Demographic Structure of a Transplanted Tlaxcalan Population in the Valley of Mexico

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ABSTRACT

This research explores the evolutionary consequences of the transplantation and subsequent demographic adaptation of Cuanalan, a migrant population in the Valley of Mexico. Through comparisons with historical and contemporary populations from the area of origination—the state of Tlaxcala—an attempt is made to reconstruct the demographic and evolutionary changes which have occurred in the splinter population over the past four centuries. Both demographic and preliminary genetic data indicate that Cuanalan is a hybridized population. About two-thirds of marriages of Cuanalan-born individuals are endogamous. Average number of liveborn children for prolific women over 40 is 6.5. Since 1866, mean age at death in the community is 20.8 years, and the infant death rate is 30%. Major causes of death are respiratory diseases, gastrointestinal disorders, and childhood infections. The high variance in completed fertility and high pre-reproductive mortality indicate a continuation of conditions making for the rapid action of natural selection which have historically characterized Tlaxcalan populations. Genetic drift was probably an important factor in the early differentiation of the migrant population. The data suggest that the evolutionary divergence of Cuanalan from the Tlaxcalan gene pool has been rapid and extensive.

Demographic and genetic studies of migrant or transplanted populations offer an opportunity to observe the mechanisms of evolutionary microdifferentiation. The splintering of gene pools into smaller "offshoot" populations has been implicated as a frequent demographic occurrence, both in the past and present, which may appreciably alter frequencies and distributions of different genes. (Cavalli-Sforza, 1967, 1969; Gajdusek, 1964; Neel, 1967; Roberts, 1968). In a number of investigations, the degree of evolutionary divergence of migrant populations has been measured by comparing their genetic structures with

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samples representing both the area of origination and the new sur-
rounding geographic region (Giles et al. 1966, 1970; Glass et al. 1952;
Laughlin, 1966; Martin, 1970; McKusick et al. 1964). Other workers
have considered the evolutionary results of the fragmentation of his-
torically related populations (Cavalli-Sforza et al. 1964; Friedlaender
et al. 1971; Hainline, 1966; Nei and Imaizumi, 1966; Workman and
Niswander, 1970). Research into the evolutionary differentiation of
migrant populations requires an understanding of the complex his-
torical, demographic, and cultural factors which may accompany popu-
lation migration. The importance of such a multi-faceted approach is
amply demonstrated by recent studies which explore the influence of
varying demographic and cultural patterns upon the genetic composi-
tion of populations (Angel, 1972; Cavalli-Sforza, 1974; Chagnon et al.
1970; Freire-Maia, 1974; Friedlaender, 1971; Niswander et al. 1970;
Oliveira and Salzano, 1969; Spielman et al. 1974; Ward and Neel, 1970;
White and Parsons, 1973).

The primary purpose of this report is to document the demographic
consequences of population transplantation. As part of a broader study
of demography, microevolution, and genetic distance in populations
from Tlaxcala, Mexico, the present research focuses upon a population
of Tlaxcalan origin which became separated from the parental gene
pool during the Sixteenth Century.

The demographic structure and dynamics of Cuanalan, a migrant
community in the Valley of Mexico, are ascertained from census mate-
rials, questionnaire data, and vital statistics records dating from 1866.
Through comparisons with historical and recent populations already
investigated in the area of origination (the state of Tlaxcala in the
adjoining Tlaxcala-Pueblan Valley), an attempt is made to reconstruct
the demographic changes which have occurred in the migrant popula-
tion during its development in a new geographic and cultural environ-
ment. The observed demographic patterns in Cuanalan are discussed
in terms of their possible effects upon the action of evolutionary proc-
esses, particularly genetic drift, natural selection, and hybridization.
These findings are also compared to the trends which were discovered
in Indian and Mestizo populations in the state of Tlaxcala by Halber-
stein and Crawford (1972) and Halberstein, Crawford and Nutini
(1973).

HISTORICAL BACKGROUND

Spanish contact with Tlaxcala first occurred in 1519 and lasted un-
til the formal termination of the colonial period in 1823 (Halberstein,

Crawford and Nutini, 1973). Spaniards and Tlaxcalans formed a military alliance against the Aztecs, and Tlaxcalan cities were often used as base camps by Spanish soldiers (Bernal Diaz, 1568: 269; Ixtlilxochitl, 1969: 138). The Spaniards established administrative headquarters in the City of Tlaxcala, which became a major station on the route travelled by Spanish soldiers from the east coast of Mexico to the Aztec capital of Tenotchtitlan (White, 1971: 187).

Immediately following the Spanish invasion of 1519, the population of Tlaxcala underwent a drastic numerical decline that persisted until the turn of the Seventeenth Century. The decimation of two-thirds of the population of the state in 81 years (1519-1600) was due to war casualties, widespread epidemic diseases introduced by the conquerors, and supervised migrations of Tlaxcalans to other regions as part of the colonization (Halberstein, Crawford and Nutini, 1973).

The earliest residents of Cuanalan were Tlaxcalans, relocated for political and military reasons by Spanish authorities during the early colonial period. Informants in the community reported that the original migrants were transported to Cuanalan for the purpose of constructing a dike at the edge of Lake Texcoco. According to its commemorative plaque, work on the dike proceeded intermittently and was not completed until 1751. The large stone structure has since delineated the western boundary of Cuanalan. The exact date of the migration is uncertain, but there are two possible times suggested in the literature dealing with the colonization of Tlaxcala. Some 16,000 Tlaxcalan warriors were mobilized and sent into the Valley of Mexico between 1519 and 1520 (Prescott, 1843, Vol. II: 66, 393; White, 1971: 241). The residents of Cuanalan may be the descendants of a portion of the original army garrison. According to Gibson (1967: 185), a colonizing effort by the Spaniards involved the transplantation of 401 Tlaxcalan families to four new villages to the north and to two additional locations west of Tlaxcala in 1591.

MATERIALS AND METHODS

The Tlaxcalan Populations

Indian and Mestizo *municipios* (townships) in the state of Tlaxcala, Mexico were compared by Halberstein and Crawford (1972) with respect to demographic structure as one phase of an investigation of genetic hybridization and other aspects of biological evolution. San Pablo del Monte, a rural, agricultural settlement of approximately 10,000 inhabitants is located near the southernmost border of the state (see
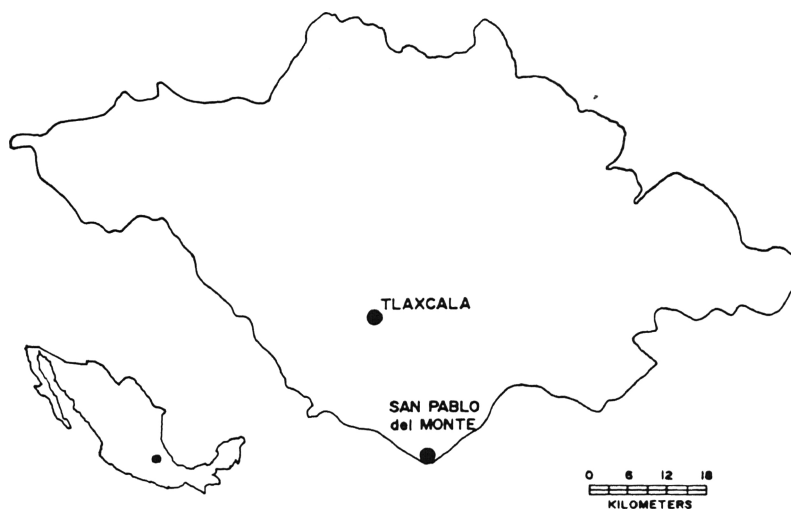
FIG. 1.   The state of Tlaxcala, Mexico

Figure 1). The City of Tlaxcala, the state capital, was initially founded by Spanish colonists in the early Sixteenth Century and at present numbers 15,000. The work of Crawford (1973, 1974) and Crawford et al. (1974) indicates that the people of San Pablo, traditionally a Nahuatl-speaking community, are closely related in genetic structure to nearby Indian populations. These studies also suggest that a considerable proportion of the genes in the present City of Tlaxcala gene pool are of Spanish origin.

Information on population structure and movement, patterns of mate selection, fertility, and mortality was obtained through the administration of demographic questionnaires in the public health clinics of each community. Censuses located in the State Archives of the City of Tlaxcala permitted the analysis of historical trends in population size and structure.

Cuanalan

The state of Mexico, located in the Valley of Mexico, is divided into 120 *municipios.* Figure 2 situates the state of Mexico in relation to bordering states (including Tlaxcala), the Federal District (the metropolitan area of Mexico City), and the rest of the country. One *municipio,*
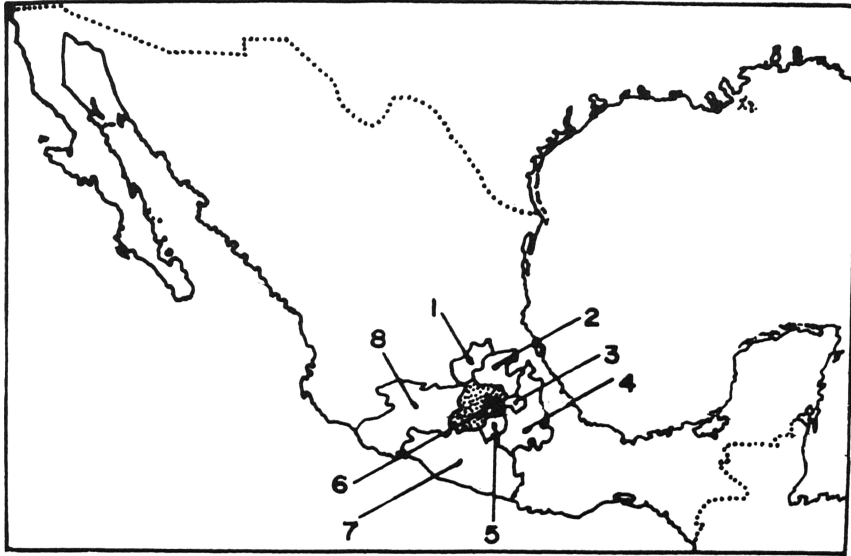
FIG. 2.   The state of Mexico (shaded) and the states and districts which border
it: (1)—Queretaro;   (2)-Hidalgo;   (3)-Tlaxcala;   (4)-Puebla;   (5)-
Morelos;   (6)—Federal District;   (7)—Guerrero;   (8)—Michoacan.

Acolman, encompasses 86.29 square kilometers in the eastern portion
of the state and consists of 17 *barrios* (territorial subdivisions). The
migrant Tlaxcalan population is Cuanalan, a *barrio* of 2,040 inhabitants
(see Figure 3). Cuanalan lies in an ecological zone that is characterized
by the finest farmland in the Valley of Mexico (Sanders, 1965: 26),
and agriculture forms the subsistence base of the community, occupy-
ing nearly three-fourths of the working adults.

In 1972 a team of seven researchers collected the following data in
Cuanalan: culture history, blood specimens, dermatoglyphics, dental
impressions, color vision tests, demographic information, anthropo-
metric measurements, disease patterns, nutritional status, and com-
plete medical examinations (Crawford, 1975; Halberstein and Craw-
ford, 1974).

The demographic information was secured from three sources: 1)
the 1970 government census of the *barrio*, 2) vital statistics registers
kept in the municipal executive office, and 3) a demographic question-
naire administered in the community. The census provided data on
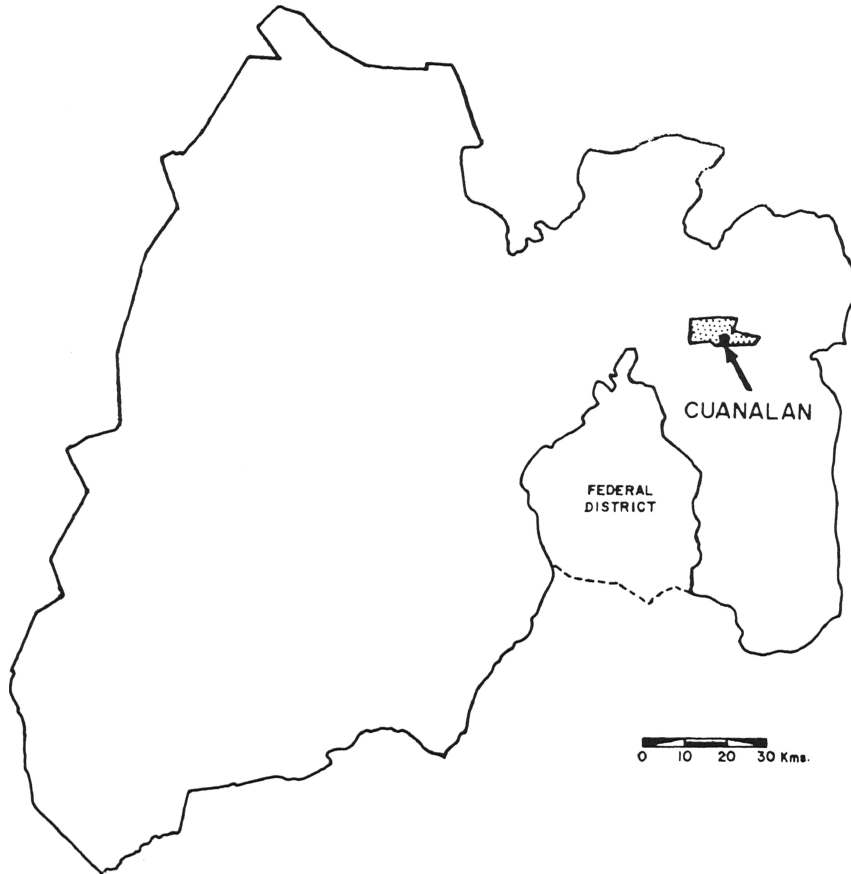population size, household size and composition, population structure,

FIG. 3.   The state of Mexico, Mexico. The shaded portion demarcates the *muni-cipio* of Acolman, within which is located the *barrio* of Cuanalan.

and occupations of Cuanalan residents. The municipal records contain certificates of births, deaths, and marriages from 1866 through 1970. Entries pertinent to Cuanalan were microfilmed. A "BMD07D" (Bio-medical) computer program (Dixon, 1971: 95) cross-tabulated the data according to the type of demographic parameter and the date of each record. The same program produced stratified histograms of the variables by selected time units. A total of 1,529 death notices and 281 marriage certificates were transcribed.

Two hundred and seventy-eight demographic interviews, similar in format to the questionnaire employed in the Tlaxcalan populations, re-

suited in information regarding 2,570 consanguineal relatives from Cuanalan, including deceased persons, immigrants, and emigrants for whom data were received. Informants voluntarily provided the demographic data as part of their participation in the clinical study. The demographic questionnaires contained built-in tests of data accuracy through the determination of the degree of internal consistency of informant responses.

RESULTS

Population Structure and Movement

The age-sex structure of Cuanalan, as determined from the 1970 census, is graphically depicted in Figure 4. A broad-based, tapering population pyramid, indicative of a sizeable proportion of young people, characterizes Cuanalan, both Tlaxcalan populations (Halberstein and Crawford, 1972), and the Mexican nation as a whole (Sanders, 1974: 19). Based upon the percentage of the population under age 15, Cuanalan (44.94%) is more youthful than 25 of the 40 modern Latin American populations recently surveyed by Salzano (1972).
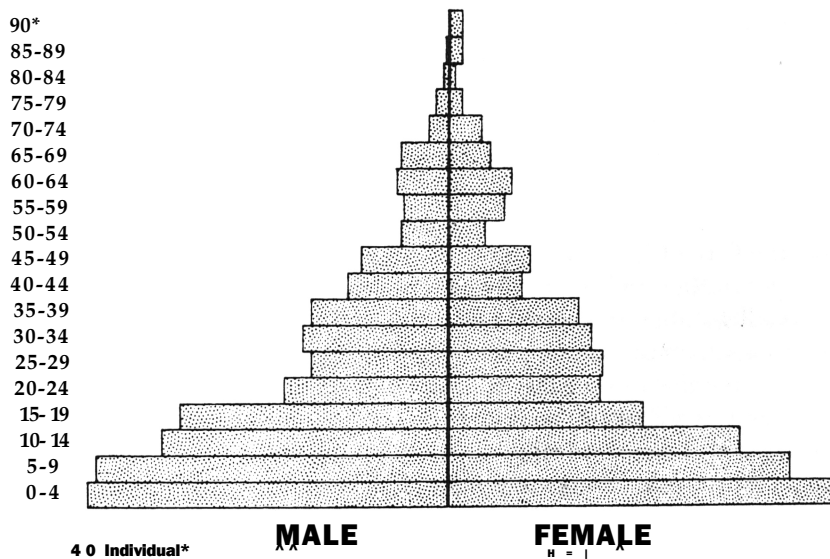

FIG. 4.   Population pyramid of Cuanalan depicting the age-sex structure of the population according to the 1970 census of the community.

The 1970 Cuanalan population resembles the Tlaxcalan Indian population of San Pablo in overall sex ratio. Males outnumber females from age 15 to 19, and females predominate numerically above age 55 in the two communities. Similar sex ratios are observed for the entire country of Mexico (Keyfitz and Flieger, 1971: 25), but the reverse is found in the Mestizo population in the City of Tlaxcalan.

Patterns of migratory behavior were investigated through the questionnaires. Places of residence or death were recorded for 1,862 Cuanalan-born individuals over five years of age. Rates and distances of emigration are compared with the Indian and Mestizo Tlaxcalan populations in Table 1. Although both Cuanalan and San Pablo are rural, agricultural communities, they differ in migration patterns. Movement out of the *barrio* of birth is more pronounced in Cuanalan, but the rate is well below that found in the *barrios* of the City of Tlaxcala:

Cuanalan	(N = 1,862)	18.69%
San Pablo	(N = 2,516)	11.85
City of Tlaxcala	(N = 1,060)	43.40

The average distance of emigration from Cuanalan is also intermediate between the Tlaxcalan samples. The following percentages designate the frequency of new residences established outside the boundaries of the respective *municipios:*

Cuanalan	(N = 1,862)	12.67%
San Pablo	(N = 2,516)	2.00
City of Tlaxcala	(N = 1,060)	17.10

Like the City of Tlaxcala sample, Cuanalan males have moved, on the average, further and more often than females. The opposite is seen in the small number of emigrants from San Pablo *barrios.* In both Tlaxcalan populations, the frequency of translocation is inversely proportional to the distance of the destination, and the majority of emigrants move into neighboring *barrios.* In Cuanalan, however, emigration has not proceeded concentrically, due in large part to the community's close proximity (21 kilometers) to the Federal District, which has historically been a more frequent destination than surrounding *barrios* of Acolman. Of the Cuanalan-born migrants, 42.27% had moved to the Federal District. In all three populations, the average amount and distance of emigration have increased from earlier to later generations.

Table 1

Population Movement by Sex in each Sample Population

		Sample Number	Birth, Residence in Same Barrio	Movement within Municipio	Movement outside Municipio
CUANALAN	Male	964	79.66%	6.01%	14.33%
	Female	898	83.07	6.02	10.91
	Total	1,862	81.31	6.02	12.67
SAN PABLO	Male	1,269	89.40	8.80	1.80
	Female	1,247	86.90	10.90	2.20
	Total	2,516	88.10	9.90	2.00
CITY OF TLAXCALA	Male	533	55.70	27.40	16.90
	Female	527	57.30	25.20	17.50
	Total	1,060	56.60	26.30	17.10

The category "Movement within *municipio*" designates those emigrants who moved to another *barrio* within their *municipio* of origin. "Movement outside *municipio*" signifies emigrants who established a new residence outside the boundaries of their municipio of birth.

Immigration into Cuanalan over the last four generations has occurred at approximately four times the rate observed for the individual *barrios* in the *municipio* of San Pablo. The immigration, rate for Cuanalan is closer to that observed in the City of Tlaxcala:

Cuanalan	16.30%
San Pablo	4.09
City of Tlaxcala	18.75

Prior to 1920 immigration into Cuanalan was very sparse, but since that date it has steadily increased. In each population there is a higher proportion of female than male immigrants. San Pablo has experienced some inter-*barrio* movement, but the low level of immigration has exclusively involved people from adjacent *municipios.* As is the case in the City of Tlaxcala, the migrants to Cuanalan have come from diverse regions. Large proportions of Cuanalan immigrants were born in the Federal District (43.2%), states bordering the state of Mexico (20%), and other parts of the country (5.2%). In San Pablo and the City of Tlaxcala, immigration has exceeded emigration to a small extent; the opposite has been the case in Cuanalan.

Mate   Selection

A sample of 277 certificates of marriages contracted in Cuanalan be-
tween 1866 and 1970 was available for analysis in the municipal reg-
istry. Each bears the names, birthplaces, residences, and ages of both
partners. Eighty-one of the marriages, or just under 30%, involved a
mate not born in Cuanalan. Females were the non-local spouses in 55
of these unions (67.9%). 12.7% of the total sample of 277 marriages in-
cluded a mate born in a location exterior to the *municipio* of Acolman.
The civil records revealed a temporally progressive increase in the pro-
portion of marriages with outsiders, from 17% in 1866-1900 to over 40%
during the period 1933-1970.

The interviews provided additional information on the geographical
aspects of mate selection in Cuanalan. Discrepancies between the inter-
views and the municipal records may be due to the different sample of
marriages represented and the fact that the questionnaire provided data
on marriages transacted outside of Cuanalan while the records did not
Over 36% of this sample of 980 pairings involve a partner born else-
where, and one-fourth of these were from the Federal District.

Mate selection in Cuanalan varies both in scope and pattern from
the Tlaxcalan Indian and Mestizo populations (see Table 2). While
there is some inter-*barrio* mate exchange in San Pablo, the municipal
boundaries effectively define the gene pool, with only 2.32% of the
sample of married persons having acquired externally-born mates, and
all of the non-local spouses being born within 16 km of the *municipio*.
City of Tlaxcala subjects encompass a wider area in their selection of
mates. The distribution of marriage distances in the City of Tlaxcala is
well described by the leptokurtic model of mate selection (decreasing
frequency of marriage with increasing distance from birthplace) which
has been reported for other populations (Sutter and Tran-Ngoc-Toan,
1957; Boyce et al. 1967; Swedlund, 1972). The Cuanalan data are not
exactly consonant with the formulation, however—mating with non-
local partners shows an irregular relationship to birthplace distances
(Halberstein, 1973). The geographic location of Cuanalan is an im-
portant factor in this respect, since within 33 kilometers of the com-
munity are the boundaries of three different Mexican states and the
Federal District. Mate selection in Cuanalan is probably also affected
by the fact that the population is distinct in its cultural heritage and
ethnohistory from the surrounding *barrios.* The findings in Table 2 sug-
gest that the major difference between the three populations lies not in

the degree of *barrio* endogamy, but rather in the frequency of obtaining mates born outside of the *municipio*. In each population, males appear to cover a broader geographic range in their selection of mates than do females. An expansion of the geographic network of mate selection since earlier times is also common to all three communities.

Table 2

Mate Selection for all Generations Combined in Cuanalan, San Pablo, and the City of Tlaxcala. All Marriages Involve a Partner Born in One of the Populations

	Number of Marriages	Both Partners Born in Same Barrio	One Partner Born in Different Barrio of the Municipio	One Partner Born Outside Municipio
CUANALAN				
A) Civil Records	277	70.76%	16.24%	13.00%
B) Interview Data	980	63.97	13.87	22.16
SAN PABLO	1,074	74.67	23.00	2.33
CITY OF TLAXCALA	465	67.70	12.50	19.80

Age at first marriage in Cuanalan is intermediate between the Tlaxcalan samples, and there is a similarity among the three populations in that males, on the average, marry younger females (Table 3). The Mestizo subjects of the City of Tlaxcala exhibit the latest overall ages at marriage, but the greatest ranges in marital ages are found in San Pablo. Sexual differences are greatest in the City of Tlaxcala group. Each population manifests a trend of delayed marriage in the younger generations (Halberstein, 1973).

Lasker (1968) points out that isonymy (marital surname concordance) may be a useful indicator of the level of inbreeding in a population. The occurrence of isonymous unions was examined in each population:

San Pablo	(N = 556)	2.16%
City of Tlaxcala	(N = 231)	1.30
Cuanalan	(N = 272)	1.84

Table 3

*Age at First Marriage in Cuanalan, San Pablo, and the
City of Tlaxcala*

	N	Mean	Standard Deviation	Median	Maximum	Minimum
CUANALAN						
Civil Records						
Males	267	23.03	4.19	22.04	49	16
Females	269	20.08	4.12	19.69	45	14
Interview Data						
Males	320	22.14	4.19	22.02	40	14
Females %	329	19.37	3.95	19.29	35	12
SAN PABLO						
Males	98	21.70	4.51	21.00	57	10
Females	95	18.56	4.24	18.00	40	10
CITY OF TLAXCALA						
Males	77	25.21	4.02	23.00	49	15
Females	78	19.71	3.86	19.00	27	13

Fertility

Reproductive behavior is compared in Table 4. The 415 prolific Cuanalan females exhibit the highest levels of achieved reproduction and variance in the number of progeny per completed family. Variance in the number of live births is higher among women past age 40 than in the total sample in Cuanalan but in neither of the Tlaxcalan populations. The mean of 6.5 liveborn children for Cuanalan women who have completed their reproductive careers is above the figure of 6.18 for a recent sample of prolific Mexican women over age 40 (United Nations, 1970: 225). Cuanalan females are also more reproductive than women in other modern Latin American populations studied by Salzano (1961, 1964), Salzano and Oliveira (1970), Salzano et al. (1967), Neel and Chagnon (1968), and Freire-Maia and Kreiger (1963). Salzano and Freire-Maia (1970: 65) cite Caingang populations in Brazil with slightly larger average completed family size—6.8 liveborn children. Erickson et al. (1970) report a mean of 6.94 children in a sample of 52 women aged 50 and over in a population from Chiapas, Mexico, but the authors include stillbirths as well as live births in the calculation.

Table 5

A Comparison of the Achieved Reproduction of Fertile Married Women in San Pablo, City of Tlaxcala, and Cuanalan. Average Number of Reproductive Years Was Calculated by Subtracting Mean Age at Marriage from 45 Years

	Cuanalan	San Pablo	City of Tlaxcala	Mexico City[1]	Mexico[2]
Total number of prolific (ever pregnant) women studied	415	265	129	1,622	5,870,575
Mean number live-born children	5.51	4.71	4.22	4.07	5.07
Variance in offspring number	10.54	12.35	10.56		
Standard deviation	3.25	3.51	3.25		
Average number of reproductive years	25.63	26.60	25.20		
Average number of liveborn children per reproductive year	0.21	0.18	0.17		
Mean interval between marriage and first childbirth (months)	14.88	14.14	18.30		
Per cent reporting abortion, miscarriage, or stillbirth	22.2	12.1	15.5		
Number of prolific women over age 40	170	125	63	458	2,389,427
Mean number liveborn children per prolific woman over 40	6.50	6.10	5.36	5.11	6.18
Variance in offspring number	11.85	11.68	10.04		
Standard deviation	3.44	3.42	3.16		
Per cent married over 40 childless	7.60	4.35	4.10		

[1] **Mexico City data from Davidson (1973).**
[2] **Mexican national figures from United Nations (1970: 225).**

In the three Tlaxcalan populations discussed in this report, the interval between marriage and initial childbirth is much shorter than the mean of 25.38 months found by Pakrasi and Malaker (1973) in a sample of 861 women from Calcutta, India. Even though female age at marriage and mean interval between marriage and birth of first child are intermediate in the Cuanalan sample, the average fertile woman from Cuanalan reproduces at a faster rate. The average number of births per average number of fertile years in Cuanalan (0.215) indicates that the typical female there bears more than one live child for every four and one-half years of her reproductive period. Lower values were found for the Indian and Mestizo Tlaxcalan women, who are nearly equivalent in this rough index of reproductive rate. The greater overall achieved fertility of Cuanalan females is thus probably due to briefer child spacing and more continuous reproduction throughout the later fertile years.

According to the samples described in Table 4, reproductive wastage, including sterility, occurs much more frequently in Cuanalan than in San Pablo or the City of Tlaxcala. The higher rates of achieved reproduction of Cuanalan females are thus further attested by the comparative data on reproductive failure—the higher rates in Cuanalan women are overcompensated by their enormous levels of achieved fertility by the close of the reproductive period.

Mortality

The death records from the municipal office permitted an analysis of mortality in Cuanalan from 1866 to 1970. After 1930, the death notices were signed by a licensed physician; prior to that date, the accounts were rendered by relatives of the deceased.

Average ages at death in Cuanalan and the Tlaxcalan Indian and Mestizo populations are listed, by sex, in Table 5. Mortality rates are high in the younger age groups in all three populations, but particularly so in San Pablo and Cuanalan; the mean ages at death in these two communities are nearly identical.

Infant mortality (under one year of age) in Cuanalan is almost as severe as in San Pablo, which shows a level three times that found in the City of Tlaxcala. Both the Cuanalan (30.09%) and San Pablo (33.33%) proportions fall above recent national figures-28.97% of the deaths in Mexico in 1966 were infants under one year (Keyfitz and Flieger, 1971: 344).

Evolutionarily, an important biological parameter of a population is the proportion of individuals who die before reproductive maturity

Table 5

Age at Death (in Years) and the Frequency of Infant Death in Cuanalan, San Pablo, and the City of Tlaxcala. Adjusted Mean Age of Death Was Calculated excluding Deaths during the First Year of Life

	N	Mean Age at Death	Adjusted Mean Age at Death	Per cent of Deaths in First Year of Life
CUANALAN				
Males	747	20.70	30.29	32.00%
Females	782	20.96	29.08	28.26
Total	1,529	20.83	29.66	30.09
SAN PABLO				
Males	88	20.84	29.41	29.55%
Females	80	19.49	30.88	37.50
Total	168	20.22	30.06	33.33
CITY OF TLAXCALA				
Males	96	39.66	46.95	13.54%
Females	66	29.67	32.58	9.09
Total	162	35.59	39.58	11.11

(usually defined as age 15). The following percentages apply to pre-reproductive deaths in the sample populations:

Cuanalan	(N = 1,529)	59.5%
San Pablo	(N= 168)	64.9
City of Tlaxcala	(N = 162)	37.0

Pre-reproductive mortality is higher in Cuanalan than in ten of the twelve Latin American populations discussed by Salzano (1972).

   Survivorship in Cuanalan is compared to San Pablo, the City of Tlaxcala, and Mexico (for 1966) in Table 6. Over 30% of all deaths in Cuanalan between 1866 and 1970 were of infants younger than one year, and more than half were children less than five years of age. The probability of early death is much higher in Cuanalan and San Pablo than in the Tlaxcalan Mestizos. Cuanalan also resembles San Pablo in survival to older ages. The proportion of deaths at age 70 or above in the City of Tlaxcala sample is more than two and one-half times what was discovered in either Cuanalan or San Pablo. Females manifest

Table 6

*Survivorship in Cuanalan, San Pablo, the City of
Tlaxcala, and Mexico for 1966*

Per Cent Surviving to Age	Cuanalan (N = 1,529)	San Pablo (N = 168)	City of Tlaxcala (N = 162)	Mexico, 1966[1] (N = 424,141)
80+	4.72%	5.48%	11.72%	9.85%
70-79	9.17	9.52	24.07	18.14
60-69	14.21	14.88	29.62	27.25
50-59	19.77	19.64	38.27	33.64
40-49	25.40	26.78	47.53	39.10
30-39	32.02	30.95	53.70	44.47
20-29	37.46	33.33	57.40	49.18
10-19	42.57	35.11	61.11	52.57
5-9	47.15	41.66	64.81	55.96
1-4	69.91	66.67	88.27	71.03

[1] **Data for Mexico adapted from Keyfitz and Flieger (1971: 344).**

greater longevity than males in Cuanalan and San Pablo, but not in the City of Tlaxcala. In Cuanalan, females attain ages greater than 80 more than twice as often as do males. Of the three populations under investigation, only the City of Tlaxcala exhibits greater survivorship than the Mexican nation overall.

Leading causes of death, compiled in Table 7, are not uniform, although some trends are noticeable. The predominance of respiratory infections in all three Tlaxcalan populations poses a theoretical problem because secondary respiratory infections often accompany major systemic infections. Infectious diseases are the most prominent agencies of death in Cuanalan and San Pablo, where the three leading causes of fatality are identical. One factor contributing to the high rates of gastrointestinal disorders in these two communities is the consumption of contaminated water. Cockburn (1971) points out that an agricultural economy creates ecological circumstances which often promote the contraction of infectious diseases. The general state of health of Cuanalan residents was observed to be quite poor. Over half of the juveniles examined by the research team physician, Dr. Ivanhoe Gamboa, were diagnosed to be suffering from varying degrees of malnutrition. The sample medically examined in the clinic represented about 25% of the total community. The most preponderant diseases encountered were

clinical anemia, gastro-intestinal disorders, and respiratory infections. Cuanalan does not possess a public health facility, and the nearest medical service is 6.5 kilometers away. Few Cuanalan patients had previously visited a physician or a dentist. The City of Tlaxcala, in contrast to the mortality patterns observed in Cuanalan and San Pablo, exhibits high mortality from degenerative diseases. Cardiovascular dysfunction is the second-ranked cause of death there, and cancer (5.08%) is almost as lethal as gastro-intestinal disorders (5.75%), with the latter comprising only the fifth leading cause of death. The differences between Cuanalan, San Pablo, and the City of Tlaxcala regarding ratio of deaths caused by infectious and degenerative diseases correspond to the world-wide rural and urban distributions of causes of death as noted by Thomlinson (1965: 129; 132). In Cuanalan, males and females do not differ significantly in the causes of mortality according to a chi-square value of 21.7 with 21 degrees of freedom. Only the City of Tlaxcala is characterized by significant sexual differences in cause of death (Halberstein and Crawford, 1972). The major causes of death in Mexico for 1960, as described by Gabaldon (1965), are given in Table 8. More recent statistics (Preston et al. 1972; Cortes, 1972; Pan American Health Organization, 1974: 176) indicate that respiratory and gastro-intestinal infections continue to comprise the two leading causes of death in Mexico.

DISCUSSION

The initial divergence of Cuanalan, San Pablo, and the City of Tlaxcala can be traced to the political activities of the Spaniards in the Sixteenth Century. The establishment of the City of Tlaxcala as an administrative center and the original splintering of the Cuanalan population are both products of the Spanish colonization of the Tlaxcalan area. Thus, the Spanish occupation of Tlaxcala not only disturbed the existing gene pool, but also set in motion the differentiation of the three populations analyzed in the present work.

Although certain of the populational characteristics of Cuanalan are unique, the demography of the migrant community in several respects represents a mixture of some of the contrasting features of the contemporary populations examined in the area of origination.

The most striking demographic differences between San Pablo and the City of Tlaxcala are found in the patterns of population movement and mate selection. The present dispersion of Cuanalan-born individu-

Table 10

Leading Causes of Death in Cuanalan, San Pablo, and fhe Cifr/ of Tlaxcala (in %)

Cuanalan—Civil Records (N = 1,529)		Cuanalan—Interviews (N = 418)		San Pablo (N = 245)		City of Tlaxcala	
1. Respiratory infections	38.91	1. Respiratory infections	21.05	1. Respiratory infections	32.65	1. Respiratory infections	25.89
2. Gastro-intestinal disorders	16.'.	2. Gastro-intestinal disorders	19.85	2. Gastro-intestinal disorders	17.55	2. Cardiovascular dysfunction	17.98
3. Ill-defined or unknown	15.56	3. Childhood infections	12.67	3. Childhood infections	11.42	3. Childhood infections	12.22
4. Childhood infections	12.55	4. Cardiovascular dysfunction	8.37	4. Accident or violence	10.61	4. Accident or violence	8.63
5. Cardiovascular dysfunction	2.22	5. Accident or violence	7.17	5. Cardiovascular dysfunction	3.67	5. Gastro-intestinal disorders	5.75
6. Senility	2.09	6. Cancer	7.17	6. Tuberculosis	1.63	6. Cancer	5.03
7. Cirrhosis of the liver	1.76	7. Cirrhosis of the liver	4.54	7. All others	22.47	7. Tuberculosis	4.31
8. All others	10.84	8. All others	15.54			8. All others	20.19

"Respiratory infections" includes pneumonia, pneumonitis, emphysema, and bronchitis. "Gastro-intestinal disorders" denotes such conditions as gastroenteritis, gastritis, dysentery, entercolitis, diarrhea, parasitosis, and related diseases. "Childhood infections" designates measles, scarlet fever, chicken pox, whooping cough, and other diseases common to early childhood. Drownings, poisonings, homicide, and asphyxiation are subsumed under the heading "Accident or violence."

Table 8

Leading Causes of Death in Mexico in 1960 (after Gabaldon, 1965)

Cause of Death	Death Rate per 100,000
1. Gastro-intestinal disorders	170.5
2. Pneumonia	141.4
3. Diseases or early infancy including prematurity	134.0
4. Ill-defined or unknown	130.4
5. Diseases of the heart	68.4
6. Accidents	38.9
7. Cancer	35.7
8. Homicide	31.8
9. Bronchitis	30.9
10. Tuberculosis	27.9
11. Cirrhosis of the liver	22.0

als, the level of immigration into the community, and the distribution of Cuanalan marriage distances are intermediate between the Tlaxcalan Indian and Mestizo populations, but they bear a stronger resemblance to the trends seen in the City of Tlaxcala.

Fertility levels in Cuanalan surpass Mexican national averages and are the highest of the three populations under investigation, even though reproductive wastage is comparatively most common in Cuanalan. The Tlaxcalan Indian women more closely approach the Cuanalan sample in achieved reproduction than do the Mestizos.

With reference to the mortality parameters, Cuanalan approximates San Pablo in most of the measures. The two populations nearly parallel each other in mean age at death, adjusted mean age at death, magnitude of infant mortality, rate of pre-reproductive mortality, survivorship, and cause of death. The vast differences between the City of Tlaxcala and the other two populations are probably related to the relatively greater incidence of infectious diseases in Cuanalan and San Pablo.

The above observations provide a picture of the demographic changes which have occurred in the migrant population since its departure from the Tlaxcalan area over three and one-half centuries ago. In the more cultural aspects of demography—migratory behavior and mate selection—Cuanalan has recently been developing in a direction similar to the mobile and hybridized City of Tlaxcala. At the same time,

however, Cuanalan has retained a greater biological similarity to the Indian population of San Pablo in its patterns of reproduction and mortality.

The assessment of Cuanalan's evolutionary relationship to the Tlaxcalan communities hinges upon an understanding of the scope and intensity of genetic drift, natural selection, and genetic admixture in each population. The historical and demographic factors that have been described might serve as indicators of the potential action of these forces of evolution.

Genetic Drift

Of the three populations under investigation, only San Pablo can be characterized as reproductively isolated, but its large size reduces the likelihood of drift. The City of Tlaxcala and Cuanalan are also sizeable populations, and their patterns of mate selection and migration further decrease the probability of drift. The low frequency of isonymous marriages in Cuanalan and the City of Tlaxcala suggest that these populations are not highly inbred. Lasker (1952, 1954) and Roberts (1956) state that continuous gene flow often counteracts the dispersive effects of drift by leading to increased genetic amalgamation and heterozygosity. Lasker (1954) and Lasker and Kaplan (1964) have developed a relative index of the opportunity for drift. The "coefficient of breeding isolation" is defined as the product of effective breeding population size multiplied by the immigration rate. Since the complete age-sex structure of Cuanalan was made available by the census, it was possible to compute the effective population size by employing Wright's 11938) formula:

$$x_j \quad \frac{4(N_m \, N_f)}{N_m + N_f}$$

where N_m and N_f represent the number of reproductively capable males and females (aged 15-40) in the population. The effective breeding population of Cuanalan is 735, or 36% of the total population. Table 9 compares Cuanalan, San Pablo, and the City of Tlaxcala in the calculation of the coefficient. Lasker (1956) and Lasker and Kaplan (1964) suggest that the evolutionary effects of drift are likely to be negligible in a population where the coefficient is greater than 50. Thus, present demographic conditions in the three populations are not favorable for the operation of genetic drift.

Table 9

The Coefficient of Breeding Isolation for Cuanalan, San Pablo, the City of Tlaxcala, and three other Mexican populations

Population and Investigator	Population Size	Effective Breeding Population	Immigration Rate (% of Population)	Coefficient of Breeding Isolation
Cuanalan, Mexico (This study)	2,040	735	16.30%	119.81
San Pablo, Tlaxcala (Halberstein and Crawford, 1972)	10,000	2,900	4.09	118.61
City of Tlaxcala, Tlaxcala (Halberstein and Crawford, 1972)	15,000	4,350	18.75	815.63
Paracho, Michoacan (Lasker, 1954)	4,593	967	34.90	337.48
Ranches of Quiroga, Michoacan (Lasker, 1954)	133	39	10.00	3.90
Tzintzuntzan, Michoacan (Lasker, 1954)	1,231	357	12.00	42.84

Size of the effective breeding population of Cuanalan was derived by Wright's (1938) formula, and following Lasker (1954), it was estimated as 29% of the total population for the Tlaxcalan communities. The Coefficient of Breeding Isolation, a measure of the relative opportunity for the action of genetic drift, is the product of the effective breeding population size times the immigration rate (after Lasker, 1954, 1956; Lasker and Kaplan, 1964).

Drift may have been a more important factor in gene frequency distributions in the early history of Cuanalan because the ancestral gene pool underwent a rapid reduction in size during the Sixteenth Century. Roberts (1968) and Gajdusek (1964) point out that a "bottleneck" in population size is conducive to gene frequency fluctuations through drift. The fact that the founders of Cuanalan were displaced from the state of Tlaxcala during this period of sharp population reduction suggests that drift may have been a significant force in the initial divergence of the migrant population. Since the Spanish colonists helped split apart the Tlaxcalan gene pool by transplanting residents to Cuanalan and other new locations, the possibility of drift would have been enhanced in the early development of these "offshoot" populations.

Natural Selection

Certain of the demographic aspects of the presently analyzed populations favor rapid evolutionary changes through natural selection. Mortality prior to the age of reproduction is high in both Tlaxcalan populations, but notably greater in San Pablo. In Cuanalan, the proportion of deaths under age 15 has been high since 1866 (59.53%), and childhood mortality continues to claim a large segment of the population. San Pablo and Cuanalan experience higher mortality rates than the City of Tlaxcala in the under-15 age group, probably because infectious diseases are more pervasive in these two populations. Reproductive wastage occurs most frequently in Cuanalan, and this also contributes to genetic discontinuity. Variance in overall and completed fertility is high in all three populations, implying extensive differences in the achieved reproduction of females constituting the samples. This high variance may lead to the differential perpetuation of genotypes in succeeding generations if the most prolific or least prolific couples differ from the remainder of the population in some features of their genetic makeups. The fertility and mortality patterns in the populations under study suggest rapidly changing population compositions, a situation that promotes the swift "turnover" of genotypes through the action of natural selection.

The index devised by Crow (1958, 1962) for measuring the relative opportunity for natural selection from demographic data was calculated for the three Tlaxcalan populations. The formula $I = I_m + \frac{I_f}{}$ describes the total index, which can be partitioned into the fertility (I_f) and the mortality (I_m) components: $I_m = P_d/P_s$; and $I_f = {}^{V_f}$ where P_d is the proportion of the population which dies before reaching reproductive maturity (15 years), P_s is $1 - P_d$, X is the mean number of live births for women aged 40 and above, and V_f is variance in number of offspring among these women. San Pablo exhibits the highest index while City of Tlaxcala has the lowest. The index for Cuanalan is closer numerically to the Tlaxcalan Indians than to the Mestizos. A lower mortality component distinguishes the latter population. In Table 10 the total indices and the fertility and mortality components are compared to published values for the country of Mexico and other previously studied Latin American populations. The mortality components for San Pablo and Cuanalan are the highest of all populations compared. The total indices

Table 10

The Index for the Opportunity of Natural Selection in Cuanalan, San Pablo, the City of Tlaxcala, and other Latin American populations. The total Index (I) is subdivided into Components of Fertility (I_f) and Mortality (I_m) following Crow (1958, 1962)

Population	Investigator	I_m	If	I
Cuanalan	This study	1.47	0.28	2.16 [f]
San Pablo	Halberstein and Crawford (1972)	1.63	0.31	2.46
City of Tlaxcala	Halberstein and Crawford (1972)	0.59	0.35	1.14
Mexico	Spuhler (1962, 1963)	0.49	0.61	1.41
Cashinahua (Peru)	Johnston and Kensinger (1971)	0.79	0.11	0.98
Maca (Paraguay)	Salzano etal. (1970)	0.56	0.21	0.88
Yanomamo (Venezuela)	Neel and Chagnon (1968)	0.22	—	0.88
Chile:				
a) towns		0.15	0.45	0.67
b) villages	Crow (1966)	0.33	0.22	0.62
c) nomads		1.38	0.17	1.78
Terena (Brazil)	Salzano and Oliveira (1970)	0.27	0.28	0.63
Xavante (Brazil)	Salzano etal. (1967)	0.49		0.90
Cayapo (Brazil)	Salzano (1971)	0.34	0.38	0.71
6 Caingang tribes (Brazil)	Salzano (1961, 1964, 1965)	0.49-0.78	0.26-0.81	0.90-2.20

of the three present populations are found on the elevated end of the scale, although the value for Mexico is larger than for the City of Tlaxcala. Spuhler (1962, 1963) describes a range of 0.605 to 3.689 in total index for ten tribal populations in various parts of the world. Cuanalan, San Pablo, and the City of Tlaxcala all display greater mortality than fertility components; the same ratio is seen in nine of the thirteen tabulated populations (including five of the six Caingang tribes), five of the ten populations described by Spuhler (1962, 1963), and in three Pahira populations of India studied by Basu (1967).

The demographic attributes of the three Tlaxcalan populations are thus optimal for the action of natural selection through both differential fertility and differential mortality. Cuanalan's closer relationship to San Pablo in this regard is linked to the fact that infectious diseases comprise the three leading causes of death in these three communities. If certain genotypes in these populations provide greater resistance to the diseases, it is likely that selection is proceeding at a rapid rate. The data of Crawford, Cockburn and Gamboa (1973) and Halberstein, Crawford and Nutini (1973) suggest that infectious diseases have constituted a primary selective "pressure" in the recent evolution of Tlaxcalan populations. Thus, the prime conditions for natural selection which have historically typified Tlaxcalan populations are also found in the migrant population of Cuanalan. The biological resemblance of San Pablo and Cuanalan warrants the speculation that the opportunity for selection has long been prominent in Cuanalan, probably since its inception as a separate population.

Gene Flow and Hybridization

Cuanalan, San Pablo, and the City of Tlaxcala vary with respect to historical and recent patterns of migration and mate selection, suggesting that the communities have been differentially exposed to the potential for genetic admixture. The Indian population of San Pablo is characterised by restricted mobility—the *municipio* can be considered as a well-defined breeding population since few mates have been acquired from external localities over the past four generations, and there is no biological or cultural evidence that San Pablo has been in contact with genetically "distant" peoples. The City of Tlaxcala, on the other hand, has long been a highly mobile population characterized by the commingling and intermarriage of many different peoples. Perhaps the most important feature of the Tlaxcalan population is its historical place in Spanish colonizing activities. The military and political col-

laboration of Spaniards and Tlaxcalans in the city for almost three cen-
turies has resulted in a disproportionately large amount of Spanish
admixture (Crawford, 1974; Crawford et al. 1974; and Crawford, Work-
man and MacLean, 1974). The San Pablo population has retained al-
lelic frequencies more allied to Indian populations in surrounding areas,
while the City of Tlaxcala exhibits genetic affinities with recent Span-
ish populations.

Whereas Cuanalan was formerly a relatively closed population, it
currently appears to be in the process of transition to a state of greater
mobility. The present degree of migration and outmarriage in Cuanalan
is intermediate between the Tlaxcalan Indian and Mestizo populations.
The geographic location of Cuanalan makes admixture possible with
several different, and highly accessible, populations, some of which
are presently contributing genes to Cuanalans gene pool. Both genetic
and demographic data indicate that Cuanalan is a hybridized popula-
tion. Preliminary analyses, based upon Gm and Inv polymorphisms,
suggest that the genetic composition of Cuanalan is approximately
79% Indian, 15% Spanish and 6% African genes (Crawford and Schan-
field, unpublished data). Two factors have influenced the formation of
this unique genetic structure: 1. the original Tlaxcalan migrants were
accompanied to the settlement in Cuanalan by Spanish supervisors, and
2. Cuanalan-born individuals have recently been acquiring mates from
the Federal District and other mixed populations nearby.

Evolutionary Relationships of the Three Populations

Though many of the ancestors of Cuanalan, San Pablo, and the
City of Tlaxcala belonged to an inclusive Tlaxcalan gene pool prior to
1519, the populations have subsequently grown distinct in patterns of
population structure and evolution. The potential for widespread and
rapid evolutionary modification has characterized each population for
a number of generations and the populations have been affected by dif-
ferent historical and demographic trends influencing their microevolu-
tion. The demographic data are suggestive of a rapid evolutionary
divergence of Cuanalan, San Pablo, and the City of Tlaxcala. This sug-
gestion is substantiated by the genetic comparison of the three com-
munities (manuscript in preparation).

The past and present demographic dynamics of Cuanalan have pro-
vided a favorable context for the extensive operation of several evolu-
tionary processes, and it is probable that the population has been of a
similar disposition since its displacement from Tlaxcala over three and

one-half centuries ago. The evidence that Cuanalan, throughout its history, has variously been exposed to the opportunity for rapid evolutionary changes through drift, selection, and hybridization warrants the prediction that the genetic composition of the population has been steadily losing its Tlaxcalan identity. In fact, Cuanalan, San Pablo, and the City of Tlaxcala have been following different evolutionary courses due to variations in historical and demographic factors. Ongoing evolution should serve to further accentuate their genetic diversification.

CONCLUSIONS

While population splintering and transplantation have been recurrent themes in human demographic history, a clear understanding of their evolutionary implications has not yet been achieved. This problem deserves attention because, as the present study demonstrates, the fragmentation of gene pools promotes the pronounced demographic and evolutionary divergence of populations. It has been shown, for example, that both cultural and biological elements of population structure are affected by the demographic adjustment of a migrant population to a new environment. This study further suggests that population displacement can produce sudden shifts in the demographic conditions influencing the operation of different evolutionary processes such as genetic drift, natural selection, and hybridization.

The three biologically-related populations discussed in the present investigation represent extensive demographic variation. In the case of Cuanalan, the transplantation and "mestizoization" of the population have been accompanied by marked increases in population movement and outmarriage to levels approaching those of the City of Tlaxcala. The biological elements of the migrant population's demographic structure (fertility and mortality), on the other hand, show a closer relationship to the Indian community of San Pablo, indicating that "mestizoization" has not totally disrupted the similarity of these two populations in these respects.

The following findings of the present study bear directly upon the question of Cuanalan's evolutionary relationship to the Tlaxcalan populations: 1. The original migrant population possibly did not genetically represent the parental gene pool. 2. Cuanalan has undergone significant evolutionary changes during its existence as a separate population. 3. The demographic structure of the splinter population has recently opened it to heightened opportunities for the widespread action of a

number of evolutionary forces. 4. Judging from the demographic patterns of the three populations and from preliminary genetic data, Cuanalan should prove to be intermediate between the Indian and Mestizo Tlaxcalan populations in several aspects of its genetic makeup, including the amount of Spanish admixture. 5. The transplantation of Cuanalan has affected both the biological and the cultural components of its demographic adaptation.

The salient demographic features of Cuanalan—high childhood mortality, high variance in completed fertility, and expanding range of mate selection and residential mobility—suggest that the population is currently experiencing two of the more predominant trends of recent human evolution, namely increasing genetic admixture and natural selection through infectious diseases. It thus appears from the present research that Cuanalan is becoming increasingly differentiated from the Tlaxcalan gene pool.

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