
	BBH	-.001258739949310	1.099720616085848	778	778.000
	AUB	.002070393222931	1.004960866261384	778	778.000
	UFHT	-.005635309167224	1.007074666609103	778	778.000
	NLH	-.000861405684332	1.007430732456169	778	778.000
	NLB	-.002414173230628	.999229885017224	778	778.000
	OBB	-.005867731216173	1.004429280745754	778	778.000
	OBH	-.006306259890326	1.003838743582898	778	778.000
	EKB	-.002006382293256	1.003714524604043	778	778.000
	FRC	.008675833085509	.999064421208760	778	778.000
	PAC	-.005613630855993	.989366600157082	778	778.000
	OCC	.000073795949659	1.004657544286220	778	778.000

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
GOL	.965	5.549	5	772	.000
XCB	.901	16.927	5	772	.000
BBH	.753	50.621	5	772	.000
AUB	.906	15.957	5	772	.000
UFHT	.880	21.105	5	772	.000
NLH	.934	10.877	5	772	.000
NLB	.994	.923	5	772	.465
OBB	.869	23.307	5	772	.000
OBH	.929	11.722	5	772	.000
EKB	.897	17.803	5	772	.000
FRC	.914	14.550	5	772	.000
PAC	.952	7.792	5	772	.000
OCC	.973	4.237	5	772	.001

Analysis 1

Box's Test of Equality of Covariance Matrices

Log Determinants

GROUP	Rank	Log Determinant
1	13	-4.936
2	13	-7.842
3	13	-12.358
4	13	-12.317
5	13	-9.133
6	13	-8.451
Pooled within-groups	13	-6.479

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Test Results

Box's M		1000.323
F	Approx.	2.043
	df1	455
	df2	107653.455
	Sig.	.000

Tests null hypothesis of equal population covariance matrices.

Summary of Canonical Discriminant Functions

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.681[a]	54.9	54.9	.636
2	.233[a]	18.8	73.7	.435
3	.194[a]	15.6	89.4	.403
4	.120[a]	9.7	99.0	.327
5	.012[a]	1.0	100.0	.109

a. First 5 canonical discriminant functions were used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 5	.357	791.271	65	.000
2 through 5	.599	392.848	48	.000
3 through 5	.739	231.911	33	.000
4 through 5	.882	96.125	20	.000
5	.988	9.154	9	.423

Standardized Canonical Discriminant Function Coefficients

	Function 1	2	3	4	5
GOL	.157	-.033	-.128	-.176	.195
XCB	.356	.870	-.397	.098	.228
BBH	1.053	-.232	.466	.305	.186
AUB	-.853	-.196	.390	.610	.341
UFHT	-.521	.049	.692	-.259	.205
NLH	.247	.349	-.414	.081	-.084
NLB	-.049	-.023	.045	.401	.210
OBB	.192	.443	.427	.618	-.265
OBH	-.077	-.154	.428	-.032	-.560
EKB	.165	.018	-.323	-1.524	.065
FRC	-.079	-.389	-.156	-.099	.107
PAC	-.221	.061	.093	.116	-.353
OCC	-.366	-.344	-.026	-.048	.282

Structure Matrix

	Function 1	2	3	4	5
BBH	.624*	-.118	.542	.061	.464
PAC	.253*	.064	.176	-.002	-.026
XCB	.087	.657*	.052	.040	.511
UFHT	-.159	.242	.709*	-.253	.284
OBH	-.108	.141	.554*	-.147	-.358
OBB	.250	.449	.542*	-.191	.027
NLH	.053	.384	.416*	-.044	.153
EKB	.155	.377	.342	-.591*	.328
AUB	-.236	.345	.412	.102	.563*
OCC	.017	-.263	.183	-.118	.498*
FRC	.317	-.119	.307	-.128	.443*
GOL	.134	-.043	.251	-.279	.389*
NLB	.009	.138	-.013	-.002	.344*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
Variables ordered by absolute size of correlation within function.
*. Largest absolute correlation between each variable and any discriminant function

Canonical Discriminant Function Coefficients

	Function 1	2	3	4	5
GOL	.161	-.034	-.131	-.181	.200
XCB	.373	.914	-.416	.102	.239
BBH	1.100	-.243	.487	.319	.194
AUB	-.888	-.205	.407	.636	.355
UFHT	-.550	.051	.730	-.273	.216
NLH	.253	.357	-.424	.083	-.086
NLB	-.049	-.023	.045	.401	.210
OBB	.205	.471	.455	.658	-.283
OBH	-.079	-.159	.441	-.033	-.577
EKB	.173	.019	-.339	-1.598	.068
FRC	-.082	-.406	-.163	-.103	.112
PAC	-.228	.063	.096	.120	-.365
OCC	-.368	-.346	-.026	-.048	.284
(Constant)	-.002	.006	.012	.002	-.010

Unstandardized coefficients

Functions at Group Centroids

GROUP	Function 1	2	3	4	5
1	.874	-.003	-.300	.041	-.008
2	-.120	-.034	.384	-.741	-.018
3	-1.245	-.806	-.383	.082	.042
4	-.530	-.107	.497	.453	-.468
5	-1.427	1.362	-.558	-.010	.000
6	-.055	.125	.627	.337	.099

Unstandardized canonical discriminant functions evaluated at group means

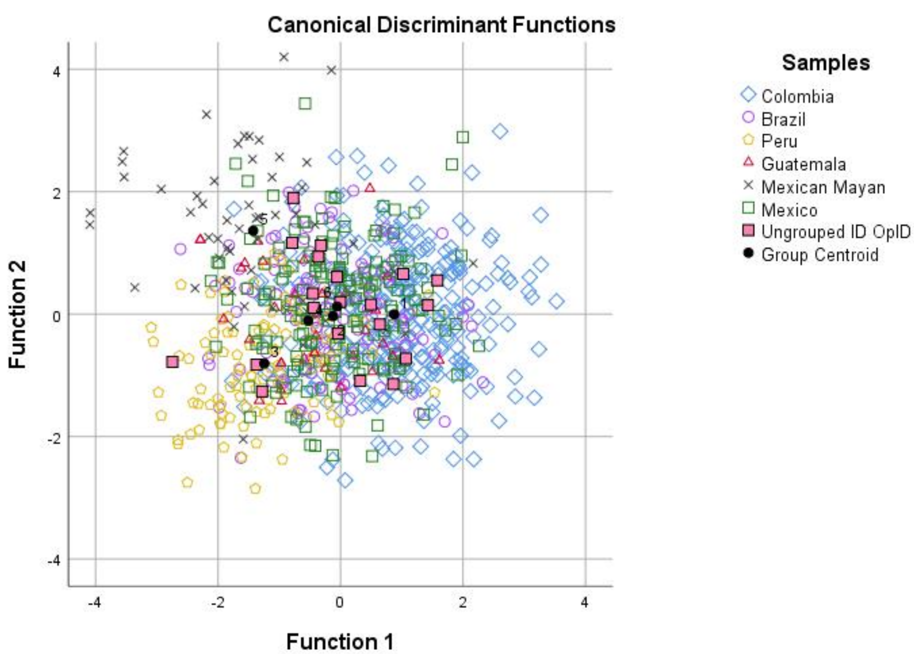
Classification Statistics

Classification Processing Summary

Processed		798
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	0
Used in Output		798

Prior Probabilities for Groups

GROUP	Prior	Cases Used in Analysis: Unweighted	Weighted
1	.382	297	297.000
2	.156	121	121.000
3	.141	110	110.000
4	.044	34	34.000
5	.073	57	57.000
6	.204	159	159.000
Total	1.000	778	778.000



Classification Results[a,c]

		GROUP	Predicted Group Membership 1	2	3	4	5	6	Total
Original	Count	1	225	23	13	0	5	31	297
		2	40	46	7	0	8	20	121
		3	18	9	71	0	1	11	110
		4	12	2	6	0	1	13	34
		5	6	4	4	0	36	7	57
		6	56	13	12	1	7	70	159
		Ungrouped cases	9	1	3	0	0	7	20
	%	1	75.8	7.7	4.4	.0	1.7	10.4	100.0
		2	33.1	38.0	5.8	.0	6.6	16.5	100.0
		3	16.4	8.2	64.5	.0	.9	10.0	100.0
		4	35.3	5.9	17.6	.0	2.9	38.2	100.0
		5	10.5	7.0	7.0	.0	63.2	12.3	100.0
		6	35.2	8.2	7.5	.6	4.4	44.0	100.0
		Ungrouped cases	45.0	5.0	15.0	.0	.0	35.0	100.0
Cross-validated[b]	Count	1	222	23	14	0	7	31	297
		2	43	36	9	0	8	25	121
		3	18	10	69	0	2	11	110
		4	13	2	6	0	1	12	34
		5	6	4	5	0	34	8	57
		6	60	14	13	1	7	64	159
	%	1	74.7	7.7	4.7	.0	2.4	10.4	100.0
		2	35.5	29.8	7.4	.0	6.6	20.7	100.0
		3	16.4	9.1	62.7	.0	1.8	10.0	100.0
		4	38.2	5.9	17.6	.0	2.9	35.3	100.0
		5	10.5	7.0	8.8	.0	59.6	14.0	100.0
		6	37.7	8.8	8.2	.6	4.4	40.3	100.0

a. 57.6% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 54.6% of cross-validated grouped cases correctly classified.

APPENDIX F: Discriminant Function Analysis Output of Modern Country Samples and Identified OpID Individuals

Analysis Case Processing Summary

Unweighted Cases		N	Percent
Valid		564	96.6
Excluded	Missing or out-of-range group codes	20	3.4
	At least one missing discriminating variable	0	.0
	Both missing or out-of-range group codes and at least one missing discriminating variable	0	.0
	Total	20	3.4
Total		584	100.0

Group Statistics

GROUP		Mean	Std. Deviation	Valid N (listwise) Unweighted	Valid N (listwise) Weighted
1	GOL	.037590504722030	1.108799723545067	297	297.000
	XCB	.054626837747734	1.013729760385414	297	297.000
	BBH	.364661687976555	1.010230692376298	297	297.000
	AUB	-.315486558200961	1.125796485352505	297	297.000
	UFHT	-.351328725841595	1.197495261466337	297	297.000
	NLH	-.081429008551320	1.088052527868880	297	297.000
	NLB	.005948178757291	1.102102435259154	297	297.000
	OBB	.037655540686754	.990374641651846	297	297.000
	OBH	-.262494589714022	.986412351656611	297	297.000
	EKB	.002139394628122	1.043231484449991	297	297.000
	FRC	.178346573622569	1.029566044515583	297	297.000
	PAC	.157065862499075	1.007771622887045	297	297.000
	OCC	-.047777341571457	1.037123178002949	297	297.000
2	GOL	-.216709961558230	1.010651391559265	44	44.000
	XCB	-.262233712947100	.886907584823269	44	44.000
	BBH	-.217730940488190	.795117810415777	44	44.000
	AUB	.067537001470609	.861533914443297	44	44.000
	UFHT	.216970436011609	.784767852664821	44	44.000
	NLH	.067444473728260	.855814610234563	44	44.000
	NLB	-.030578258641393	.924272658038057	44	44.000
	OBB	.097312398961703	.941585230930289	44	44.000
	OBH	.479783211483848	1.005508936070764	44	44.000
	EKB	-.237685298686205	.863184388020095	44	44.000
	FRC	-.202667945813926	.942554583074191	44	44.000
	PAC	-.018748702764735	.936823810129703	44	44.000
	OCC	-.073716174450188	.833819099862998	44	44.000
3	GOL	-.366122812319439	1.056127935829469	57	57.000
	XCB	.706186238929775	.977503837185195	57	57.000
	BBH	-1.298061380258967	1.211081528854625	57	57.000
	AUB	.553867607378451	.855337373201923	57	57.000
	UFHT	.147796211153862	.776769403434642	57	57.000
	NLH	.209351852739443	.987687762934914	57	57.000
	NLB	.180450763477050	.890654864408820	57	57.000
	OBB	-.048950644333609	.833120010690647	57	57.000
	OBH	.030059035458995	.892568015078486	57	57.000
	EKB	.101074653960879	.787974057750278	57	57.000
	FRC	-.742764069879303	.989396280293260	57	57.000
	PAC	-.365691155748802	1.153987042109636	57	57.000
	OCC	-.479860035999165	.883031202033645	57	57.000
4	GOL	.059127257989505	.946800507530844	166	166.000
	XCB	.152157300796524	.962161765188976	166	166.000
	BBH	.337159218353840	.769259678691608	166	166.000

	AUB	.363223157973211	.804038634851085	166	166.000
	UFHT	.372269507826314	.690207321508218	166	166.000
	NLH	.279537276340978	.849717705705676	166	166.000
	NLB	.028047072374025	.989677913942276	166	166.000
	OBB	.262237649661964	.923556398896714	166	166.000
	OBH	.234355198220323	.982162193248318	166	166.000
	EKB	.059321814038601	.867632484906498	166	166.000
	FRC	.119262884063058	.852808303947143	166	166.000
	PAC	.080024692594621	.982944216173687	166	166.000
	OCC	.078166480412631	.880203025127333	166	166.000
Total	GOL	-.016710521067499	1.056786927321857	564	564.000
	XCB	.124462083320257	1.007706060200498	564	564.000
	BBH	.143090942410519	1.077787246028416	564	564.000
	AUB	.002017053409834	1.052659951435783	564	564.000
	UFHT	-.043575904353731	1.053832356773976	564	564.000
	NLH	.065814512026688	1.006969496302782	564	564.000
	NLB	.027238782345699	1.035702348369378	564	564.000
	OBB	.099657277048140	.956280181324512	564	564.000
	OBH	-.028783872188012	1.010214175491479	564	564.000
	EKB	.010258729554144	.958054132310751	564	564.000
	FRC	.038141187094747	1.007101960586161	564	564.000
	PAC	.067842768321990	1.020033173315993	564	564.000
	OCC	-.056400298627636	.973032279351798	564	564.000

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
GOL	.983	3.185	3	560	.024
XCB	.952	9.413	3	560	.000
BBH	.778	53.151	3	560	.000
AUB	.889	23.268	3	560	.000
UFHT	.901	20.514	3	560	.000
NLH	.973	5.105	3	560	.002
NLB	.997	.502	3	560	.681
OBB	.987	2.494	3	560	.059
OBH	.932	13.703	3	560	.000
EKB	.993	1.307	3	560	.271
FRC	.923	15.677	3	560	.000
PAC	.977	4.381	3	560	.005
OCC	.975	4.763	3	560	.003

Analysis 1

Box's Test of Equality of Covariance Matrices

Log Determinants

GROUP	Rank	Log Determinant
1	13	-4.936
2	13	-11.699
3	13	-9.133
4	13	-8.657
Pooled within-groups	13	-6.021

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Test Results

Box's M		532.185
F	Approx.	1.800
	df1	273
	df2	73288.244
	Sig.	.000

Tests null hypothesis of equal population covariance matrices.

Summary of Canonical Discriminant Functions

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	.661[a]	69.2	69.2	.631
2	.265[a]	27.7	96.8	.457
3	.030[a]	3.2	100.0	.172

a. First 3 canonical discriminant functions were used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 3	.462	428.259	39	.000
2 through 3	.767	146.783	24	.000
3	.970	16.630	11	.119

Standardized Canonical Discriminant Function Coefficients

	Function		
	1	2	3
GOL	-.207	-.322	.455
XCB	.006	-.820	.486
BBH	-.987	.462	.581
AUB	.746	.700	.254
UFHT	.515	.472	.227
NLH	-.099	-.407	.061
NLB	.085	.149	-.134
OBB	.080	.325	-.057
OBH	.128	.426	-.444
EKB	-.333	-.618	.079
FRC	-.105	.059	-.396
PAC	.311	.147	-.470
OCC	.167	.223	-.218

Structure Matrix

	Function		
	1	2	3
BBH	-.571*	.472	.566
FRC	-.322*	.215	.315
PAC	-.178*	.097	.046
OBH	.222	.389*	-.148
OCC	-.117	.240*	.198
AUB	.382	.219	.714*
XCB	.180	-.239	.677*
UFHT	.292	.418	.488*
EKB	.016	-.051	.449*
NLH	.147	.166	.433*
GOL	-.132	.099	.314*
OBB	.010	.201	.294*
NLB	.049	-.053	.103*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
 Variables ordered by absolute size of correlation within function.
*. Largest absolute correlation between each variable and any discriminant function

Canonical Discriminant Function Coefficients

	Function		
	1	2	3
GOL	-.197	-.307	.433
XCB	.006	-.832	.493
BBH	-1.035	.485	.609
AUB	.750	.704	.255
UFHT	.513	.471	.227
NLH	-.100	-.409	.062
NLB	.082	.144	-.129
OBB	.084	.341	-.059
OBH	.131	.435	-.455
EKB	-.348	-.646	.083
FRC	-.108	.061	-.409
PAC	.307	.146	-.465
OCC	.173	.231	-.226
(Constant)	.161	.057	-.106

Unstandardized coefficients

Functions at Group Centroids

	Function		
GROUP	1	2	3
1	-.643	-.256	-.024
2	.738	.717	-.523
3	1.915	-.926	.036
4	.297	.587	.170

Unstandardized canonical discriminant functions evaluated at group means

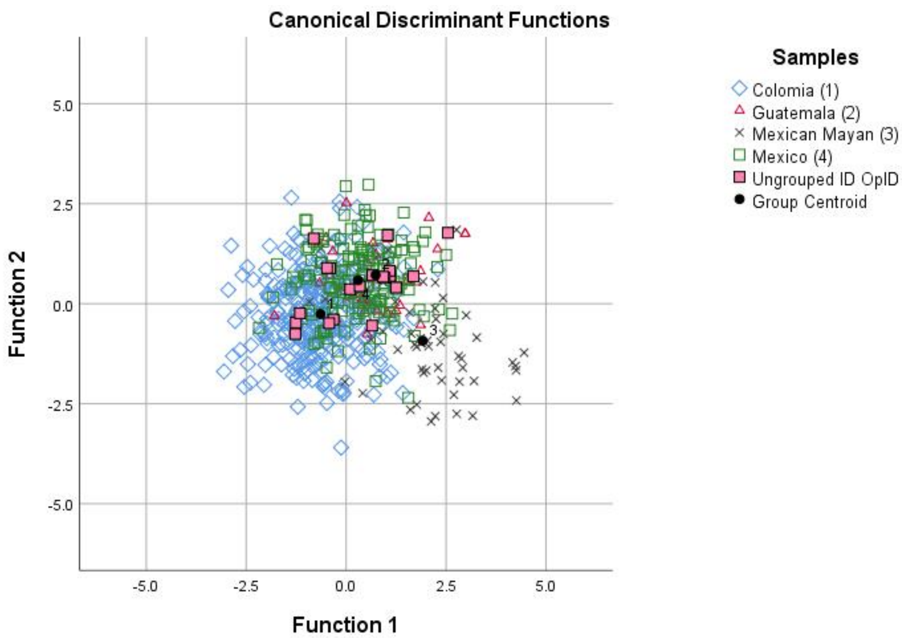
Classification Statistics

Classification Processing Summary

Processed		584
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	0
Used in Output		584

Prior Probabilities for Groups

		Cases Used in Analysis	
GROUP	Prior	Unweighted	Weighted
1	.527	297	297.000
2	.078	44	44.000
3	.101	57	57.000
4	.294	166	166.000
Total	1.000	564	564.000



Classification Results[a,c]

		GROUP	Predicted Group Membership 1	2	3	4	Total
Original	Count	1	251	0	5	41	297
		2	17	4	1	22	44
		3	8	0	38	11	57
		4	67	3	6	90	166
		Ungrouped cases	10	2	0	8	20
	%	1	84.5	.0	1.7	13.8	100.0
		2	38.6	9.1	2.3	50.0	100.0
		3	14.0	.0	66.7	19.3	100.0
		4	40.4	1.8	3.6	54.2	100.0
		Ungrouped cases	50.0	10.0	.0	40.0	100.0
Cross-validated[b]	Count	1	247	0	5	45	297
		2	17	1	1	25	44
		3	8	0	38	11	57
		4	71	3	7	85	166
	%	1	83.2	.0	1.7	15.2	100.0
		2	38.6	2.3	2.3	56.8	100.0
		3	14.0	.0	66.7	19.3	100.0
		4	42.8	1.8	4.2	51.2	100.0

a. 67.9% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 65.8% of cross-validated grouped cases correctly classified.

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