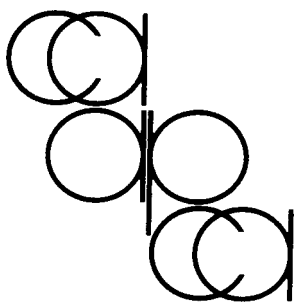

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Demographic Effects on the Distribution of Some Hemoglobin Types, G6PD (A,B) and Duffy (A,B)

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KEY WORDS HbS • G6PD • Duffy • Migration • Education

ABSTRACT The sampling frame and distributions of HbS, G6PD and Duffy systems obtained from a sickle cell screening clinic in Stockton, California, are analyzed. A probable sex difference in the frequency of HbS was observed. No other system is associated with any demographic variable. A possible association of Duffy with education was present.

RESUME L'article analyse l'échantillonnage et la distribution des systèmes HbS, G6PD et Duffy obtenus lors d'une clinique de détection de sicklémie à Stockton, Californie. On a pu observer une différence sexuelle possible dans la fréquence du HbS; aucun système n'a pu être associé avec des variables démographiques mais l'association du Duffy avec le niveau d'éducation demeure une possibilité.

INTRODUCTION

In 1972 the University of California (San Francisco) conducted a sickle-cell anemia screening clinic in Stockton, California. Petrakis and King ('74) have reported preliminary genetic results. Here we consider in detail some aspects of the migrant black patient subset.

We will describe some relationships between genetic systems and demographic variables in a migrant population. Where such relationships exist, the possibility of long term effects exists. For example, if the fertile age range of migrants should have a markedly different frequency for an allele than the remainder, and the average frequency is close to that of the recipient population, then the inevitable change in frequency at the destination after a few years will be surprising and probably misinterpreted. On the strength of an observed relationship of sickle-cell trait with age Alfred ('79) was able to demonstrate that a fertility differential is the predominant evolutionary force under relaxed

selection. Sex differences, where present, may also result in perturbations. In general, demographic attributes will define assortative mating subsets of a population, and consequently those genes which are associated will tend to clump within these subsets.

Blood was drawn at a stationary clinic and transported to Petrakis' laboratory at UCSF for typing. When observations are self-selected, as with such clinics, the problem of sampling bias must always be considered. Janerich et al. ('73) noted that if a bias was operating during the New York sickle-cell screening effort it was independent of low hematocrit levels.

Our strategy will be to control this source of variability, insofar as possible, statistically. We shall be using multi-dimensional contingency tables, hierarchical models, and the log-likelihood ratio chi-square test statistic, G^2 (Bishop, Fienberg and Holland, '75; Goodman, '70, '71, '72). The primary goal is not allele frequency estimation but rather the determination of rela-

tionships between genetic systems and demographic variables. This will be achieved by the construction of log-linear models designed to evaluate the goodness-of-fit to a particular hypothesis. Such models are characterized by an additive set of terms with hierarchical structure. The total set specifies an hypothesis about which of the variables are associated and which are independent. Successive hypotheses will

helpful in understanding data structures, so one is usually interested in locating a simpler model – i.e., one which does not include all possible terms. Procedurally it is easiest to begin with the simplest and add complexity only if necessary. As in the analysis of variance the simplest interesting model (excluding that which asserts all p's are the same) is that which asserts that the p's can be adequately modeled by the main

TABLE 1

Observed joint distribution of age x sex x birthplace (ASB)

| Sex | Birthplace | Age | | |
|--------|------------|----------|-----------|-----|
| | | 1 to <20 | 20 to <40 | 40+ |
| Male | California | 117 | 14 | 1 |
| | S.E. Coast | 5 | 8 | 4 |
| | Elsewhere | 9 | 8 | 8 |
| Female | California | 154 | 22 | 1 |
| | S.E. Coast | 7 | 11 | 9 |
| | Elsewhere | 14 | 31 | 19 |

usually differ by the presence or absence of a single term specifying an interaction, or association, between variables. Attention, therefore, is not directed so much at tests for goodness-of-fit but at the reduction of G^2 when a particular term is included in the model. A significant reduction of G^2 implies an improvement in the fit of the new model to the data as compared with an earlier model.

To fix concepts consider the 3-way table (table 1) giving the frequency distribution of observations on age (variable **A**), sex (**S**) and birthplace (**B**). The general element of the table is f_{ijk} , $i=1,2,3$ (for the age categories), $j=1,2$ (for male and female), and $k=1,2,3$ (for the birthplace areas). The observed frequencies may be converted to proportions, p_{ijk} , by dividing each cell frequency by the sum over all cells. It turns out to be very simple to construct a linear model for the natural logs of the p's which is analogous to the analysis of variance model, i.e., a term for the grand mean, one each for main effects, 2-way interactions, etc. – hence the descriptive term “log-linear models.” When the model contains all possible terms it is said to be saturated. Saturated models are not

effects only. This is the model of mutual independence, i.e.,

$$p_{ijk} = p_{i++}p_{+j+}p_{++k}$$

where the “+” indicates summation over the missing subscript. The hypothesis to be tested is completely specified by the terms which are present in the model. As it is not always possible to obtain an expression for the p's in terms of the marginal probabilities, it is convenient to write the models in another way. For heuristic purposes let t be the “grand mean” (actually the mean of the logs of the p's); and let $t_1(i)$ be the main effect of level i variable 1; $t_2(j)$ and $t_3(k)$ are similarly defined; $t_{12}(ij)$ is the interaction of variables 1 and 2 at levels i and j ; etc.; and g_{ijk} is the natural log of p_{ijk} . Then the model above would be written

$$g_{ijk} = t + t_1(i) + t_2(j) + t_3(k).$$

The hypothesis which asserts that only the interaction of variables 2 and 3 is required to describe the g_{ijk} is written

$$g_{ijk} = t + t_1(i) + t_2(j) + t_3(k) + t_{23}(jk)$$

and the saturated model is

$$g_{ijk} = t + t_1(i) + t_2(j) + t_3(k) + t_{12}(ij) \\ + t_{13}(ik) + t_{23}(jk) + t_{123}(ijk).$$

Note that whenever a term with 2 subscripts, e.g., i and j , is in the model both the terms with the single subscripts i or j are also present. The number of subscripts is the order of the term. The hierarchical principle specifies that all lower order terms with the same subscripts are present when a higher order term is present. So the saturated model could have been written

$$g_{ijk} = t_{123}(ijk).$$

In order to simplify notation, models will be described in terms of the variable labels – e.g., the saturated model for table 1 is “ASB,” the model of mutual independence is “A,S,B,” and that specifying that age is independent of sex x birthplace is “A,BS.”

When an hypothesis is specified the test for goodness-of-fit to the data is relatively straightforward. By comparing the goodness-of-fit of models which differ by single terms one can observe the effect of the presence or absence of the term. (A remarkably comprehensive treatment of the analysis of contingency tables is Bishop, Fienberg and Holland, '75.)

The primary demographic variables observed and their level are:

1. *Age (A)*: (1) 1 to less than 20 years, (2) 20 to less than 40 years, (3) 40 or more years. When considering G6PD and Duffy, categories 2 and 3 are combined.

2. *Sex (S)*: (1) male, (2) female.

3. *Birthplace (B)*: (1) California other than Stockton, (2) South-east coast (Alabama, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Washington D.C.), (3) Elsewhere (Alaska, Arkansas, Arizona, Illinois, Kansas, Missouri, New Mexico, Oklahoma, Oregon, Texas, Washington). When considering G6PD and Duffy, categories 2 and 3 are combined.

Later we shall consider some observations on highest school grade completed. The education variable (E), has levels

(1) at most grade 6, (2) grade 7 to high school graduate, (3) more than high school (not trade school).

When this variable is used, the age variable is modified to become a dichotomy: (1) 1 to less

than 25 years, (2) 25 or more years. This modification eliminates structural zeros from those tables. (A structural zero occurs when the conditions specified by the combination of levels cannot be met – e.g., a 5 year old professor of anthropology.)

By restricting attention to the subset of models in which the demographic variables enter as a 3-way fixed compound variable several advantages obtain. The number of possible models is greatly reduced, and by considering the demographic variables to determine the sampling design, any relationship between a genetic system and a demographic variable is statistically independent of sampling, being based on residual variation. This is an important point. The principal effect is to obviate doubt based on peculiarities of the attractiveness of Stockton (or the clinic) for the several subsets of the population. The notation “ASB” (age x sex x birthplace) is used for this variable.

In the next section we first consider the demographic variables only in order to establish the characteristics of the sample. Then attention is directed to genetic associations with these variables such that the tests are independent of the sampling frame.

RESULTS

In the following presentation each of the genetic systems will be considered serially. This structure is chosen because the systems segregate independently and any interaction among them would be quite suspicious. When a genetic system is shown to interact with a sociological variable this is inherently interesting but the question of cause and effect follows immediately; i.e., does the genetic system “cause” the sociological variable, or does the sociological state “select” the genes, or are they both “caused” by some unobserved intervening variable? Needless to say such questions are central to the development of comprehensive theory. We will take no position on these questions as none of the effects described below is sufficiently strong that its very existence may not be validly challenged.

Demography

In this section the 3-way joint distribution

of age x sex x birthplace is examined. The distribution is presented in table 1. The variables are not mutually independent ($G^2 = 191.6$, 12 df, $p \sim 0$). As blacks are relatively recent migrants to California, there is an expected interaction age x birthplace (AB). The hypothesis of an AB interaction, with sex independent of both jointly, the model "AB,S", results in $G^2 = 9.70$, 8 df, $p = 0.29$. Clearly the hypothesis specified by an interaction between age and birthplace with sex independent fits the data better than the hypothesis of mutual independence of the variables. And, since the associated probability is large, a parsimonious goal would indicate no further tests; the hypothesis fits the data adequately. We examine the table further for additional possible effects. The hypothesis of interactions AB and BS results in $G^2 = 3.29$, 6 df, $p = 0.77$. The latter model reduces G^2 by 6.41 with 2 degrees of freedom and $p = 0.04$ which is a significant improvement in goodness-of-fit. So, even though an adequate description is provided by the simpler model, a significantly better fit results when a term for the relationship between birthplace and sex is included. The model which is accepted, then, is "AB,BS"; the AS and ASB terms are absent. The hypothesis is that age and sex are conditionally independent. This is an "elementary hypothesis" (Goodman, '70) and the cell estimates, c , are obtained directly by $c_{ijk} = (f_{ij} + f_{jk}) / f_{++k}$.

In order to examine the BS interaction consider the ratio of the number of males to the number of females for each birthplace over all ages: California, 0.75; SE coast, 0.63; Elsewhere, 0.39.

These observations are consistent with sex dependent migration patterns. There has been a distinctly different sex composition of migrants which depends partially on point of origin. It will be noted that, for all birthplaces there are consistently fewer male than female migrants, but the relationship apparently is not a simple function of distance. In order to expand this observation, it would have been useful, for example, to know the number of migratory steps taken. But at any rate it seems clear that a sex bias exists for migration in this population. One would anticipate important social structural consequences as a result. The causes of the differential should be sought in

the sociological context; these data cannot further elaborate the observation.

In the remainder of this paper we fix the entire set of demographic variables (ASB) thereby eliminating these sources of variability. That is, all further tests will be conditional on the age x sex x birthplace marginals.

Hemoglobins

The minimum age of patients considered here is 1 year, thus eliminating HbF. There were 13 cases of type AC observed, but as its inclusion would greatly complicate the analysis by introducing a large number of random zeros, it has been excluded. The only other types observed were AA and As. In table 2 is the joint distribution of age, sex, birthplace (ASB) and hemoglobin type (H). The test for the independence of hemoglobin types and the demographic variables jointly ("H,ASB") results in $G^2 = 21.26$, 17 df, $p = 0.22$. We would be justified in terminating testing at this point; this model fits the data adequately. We proceed, however, in the expectation of extending the interpretation. The test for an interaction HS results in $G^2 = 17.98$, 16 df, $p = 0.33$. It will be noted that the HS reduces G^2 by 3.28 with 1 degree of freedom and $p = 0.07$. A sex effect seems likely. Adding the interaction HA results in $G^2 = 14.99$, 14 df, $p = 0.38$. This term reduces G^2 by 2.99 with with 2 degrees of freedom and $p = 0.22$ which is non-significant. The accepted model is "HS,ASB." This is also an elementary hypothesis; cell estimates may be obtained from $(f_{+jk} | f_{i+k+}) / f_{++k+}$. The expected odds for hemoglobin types AS are 0.14 for males and 0.08 for females. Note that male odds are about 1.84 times as large as for females.

G6PD

The data are insufficient to support a similar level of demographic detail in tests on the G6PD variants. A dichotomy has been created on the age variables with level 1 as previously and level 2 being age 20 or more years; birthplace has been dichotomized with level 1 being California and level 2 being all others. And the A and B variants cannot be analyzed simultaneously. Type A was observed only for males; there is no evidence of departure from indepen-

TABLE 2

Observed joint distribution of hemoglobin types AA and AS with age, sex and birthplace (ASB)

| Age | Birthplace | Male | | Female | |
|-----------|------------|------|----|--------|----|
| | | AA | AS | AA | AS |
| 1 to <20 | California | 101 | 16 | 138 | 9 |
| | S.E. Coast | 5 | 0 | 6 | 1 |
| | Elsewhere | 8 | 0 | 12 | 2 |
| 20 to <40 | California | 11 | 2 | 20 | 1 |
| | S.E. Coast | 7 | 1 | 10 | 1 |
| | Elsewhere | 7 | 1 | 25 | 4 |
| 40+ | California | 0 | 1 | 1 | 0 |
| | S.E. Coast | 4 | 0 | 8 | 0 |
| | Elsewhere | 7 | 0 | 17 | 0 |

dence of age \times birthplace and G6PD(A), $G^2 = 2.73$, 4 df.

There is also no evidence of departure from independence of G6PD(B) and ASB, $G^2 = 9.80$, 10 df. The failure to observe a sex \times G6PD(B) interaction implies $q \sigma = q^2 \varphi$ approximately, where q is the allele frequency for G6PD(B-).

Duffy

As with G6PD, the data for Duffy are not sufficient to allow retaining the demographic detail present for the hemoglobin types. The age and birthplace dichotomies created for G6PD were used with Duffy. There is no evi-

dence of departure from independence of Duffy(A,B) and ASB, $G^2 = 15.46$, 24 df.

Education

The highest school grade completed was determined for some subjects. Here we check for interactions between the several genetic systems and education which are independent of the age \times education (AE) joint distribution. The age categories are now 1 to < 25 and 25+ in order to eliminate structural zeros in the table. Neither hemoglobin nor G6PD types interact with education independently of AE.

The data do not support an unequivocal statement about the relationship of Duffy and

TABLE 3

Observed distribution of Duffy(A,B) types, age, and education

| Education level | Age | Fy(a+b+) | Fy(a+b-) | Fy(a-b+) | Fy(a-b-) |
|------------------------------|----------|----------|----------|----------|----------|
| At most grade 6 | 1 to <25 | 11 | 15 | 45 | 69 |
| | > 25 | 3 | 0 | 0 | 6 |
| Grade 7 to high school grad. | 1 to <25 | 3 | 6 | 21 | 48 |
| | > 25 | 2 | 4 | 11 | 29 |
| More than high school | 1 to <25 | 2 | 0 | 4 | 9 |
| | > 25 | 2 | 1 | 3 | 13 |

education. Table 3 contains the observations for the Duffy types by age and education. The test for the independence of Duffy from the AE joint distribution results in $G^2 = 22.66$, 15 df and probability 0.09. If this is accepted as evidence of a poor fit to the hypothesis, and it is not compelling either way, the next step is to check for the interaction of Duffy and education independently of AE. This results in $G^2 = 13.56$, 9 df and probability of 0.14. This is still not strong enough to allow a clear decision. When the two types are separated, i.e., into Fy(a+) and Fy(b+), both are convincingly independent of AE in isolation. So if an effect exists it is due to the simultaneous occurrence of the two types.

SUMMARY AND CONCLUSIONS

G6PD and Duffy were shown to be independent of the age x sex x birthplace joint distribution. And HbS and G6PD were shown to be independent of the age x education joint distribution. We were unable to show, convincingly, the independence of Duffy from the age x education distribution. This is of some potential interest in light of Reed's work ('69) showing that the Duffy system is perhaps the best marker for African ancestry.

We have established a (probable) sex dependent differential in the frequency of HbS and a sex dependent differential in birthplace. But we failed to observe a birthplace differential for HbS. Different regions of the U.S. are clearly characterized by significant differences in HbS frequency (Alfred, '79). So the absence of a birthplace differential in this sample is curious. Possible explanations may be as simple as small numbers of observations or as complex as the Rococo scenario needed to explain the absence as sampling bias. Assuming the effect to be true, it is interesting to speculate on its origin. It appears that most of the U.S. is characterized by regional differences and an age effect but locally similar frequencies for male and female (Alfred, '79). There is no known selective agent there which favors HbS. While there is an excess of females among the migrants from each birthplace, the ratio of trait carriers to normals is nearly twice as great among males as among females. The sex ratio of migrants is partially determined by birthplace. But whatever that ratio, the ratio of the odds for male trait carriers

to the odds for female trait carriers is constant. These observations possibly indicate a complex set of selective migratory decisions. Males are apparently less disposed than females to migrate, but of those who do, there is an excess of trait carriers.

It should be mentioned that interpreting these observations as selective migratory decisions implies that there is no selective attrition among the migrants. The same observations could be produced if decisions are non-selective but, as a consequence of an interaction of sex and hemoglobin, arrival at Stockton is selective. To develop this a bit, assume that equal numbers of males and females decide to migrate independently of hemoglobin. The ratio of male trait odds to female odds is 1.0. On arrival this odds ratio has become approximately 1.9 and the overall sex ratio changes from 1.0 to something less than 1.0 depending on the starting place. This implies that males are dropping out more rapidly than females, but male trait carriers are continuing more frequently than female trait carriers.

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Variation des Niveaux de Santé et Environnement Socio-culturel: Anthropobiologie d'une Population de Travailleurs Suisses

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KEY WORDS Human Biology • Health • Switzerland

RESUME Les études de variations biologiques des sociétés humaines ne sauraient faire abstraction de cette importante source de variation qu'est l'environnement socio-culturel. Ayant eu à analyser en profondeur les principales sources de variation des niveaux de santé d'une société Suisse, nous avons développé un modèle opératoire d'une quarantaine de critères de classification rendant compte de l'environnement socio-culturel. On y retrouve des indicateurs de stratification sociale et de socio-démographie, des variables représentant le milieu familial et culturel d'origine, le milieu actuel de résidence, le milieu travail et les habitudes de vie. Ce modèle a été utilisé dans le cadre d'analyses de variance multiples basées sur la régression multiple.

ABSTRACT One should not forget the importance of sociocultural environmental variation in the study of biological variations of human societies. In order to analyse the variation of health levels in a Swiss society, we developed a forty-variable model representing the sociocultural environment. Within this classification system, we can take into account social stratification and demography, familial and cultural background, present residential and working environment, and living habits. This model was successfully used in multivariate analysis using multiple regression techniques.

INTRODUCTION

L'étude de la variation biologique de l'être humain demeure le principal objectif de l'anthropobiologie. Cette étude, cependant, peut se caractériser par la très grande importance que l'on doit accorder à cette partie de l'environnement qui est le produit de l'être humain: l'environnement socioculturel d'une part, et matériel "artificiel" de l'autre. Si les recherches sur l'adaptabilité humaine à différents climats, de même que les diverses études en épidémiologie ou en hygiène des milieux, tiennent compte de l'aspect matériel de l'environnement, de moins nombreuses recherches par-

viennent à définir et à quantifier de façon opératoire l'aspect plus socio-culturel de la variation de l'environnement de l'être humain, aspect qui peut aussi être source d'une importante partie de la variation biologique de notre espèce. Et pourtant, nos contacts fréquents avec nos confrères ethnologues, ethnolinguistes, archéologues, sociologues, psychologues et démographes devraient nous y préparer directement. L'étude de la variation biologique de l'être humain ne saurait se passer de nombre d'aspects de l'environnement socio-culturel.

L'OPERATIONALISATION DE L'ENVIRONNEMENT SOCIO-CULTUREL

Ce qui est vrai en théorie devrait se retrouver au niveau de la pratique. Nous avons été confrontés à ce problème alors que nous faisons partie d'une équipe multidisciplinaire de l'Institut de Médecine sociale et préventive de l'Université de Zurich. L'objectif de cette équipe était de décrire, et si possible d'expliquer, la variation des niveaux de santé dans une population de travailleurs industriels de 6 cantons du nord-est de la Suisse. Nous avons pu examiner ainsi, en deux années et demie de terrain, 1053 employés de 44 entreprises industrielles différentes; tous étaient masculins, âgés de 20 à 65 ans, et originaires de cette région de la Suisse.

Nous avons pu développer, au niveau des variables dépendantes, un modèle d'analyse dans lequel pourrait se retrouver un certain nombre de variables opératoires représentant, bien imparfaitement il est vrai, des aspects importants de la variation de l'environnement socio-culturel. Ce modèle, présenté à la table 1, variait bien sûr en fonction de la nature des variables dépendantes auxquelles il était appliqué. Il se présente en 10 groupes de variables indépendantes totalisant 45 critères de classification; nous retrouvons à la table 1 le nombre de niveaux utilisés pour chacune de ces variables.

Le premier groupe présente différents indicateurs de ce très important phénomène qu'est la stratification sociale. Chacun de ces indicateurs s'est avéré sensible pour l'une ou l'autre de nos variables dépendantes, et c'est souvent l'ensemble de ces 5 variables indépendantes qui présentait des résultats significatifs pour nombre de variables physio-pathologiques. La responsabilité humaine au travail, en particulier, s'est avérée une variable indépendante particulièrement sensible dans la genèse de plusieurs tendances pathologiques.

Les variables du groupe "démographie" ont été utilisées à la fois comme variables indépendantes et comme variables de contrôle. L'âge, s'il représente en partie le vieillissement, rend aussi compte des différences d'époque et d'environnement socio-culturel; l'état civil est lié des très près à des différences considérables de l'environnement de chaque individu. Les variables témoignant de la macro-origine de

chacun sont particulièrement éloquentes en ce qui concerne les différences de contexte socio-culturel de l'individu pendant son enfance; elles peuvent aussi impliquer d'éventuelles différences d'ordre génétique. Les caractéristiques de la commune de vie pendant l'enfance ont été générées à partir d'une vingtaine de variables socio-démographiques tirées des recensements fédéraux des années 1940, pour chacune des 515 communes que comporte le territoire étudié.

Si l'environnement socio-culturel communautaire peut faire sentir son influence au niveau de la variation individuelle, il est aussi vrai que l'environnement familial pendant l'enfance peut aussi avoir une très grande importance; la psychanalyse nous le rappelle tous les jours. Un total de 7 indicateurs a été utilisé pour tenter de représenter ce type d'environnement socio-culturel dans notre modèle. Les 3 derniers de ces indicateurs proviennent d'une échelle de mesure représentant les relations avec les parents; ils se sont avérés très importants pour plusieurs variables dépendantes, en particulier pour la morphologie individuelle. Le cinquième groupe de variables indépendantes essaie de tenir compte d'un certain nombre de prédispositions héréditaires, par la présence ou l'absence, au sein de la famille d'origine, de diverses catégories de maladies. Cependant, ce sont aussi des différences d'environnement que ce groupe représente, un père alcoolique ou suicidaire, par exemple, pouvant grandement affecter l'équilibre mental de ses enfants, comme nous l'ont confirmé nos analyses.

Le milieu de résidence et diverses variables témoignant de certains aspects du milieu de travail représentent aussi d'importantes différences dans l'environnement socio-culturel de chaque individu. C'est ainsi que la mixité au travail s'est avérée fortement liée à une baisse des tendances névrotiques et des maladies du système digestif chez nos sujets. Les habitudes de vie, variables indépendantes privilégiées de la médecine sociale et préventive, n'ont pas été oubliées dans le modèle. Elles représentent à la fois une réaction subjective de l'individu face à son environnement (le fait de fumer ou de ne pas fumer, par exemple), et un nouvel environnement que l'individu génère lui-même et qui pourra avoir un impact important sur d'autres aspects du phénotype (affections respiratoires

TABLE 1

Le modtle d'analyse

| groupes | variables indépendantes | niveaux |
|--|---|--|
| I– stratification sociale | 1– niveau professionnel | 6 |
| | 2– niveau d'instruction | 5 |
| | 3– responsabilité humaine au travail | 3 |
| | 4– propriété ou location du logement | 2 |
| | 5– niveau des revenus de toutes sources | 5 |
| 11– démographie | 6– âge du sujet | 5 |
| | 7– état civil | 2 |
| | 8– saison de l'année lors de l'examen | 4 |
| 111– macro-origine | 9– canton de naissance | 6 |
| | 10– niveau de developpement de la commune d'enfance | 3 |
| | 11– valeurs culturelles de la commune d'enfance | 3 |
| | 12– confession d'origine | 2 |
| IV– famille d'origine | 13– niveau professionnel du père | 5 |
| | 14– effectif de la fratrie | 3 |
| | 15– rang de naissance | 3 |
| | 16– âge de la mere à la naissance du sujet | 3 |
| | 17– autorité des parents du sujet | 3 |
| V– predispositions héréditaires | 18– soutien de la part des parents du sujet | 3 |
| | 19– inconsistance pédagogique des parents du sujet | 3 |
| | 20– maladies cardio-vasculaires | 2 |
| | 21– maladies neurologiques et neuro-psychiatriques | 2 |
| | 22– maladies organiques en général | 2 |
| | 23– maladies immunologiques | 2 |
| | 24– toutes les formes de cancer | 2 |
| | VI– milieu de residence | 25– niveau de developpement de la commune de residence |
| 26– valeurs culturelles de la commune de residence | | 3 |
| VII– entreprise employeur | 27– branche industrielle | 5 |
| | 28– grandeur de l'entreprise | 3 |
| | 29– pourcentage de la main d'oeuvre feminine | 3 |
| | 30– pourcentage de la main d'oeuvre étrangère | 3 |
| VIII– habitudes de vie | 31– pratique des sports | 3 |
| | 32– consommation de tabac | 5 |
| | 33– consommation de médicaments | 3 |
| | 34– quantité globale de la consommation alimentaire | 3 |
| | 35– consommation d'alcool | 3 |
| | 36– consommation de charcuterie ou de viandes | 3 |
| | 37– consommation de protéines animales ou végétales | 3 |
| IX– comportements et attitudes | 38– migration géographique | 3 |
| | 39– migration sociale | 3 |
| | 40– pratique religieuse | 3 |
| | 41– motivation à la performance | 3 |
| | 42– attitudes pédagogiques générales | 3 |
| X– morphologie | 43– format morphologique | 3 |
| | 44– forme morphologique | 3 |
| | 45– constitution morphologique | 3 |

et cardio-vasculaires). Les 4 variables indépendantes représentant les habitudes alimentaires résultent d'une enquête alimentaire relativement complexe.

On pourra s'étonner de trouver, au sein de ce modèle de variables indépendantes, des comportements et attitudes, de même que des indicateurs de la morphologie individuelle. La migration géographique, par exemple, dans toutes les études portant sur le sujet, a toujours été associée de très près à d'importantes différences d'ordre morphologique. Le migrant, en plus d'un phénomène de pré-sélection associant morphologie et personnalité, génère par sa migration un nouvel environnement qui pourra être lié à plusieurs autres aspects de la variation du phénotype. Il en est de même pour plusieurs autres comportements et attitudes. De plus, il faut tenir compte de la variation morphologique lorsque l'on étudie, par exemple, les relations entre la stratification sociale et l'épreuve respiratoire de la spirométrie, afin que les résultats obtenus soient calculés à morphologie équivalente.

L'UTILISATION DU MODELE ET SES RESULTATS

Nous avons largement fait appel, dans la genèse de ce modèle, à des techniques telles que l'analyse en composantes principales (variables 10, 11, 25, 26, 34, 35, 36 et 37), l'utilisation d'échelles de mesure validées (variables 17, 18 et 19), ou encore de techniques originales développées pour la circonstance (les trois indicateurs de la morphologie individuelle, générés à partir des déviations individuelles de 32 mensurations anthropométriques, en utilisant des contrastes orthogonaux). Il en a été de même pour l'opérationnalisation de quelques 200 variables dépendantes.

L'analyse des variables dépendantes s'est faite à l'aide d'une technique d'analyse de variance multiple basée sur la régression multiple (Overall and Klett, '72). Cette méthode permet de considérer simultanément toutes les variables indépendantes, les effets principaux de chacune sur les variables dépendantes étant "ajustés" aux effets principaux de toutes les autres. En d'autres termes, dans un modèle à 45 variables indépendantes, l'effet principal de chaque variable indépendante sur les variables

dépendantes est calculé en maintenant artificiellement constantes et inopérantes les 44 autres variables indépendantes. Lorsque couplée à des analyses classiques de variance à un seul critère de classification, cette technique permet l'obtention de résultats "empiriques" représentant les différences de moyennes entre les niveaux d'un critère, et de résultats ajustés, témoignant d'une association épurée entre ce critère et la variable dépendante.

Les variables dépendantes de cette enquête ont été groupées en 3 grands ensembles, correspondant aux 3 grandes étapes de l'analyse des données. Le premier ensemble constituait une étude, plus ethnologique qu'anthropobiologique, de la variation des valeurs et des attitudes en société industrielle, en fonction des variables indépendantes des 8 premiers groupes présentés à la table 1. Cette étude ethnologique et socio-psychologique s'est avérée très importante lors des deux autres étapes analytiques. On trouvera ailleurs ses principaux résultats (Forest-Streit '77). La seconde étape des analyses était consacrée à l'étude de la variation de la morphologie individuelle, et ce sont alors les variables indépendantes des 9 premiers groupes présentés à la table 1 qui ont été utilisées (Forest, '76 a, b). L'étude de la variation des niveaux de santé a fait l'objet de la troisième série d'analyses, à partir de variables indépendantes tirées des 10 groupes présentés à la table 1, (Forest, '75; Biener et al., '76 a, b).

DISCUSSION ET CONCLUSION

Il a été pour nous scientifiquement très rentable d'utiliser un tel modèle de variables indépendantes représentant certains aspects de l'environnement socio-culturel. Pour un très grand nombre de variables dépendantes, divers indicateurs des niveaux de santé par exemple, les groupes de critères témoignant de situations socio-culturelles se sont avérés tout aussi importants, et parfois même plus importants, que les groupes de critères représentant des éléments plus matériels de l'environnement, telles les habitudes de vie, la branche industrielle, etc. Le vieillissement physiologique différentiel, par exemple, est plus sensible, dans nos résultats, à ce grand phénomène de stratification sociale et à ses repercussions psychiques pour l'individu, qu'au groupe de critères représentant les habi-

tudes de vie et les conditions matérielles de travail. Ces résultats ouvrent des perspectives très intéressantes à l'anthropobiologie qui, contrairement à d'autres disciplines, devrait être très sensible à l'importance de l'environnement socio-culturel.

Le modèle présenté à la table 1 demeure cependant très imparfait et incomplet. Nous travaillons présentement (Bastarache et al., '78; Auger, et al.) dans un contexte québécois, à l'améliorer, à choisir des indicateurs plus pertinents, pouvant expliquer un pourcentage encore plus élevé de la variation biologique de l'être humain dans notre type de société. Ces nouveaux indicateurs ne sont cependant pas toujours aisés à relever auprès des individus, compte tenu des circonstances particulières des études anthropo-médicales en usine. Nous croyons cependant parvenir à améliorer substantiellement ce qui a déjà été fait, pour parvenir à une meilleure connaissance des milieux dans lesquels les travailleurs évoluent.

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Early Neolithic Cranial Deformation at Ganj Dareh Tepe, Iran

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KEY WORDS Cranial Deformation • Paleopathology • Neolithic • Iran

ABSTRACT In the study of human skeletal remains from an Early Neolithic site, six of the crania were observed to be artificially deformed. This paper presents the analysis and interpretation of these deformations in the light of existing typologies and in relation to comparable material from other Middle Eastern sites.

RESUME L'étude des restes de squelettes humains d'un gisement du néolithique ancien nous a permis d'observer la déformation artificielle de six crânes. Cette communication présente l'analyse et l'interprétation de ces déformations à la lumière des typologies disponibles et dans une perspective comparative avec d'autres sites du Moyen Orient.

The resulting shape of an intentionally deformed skull depends on the interaction of a number of cultural and physical variables. These include the prescribed shape, the device whereby force is applied to the skull, the age at which deformation is initiated, and the duration of deformation (Stewart, '41; Falkenberger, '38). Numerous reasons have been suggested for deformations observed in many populations, principally from the New World. Rogers ('75, p. 4) reviews some of these, including the ". . . exaggeration of a naturally brachycephalic head form" by the Maya (Dingwall, '31), and a desire to reflect ". . . motives of a ritual origin" among Mexicans (Romano, '74). As well as being particularistic, the diverse explanations of underlying behaviour are largely conjectural.

Better information exists on the process of deformation. A number of societies are known to have initiated deformation among the very young. For the Maya, deformation began four or five days after birth (McGibbon, '12, cited by Rogers, '75). Dingwall ('31) reports that deforming devices were worn by Peruvians from the age of three months until about the fifth birthday. The Chinook, however, discon-

tinued their attempts at about twelve months of age (Dingwall, '31, cited by Rogers, '75).

There has been considerable interest in the classification of deformed skulls. The first attempt to develop a typology was made by Morton in 1839 (Falkenberger, '38, p. 2). Morton used shape as the criterion for distinguishing four types: 1) fronto-occipital, 2) fronto-sincipital-parietal, 3) irregular compression, and, 4) quadrangular. In 1899, Goss developed another typology that was also based on shape. Both typologies, however, were limited in their application because specimens not exhibiting one of the modal shapes could not be accurately classified.

Another shortcoming inherent to these early typologies was their lack of consideration for the means of deformation. This was rectified in 1875 when Broca established a new terminology describing shape with reference to the appliances used to promote any particular cranial shape. Categories included: 1) simple, 2) annular, 3) frontal simple, 4) frontal tabular (flattened), and, 5) frontal elevated. In 1923, Imbelloni simplified Broca's typology by describing deformation types in terms of the two basic appliances used to effect deformation.

The tabular type was subdivided to both intentional and unintentional cranial deformations. There were "...la deformation fronto-occipitale oblique provoquée par planchettes fixés à la tête, et la déformation fronto-occipitale droit produit par berceau d'une telle façon que la tête est fixée directement sur une surface aplatie (Falkenberger, '38, p. 3)." The two tabular forms were distinguished by abbreviation in length and increase in breadth, producing a lateralized skull shape. These changes were noted by both Broca and Imbelloni to be more exaggerated for specimens deformed by planks. The annular type of deformation was characterized by exaggerated head length and relatively narrow breadth. This form was caused by a bandage or hood ("bonnet") device (Broca, 1875; Imbelloni, '23, cited by Falkenberger, '38, p. 4).

The remains of 49 individuals, including twelve males, eleven females, six adults of undetermined sex, and twenty preadolescents, were recovered by P.E.L. Smith from Ganj Dareh Tepe, a small Early Neolithic village in Kermanshah Province, Iran.

Dates, in years B.C., from the site are as follows: Level A – 6960±170 (GAK-994); Level B – 6938±298 (P-1486); Level C – 7289±2196 (P-1485); Level D – 7018±100 (P-1484); and the base of Level D – 8500±150 (GAK-807) (Kunihiko, '67; Lawn, '70; Smith, '74, '75).

Ten of the crania were sufficiently complete to permit significant morphological evaluation. Of these, six showed changes indicative of intentional deformation. This group of six includes two males, two females, and two preadolescents (Lambert, '80; Meiklejohn et al., '80). One of the females is associated with Level D and one of the males with Level E. The remaining four cannot as yet be associated with a specific level, although it is worth noting that three of these, the two adults and one of the youngsters, were recovered together from a mud-brick sarcophagus.

All cases of deformation at Ganj Dareh were of the annular variety characterized by the simultaneous occurrence of three specific modifications and by the general shape of the skull (fig. 1). The first modification is a depression located slightly posterior to the coronal suture on both parietals. This postcoronal depression is linear, extending across the region behind

bregma to points superior to the temporal fossae.

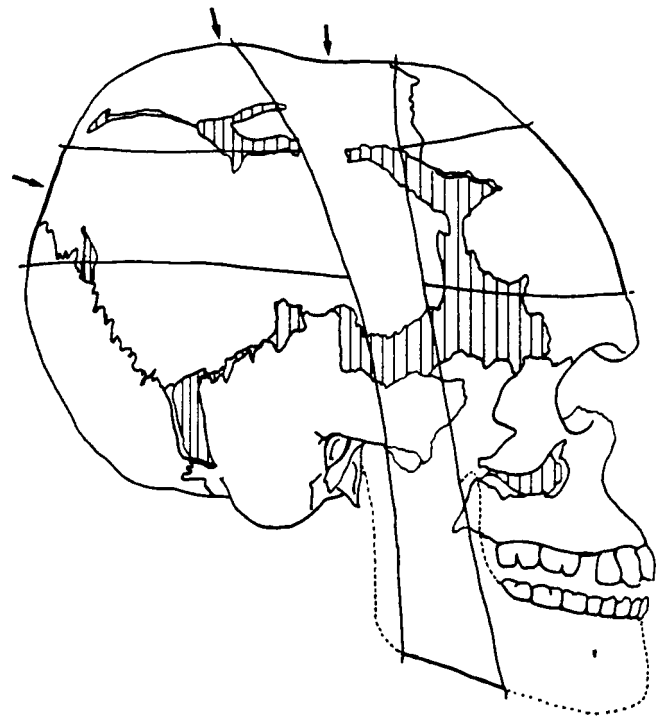


Fig. 1 Annular deformation of Individual 17, a young adult male. The three features of this style are shown in relation to bandages in their probable orientations. The mandible is from an unrelated specimen.

The second characteristic is an elevated area of bone parallel and posterior to the postcoronal depression. This is too far back on the skull to be considered the 'frontal bulge' or *ementia rhomboidea* observed on other annular specimens (Aichel, '33, pp. 50-51; Rogers, '75). On the Ganj Dareh specimens, the eminence runs bilaterally from apex to the area above the origins of the *temporalis*.

The third characteristic, shown by four of the more complete specimens, is a flattened area immediately above lambda. This feature is the most variable in expression, ranging from a slight depression (fig. 2) to bone misalignment. In the latter case (fig. 3), the parietals are curved inward and are slightly overlapped by the occipital.

The figures illustrate the resulting shapes of an adult male and two preadolescent crania. The preadolescents show the first two characteristics and overall shape similarity. The pos-

terior half of these is elongated and elevated while behind the coronal suture, the vault is laterally compressed. The postcoronal depression and the bulge are both fairly distinct. The shape shown by the adult cranium is different as the vault is less elevated and the lateral constriction is markedly reduced. All three charac-

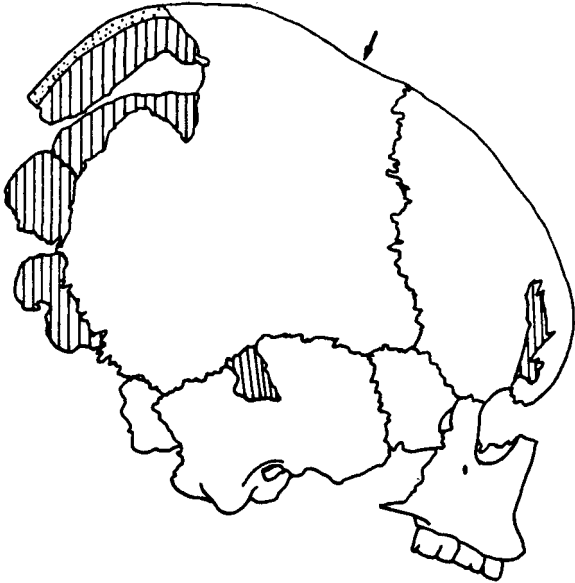


Fig. 2 Individual 14, a preadolescent of undetermined sex. The posterior portion of the vault is elevated above the postcoronal eminence and the depression (arrow) is well marked. Age is between 5% and 6% years.



Fig. 3 Deformation of Individual 16, a preadolescent of undetermined sex. The area at lambda shows how deformation has caused misalignment in the suture.

teristics associated with Ganj Dareh deformation are well developed.

Comparison of the shapes of the preadolescent and adult crania suggests that the distinctive adult shape probably resulted from compensatory or continued bone growth following removal of the bandages. Age of this adult is ca. 19 years while the two younger specimens are ca. 5½-6½ and 6-8 years of age. Three additional deformed, but less complete, individuals also show differences in shape consistent with those noted for preadolescents and adults. One of these is ca. 15 years of age while the others are unaged adults.

Perhaps the most significant feature of this early occurrence of cranial deformation is the large proportion of the series that was unaffected. It has been suggested repeatedly that selective deformation of crania is a feature associated exclusively with socially stratified populations or in societies with copious leisure time (Rogers, '75). Dingwall ('31, p. 169, cited by Rogers, '75) observed that, among the Chinook, slaves were generally not permitted to practice deformation. Further, in some South American and Meso-American populations, deformation was a privilege of rank. It is interesting to speculate on the existence of social stratification at Ganj Dareh, particularly, since half of the individuals with deformed crania were recovered from within a single mud-brick sarcophagus. This style of burial was unique at the site. The remaining individuals comprising the series were recovered from discrete burial pits.

Few cases of artificial cranial deformation have been reported from Middle Eastern sites (Finkel, '74). The earliest, from Ali Kosh, Iran, are dated between 6750 and 6000 B.C. (Hole, Flannery and Neely, '69). Two crania from Level B2 (burials 33 and 34) at Ali Kosh show annular variations. A second Iranian site with artificially deformed skulls is Seh Gabi, which dates to about 4000 B.C. Several preadolescents at this site display annular deformation produced by a single bandage wrapped around the frontal and extending beneath the occipital, producing a characteristically elongated occipital (Meiklejohn, pers. comm.). A further occurrence is at Byblos, Lebanon (Ozbek, '74), where annular deformation was found in a high proportion of the female skulls. One of the

deformation types identified by Ozbek was caused by bandaging. This was "Byblos type b," whose bandage configuration is similar to that proposed for Ganj Dareh (fig. 1). Dates from Byblos are close to those from Seh Gabi. There is presently no further information available from either of these Iranian series.

In conclusion, examination of the few known examples of intentional cranial deformation in the Middle East suggests that annular variants were more common than tabular forms during the initial development of the practice. **This** may indicate a functional basis for deformation, as the annular style was perhaps simpler to effect or was preferable to the tabular style. Further, there is no evidence for the use of cradleboards by these Middle Eastern groups.

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Assignment of Sex to Adult Femora from an Ossuary Population¹

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KEY WORDS Sex Determination • Ossuary •
Discriminant Function • Femoral Head Diameter

ABSTRACT The Kleinburg Ossuary, Kleinburg, Ontario, Canada, contained the remains of at least 561 individuals, with all skeletal elements thoroughly mixed. The problem discussed is that of assigning a sex to the over six hundred adult femora. Discriminant function analysis is used to discriminate putative males and putative females, working from the primary assumption that adult sex ratio will be approximately balanced, males will tend to be taller than females, and males will tend to be more robust than females. Eight femoral measurements are used. The most useful measure for discrimination is that of maximum head diameter. Direct discriminations of left and right femora are statistically successful and it is argued that they are biologically successful as well. Besides appropriate sex ratios, the discriminations also yield bimodal distributions with sizeable regions of overlap and reduced coefficients of variation for each measurement.

RESUME L'ossuaire de Kleinburg, près de Kleinburg, Ontario, Canada, contient les restes d'au moins 561 individus dont les parties du squelette sont complètement mélangées. Le problème traité consiste à déterminer le sexe de plus de 600 femurs adultes. Pour distinguer les mâles possibles des femelles possible nous avons recours à une analyse fonctionnelle discriminante, en postulant en principe que le sexe adulte se présente dans un rapport bien balance, que les mâles seront de plus haute taille que les femmes, et que les mâles seront plus robustes que les femmes. Nous avons recours à huit mensurations fémorales. La mensuration la plus utile pour établir cette distinction reste le diamètre maximum de la tête. La distinction directe de fémurs droits ou gauches a montré un succès statistique certain et nous pouvons suggérer que ce succès se présentera également au niveau biologique. En plus de rapports de sexes adéquats, les distinctions nous fournissent aussi de distributions bimodales avec des surfaces importantes qui se chevauchent et de coefficients de variation réduits pour chaque mensuration.

INTRODUCTION

The research utility of a large, well-preserved ossuary population is lessened by two major factors: the mixing of skeletal elements, and the resulting mixture of males and females. Virtually any bone of the body can be categorized with varying degrees of confidence as mature or immature yet few areas of the skeleton can be confidently "sexed". As long as

males and females are mixed, the descriptive statistics have high coefficients of variation and sex-influenced differences in morphology are obscured.

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It is recognized that there is some sexual dimorphism of the appendicular skeleton. The femur has been extensively studied in this regard. Early studies like those of Dwight ('04/'05), Pearson ('17-'19) and Thieme ('57) are well summarized by Krogman ('62), and their figures for transverse head diameter continue to be cited in recent texts as useful criteria for estimation of sex (cf. Bass, '71; Ubelaker, '78). Femoral shaft circumference has been recently proposed (Black, '78) as yet another aspect of femoral size/shape likely to show a bimodal distribution. The most successful results have generally come from studies using multiple measurements considered together through the use of a multivariate statistical technique like discriminant function analysis (cf. Thieme, '57; Hanihara, '58). Measurement of success, however, normally comes from testing the technique on individuals of known sex and arriving at a percentage error figure.

The Kleinburg Ossuary is a skeletal sample from near Toronto, Ontario, dating from approximately 1600 A.D. (Melbye, pers. com.). In the case of the Kleinburg Ossuary population, there is no subset of known sex individuals. Nevertheless, it would be highly desirable to have an estimate of sex for some proportion of the over six hundred femora. Division by sex would add utility to all summary statistics and it would be very important to paleodemographic analysis. Sex ratios for the population have been estimated on the basis of innominates (Saunders, '74) and crania (Pfeiffer, '74). Visual examination of 89 moderately complete crania from individuals 20 years and older yields a sex ratio of 1:1.5, or 40% male, 60% female. This is surprising, but may be plausible given the Jesuits' observation that those who died violent deaths, like males killed in battle, were not included in the ossuary. However, both left and right innominates consistently give a sex ratio very close to 1:1. The innominate estimates are more likely to reflect biological fact. Therefore, we may logically expect a sex ratio reasonably close to unity. A third estimate based on long bone data would be very useful for comparison. Finally, if internal bone remodelling of the femur is to be assessed for estimates of adult age at death (cf. Kerley, '65; Ubelaker, '74), an estimate of both sex and age for each individual would yield data suitable for

sex-specific demographic profiles, certainly a desirable goal. Therefore, a group of eight femoral measurements has been organized, using discriminant function analysis, into two groups of overlapping frequency distributions that can be thought to represent putative males and putative females. In the absence of subsamples of known sex, certain assumptions are made: adult sex ratio will be approximately balanced; males will tend to be taller than females; males will tend to be more robust than females. These assumptions are used to construct suitable subsample divisions.

MATERIALS AND METHODS

The Kleinburg Ossuary site, Kleinburg, Ontario, Canada (A1Gv-1) was excavated in 1970 under the directorship of F. J. Melbye, University of Toronto. The structure of the ossuary conformed to the descriptions of ossuary construction found in the Jesuit Relations and associated documents (cf. Tooker, '64; Trigger, '69, '76). However, a specific ethnographic affiliation such as Huron or Neutral has not yet been established (Wright, '77). The remains of at least 561 individuals were tightly packed and thoroughly mixed within the burial pit. Approximately one half million fragments were cleaned and catalogued. Data have now been keypunched and constitute a data bank of approximately 25,000 cards set up for quick retrieval through the SPSS programs (Nie et al., '75). Dental analysis indicates that there are at least 157 subadults and 404 adults represented (Pfeiffer, '74). Minimum numbers derived from the femora are 323 right and 344 left (both counts are based on measurements of transverse shaft diameter).

The eight measurements available for analysis are listed in table 1. These measurements were taken by a small number of advanced skeletal biology students during a six month period. The magnitude of the project plus very limited funds precluded any one researcher from gathering all data. Duplicate measurements were taken on a subsample of complete bones from each long bone category so that interobserver error could be quantified. Fifty left femora were re-examined. Correlation coefficients based on paired comparisons range from $r = .71$ to $r = .99$. The lowest correlation

TABLE 1
Variables available for analysis

| | N | \bar{X} | s | V |
|--|-----|-----------|-------|------|
| MAXIMUM LENGTH | | | | |
| Right | 117 | 440.62 | 23.97 | 5.44 |
| Left | 118 | 442.47 | 22.77 | 5.15 |
| PHYSIOLOGICAL LENGTH | | | | |
| Right | 125 | 436.26 | 23.93 | 5.48 |
| Left | 128 | 437.53 | 23.32 | 5.33 |
| PROXIMAL ANTERO-POSTERIOR DIAMETER | | | | |
| Right | 321 | 23.76 | 1.98 | 8.33 |
| Left | 340 | 24.34 | 1.98 | 8.13 |
| PROXIMAL LATERAL SHAFT DIAMETER | | | | |
| Right | 323 | 32.83 | 2.37 | 7.22 |
| Left | 344 | 32.97 | 2.37 | 7.19 |
| MID-SHAFT ANTERO-POSTERIOR DIAMETER | | | | |
| Right | 272 | 27.24 | 2.37 | 8.70 |
| Left | 276 | 27.56 | 2.48 | 9.00 |
| MID-SHAFT LATERAL DIAMETER | | | | |
| Right | 272 | 24.69 | 1.98 | 8.02 |
| Left | 276 | 25.68 | 1.73 | 6.74 |
| MAXIMUM HEAD DIAMETER | | | | |
| Right | 121 | 44.81 | 2.94 | 6.56 |
| Left | 134 | 44.16 | 2.75 | 6.23 |
| CONDYLE-SHAFT ANGLE | | | | |
| Right | 177 | 78.43 | 2.04 | 2.60 |
| Left | 187 | 77.81 | 2.24 | 2.88 |

$$V, \text{ coefficient of variation or variability} = \frac{100s}{\bar{X}}$$

($r = .71$) is for the measurement of mid-shaft antero-posterior diameter. All other correlations are above 90%. Hence, interobserver error makes very little contribution to the variability within the sample.

As a first step in choosing discriminating variables, histograms were plotted for each variable. No bimodal distributions occur, but distributions of maximum length, physiological length, head diameter and condyle-shaft angle are platykurtotic for both left and right femora. Scattergrams of all possible combinations of two were also constructed. It is clear from these histograms and scattergrams that no single measurement or combination of two measure-

ments will sufficiently discriminate males and females. For example, based on Dwight's ('04/'05) or Maltby's ('17-'18) means for head diameter, the Kleinburg left femora represent 30% females, 13% males, and 57% individuals of unknown sex. Absolute cut-off values like 42 mm and 48 mm have little meaning for a sample unrelated to the reference population. Furthermore, in the Kleinburg sample overlap between sexes appears to be considerable.

Based on the assumptions of difference in height and robusticity and on the platykurtotic distributions, it was decided to use maximum length and maximum head diameter as bases for forming the needed reference groups. To begin,

TABLE 2
Summary statistics from the discriminated males and females

| | | N | \bar{X} | s | V |
|--|---|----|-----------|-------|------|
| MAXIMUM LENGTH | | | | | |
| Right | d | 33 | 453.12 | 18.83 | 4.15 |
| | ♀ | 33 | 433.12 | 23.35 | 5.39 |
| Left | d | 41 | 450.46 | 20.09 | 4.46 |
| | ♀ | 39 | 427.67 | 18.56 | 4.34 |
| PHYSIOLOGICAL LENGTH | | | | | |
| Right | d | 38 | 449.34 | 18.52 | 4.12 |
| | ♀ | 34 | 428.18 | 23.25 | 5.45 |
| Left | d | 43 | 445.79 | 19.89 | 4.46 |
| | ♀ | 41 | 421.90 | 18.21 | 4.32 |
| PROXIMAL ANTERIO-POSTERIOR SHAFT DIAMETER | | | | | |
| Right | d | 38 | 24.37 | 1.96 | 8.04 |
| | ♀ | 34 | 23.41 | 1.60 | 6.83 |
| Left | d | 43 | 25.09 | 1.77 | 7.05 |
| | ♀ | 42 | 23.7 1 | 2.06 | 8.69 |
| PROXIMAL LATERAL SHAFT DIAMETER | | | | | |
| Right | d | 38 | 34.05 | 2.51 | 7.37 |
| | ♀ | 34 | 32.71 | 1.93 | 5.90 |
| Left | d | 43 | 34.35 | 2.35 | 6.84 |
| | ♀ | 42 | 31.90 | 1.48 | 4.64 |
| MID-SHAFT ANTERO-POSTERIOR DIAMETER | | | | | |
| Right | d | 38 | 28.29 | 2.31 | 8.16 |
| | ♀ | 34 | 26.82 | 2.04 | 7.61 |
| Left | d | 43 | 28.44 | 2.48 | 8.72 |
| | ♀ | 42 | 26.09 | 1.85 | 7.09 |
| MID-SHAFT LATERAL DIAMETER | | | | | |
| Right | d | 38 | 25.92 | 1.88 | 7.25 |
| | ♀ | 34 | 24.7 1 | 2.18 | 8.82 |
| Left | d | 43 | 26.49 | 1.53 | 5.77 |
| | ♀ | 42 | 24.95 | 1.40 | 5.61 |
| MAXIMUM HEAD DIAMETER | | | | | |
| Right | d | 38 | 47.37 | 1.79 | 3.78 |
| | ♀ | 34 | 43.15 | 2.00 | 4.63 |
| Left | d | 43 | 45.81 | 1.80 | 3.93 |
| | ♀ | 42 | 41.69 | 1.26 | 3.02 |
| CONDYLE-SHAFT ANGLE | | | | | |
| Right | ♂ | 38 | 78.76 | 1.78 | 2.26 |
| | ♀ | 34 | 77.7 1 | 2.02 | 2.60 |
| Left | d | 43 | 78.19 | 2.24 | 2.86 |
| | ♀ | 42 | 77.21 | 2.01 | 2.60 |

lengths and head diameters outside the range of one standard deviation of the mean were arbitrarily designated to be "male" at the right tail, "female" at the left. At the same time as these criteria were being tested, the two basic approaches to discriminant function analysis (stepwise and direct) needed to be evaluated. Hence, four sets of tests were begun. Stepwise and direct functions were constructed from reference groups defined by maximum length. Stepwise and direct functions were also constructed working from reference groups defined by maximum head diameter. Calculations were done with Klecka's Discriminant subprogram of the Statistical Package for the Social Sciences, Version 7 (Nie et al., '75). The stepwise analysis used the smallest value of Wilk's

lambda as the criterion for entry. Minimum F values for entry or removal were set at 1.0. Variables were entered into the stepwise computations in two fashions, equally weighted and with varying inclusion levels set to reflect the relative importance of each variable.

Discriminant function analysis requires a complete data set for each case. This lessened potential sample sizes considerably. A "typical run" would have a subsample of approximately fifteen of the longest or largest femora and fifteen of the shortest or smallest functioning as "males" and "females", with forty complete cases of "unknown sex" left to be classified. A calculation was considered successful if it showed a balanced sex ratio and if the distributions of all the variables showed appropriate overlap.

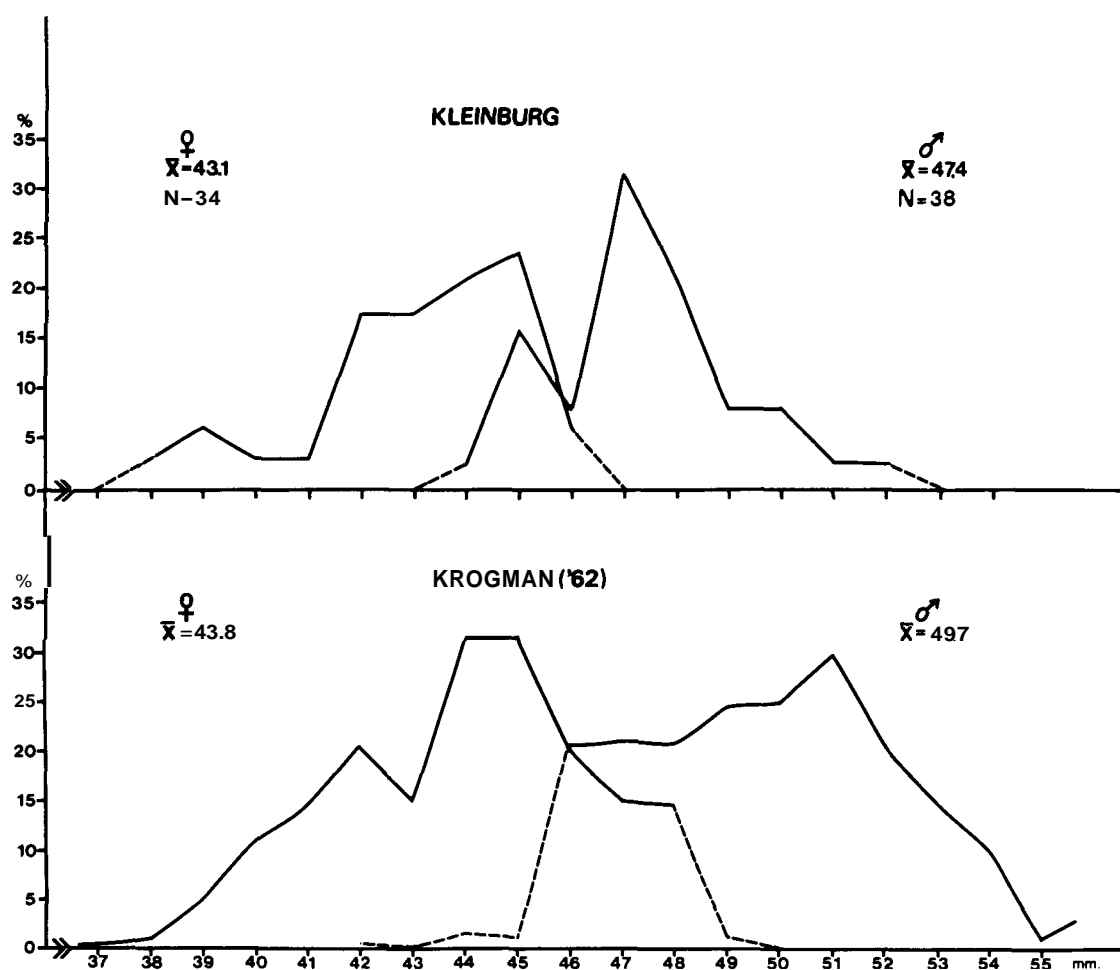


Fig. 1 Comparison of right femoral head diameters, Kleinburg Ossuary and a Caucasian sample of known sex (Dwight '04/05) as plotted by Krogman ('62).

RESULTS

The final, most successful functions used maximum head diameter as the criterion for formation of the reference groups with different cut-off values for right and left femora. The most successful functions came from the direct approach, and no discriminating power was lost when certain variables were deleted in the interest of increasing sample sizes. Maximum length and maximum physiological length are therefore deleted from the final functions. Values of maximum head diameter used as cut-off points for formation of the reference groups are **42 mm** and **49 mm** for the right femora, **40 mm** and **47 mm** for the left femora. Sample sizes and summary statistics representing the discriminated males and females are presented in table 2. The sex ratios of the right and left femora are 1.13 and 1.02 respectively. Each variable when plotted independently shows an overlapping bimodal distribution. An example of one such distribution is presented in figure 1.

The major problem was finding a function that did not place excessive weight on any one variable. Lack of the necessary balance was the main reason for discarding the stepwise approach. The bulk of the variability could be explained in the first step with a size variable like maximum length. Few variables were entered prior to the F-values reaching critically low levels. All cases would be successfully classified in a statistical sense, but the results were unrealistic in a biological sense. For example, in the setup for one such test all femora longer than **460 mm** were specified to be those of males, all those shorter than **420 mm** were specified to be those of females. The results of the discriminant function analysis simply showed the midpoint, **440 mm**, as a dividing line between males and females. There was no overlap of distribution and no other variable had any real input into the function.

Direct functions based on maximum length cut-off values generally proved unsatisfactory. Distributions of the resulting summary statistics appeared to be biologically unrealistic. There was very little overlap of length measurements, but a large overlap of head diameter measurements. The degree of sexual dimorphism and the form that it takes will, of course, differ for each population. Still, one expects

some balance among size and shape parameters. It seems highly unlikely that only approximately **2%** of the females would attain the height of the shortest males. It was found that calculations were improved by the deletion of the maximum length and physiological length variables. This deletion eliminated the problem of excessive weighting as discussed above and it increased sample sizes. Eight more right cases and six more left cases were added to the available sample.

As stated above, it proved necessary to specify different cut-off values for right and left sides. This qualification, though logical, was not immediately apparent. The mean head diameter of all left femora (**44.2mm**) is almost identical to the mean (**44.8mm**) for the right side. Still, when the same values were used for both right and left femora, discriminations created a characteristic imbalance showing too many females among the left femora and too many males among the right femora. In the case of the head diameter variable, one must use left cut-off values that are two millimeters lower than those for the right to achieve suitable results. The reason for this can be seen in the distribution of the left values. A small number of very high values obscure the modal trend. For both right and left femora there is a six millimeter range within which sex is unknown, that is, determined by the discriminant function analysis.

DISCUSSION

As described above, a single direct discriminant function "successfully" classifies all available cases as either male or female. This, of course, is success in a statistical sense. Because there is no subset of adults among whom sex is known, one cannot measure success of classification in the most obvious fashion, that is by comparing this classification with the true sex of each individual. Rather, one must assess success according to other criteria.

It was expected that an approximately balanced sex ratio would be achieved. The ratios of 1.13 among right femora and 1.02 among left femora appear satisfactory in this regard. It was expected that all parameters would be distributed bimodally with considerable overlap of male and female values. This result has been

achieved as well. Furthermore, the summary statistics show that the discrimination has succeeded in lowering variability within the majority of subsets. The coefficients of variation are lower in **28** of the total 32 categories (eight parameters, divided into males, females, right and left sides). This, too, can be viewed as criterion of success.

In most categories, the coefficients of variation were not lowered substantially. The greatest reduction is found in the measurement of maximum head diameter. This could be because a disproportionate weighting was placed on it by the discriminant function, and this would be undesirable. On the other hand, this reduction in variability could simply indicate that a great deal of the variability within this parameter is sex-dependent. If this were the case, the result would be desirable. This second explanation seems quite plausible. The coefficients of variation appear to be of a reasonable dimension throughout. Summary data from other prehistoric skeletal samples frequently show larger coefficients of variation, both with sexes pooled and with sexes divided.

The final test of the discriminant function is to reduce it to the traditional head diameter cut-off values. Only 72 right and 85 left femora are complete enough to classify using the multivariate technique, while 121 right and 134 left femora yield measurements of maximum head diameter. Based on the final ranges for males and females one can suggest that a right femur is female if the head diameter is 43 mm or less, and is male if the head diameter is 47 mm or more. This divides the sample of right femora into 35% females, 34% males, 31% sex undetermined. This appears to be a very reasonable division. Cut-off values for the left femora are 42 mm and 45 mm. Using these figures, the left femora include 30% females, 41% males and 29% sex undetermined. These percentages are not as balanced as the percentages derived from the right cut-off values. However, given that the total range of left head diameters is only twelve millimeters (39-51 mm), these values appear satisfactory.

Based on these rather pragmatic tests of success, then, the Kleinburg femora appear to have been successfully discriminated on the basis of sex. Sex ratios appear balanced, frequency distributions are bimodal with sizeable

overlap, and variability has been reduced. It should be noted that the cut-off values for femoral head diameter derived from these discriminations are applicable only to this sample. This exercise had demonstrated the inappropriateness of applying the same quantitative criteria of sex estimation across many populations of varying shape and size.

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Infant Mortality Among the Jews of Gibraltar, 1869 to 1977

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KEY WORDS Infant Mortality • Historic Demography •
Sephardic Jews • Gibraltar

ABSTRACT An examination of 149 infant deaths among the Sephardic Jews of Gibraltar from 1869 to 1977 revealed that the rate of infant mortality underwent a progressive decline after 1909. The improvement in infant viability can be ascribed primarily to the reduction in the number of deaths due to infectious disease, particularly in terms of pneumonia and bronchitis, as well as gastro-enteritis and diarrhea. Factors responsible for the decline in Jewish infant mortality are discussed. Ethnohistoric and demographic information presented here also supports the contention that the rate of infant mortality observed among the Jews of Gibraltar was typically lower than that which has been reported for their co-religionists and non-Jews in other countries over a comparable time period.

RESUME L'examen de 149 mortalités infantiles chez les Juifs Séphardiques de Gibraltar entre 1869 et 1977 révèle que le taux de mortalité chez l'enfant a connu un déclin progressif après 1909. Cette amélioration de la viabilité chez l'enfant peut être attribuée à la réduction du nombre de décès dus à des maladies infectieuses, en particulier les pneumonies et les bronchites aussi bien que les diarrhées et gastro-entérites. L'article passe en revue les facteurs responsables de déclin de la mortalité chez les enfants Juifs. Les données ethnohistoriques et démographiques auxquelles on a eu recours appuient la conclusion que le taux de mortalité infantile observé chez les Juifs de Gibraltar était typiquement inférieur à celui de leurs coréligionnaires et non-Juifs d'autres pays à des périodes comparables.

INTRODUCTION

The study of the medical history of a community using demographic information represents an important research strategy in the assessment of micro-evolutionary change at the intra-population level. Demographic information from death registers provides an analytical base by which qualitative and quantitative change in the mortality/morbidity parameters of a community can be assessed over time. Information derived from these measures in turn permit the generation and testing of hypotheses regarding the evolutionary implications of changes in the medical history of the community.

Recent investigation of the demographic structure of industrialized western countries has demonstrated that over the last three centuries the mortality rate has declined and, concomitantly, that there has been a reduction in the opportunity for selection occurring through mortality differentials (see, e.g., Jacquard and Ward, '76). The dampening of mortality differentials can be ascribed primarily to improvements in the viability of the pre-reproductive segment of the population and, in particular, to a reduction in infant mortality. The number of children dying under the age of one year therefore constitutes an impor-

tant component of biological wastage as well as representing a sensitive index of community health and sanitary conditions. Documentation of secular trends in the pattern of infant mortality for a given community framed within its socio-cultural milieu is expected to yield insight into those factors that may have played an important role in shaping the biological constitution of the contemporary population.

The present study, part of an ongoing investigation into the bio-demographic structure of the Sephardic community of Gibraltar, examines the changes in the pattern of Jewish infant mortality over the last century. The Jewish settlement at Gibraltar under British rule dates back to 1704 and was one of a number of such communities found by the mercantile Jews of Tetuan and Tangier in concert with the colonial expansion of the British. Initial colonization of Gibraltar was in large part stimulated by the entrepreneurial enterprises of the Moroccan Jews who provided the necessary provisions and building supplies to maintain the British garrison at Gibraltar. The prosperity and growth of the Jewish settlement was further enhanced by the fact that the majority of maritime trade in the western Mediterranean was in the hands of a closed society of Jewish merchants from Morocco until the 20th century (Corcos and Cohen, '71). As of 1970, the Jews comprised 2.2 percent of the 24,672 individuals resident in the British crown colony of Gibraltar (Government of Gibraltar, '70). Physically Gibraltar is a shrub covered mass of limestone of approximately 3.62 kilometers in area, including reclaimed land. The town lies densely packed at the north-western portion of the Rock and covers approximately one-ninth of the entire area. There are no natural resources of economic importance and the residents are largely dependent on the tourist trade, on re-exports and on work provided by the dockyard, service departments, and the government and city council.

As members of the Sephardic division of world Jewry, the Jews of Gibraltar are "the descendants of Jews who lived in Spain and Portugal until the expulsion in 1492, or their voluntary emigration prior to 1492, or their subsequent escape after a period of existence as marranos or crypto Jews" (Patai, '71, p. 259). The Jews of Gibraltar have retained their bio-

social continuity with the past through their adherence to orthodox customs and beliefs, strict religious endogamy, and retention of their own Spanish idiom, Ladino. By virtue of these characteristics and their nearly exclusive participation in commercial activities, the Jews have remained a highly definable unit in Gibraltar since their origin in 1704. Reconstitution of the demographic properties of the Jewish community is further enhanced by the existence of extensive vital registers of births, deaths and marriages from both civil and religious sources that date back to the 19th century. It was also during the 1800's that Gibraltar began to experience rapid population growth as well as a series of infectious epidemics that reflected the change to a more urban setting. For these reasons, the Sephardic community of Gibraltar represents an unusual resource for a demographic inquiry into the medical history of a population.

MATERIALS AND METHODS

During the summer of 1978, vital statistics pertaining to the Sephardic Jews of Gibraltar were collected by the authors. This included transcribing demographic information with respect to: (1) births from 1848 to 1978, (2) deaths from 1879 to 1977, and (3) census nominal rolls for the years 1868, 1891, 1901, 1911, 1921 and 1931. In addition, informant based information was obtained through a number of interviews with various members of the Jewish community. This information was then incorporated into the larger data base compiled by the principal investigator since 1974 (Sawchuk, '78).

Using the civil birth register, the annual numbers of Jewish male and female births were obtained. This in turn provided the means of calculating age-specific infant mortality rates. Information on primary and secondary cause(s) of death listed in the civil death registry was coded following the criteria set out in the *Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death* (W.H.O., '77). In addition to the cause(s) of death, sex and birthplace of the deceased were translated into a computer oriented format, and thereafter transferred to a disk.

Infant mortality was partitioned into 2 components: neonatal deaths (under 28 days) and

post-natal deaths (after the 28th day but before the first birthday). Neonatal mortality was further subdivided into perinatal deaths (under 7 days) and post-perinatal deaths (after 7 days but within the first month of life). Causes of neonatal deaths are largely intrauterine and brought about by genetic and developmental factors. Accordingly, neonatal mortality exhibits relatively little interpopulational variability and has shown little susceptibility to reduction under pressure from modern medicine (Thomlinson, '76). Post-neonatal mortality, on the other hand, is described as largely extrauterine and subject to greater environmental pressure.

To facilitate the examination of infant mortality and its components, the cause of death was classified into three broad categories: (1) infectious diseases, (2) non-infectious diseases, and (3) ill-defined conditions. Infectious diseases were further differentiated according to their mode of transmission, that is, air-borne, water and food-borne and other diseases attributable to micro-organisms. According to McKeown and co-workers,

“This classification is important . . . particularly because it separates water- and food-borne

diseases, in which prevention of transmission of micro-organisms by improved hygiene was critical for the decline of mortality, from air-borne infections in which reduction of exposure through advances in hygiene played little or no part ('75, p. 407).”

As would be expected, the analysis and subsequent interpretation of cause-specific mortality based on death registers that date back to the 19th century presents a number of difficulties. Logan's early work on the death registers of England and Wales identified the following difficulties:

“symptomatic or terminal conditions (on death certificates) that fail to indicate the underlying disease that was the real cause of death”,

“with increasing knowledge new diseases are recognized and given new names”, and

“continuously changing fashions in medical certification, so that it is often a difficult matter to decide whether an increase in the frequency with which a particular cause of death is certified reflects a real increase in the incidence of that condition or represents a new attitude in regard to its medical certification ('50, pp. 132-133).”

TABLE 1

Number of births by decade for the Sephardic community of Gibraltar

| Period | Number of births | | Mean | Coefficient of variation (%) |
|----------|------------------|---------|------|------------------------------|
| | males | females | | |
| 1869-79 | 147 | 110 | 23.4 | 20.82 |
| 1880-89 | 133 | 126 | 25.9 | 19.89 |
| 1890-99 | 131 | 130 | 26.1 | 23.79 |
| 1900-09 | 86 | 88 | 17.4 | 22.86 |
| 1910-19 | 106 | 80 | 18.6 | 19.99 |
| 1920-29 | 100 | 78 | 17.8 | 31.31 |
| 1930-39 | 51 | 50 | 10.1 | 28.56 |
| 1940-49* | 41 | 41 | 13.7 | 35.45 |
| 1950-59 | 66 | 60 | 13.6 | 49.04 |
| 1960-69 | 64 | 49 | 11.3 | 60.17 |
| 1970-78 | 31 | 30 | 7.6 | 37.05 |
| TOTAL | 956 | 842 | | |

*No births were recorded between 1942 and 1944, as all women (and children) were evacuated from the Rock during this period.

In addition, systematic under-reporting and erratic registration of deaths and/or births can adversely affect the accuracy of the rate of mortality for any given point in time. Estimates of infant mortality for a small community where the number of births or deaths is small are particularly sensitive to this type of problem. This difficulty can be further compounded when the target population is an 'open community' subject to varying rates of emigration and/or immigration over time. It is our contention, however, that when information derived from birth and death registers is viewed judiciously, important insights into the changing pattern of mortality/morbidity can be yielded.

RESULTS

As table 1 indicates there has been a steady decline in the number of children born within the Sephardic community of Gibraltar. With the reduction in the mean number of children born per decade, there has been a modest increase in the relative amount of variation seen in the annual birth rate. A further trend revealed in table 1 is that the number of male births per decade typically outnumbered the female births. For the entire study period, the

sex ratio at birth was 113.52.

Table 2 sets out information on the rate of male and female infant mortality (IMR) by decade, as well as an adjusted rate which only includes native-born infants in the computation of infant mortality (C.IMR). The pattern that emerges from table 1 is that, while there is considerable fluctuation in the male and female IMR per decade, male deaths typically outnumber female deaths. However, when the birthplace of the deceased is used as a criterion for inclusion, the disparity in IMR between the sexes becomes negligible. A further salient point is that the first four decades of the study period (1869 to 1909) can be characterized as a period of moderately high infant mortality (IMR = 121.98), where the number of infant deaths fluctuated from a high of 139.00 to a low of 103.45. In contrast, the rate of infant mortality after 1909 underwent a steady decline, and collectively the interval from 1910 to 1977 can be described as a period of low infant mortality (IMR = 38.96).

Standardized cause-specific mortality rates given in table 3 reveal that during the period from 1869 to 1909 infectious diseases were the major cause of infant death, accounting for 61.12 percent of all deaths. Air-borne infec-

TABLE 2

*Infant mortality rates, corrected for birthplace, for Jewish community of Gibraltar, 1869-1977**

| Period | Males | | | Females | | | Total | | |
|---------|-------|--------|--------|---------|--------|--------|-------|--------|--------|
| | n | IMR | C.IMR | n | IMR | C.IMR | n | IMR | C.IMR |
| 1869-79 | 12 | 88.44 | 74.83 | 19 | 172.73 | 154.55 | 32 | 124.51 | 108.95 |
| 1880-89 | 22 | 165.41 | 142.86 | 14 | 111.11 | | 36 | 139.00 | 127.41 |
| 1890-99 | 15 | 114.50 | — | 12 | 92.31 | 84.62 | 27 | 103.45 | 99.62 |
| 1900-09 | 13 | 151.16 | — | 8 | 90.91 | — | 21 | 120.69 | — |
| 1910-19 | 7 | 66.04 | 56.60 | 8 | 100.00 | — | 15 | 80.05 | 69.89 |
| 1920-29 | 6 | 60.00 | — | 2 | 25.64 | — | 8 | 44.94 | — |
| 1930-39 | 3 | 58.82 | 39.22 | 0 | — | — | 3 | 29.70 | 49.50 |
| 1940-49 | 2 | 48.78 | — | 1 | 24.39 | — | 3 | 36.59 | — |
| 1950-59 | 0 | — | — | 3 | 50.00 | — | 3 | 23.81 | — |
| 1960-69 | 0 | — | — | 0 | — | — | 0 | — | — |
| 1970-77 | 0 | — | — | 1 | 33.33 | — | 1 | 16.39 | — |
| TOTAL | 81 | 85.17 | 77.81 | 68 | 80.38 | 76.33 | 149 | 82.91 | 77.35 |

*Where n = number of deaths

IMR = the number of deaths under 1 year per 1000 live births

C.IMR = corrected infant mortality rates, excluding foreign-born infants.

tions, particularly bronchitis and pneumonia, comprised the single most important cause of death among our Jewish sample. Pneumonia was reported as the primary cause of death twice as frequently as bronchitis. Diarrhea and gastro-enteritis comprised the majority of the water- and food-borne infections with a death rate of **22.08** per 1000 live births. Gastro-enteritis was seven times more frequently listed as the cause of death than was diarrhea. Infant mortality due to non-infectious agents comprised 21.64 percent of all infant deaths. Principal causes of death under this heading included prematurity (6.90%) and nutritional and meta-

bolic disorders/diseases (5.17%). The latter condition consisted specifically of four cases of marasmus, one case of inanition and one case of rachitis. Ill-defined causes of death constituted 17.24 percent of all infant deaths and consisted primarily of a class of conditions listing teething and/or convulsions as the cause of death.

After 1909, infant mortality underwent a steady decline and yielded an IMR rate for the 1910 to 1977 interval of 38.96 infant deaths per 1000 live births. Nearly two-thirds of this decline can be attributed to reduced mortality due to infectious diseases, particularly to

TABLE 3

Standardized death rates (per 1000 livebirths) for Jewish infants in Gibraltar from 1869 to 1977

| | Period | | % decline in total mortality |
|---|---------------|--------------|------------------------------------|
| | 1869-1909 | 1910-1977 | |
| I. Conditions attributable to micro-organisms | | | |
| 1. Air-borne diseases: | | | |
| Bronchitis, pneumonia | 28.39 | 3.55 | 29.92 |
| Tuberculosis (respiratory) | 1.05 | — | 1.46 |
| Whooping cough | 4.21 | 1.18 | 3.65 |
| Measles | 2.10 | 2.36 | +0.31 |
| Diphtheria | 1.05 | — | 1.26 |
| Smallpox | 1.05 | — | 1.26 |
| Meningitis | 10.52 | 3.55 | 8.39 |
| Infections of ear, pharynx, larynx | 1.05 | — | 1.26 |
| 2. Water and food-borne diseases: | | | |
| Diarrhea, dysentery, enteritis | 22.08 | 11.81 | 12.37 |
| Tuberculosis (non-respiratory) | 3.15 | — | 3.64 |
| 3. Other conditions: | | | |
| Syphilis | — | 1.18 | +1.42 |
| II. Conditions not attributable to micro-organisms | | | |
| Nutritional and metabolic disorders/diseases | 6.31 | — | 7.60 |
| Other diseases of the respiratory system | 3.15 | — | 3.79 |
| Other diseases of the digestive system | 4.21 | 3.55 | 0.79 |
| Other diseases of the urinary system | — | 1.18 | +1.42 |
| Congenital defects | 4.21 | 1.18 | 3.65 |
| Prematurity and immaturity | 8.41 | 4.72 | 4.44 |
| Accidental death | — | 1.18 | +1.42 |
| III. Ill-defined conditions | | | |
| Dentition, teething and convulsions | 7.36 | — | 8.87 |
| Other ill-defined conditions | 13.67 | 3.55 | 12.19 |
| TOTAL | 121.98 | 38.96 | |

bronchitis and pneumonia (29.92%), diarrhea and gastro-entritis (12.37%) and meningitis (8.39%). It is noteworthy to add that nearly all (77.78%) of the cases of mortality due to intestinal infections were confined to the 1910-19 decade. Ill-defined causes of deaths declined by 21.06 percent after 1909. It is reasonable to conclude that this reduction can be attributed to an increased precision in identifying and/or listing the cause of death. The remaining 17.67 percent of the reduction in infant mortality can be ascribed to the decline in non-infectious conditions, particularly in nutritional and/or metabolic diseases/disorders (7.60%) and in prematurity (4.4%).

Given the decline in infant mortality after 1909, our *a priori* expectations would be that "as infant mortality drops, the proportion of all infant deaths occurring in the first 4 weeks will increase (Bouvier and Tak, '76, p. 16)." While

this observation is valid for our Jewish sample, it should be noted that the increase in neonatal mortality is primarily confined to a proportionate elevation in the number of deaths occurring under 1 week (see table 4). Of the 42 neonatal deaths, there were 23 male deaths and 19 female deaths under 28 days. Approximately one-quarter of all neonatal deaths were infectious in origin and, of these, only two perinatal deaths were attributable to an infectious disease. Leading causes of death under 28 days were prematurity (28.57%), ill-defined conditions (23.81%), and pneumonia (11.90%).

The distribution of 146 recorded infant deaths among the 478 fertile women surveyed from 1909 to 1977 did not deviate significantly from random expectations generated under Poisson assumptions ($\chi^2 = 2.07$, 3 d.f.). There were 119 women with one infant death (.05), 14 women with two, 5 women with three, and 1 woman with four infant deaths.

TABLE 4
*Number of infant deaths by age for Sephardic Jews
of Gibraltar, 1869-1977*

| Period | Neonatal | | | | Post-neonatal | | Total |
|----------|---------------|------------|----------------|-------------|-----------------|-------|-------|
| | \leq 7 days | $>$ 7 days | \leq 28 days | $>$ 28 days | \leq 365 days | | |
| | n | % | n | % | n | % | n |
| 1869-909 | 11 | 9.48 | 20 | 17.24 | 85 | 73.28 | 116 |
| 1910-977 | 6 | 18.18 | 5 | 15.15 | 22 | 66.67 | 33 |
| TOTAL | 17 | | 25 | | 107 | | 149 |

| Hypotheses tested | dF | χ^2 |
|--|----|----------|
| neonatal vs post-neonatal | 1 | 0.56 ns |
| \leq 7 days vs \leq 28 days vs \leq 365 days | 2 | 2.83 ns |

DISCUSSION

Infant mortality rates reported here for the Jews of Gibraltar stand in contrast to the higher rates reported by Schmelz ('71) for a large series of Jewish and non-Jewish populations over a comparable period of time. It is our contention that the lower IMR among the Jews of Gibraltar is not the product of a systematic bias in under-reporting but rather reflects the

fact that the Jews enjoyed a relatively better standard of living and health care than their non-Jewish counterparts in Gibraltar (see fig. 1) as well as their co-religionists in other countries. The following observations are offered here in support of our argument:

(1) "Illegitimate births, which are characterized by higher infant mortality, have been more infrequent among Jews than non-Jews

(Schmelz, '71, p. 78).” Of the 1798 births listing a Jewish parent in the Gibraltar civil registry, only 15 illegitimate births (0.83%) were recorded over the study period.

(2) An earlier investigation into the fertility differentials of the Sephardic women in Gibraltar demonstrated that a comparatively small proportion of females actually initiated their

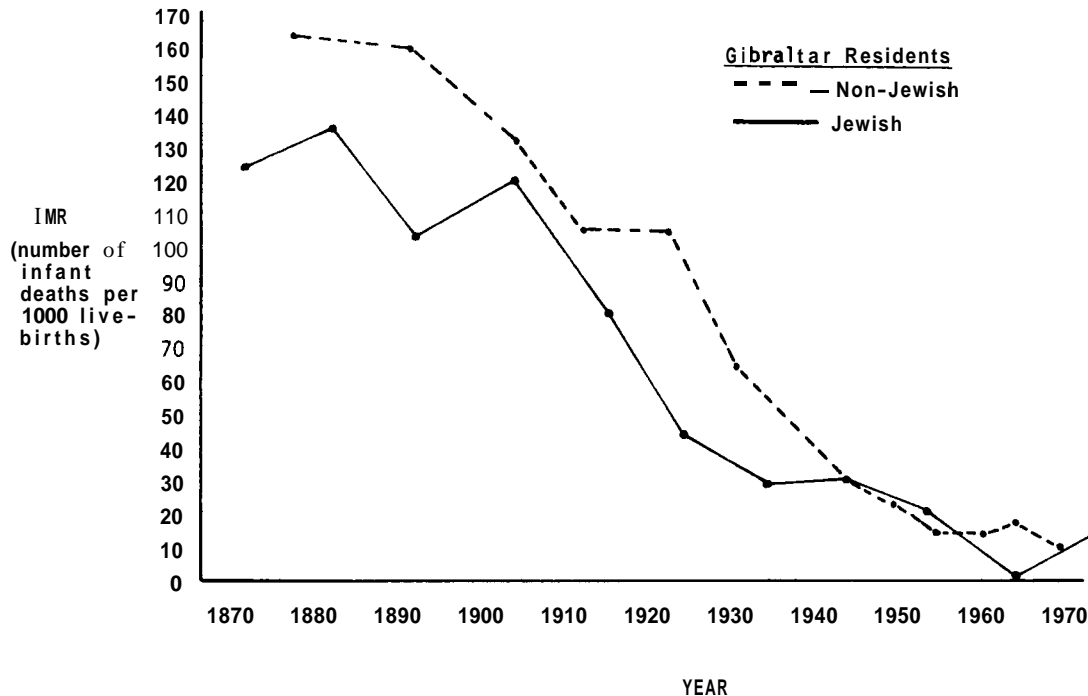


Fig. 1 Infant mortality among the residents of Gibraltar, 1869 to 1977

reproductive period before the age of twenty when, according to Bouvier and van der Tak ('76), infant mortality is expected to be quite high. Among the women of the marriage cohorts of 1850-1879, 1880-1909 and 1910-1939, for example, the proportion of women under twenty giving birth was 7.8, 7.3 and 2.0 percent respectively (Sawchuk, '78).

(3) By virtue of their nearly exclusive participation in commercial activities, the Jews of Gibraltar represent a class of comparatively high socio-economic status who would be expected to have better access to proper pre- and post-natal care as well as a higher standard of living in terms of housing and nutrition. Noteworthy in this context is the report by Henen on housing conditions in Gibraltar in the 1820s:

“Some of the higher classes of natives and merchants occupy entire houses; but by far the greater number of buildings are divided into

suites or apartments, or single rooms tenanted by distinct families. . . . The poorer classes of society are crowded together in apartments of a very bad description; . . . the majority are strikingly deficient in size, ventilation and the means of cleanliness, and that some are utterly unfit for human habitation (1831, p. 68).”

(4) The Jews may have had greater access to health care by virtue of the fact that “physicians have been comparatively numerous among the Jews (Schmelz, '71, p. 78).” This tendency for Jews to be disproportionately represented in medically oriented professions is also evident in Gibraltar. For example, the only civilian doctor listed in the 1791 census was a Jew (Sawchuk, '78).

(5) Adherence to strict dietary laws, greater concern for post-natal care by Jewish mothers and the common practice of breast feeding may have also contributed to the lower infant mortality rates reported among Jews (McMurphy, '10; Fishberg, '11; Schmelz, '71).

(6) Preliminary analysis of the overall Jewish mortality pattern yielded a good fit to the Sephardic 1, values with those generated from the appropriate Model Life Tables of Coale and Demeny ('66). Empirically derived lifetables show an expectation of life at birth (e_0^o) for the 1869-1909 interval were 47.39 for males and 52.14 for females; and for the 1909-1977 interval, the e_0^o values were 59.64 and 66.62 respectively. These findings suggest that the observed infant mortality rates are consistent with those generated by the overall pattern of mortality among the Jews.

While the present study has documented that a substantial reduction in infant mortality occurred after 1909, it is important to point out that the conditions of the preceding period (1869-1909) were a vast improvement over the conditions that the Jews endured since their occupation of Gibraltar under British rule in 1704. The brief ethnohistorical account of the community should provide some insight into the changing pattern of health and disease among the residents of the British colony.

The development of the civilian community at Gibraltar during the 18th century for the most part was slow and marred by the near constant state of war that existed between Great Britain and Spain. Under a periodic state of siege and isolation, the residents of Gibraltar encountered a scarcity of food and supplies, inadequate housing, temporary relocation, and epidemics of smallpox and measles. These harsh conditions hampered the growth of the civilian community at Gibraltar and undoubtedly had an adverse effect on the longevity of the residents.

By the beginning of the 19th century, the size of the population began to increase dramatically. Stimulated by massive immigration, the number of inhabitants increased from 2,885 in 1791 to 5,339 a decade later. The rapid expansion in population size within the habitable portion of the Rock further aggravated the existing conditions that could at best be described as deplorable. As Henen has remarked,

“Previous to the year 1814, the garrison was infamous for its filth; without sufficient common sewers, without an efficient scavenging department, without pavement on proper principles; in short, without everything that was requisite for ordinary purposes of public clean-

liness; it has obtained the bad pre-eminence of being the dirtiest garrison under the British crown (1830, p. 81).”

At the same time, the residents of Gibraltar began to experience the first of a series of major infectious epidemics that would ultimately prevail for more than half a century. The first epidemic, one of yellow fever, began in August of 1804 and by December of that same year, 4,946 inhabitants of Gibraltar succumbed (Pym, 1848). Over the next two generations, epidemics of yellow fever (1810, 1813, 1814, 1824), smallpox (1824) and cholera (1834, 1865) raged within the town of Gibraltar killing more than 3,000 of its inhabitants. While overcrowding and poor sanitation contributed to the spread of disease, Gibraltar's strategic position in the Mediterranean also contributed to the occurrence of these epidemics within the fortress walls. As an important military outpost and seaport, Gibraltar was linked to other human settlements that collectively served as a large reservoir of potential hosts for an infectious disease. Communication between these settlements not only served then to increase the likelihood of the spread of a pathogen over a vast area, but also served to increase population size to a critical level where certain infectious agents could remain endemic to an area (see e.g., Cockburn, '67; Black, :66). As McNeil has commented,

“... within such well-traveled waters as the Mediterranean, movement by sea could, with favouring winds, attain an average of well over 100 miles per day. Thus, all the coastal cities of the Mediterranean constituted a single disease pool. A person seemingly in good health at the time of embarkation might fall sick en route and communicate his illness to others on board. Shipboard travel could therefore easily carry an infection from one port to another, across hundreds or thousands of miles of water ('76, p. 96).”

Despite the absence of detailed death records, it is reasonable to propose that during the interval 1800 to 1865 infant mortality attained very high levels that fluctuated rather dramatically over time. Given the number and severity of epidemics that prevailed in Gibraltar during this period, it is likely that selection due to infectious disease assumed its maximum intensity.

After the last major epidemic, one of cholera

in 1865 in which 240 civilians died, a Board of Sanitary Commissioners was established. Three years later, the Board undertook the development of a new drainage and water supply works. Despite these improvements in sanitation an epidemic of cholera broke out in August of 1885 and lasted until the 14th of October. Twenty-two civilian deaths were recorded. However, no Jewish infants succumbed to cholera. In 1887, vaccination against smallpox was made compulsory within three months of birth. The state of infant health within the British colony remained grim as the Gibraltar Annual Report of 1888 stated that "on the average, one third of the children born within the fortress die before they reach the age of five". As shown earlier, infant mortality among the Jews of Gibraltar over the 1869 to 1909 interval continued to remain relatively high with rates in excess of 100 infant deaths per 1000 live births. While epidemics no longer prevailed within the fortress, infectious diseases still constituted the major cause of infant mortality, accounting for nearly two-thirds of all Jewish deaths under the age of one. Chief contributors to the high rate of infant mortality due to infectious disease were respiratory (notably, pneumonia and bronchitis) and intestinal infections (particularly, gastro-enteritis and diarrhea).

By the second decade of the 20th century, infant mortality among the Jews dropped to 80.05 per 1000 live births, and thereafter continued to decline. Major improvements in the number of offspring surviving past the age of one can be ascribed to a decline in the number of infant deaths due to bronchitis and pneumonia; diarrhea and gastro-enteritis; meningitis; and nutritional and metabolic disorders, respectively. Enlarging upon the comments of Smales ('26) and Holmes ('66), the following explanations are offered for the decline in Jewish infant mortality after the turn of the century. These include:

- (1) improvements in the public sewage system that were undertaken in the 1900s,
- (2) sanitary conditions were improved with the more frequent removal of refuse from the streets during the summer months,
- (3) the advent of mechanized transportation in Gibraltar brought about a decline in horse traffic and, in turn, the amount of fecal matter deposited in the streets,

(4) the onset of the 20th century was also marked by a greater appreciation of the inhabitants for proper pre-natal and post-natal care,

(5) by the 1900s, all imported milk in Gibraltar was boiled and this in turn contributed to a safer and more hygienic food source for infants, and

(6) the overcrowded conditions that once prevailed were alleviated to some degree when the number of inhabitants declined as the result of the Alien Order in Council of 1885 and 1900 in which government legislation restricted foreign-born males and the offspring issued from a male alien from attaining permanent residency in Gibraltar.

The reduction in infant mortality due to infectious disease after 1909 observed among the Jewish inhabitants of Gibraltar can be attributed then to improvements in the standard of living (4, 5), and a reduction in overcrowding (6). More specifically, the decline of intestinal infections due to water- and food-borne microorganisms (e.g., diarrhea and gastro-enteritis) can be ascribed to improvements in public sanitation, infant health care and food hygiene. The decline in air-borne infectious diseases (e.g., pneumonia and bronchitis) can be in large part attributed to the relaxation of overcrowding within the town of Gibraltar and to an improvement in the nutrition of infants. With the possible exception of smallpox, most of the reduction of infant mortality due to infectious disease occurred before specific measures of prophylaxis or treatment were introduced. Similar findings have also been reported by McKeown and Record ('62) and Beaver ('73) for the decline in infectious diseases in England and Wales during the latter part of the 19th and early 20th century.

CONCLUSION

Historical and demographic information presented in this report indicates that during the 19th century infectious diseases constituted the primary selective pressure exerted on the Jewish infants of Gibraltar. The maximum opportunity for selection through differential mortality occurred during the first half of the 19th century when a series of major infectious epidemics ravaged the population of Gibraltar. While comparative data on the non-Jewish segment of Gibraltar is at present incomplete,

there is substantial evidence to support the proposition that the Jews came under less stringent pressure from infectious diseases. By the second decade of the 20th century, infant viability began to improve gradually due to reduction in the number of infant deaths attributable to respiratory and intestinal infections. Improvements in sanitary conditions and in the standard of living as well as a reduction in overcrowding are viewed as the principal factors contributing to the gradual reduction in infant mortality observed over the last two generations.

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Sequence of Relative Molar Sizes in Living Pongids

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KEY WORDS Pongids • Molars • Sexual Dimorphism

ABSTRACT Areal measurements were made of 1,289 permanent molar crowns of *Pan troglodytes*, *Pongo* and *Gorilla*. Contrary to popular opinion it was found that third molar dominance, or distal increase in crown size does not exist in any of the series treated (male/female, upper/lower for the three genera). The only general trend seems to be toward M2 dominance, but there is one exception to this: *Pan* upper molars. Sexual dimorphism was examined by subjecting the mean total areas to t-tests. In *Pongo* and *Gorilla*, molars of males and females were significantly different at the 99% level of confidence in all cases. *Pan* molars show no sexual dimorphism.

RESUME Des mensurations de surface ont été prélevées sur 1289 couronnes de molaires permanentes de *Pan troglodytes*, *Pongo*, et *Gorilla*. Contrairement à une opinion répandue, on a découvert que la dominance de la troisième molaire, ou l'accroissement distal de la dimension de la couronne, n'apparaît dans aucune série considérée (mâle/femelle, supérieur/inférieur pour ces trois genres). La seule tendance générale semble être vers une dominance de M2 mais avec une exception: la molaire supérieure de *Pan*. On a aussi examiné le dimorphisme sexuel en soumettant les surfaces totales moyennes au test-t. Chez *Pongo* et *Gorilla*, les molaires des mâles et des femelles étaient fortement différentes avec un niveau de confiance de 99% dans tous les cas. Les molaires de *Pan* ne montrent aucun dimorphisme sexuel.

One of the major distinctions often cited between pongid and hominid dentitions rests on the different sequence of relative molar sizes found in the two families. It is generally assumed that human molars typically decrease in size distally, while pongid molars are thought, typically, to increase in size distally.

Before an examination of this issue can be undertaken, the subject of what constitutes "size" must be addressed. "Size" is difficult to define, much less evaluate. Length, width, height, mass, volume and area are all valid measures of "size", and in specific situations one or two of them may constitute the "best possible" measure. While I would, in most instances, consider either mass or volume as the ideal prognosticator of relative size, the obvious difficulties encountered in attempting such analysis

generally preclude their use. Length, width and height assessments, which are readily obtainable and used the most frequently, usually yield the least information. The best compromise is probably the use of areal assessments. Obtaining accurate areal assessments is, however, an approach fraught with difficulties. Macrophotogrammetry offers the most practical solution to this problem. The technique employed in this study is described in detail elsewhere (Williams, '79). Suffice it to say that photographic enlargements of occlusal views of molar teeth representing *Pongo*, *Pan troglodytes* and *Gorilla* were measured using an optical plainmeter. The results appear in tables 1, 2 and 3.

As can be readily observed from the tables the expected $M1 < M2 < M3$ sequence does not obtain in either the upper or lower molar

TABLE 1

*Mean total areas at the height of contour (mm²)
Upper and lower permanent molar teeth: Pongo.*

| | Male (N) | Female (N) | Total (N) | |
|----------------|-------------|-------------|-------------|----|
| M ¹ | 149.12 (40) | 119.81 (48) | 132.80 (95) | ** |
| M ² | 150.31 (31) | 126.09 (40) | 136.97 (73) | ** |
| M ³ | 135.65 (15) | 106.29 (33) | 115.35 (49) | ** |
| M ₁ | 145.90 (48) | 115.91 (42) | 131.87 (98) | ** |
| M ₂ | 166.16 (37) | 134.08 (39) | 149.70 (76) | ** |
| M ₃ | 156.61 (17) | 124.98 (29) | 136.23 (45) | ** |

** = significance at .01 level.

TABLE 2

*Mean total areas at the height of contour (mm²)
Upper and lower permanent molar teeth: Pan troglodytes.*

| | Male (N) | Female (N) | Total (N) |
|----------------|-------------|-------------|-------------|
| M ¹ | 100.51 (27) | 104.60 (22) | 102.14 (65) |
| M ² | 96.50 (22) | 97.96 (16) | 98.48 (46) |
| M ³ | 82.23 (15) | 79.25 (11) | 80.71 (29) |
| M ₁ | 94.78 (32) | 99.70 (25) | 96.15 (76) |
| M ₂ | 105.11 (24) | 100.59 (18) | 102.85 (52) |
| M ₃ | 94.92 (14) | 83.77 (11) | 92.03 (31) |

TABLE 3

*Mean total areas at the height of contour (mm²).
Upper and lower permanent molar teeth: Gorilla.*

| | Male (N) | Female (N) | Total (N) | |
|----------------|-------------|-------------|--------------|----|
| M ¹ | 191.83 (70) | 165.56 (25) | 185.04 (100) | ** |
| M ² | 218.06 (73) | 178.69 (25) | 207.78 (100) | ** |
| M ³ | 185.34 (61) | 152.58 (17) | 178.20 (78) | ** |
| M ₁ | 181.33 (76) | 159.64 (19) | 176.96 (98) | ** |
| M ₂ | 225.28 (74) | 187.08 (19) | 217.21 (94) | ** |
| M ₃ | 210.27 (64) | 176.00 (18) | 203.13 (84) | ** |

** = significance at .01 level.

series of any species studied, regardless of sex. The patterns that emerge in *Pongo* and *Gorilla* are $M1 < M3 < M2$ in the mandibular series and $M3 < M1 < M2$ in the maxillary molars. In *Pan* the situation is rather different. The mandibular molars present an ambiguous picture with $M1$ and $M3$ sub-equal in area. In the maxillary series, *Pan* exhibits the "human" $M1 > M2 > M3$ condition.

These data provide an interesting comparison between *Pan* and *Gorilla*. Pilbeam and Gould ('74) have suggested that, in effect, larger animals would require relatively larger posterior teeth for processing the considerably greater amounts of food their allometrically increased mass would require. Superficially this appears to account for the differences observed in this study. It is well known, and has been emphasized, that chimpanzees possess relatively larger anterior teeth than do gorillas (Pilbeam, '72), but perhaps greater significance is to be found in the larger cheek teeth of the gorillas. This alleged need for larger cheek teeth by the relatively more massive gorilla, purports to account for the greater area taken up by $M2$ and $M3$. However, the total picture is not quite so clear. In the limited samples of Oligocene and Miocene fossil apes from Africa and Asia which I have been able to measure, or which have been reported in detail (Pilbeam, '69), the molar teeth tend typically to increase in area distally. The only notable exceptions are one which I found in the maxillary series in the skull of *Aegyptopithecus* (YPM 23975) and a very limited sample of *D. major* reported by Pilbeam ('69). If allometry and related caloric demands result in the relative increase of distal molars, why are these rather small fossil apes possessed of dentitions that tend, with few exceptions, to show distal molar increase? Kay ('75) has suggested that allometry may not be a significant factor in relative dental size, and Kay and Simons ('79) have stressed the influence of

dietary differences on morphology. This would presumably affect the size of chimpanzee and gorilla molars.

In addition to comparing the areal size of molar crowns between species, t-tests were performed to test for significant levels of sexual dimorphism within the three genera. The results are remarkably consistent. In both *Pongo* and *Gorilla* there is significant dimorphism evident in all permanent molar crowns at the 99% level of confidence. In *Pan* no significant differences were found in any of the molars examined.

Two major points emerge from this analysis. First, sexual dimorphism in molar crowns is obvious in *Pongo* and *Gorilla* while nonexistent in *Pan*. This seems to reflect the respective levels of sexual dimorphism observable in the body mass of these pongids. Second, in none of the six molar series investigated was the third molar the largest. This condition seems to be a primitive pongid dental trait upon which I hope to report in the near future. The only apparent general trend is that the second molar is typically the largest. The obvious exception to this is seen in the maxillary series of *Pan* which, in general, seems to approximate the condition in *Homo*.

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Book Review

VARIATION IN MORPHOLOGY OF TEETH: ANTHROPOLOGIC AND FORENSIC ASPECTS. By R. M. S. Taylor. Foreword by J. E. Morton. Charles C. Thomas, Springfield, Ill. 1978. xxiii + 384 pp., 267 figures, tables, references, index. \$54.50 (cloth).

"Although teeth may be the only identifiable human remains, they may be eloquent."

R. M. S. Taylor, 1978

The science of odontology is in large degree based upon the measurement of teeth, the philosophy of which is founded upon Charles Darwin's observation ". . . I have no faith in anything short of actual measurement and the Rule of Three' (F. Darwin, 1888:51)."

Dr. Taylor's thesis sets out to refuse these premises. The fundamental conclusion of his survey is that teeth are unsuitable for measurement, and that mensuration of teeth produces no sound basic data. Consequently, no tooth measurements are found in this work. It is the author's contention "that tooth morphology and its variations render teeth unsuitable for quantitative or dimensional measurement and comparison. It follows that statistics based on these are not acceptable."

This comprehensive report is a meticulous description of a collection of 7,555 permanent teeth extracted from mostly "European" (i.e., white or Caucasoid) New Zealanders, with a few of Maori and mixed racial origin that were collected in the main between 1927 and 1947. Few teeth have data of sex and age accompanying them. For the majority of specimens no records were made of age, race or sexual distinction; and indeed, a good deal of the work is devoted to speculating on these identifications for specific teeth described.

Of the 7,555 teeth studied, some 1,715 are represented by 2,549 outlines drawn to scale by using a camera lucida with specially made lenses. The majority of teeth portrayed were selected for their "normality." The work reveals a range of "normal" dental anatomy astounding even for experienced dentists.

Pathological specimens were largely excluded. The painstaking labour involved in this

formidable task is fully evident, and the author ultimately concedes his weariness in the fourth appendix, where he affirms that he does not propose to report on a further 4,314 deciduous teeth and 5,142 permanent teeth displaying pathological lesions in his collection "even if he should happen to be reincarnated!"

Of the ten chapters of the book, seven are devoted to detailed descriptions of the different classes of teeth, i.e., maxillary incisors, mandibular premolars, etc. The three remaining chapters deal with "Aspects of Variation in Tooth Morphology", "Occlusion, Dental Profiles and Arches" and "Concepts of Variations". One of the six appendices is a reprint of the author's first report on dental morphology entitled "The dentition of the Piltdown fossil man (*Eoanthropus dawsoni*) from a new aspect" that is of interest in view of the recent revelations regarding that famous hoax.

The work is written in the tradition of the classical anatomists of a century or so ago, although curiously, no reference is made to the evolutionary nomenclature of the cusps and fissures (i.e., protocone, metacone, Y-fissure pattern, etc.). Indeed, human dental variation is discounted as being of no phylogenetic or evolutionary importance, and so-called "atavistic phenomena" are dismissed as false identification.

"Variation in Morphology of Teeth" is an exhausting book to read from cover to cover. Many figures have too brief explanatory captions with reliance on an explanatory text several pages remote from the illustrations. This awkward arrangement, whereby figures and detailed textual references to these are frequently pages apart, requires so much page switching that serious study of the work is difficult. Certainly this format would discourage the interest of the casual reader.

The text is remarkably free of typographical errors, attesting to meticulous proof-reading. Indeed, painstaking care is a hallmark of this *tour de force*, and in this respect it is possibly an unparalleled example of prodigious dental scholarship.

With forensic odontology becoming of increasing significance in the identification of

'Rule of three': In mathematics, the method of finding the fourth term of a proportion when three terms are given.

victims of mass disasters, this book is both important and timely. Though not destined to become a textbook for basic dental anatomy teaching, it will serve a useful role as a reference for current dental anthropological and forensic investigation.

G. H. Sperber
University of Alberta

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Book Notice

The following publication can be obtained for review by written request to the Managing Editor:

Molto, J. E. 1979 Saugeen osteology: the evidence of the second cemetery at the Donaldson site. *Bulletin of the Museum of Indian Archaeology at the University of Western Ontario*, **14**, London. vi + 95 pp. \$5.50 (paper). ISBN 0-7714-0111-6; ISSN 0709-2628.

*ABSTRACTS OF PAPERS PRESENTED AT
THE SIXTH ANNUAL MEETING OF THE
CANADIAN ASSOCIATION FOR PHYSICAL
ANTHROPOLOGY/L'ASSOCIATION POUR
L'ANTHROPOLOGIE PHYSIQUE AU CANADA
NIAGARA-ON-THE-LAKE, ONTARIO, NOVEMBER 9-12, 1978*

**AN ANTHROPOLOGICAL PROJECT
ON FRENCH CANADIAN
INDUSTRIAL WORKERS**

F. AUGER,
Université de Montréal.

A reorientation towards worker's health and safety is needed and it means that the health, strength and longevity of the workers be one of the conditions for the efficiency of their work.

For our project we have an ecological approach emphasizing the importance of multiple and complex environmental influences in disease causation to establish an health index for individual workers and for the population and to evaluate how those factors might affect biological ageing.

Data are obtained through a medical questionnaire (323 questions), a clinical investigation, anthropometry dynamometry and some physiological tests (blood pressure, vision test, audiometer, spirometry). Socio-demographic data and behavioral factors come from the questionnaire (income, education, place of residence, housing, family size, religion, smoking habits, alcohol, drugs, etc.). Such data have already been collected for 3,000 individuals.

For the moment, we will only give some preliminary results obtained with the medical questionnaire which is used to evaluate health status.

**IMPACT OF SOCIO-ECONOMIC
CHANGES ON THE DEMOGRAPHIC
AND GENETIC STRUCTURE OF
BARR'D ISLANDS,
NEWFOUNDLAND.**

MARIAN BINKLEY,
University of Toronto.

The justification for the existence and continuity of settlements in Newfoundland has been a major theme in the island's history. Both economists of today and west country English merchants of the 17th century share the belief that the fewer Newfoundlanders there were the better. Most of the work on the Newfoundland fishery is of an economic and historical nature. These studies have been carried out on a macro-level based predominantly on census, colonial and dominion records (Alexander, 1974, and other members of the Maritime History Group at MUN). A few focus on the micro-level and these are socio-economic in nature (Faris, 1972; De Witt, 1969; Wadel, 1969). However, no attempt has been made to correlate the historical or present socio-economic conditions directly or indirectly with the biological nature of the population.

The purpose of this paper is to examine possible correlations between the fluctuations in the fishing economy and the biological parameters of fertility and reproductive success of a Newfoundland outport population. The community of Barr'd Islands for the period from 1850-1950 was chosen for this study. Data for this paper were collected in the summer of 1976.

MACACA SYLVANUS IN FRANCE: PROBLEMS AND PROCESS.

F.D. BURTON,
University of Toronto.

Two multi-male groups of *Macaca sylvanus* are maintained as tourist attractions in France. Totally provisioned and artificially bounded, they exceed group sizes of their Moroccan parental stock by a factor of ten. The slide presentation reviews the habitat, conditions of study, methodological problems and specific findings concerning socialization patterns.

SEXUAL BEHAVIOR IN A GROUP OF CAPTIVE YOUNG GORILLAS AT THE METRO TORONTO ZOO.

ROBERT COFFIN,
University of Toronto.

A number of field studies have now been carried out on wild gorillas but for the most part these studies are of an ecological, rather than behavioral, nature. Thus, there is still a great deal to be learned about gorilla social behavior, especially sexual behavior.

In this study the sexual behavior of a group of captive young gorillas was observed over a twenty-eight month period at the Metro Toronto Zoo.

Data on female menstrual cycles will be presented and the effects of female hormonal levels on sexual behavior will be discussed. Individual differences, partner preferences, and the influence of social organization on sexual behavior will also be examined. Finally, the results of this study will be compared with other research carried out on the behavior of the great apes.

THE PALEOPATHOLOGY OF A SMALL GROUP OF SKELETONS FROM DODGE ISLAND, BRITISH COLUMBIA.

JEROME S. CYBULSKI,
National Museum of Man.

Seven categories of pathology are detailed

for a group of skeletons excavated from a northern Northwest Coast shell-midden in 1967. C¹⁴ bone collagen dates place the remains between 1000 B.C. and 400 B.C. The sample consists of 13 variably complete skeletons recovered as burials and the scattered bones of seven other people. Included are six infants, one juvenile, two late adolescents, a subadult or early young adult, and 10 adults, six between 20 and 35 years of age. Degenerative joint disease, trauma, secondary skull infection, dental infection, spondylolysis, Scheuermann's Disease, and craniosynostosis are represented among the adolescents and adults. In part the varied pathology in this small sample reflects the cultural and natural environment on the whole it provides a capsule view of a much broader pattern of frequent bone pathology in northern coast British Columbia archaeological sites.

ORIGINS OF *CERCOPITHECUS* *AETHIOPS* ON THE CARIBBEAN ISLANDS OF BARBADOS, ST. KITTS AND NEVIS

WOODROW W. DENHAM,
McMaster University.

Feral populations of African green monkeys live on the Caribbean islands of Barbados, St. Kitts and Nevis. Where did they come from? When did they arrive? How isolated have they been? Answers to these questions have important implications for social, ecological, and genetic research, but currently accepted reconstructions of the monkeys' history are unconvincing. This paper summarizes 17th to 20th century sources that bear on the history of the West Indian populations; reviews data that suggest heterogeneous origins of the monkeys of St. Kitts; examines a disagreement concerning the genus of which 17th to 19th century Barbadian monkeys belonged; and examines the origins, species, and likely numbers of monkeys that went from Africa to the Caribbean as sailors' pets and as cargo aboard slave ships. Several competing testable hypotheses are proposed concerning the origins and isolation of the West Indian monkey populations.

THE USE OF NON-HUMAN PRIMATES IN CLEFT PALATE RESEARCH.

W.J. DOYLE^{1,2}, K. KIMES¹, D. SADLER¹,
and M.I. SIEGEL^{1,2}.

¹ *University of Pittsburgh, and* ²*Children's Hospital of Pittsburgh.*

The cleft palate population exhibits a nearly universal presence of *otitis media* with effusion. Anatomic radiographic and manometric studies evidence a functional obstruction of the eustachian tube to be causal in the pathogenesis of these diseases. Abolition of the disease is not necessarily a consequence of palatal closure and restoration of velopharyngeal adequacy, however. Additionally, during reconstructive surgery, manipulation of the cartilagenous nasal septum has been avoided resulting in septal deviation and airway obstruction.

Preliminary data from a study on middle ear status in rhesus monkeys with surgically produced clefts have been collected. They suggest that a middle ear effusion which is sterile for bacteria results, though this is an inconsistent finding and probably dependent on the pre-operative status of the eustachian tube as well as the degree of clefting. Changes noted in the manometric eustachian tube function tests include: (1) a decrease in the forced opening pressure; (2) a decrease in the passive resistance to air flow; (3) a decrease or abolition of the ability to reduce positive or negative middle ear pressures with native swallowing; and (4) a relative increase in tubal compliance. These results are consistent with those reported for the cleft palate child and allow for the testing of new reconstructive surgical procedures.

In our earliest study of septo-maxillary relationships, baboons were used as models. The results of this study (Siegel 1971, 1974, 1976), indicated that growth retardation varies as a consequence of varying the age at surgery and the amount of nasal septum resected. While these results suggest alterations in surgical techniques, it was felt that differences in anterior facial growth between baboons and humans precluded a direct application to humans. Chimpanzees, however, exhibit a downward pattern of growth which more clearly approximates that of man. In our current study of

septo-maxillary relationships, the nasal septum is resected in 2-4 month old chimpanzees. Data obtained through the use of lateral cephalograms with metallic implants and dental casts indicate no significant differences between control and operated animals in the linear regression equations ($y=a+bx$) which describe the anterior facial growth. This suggests that some manipulation of the cartilagenous nasal septum may be tolerated during human reconstructive surgery.

VEGETABLE PROTEIN IN THE DIET OF INDIANS IN THE NORTH-WESTERN AMAZON.

DARNA DUFOUR.

State University of New York at Binghamton.

In recent years a number of investigators have suggested that protein is a limiting resource in the American tropics and influences the size, distribution and permanency of aboriginal populations pursuing traditional subsistence strategies. This is seen as the result of a dependence on animal protein in an ecosystem where animal species are both thinly distributed and generally small in biomass. There is, however, little quantitative information on non-animal protein sources or their role in meeting the calorie-protein requirements of indigenous groups.

The question of non-animal protein sources is addressed here by a discussion of the exploitation of high protein plant foods which are an integral part of the diet of Tatuyo Indians in the northwestern Amazon. Fieldwork with the Tatuyo was conducted during a 16-month period. Production of wild and cultivated food resources was monitored. The composition of wild foods was determined through the use of standardized tables and through biochemical analysis. Four 24-hour weighed dietary surveys were used to measure protein-calorie intake.

Results indicate that gathered seeds of certain species of Euphorbiaceae, Caryocaraceae and Calsalpinaceae are relatively high in protein. Further, these seeds seasonally provide significant amounts of dietary protein. Of particular importance is a legume of the family Caesalpinaceae which is collected and con-

sumed in large quantities during the first part of the rainy season when animal protein is particularly difficult to obtain. The role of this legume is discussed within the framework of the satisfaction of dietary protein requirements.

(Supported in part by SSRC Dissertation Fellowship and NSF Grant BNS 75-20169.)

PRELIMINARY ANALYSIS OF THE VOCAL REPERTOIRE OF A GROUP OF BONNET MACAQUES (*MACACA RADIIATA*).

GEORGE ELLIS,
University of Western Ontario.

This paper describes the vocal repertoire of a group of forest living bonnet macaques. The wide range of vocal signals is categorized into a small number of sound categories. These acoustic categories are loosely correlated with various emotional states, ontogenetic variables and behavior situations. Precise understanding of the "meaning" of vocal signals comes from an analysis of (1) patterns of variation in the signals due to grading within and between categories, (2) the simultaneous combination of vocal signals with other modes of communication (visual, olfactory, tactile), and (3) the context in which the vocal signal (or its multimodal manifestation) occurs. The emphasis in this paper is on understanding the first of the above three pragmatic considerations.

TEA INTAKE AMONG NORTHERN CANADIAN INDIAN POPULATIONS: CONSIDERATION OF POTENTIAL HEALTH IMPLICATIONS.

CAROL SPINDELL FARKAS,
University of Waterloo.

Information on methods of tea preparation and consumption of tea by northern Canadian Indian people was obtained as part of a larger work which surveyed dietary intake patterns and food intake of this segment of the population.

Seventy-seven useful responses were ob-

tained from a survey of the observations of professional workers in northern Canadian Indian communities in regard to food intake and dietary patterns: 48% of the responses were from medical/health workers, 21% educators, 18% Hudson Bay Company managers, 12% anthropologists, and one church worker. Of these responses 21% were either answered by or had contribution from Indian people. Responses were received from 10 provinces: 26 Ontario, 10 Saskatchewan, 10 Quebec, 10 Manitoba, 7 Alberta, 6 British Columbia, 3 New Brunswick, 3 Yukon, 1 Nova Scotia, 1 Northwest Territories.

Attention will be given in this paper to the health implications of tea ingestion by various age groups of northern Canadian Indian populations. Special attention will be given to caffeine, tannin and manganese in tea; also discussed will be the importance of steeping time, cup size, proportion of tea to water, seasonal variation of intake and sugar.

Needs for further research in these areas will be cited.

THE HOOD SITE: LONGHOUSE BURIALS IN AN HISTORIC NEUTRAL VILLAGE.

BILL FITZGERALD,
McMaster University.

Excavations at the historic Neutral Hood site produced the first occurrence of burials within Neutral longhouses, and despite a relatively small sample size, certain inhumation patterns have been interpreted. A dichotomy between temporary and permanent burials has been proposed, based on the location within the longhouse, the presence or absence of grave goods, the performance of sacrifice and associated ceremonialism, and the physical state of the individual.

Utilizing the *Jesuit Relations* and the osteological data as aids in the interpretation of the interments it has been suggested that certain age groups may have been permanently interred within the longhouse. This is based on the belief that the souls of both the very young and the very old, among which I have included the chronically ill, remained near the village after death, instead of proceeding to the land of the souls.

THE STUDY OF HEALTH LEVEL VARIATIONS AMONG NORTH-EASTERN SWITZERLAND INDUSTRIAL WORKERS: AN ANTHROPOLOGICAL APPROACH.

FRANCIS FOREST,
Université de Montréal.

More than 1,000 workers of 44 different firms have been examined with the intention of studying the multiple relations which can exist between the socio-cultural environment and the variation of different health aspects. The socio-cultural environment has been studied with the help of 35 indicators and health was evaluated according to approximately sixty variables. Multiple variance analyses, based on multiple regression, have then enabled us to bring out the adjusted effects of each of the environmental factors studied, that is to say effects calculated by maintaining constant the effects of 34 other independent variables studied simultaneously. A particular interest for environmental and socio-professional factors of differential ageing has emerged from these analyses.

THE ASSESSMENT AND CONSEQUENCES OF INTRA- AND INTER-OBSERVER ERROR IN CRANIOMETRY.

GARY M. HEATHCOTE,
University of Toronto.

Thirty-eight craniometric measures were taken on 25 crania by three observers. Since two of the observers triplicated their measurements, the data base allows for an investigation of craniometric precision (reproducibility) at both the intra- and inter-observer levels. Both ANOVA and Pearsonian correlation statistical procedures are employed in assessing the type and magnitude of measurement error for each variable. On the basis of these and other analyses, recommendations are offered regarding the selection of craniometric variables for use in descriptive and/or comparative skeletal studies. The effect of measurement error on a multi-

variate assessment of biological distance will also be explored by way of Penrose's phenetic distances. Attention will also be given to the identification of the material *sources* of measurement error, such as landmark ambiguities and mechanical difficulties in the usage of standard calipers.

ANTHROPOLOGY: WAMPETERS, FOMA AND GRANFALLOONS.

MIMA KAPCHES and JOHN T. MAYHALL,
University of Toronto.

(Complete paper published in Vol. 1, No. 1)

MODELLING TAPHONOMIC PROCESSES IN THE OLD CROW BASIN, YUKON TERRITORY.

C.P. KOCH,
University of Toronto.

A theoretical model for the interpretation of the taphonomic history of an Upper Pleistocene vertebrate assemblage from Old Crow Basin is presented. Taphonomy is viewed as a sequence of interacting dynamic processes within the framework of Palaeoecology. The depositional history of Old Crow Basin is reviewed, as relevant to the origin and distribution of the assemblage. The approach presented to taphonomic processes is drawn from general systems theory and communications theory.

CRANIAL MORPHOLOGY, CHARACTER ANALYSIS, AND AFFINITIES OF TREE SHREWS (*MAMMALIA : SCANDENTIA*).

R.D.E. MACPHEE,
University of Manitoba,
and MATT CARTMILL,
Duke University.

Although tree shrews are the best known of all contemporary mammalian insectivores, their systematic position within Eutheria is not substantially clearer than it was a century and a

half ago, when scandentians first became known to Western science. At various times within this period they have been allied with one or more of the orders Insectivora, Macroscelidea, Primates, Dermoptera and Chiroptera. This study provides a re-analysis of a number of the cranial features that have been used to support these hypotheses of scandentian affinities, with specific emphasis on traits of the carotid system, basi-cranium and orbital region. There are three major findings. (1) Of the supposedly homologous shared derived traits linking tree shrews and primates, most appear to be either not homologous, not shared or not derived. (2) Most of the traits that do not fall into the first category are either of indeterminate primitiveness or derivedness, or, if they are indeed primate-tupaïid synapomorphies, force the troublesome conclusion that plesiadipoids (which lack these same character states) cannot be retained in a monophyletic order Primates. (3) The cranial morphology of the other possible sister groups of scandentians, to the extent it is known, does not support hypotheses of their proximate relationship with tree shrews. Because we do not find a paraphyletic order Insectivora abhorrent, we prefer to leave the tree shrews at their old address – the insectivore dustbin.

CURRENT REVIEW OF DERMATOGlyphics AT THE GLOBAL LEVEL: THE LAST FIFTY YEARS.

JAMSHED MAVALWALA,
University of Toronto.

First used in the 19th century, dermatoglyphics becomes a part of the sciences of the western world only in the early 20th century and since the 30's has been used to describe populational variability among primates, both human and non-human, and to aid diagnosis in those patients whose dermatoglyphics are affected by disturbances in early foetal life. This review concentrates on work done by anthropologists and geneticists in the last fifty years.

The review covers work done in printing and automation, secondary ridges, metacarpophalangeal creases, palmar flexion creases, proximal and midphalangeal configurations,

finger and palm prints, quantitative analyses, dermatoglyphics in medicine, and dermatoglyphics in non-human primates.

A PRELIMINARY INVESTIGATION OF HISTOLOGICAL AGING OF OSSUARY BONE.

GERRY MULLIGAN,
McMaster University.

Chronological age determination of archaeological skeletal material has posed a problem for physical anthropologists. Techniques which are currently used for dating skeletal material require observation of dental eruption, sutural closure and obliteration, epiphyseal fusion, and appearance of the pubic symphysis. The difficulty in using any or all of these approaches to determine age at death, particularly, is well known.

Within the last decade histological methods have been used to determine chronological age. Three major articles have been published, each claiming success with the approaches used. Singh and Gunberg's (1970) method was applied to two mandibles from the Donaldson site, carbon dated at approximately A.D. 75, to determine whether the approach is likely to be useful in aging archaeological bone. The results showed that age determination was impossible principally because of deterioration of the osteons and the surrounding cortex.

A THEORETICAL ARGUMENT FOR THE USE OF TOTAL SIDE FREQUENCIES OF BILATERAL DISCRETE TRAITS IN POPULATION DISTANCE ANALYSIS.

N.S. OSSENBERG,
Queen's University.

In the controversy concerning whether discrete skeletal traits used in population studies should be scored in sides or in individuals, it has been argued that side scoring introduces redundant information deriving from the strong positive left-right correlation in trait occurrence. On the other hand, I argue, through considera-

tion of the theory of threshold variants and of actual patterns of trait distribution, that bilateral correlation is meaningful in quantifying the liability for the trait in the population; hence side scoring is the preferable method.

Analysis of two independent mandibular features, mylohyoid bridge and suppressed third molar, in Indian and Eskimo population samples (total $N \approx 1200$) reveals a statistically-significant pattern of increasing bilateral occurrence with increasing population incidence. This pattern is consistent with the theory that trait liability for a "quasi-continuous" variant is normally distributed with constant increment between thresholds on an underlying scale. According to theory, phenotypes with more pronounced expression (bilateral occurrence) have greater liability than those with less pronounced expression (unilateral occurrence). Therefore, scoring traits in total left and right sides, by giving greater weight to bilaterally-affected individuals, may provide a better estimate of the liability for the trait in the population.

ASSIGNMENT OF PUTATIVE SEX TO ADULT FEMORA FROM THE KLEINBURG OSSUARY: A RESEARCH REPORT.

SUSAN PFEIFFER,
University of Guelph.

(Complete paper published in this number)

A MICRO-HABITAT STUDY OF HOWLER MONKEYS (*ALOUATTA* *VILLOSA*) IN VERACRUZ, MEXICO.

WAYNE RHODES,
University of Toronto.

This research is part of a three-month study of howler monkeys (*A. villosa*) in a tropical rainforest in Tuxtla, Veracruz, Mexico. The study area is located in an isolated tract of rainforest near the Gulf coast and is contained in the 700 hectare Field Station for Tropical Biological Research belonging to the Universidad Nacional Autonoma de Mexico. The data

pertaining to the present paper were collected during the last five weeks of the study. The focus of this research was on micro-habitat utilization by one howler group which is now being investigated by the U. N. A. M. research team headed by Dr. A. Estrada, with respect to overall ecological parameters and detailed behavioral study. Therefore, micro-habitat data complements the more extensive work being carried out by this research team. Major variables examined and analyzed by this micro-study include tree shape, size, and species; location of howler individuals in these trees during particular activities; and temperature and humidity measurements occurring during these activities, in addition to general climatic conditions at the time. The study was undertaken to provide preliminary information for a longer study to be carried out in the near future.

CHILDLESSNESS AMONG THE SEPHARDIC JEWS OF GIBRALTAR: INSIGHTS INTO POPULATION STRUCTURE.

L. SAWCHUK and L. FLANAGAN,
University of Toronto.

The analysis of secular trends in differential reproductive success of the Sephardic Jews of Gibraltar reveals that the infertility of married couples and celibacy are a major source of demographic loss to the local breeding unit. Recent field research has clarified in part the high rate of infertility observed among spatially exogamous matings and to a lesser extent factors responsible for the high rate of celibacy observed among the Jews. Biological implications of this source of demographic loss are discussed.

A MONTH WITH THE KALAHARI BUSHMEN, MAZANE REGION, KWENING DISTRICT, BOTSWANA: A PILOT STUDY.

B.A. SIGMON,
University of Toronto.

During the summer of 1978, the author

spent a month with a group of Kalahari Bushmen. The purpose of the visit (made possible by the assistance of Helga Vierich) was to carry out the initial footwork necessary before planning a future research project there. This involved (a) meeting the people and understanding the conditions under which future work could or could not be pursued, and (b) establishing contact with representatives of the government in order to obtain relevant information concerning policies on research by foreigners, and specifically the research that I was proposing.

My original research plan was intended to focus on energy expenditure studies. After spending time in Botswana, I saw reasons for redirecting the research program. These reasons were presented and tied in with a consideration of the problems one faces in trying to undertake research on living peoples in newly developing nations. A new thrust for research possibilities was presented, taking into consideration the policies of the government and the differing life styles and attitudes of the Botswana peoples.

HUMAN FACIAL TEMPERATURES AND FROSTBITE RESISTANCE: FIELD AND LABORATORY OBSERVATIONS.

A.T. STEEGMANN,

State University of New York at Buffalo.

Men of Asian and European origins were subjected to laboratory craniofacial cooling tests (both still and moving air) to determine relative ranking and temperature curves of various facial skin sites. The resulting variation was employed to gauge which conditions most tax capacities for cooling resistance.

Using the foregoing as a base, comparisons were made with samples of facial temperatures gathered from American soldiers and from Canadian Cree and Ojibwa men, all groups working outdoors, under natural winter conditions in the boreal forest.

It is concluded that the human face has great physiological capacity to resist serious frostbite, aided by behavioral adjustments. Some facial cold injury is now being seen, however, as

a result of the unique conditions of high wind speed, low exercise, and low temperature experienced during snowmobile driving.

SUBADULT MORTALITY AT THE OSSOSSANÉ OSSUARY.

N.C. SULLIVAN and F.J. MELBYE,
University of Toronto.

The Ossossané ossuary is located in Simcoe County in the Georgian Bay region of Ontario. The estimated 800 individuals in this ossuary were excavated by a Royal Ontario Museum crew under the supervision of Kenneth E. Kidd in 1946. On the basis of site location, artifact associations and other details, Kidd has convincingly argued that this ossuary represents the Feast of the Dead ceremony witnessed by Brebeuf in 1636. The analysis of the skeletal remains is an ongoing research project begun in 1975 at Erindale College under the direction of Dr. Melbye.

An analysis was made of the mortality of the estimated minimum of 132 subadults in the ossuary. Crown and root calcification of the mandibular dentition was observed and ages at death were assigned on the basis of the formation standards of Moorrees, Fanning and Hunt. The resulting mortality and survivorship rates are then compared to the demographic experience of the subadults from the Kleinburg and Grimsby ossuaries. The results suggest that, up to the age of about five years, the Ossossané subadults have a slightly higher mortality rate than Kleinburg or Grimsby subadults. After this age, the mortality rate observed at Ossossané is still higher than that of the Kleinburg series, but lower than the observed rate for the Grimsby subadults.

INDIAN-ESKIMO ADMIXTURE: A CONSIDERATION OF THE EVIDENCE.

E.J.E. SZATHMARY,
McMaster University.

Eskimos and Indians are known to differ in several craniometric dimensions as well as the frequencies of several genetic markers. The dis-

parities have led to the view that great biological differences exist between these branches of the Mongoloid stock. The maintenance of these differences has been attributed to a number of factors, foremost of which was the absence of meaningful amounts of inter-group gene flow.

Recently ethnological evidence was presented which indicated extensive culture contact between Indians and Eskimos in specific areas of the north. To determine whether cultural transmission was accompanied by infusion of genes, craniometric, anthropometric and genetic data from relevant populations on the Indian-Eskimo frontier were examined.

It is argued that there is insufficient cranial material to allow the conclusion that observed similarity between Eskimo and a single group of Indians is attributable solely to admixture. Six anthropometric measures of the head, nose and face were also obtained from the literature. Penrose shape distances were calculated and these were subjected to a clustering procedure. The results did not contradict published con-

clusions dating to the 1930s. Great similarity appears to exist between speakers of Na-Dene languages and west and southwest Alaskan Eskimo, and between Cree and Caribou Eskimo, respectively. Unfortunately, little confidence can be expressed in these findings, for the data on which the analysis was based were gathered by several investigators and are likely systematically biased. The genetic markers indicated that Indian gene flow had occurred only in Wainwright, Alaska and Ft. Chimo, Quebec. In neither of these two communities could the magnitude of mixture be measured with precision and accuracy. These findings suggest two interpretations: (1) Gene flow has not been extensive between Indians and Eskimos, else more conclusive evidence of this process could be obtained with the genetic markers. (2) If gene flow has been extensive, demonstration of it is difficult even with genetic markers, for the populations are not as divergent genetically as has been commonly assumed.

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