# Studies on the Xavante Indians of the Brazilian Mato Grosso

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## I. INTRODUCTION. PLAN OF STUDY

FOR PERHAPS 99 per cent of its biological history, the human species has lived in small aggregates whose livelihood came primarily from hunting and gathering. The time factor in evolution being what it is, there can be little doubt that many—most—of the genetic attributes of civilized man have been determined by the selective pressures and breeding structures of these primitive communities. If we would understand modern man, we must study such of these primitive groups as still remain in a way in which they have rarely if ever been investigated to date. So rapidly are the remaining primitive communities disappearing, the matter of these investigations has an urgency not common in scientific problems.

The following account records a pilot study of a Xavante Indian village near the Rio das Mortes in the State of Mato Grosso, Brazil. It is a pilot study

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in the sense that a primary reason for the undertaking was to test the methodology of such studies as well as the feasibility of employing the same team approach in much more extensive investigations along similar lines among these and other Ge speaking tribes of this general area. These Indians were selected because they appeared to meet the combination of rather exacting circumstances which render studies of the type contemplated feasible and valid. There are only a few scattered references to the Xavante in the literature on Central Brazil. We know they fought the settlers in the eighteenth century and that they probably moved westward to their present habitat about the middle of the nineteenth century. Since then they have reacted violently to anything which they considered encroachment on their territory, so that until the 1940's their contacts with western culture were largely hostile. As late as 1941, the inhabitants of the village selected for study formed part of a band which killed an agent of the Indian Protective Service and five of his assistants who had been entrusted with the mission of establishing friendly contacts with the Xavante and setting up a "Post of Attraction" for them. The present chief of the village took part in that attack. However, as will be evident from the following, Xavante acceptance of outsiders has progressed rapidly in recent years. The group is thus at that critical point in its relations with the outside world when it is approachable but yet culturally intact. Mr. Ismael Leitão, the agent of the Indian Protective Service assigned to the Post near the village studied is a man of uncommon ability who, during his 14 years at this station (Post Pimental Barbosa, Lat. 13°30′ S, Long. 51° 25′ W Gr.), has come to command the respect and confidence of the Indians and speaks their language. During 1958, one of the authors (D. M. –L.) conducted the first detailed investigations of the group, directing his studies primarily towards kinship and political structure. There was thus the necessary background of experience and communication with the tribe. Finally, there is a small airstrip near the Post, providing the means for rapid transportation of blood samples to a base laboratory in Rio de Janeiro.

The specific objectives of the present study, carried out during the summer of 1962, were (1) to identify those cultural elements with particularly biological implications; (2) to obtain as complete a pedigree of a Xavante village as possible; and, for as many individuals as possible in the time available, (3) to perform physical examinations and anthropometric studies; (4) to obtain blood and saliva specimens and to extract the maximum amount of genetic and medical information from these specimens; and (5) to utilize these data to explore a variety of parameters of genetic interest.

Since the Indian village selected for study is now located approximately 1 km from the five houses of the Post, and since facilities at the Post were far better than in the village, all examinations were performed at the Post. Each subject was seen on two different occasions. The first time, a pedigree was obtained, and a physical examination and anthropometric study were performed. On the second round, a whole blood specimen was drawn, thick and thin blood films made, and dermatoglyphics obtained. Because the sample on the first round does not correspond entirely to the sample on the second round, observations are incomplete for some individuals. Although it would have been desirable to have completed the entire battery of observations on a single contact, the limited working facilities, the limited patience of the Indians, and the problem of minimizing the time interval between drawing the blood and conducting the serological studies rendered this impossible. In the following, we shall provide a brief factual account of the Xavantes as they are today and then proceed to a discussion of certain genetic determinants insofar as they can be defined in a preliminary way by these studies.

## II. DISTRIBUTION, HISTORY, LINGUISTIC CHARACTERISTICS, AND SOCIAL ANTHROPOLOGY

The term *Xavante* (in English orthography, "Xavante" is sometimes rendered as "Shavante") was at one time applied indiscriminately by Portuguese explorers and writers to a number of little-known tribes in the interior of Brazil. Its technical use has now come to be restricted to three groups: the Oti-Xavante, Opaie- (or Ofaie-) Xavante, and Acuen-Xavante, even though these people are known to be culturally and linguistically distinct. This study deals with a group of Acuen-Xavante; whenever the word "Xavante" is used without prefix, this is the connotation that it has. There are today between 1500 and 2000 Xavante, living in a number of autonomous communities along the Rio das Mortes from the Ilha do Bananal in the east to the region of the headwaters of the Río Telles Pires in the west. They share a common language and the common consciousness of being a single people. In practical terms, this means that a Xavante enjoys the right to take up residence in any Xavante community, even in one where he is not known. It also means that Xavante will apply a relationship term to any other Xavante, although, in the case of an unknown person come from afar, some discussion might be required in order to establish the appropriate relationship category into which he falls with reference to the speaker. These relationship terms must be well understood if one is concerned with biological descent. A comprehensive account of the social anthropology of this group, based on field work in 1958 as well as the present experience, will be presented elsewhere (Maybury-Lewis, in press). In this section, we have endeavored to restrict our treatment to those aspects of their culture of genetic significance. Full documentation of the statements in this section regarding social organization will be found in the monograph now in press.

### *Language*

The Xavante language is spoken only by themselves. However, it bears a close resemblance to Xerente, so much so that Xavante and Xerente may be separated dialects of what was once a common Xavante-Xerente language. Following Greenberg's tentative classification (1960), these languages may be assigned to the Ge group of the Macro-Ge subfamily of the Ge-Pano-Carib linguistic family. The Ge speaking peoples are to be found in the highlands of eastern and central Brazil, an area which is remarkable for the fact that it is only minimally infiltrated by Amerindian groups of other language families.

*History*

The admittedly scanty information which ethnologists have at their disposal seems to indicate that the Ge are some of the oldest inhabitants of the central uplands of Brazil and perhaps of the entire South American continent (e.g., Mason, 1950). Their history proper begins with their resistance to the Portuguese in the late seventeenth and early eighteenth centuries. The earliest known reference to the Xavante dates back to 1756, but in view of the terminological confusion already mentioned, we cannot be certain that these Xavante were in fact the ancestors of the Xavante referred to in this study. Eighteenth century writers regularly used Xavante and Xerente (terms which today designate two separate, although closely related, peoples) interchangeably. It seems certain, however, that the Xavante and the Xerente were either a single people or two closely related and geographically contiguous peoples until the beginning of the nineteenth century.

They fought the gold miners in what was then the Province of Goyaz throughout most of the latter half of the eighteenth century and had some success against the small numbers of troops which could be levied to deal with them. In 1786, a liberal governor attempted to make peace with them by persuading them to accept resettlement in government-built villages, and, after protracted and cautious negotiations, over 2000 of them did come south in 1788. They embarrassed the administration which could barely feed such a large number of extra mouths and could certainly not have dealt with any sudden renewal of hostilities on their part. Nevertheless, they were received with as much pomp as the governor could muster and settled into their village.

The resettlement system was a failure, however. One of the important factors in the failure was an epidemic, allegedly of measles, which killed off a large number of the Indians and caused others to flee to escape infection. The population of the settlement rapidly dwindled. Where before the system of resettling Indians had been defended as politically astute, it was now attacked as an unnecessary drain on the public purse and, moreover, as morally wrong in that it encouraged Indians to look for government assistance rather than to fend for themselves. The various settlements were allowed, therefore, to languish for want of financial support.

The consequent withdrawal of the Xavante from the Province of Goyaz (now the State of Goias) to their present habitat in Mato Grosso and their subsequent hostility to outsiders has often been attributed to their maltreatment in the settlements. In this they offer a contrast to the Xerente who remained in Goias and long ago accepted peaceful contacts with outsiders, supposedly because they had not had the bitter experience of resettlement. In fact, there is no reason to believe that such Xavante as might have been resettled constituted a significant proportion of this tribe or that the Xerente were not involved in the resettlement plan. Furthermore, we know that many Indian tribes which were not resettled were treated with considerable cruelty, and the Xerente are a case in point. It is certain, in any case, that at the beginning of the nineteenth century the Xavante-Xerente were once more fighting the settlers and the hostilities continued until after the Xavante had moved westward.

It is impossible to date this move with any certainty, but it seems to have taken place somewhere between 1844 and 1862, probably as a westward migration over a period of time rather than a removal of the entire tribe at any given moment. In 1844, the Xavante are still reported in the State of Goias. By 1848, some of them are mentioned as "new arrivals" on the Araguaia River far to the west. In 1854, an expedition actually went up the Rio das Mortes to look for them. Although it returned without meeting them, this indicates at least that the Xavante were at this time presumed to be in the region where they are today. Their presence there in 1862 is established.

Thus it seems that the Xavante of today are the descendants of the western group of the Xavante-Xerente and were originally located between the Tocantins and the Araguaia Rivers, while the Xerente roamed the lands to the east of the Tocantins. In all probability, the Xavante withdrawal and the Xerente peaceableness were different ways of reacting to the pressure of the settlers. The Xerente were hemmed in on the right bank of the Tocantins between those settlers who established themselves along the river, the most important artery of communication in this region, and those who came overland from the east and northeast. When they were no longer in any position to offer resistance, they made peace. The Xavante, on the other hand, could and did withdraw westward into an unsettled no-man's-land west of the Araguaia River, later retreating across the Rio das Mortes as well. Whether in this movement they met other Indian groups (and the fate of these groups—flight, extermination, or amalgamation) is unknown. Whether, also, this movement resulted in any significant cultural changes is unknown.

*Present Circumstances*

In 1958, there were at least nine autonomous Xavante communities. One of these had had no friendly contacts with the outside world and its exact location was unknown. Its existence and approximate position were vouched for by the Xavante of other villages. By 1962, the number of communities had been reduced to eight, and it was rumored that the group which had not previously accepted outsiders had established peaceful contact with the Brazilians. It is quite possible that some communities are unlisted in this survey since the Xavante habitat is virtually unsettled and only poorly known.

Until recently, the Xavante lived by hunting and gathering and some rudimentary agriculture. A Xavante group would not devote more than a month of the year to the tasks connected with its limited crops, which were maize (*Zea mays*), beans (*Phaesolus* sp.), and pumpkins (*Cucurbita* sp.). The two harvests, of maize and of beans plus pumpkins, respectively, were used primarily as food surpluses to sustain the group during the performance of long ceremonies, enabling them to remain in one place for a considerable time without being obliged to move on and exploit new tracts of country. A Xavante village should be thought of more as a base than as a village in the usual sense of the term. The large, beehive-shaped huts were built to last for only a few years. Important ceremonies were performed at the village, but for most of the year it was deserted except for a few people who were too aged or sick to accompany the rest on trek. The majority of the villagers—men, women, and children—traveled slowly in a wide loop, hunting and gathering as they went, until they got back to their base village after a period of six to twelve weeks. The length of time which the band spent at its base depended on whatever activities were scheduled for the period. When it set off again on trek, it would move in a different direction from the one taken on the previous trek, so that a community would exploit a wide area systematically over the year.

It is in this sense that the Xavante occupied their land. Each group knew approximately which territory it could exploit with impunity and which territory might be disputed by a neighboring band. Thus a strong group could range widely, if circumspectly, while a weaker group would try to avoid stronger neighbors. This seminomadic pattern of life, however, is already beginning to be modified. There is now a tendency for Xavante communities to attach themselves to a patron from the outside world, usually a mission station or a post of the Indian Protective Service. Originally, this attachment took the form of constructing a base village close to the post of the patron, who could be relied on to supply a certain quantity of gifts in the form of food, knives, and other manufactured goods. Such groups, however, went on trek as usual and did not appreciably alter their way of life. In 1958, the group discussed here came into this category as did virtually all the other known Xavante communities. By 1962, however, this group was beginning to show signs of modifying its nomadism. They had begun to plant manioc, a thing which they had refused to do as late as 1958 on the grounds that the care of manioc plantations would interfere with their treks. They did not plan to go on trek for such long periods as formerly, and when the men discussed travel it was more likely to be travel to a Brazilian settlement in an attempt to acquire manufactured goods than a hunting trip. Yet in 1958, hunting had been the main, almost the sole, topic of conversation among the adult men.

*Diet*

Despite a rudimentary agriculture, the Xavante depend very heavily on the wild products which they gather. They eat numerous varieties of roots in large quantities, which provide a nourishing, if starchy, diet. These roots are available all year but are particularly important in the Xavante diet from April to June in the first half of the dry season when there are no more fruits. The maize harvest does not last long and is usually saved for a period of ceremonies. Until the second harvest of beans and pumpkins, the Xavante subsist largely on roots and palmito (*Chamacrops* sp.), their year-round staples.

From late August until mid-February, there are also plenty of nuts and fruits available. The earliest and most important in their diet is the carob or ceretona (*Ceretona* sp.), sometimes known as St. John's bread. Later come the fruits of the buriti palm (*Mauritia* sp.) and the piqui (*Caryocar* sp.).

These are the basis of the food supply throughout the rainy season. Other fruits, such as mangoes, genipapo (*Genipa americana*), and a number of still unidentified varieties are also available.

The casual observer could easily be misled into thinking that the Xavante "live on meat." Certainly they talk a great deal about meat, which is the most highly esteemed food among them, in some respects the only commodity which they really consider "food" at all. Similarly, hunting was and still is amongst the majority of Xavante the most prestigious occupation for a man. Important ceremonies are invariably preceded by communal hunts. The meat so obtained is roasted and then smoked but remains edible for only a few days. Ceremonies, then, are occasions for an orgy of meat eating. Furthermore, their important symbolic food exchanges take the form of meat pies. Yet, although the Xavante could probably survive without meat, they would certainly starve without the wild products which supplement their diet. They do not eat meat every day and may go without meat for several days at a stretch, but the gathered products of the region are always available for consumption in the community.

Recently, the Xavante have begun to eat large quantities of fish. It is likely that at one time fish were an insignificant extra in their diet because they shared the attitude prevalent among the Ge speaking peoples of Central Brazil that fishing was a pastime for small boys. Nowadays, all Xavante eat fish when they can get them, but, significantly, they do not generally fish unless there is some reason which prevents their hunting. Fish become particularly important in the diet of the people discussed here during those periods when they are living in their base village and wish to remain there for some time, even though the nearby region has been hunted through. Fishing is thus gaining in importance as the Xavante come to value staying close to their patrons. The most important method they use to catch fish is by hook and line—invariably imported fish hooks and nylon line which they acquire from their patrons and other visitors, a further indication that intensive fishing is a newly formed habit with them.

*Political Organization*

Xavante society is divided into three exogamous patriclans which are unevenly distributed throughout Xavante-land. Fellow clansmen recognize that they are united by a bond which they express as a tie of kinship, although they may not be able to trace the specific genealogical links which bind them. Xavante are uninterested in such ties. Their highly classificatory relationship terminology enables them to place all other members of their society in one or another of a number of relationship categories independently of genealogical referents. In this terminological system, the major distinction is between those who are classed and addressed as "kin" (essentially Ego's fellow clansmen) and those who are classed and addressed as "affines" (essentially all those who are not members of Ego's clan). This is a crucial distinction in all areas of Xavante life and particularly as regards the political structure of their society.

Each Xavante village is an autonomous community which recognizes no formal links with any other Xavante village and, indeed, is usually on bad terms with its neighbors. Each community has a chief who is the senior man of the dominant faction in the village. Should there be no faction which is clearly dominant, then there may be rival chiefs in a single group. A chief is invariably supported by the fellow members of his patrilineage (clansmen to whom he *can* trace a genealogical connection such that they are both descended in the male line from a common male ancestor) and generally by the members of the other patrilineages in his patriclan. He may be supported too by individuals or patrilineages of other clans, particularly if he is a strong chief. In this case, the outsiders are likely to be regarded as members of the chief's clan and called by appropriate kinship terms. The office of the chief is not transmitted according to any set pattern but is bestowed, at the death of the chief, on the outstanding contender—not necessarily a son of the previous chief.

All items of news are discussed in a council composed of all the "mature men" of the community and all disputes are aired there. ("Mature men" is a technical term here which is explained below in the discussion of age-sets.) In this council, the dominant faction has a majority by definition and is represented by the best speakers, since Xavante place a high value on oratory and no man who is not a good speaker could hope to become influential. Xavante elders attempt to "talk out" serious quarrels, prolonging discussion for days in the hope that an open breach may be avoided while men's passions are still aroused and that, eventually, the whole issue might even be forgotten or buried in oratory. Sometimes, the community as a whole does decide to take action against one of its members. Such a decision must, of course, have the approval of the dominant faction or there would be no way of implementing it; but it must also gain the approval of the other factions. This usually happens only in cases of sorcery, which the Xavante regard as a particularly serious crime. A suspected sorcerer may fail to be supported by his kinsmen and so be convicted by the men's council. He is then put to death by a party of men from all three clans, unless he has got wind of what is about to happen and has already fled to some other community. On the other hand, the dominant faction may act on its own against other members of the community. Thus, a member of a minor lineage may at any time suffer what he considers an injustice at the hands of the dominant faction.

Nevertheless, the dominant faction cannot tyrannize over the community. A man or a lineage which feels unjustly treated can always go elsewhere in the certainty of being taken in by a neighboring community. Alternatively, he can attempt to get his revenge through sorcery. A wise chief will try to obviate or smooth over such conflicts as lead to charges of sorcery, for this generally leads to fighting. He must also try to avoid the type of schism which would lead a minor lineage to break away from the community, for this weakens his own village against other villages. It might even lead to a state of affairs where his village is no longer a viable political unit and is forced to seek amalgamation with another group where his hitherto dominant lineage will be obliged to accept a minor status.

Where there are contenders for the chieftaincy, one faction may strike at another, killing as many of the adult men as possible in order to establish its own supremacy. Where a chief feels his own position threatened by the rise of an influential and strongly supported outsider, he may take a calcu-late risk and instruct his faction to annihilate the opposition. Casualties in such encounters are not very heavy. There are rarely more than two or three men killed; the rest flee for their lives. Apewe, the chief of the community here described, purged an opposition faction in 1953. On that occasion eight men were killed in their sleep. Their kinsmen and factionaries fled, resulting in a loss to the village of about 30 to 40 people. This massacre is still talked about throughout the Xavante communities and is invariably mentioned by Apewe's detractors, of whom there are many. The action seriously weakened Apewe's village, but as a calculated risk, it appears that Apewe gambled and won. He is now incontestably chief of his community and is regarded by all Xavante as one of the strongest chiefs in the tribe.

This struggle for the chieftaincy, which is less a *de jure* status than a *de facto* possession of power in Xavante communities, appears to thin out the ranks of older men as they enter into lethal competition for the prize of leadership. Precise data on this point are for obvious reasons unfortunately incomplete. Xavante are reluctant to speak of such matters and those who do are prone to slanderous exaggeration. In the community here described, it is significant that the one man approaching Apewe's age and generally regarded as the "father" of the strongest minor clan (Prapá) is a person of extremely retiring disposition who did not often speak in the men's council. On the other hand, Suwapté, a son-in-law of Apewe and the tacitly accepted leader of a small minor faction, is a fiery and frequent orator. In 1958, Apewe's eldest son Waarodi, a person of great influence and generally regarded, on the basis of his personal attributes, as the man who will assume the leadership of the dominant faction at his father's death, accused Suwapté of sorcery. A serious split in the community was avoided at that time only by protracted discussions and by the matter being "talked out" by the elders.

### *Sorcery*

Accusations of sorcery are thus a normal function in the relation between factions in Xavante communities. Apewe's purge in 1953 was instigated by the death of his brother. This death was attributed to the sorcery of relatives-by-marriage. Two of the eight men killed in revenge were sons-in-law of the dead man. A third was the father-in-law of one of Apewe's sons. The others were all members of the same lineage. In this case, it appears that suspicion of sorcery centering on certain individuals was used as a pretext for a purge of the entire "sorcerous" faction.

### *Recent Contacts with Other Tribes*

While sorcery is generally held to be an internal affair in any community, Xavante also belive that they may be affected by the canalized malevolence of hostile groups, both Xavante and non-Xavante. This applies particularly to the Carajá Indians with whom the Xavante have a long history of intermittent hostilities. The Carajá word for the Xavante has the connotations of *sorcerer, malevolent person, evildoer,* and even today, the Carajá are physically afraid of their bellicose neighbors. The Xavante fear the Carajá in a different way, claiming that the Carajá infect them with sickness, which is attributed to sorcery or contagion depending on the mood of the informant.

Since the late nineteenth century, the Xavante also have fought with the Bororo to the west of them, who have a long history of contact with civilization, and with the tribes on the upper Xingú. Groups such as Apewe's on the lower reaches of the Rio das Mortes have probably not, in living memory, had any contact with the Bororo, but they have definitely had dealings with the Xingú region.

### *The Age-Set System*

The Xavante think of time in terms of their age-set cycle. *Boys* enter into the bachelors' hut between the ages of seven and twelve, though there is a current tendency, deplored by traditionalists, to allow them to enter as early as five. All eligible boys enter an age-set simultaneously. From the moment when a boy enters the bachelors' hut, he is a member of an age-set. (Girls are also said to belong to age-sets, but the circumstances of their membership are rather different and will be discussed later.) After five years of living apart, though by no means in seclusion, in the bachelors' hut, this age-set will be promoted to the age-grade of *young men.* Approximately five years later, when the age-set junior to them is emerging from the bachelors' hut, they will be promoted to the age-grade of *mature men.* Since there are eight named age-sets in all, there are at any given moment six age-sets who are mature men, one which is in the young men's age-grade and one which is in the boys' age-grade. Children who have not yet entered the bachelors' hut are regarded as outside the age-set system altogether, although they may be referred to by the name of their future age-set as the time approaches for them to enter the hut.

Each time an age-set completes its initiation ceremonies and moves from the boys' age-grade to the young men's age-grade, there is a corresponding promotion of the age-set in the younger men's grade to the mature men's grade. At the same time the most senior age-set reverts to the beginning of the cycle and is reincarnated in the boys who are entering the bachelors' hut. The span of the age-set cycle appears to be somewhat more than the Xavante expectation of life. It takes 40 years for a man's age-set to pass through all the positions in the cycle and return to the bachelors' hut again; yet it is only exceptionally old Xavante who live to see their age-sets renewed in this way. During the period in which this community has been under observation, only Apewe, the chief, has lived to see his age-set incorporate a fresh intake, although Prapá may also see the cycle through in 1963.

For a Xavante male, the passage of his age-set from one age-grade to another is an important transition. As a boy he is outside the ceremonial life of the community and in a sense emasculated. He wears no genital covering and this is not considered shameful. He and his age-mates are only formally accepted as constituting an age-set when they enter the bachelors' hut. At this time, they don the penis sheaths worn by all Xavante men. Until very recently (and this applied to Apewe's village in 1958), Xavante of both sexes went entirely naked except for this one item of male attire. Men are, however, exceedingly modest about exposing the tip of the penis by removing the tiny sheath.

A boy is expected to remain continent during his time in the bachelors' hut. On the completion of an initiation ceremony, the entire boys' age-set is married in a single ceremony and passes into the young men's age-grade. The young men are the dandies of any Xavante community. They are expected to take great care of their persons and appear each evening in the council wearing fresh paint, fresh wrist and ankle cords, and with their hair and bodies thoroughly oiled to acquire the gloss which Xavante prize. They are the warriors, and virility and bellicosity are ascribed to them by convention. One might say that their role is to strut, for their elaborate preparations are made for an evening council which has no authority to make decisions. All decisions affecting the community are taken in the mature men's council to which young men are not admitted. They even have very little opportunity to exercise their virility, for their wives generally are too young for cohabitation, and to commit adultery is a very dangerous matter among the Xavante.

The transition from the age grade of young men to that of mature men is less spectacular for the members of the age-set concerned. It is not marked by elaborate ceremonial, nor does it involve any change in sexual status. Yet it is perhaps the more important change. A man does not play his full part in the society until he is admitted to the councils of the mature men. As his age-set becomes progressively more senior and he becomes a more practiced orator, a Xavante can hope to acquire some standing in the community. An inevitable result of this is that he tends to participate less and less in age-set ceremonial and to act more and more as an individual through the factional structure of the community.

Women are assigned to the age-sets corresponding to their male coevals, but theirs is only a secondary membership. They have no institutions corresponding to the bachelors' hut or to initiation. Indeed, the sexual implications of the initiation ceremony would be superfluous for them, since they are married at an early age to much older men and, therefore, have been married for some time when their male contemporaries reach initiation. They receive no corresponding privileges such as the men of their age-set enjoy when they reach the grade of young men or mature men. Finally, they are forbidden to witness the most solemn of all Xavante ceremonies, the *wai'a,* which is performed by initiated men only. In the course of this ceremony, a number of women, generally one from each clan, are taken out by the celebrants and obliged to have sexual relations with members of the officiating age-set. These are the only community-sanctioned extramarital relations.

*Sex and Marriage*

A Xavante may not marry within his own clan but must select a wife from either of the other two clans. This prohibition is apparently not contravened.

Any man may take more than one wife. Indeed, Xavante welcome additional wives since they go out gathering and contribute substantially to the maintenance of the household. As Xavante do not practice celibacy, however, and there are not many more women than men in their communities, the result of polygyny is that men take as additional wives women who are much younger than themselves. Consequently, when the boys' age-set reaches initiation, the girls available for them to marry are immature, sometimes no more than toddlers. Nevertheless, a wife is found for each boy being initiated, even if the girl in question has to be carried to the wedding ceremony. After the wedding the girls return home to their mothers. The boys are now considered to be formally married. Each one will be claimed as a son-in-law by his wife's parents. He often will deny it strenuously, since a son-in-law has an inferior status and fairly onerous obligations towards his father-in-law. So long as he does not cohabit with his wife, he will ignore her and reject his obligations to her parents. As soon as she is sufficiently developed, however, he will start to have sexual relations with her. This may take place when the girl is as young as about eight years old. He visits her stealthily by night in her parents' hut, and she receives him there. As soon as her parents discover that he is visiting her, they construct a thatch partition within the hut. Ostensibly this is done so that the couple may have privacy and so that "they are not ashamed." In fact, it is a demonstration that their son-in-law is sleeping with their daughter and that the marriage has now entered a new phase. Eventually, the young man will come and take up residence in his wife's household. This takes place either at the birth of her first child or when his age-set is promoted to the mature men's grade.

As a young man married into another household, he is an outsider and made to feel so. The men of the household where he now sleeps are his wife's father and her brothers. They are of an alien clan and probably of a different faction. They tend to be suspicious of him and he of them. On the other hand, he has most of the household duties to perform. He hunts for the house and watches his brothers-in-law eat the best portions of the kill. He assists his father-in-law in looking after the household plantation. The building and maintenance of the house is his responsibility, assisted by the other men who have "married in," but under the directions of their father-in-law. While he works on the house, his brothers-in-law may well be lying in the shade. Their responsibilities are to their wives' households, and so on. Eventually, of course, his wife's father grows old, and her brothers become progressively engrossed in their affinal homes. At the same time, his own sons grow up and support him so that he comes to be the senior man in his wife's home (or at least one of the senior men in it) and in the position of father-in-law to the "outsiders" who come in to marry the daughters of the house.

A Xavante household is thus always divided sharply and explicitly between "insiders" and "outsiders," which is why the Xavante ensure that in any given generation only men of a single clan may marry into a certain household. Such men are, wherever possible, actual brothers. The stated ideal pattern of marriage then is where a number of full brothers marries a number of co-resident full sisters. In point of fact, the village pedigree to be described later reveals only two instances in which this ideal was attained. Where marriages of this type are involved, there generally will be fewer brothers than sisters involved, for a man will frequently marry more than one sister. Although sororal polygyny is explicitly the ideal form of plural marriage, the Xavante regard it as quite licit for a man to take a number of completely unrelated wives. The dominant consideration in such a case is that of residence. Parents will insist when possible that their son-in-law come to live with them in order to discharge his obligations to them. An elderly man who is head of his own household is unlikely to agree to this. He will prefer to look for a young girl who has lost her father and to offer both her and her mother a home, or failing that he will seek an older widow without parents to complicate the remarriage. Clearly, the more prestige and influence a man has, the more wives he is likely to have.

If a widow cannot or will not go as an extra wife to some senior man, she may be able to marry an incoming refugee from some other community, or she may herself move to another community to see if there are men available there. Otherwise, she may simply live with her closest kin and remain unmarried.

It is difficult to tell whether a marriage is ever jurally terminated by a divorce. A man has little incentive to divorce his wife, since providing for her is not onerous and he can take another wife if he wants, and is able, to do so. Women occasionally leave their husbands after a quarrel or simply cease to live in the same household with them. One or two elderly women in Apewe's group were living apart from their husbands but were still referred to as being married to the men in question. Their children came and went in the father's household in the same way as did the children of the wife actually living with him.

Adultery was alleged to be very rare and leads to friction between the men concerned, rather than to a break between husband and wife. The social anthropologist heard only two instances discussed in his contacts with the village. In one case, a man accused Apewe's brother's son of seducing his wife. Subsequently, the alleged seducer and another member of his lineage fell ill. The aggrieved husband was suspected of sorcery; he was convicted and eventually executed. The woman concerned and her widowed mother left the community. On another occasion an accusation of adultery brought a dispute between two factions to a head, led to mutual accusations of sorcery, and eventually caused a schism in the community.

## III. PHYSICAL ANTHROPOLOGY AND MORPHOLOGICAL CHARACTERISTICS

A total of 91 individuals, ranging in age from less than one year to approximately 60 years of age, were subjected to eleven anthropological measurements (as listed in table 1). In addition, the color of the iris, hair, and skin was recorded; the breadth of the inner zone of the iris was estimated; and the occurrence of iris crypts was noted. Anthropological measurements were obtained according to the well-established techniques described in Martin (Saller, 1956). Skin and eye color were recorded on the Kruse scale, as modi-

TABLE 1. ELEVEN ANTHROPOMETRIC MEASUREMENTS AND EIGHT INDICES IN XAVANTE MALES AND FEMALES

| | Men | | | Women | | | Ratio of female:male measurement |
|---|---|---|---|---|---|---|---|
| | M | $\sigma$ | $\sigma_M$ | M | $\sigma$ | $\sigma_M$ | |
| Stature (cm) | 168.1 | 4.6 | 0.9 | 154.7 | 5.5 | 0.9 | 93 |
| Weight (kg) | 67.2 | 5.7 | 1.1 | 54.0 | 5.2 | 0.9 | 81 |
| Head length (mm) | 194.9 | 6.0 | 1.2 | 184.6 | 5.0 | 0.9 | 95 |
| Head breadth (mm) | 149.0 | 4.8 | 1.0 | 139.8 | 3.8 | 0.7 | 94 |
| Bizygomatic breadth (mm) | 152.3 | 5.6 | 1.1 | 139.0 | 3.9 | 0.7 | 92 |
| Mandibular breadth (mm) | 109.8 | 5.5 | 1.1 | 101.7 | 4.7 | 0.8 | 93 |
| Height of forehead (mm) | 64.4 | 6.5 | 1.3 | 58.4 | 6.9 | 1.2 | 91 |
| Height of face (mm) | 125.5 | 4.8 | 1.0 | 113.1 | 4.2 | 0.7 | 90 |
| Nasal height (mm) | 52.7 | 2.5 | 0.5 | 47.5 | 3.0 | 0.5 | 90 |
| Nasal breadth (mm) | 41.6 | 2.8 | 0.6 | 37.1 | 2.2 | 0.6 | 89 |
| Thickness of lips (mm) | 19.9 | 2.9 | 0.6 | 16.6 | 4.3 | 0.7 | 84 |
| Index Rohrer (100 x wt./stature$^3$) | 141.6 | 11.3 | 2.3 | 146.5 | 15.6 | 2.7 | 104 |
| Head size (100 x (HL+HB) in mm/ stature in cm.) | 205.8 | 7.0 | 1.4 | 206.5 | 7.1 | 1.2 | 100 |
| Cephalic index | 76.4 | 2.9 | 0.6 | 76.8 | 3.6 | 0.6 | 101 |
| Index cephalofacial (100 x bizyg./head br.) | 103.0 | 2.5 | 0.5 | 99.6 | 2.5 | 0.4 | 97 |
| Index jugomandibul. (100 x mandib. br./bizyg.) | 72.7 | 3.6 | 0.7 | 73.0 | 3.1 | 0.5 | 100 |
| Rel. Ht. of forehead (100 x foreh. ht./face ht.) | 51.3 | 5.8 | 1.2 | 51.9 | 5.4 | 0.9 | 101 |
| Facial index (100 x face ht./face br.) | 82.7 | 4.3 | 0.9 | 82.1 | 4.1 | 0.7 | 99 |
| Nasal index (100 x nose br./nose ht.) | 79.3 | 6.6 | 1.3 | 76.9 | 6.6 | 1.1 | 96 |

fied by Froes da Fonseca, in which skin color ranges from one to eight (very fair to extreme depth of pigmentation) and eye color also from one to eight (blue to dark brown). Hair color was recorded in terms of the Fischer-Saller table. Finally, five standardized photographs were obtained (black and white half-profile, straight frontal, and inferior frontal, from a distance of 60 cm; color or black and white profile and frontal, from a distance of 120 cm).

*Anthropometric Measurements*

The anthropometric measurements obtained on 24 adult males and 34 adult females (estimated age greater than 18) are presented in table 1. Figure 1, based on two "typical" males, illustrates four of the five types of photographs taken, the fifth type being a closer frontal view. The data available for other Brazilian Indian groups have been summarized by d'Avila (1950), Steggerda (1950), and Newman (1953). They are unfortunately somewhat scanty and permit only a few comparisons. Since a detailed treatment of the physical anthropology of Brazilian Indians is projected by one of us (F. K.), we will confine our immediate comparisons of the Xavante to other Ge speaking tribes for which some data are available, namely, Botocudo, Carajá,

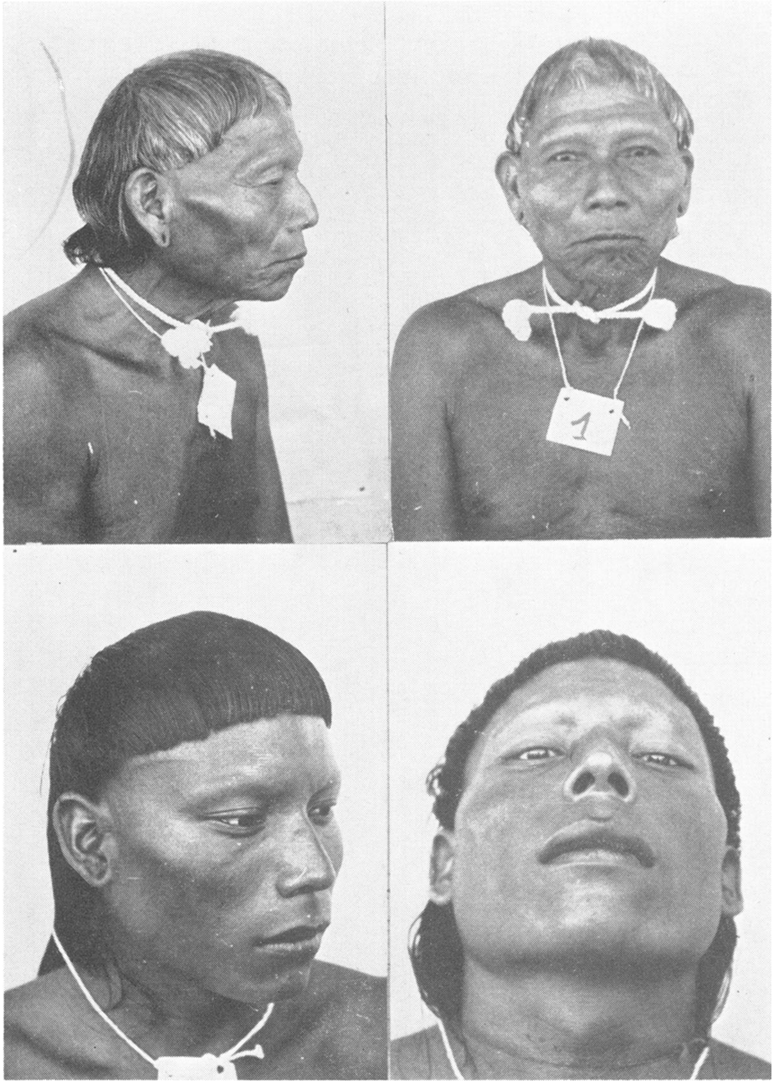


FIG. 1. Two male Xavantes, the chief and one of his sons, illustrating four of the five types of standard photograph obtained of each subject.

Nambicuara, and Cayapo (two groups). In making this restricted comparison, we are aware that language is acquired rather than inherited, i.e., these are not necessarily biologically related peoples. Since the numbers available for other tribes are even smaller than our own, these are very tentative comparisons.

Like the other Ge speakers, the Xavante are moderately tall. A remarkable anthropometric characteristic is the relatively low cephalic index, a trait shared by all the Ge speakers except one of the two Cayapo groups. Since the term "Cayapo" has been used rather loosely, and since there is evidence some

Cayapo have begun to speak Ge relatively recently (d'Avila, 1950), this one discrepancy finds a ready explanation. The Xavante have a lower nasal index than the others except for the one group of Cayapo with a similar cephalic index. This low nasal index is the result of a rather high but also quite broad nose, and is intermediate between West Europeans and West Africans. A striking feature of the Xavante is the relatively and absolutely great facial breadth, resulting in a bizygomatic:head width index greater than 100 in the males! Although the other unmixed Ge speakers for whom these data are available (Carajá, Nambicuara) have high bizygomatic:head width indices as compared with other Brazilian Indian groups, none exceeds 100. Xavante lips appear relatively thick. The mandibular angle is relatively narrow and the index jugomandibularis low, as might be expected with the great facial breadth. Finally, although foreheads are low, the relative head size or "cerebrality" ([head-length plus head-breadth]/stature) is the same for Xavantes as for Europeans. Despite the early onset of apparently greater biological demands on the female, imposed by her heavier work load and the bearing and rearing of children, the ratio of female to male measurements for the quantitative traits does not differ greatly from European data.

One of the principal objectives of this study was to determine the amount of variability encountered in such an isolated and inbred tribe. Table 2 gives the coefficients of variation for the various measurements obtained and, for comparison, the coefficient for the same measurements as derived from a study by one of us (F. K.) of the inhabitants of Hamburg. The Xavante have a lower coefficient for 13 of the 18 measurements and indices in which they can be compared with Hamburgians, although the differences are not striking.

With respect to their metrical traits, then, it is clear that the Xavantes possess the characteristics of the other Ge speakers so far as they have been defined. On the basis of the skeletal remains discovered thus far in Brazil (cf. d'Avila, 1950), they must be regarded as derived from a once widespread element which has either been displaced into the Central-Eastern Plateau of Brazil by such later arrivals as the more brachycephalic Arawak, Carib, and Tupi-Guarani speakers, or else, if long resident in this area, as persisting here although extinct elsewhere. As discussed in the preceding section, there is also historical evidence for a westward movement of the Xavante about the middle of the last century.

With respect to the color traits, there was a high degree of uniformity. Skin color was recorded as 6/7 or 7, corresponding to a dark copper brown. Hair color in adults corresponded to the darkest grades of the Fischer-Saller Table (W, X, Y). Children occasionally showed a lighter, reddish color, as will be described under the results of physical examination. This finding has been encountered in other Indian groups and may be regarded as a manifestation of the same tendency towards increasing hair pigmentation with age seen in European children. There was no baldness. Eyes were recorded as six to eight in color, a variation from brown to dark-brown. No unpigmented sec-

TABLE 2. COEFFICIENT OF VARIATION (100 × $\sigma$/M) FOR 11 PHYSICAL MEASUREMENTS AND SEVEN INDICES OF XAVANTES AND THE INHABITANTS OF HAMBURG, GERMANY

Coefficients based on males only.

| Measurement | Xavantes | Hamburgians |
|---|---|---|
| Stature | 2.74 | 3.6 |
| Weight | 8.48 | |
| Head length | 3.08 | 2.8 |
| Head breadth | 3.22 | |
| Bizygomatic breadth | 3.68 | 3.7 |
| Mandibular breadth | 5.01 | |
| Height of forehead | 10.09 | |
| Height of face | 3.82 | |
| Nasal height | 4.74 | |
| Nasal breadth | 6.73 | 7.7 |
| Thickness of lips | 14.57 | 26.0 |
| *Indices* | | |
| Rohrer | 8.0 | 12.8 |
| Cephalofacial | 2.4 | 3.3 |
| Cephalic | 3.8 | 4.0 |
| Facial | 5.2 | 5.0 |
| Jugomandibularis | 5.0 | 5.0 |
| Relative forehead height | 11.3 | 14.3 |
| Nasal | 8.3 | 10.2 |

tors of the iris were seen; as examined with a hand lens it had a velvety, granular appearance at the periphery, becoming rougher and more trabecular near the pupil. There were occasional crypts; the membrana iridis anterior was always well preserved.

### *Nonquantitative Morphological Traits*

The facial appearance of an individual results not only from the measurable characteristics summarized in table 1 but also from a host of more subtle characteristics. That genetic factors play a role in the determination of these characteristics is clear from the striking resemblance of identical twins. However, these traits have proved difficult to aproach on an objective basis. For the first several days in the field all Xavantes looked alike, by virtue of their broad faces, their large noses, and their striking uniformity in skin, eye, and hair color and style. But as familiarity grew, so did the ability to recognize differences, an ability increased by later study of the photographs obtained in the field.

In an attempt to place facial variability on a semi-quantitative basis, a method of "paired comparisons" which has been evolved over the past 15 years has been employed (Keiter, 1950, 1954, 1957, 1960). This method may be utilized both to measure the difference between two populations and to compare two populations with respect to the within-population variability. We will first consider a hypothetical example of a comparison with respect to the

TABLE 3. AN ILLUSTRATIVE EXAMPLE OF THE DERIVATION OF A MEAN CRITICAL VALUE FOR THE COMPARISON OF TWO MORPHOLOGICAL TRAITS
Details in text.

| | Xavantes | Hamburgians | Weighting factor |
|---|---|---|---|
| No appreciable difference | 18 | 18 | 1 |
| Equivocally greater | 20 | 10 | 2 |
| Plainly greater | 30 | 10 | 3 |
| Very much greater | 10 | 2 | 5 |

prominence of the mandibular angle in two "populations," Xavantes and Hamburgians, for which we assume we have a series of 100 pairs approximately matched by age and sex but otherwise randomly assembled. Each pair is graded as to which individual shows the trait in the more developed form, in one of four judgment categories: (1) no appreciable difference, (2) equivocally greater, (3) plainly greater, and (4) very much greater. A table is established, as illustrated in table 3. Where there is no appreciable difference, an entry is made in both columns. Otherwise a single entry is made in the appropriate column. A series of weights to be attached to each of the possible differences is given in the column headed "weighting factor." In this particular example, these weights are the actual ratios of corresponding entries in the first two columns, and one can develop weighting factors for each comparison. In practice, it is convenient to assign to all comparisons the same weights, as given in that column, since fractions are avoided; the precise choice of numbers has been guided by experience in comparing a series of populations (Keiter, 1960). A score is then derived by multiplying each entry in each column by the weighting factor and summing for the columns, which for the distribution given yields values cf 198 and 78. From these a *mean critical value* of 2.54 (the ratio of the two sums) is obtained. If the two populations being contrasted do not differ sensibly as regards the trait in question, then the corresponding entries in the two columns should be the same, and the mean critical value will approximate 1.

The summary of the results of these comparisons is in table 4. The approach serves to quantify certain general impressions. Although the subjective nature of the comparisons makes it difficult to say that a given mean critical value for one trait has the same significance as the same value for another trait, values over three are certainly meaningful. The justification for this criterion will be given shortly. By this criterion, the Xavantes differ most clearly from the Hamburgians in the flatness of the parietal region; the protrusion of the zygomatic angles; the striking size of the mouth and protrusion of the upper lip; the large, transversely oriented, flared nostrils in a somewhat "hooked" nose which has a relatively narrow root; a relatively narrow palpebral fissure, sometimes with a mongolian fold; and an ear with a deeper antihelix, a narrower incisura intertragica, and a shorter corpus antihelicis.

The matter of the mongolian fold deserves special consideration. Although usually considered as a clear and discrete trait, the mongolian appearance of the eye, including the fold, is actually a quite complex phenomenon, in

TABLE 4. THE MEAN CRITICAL VALUES FOR A SERIES OF 41 NONMEASURABLE PHYSIOGNOMICAL TRAITS CONTRASTED IN XAVANTES AND HAMBURGIANS

| Physiognomical trait | MCV |
|---|---|
| *General form of head and face* | |
| Better nutritional state | 1.5 |
| Zygomatic angles more protruding | 3.7 |
| Mandibular angles more protruding | 1.6 |
| Parietalia flatter | 16.7 |
| Under part of the face higher | 1.8 |
| Forehead less curved (globular) | 1.8 |
| *Mouth and chin* | |
| Mouth bigger | 31.0 |
| Chin more receding | 2.3 |
| Lips less protruding—chin flatter | 2.5 |
| Median seam of upper lip smaller | 1.4 |
| Upper lip thicker than under lip | 3.0 |
| Lips thicker (than in Hamburg) | 2.7 |
| Upper integumental lip more protruding | 21.5 |
| Under lip more outwardly everted | 1.5 |
| *Nose* | |
| Nose bigger (within the face) | 1.4 |
| Nose less protruding | 1.9 |
| Profile of the nose more convex | 2.0 |
| Root of the nose narrower | 3.8 |
| Nostrils larger | 10.2 |
| Rim of the sides of the nose more incurved | 2.7 |
| Septum nasi tapering posteriorly | 2.8 |
| Septum nasi tapering anteriorly | 6.5 |
| Weaker step between nostrils and upper lip | 2.5 |
| Incurvature tip—sides of the nose deeper | 2.7 |
| Puffing up of the nostrils more pronounced | 3.6 |
| Direction of the nostrils more transverse | 21.5 |
| Nose-tip from beneath slimmer | 1.5 |
| *Eye* | |
| Eye narrower | 9.1 |
| Aperture of the eye more ascending sidewards | 4.9 |
| Height of the upper lid less | 2.6 |
| Eyebrows more ascending | 1.2 |
| Fold on the upper lid heavier | 3.8 |
| "Mongolian fold" | cf. table 5 |
| *Ear* | |
| Antihelix deeper | 4.5 |
| Lobe of the ear less free | 1.4 |
| Lobe of the ear of lesser height | 1.5 |
| Lobe of the ear more pointed | 1.8 |
| Incisura intertragica narrower | 3.2 |
| Corpus antihelicis shorter | 3.2 |
| Incisura supratragica deeper (crus helicis more oblique) | 1.7 |
| Greatest breadth of the concha relatively high | 2.2 |

which the following components may be recognized: (1) narrowness of the aperture of the eye; (2) prominence of the upper eyelid, due to such diverse causes as puffiness from subcutaneous fat or edema or a sunken eyelid accompanying loss of turgor; (3) an ascending direction of the eye, the outer angle being situated higher than the inner angle; (4) a fold *beneath* the normal fold of the upper lid, descending to the inner angle of the eye ("Indian fold" or *Indianerfalte;* Aichel, 1932); (5) increasing prominence of the *normal* fold of the upper eyelid towards the inner angle, i.e., suggestion of a mongolian fold; and (6) a true mongolian fold, extending obliquely from the inner aspect of the upper eyelid towards the inner angle of the eye.

If, now, we confine our attention to items (5) and (6), attempting to avoid the impression conveyed by the first four morphological traits, then the Xavantes and Hamburgians may be contrasted as shown in table 5. With these criteria, the "mongolian fold" is not uncommon in some European groups. While it may be argued that a true mongolian fold should not disappear, the fact is that more children appear to possess such a fold than adults. The notable point which emerges from table 5 is the low percentage of Xavante adults who exhibit a fully developed mongolian fold in comparison with Asiatic mongolian groups, as well as some other groups of South American Indians.

The demonstration of striking differences in the physiognomy of Xavantes and Hamburgians is no great surprise, confirming what by inspection is obvious. However, this same method offers opportunities to contrast various Indian populations in an objective manner, opportunities which hopefully will be utilized in the future. For example, will groups discordant in blood groups also tend to be discordant in their (probably genetically more "conservative") morphological details? There is, however, another reason for introducing this method. It offers the opportunity of quantifying intrapopulation variability, providing data on nonquantitative morphological traits to parallel that supplied by anthropometry and blood grouping. A measure of intrapopulational variability can be derived as follows: A series of within-population pairs matched by age and sex but otherwise randomly chosen is assembled for each of two populations. Ideally, the members of a pair are biologically unrelated and each individual is used but once. In the case of small populations such as the Xavantes, a compromise with the ideal became necessary; no pair was permitted whose coefficient of relationship was 0.5 or greater, and no individual was used more than twice. By this means, a series of 20 pairs of Xavantes was established, as was a series of 20 Hamburgians. Each Xavante and each Hamburgian pair was compared with respect to 20 traits and for each of the 400 comparisons was placed in one of four categories similar to those previously described. The result is shown in table 6. Each entry in each column was multiplied by the weight, and a total score obtained for the group. This was 805 for the Xavantes and 860 for the Hamburgians. The mean score is 2.01 for the Xavantes and 2.15 for the Hamburgians. The actual comparisons for the 20 traits are given in table 7. The Xavantes are more vari-

TABLE 5. FREQUENCY OF A VERY MILD OR FULLY EXPRESSED MONGOLIAN FOLD IN XAVANTES AND HAMBURGIANS

| | | Very minimal fold (%) | Fully expressed fold (%) |
|---|---|---|---|
| Xavantes: | men | 12 | 0 |
| | women | 21 | 12 |
| | children | 13 | 13 |
| | babies | 10 | 60 |
| Hamburg: | men | 1 | 0 |
| | women | 12 | 2 |
| | children | 13 | 13 |

TABLE 6. THE DERIVATION OF A COMPARISON OF INTRAPOPULATION VARIABILITY FOR XAVANTES AND HAMBURGIANS

Details in text.

| | Xavantes | Hamburgians | Weight |
|---|---|---|---|
| No appreciable difference | 139 | 120 | 1 |
| Equivocally different | 137 | 136 | 2 |
| Plainly different | 114 | 126 | 3 |
| Markedly different | 10 | 18 | 5 |
| | 400 | 400 | |

able for six traits, the Hamburgians for 13, and for one there is no difference.

Earlier we suggested that a *mean critical value* of 3.0 is meaningful. This suggestion was based on the following considerations. In the comparisons just described let us give sign to the differences encountered between arbitrarily established pairs of Xavantes. Let us further assign a value of 0 to the "no appreciable difference" class and values of ±1, 2, or 3 to the "equivocally different," "plainly different," and "markedly different" classes, the sign depending on whether the first member of the arbitrary pair has a greater or lesser degree of the trait in question. Finally, let us assume symmetry in the distribution because of the method of pairing. Now, the comparison on which the mean critical value is based can also be regarded as a distribution of similar sign, provided that for the "no appreciable difference" class the value of 0.5 be assigned to the proper entry in both columns, instead of the value of 1.0 as in the calculation of this value. Then for the trait used for illustration (prominence of the mandibular angle), we have the comparison shown in table 8. A $\chi^2$ test for the difference between these two distributions is highly significant ($\chi^2$, corrected for continuity, $= 37.92$, d.f. $= 6$, $P < 0.001$). This is admittedly an imperfect test, because of the etiological interrelations of some of the traits. Furthermore, there are a very large number of ways in which a mean critical value of 3.0 may arise. We have provided calculations for only one illustration, and this for a value of 2.54. However, the large $\chi^2$ for this value leaves little doubt that a value of 3.0 will be "significant," as the reader can illustrate if he wishes to explore simulated situations yielding such a value. In fact, for many comparisons a value of 2.0 may have meaning.

TABLE 7. MEAN CRITICAL VALUES BASED ON PAIRED COMPARISONS OF NONMEASURABLE PHYSIOGNOMICAL TRAITS WITHIN THE XAVANTES AND WITHIN HAMBURGIANS

Further explanation in text.

| Physiognomical trait | Xavantes | Hamburgians |
|---|---|---|
| Protrusion of zygomatic arches | 1.9 | 1.9 |
| Protrusion of mandibular angles | 2.2 | 2.1 |
| Notch in the upper lip | 2.2 | 2.5 |
| Size of the mouth | 2.1 | 2.2 |
| Recession of the chin | 2.5 | 2.1 |
| Incurvature mouth-chin | 2.2 | 2.6 |
| Size of the nostrils | 2.1 | 2.6 |
| Convergence of the septum posteriorly | 2.3 | 2.0 |
| Incurvature tip-sides of the nose | 1.9 | 1.8 |
| Direction of the axis of the nostrils | 2.4 | 2.1 |
| Breadth of the nose tip | 1.8 | 2.6 |
| Size of the nose | 1.9 | 2.3 |
| Heaviness of lidfold | 1.8 | 2.4 |
| Eyebrows ascending sideward | 1.7 | 2.3 |
| Width of aperture of the eye | 1.9 | 2.0 |
| Protrusion of the nose | 2.1 | 2.3 |
| Direction of the eye, ascend-descend | 1.5 | 1.6 |
| Height of the antihelix | 2.0 | 2.2 |
| Height of the earlobe | 2.1 | 2.2 |
| Contour of the ear from *en face* | 2.1 | 1.6 |

TABLE 8. AN APPROACH TO THE EVALUATION OF THE SIGNIFICANCE OF A GIVEN MEAN CRITICAL VALUE

Details in text.

| | Difference | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | −3 | −2 | −1 | 0 | 1 | 2 | 3 | Total |
| Within Xavante comparison, all traits: | 5 | 57 | 68.5 | 139 | 68.5 | 57 | 5 | 400 |
| Xavante-Hamburg comparison, mandibular angle: | 2 | 10 | 10 | 18 | 20 | 30 | 10 | 100 |

## *Dermatoglyphics*

Fingerprints and palm prints were obtained on a total of 76 individuals. In addition, toe patterns were read directly on the same 76 persons. The distribution of patterns by fingers is given in table 9. The prints could not be read for two male fingers, resulting in totals of 184 for both the right and left hands rather than 185. As far as we can determine, there are no similar published data for other Brazilian Indian tribes, so that in commenting on the noteworthy features in these dermatoglyphics, we shall be forced for purposes of comparison to turn to North and Central American Indians and one series from Chile (references in Cummins and Midlo, 1943; Newman, 1960). Indices of Pattern Intensity have been computed for the fingerprints, employing Keiter's modification (Keiter, 1950) of the Cummins and Steggerda (1935) meth-

TABLE 9. THE CLASSIFICATION OF THE FINGERPRINTS IN A SERIES OF 37 MALES AND 39 FEMALES

| | Male | | | | | | | Female | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Right* | Arch | Arch-loop transition | Loop | Loop-whorl transition | Whorl, unicentric | Whorl, dicentric | No. | Arch | Arch-loop transition | Loop | Loop-whorl transition | Whorl, unicentric | Whorl, dicentric | No. |
| I | 1 | 0 | 1 | 6 | 27 | 2 | 37 | 2 | 0 | 5 | 5 | 25 | 2 | 39 |
| II | 2 | 6 | 6 | 3 | 17 | 2 | 36 | 1 | 2 | 8 | 2 | 23 | 3 | 39 |
| III | 1 | 3 | 20 | 2 | 10 | 1 | 37 | 1 | 3 | 20 | 2 | 11 | 2 | 39 |
| IV | 1 | 0 | 10 | 5 | 21 | 0 | 37 | 1 | 0 | 8 | 8 | 22 | 0 | 39 |
| V | 1 | 2 | 22 | 6 | 6 | 0 | 37 | 0 | 5 | 30 | 1 | 2 | 1 | 39 |
| | 6 | 11 | 59 | 22 | 81 | 5 | 184 | 5 | 10 | 71 | 18 | 83 | 8 | 195 |
| *Left* | Male | | | | | | | Female | | | | | | |
| I | 1 | 0 | 2 | 6 | 24 | 4 | 37 | 2 | 0 | 1 | 9 | 26 | 1 | 39 |
| II | 3 | 6 | 5 | 5 | 14 | 4 | 37 | 2 | 0 | 6 | 7 | 23 | 1 | 39 |
| III | 1 | 2 | 20 | 1 | 12 | 1 | 37 | 1 | 1 | 13 | 4 | 20 | 0 | 39 |
| IV | 0 | 0 | 12 | 5 | 19 | 1 | 37 | 1 | 1 | 5 | 7 | 25 | 0 | 39 |
| V | 0 | 4 | 21 | 5 | 5 | 1 | 36 | 0 | 3 | 25 | 8 | 3 | 0 | 39 |
| | 5 | 12 | 60 | 22 | 74 | 11 | 184 | 6 | 5 | 50 | 35 | 97 | 2 | 195 |

TABLE 10. THE INDICES OF PATTERN INTENSITY FOR THE XAVANTE FINGERPRINTS

| Finger | Right hand | Left hand | Combined hands |
|---|---|---|---|
| I | 45.6 | 45.8 | 45.7 |
| II | 41.8 | 41.2 | 41.5 |
| III | 35.2 | 37.2 | 36.2 |
| IV | 42.4 | 42.4 | 42.4 |
| V | 32.2 | 33.1 | 32.7 |

od. This modification scores an arch as 1, an arch-loop transitional pattern as 2, a loop as 3, a loop-whorl transitional pattern as 4, and a whorl as 5. The resulting indices are shown in table 10. The differences between fingers are similar to those encountered in other ethnic groups, where also digit I reveals the highest index, followed by digits II and IV, with III and V exhibiting the simplest patterns. These are relatively high indices, the mean for the right hand being 39.4 and for the left, 39.7. There is no difference between sexes. Similar relatively high indices have been observed in all studies to date on American Indians, a consequence of the high frequencies of whorls (cf. Biswas, 1961).

The Index of Pattern Form (100 × breadth of pattern/height of pattern; method of Geipel, 1935) is distributed as follows for 100 prints: very low (80 and less), none; low (81–95), 4 per cent; medium (96–117), 60 per cent; and high (118 and above), 36 per cent. By contrast, the corresponding figures for Hamburgians are 8, 24, 48, and 20 per cent. In general this index tends to be high in Xavantes, with many persons possessing strikingly low, broad whorls and none showing the very high, narrow forms observed in 8 per cent of the prints of Hamburgians. Pattern Size (sum of the ridges from triradius to point of core for all ten fingers; cf. Cummins and Midlo, 1943, p. 74) has a mean value of 149 for Xavante males and 159 for Xavante females. Aside from this absence of high, narrow patterns, there is no distinguishing characteristic for individual Xavante prints as compared with individual Hamburgian prints.

The findings with respect to toe patterns are presented in table 11. Four toe prints could not be read directly. The outstanding feature is the high frequency of arches, the more surprising when contrasted with the low frequency of arches in the fingers. The result is a much lower Index of Pattern Intensity than for the fingerprints. For the individual toes, the indices are given in table 12. There is no difference between the sexes. In European populations, one also sees the highest index for the third toe and the lowest for the fifth. However, although in Europeans pattern intensity is also lower in toe- than fingerprints (Keiter, 1950, 1954), the difference is by no means as striking as in the Xavantes. So far as we are aware, toe patterns have not been recorded for other Indian groups. In Japanese and Chinese, who share with the Indians a high frequency of whorls on the fingers, the frequency of arches on the toes is also much greater than on the fingers but attains only about half the Xavante values (Wilder, 1922). The Xavantes thus manifest an extreme form of a mongolian dermatoglyphic characteristic. The coefficient of

TABLE 11. THE CLASSIFICATION OF THE TOE PRINTS IN A SERIES OF 37 MALES AND 39 FEMALES

| | Right: Male | | | | | | | Right: Female | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Arch | Arch-loop transition | Loop | Whorl, unicentric | Whorl, dicentric | Other double & triple-patterns | No. | Arch | Arch-loop transition | Loop | Whorl, unicentric | Whorl, dicentric | Other double & triple-patterns | No. |
| I | 6 | 7 | 18 | 3 | 2 | 1 | 37 | 5 | 6 | 18 | 5 | 4 | 1 | 39 |
| II | 3 | 13 | 10 | 2 | 5 | 4 | 37 | 4 | 7 | 17 | 2 | 8 | 1 | 39 |
| III | 6 | 6 | 11 | – | 9 | 5 | 37 | 4 | 10 | 8 | 5 | 10 | 2 | 39 |
| IV | 27 | 8 | 7 | – | 1 | – | 37 | 28 | 8 | 1 | – | – | 1 | 38 |
| V | 34 | 3 | – | – | – | – | 37 | 38 | 1 | – | – | – | – | 39 |
| | 70 | 37 | 46 | 5 | 17 | 10 | 185 | 79 | 32 | 44 | 12 | 22 | 5 | 194 |
| | Left: Male | | | | | | | Left: Female | | | | | | |
| I | 8 | 5 | 16 | 5 | 2 | – | 36 | 9 | 7 | 17 | 3 | 2 | – | 38 |
| II | 7 | 9 | 13 | 2 | 5 | 1 | 37 | 5 | 7 | 16 | 2 | 8 | 1 | 39 |
| III | 4 | 10 | 7 | 9 | 4 | 3 | 37 | 3 | 11 | 9 | 7 | 6 | 3 | 39 |
| IV | 22 | 6 | 7 | – | – | 2 | 37 | 29 | 7 | 2 | – | – | – | 38 |
| V | 32 | 3 | 2 | – | – | – | 37 | 39 | – | – | – | – | – | 39 |
| | 73 | 33 | 45 | 16 | 11 | 6 | 184 | 85 | 32 | 44 | 12 | 16 | 4 | 193 |

Some few toes are missing.

TABLE 12. THE INDICES OF PATTERN INTENSITY IN THE XAVANTE TOE PRINTS

| Toe | Right foot | Left foot | Combined |
|---|---|---|---|
| I | 29.7 | 27.7 | 28.7 |
| II | 32.2 | 30.5 | 31.3 |
| III | 32.7 | 33.8 | 33.3 |
| IV | 15.2 | 15.0 | 15.1 |
| V | 10.6 | 11.0 | 10.8 |

correlation for the 76 individuals for the Index of Pattern Intensity of the fingers and toes was 0.35, quite similar to the 0.42 observed in Hamburg (Keiter, 1950). There is thus considerable independence between finger and toe patterns.

Among these 76 individuals, patterns in the thenar-interdigital I area are common, with 18 per cent exhibiting complete patterns on the right hand and 40 per cent on the left, and another 24 per cent showing poorly developed patterns on the right and 17 per cent on the left. By contrast, only 12 per cent of the hands show hypothenar patterns. This high frequency of thenar patterns and the high ratio of thenar to hypothenar patterns, which is just the opposite to the situation in most Caucasians, have also been recorded in the Indians of North and Central America (Cummins, 1930, 1941; Cummins and Goldstein, 1932; Newman, 1960). It would appear to be an outstanding feature of Indian dermatoglyphics. Newman (1960), in discussing the particularly high frequency (approximately 45 per cent) of thenar-interdigital I patterns in Mayan Indians, wrote, "Incomplete evidence suggests that high thenar-first interdigital pattern expression does not extend to South America." The present data indicate that at least one South American tribe may also have a high frequency of these patterns.

Finally, we consider the pattern of the main lines of the palm, and particularly those involving triradii b, c, d. Among the 90 palm prints analyzed, 59 per cent exhibited a pattern in which the c triradius extended to terminate in the interdigital IV region on both hands; 15 per cent a pattern in which the c triradius terminated in interdigital IV on one hand and interdigital III on the other; 8 per cent a pattern with a c triradius terminating in the interdigital III area for both hands; 12 per cent a rudimentary, very reduced pattern at the c triradius bilaterally; 3 per cent such a reduced pattern on one hand and a full pattern terminating either in the interdigital III or IV area on the other; and 3 per cent with a fully developed pattern for the c triradius and also a d triradius pattern (terminating in interdigital IV).

In summary, although the Xavante appear less variable in the various morphological traits under consideration than the population of Hamburg (a cosmopolitan city whose inhabitants were chosen for comparison simply because one of the authors has conducted comparable studies there), the differences are not large. On an intuitive level, this was unexpected in the light of the probably smaller "founding stock" and higher level of inbreeding in the Xavante. Furthermore, as will become apparent later, a large proportion of these individuals are related to one another, undoubtedly a higher proportion than in the Hamburg population. This, too, should reduce intrapopulation variability. As we shall discuss later, we are handicapped in drawing conclusions from this variability by a relative lack of knowledge of both the genetic and environmental components of most quantitative traits, as well as by inadequate information concerning the amount of genetic exchange between Xavante villages and the time of emergence of the Xavantes as a distinct tribe.

## IV. PHENOTYPE AND GENE FREQUENCIES FOR SPECIFIED GENETIC TRAITS

### *Materials and Methods*

With the exception of color vision and the secretor trait, all the specific genetic traits studied are characteristics of blood cells or plasma. Samples of venous blood were collected in BD-Vacutainers with 10 mg EDTA as the anticoagulant and kept under refrigeration from one to two days until air shipment in an ice-packed thermos to Rio de Janeiro. Saliva specimens were collected in paper cups, transfered to test tubes, and immediately placed in a boiling water bath for 10 minutes. The blood arrived in Rio in excellent condition, only four of the specimens being significantly hemolyzed. The per cent of hemoglobin was determined by the photoelectric method of Drabkin. Immediately after this, the plasma and red cells were separated by centrifugation. Where cells and plasma were in excess of the needs in Rio de Janeiro, aliquots of both were stored at −15° C until they were carried to Ann Arbor in a container packed with dry ice. The cells were glycerolyzed before freezing. All blood specimens were examined for variation with respect to the following genetic systems (components as indicated): ABO, MNSs (including tests with antisera for $M^g$, Vw, and U), Rh (D, C, c, $C^w$, E, e, f, V), Kidd ($Jk^b$), Kell (K, k, $Kp^a$, $Kp^b$), Lutheran ($Lu^a$), Duffy ($Fy^a$), Diego ($Di^a$), P, Wright ($Wr^a$), haptoglobins, transferrins, Gm groups ($Gm^a$, $Gm^b$, $Gm^x$, and Gm-like), group specific component (Gc), erythrocyte nonspecific esterases, erythrocyte lactic dehydrogenases, erythrocyte glucose-6-phosphate dehydrogenase, and hemoglobin types. Secretor types were determined from the saliva specimens, using anti-A, anti-B, and anti-H (*Ulex europeus*).

In Rio de Janeiro all blood group determinations were performed by the tube method, using washed 2 per cent suspensions in saline for tests employing the antisera listed in table 13, 2 per cent or 5 per cent suspensions in saline for those sera listed in table 14 which utilize an indirect Coombs test, and 2 per cent suspensions in albumin for those sera of table 14 which demand albumin test tube methods. Appropriate times and temperatures of incubation are listed in tables 13 and 14. All tests were set up with one drop of serum and one drop of red cell suspension. For the anti-A, anti-B, anti-A+B, anti-$Lu^a$, anti-N (*Vicia*), anti-M (human), and anti-N (rabbit) sera, readings were made macroscopically. Readings for the anti-$M^g$, anti-Vw, anti-$Wr^a$, and anti-P sera were made after centrifugation at 1,000 rpm for one minute. In the readings for anti-D, anti-C, anti-E, anti-c, anti-e, and anti-$C^w$, the tube was gently tapped, and if the cells were not together in one large clump or in a few large clumps, the contents of the tube were transferred onto a glass slide, gently spread out with the stem of the pipette, and examined under the low power of a microscope. Negative and positive controls were used for each antiserum

TABLE 13. TEST CONDITIONS FOR SERA CONTAINING SALINE AGGLUTININ

| Incubate | 4°C | 16°C | Room temperature | 37°C |
|---|---|---|---|---|
| 5′ | | | Anti-$M^g$ (BGL) | |
| 15′ | | | Anti-N (rabbit—DHG) (Vicia—IH) | |
| 20′ | | | | Anti-N (Vicia) |
| 30′ | Anti-P (Kni) | | Anti-Vw (BGL) | Anti-S (CBDS) |
| 60′ | | Anti-$Lu^a$ (Stratton) | Anti-M (human—BGL), Anti-A, Anti-B, Anti-B (IH) | Anti-$Wr^a$ (BGL), Anti-D, Anti-C, Anti-E (Ortho) |

Key to source of antisera: Kni = Knickerbocker, BGL = Blood Grouping Laboratory of Boston, CBDS = Certified Blood Donor Service, Ortho = Ortho Research Foundation, Stratton = Dr. Fred A. Stratton, DHG = Department of Human Genetics, Rosenfield = Dr. R. R. Rosenfield, IH = Instituto de Hematologia (Dr. Miguel A. Layrisse).

TABLE 14. TEST CONDITIONS FOR SERA CONTAINING INCOMPLETE ANTIBODIES

| Albumin test tube 37°C, 60 minutes | Indirect Coombs test | |
|---|---|---|
| | | Human complement added |
| | Anti-k (CBDS) | |
| Anti-c (Ortho), Anti-e (CBDS) | Anti-s, Anti-K, Anti-$Kp^a$, Anti-$Kp^b$ (BGL) | Anti-$Jk^a$ (Stratton) |
| Anti-$C^w$ (BGL) | Anti-$Fy^a$ (CBDS), Anti-V (Stratton) | Anti-$Jk^b$ (Kni) |
| | Anti-f (Rosenfield), Anti-$Di^a$ (Layrisse) | |

with the exception of the following: $M^g$, Vw, $Wr^a$, $Kp^a$, $Kp^b$, and k negative. Readings for the MN groups were difficult because only the *Vicia* anti-N yielded clear-cut reactions; weak false positive reactions were frequent. This difficulty was not encountered in testing six Caucasoid M, MN, and N controls. The tests were accordingly repeated three times. For the ABO system, in addition to typing the erythrocytes, plasma from each individual was tested with 2 per cent saline suspensions of pooled red cells, types A and B, by the tube method.

In Ann Arbor, essentially similar typing procedures were employed in the laboratory of Dr. Henry Gershowitz. The glycerolyzed bloods, packed in dry ice, had thawed by the time they reached Ann Arbor; they had been in transit 24 hours. All the specimens were refrozen and kept at −70° C until retesting some six weeks later. In view of the fact that some difficulties had been encountered in Rio de Janeiro in the MN typing, five anti-M sera (three human, one rabbit immune, and one cow immune) and three anti-N (two rabbit immune and the human anti-N described by Gershowitz, in press) were employed. Only one antiserum was used for the detection of each of the other antigens, with the exception that all bloods were screened with two anti-$Fy^a$ reagents. Many of the typing sera were identical to those used in Rio de Janeiro; these were antisera for M (one of the human sera), N (one of the rabbit sera), $M^g$, S, s, C, E, e, $Jk^b$, P, Vw, $Wr^a$, $Kp^a$, and the $Kp^b$ antigen. Since all the blood specimens had been typed as O and confirmed by back-typing, retesting with anti-A and anti-B was not done. All tests in Ann Arbor were performed using 2 per cent suspensions of washed red blood cells, one drop of cells being added to one drop of serum in each case. All readings were macroscopic. Fifty-six specimens were retyped. In case of discrepancies between the typings of the two laboratories, additional typings were performed in Ann Arbor and the discrepancy resolved. The nature of the discrepancies will be discussed later (p. 102).

With respect to the study of the inherited components of the plasma, the following techniques were employed: "Group specific component" (Gc) types were determined by the method of Hirschfeld (1959), employing, however, a rabbit antiserum prepared by multiple injections with pooled human serum. Gm types were determined by a modification of the method of Linnet-Jepsen, Galatius-Jensen, and Hauge (1958). The Gm typing sera employed included anti-a, anti-b, anti-x, and anti-Gm-like, obtained from Dr. A. Steinberg; the anti-D test sera used in this system were either prepared by Dr. Steinberg or Dr. Gershowitz. The haptoglobin and transferrin types were determined as described by Smithies (1959). Finally, starch gel electrophoretic studies of erythrocyte hemolyzates were examined with respect to nonspecific esterases, lactic dehydrogenases, glucose-6-phophate dehydrogenase, and hemoglobin as described by Tashian (1961), Vesell and Bearn (1962), and Boyer, Porter and Weilbacher (1962).

### *Results of Typings*

The final results of the various blood and serum typings with respect to which differences were observed among individuals are summarized by individual in table 15 and by blood group in table 16. The smaller number of specimens typed for the secretor trait is due to the difficulty in obtaining adequate saliva specimens from small children and infants. In addition, the following determinations yielded uniform results: ABO system, all O; Kell system, all K−, k+, Kp(a−), Kp(b+); MNSs system, all Vw− and $M^g$−; Wright system, all Wr(a−); Lutheran system, all Lu(a−); and Rh system, all $C^W$− and V−. All 19 S− bloods tested in Ann Arbor reacted with an anti-U serum.

One of the type M bloods (II–42) reacted with the human anti-N employed, and so possessed the rare Armstrong antigen described by Gershowitz (in press). A brother and a grandchild of this individual were included in the series; neither possessed the antigen. Two apparently unrelated individuals (III–53 and III–82) gave such weak reactions with the saline anti-C employed in Ann Arbor that their cells were tested with a battery of eight saline anti-C reagents. Both failed to react with the same two anti-C antisera but reacted with the other six, suggesting the possibility of a $C^u$ variant. However, for the gene frequency analysis these were scored as C. All hemoglobin specimens were type A, and with the technique of starch gel electrophoresis the erythrocyte esterases, lactic dehydrogenases, and glucose-6-phosphate dehydrogenase appeared identical with the usual Caucasian pattern. All transferrins were type C. Finally, all bloods were Gm(a+), Gm(b−), Gm-like(−), and varied for $Gm^x$ as shown in table 15.

### *Problems in Calculating Gene Frequencies*

The methods commonly employed for calculating gene frequencies, whether applicable only to unrelated individuals or to family data, are based upon the assumption of Hardy-Weinberg equilibrium in the population. There are many characteristics of the population under study which suggest that it does not meet the requirements of the Hardy-Weinberg equilibrium. In connection with the interest in calculating gene frequencies for this population, the pragmatic question is not whether there is departure from Hardy-Weinberg equilibrium conditions, but whether this departure is sufficient to introduce significant errors in calculations of gene frequencies which assume equilibrium. Table 17 is a summary of the findings in the total sample with respect to the six inherited traits where phenotype accurately reflects genotype, namely, M, MN, and N and S, Ss, and s of the MNSs system; C, Cc, and c and E, Ee, and e of the Rh system; Hp 1-1, Hp 2-1, and Hp 2-2 of the haptoglobin system; and Gc 1-1, Gc 2-1, and Gc 2-2 of the Gc system. In the case of the haptoglobins, we have elected to omit the Hp 2-1 (modified) and Hp 0 types from the calculation because of their complex and still somewhat unsettled etiology, thus rendering this particular calculation only approximate. It will be observed that for all six traits the agreement with Hardy-Weinberg proportions is strikingly good. We find this somewhat surprising in view of the fact, to be documented in some detail later, that the population may well violate most or all of the prerequisites for Hardy-Weinberg equilibrium, i.e., mating is not random; there is differential fertility; there is both selection and, presumably, mutation; generations overlap; and the population is small. If this is not a statistical accident, then one is forced to attribute a remarkable insensitiveness to this statistic when applied to small populations, an insensitiveness which in some ways impairs its usefulness. This is an aspect of the Hardy-Weinberg equilibrium which is insufficiently appreciated.

Under these circumstances, we have deemed it permissible to calculate gene frequencies in this population on the assumption of Hardy-Weinberg equilibrium. However, attempts at the estimation of gene frequencies for populations such as this present two additional problems. The first is the question of the limits of the "statistical universe." Our primary interest at this point is to determine the frequency of specified traits in a Xavante village, for comparison with other such villages. Ideally, we would have collected blood from each individual. Our estimate would then have been based on a complete enumeration rather than on sampling from a hypothetical population of infinite size, as is assumed for most procedures in which one derives a variance estimation. In fact, as will be apparent later, we examined blood specimens from approximately 70 per cent of our "universe." Should this be treated as a sample or an incomplete enumeration, and if the former, what kind of sample?

The second question has to do with the definition of the unit of enumeration in this situation. Various methods have been devised for estimating gene frequencies and their variances when some of the individuals in a sample are related to others. However, in our opinion none of these methods is adequate for the present situation. Because of the complex nexus of biological descent portrayed in Fig. 2, the sample contains very few discrete, non-overlapping family units. Thus, although blood samples were obtained for typing from 79 persons, the maximum number of apparently completely unrelated persons that can be drawn from this group is only 13, and, because of the degree of inbreeding in the group (cf. Section v), it is obvious that some of these 13 have a high probability of being related to one another, perhaps closely. Another way to emphasize the problem is to point out that 53 among the 79 individuals tested appear to trace their ancestry back to an (assumed) couple in the generation preceding the first shown on the pedigree, and of the remaining 26 individuals, ten trace ancestry to another couple in generation I—and, of course, we cannot exclude a relationship between these two couples.

TABLE 15. PHENOTYPES OF THE XAVANTE INDIANS FOR MNSs, RH, P, DUFFY, KIDD, AND DIEGO BLOOD GROUPS, THE HAPTOGLOBIN, GM, AND GC SERUM TYPES, AND THE SECRETOR TRAIT

Where there is no entry there was insufficient plasma for the determination.

| Pedigree no. | Parents | Sex | Age | MNSs | Rh | | P | $Fy^a$ | Jk | | $Di^a$ | Hp | Gm | | Gc | Secretor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phenotype | Probable genotype | | | a | b | | | a | x | | |
| II 10 | I 4, 3 | M | 26 | Ms | CcDEe | $R_1R_2$ | + | + | + | + | + | 2-2 | + | − | 2-2 | |
| 29 | I 9, 10 | F | 50 | Ms | CDe | $R_1R_1$ | + | − | + | + | − | 1-1 | * | | 2-1 | − |
| 33 | I 13, 14 | M | 60 | MSs | CcDEe | $R_1R_2$ | − | + | − | + | − | 2-2 | + | − | 2-1 | + |
| 38 | I 11, 12 | F | 40 | MNs | CDe | $R_1R_1$ | − | + | − | + | − | 1-1 | + | + | 2-2 | − |
| 42 | I 13, 14 | F | 65 | Ms | CcDEe | $R_1R_2$ | + | − | + | − | − | 1-1 | * | | 2-1 | − |
| 52 | I 20, 19 | F | 48 | MSs | cDE | $R_2R_2$ | + | + | + | + | − | 2-2 | + | + | 2-2 | + |
| 60 | I 20, 21 | M | 39 | MNs | cDE | $R_2R_2$ | + | + | + | + | − | 2-1 | + | − | 2-2 | − |
| 61 | | F | 18 | MNSs | CDe | $R_1R_1$ | + | + | + | + | + | 2-1 | + | − | 2-1 | |
| 63 | I 22, 23 | M | 17 | MS | CcDEe | $R_1R_2$ | + | − | + | + | − | 2-1 | + | + | 2-1 | − |
| III 6 | II 12, 13 | M | 12 | MNSs | CcDEe | $R_1R_2$ | + | + | + | + | − | 1-1 | + | + | 2-1 | − |
| 8 | II 15, 16 | F | 10 | MS | CDe | $R_1R_1$ | + | + | + | + | − | 2-1 | + | − | 2-1 | + |
| 17 | II 18, 17 | F | 40 | Ms | CDe | $R_1R_1$ | + | + | + | − | + | 2-1 | + | − | 2-2 | + |
| 18 | II 18, 17 | M | 35 | NSs | CcDEe | $R_1R_2$ | − | + | + | + | + | 2-1 | + | − | 2-1 | + |
| 22 | II 33, 23 | F | 12 | MNs | CDe | $R_1R_1$ | + | − | + | − | − | 2-1 | + | − | 1-1 | + |
| 27 | II 33, 25 | F | 15 | MNS | CcDEe | $R_1R_2$ | + | − | + | + | − | 2-1 | + | − | 2-2 | + |
| 29 | II 33, 27 | M | 21 | MS | CcDEe | $R_1R_2$ | + | + | + | − | − | 2-1 | + | − | 2-1 | + |
| 30 | II 33, 27 | M | 17 | MS | CDe | $R_1R_1$ | + | + | + | + | − | 2-1 | + | − | 1-1 | + |
| 32 | II 33, 28 | M | 27 | Ms | CcDEe | $R_1R_2$ | + | + | + | − | − | 2-1 | + | − | 2-1 | |
| 38 | II 33, 29 | M | 28 | Ms | CcDEe | $R_1R_2$ | + | − | + | + | − | 2-1 | + | − | 2-2 | − |
| 41 | II 33, 29 | F | 27 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | − | 2-1 | + | − | 2-1 | − |
| 42 | II 33, 29 | M | 21 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | − | 2-1 | + | − | 2-2 | + |
| 43 | II 33, 29 | M | 19 | MSs | CDe | $R_1R_1$ | + | + | + | + | − | 2-1 | + | − | 1-1 | − |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 | II 33, 29 | M | 17 | MSs | CcDEe | $R_1R_2$ | + | − | + | + | − | 2-1 | + | − | 2-1 | − |
| 45 | II 33, 29 | F | 13 | Ms | CcDEe | $R_1R_2$ | + | + | + | + | − | 0 | + | − | 2-2 | |
| 46 | II 33, 29 | M | 10 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | − | 2-1 | + | − | 2-2 | |
| 47 | II 34, 30 | F | 26 | Ns | CcDef | $R_1R_0$ or $R_1r$ | + | + | + | + | − | 2-1 | + | + | 2-2 | + |
| 48 | II 34, 30 | M | 20 | NSs | CDe | $R_1R_1$ | + | + | + | − | − | 2-2 | + | − | 2-2 | |
| 49 | II 34, 30 | F | 17 | NSs | CcDEef | $R_zR_0$ or $R_zr$ | + | + | + | + | − | 0 | + | + | 2-1 | + |
| 50 | II 34, 30 | F | 9 | MNSs | CcDef | $R_1R_0$ or $R_1r$ | + | + | + | − | + | 2-1 | + | + | 2-2 | + |
| 51 | II 34, 30 | M | 10 | NSs | CDe | $R_1R_1$ | + | + | + | + | + | 2-1 | + | + | 2-2 | + |
| 52 | II 31, 32 | F | 20 | MNs | CcDEe | $R_1R_2$ | − | − | + | + | − | 2-1 | + | − | 2-1 | + |
| 53 | II 31, 32 | M | 22 | MNs | CcDE | $R_zR_2$ | + | + | + | + | + | 1-1 | + | − | 2-1 | |
| 60 | | M | 21 | MSs | cDE | $R_2R_2$ | + | + | + | + | − | 1-1 | + | + | 2-2 | + |
| 64 | | F | 15 | Ms | CDe | $R_1R_1$ | + | + | + | + | + | 0 | * | | 2-1 | + |
| 68 | II 39, 41 | F | 26 | MSs | CDe | $R_1R_1$ | + | + | + | + | − | 2-1 | + | − | 2-1 | − |
| 69 | II 39, 41 | F | 20 | MSs | CDe | $R_1R_1$ | + | − | + | + | + | 2-2 | + | + | 2-2 | − |
| 70 | II 39, 41 | F | 17 | MNSs | CDe | $R_1R_1$ | + | + | + | + | + | 2-2 | + | − | 2-2 | − |
| 73 | II 45, 44 | F | 12 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | − | 2-1 | + | + | 1-1 | + |
| 75 | II 45, 52 | M | 10 | MS | CcDEe | $R_1R_2$ | + | + | + | + | + | 2-1 | + | + | 2-2 | + |
| 77 | | F | 14 | MSs | CDe | $R_1R_1$ | + | − | + | + | − | 1-1 | + | − | 2-1 | + |
| 79 | I 16, 17 | F | 18 | MNSs | CcDEe | $R_1R_2$ | + | + | + | + | − | 1-1 | + | − | 2-1 | − |
| 80 | I 16, 17 | F | 17 | MNSs | cDE | $R_2R_2$ | + | − | + | + | − | 2-1 | + | − | 2-1 | − |
| 82 | II 45, 52 | M | 28 | Ms | CcDE | $R_zR_2$ | + | + | + | + | − | 0 | + | + | 2-2 | |
| 83 | II 45, 52 | F | 32 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | + | 2-2 | + | − | 2-2 | − |
| 89 | II 46, 47 | M | 40 | Ms | cDE | $R_2R_2$ | + | + | + | − | − | 2-1 | + | − | 2-1 | + |
| 92 | II 48, 49 | F | 10 | MSs | CDe | $R_1R_1$ | + | − | − | + | − | 0 | + | + | 2-1 | |
| 96 | II 50, 51 | F | 15 | MNSs | cDE | $R_2R_2$ | + | + | + | + | − | 2-1 | + | − | 2-1 | − |
| 97 | II 50, 51 | F | 17 | MNSs | cDE | $R_2R_2$ | + | + | + | + | − | 2-2 | + | − | 2-2 | − |
| 99 | II 60, 61 | F | 2 | Ns | CcDEe | $R_1R_2$ | − | + | + | + | + | 2-1 | + | − | 2-2 | |
| 100 | II 60, 62 | F | 15 | MS | cDE | $R_2R_2$ | + | − | + | + | − | 2-2 | + | − | 2-1 | |
| 101 | II 60, 62 | M | 21 | MS | CcDEe | $R_1R_2$ | + | + | + | + | − | 2-1 | * | | 2-2 | |
| 107 | II 65, III 90 | M | 17 | MS | CDe | $R_1R_1$ | + | + | + | − | − | 2-1 | + | − | 2-1 | + |

TABLE 15. *(Continued)*

| Pedigree no. | Parents | Sex | Age | MNSs | Rh | | P | $Fy^a$ | Jk | | $Di^a$ | Hp | Gm | | Gc | Secretor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Phenotype | Probable genotype | | | a | b | | | a | x | | |
| IV 1 | III 9, 83 | F | <1 | MS | CcDEe | $R_1R_2$ | – | – | + | – | + | 2-2 | + | – | 2-2 | |
| 2 | III 2, 17 | F | 7 | NSs | CDe | $R_1R_1$ | + | + | + | – | + | 1-1 | + | – | 2-2 | – |
| 3 | III 2, 17 | M | 10 | MSs | CcDEe | $R_1R_2$ | + | + | + | – | – | 2-1 | * | | 2-2 | + |
| 4 | III 2, 17 | M | 9 | Ms | CcDEe | $R_1R_2$ | + | + | + | – | + | 0 | + | – | 2-1 | |
| 5 | III 16, 17 | F | 20 | Ms | CcDEe | $R_1R_2$ | + | + | + | – | + | 0 | + | – | 2-1 | + |
| 9 | III 38, 52 | F | <1 | MNs | CDe | $R_1R_1$ | + | – | + | + | – | 2-1 | + | – | 2-2 | |
| 11 | II 60, III 41 | M | 7 | MNs | cDE | $R_2R_2$ | + | + | + | + | – | 2-2 | + | – | 2-1 | – |
| 14 | II 59, III 47 | F | 11 | MNSs | CcDef | $R_1R_0$ *or* $R_1r$ | – | – | + | + | – | 0 | + | + | 2-1 | + |
| 15 | II 58, III 47 | M | 2 | MNs | cDEef | $R_2R_0$ *or* $R_2r$ | – | + | + | + | – | 1-1 | + | + | 2-1 | |
| 16 | III 48, 100 | F | <1 | MNS | CcDEe | $R_1R_2$ | + | – | + | + | – | 2-2 | + | – | 2-2 | |
| 19 | III 54, IV 5 | F | <1 | MNs | CDe | $R_1R_1$ | | | | | | | | | | |
| 20 | III 60, 59 | F | 2 | MS | CcDE | $R_zR_2$ | + | – | + | + | + | 1-1 | + | – | 2-2 | + |
| 21 | III 60, 59 | F | <1 | MNS | CcDEe | $R_1R_2$ | + | + | + | + | + | 2-1 | + | + | 2-2 | |
| 22 | III 18, 68 | M | 4 | MNs | CcDEe | $R_1R_2$ | + | + | + | + | + | 2-2 | + | – | 1-1 | + |
| 23 | III 18, 68 | M | 1 | MNSs | CDe | $R_1R_1$ | – | + | + | + | – | 2-1 | + | – | 1-1 | |
| 24 | III 18, 69 | F | 5 | MNs | CDe | $R_1R_1$ | + | – | + | + | + | 2-2 | + | – | 2-2 | – |
| 25 | III 18, 69 | M | 2 | Ns | CDe | $R_1R_1$ | – | + | + | + | + | 2-1 | + | – | 2-1 | |
| 26 | III 72, 71 | F | 17 | MS | CDe | $R_1R_1$ | + | + | + | + | + | 0 | + | – | 2-1 | – |
| 30 | III 72, 71 | F | 20 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | + | 2-1M | + | – | 1-1 | + |
| 31 | III 78, 79 | F | 2 | MNs | CDEe | $R_zR_1$ | + | + | + | – | – | 2-1 | + | + | 2-1 | + |
| 32 | III 82, 97 | M | 5 | Ms | cDE | $R_2R_2$ | – | + | + | + | – | 2-2 | + | – | 2-2 | |
| 33 | III 82, 97 | M | <1 | MNSs | CcDE | $R_zR_2$ | + | + | + | + | – | 2-2 | + | + | 2-2 | |
| 34 | III 84, 83 | M | 17 | MNS | CcDEe | $R_1R_2$ | + | + | + | + | – | 2-1 | + | + | 2-1 | + |
| 36 | III 84, 83 | F | 13 | MNs | cDE | $R_2R_2$ | + | + | + | + | + | 2-1 | + | + | 2-1 | – |
| 38 | III 86,87 | M | 9 | MNSs | cDE | $R_2R_2$ | + | – | + | + | – | 2-1 | + | + | 1-1 | – |
| 39 | III 89, 90 | M | 8 | MSs | CDe | $R_1R_1$ | + | + | + | – | – | 0 | + | – | 2-1 | + |
| 41 | III 89, 90 | F | 3 | MSs | CcDEe | $R_1R_2$ | + | + | + | + | – | 2-2 | + | – | 2-2 | |

*Serum agglutinated in the saline control tube, the cells sensitized with each of the four anti-D sera used; Gm types could not be determined.

Consanguinity rates are undoubtedly even higher than would be expected in so small a population with random mating because of the high fertility of the chief and the possibility (even assuming no inheritance of ability) that the "best man" selected as chief will be a son of the preceding chief.

Under these circumstances, we have elected to compute gene frequencies utilizing the total sample as if it were composed of unrelated individuals drawn from a population of infinite size in Hardy-Weinberg equilibrium. Parenthetically, it is surprising how little difference it makes to the estimate if, for instance, one eliminates from the estimate all children one or both of whose parents have been studied. No variance estimates have been derived; the question of how to proceed with such estimates under these circumstances is reserved for a later publication when, it is hoped, data from one or more additional Xavante villages will be available. For one system, Kidd (Jk), gene frequencies have not been calculated because of a very gross departure from Hardy-Weinberg proportions. Since both $Jk^a$ and $Jk^b$ antisera are notoriously unstable and difficult to work with, we do not feel the present results are valid.

The results of the calculations employing methods summarized in Neel and Schull (1954) and Race and Sanger (1962) are given in table 18. A brief comment is indicated concerning the problem presented by the Rh frequencies in a population such as this. With the test sera available (anti-C, -D, -E, -c, -e, -f), there are some phenotypes in which one is led to postulate the presence of either the $R_0$ or the $r$ gene. But since neither the phenotypes ccdee or ccDee (with one exception; Layrisse, Layrisse, and Wilbert, 1963) has been encountered in the members of this or any other presumably pure South American Indian population to date, one cannot state with assurance which of these genes is the more reasonable postulate. In point of fact, both could be present in the population. In the genotypic designations of table 15, we have indicated those cases where the phenotype is compatible with either $R_0$ or $r$. There are as yet no phenotypic grounds for postulating the presence of the $R'$, $R''$, or $R_y$ genes in this or other South American Indian groups. Under these circumstances, with the phenotypes encountered and listed in table 15, one can with small error assign genotypes to individuals, the more so since we have family material. Accordingly, with one exception ($R_0$ or $r$), it appears we are in a position to determine Rh gene frequencies with high accuracy by a simple counting procedure.

There are several apparently noteworthy features of the gene frequencies. With respect to the blood types, given the nature of the populations involved, the technical problems to be discussed later, and the probable magnitude of the sampling errors, the results are reasonably close to those published for other Brazilian and South American Indian groups. (Reviews in Salzano, 1957, 1961b; Layrisse, Wilbert and Arends, 1958; Best, Layrisse and Bermejo, 1962; Layrisse, Layrisse and Wilbert, 1963; Ellis, Cawley and Lasker, 1963.) Thus, we see the absence of the genes $I^A$ and $I^B$, $V$ (of the Rh system), $K$, and $Lu^a$; a high frequency of the $M$, $R_1$, $R_2$, and $Di^a$ genes; and values for the $Fy^a$ gene close to 50 per cent. The only apparent difference which seems worthy

TABLE 16. A SUMMARY OF THE MN, RH, P, DUFFY, KIDD, DIEGO, SECRETOR, GC, GM, AND HP REACTIONS IN THE XAVANTES
The specimen obtained from one child did not permit complete typing; salivas were obtained only from adults.

| Trait | Genotype or phenotype | Frequency | Per cent |
|---|---|---|---|
| MNSs | MMSS | 11 | 13.9 |
| | MMSs | 17 | 21.5 |
| | MMss | 13 | 16.5 |
| | MNSS | 4 | 5.1 |
| | MNSs | 13 | 16.5 |
| | MNss | 13 | 16.5 |
| | NNSs | 5 | 6.3 |
| | NNss | 3 | 3.8 |
| | | 79 | 100.0 |
| P | P+ | 69 | 88.5 |
| | P− | 9 | 11.5 |
| | | 78 | 100.0 |
| Rh | $R_1R_1$ | 25 | 31.6 |
| | $R_2R_2$ | 12 | 15.2 |
| | $R_1R_2$ | 32 | 40.5 |
| | $R_zR_2$ | 4 | 5.1 |
| | $R_zR_1$ | 1 | 1.3 |
| | $R_1R_0$ (or $R_1r$) | 3 | 3.8 |
| | $R_2R_0$ (or $R_2r$) | 1 | 1.3 |
| | $R_zR_0$ (or $R_zr$) | 1 | 1.3 |
| | | 79 | 100.1 |
| Duffy | Fy(a+) | 59 | 74.7 |
| | Fy(a−) | 20 | 25.3 |
| | | 79 | 100.0 |
| Kidd | Jk(a+b−) | 16 | 20.5 |
| | Jk(a+b+) | 60 | 76.9 |
| | Jk(a−b+) | 2 | 2.6 |
| | | 78 | 100.0 |
| Diego | Di(a+) | 24 | 30.8 |
| | Di(a−) | 54 | 69.2 |
| | | 78 | 100.0 |
| Secretor | Secretor | 31 | 56.4 |
| | Non-secretor | 24 | 43.6 |
| | | 55 | 100.0 |
| Gc | 1-1 | 8 | 10.3 |
| | 2-1 | 36 | 46.2 |
| | 2-2 | 34 | 43.6 |
| | | 78 | 100.1 |

TABLE 16. *(Continued)*

| | | | |
|---|---|---|---|
| Gm* | (a+b−c−x+) | 22 | 30.1 |
| | (a+b−c−x−) | 51 | 69.9 |
| | | 73 | 100.0 |
| Hp | 2-2 | 17 | 21.8 |
| | 2-1 | 39 | 50.0 |
| | 1-1 | 11 | 14.1 |
| | 2-1M | 1 | 1.3 |
| | 0 | 10 | 12.8 |
| | | 78 | 100.0 |

*See footnote in table 10.

TABLE 17. A COMPARISON OF THE OBSERVED PHENOTYPE FREQUENCIES WITH THOSE EXPECTED AT HARDY-WEINBERG EQUILIBRIUM, FOR FIVE GENETIC SYSTEMS STUDIED AMONG THE XAVANTES

$\chi^2$ values are corrected for continuity.

| System | | Phenotype | | | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|
| MN of MNSs | | *M* | *MN* | *N* | *Total* | | |
| | Obs. | 41 | 30 | 8 | 79 | | |
| | Exp. | 39.70 | 32.60 | 6.69 | 78.99 | 0.249 | .9 > *P* > .8 |
| Ss of MNSs | | *S* | *Ss* | *s* | *Total* | | |
| | Obs. | 15 | 35 | 29 | 79 | | |
| | Exp. | 13.37 | 38.26 | 27.37 | 79 | 0.341 | .9 > *P* > .8 |
| Cc of Rh | | *C* | *Cc* | *c* | *Total* | | |
| | Obs. | 26 | 40 | 13 | 79 | | |
| | Exp. | 26.20 | 38.59 | 14.21 | 79 | 0.039 | .99 > *P* > .98 |
| Ee of Rh | | *E* | *Ee* | *e* | *Total* | | |
| | Obs | 16 | 35 | 28 | 79 | | |
| | Exp. | 15.07 | 38.87 | 25.07 | 79.01 | 0.429 | .9 > *P* > .8 |
| Hp 1 and 2* | | *2-2* | *2-1* | *1-1* | *Total* | | |
| of Hp | Obs. | 17 | 39 | 11 | 67 | | |
| | Exp. | 20.20 | 32.72 | 14.08 | 67 | 1.855 | .5 > *P* > .3 |
| | | *1-1* | *2-1* | *2-2* | *Total* | | |
| Gc | Obs. | 8 | 36 | 34 | 78 | | |
| | Exp. | 8.65 | 34.65 | 34.70 | 78 | 0.116 | .95 > *P* > .9 |

*Types 2-1M and 0 excluded from calculation; see text.

of comment at this time is the relatively high frequency of the *P* gene, but the unreliability of this determination (cf. Section VI) makes this observation of dubious validity. Only two other groups of Ge speaking Indians, the Carajá and the Caingang, have been the object of blood typing studies (Fernandes *et al.*, 1957; Junqueira, Kalmus and Wishart, 1957; Salzano, 1961b). The only apparently noteworthy difference between these groups and the Xavantes is the report that 7 of 35 Carajá were K+. This finding requires confirmation. Layrisse and Wilbert (1961) have suggested that the earliest Indians to reach South America were characterized by low frequencies of

TABLE 18. THE FREQUENCY OF CERTAIN GENES AMONG THE XAVANTE INDIANS OF BRAZIL

Only those systems showing variations are included.

| System | Gene | Frequency |
|---|---|---|
| MNSs | *MS* | 0.33 |
| | *NS* | 0.09 |
| | *Ms* | 0.38 |
| | *Ns* | 0.20 |
| P | $P_1$ | 0.66 |
| | $P_2$ | 0.34 |
| Rh | $R_1$ | 0.54 |
| | $R_2$ | 0.39 |
| | $R_z$ | 0.04 |
| | $R_0$* | 0.03 |
| Duffy† | $Fy^a$ | 0.50 |
| | $Fy$ | 0.50 |
| Diego† | $Di^a$ | 0.17 |
| | $Di$ | 0.83 |
| Secretor | *Se* | 0.34 |
| | *se* | 0.66 |
| Gc | $Gc^1$ | 0.33 |
| | $Gc^2$ | 0.67 |
| Gm | $Gm^{ax}$ | 0.16 |
| | $Gm^a$ | 0.84 |
| Hp‡ | $Hp^1$ | 0.46 |
| | $Hp^2$ | 0.54 |

*This could also be *r*, or both $R_0$ *and* *r* may be present; see text.

†Computations based on the assumption of only two alleles in the system.

‡The Hp 2-1M and the ahaptoglobinemic individuals have been omitted in computing the gene frequencies.

the Di[a] antigen. Since the Xavante possess many of the characteristics attributed to the descendants of these groups, usually termed Marginal Indians, our findings do not confirm this suggestion. Layrisse, Layrisse and Wilbert (1962) have reported rather considerable differences in the frequency of the $M$, $R_2$, and $R_z$ genes between Marginal Indian groups in Venezuela. When consideration of the Marginals is extended beyond Venezuela, the $Di^a$ gene would appear to share the variability of other blood group systems.

The results of the Gc groups of serum proteins are in marked contrast to those of the Navajo, the only other American Indian group studied to date, where the $Gc^1$ gene has a frequency of 0.98 (Cleve and Bearn, 1961). There are also marked differences with respect to the Gm groups. Previous investigators (Steinberg, Stauffer and Fudenberg, 1960; Steinberg *et al.*, 1961; and Steinberg and Salzano, unpublished) have found that American Indians are all Gm(a+) and, in small samples, approximately 30–50 per cent Gm(x+), with which these results agree. However, these same previous studies have revealed a 2 per cent frequency of Gm(b+) in Alaskan Indians, an 80 per cent frequency of Gm(b+) in the Oayana and Carib Indians of Surinam, and a 15 per cent frequency of Gm(b+) in Caingangs, whereas we failed to detect any Gm (b+). The $Hp^1$ frequency is within the range of those encountered in the Indian tribes of Southern Mexico, Guatemala, and Venezuela (Sutton *et al.*, 1960; Arends and Gallango, 1962). However, it appears somewhat low in comparison with the values thus far reported for South American Indians south of Venezuela: assorted Peruvian natives, 0.73 (Giblett and Best, 1961); Mapuches from Central Chile, 0.72 (Parker and Bearn, 1961; Nagel and Etcheverry, 1963); Pehuenches from Southern Chile, 0.78 (Nagel and Etcheverry, 1963); Caingangs from Southern Brazil, 0.73 (Salzano and Sutton, 1963). With respect to the secretor trait, few studies have been carried out on South American Indians, but the North American Indians so far tested are almost all secretors (e.g., Chown and Lewis, 1953, 1955; Pollitzer *et al.*, 1962). The finding of some 40 per cent non-secretors is thus unexpected.

In summary, the Xavantes as thus far studied appear similar in most measurable genetic attributes of blood to the other Indian groups of South America, insofar as these have been characterized. Possible significant differences were encountered in respect to the P, Gm, Gc, and Hp traits, as well as the secretor characteristics of saliva. Definite conclusions are impossible because of the difficulty in attaching errors to gene frequency estimates. Although no technical problems were recognized in the study of these specific systems, the possibility of typing artifacts cannot be excluded. Assuming the validity of the findings, the results can be viewed in either of two ways. Taken in conjunction with the observations on the anthropometric and nonquantitative morphological traits, one can be impressed, in view of the breeding structure to be described in the next section, either by the amount of genetic variability in this group and the similarity of this variation to that encountered in other Indian groups, or by the specific unusual features enumerated above. Otherwise stated, although significant differences may have been encountered between the Xavante and other Indian groups, when one considers all the factors that might be expected to lead to differences (cf. Section v), it is noteworthy that these are no more pronounced than they are.

## V. DEMOGRAPHIC PARAMETERS OF GENETIC INTEREST

### *Methodology*

Despite the enormous amount of descriptive material available concerning the Indian tribes of the Americas, not to mention other primitive groups, data concerning their vital statistics have simply not been collected in the detail necessary for genetic purposes. Quite aside from the fact that this has not been the focus of interest of the physical and cultural anthropologists who have studied those peoples, this is difficult information to obtain. There is no need to dwell upon the problems inherent in eliciting accurate pedigree and demographic data from a short-lived, illiterate people where marriage occurs at an extremely early age and the resulting clan affiliation is regarded as more meaningful than biological descent.

To ensure the maximum accuracy possible under the circumstances, two more or less independent approaches to eliciting biological relationships were employed in this investigation. On the one hand, with the assistance (and interpretation) of the resident agent of the Indian Protective Service, one or both members of as many as possible of the married couples present in the village were interviewed at the Post at the time of the various examinations, and information was obtained on the following specific points: (1) name, and name or names of spouses; (2) sex; (3) age group and position in age group; (4) place of birth; (5) names of brothers or sisters living in the village; (6) name, sex, age group and position in age group of all living children; (7) number of stillbirths; (8) number of dead children and estimated age of each at death; (9) place of birth of all members of the family; and (10) information on siblings or children who might have left the village. The actual ages used in the tabulations to be presented were estimated from the known sequence of five year age-sets and the individual's position within that set. A working pedigree was then constructed, followed by an effort to clarify possible relationships between the various family units. Independently, the social anthropologist, who was living in the Xavante village, attempted to extend the pedigree which he had obtained during his earlier field work. The results were compared prior to departure from the field and afterwards in Pôrto Alegre, and an effort was made to clear up any ambiguities or discrepancies. There was good agreement between the two approaches; the results are felt to be as accurate and extensive as possible under these circumstances.

### *The Village Schism*

In 1958, the population of the village under study had fluctuated between 200 and 220. The size of the village on this visit was approximately 110. This striking reduction was due primarily to the earlier mentioned village schism occurring shortly after the studies of 1958. The resulting offshoot village was visited by one of us (D. M.-L.). Unfortunately, its inhabitants were away on trek, but from the number of houses and the information supplied by others, its population was placed at 80–90.

Despite the problems which precipitated the schism, the two villages appear to maintain close contacts. It seems quite possible this is a temporary situation and the two villages will fuse after Apewe's death. Because of the intimate biological relationships between the two villages, the pedigree which was drawn up includes many of the inhabitants of the offshoot village as well as the parent village. Since 91 of the estimated 110 persons of the parent village were examined and are so indicated on the pedigree, an approximate idea of the biological lines along which the village split can be derived from study of the pedigree. The opportunity to record to some measure how this important sampling event in the lives of such populations occurs offsets to some degree our disappointment at finding a smaller village than anticipated. It can be inferred from the persons in the pedigree who were not examined that entire sibships, or all the males of a sibship (the females having married into another clan), tended to leave the village at the time of the schism. The sampling of the gene pool at such a time appears anything but random.

The light in which our demographic data are to be viewed depends on whether this is an expanding, stable, or declining population. The total population of the two villages is estimated at 190 to 200, a figure which agrees well with the pedigree data. This is only slightly less than in 1958. Our informants indicated that a number of Xavante, presumably dissidents from other villages, had joined the splinter village, where Apewe's faction is, of course, not the dominant one. This would lead to the expectation of some increase in population numbers. On the other hand, the Xavantes of the village near Xavantina, who were interviewed later in the summer of 1962, were most insistent that a number of men in Apewe's village had recently been killed. The information obtained in Apewe's village was that these same people had died in an outbreak of disease while out on trek. From the data obtained this time and the records of 1958, it could be determined that one minor lineage of four men had all succumbed to the disease. It seems quite possible that some of these men were killed on the grounds of having brought the illness about by sorcery. All things considered, it appears that this population has undergone no marked shift in the past five years in the balance between births and deaths.

There are three previous sets of figures regarding the size of this group. In 1954, Sadock de Freitas, a physician employed by the Indian Protective Service, estimated their number at 618. At that time, the village was located about 60 km from its present site. In 1957, after the village had moved to its present site, Blomberg (the leader of a photographic team) was told by the Indian agent that there were 450 in the group (Blomberg, 1960). It is quite possible, Xavante social structure being what it is, that some of the group had elected not to participate in the move. Furthermore, it is not clear whether the figure of 450 was an estimate or based upon an exact census. In 1958, the Indian agent undertook an official census for the Indian Protective Service, noting the presence of 219 persons, a figure in good agreement with M.-L.'s 1958 results. Taken at face value, these figures could indicate a very rapid decrease in the size of the group. Yet we learned of no major epidemic and, although the mound burials in the village graveyard (representing a 6 to 7 year accumulation) were not counted, retrospectively the number was thought to be no more than 30. There is thus a large element of uncertainty concerning population trends in this group.

The pedigree constitutes Fig. 2. The rather striking absence of offspring from the marriages of the proximal generation is due to the fact that, almost without exception, the wife is below the age of reproduction. Deceased individuals are shown only as necessary to tie the pedigree together; individuals not surviving to reproduction have been omitted from the pedigree. Furthermore, in order to develop a legible pedigree, it has sometimes been necessary to ignore the usual convention of placing the members of a sibship in order of descending age, from left to right. Finally, it has been found less confusing in such a pedigree to use an unusually heavy line to connect spouses who are consanguineous rather than the usual double line.

### *The Breeding Structure of the Village: Age and Sex Distribution*

The age (adults *vs.* "children") and sex distribution of 178 of the 184 persons represented on the pedigree is shown in table 19. Age and other data are lacking for the remaining six. For comparison, data are presented on the only other Brazilian Indians for whom similar recent data are available, the

TABLE 19. AGE AND SEX OF THE INDIVIDUALS STUDIED IN THE XAVANTE POPULATION OF SAO DOMINGOS, AND A COMPARISON WITH THE CAINGANG INDIANS OF RIO GRANDE DO SUL AND THE BRAZILIAN POPULATION IN GENERAL

| | Age 15 and over | | | | Younger than 15 | | | | | Total population | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males | Females | Sex ratio | Total | Males | Females | Un-known | Sex ratio | Total | Men | Women | Un-known | Sex ratio | Total |
| *Xavantes* | | | | | | | | | | | | | | |
| Present census | 54 | 54 | | 108 | 30 | 40 | — | | 70 | 84 | 94 | — | | 178 |
| % | 30.3 | 30.4 | 100.0 | 60.7 | 16.8 | 22.5 | — | 75.0 | 39.3 | 47.2 | 52.8 | — | 89.4 | |
| Caingang* (1958–60) | 512 | 554 | | 1066 | 286 | 302 | 4 | | 592 | 798 | 856 | 4 | | 1,658 |
| % | 30.9 | 33.4 | 92.4 | 64.3 | 17.3 | 18.2 | 0.2 | 94.7 | 35.7 | 48.2 | 51.6 | 0.2 | 93.2 | |
| Brazil (1950) | | | | | | | | | | | | | | 51,944,397 |
| % | 28.7 | 29.4 | 97.4 | 58.1 | 21.2 | 20.7 | — | 102.1 | 41.9 | 49.8 | 50.2 | — | 99.3 | |

*Salzano (1961).

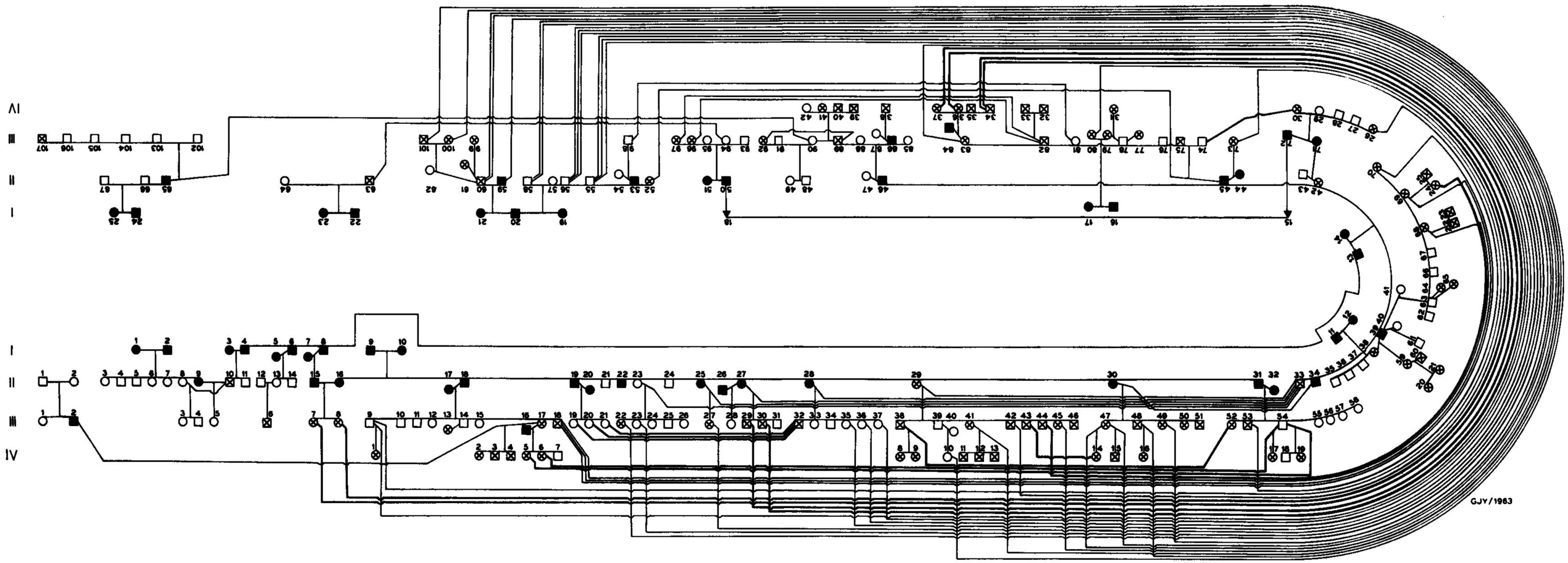

FIG. 2. The village pedigree, combining not only the village examined but its recent offshoot (see text). Individuals indicated by solid symbols are deceased. Individuals who were examined and/or from whom blood specimens were obtained are indicated by an X in the symbol. Marriages known to be consanguineous are indicated by a double-thickness connecting line.

semi-acculturated Caingang Indians of Southern Brazil (Salzano, 1961a.). The Caingangs are classed linguistically as belonging to the Macro-Ge subfamily, together with Ge speakers, so that a relationship with the Xavantes may be inferred, but they have now adopted the agricultural life of the frontier Brazilian (Ribeiro, 1957). We have here, then, the opportunity for cautious exploration of the impact of changing culture on certain aspects of breeding structure. Data are also presented for all Brazil. There are no obvious differences between the three groups; the similarity of the proportion of individuals below age 15 between the Xavantes and a known expanding population such as the Brazilians suggests the former are maintaining their numbers. The average age in the two villages of persons whose age could be estimated was 15.5 years.

Some 65 years ago, Ranke (1898) described the demographic status of some of the many small tribes found in the headwaters of the Xingú River, approximately 200 miles to the west of the locale of this study. This pioneer work is apparently the only detailed documentation of these matters up until recent times; we shall refer to it frequently. With regard to age structure, Ranke, without giving the exact data, states that 31 per cent of the population he encountered were in the first decade of life and 24.6 in the second. These figures suggest a slightly broader base to the age pyramid than we encountered, but the difference may not be significant.

*Isolation*

Table 20 indicates the origin of the marital partners in the two villages. The degree of village endogamy is striking. We shall distinguish between "adult" and "child" marriages, the latter involving a wife under 15 years of age. The similarity between the frequency of exogamy for the two types of marriage indicates no tendency towards lessening isolation in recent years. The few marriages contracted out of the village involved other Xavante and probably were contracted under peaceful circumstances, although there was a degree of vagueness on this point. The nomadic character of Xavante life would make an attempt to estimate mean distance from which outside marital partners were drawn (if this were possible) meaningless. The high degree of endogamy probably reflects not only the isolation and mating structure of this group but also the suspicious and hostile attitude of the Xavante to the outside world, including other Xavante villages. However, we must recognize the possibility that the relatively prolonged and dominant nature of Apewe's chiefship has discouraged immigration to the village but encouraged emigration, as suggested from the snatches of history available. Data from other Xavante villages should help develop the proper perspective.

*Marriage Structure: Polygamy*

Sixteen (43 per cent) of 37 married men for whom reliable data were available were polygamous (table 21). Polygamous marriages commonly involved sisters. Sixty-five (73 per cent) of the 89 surviving children were the issue of polygamous marriages, but it must be remembered that the men with only

TABLE 20. NUMBER OF ENDOGAMOUS AND EXOGAMOUS MARRIAGES IN THE XAVANTE POPULATION OF SAO DOMINGOS

| Population | | Both partners from same locality | One partner from another locality | Origin of one partner unknown | Total number of marriages |
|---|---|---|---|---|---|
| Adult marriages | No. | 35 | 3 | 2 | 40 |
| | % | 87.5 | 7.5 | 5.0 | — |
| Child marriages | No. | 15 | 1 | — | 16 |
| | % | 93.7 | 6.3 | — | — |
| Total | No. | 50 | 4 | 2 | 56 |
| | % | 89.3 | 7.1 | 3.6 | — |

one wife tended to be younger. In this connection, the reproductive history of the chief, Apewe, is striking. As befits the chief, he had had more wives (five) than any other member of the tribe. It has proved very difficult to unravel the relationship of these women. Three of them are almost certainly full sisters. The other two are either additional sisters or parallel first cousins, the descent being through brothers. As the pedigree stands, it indicates 13 individuals surviving to adult life in the sibship from which these women were drawn. This would be a most unusual circumstance and leads us to suspect that, despite repeated efforts to clarify this portion of the pedigree, our informants have combined the children of two or more brothers into a single sibship. The experienced field worker will readily appreciate how elusive the clarification of such matters can be. These five unions have resulted in 23 surviving children. This is approximately one-quarter of the individuals in the generation to which we have assigned Apewe's children. The implications of this reproductive pattern for the consanguinity structure of the group will be discussed shortly.

It will be noted that of the 67 persons depicted in generation II, 17 are shown as unmarried. Four of these are below the age of 20 and may well be unmarried. None of the remaining 13 were interviewed, from which we infer some of them were living in the splinter village. It seems quite likely, marriage pressure being as strong as it is, that most or all of these persons have been married, to one another or to persons not shown on the pedigree, and that there may be offspring of those unions. Our pedigree is thus clearly incomplete.

### *Family Size*

Table 22 summarizes the number of surviving offspring per adult married female per marriage. (Five females were married twice.) Table 23 presents the number of livebirths per male and female by age group, while table 24 presents similar data on survival. The paucity of numbers makes inferences hazardous, but several points seen noteworthy: (1) There was no evidence for absolute sterility where the wife was above the age of 15. Only two couples reported no livebirths. In one case, the wife was then pregnant, while in the second instance there had been one stillborn offspring (the only one reported in the entire series). These limited data confirm the rarity of sterility

TABLE 21. THE POLYGAMY STATUS OF 37 MARRIED MEN ON THE BASIS OF INFORMATION SUPPLIED BY THEMSELVES OR, IF THEY WERE DECEASED, BY THEIR WIVES

An additional marriage shown in the pedigree has not been tabulated because no partner to the marriage was available for interview and the hearsay data were not thought sufficiently accurate for tabulation. In the case of four individuals included in the tabulation (II-39, II-45, II-56, and II-60), information about wives in addition to those mentioned by the man was obtained from other apparently reliable sources. The reasons why a wife might not be readily mentioned are complex and need not be discussed here.

| | No. of men | Biological relation of wives in polygamous marriages | | | | | No. surviving offspring |
|---|---|---|---|---|---|---|---|
| | | Sisters | Half sisters | 2 Sisters + 1½ sib | 2 Sisters + 2 unrelated | Un-related | |
| Men with one wife | 21 | – | – | – | – | – | 24 |
| Men with two wives | 10 | 6 | 1 | – | – | 3 | 23 |
| Men with three wives | 4 | 2 | – | 1 | – | 1 | 13 |
| Men with four wives | 1 | – | – | – | 1 | – | 6 |
| Men with five wives* | 1 | 1 | – | – | – | – | 23 |

*Since three of them are already dead, it is not known if he had the five simultaneously.

reported by a number of early observers of Indians (discussion in Krzywicki, 1934, p. 223). (2) The average number of livebirths per adult married female (3.1 ± 0.5) is similar to that encountered in the expanding population of Brazil (Mortara, 1957). (3) The mean number of livebirths for women who have completed reproduction is about 7, which, from the data summarized by Henry (1961), appears to be significantly below 10, the maximum average reproductive potential of the human female. In 1898, Ranke recorded the data on reproductive performances in the Xingú region shown in table 25. The nature of the factors reducing fertility in these societies to a level consistent with the ability of the mother to cope with young children has been subject to much speculation; we shall return to this question later.

### *Mortality*

The mortality prior to the age of reproduction, as derived from tables 23 and 24, is 21/104 or 30.8 per cent of liveborn children when all age intervals are considered. (This calculation excludes one sibship of six for whom accurate mortality data are lacking.) Since many of the surviving children were born less than 15 years ago, this is a minimal figure. There appears to be a higher mortality among the children of the younger mothers, a finding whose possible significance is augmented by the fact that the children of the younger mothers have had a shorter risk period. We may wonder whether here is a hint that these relatively low death rates are soon to rise to those more characteristic of primitive agriculturalists in contact with western culture. Thus, in the Caingangs, 41 per cent of liveborn children die before the age of 15, a figure almost identical with that for more recent births among

TABLE 22. FAMILY SIZES (NUMBER OF SURVIVING OFFSPRING PER MARRIED ADULT FEMALE) PER MARRIAGE IN THE XAVANTE POPULATION OF SAO DOMINGOS AND A COMPARISON WITH THE CAINGANG INDIANS FROM RIO GRANDE DO SUL

It will be noted that 40 marriages are listed here but table 18 lists only 35 females. The discrepancy is due to the fact that some women were married several times.

| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 14 | No. of families | Average no. of children |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Xavantes, present sample | N | 10 | 12 | 7 | 4 | 2 | 1 | 2 | 1 | 1 | – | 40 | 2.0 ± 0.3 |
| | % | 25.0 | 30.0 | 17.5 | 10.0 | 5.0 | 2.5 | 5.0 | 2.5 | 2.5 | – | | |
| Caingangs, Rio Grande do Sul* | N | 122 | 114 | 81 | 66 | 40 | 25 | 27 | 14 | 4 | 1 | 494 | 2.2 ± 0.1 |
| | % | 24.7 | 23.1 | 16.4 | 13.4 | 8.1 | 5.0 | 5.5 | 2.8 | 0.8 | 0.2 | | |

*Salzano (1961a).

TABLE 23. NUMBER OF LIVEBIRTHS PER FEMALE AND MALE PARENT, BY AGE GROUPS [a]

| Maternal age | No. of females | Average no. of livebirths |
|---|---|---|
| 15–19 | 15 | 1.2 |
| 20–29 | 9 | 2.8 |
| 30–39 | 4 | 5.5 |
| 40–49 | 5 | 7.0 |
| All ages | 35[b] | 3.1 ± 0.5 |
| **Paternal age** | **No. of males** | **Average no. of livebirths** |
| 20–29 | 13 | 2.2 |
| 30–39 | 6 | 3.8 |
| 40–49 | 5 | 5.4 |
| All ages | 29[c] | 3.8 ± 0.8 |

[a] Only two couples had no liveborn children. In one, the woman is now pregnant after one year of marriage; she is 18 years old and her husband is 17. The other couple (male aged 27 and female 16) have had a stillborn child (the only stillbirth reported in the whole series).

[b] Including also one female 50 years of age with 8 children and another of 60 with one liveborn child.

[c] Including also one male of 18 with one child, one of 17 with no children, one of 50 with 4, one of 60 with 24, and another of 65 with one liveborn child.

the Xavantes. An alternative explanation is that older women are failing to report deaths among their offspring with the completeness of the younger. Ranke (1898) records that 86 married women from six villages had borne 360 children of whom only 141 (39 per cent) were alive at the time of his visit. On the face of it, this is a higher mortality than we encountered, but because of the large proportion of women over 40 whom he appears to have questioned, it is possible that these figures include young adults lost in accidents and battle. Taken at face value, our data indicate a population at present replacing itself, but there are ominous signs that this situation may not persist.

*Inbreeding*

Thirteen (24 per cent) of the 55 marriages represented in this population can be shown to be consanguineous (table 26). The resulting coefficient of inbreeding is 0.0094. This, of course, is a gross underestimate of the true coefficient. Thus, for only five marriages in the entire pedigree can we identify all four grandparents for each of the marital partners. The possibilities for hidden consanguinity are obvious. The coefficient of inbreeding (calculated on the basis of marriages rather than people) for 39 "adult" marriages is 0.0056, but for the 16 "child" marriages, 0.0186. This apparently increasing consanguinity rate is often seen in efforts to estimate the amount of inbreeding in populations (cf. Ishikuni *et al.*, 1960) and almost certainly is in large part spurious, resulting from better knowledge of the ancestors of the more proximal generation. The low rate of village exogamy, the practice of marrying sisters, and the possible differential reproductive performance of some favored individuals

TABLE 24. NUMBER OF SURVIVING OFFSPRING PER FEMALE AND MALE WHO HAD AT LEAST ONE LIVEBORN CHILD, BY AGE GROUPS

| Maternal age | No. of females | Average no. of surviving offspring | Decrease in relation to average no. of livebirths (%) |
|---|---|---|---|
| 15–19 | 13 | 0.7 | 41.7 |
| 20–29 | 9 | 1.8 | 35.7 |
| 30–39 | 4 | 5.0 | 9.1 |
| 40–49 | 5 | 5.0 | 28.6 |
| All ages | 33[a] | 2.4 ± 0.5 | 22.6 |

| Paternal age | No. of males | Average no. of surviving offspring | Decrease in relation to average no. of livebirths (%) |
|---|---|---|---|
| 20–29 | 12 | 1.3 | 40.9 |
| 30–39 | 6 | 2.8 | 26.3 |
| 40–49 | 5 | 3.8 | 29.6 |
| All ages | 27[b] | 2.9 ± 0.8 | 23.7 |

[a] Including also one female 50 years old with 8 children and another of 60 with no children alive.

[b] Including also one male 18 years old with one child, one of 50 with 3, one of 60 with 23, and another of 65 with no children alive.

such as the chief all lead to the impression that the true coefficient of inbreeding is at least four or five times that recorded. Unfortunately, it probably will never be possible to obtain much better estimates than the present one.

### *Other Demographic Variables of Genetic Interest*

The breeding size of a population is the number of individuals in a given generation who contribute to the next generation. One would prefer to base this calculation on a generation which has passed through the age of reproduction—an obvious impossibility for a group such as the Xavantes, both because of inadequate data and the usual complication of overlapping generations further complicated here by "cross generation" marriages involving an adult male and a female child. An approximate enumeration of breeding size may be obtained from an analysis of generation II, the "adult" generation of the pedigree. It contains 67 persons, of whom 50 are known to be married, and 41 have offspring. In view of the high fertility of this group, it seems likely virtually all married members of the group will in time reproduce, so that a minimum population breeding size would be approximately 50. Further, since it is the rare adult who fails to marry (see also Ranke, 1898), it seems likely that the remaining 13 members of generation II are either now married or, if below the age of marriage, will be married if they survive to adulthood. However, some of these may not reach the age of marriage or may survive only a few years of marriage. In round numbers, the number of breeding individuals per generation for the villages combined would appear to be about 55 to 60.

Theoretically, a figure of this kind is subject to a number of corrections before an estimate of the *effective* breeding size is obtained. Inequality in the numbers of the two sexes contributing to the next generation lowers the

TABLE 25. THE DATA OF RANKE (1898) ON THE REPRODUCTIVE PERFORMANCE OF INDIAN WOMEN IN THE UPPER XINGU REGION OF THE BRAZILIAN MATO GROSSO

| Age of mother | No. of women | No. of children born: Total | No. of children born: Average |
|---|---|---|---|
| <20 | 10 | 6 | .6 |
| 20–30 | 22 | 57 | 2.59 |
| 30–40 | 19 | 67 | 4.78 |
| >40 | 24 | 128 | 5.33 |

TABLE 26. FREQUENCIES OF CONSANGUINEOUS MARRIAGES IN THE XAVANTE POPULATION OF SAO DOMINGOS
COMPARISON WITH CAINGANG INDIANS FROM RIO GRANDE DO SUL

| Consanguineous marriages | | Xavantes: Adult marriages | Xavantes: "Child" marriages | Xavantes: Grand total | Caingangs, Rio Grande du Sul* |
|---|---|---|---|---|---|
| First cousins | No. | 2 | 2 | 4 | — |
| | % | 5.1 | 12.5 | 7.3 | 4.5 |
| Double first cousins once removed | No. | — | 1 | 1 | — |
| | % | — | 6.3 | 1.8 | — |
| First cousins once removed | No. | 3 | 3 | 6 | — |
| | % | 7.7 | 18.8 | 10.9 | 2.6 |
| Second cousins once removed | No. | — | 2 | 2 | — |
| | % | — | 12.5 | 3.6 | 0.2 |
| Others | No. | — | — | — | — |
| | % | — | — | — | 6.7 |
| Total | No. | 5 | 8 | 13 | — |
| | % | 12.8 | 50.0 | 23.6 | 14.0 |
| No. of marriages | | 39 | 16 | 55 | 465 |
| Inbreeding coefficient | | 0.0056 | 0.019 | 0.0094 | 0.0021–0.0088 |

*Salzano (1961a).

effective population size. Of the 50 married individuals in generation II, 24 are males and 27 females. At first glance this would seem to belie the data on polygamy of table 21; however, the polygamous marriages are often cross-generational and so would not be reflected adequately in this tabulation. For this situation to perpetuate itself, there should be an excess of male deaths before these marriages are consummated, with the females then remarrying, a possibility rendered plausible by the short life span, the cross-generation character of the marriage, and the data in Section II on violent death. In other words, some of these would be "pro forma" marriages. The difference in the number of livebirths per male and per female parent (table 23) suggests that the polygamy is biologically meaningful. However, the present data simply do not permit us to evaluate accurately the differing contributions of males and females to effective population size. Inbreeding also necessitates a correction in population size; the data permit no realistic approach to such a correction. In addition, where population numbers fluctuate, effective size is closer to the lower number. If the village schism we have described becomes permanent, this will, of course, greatly reduce effective population size. There are no real data on the frequency of these schisms or how much more severe they may be. Later we will raise the question of whether, even in the absence of contacts with the white man, population numbers fluctuated sharply because of periodic decimations by disease. Finally, differential reproduction requires a correction in population size; there is not a sufficient number of completed families available to permit an estimate of the variance in number of children per male or female for completed families. However, it should be noted that all of these variables which influence *effective* population size result in a calculated figure lower than the estimates of 55 to 60 breeding individuals per generation.

Another genetic statistic which would be of great interest is Crow's Index of Total Selection (1958). This is an index of *potential* genetic selection, with components due to mortality and differential fertility, which is useful if applied with care in comparing populations. However, it requires data on completed families; our sample is not large enough for a meaningful calculation. On an intuitive basis, one may surmise that the rather large infant mortalities coupled with the practice of polygamy, which practice at least in the case of the chief has genetic implications, should lead in this group to a relatively high selection index.

In summary, this is a small, quite endogamous group with a relatively high coefficient of inbreeding where polygamy is common and sterility is rare. Of particular interest, should it be found to be a general phenomenon, is the disproportionate contribution of the village chief (and possibly certain other outstanding members of the village, such as the heads of clans) to the next generation. The population appears to be at the replacement level, achieving this by moderately high birth rates accompanied by moderate death rates prior to reproduction. There are indications the death rates may be increasing. Effective population size in the sense of Wright is difficult to estimate, but is something less than 55 to 60, the estimated number of breeding individuals in a generation. For reasons stated above, we are reluctant at this time to attempt a precise calculation of effective population size or, as has been done for a number of populations, random genetic drift per generation as defined by Wright (1940) or an "index of isolation" as defined by Lasker (1960).

Data with which the present findings might be compared are very limited. We have referred already to the only pertinent data on Brazilian Indians living at this cultural level, those of Ranke (1898). There is, of course, a larger material documenting the generally small size of primitive communities. However, we have not been able to locate any other studies of the consanguinity structure of hunters and gatherers. With respect to reproductive performance, although there is no want of generalizations concerning the "intermediate" family size among hunters and gatherers (summaries in Carr-Saunders, 1922;

Krzywicki, 1934), there is a dearth of solid quantitative data. In general, those tribes for which similar data are available either displayed far greater evidences of social disruption than the Xavantes or could be inferred to have been rapidly declining in numbers, or both. See, for instance, the data of Boas (1895) on the Indians of British Columbia. With respect to the only other hunting and gathering groups thus far studied in this fashion, the Australian aborigines, the only precise early data appear to be those of Grey (1841) who records an average of 4.6 children for 41 postmenopausal women. The later careful data of Sharp (1940) indicate birth and survival rates well below replacement levels, with the inference that it may now be too late to study "natural" reproduction in this group. With respect to infant and childhood mortality, the complications introduced by the widespread but unequal practice of infanticide, as well as losses in war, make comparisons from tribe to tribe very difficult, although, considering the relative stability or slow increase in population numbers among primitives, one may presume that about half the children born failed to reproduce. Our own data simply do not permit a final figure in this respect. There is (or was) a striking similarity in the polygamy structure of the Xavante and some of the Australian aborigines (Sharp, 1940; Hart and Pilling, 1960; see also Coon, 1962). On the other hand, none of the Australian aborigines seem to display the degree of isolation (and, by inference, inbreeding) encountered in the Xavante (Tindale, 1953). There is also a deficiency of data for the next level of human culture, i.e., relatively undisturbed, non-reservation, primitive agriculturalists and pastoralists. Of particular relevance in this connection are the New Guinea tribes, for whom data are just now becoming available. Interestingly, among the Kapauku the mean number of births reported by postmenopausal women is only 5.2 (Couvée, 1962b).

## VI. MATING PATTERN AS REVEALED BY THE STUDY OF MORPHOLOGICAL TRAITS AND GENETIC MARKERS

Both the popular and scientific literature pertaining to the Indian tribes of Brazil contain numerous references to the looseness of the marital bonds (e.g., Oberg, 1953; Huxley, 1957; Murphy, 1960; and Cowell, 1961; see also *Handbook of South American Indians,* J. H. Steward, ed.). Since a primary objective of the study was an evaluation of the feasibility of an analysis of mating structure, it was felt imperative that genetic systems be utilized for parentage exclusions as extensively as possible.

However, the use of serotyping in this context places on the laboratory requirements for accuracy far in excess of those which would be considered acceptable for simple gene frequency studies. Osborne (1958) has pointed out that when identical blood specimens are submitted under very favorable conditions to two highly qualified blood grouping centers, the percentage of individuals for whom discrepancies are reported varies from approximately 1 per cent for the antigens of the ABO and Rh systems through 8 to 16 per cent for the MN, Duffy, Kell, and $Le^a$ antigens to 19 per cent for the S antigen of the MNSs system, and 41 per cent for the P antigen. Ellis, Cawley, and

Lasker (1963) have presented data indicating similar discrepancies between two laboratories, although no precise tabulation is given. Livingstone *et al.* (1960) have presented evidence to this effect of a somewhat different nature, namely, the apparent differences in gene frequencies which result when responsibility for the blood grouping in a population study is transferred from one competent laboratory to another, with the added complication that the blood specimens had been en route to the laboratories for as much as a week. The principal discrepancies were encountered with the $A_1$ and $A_2$ subgroups of the ABO system, the Duffy, and the P systems. Similar interlaboratory differences have occurred in connection with animal blood grouping studies where the reagents employed varied from laboratory to laboratory (Kiddy and Hooven, 1961). Under unfavorable circumstances, the error even for the ABO groups may run as high as 9 per cent (Cohen, Neel, and Gershowitz, 1962). The term "error" as used here includes mislabeling of specimens and improper entries in the protocol as well as actual laboratory error. In medicolegal parternity studies, usually carried out with fresh blood and unusual care, it is customary to repeat all results pointing to an exclusion and to run parallel studies in two laboratories. This is a tacit recognition of the possibilities for error.

Errors of the order of 1 or 2 per cent have relatively little impact on the estimation of gene frequencies. However, they have a very powerful impact on the question of usefulness of blood groups in analyzing human mating systems. Thus, even with an error as low as 2 per cent, the probability of no error when an individual is typed with respect to seven systems is $0.98^7$, or 0.87. The probability of no error for a father-mother-child combination is $0.87^3$, or 0.66. Although many of these errors would not result in an exclusion, a sufficient number would be critical to render any conclusions regarding mating structure highly suspect.

The differing conditions under which bloods were tested in Rio de Janeiro and Ann Arbor and the differences in the state of the bloods as studied in the two cities have already been described. In table 27 are summarized the differences in the results of the typings of the specimens examined in the two laboratories. No discrepancies were encountered with respect to the following antigens: K, k, $Kp^a$, and $Kp^b$ of the Kell system; N of the MNSs system; and D and E of the Rh system. The $Di^a$, $Lu^a$, and f and V of the Rh system were not retested. For the systems in which discrepancies were encountered, the frequency ranges from 1 in 56 for the c antigen to 19 in 56 for the P antigen. The similarity of these findings to those reported by Osborne (1958) is striking. Valid reasons can be identified for at least some of these discrepancies, as follows:

*Discrepancies with anti-P:* These were all in one direction. Nineteen samples found negative in Rio de Janeiro were found positive in Ann Arbor. The reasons for these disagreements would appear to be (1) the serum used in Ann Arbor was "stronger," being a mixture of the commercial (human) serum used in Rio de Janeiro with a human antiserum prepared by Dr. Henry Gershowitz and (2) in Ann Arbor, after cold incubation, the bloods were spun in a refrigerated centrifuge and read immediately.

*Discrepancies with anti-$Fy^a$ and $Jk^b$:* With the antibodies for the detection of the $Fy^a$ and $Jk^b$ antigens the problems were the same as with the anti-P serum. A number of samples which gave doubtful (±) results in Rio de Janeiro were negative in Ann Arbor. But, in addition, a larger number of specimens found negative in Rio de Janeiro were

TABLE 27. DISCREPANCIES BETWEEN THE BLOOD GROUP DETERMINATIONS PERFORMED IN RIO DE JANEIRO AND IN ANN ARBOR

The ± differences with respect to the $Fy^a$ and $Jk^b$ reactions have not been considered as discrepancies. Further explanation in text.

| | s | | S | M | | P | $Fy^a$ | | $Jk^b$ | | C | c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rio de Janeiro | − | + | + | − | + | − | − | ± | − | ± | − | − |
| Ann Arbor | | | | | | | | | | | | |
| + | 5 | | | 1 | | 19 | 8 | | 8 | | 2 | 1 |
| − | | 1 | 2 | | 1 | | | 5 | | 3 | | |
| Total | 6/56 | | 2/56 | 2/56 | | 19/56 | 8/56 | | 8/56 | | 2/56 | 1/56 |

definitely positive in Ann Arbor. The finding of discrepancies in these two systems is not unexpected; it is well known that in these systems the Coombs test reactions, which involve non-gamma globulin components, are variable and weak.

*Discrepancies with anti-s:* Five S+ individuals who appeared s− in Rio de Janeiro were found to be s+ in Ann Arbor, i.e., to be Ss in phenotype. The weakness of the s reaction in some Ss individuals was pointed out by Levine et al. (1951).

*Discrepancies with anti-C:* Two bloods, negative in Rio de Janeiro, were weakly positive in Ann Arbor. These two specimens were retyped with eight different anti-C sera. With three antisera they yielded a weakly positive reaction; with the five other antisera the reactions were definitely positive. These different strengths of agglutination suggest the possibility of a variant of the C antigen rather than a real discrepancy between the laboratories.

It should be noted that in at least one respect, the above described procedures do not provide a fair appraisal of interlaboratory discrepancies. In a number of instances, the serologist in Rio de Janeiro was asked to work with test sera he had not previously employed. Every experienced serologist recognizes the necessity of becoming familiar with the characteristics of specific sera. The discrepancies which we present could probably be decreased were the serologists of the two laboratories able to work together with the same test sera for a period before the separate tests were conducted in the two laboratories. But it is not certain that one would then have an unbiased approach to the possibility of error in serological testing. At any rate, the results of the Ann Arbor typings have been accepted in the final assignment of phenotype given in table 15. There is, of course, an element of arbitrariness in this procedure.

With respect to parentage exclusions, the following information is available. Among 16 instances where the blood types of both parents and a child were available, there were no exclusions. Among 13 instances where only one parent and a child were available, there was one apparent exclusion, an $R_1R_1$ child with an $R_2R_2$ father. However, the mother (not tested) had been married previously; this was the oldest child attributed to this second marriage. Furthermore, a half-sibling of this child, offspring of the first marriage, was also $R_1R_1$. Information is not available on how soon after the second marriage this apparent exception was born. We consider it quite possible he was conceived during the first marriage, so that no true exclusion is involved. The data then are consistent with a rather strict observance of the marital bonds in this group. However, the weight to be attached to this statement is a function of the probability of detecting nonpaternity, a probability which has not yet been computed because of the limited data available and the complication introduced by high and poorly defined levels of inbreeding (cf. MacCluer and Schull, 1963).

There appear to be no comparable data regarding parentage exclusions in other tribes of this cultural level. However, Fernandes *et al.* (1957) have presented data for a group of the semi-acculturated Caingangs, living in southern Brazil near Palmas, state of Parana. Here there appear to be two exclusions among 21 parent-child combinations, although no attempt was made to confirm these by repeated typings (Junqueira, personal communication).

Because of the presence in the group of a physical anthropologist thoroughly familiar with the methodology of *Vaterschaftsbestimmungs*, the opportunity arose for a comparison, on a blind basis, of the usefulness under these conditions of parentage exclusion on the basis of morphological dissimilarities and on the basis of blood type incompatibilities. The application of the morphological approach requires first that parent-offspring and sibling correlations be known for all the physical traits under consideration. Unfortunately, in this case, the data are sparse, yielding only 59 pairs of allegedly full sibs, and 58 allegedly parent-offspring combinations, with the resulting large errors of the correlation coefficients. Correlations were obtained not only for metric traits but, after a suitable transformation, for qualitative traits as well. The data will be presented in full elsewhere. Allowance must be made for the intercorrelations of some traits. For any specific parent-offspring combination, then, one proceeds to derive what is essentially a probability statement of the likelihood of encountering such an unlike parent and child in the population under consideration. The details of this *Trennlogarithmusmethode* have been fully described by Keiter (1957).

An unavoidable problem in this approach is that in the derivation of the various correlation coefficients, one assumes the correctness of the very biological relationships which one will later test. In a population with a high degree of discrepancy between legal and biological parentage, this could lower the correlations from which one must work. On the other hand, in view of the problems which can arise in the transport and deterioration of blood specimens, it is necessary in studies of this type to utilize as many approaches as possible to unraveling population breeding structure. In the present instance, it was the opinion of the anthropologist, utilizing the dermatoglyphics, 11 measurements, and 41 physiognomic features which could be graded, that no discrepancies between parent and alleged child were encountered which, in a European setting, would be large enough to result in a rejection of parentage. In this connection, it will be recalled that the "variability" in this population is similar to that in a European population. Unfortunately (from the standpoint of the comparison), there were also no clear exclusions on the basis of the blood groups. Thus, while it is gratifying to have agreement between the two methods, this was not the critical comparison it might have been.

## VII. HEALTH OF THE XAVANTES: THE RESULTS OF PHYSICAL EXAMINATIONS

Physical examinations were performed on a total of 78 Indians of all ages. An additional three children were examined but were so young and frightened or unco-operative that the results were thought unreliable and not recorded. Each Indian was carefully inspected for obvious disease; this was followed by a detailed examination of the eyes, oral cavity, chest, and abdomen. We shall first describe the findings with respect to those organ systems for which certain objective measurements were obtained and then proceed to general impressions. For purposes of summary, three age groupings have been recognized: youths (approximately 0–14 years), adults (approximately 15–30 years), and elders (older than 30 years).

There has been only one previous medical study of these Indians, undertaken in 1954 by Dr. A. Sadock de Freitas, under the auspices of the Indian Protective Service. Although the physical examinations were apparently limited, largely confined to palpation for the spleen, he did derive data on malaria and intestinal parasites. Differences in the numbers examined for the various traits are due either to omission of the very young from certain examinations or unco-operativeness.

*Eyes*

The eyes were inspected, and ophthalmoscopic examinations and tests for color vision and visual acuity were performed where possible. No mydriatic was employed. Significant eye pathology was encountered in five individuals. One adult female showed a severe chronic conjunctivitis on the right; one elderly female had marked bilateral pterygia; one adult female had extensive corneal scarring with loss of vision in the left eye, attributed to damage from a flesh-fly maggot when she was a child; one elderly female had dense bilateral corneal clouding with superficial vascularization and severe visual loss, of gradual onset after marriage; and one elderly female showed marked post-traumatic scarring of the left cornea with significant visual loss. Two of the elderly individuals, one male and one female, had definite cloudiness of the lens. No significant retinal pathology was encountered. Visual acuity was tested with a Snellen Illiterate E chart at 20 feet, both eyes being tested simultaneously. There appeared to be a marked difference in the ability of males and females to grasp the instructions, the males responding quickly and indicating the position of the letter with firm, incisive gestures, the females appearing confused, easily distracted, and indicating the position of the letter with vague gestures. Many of the tests on females were felt to be unsatisfactory, and the results were not recorded. The results of the apparently satisfactory tests are summarized in table 28. No severe (bilateral) visual defects were encountered in either sex other than in the individuals with eye pathology described above. The difference between the performance of the males and females is striking. This would appear to be primarily cultural in origin. The performance of the adult males can only be described as superb, 12 out of 13 testing 20/15 or 20/10. However, in evaluating this finding, it must be remembered that performance on visual acuity tests is generally better with the illiterate than the literate chart.

Mattos (1958) has published data on the visual acuity of 290 Brazilian Indians belonging to some eight different tribes in various stages of acculturation. With respect to the groups most similar to our subjects (Cayapo, repre-

TABLE 28. THE RESULTS OF PHYSICAL EXAMINATIONS OF 78 XAVANTE INDIANS

| Age range | Sex | Visual acuity: No. tested | Acuity 20/30 | Acuity 20/20 | Acuity 20/15 | Acuity 20/10 | Dental caries: No. examined | No. caries free | No. with caries | Mean no. of caries in carious | Pulse: No. examined | Pulse: $M \pm \sigma$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–14 | M | 7 | 1 | 1 | 2 | 3 | | | | | 13 | 86.8 ± 19.6 |
| | F | 8 | 3 | 4 | 1 | 0 | | | | | 18 | 88.9 ± 23.6 |
| 15–30 | M | 13 | 0 | 1 | 7 | 5 | 15 | 13 | 2 | 1.5 | 15 | 71.0 ± 10.0 |
| | F | 14 | 5 | 7 | 1 | 1 | 21 | 15 | 6 | 2.2 | 21 | 75.3 ± 8.1 |
| 31– | M | 4 | 1 | 1 | 1 | 1 | 4 | 1 | 3 | 1.7 | 4 | 57.0 ± 6.8 |
| | F | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 5 | 6.0 | 6 | 71.3 ± 6.9 |

| Age range | Sex | Blood pressure: No. examined | Blood pressure: $M \pm \sigma$ | Grade 1 systolic murmur: No. examined | Murmur present | Splenomegaly: No. examined | 0.5–4.0 cm b.m.c.m.* | > 4 cm b.m.c.m. | Hepatomegaly: No. examined | 0.5–2.0 cm b.m.c.m. | > 2 cm b.m.c.m. | Uterus ≥ umbilicus: No. examined | Pal-pable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–14 | M | 8 | 93.3 ± 9.6 / 57.0 ± 5.5 | 12 | 0 | 13 | 1 | 0 | 13 | 2 | 0 | | |
| | F | 12 | 106.7 ± 7.0 / 66.0 ± 6.8 | 19 | 3 | 19 | 0 | 4 | 19 | 3 | 2 | | 0 |
| 15–30 | M | 15 | 115.3 ± 8.0 / 66.0 ± 8.0 | 15 | 1 | 15 | 1 | 1 | 15 | 1 | 1 | | |
| | F | 21 | 107.0 ± 8.9 / 62.4 ± 8.0 | 21 | 9 | 21 | 5 | 3 | 21 | 3 | 7 | 21 | 5 |
| 31– | M | 4 | 116.5 ± 11.5 / 64.5 ± 9.0 | 4 | 0 | 4 | 0 | 0 | 4 | 0 | 2 | | |
| | F | 6 | 110.0 ± 8.8 / 68.7 ± 8.4 | 6 | 2 | 6 | 0 | 0 | 6 | 2 | 0 | | 0 |

*Below mid-costal margin.

sentatives of the Xingú tribes, and Xavantes from Xavantina), among 77 males of an estimated age greater than 9 years, 55 had an acuity of 20/15 or better. Although this is a less impressive performance than we encountered, it is still very good. The only other data on hunters and gatherers seem to be those of Mann (1957) on the Australian aborigines. Because Mann's data on visual acuity in Australians are presented for the sexes combined, and because of a high prevalence (46 per cent) of trachoma in this group, the data cannot be readily compared with our own. It is noteworthy, however, that of the 146 individuals of all ages tested, 62 had vision of 9/5 or better in the best eye. Keen vision has two principal components, namely, a learned component, consisting of ability to recognize visual clues the uninitiated would miss, and a component based on true visual acuity, in which training plays a smaller (and ill-defined) role. It is, of course, the second component which is being measured here. The results suggest that the storied keen vision of the Indian, although undoubtedly in part the result of familiarity with the terrain and its contents, also has a firm physiological basis.

Post (1962a, 1962b) has recently summarized the literature on color vision and visual acuity among peoples with long and short histories of civilization and drawn attention to the lower frequency of myopia and defective color vision in the latter. None of the 28 Xavante males and 38 females tested had defective color vision. Defects of color vision were very infrequent in the Australian aborigines (see Mann and Turner, 1956).

*Oral Cavity*

No significant malocclusion was encountered, although two persons exhibited a slight degree of anterior crowding of the teeth. One 15-year-old female exhibited a supernumerary left upper premolar, and two individuals, a 17-year-old female and a 19-year-old male, each possessed a very small third molar. Although there was marked abrasion and staining of the teeth, and a mild degree of pyorrhea alveolaris was common, there was a remarkable absence of obvious caries. Thus, considering only adults with 28 to 32 teeth, 13 of the 16 adult males and 15 of the 21 females were caries free. Since dental X-rays were not obtained, these are, of course, minimal figures. The findings in the remaining persons are summarized in table 28. Caries were, as expected, more frequent in the elders, but much less common than in the Brazilians of this region who were examined incidentally during the course of this study. In some instances, it was difficult to be certain whether a defect in a tooth was a carious lesion or the result of trauma to the tooth. Mottling of the enamel suggestive of chronic fluorosis was not encountered. No significant disease of the oral cavity (other than caries) was noted. Again, the difference between the findings in males and females is noteworthy.

The low frequency of dental caries and malocclusions in primitive peoples has been the subject of repeated comments (reviews in Price, 1939; and Finn, 1952). Although there are groups, such as the Ibos of Nigeria (Tabrah, 1962), with lower frequencies of carious lesions than the Xavantes, the observed frequencies are comparable to those reported for Australian aborigines who have not been exposed to European foods (cf. Campbell, 1938, 1939; Barrett, 1953; Campbell and Barrett, 1953; Cran, 1955; Davidson, 1957; Heithersay, 1959).

*Cardiovascular System*

Blood pressures were obtained with subjects prone, using a Tycos certified cuff. Because of the known shifts in pulse rate and blood pressure during infancy and childhood, and the relatively few examinations, no generalizations concerning the findings in this age group seem indicated. However, it is clear from table 28 that the adults are characterized, by Caucasian standards, by relatively slow pulses and low (prone position) blood pressures, the more so if one grants that the examination procedures may have elicited moderate anxiety in some. Similar low pressures have been reported in a variety of primitive, tropical, and subtropical populations (review in Kean and Hammill, 1949) including Australian aborigines (Hicks and Matters, 1933; Nye, 1937; Casley-Smith, 1959a; Abbie and Schroder, 1960; van Dongen, Davivongs, and Abbie, 1962), the Kapauku of the New Guinea Highlands (Couvée, 1962a), the Camayura, Calapolos, Mundurucu, and Carajá Indians of Brazil (de Lima, 1950; Lowenstein, 1961), and the San Blas Indians of Panama (Kean, 1944). No cardiomegaly or disorders of cardiac rhythm were encountered. Faint (grade 1) systolic murmurs, usually apical and "non-organic" in quality, were heard in 14 of the 46 females examined, distributed by age as shown in table 28. Only 1 of the 31 males was found to have a similar murmur. The sex difference is again of note. The fact that the murmurs were of the type sometimes termed hemic will be considered when the results of the hemoglobin determinations are presented.

*Pulmonary System*

Auscultation of the lungs revealed two individuals with coarse rhonchae in both lung fields, both with upper respiratory infections, and two other individuals with widespread asthmatic wheezes bilaterally, one of whom was said by the Indian agent to have had pneumonia the preceding winter.

*Abdomen*

As shown in table 28, palpable spleens were encountered in 15 of 78 persons, 12 of the 15 being females. Palpable livers were encountered in 23 of 78 persons, 17 of whom were females. Sadock de Freitas (1955) in his earlier study of these Indians reported only one palpable spleen among 91 individuals examined. The present findings contrast rather sharply with those of Schaad (1960) among the Trios and Oayana Indians of Surinam, where 56 of 59 males and 55 of 63 females had splenomegaly. Finally, 5 of the 21 females in the 15–30 age group had uteri at or above the level of the umbilicus. Assuming that on the average (as in Caucasians) the uterus does not reach the level of the umbilicus until the completion of the sixth month of pregnancy, it follows that for every detected pregnancy there was on the average at least one undetected. The resulting pregnancy "rate" of 10/21 when placed on an annual basis would indicate for this age group a pregnancy every other year during the fertile period.

One birth occurred during the course of this study. The mother, a 20-year-old para 1 gravida 2, was seen some 4 hours prior to delivery, with complaints of malaise, chills, fever, backache, and a profuse epistaxis the preceding evening. Labor pains were denied, and no sustained uterine contractions were felt on palpation of the abdomen. Nevertheless, she delivered some four hours later. The mother brought the child to be examined at two days of age because of an extensive cephalohematoma and failure to nurse well. The cephalohematoma extended as low as the ears, but the child appeared otherwise normal and weighed 2.5 kg. The child died the following day, never having established a normal nursing pattern. The sequence of events and findings suggest intracranial damage secondary to a precipitous delivery. This isolated case raises the obvious question of how often the rapid, easy labor of primitive women is to the detriment of the child. As an aside, the fact that one of us (J. V. N.) had palpated that abdomen only a few hours before the unfortunate event led to suspicions of sorcery which for several days threatened the completion of the medical examinations.

*General*

Among the youths, a high proportion of the very young exhibited rhinitis, conjunctivitis, and scalp infections, the latter in one case amounting to an extensive carbuncle. In addition to the regional lymphadenopathy expected with such infections, two infants with no signs of current major infection of the head or neck exhibited very firm unilateral submandibular tumors, 2–3 cm in diameter, thought to be enlarged lymph nodes. One child, aged 4, had severe bilateral club foot. Three young children had patches of reddish hair, the discoloration more pronounced in the distal portion of the hair than near the scalp. Although this discoloration is similar to that seen in Africans with kwashiorkor, there were no alterations in skin pigmentation, no manifestations of vitamin deficiency, and certainly none of the apathy and edema that characterize the more advanced cases of kwashiorkor. One of these children, approximately one year of age, was still nursing (with no younger siblings), a further argument against kwashiorkor. It seems necessary to regard this as normal variation. A similar tendency for the young to exhibit depigmentation of the distal hair has been reported for Australian aborigines, where the phenomenon is apparently much more marked (review in Birdsell, 1950; Abbie and Adey, 1953). Finally, one child approximately 4 years old was encountered who could be a "problem child" in any culture—antagonistic, unco-operative, given to temper tantrums.

With respect to adults, in addition to the findings already described, several comments are in order. One female, aged 18, was alleged by the Xavantes to be subnormal mentally; our contacts neither confirm nor deny this possibility. One female, aged 26, who gave a history of chills and fever one month previously, and who had hepato- and splenomegaly, was observed to have a diffuse, firm, slightly tender but not hot, induration of the left buttock. The

Indian Agent observed that this was a rather common problem in the Xavantes and, if untreated, was followed by increasing swelling, marked tenderness, redness, local warmth, and, in some cases, pointing, and discharge of pus. Other cases regressed without local drainage. The lesion was said to respond to penicillin. It appears to correspond to tropical myositis or pyomyositis as described by Adams and Maegraith (1960) and Manson-Bahr (1960).

The general impression of the men was of exuberant health and vitality. They were erect in carriage, deep-chested, and very well muscled, with a notable absence of adiposity. Excellent pictorial documentation of this statement will be found in the semi-popular account of Blomberg (1960). By contrast, the women, although in apparent good health and nutrition when young, gave an impression of early aging, an impression more than sustained by the results of the physical examinations. Indeed, one of the most striking impressions of this study was of the different medical worlds of men and women.

With respect to the elders, too few were seen to permit generalizations. This fact is in itself quite remarkable, since the excellent physical condition of the adult males would have led one in general to predict survival to a relatively advanced age. Elsewhere (p. 60), we have discussed the high probability of violent death among these Indians. "Natural" death must be rare among this group. Since relatively few males or females appear to live beyond the age of 40, selection is primarily toward traits manifested from age 20 to 40. In view of the early age at which a village chief usually assumes office, there may be selection for early maturity in qualities of leadership, a fact to be borne in mind in contrasting the selection pressures in such societies and in our own Western culture. Should these leadership traits happen to carry with them an increased liability of later development of chronic, degenerative, or constitutional diseases, this is a price populations of this type do not have to face.

There is a marked similarity between these medical observations and the somewhat less systematic observations of Ranke on the neighboring Xingú tribes some 65 years ago. He states that among some 800–1000 Indians seen in ten different villages, there was one individual with bilateral club foot and two who were idiots. We, too, observed one child with club foot and one alleged mental defective. Since the death rate among children with these entities must be high, possibly these are relatively common problems in this region. Our combined observations suggest that defective children are not subject to infanticide. Ranke also records numerous furuncles, with a high frequency in the gluteal region, which we take to be similar to the tropical pyomyositis we encountered. Neither Ranke nor we saw evidences of syphilis or tuberculosis. In short, the scanty evidence suggests that Xavante reflect the state of health of "uncontaminated" primitive hunters and gatherers.

## VIII. HEALTH OF THE XAVANTES: BIOCHEMICAL AND MORPHOLOGICAL STUDIES OF BLOOD

Where the quantity of blood permitted, a number of biochemical and morphological determinations were performed. The results are summarized in tables 29 and 30. The precise choice of procedures was dictated by the presumed value of the determination, its feasibility under the circumstances and the availability of comparable material from other studies.

*Plasma Cholesterol*

A voluminous literature exists relating the cholesterol and lipoprotein levels and types in the blood plasma to the frequency of atherosclerosis and coronary heart disease. Although the control of cholesterol level is complex, key factors appear to be total caloric intake and proportion of calories contributed by fat, especially fat of animal origin. One of us (Neel, 1958) has elsewhere developed the thought that changing dietary and living habits are resulting in increased selective pressures against individuals with relatively limited abilities to metabolize animal fat. The cholesterol values of the Xavantes are thus of unusual interest.

Total and free cholesterol were determined by the method of Connerty, Briggs and Eaton (1961a, 1961b). The findings are summarized in table 29. A decision concerning the validity of the apparent age and sex differences must await the collection of further data. However, in the total material, the observed values are relatively low by contemporary European and American standards, the more so since these are not "fasting" values, the bloods having been drawn ordinarily between mid-morning and mid-afternoon. Similar low values have been observed in a variety of other groups, especially agriculturalists with low intakes of animal protein living under tropical and subtropical conditions (references in Bronte-Stewart, Keys and Brock, 1955; Mann, Nicol and Stare, 1955; Shaper and Jones, 1959; Juillan and Bats-Maillet, 1960; Luyken and Jansen, 1960; Luyken and Luyken-Koning, 1960; Scrimshaw *et al.*, 1961; Couvée, Nugteren and Luyken, 1962; Mathur, Wahi and Sharma, 1962; and Méndez, Tejada and Flores, 1962). Since in a number of these groups there was clinical and biochemical evidence of borderline or frank nutritional deficiencies, the apparently good nutritional status of the Xavantes seems worth emphasizing again, a clinical impression born out by the state of the plasma proteins (see below). Studies on the cholesterol levels of other hunters and gatherers with as little agriculture as the Xavantes are sparse. However, Luyken and Luyken-Koning (1960) have reported that among 33 male and female Trios and Oayana Indians of Surinam the total cholesterol values were very similar, 151 $\pm$ 27 mg/100 ml, whereas for 24 nomadic Pintubi Australian aborigines it was distinctly higher (211.7 $\pm$ 4.4 mg/100 ml; Schwartz and Casley-Smith, 1958). The observation that the tribesmen of Somali, who live almost entirely on lipid-rich camel's milk, also have low cholesterol values suggests that much more than diet alone is involved in the determination of these low cholesterol values (Lapiccirella *et al.*, 1962).

Thus far, we have found no other studies of free cholesterol either in tropical agriculturalists or hunters and gatherers. The values given in table 30 are low by European and American standards; furthermore, the percentage of the total which these values comprise (ca. 20 per cent) may be somewhat lower than the commonly accepted figure of 25 to 30 per cent (review in Cook,

TABLE 29. THE FINDINGS OF THE HEMATOLOGICAL AND BIOCHEMICAL STUDIES

Where there is no entry there was insufficient plasma for the determination.

| Individual no. | Parents | Sex | Est. age (years) | Hgb. (g/100 ml) | Est. WBC | Differential (%) PMN | L | M | E | B | Total protein (g/100 ml.) | Protein electrophoresis (g/100 ml) Alb. and $\alpha_1$ fractions | $\alpha_2$ | $\beta$ | $\gamma$ and fibrinogen | Total cholesterol (mg/100 ml.) | Non-esterified cholesterol (mg/100 ml.) | % of total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| II 10 | I 4, 3 | M | 26 | 13.1 | Normal | 31 | 40 | 8 | 19 | 2 | 7.3 | 3.92 | 0.45 | 0.87 | 2.07 | | | |
| 29 | I 9, 10 | F | 50 | 12.2 | Normal | 55 | 29 | 3 | 13 | | 8.8 | 3.32 | 0.65 | 0.88 | 3.95 | 211 | 51 | 24 |
| 33 | I 13, 14 | M | 60 | 13.2 | Normal | 52 | 26 | 5 | 17 | | 8.2 | 3.96 | 0.30 | 0.98 | 2.95 | 128 | 32 | 25 |
| 38 | I 11, 12 | F | 40 | | Normal | 39 | 30 | 6 | 23 | 2 | | | | | | | | |
| 42 | I 13, 14 | F | 65 | 10.4 | Normal | 57 | 33 | 6 | 1 | 3 | 9.3 | 3.00 | 0.59 | 0.89 | 4.81 | 112 | 31 | 28 |
| 52 | I 20, 19 | F | 48 | 11.9 | Normal | 40 | 33 | 12 | 13 | 2 | 9.2 | 4.66 | 0.48 | 0.82 | 3.24 | 198 | 29 | 15 |
| 60 | I 20, 21 | M | 39 | 12.1 | Low | 18 | 45 | 9 | 28 | | 8.9 | 4.12 | 0.47 | 0.46 | 3.84 | 128 | 18 | 14 |
| 61 | | F | 18 | 11.5 | Normal | 30 | 35 | 4 | 31 | | 8.8 | 5.04 | 0.46 | 0.54 | 2.76 | 160 | 26 | 16 |
| 63 | I 22, 23 | M | 17 | 14.6 | Normal | 62 | 24 | 6 | 8 | | | | | | | | | |
| III 6 | II 12, 13 | M | 12 | 12.7 | Normal | 39 | 33 | 6 | 22 | | 8.0 | 3.60 | 0.58 | 0.79 | 3.04 | 142 | 24 | 17 |
| 8 | II 15, 16 | F | 10 | 12.9 | Normal | 44 | 30 | 3 | 23 | | 7.5 | 4.42 | 0.51 | 0.67 | 1.91 | | | |
| 17 | II 18, 17 | F | 40 | 12.2 | Normal | 56 | 28 | 3 | 13 | | 8.5 | 4.84 | 0.37 | 0.54 | 2.75 | | | |
| 18 | II 18, 17 | M | 35 | 13.6 | Normal | 30 | 38 | 5 | 27 | | 7.7 | 3.90 | 0.64 | 0.85 | 2.32 | 178 | 42 | 24 |
| 22 | II 33, 23 | F | 12 | 10.1 | Normal | 32 | 25 | 13 | 30 | | 7.6 | 3.77 | 0.43 | 0.93 | 2.48 | 134 | 36 | 26 |
| 27 | II 33, 25 | F | 15 | 10.6 | High | 62 | 17 | 6 | 12 | 3 | 7.2 | 3.64 | 0.67 | 1.04 | 1.86 | 229 | 51 | 22 |
| 29 | II 33, 27 | M | 21 | 14.6 | Normal | 36 | 41 | 9 | 13 | 1 | 8.1 | 5.05 | 0.58 | 0.60 | 1.88 | | | |
| 30 | II 33, 27 | M | 17 | 12.7 | Normal | 50 | 28 | | 22 | | 7.1 | 4.38 | 0.40 | 0.70 | 1.63 | 155 | 23 | 15 |
| 32 | II 33, 28 | M | 27 | 12.5 | Normal | 60 | 15 | 2 | 23 | | 8.6 | 4.09 | 0.54 | 0.73 | 3.23 | 88 | 28 | 32 |
| 38 | II 33, 29 | M | 28 | 13.2 | Normal | 40 | 36 | 6 | 17 | 1 | 7.9 | 4.01 | 0.69 | 0.71 | 2.51 | 178 | 35 | 20 |
| 41 | II 33, 29 | F | 27 | 13.5 | Normal | 43 | 38 | 4 | 15 | | 8.2 | 4.77 | 0.56 | 0.71 | 2.17 | 171 | 32 | 19 |
| 42 | II 33, 29 | M | 21 | 12.7 | High | 43 | 16 | 9 | 31 | 1 | 8.1 | 4.15 | 0.40 | 0.62 | 2.94 | 101 | 14 | 14 |
| 43 | II 33, 29 | M | 19 | 13.4 | Normal | 44 | 40 | 6 | 10 | | 7.8 | 4.86 | 0.39 | 0.51 | 2.03 | 134 | 21 | 16 |
| 44 | II 33, 29 | M | 17 | 10.7 | Normal | 65 | 23 | 3 | 9 | | 7.5 | 3.89 | 0.34 | 0.60 | 2.67 | 86 | 15 | 17 |
| 45 | II 33, 29 | F | 13 | 10.3 | Normal | 47 | 41 | 1 | 11 | | 8.8 | 4.36 | 0.32 | 0.77 | 3.36 | 86 | 21 | 24 |
| 46 | II 33, 29 | M | 10 | 11.7 | Normal | 38 | 38 | 6 | 18 | | | | | | | | | |
| 47 | II 34, 30 | F | 26 | 10.6 | Normal | 48 | 30 | 8 | 14 | | 8.4 | 3.88 | 0.84 | 0.93 | 2.78 | 227 | 48 | 21 |
| 48 | II 34, 30 | M | 20 | 14.2 | Normal | 52 | 18 | 3 | 27 | | 8.4 | 5.66 | 0.39 | 0.55 | 1.81 | 153 | 35 | 23 |
| 49 | II 34, 30 | F | 17 | 6.0 | Low | 70 | 24 | – | 6 | | 8.7 | 3.97 | 0.55 | 1.04 | 3.15 | 74 | 12 | 16 |
| 50 | II 34, 30 | F | 9 | 8.7 | Normal | 21 | 34 | 4 | 40 | 1 | 8.3 | 3.80 | 0.46 | 0.66 | 3.37 | 152 | 31 | 20 |
| 51 | II 34, 30 | M | 10 | 11.5 | Low | 29 | 42 | 14 | 14 | 1 | 8.8 | 4.59 | 0.51 | 0.62 | 3.11 | 164 | 39 | 24 |
| 52 | II 31, 32 | F | 20 | 12.2 | Normal | 35 | 22 | 5 | 38 | | 8.8 | 4.09 | 0.70 | 0.81 | 3.19 | 136 | 31 | 23 |
| 53 | II 31, 32 | M | 22 | 13.8 | High | 67 | 14 | 6 | 13 | | 7.7 | 4.50 | 0.47 | 0.68 | 2.05 | | | |
| 59 | II 39, 38 | F | 17 | | Normal | 32 | 49 | 7 | 12 | | | | | | | | | |
| 60 | | M | 21 | 11.7 | Low | 51 | 26 | 6 | 16 | 1 | 8.2 | 5.48 | 0.41 | 0.57 | 1.75 | 108 | 24 | 22 |
| 64 | | F | 15 | 9.9 | Normal | 41 | 49 | 6 | 4 | | 7.8 | 4.06 | 0.23 | 0.46 | 3.05 | 119 | 27 | 23 |
| 68 | II 39, 41 | F | 26 | 10.6 | Normal | 55 | 29 | 7 | 8 | 1 | 9.3 | 2.84 | 0.69 | 0.94 | 4.84 | 155 | 33 | 21 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 69 | II 39, 41 | F | 20 | 12.5 | Normal | 55 | 29 | 2 | 14 | | 7.8 | 3.50 | 0.63 | 1.15 | 2.53 | 252 | 67 | 27 |
| | 70 | II 39, 41 | F | 17 | 11.2 | Normal | 59 | 28 | 3 | 10 | | 7.2 | 3.48 | 0.52 | 1.29 | 1.92 | 182 | 46 | 25 |
| | 73 | II 45, 44 | F | 12 | 11.9 | Normal | 34 | 47 | 1 | 18 | | 8.0 | 4.58 | 0.88 | 0.81 | 2.23 | 123 | 33 | 27 |
| | 75 | II 45, 52 | M | 10 | 12.6 | Normal | 40 | 40 | 5 | 15 | | 8.1 | 4.60 | 0.52 | 0.80 | 2.20 | 164 | 32 | 20 |
| | 77 | | F | 14 | 12.2 | High | 62 | 22 | 8 | 8 | | 8.1 | | | | | | | |
| | 79 | I 16, 17 | F | 18 | 12.6 | Low | 40 | 36 | 6 | 18 | | | | | | | | | |
| | 80 | I 16, 17 | F | 17 | 10.6 | Normal | 73 | 21 | 5 | 1 | | 6.5 | 3.79 | 0.55 | 0.70 | 1.47 | | | |
| | 82 | II 45, 52 | M | 28 | 12.3 | Normal | | | | | | 7.8 | 4.58 | 0.35 | 0.75 | 2.13 | 152 | 27 | 18 |
| | 83 | II 45, 52 | F | 32 | 12.5 | Low | 49 | 35 | 6 | 10 | | 8.2 | 5.08 | 0.33 | 0.62 | 2.16 | 134 | 18 | 13 |
| | 89 | II 46, 47 | M | 40 | 13.3 | High | 43 | 24 | 7 | 26 | | | | | | | | | |
| | 92 | II 48, 49 | F | 10 | 9.9 | Low | 31 | 42 | 13 | 14 | | 9.1 | 3.42 | 0.46 | 0.69 | 4.52 | 157 | 32 | 20 |
| | 96 | II 50, 51 | F | 15 | 9.2 | High | 83 | 12 | 4 | 1 | | 7.1 | 3.00 | 0.59 | 0.74 | 2.78 | 141 | 25 | 18 |
| | 97 | II 50,51 | F | 17 | 11.5 | Normal | 28 | 45 | 5 | 22 | | 8.7 | 5.37 | 0.53 | 0.74 | 2.05 | 148 | 18 | 12 |
| | 99 | II 60,61 | F | 2 | 9.3 | High | 60 | 28 | 7 | 5 | | | | | | | | | |
| | 100 | II 60, 62 | F | 15 | 10.3 | Normal | 49 | 27 | 6 | 18 | | 8.6 | 4.37 | 0.41 | 0.84 | 2.96 | 151 | 28 | 19 |
| | 101 | II 60, 62 | M | 21 | 13.3 | Normal | 28 | 29 | 9 | 34 | | 7.9 | 3.77 | 0.41 | 0.58 | 3.14 | 138 | 29 | 21 |
| | 107 | II 65, III 90 | M | 17 | 13.9 | Normal | 58 | 25 | 2 | 15 | | 7.3 | 4.09 | 0.37 | 0.64 | 2.21 | | | |
| IV | 1 | III 9, 83 | F | <1 | 9.7 | High | 17 | 77 | 4 | 2 | | | | | | | | | |
| | 2 | III 2, 17 | F | 7 | 12.1 | Low | 68 | 27 | 2 | 3 | | | | | | | | | |
| | 3 | III 2, 17 | M | 10 | 12.5 | High | 46 | 28 | 6 | 20 | | 8.7 | 4.92 | 0.50 | 0.50 | 2.78 | 125 | 21 | 17 |
| | 4 | III 2, 17 | M | 9 | 12.4 | Normal | 44 | 20 | 2 | 34 | | 7.7 | 4.36 | 0.45 | 0.76 | 2.14 | 224 | 42 | 19 |
| | 5 | III 16, 17 | F | 20 | 10.6 | Normal | 39 | 28 | 5 | 28 | | 8.4 | 4.77 | 0.35 | 0.72 | 2.56 | | | |
| | 9 | III 38, 52 | F | <1 | 9.6 | Normal | 21 | 74 | 2 | 3 | | | | | | | | | |
| | 11 | II 60, III 41 | M | 7 | 10.7 | Normal | 27 | 35 | 2 | 36 | | 7.9 | 3.93 | 0.41 | 0.72 | 2.85 | 214 | 29 | 14 |
| | 14 | II 59, III 47 | F | 11 | 8.0 | Low | 34 | 43 | 21 | 2 | | 7.2 | 3.49 | 0.35 | 0.66 | 2.68 | 122 | 30 | 25 |
| | 15 | II 58, III 47 | M | 2 | 9.7 | Normal | 23 | 55 | 3 | 19 | | | | | | | | | |
| | 16 | III 48, 100 | F | <1 | 10.0 | High | 34 | 66 | | | | | | | | | | | |
| | 19 | III 54, IV 5 | F | <1 | | Normal | 43 | 40 | 8 | 9 | | | | | | | | | |
| | 20 | III 60, 59 | F | 2 | 10.9 | Normal | 33 | 51 | 8 | 8 | | | | | | | | | |
| | 21 | III 60, 59 | F | <1 | 11.5 | High | 27 | 54 | 4 | 15 | | | | | | | | | |
| | 22 | III 18, 68 | M | 4 | 11.6 | Low | 33 | 42 | 6 | 19 | | 7.2 | 3.91 | 0.45 | 0.71 | 2.15 | 173 | 32 | 18 |
| | 23 | III 18, 68 | M | 1 | 9.8 | High | 33 | 36 | 1 | 30 | | | | | | | | | |
| | 24 | III 18, 69 | F | 5 | 12.4 | | | | | | | 8.4 | 5.07 | 0.41 | 0.71 | 2.20 | 129 | 18 | 14 |
| | 25 | III 18, 69 | M | 2 | 10.6 | | | | | | | | | | | | | | |
| | 26 | III 72, 71 | F | 17 | 8.6 | Normal | 42 | 35 | 5 | 18 | | 6.4 | 2.90 | 0.45 | 0.75 | 2.30 | 202 | 38 | 19 |
| | 30 | III 72, 71 | F | 20 | 12.0 | Normal | 20 | 49 | 4 | 27 | | 8.0 | 3.92 | 0.38 | 0.63 | 3.08 | 117 | 42 | 36 |
| | 31 | III 78, 79 | F | 2 | 11.3 | High | 22 | 67 | 1 | 10 | | | | | | | | | |
| | 32 | III 82, 97 | M | 5 | 10.9 | | | | | | | | | | | | | | |
| | 33 | III 82, 97 | M | <1 | 12.0 | Normal | 25 | 64 | 1 | 10 | | | | | | | | | |
| | 34 | III 84, 83 | M | 17 | 13.8 | Normal | 43 | 43 | 9 | 4 | 1 | 8.1 | 5.35 | 0.32 | 0.51 | 1.94 | 104 | 24 | 23 |
| | 36 | III 84, 83 | F | 13 | 12.4 | Normal | 49 | 30 | 6 | 15 | | | | | | | | | |
| | 38 | III 86, 87 | M | 9 | 11.6 | High | 26 | 32 | 5 | 37 | | 7.9 | 4.58 | 0.46 | 0.60 | 2.27 | 135 | 24 | 18 |
| | 39 | III 89, 90 | M | 8 | 10.1 | Normal | 37 | 29 | 8 | 26 | | 7.7 | 4.14 | 0.40 | 0.90 | 2.27 | 120 | 28 | 23 |
| | 41 | III 89, 90 | F | 3 | 10.9 | | | | | | | 7.1 | 3.94 | 0.39 | 0.68 | 2.11 | | | |

TABLE 30. SUMMARY OF LABORATORY DATA

| Age range | Sex | Total cholesterol | | Free cholesterol | | Total plasma proteins and protein fractions (g/100 ml) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. tested | M ± σ | No. tested | M ± σ | No. tested | Total | Albumin and $\alpha_1$ | $\alpha_2$ | $\beta_1$ and $\beta_2$ | $\gamma$ and fibrinogen |
| 0–14 | M | 9 | 162.3 ± 37.1 | 9 | 30.1 ± 7.0 | 9 | 8.0 ± 0.50 | 4.3 ± 0.4 | 0.5 ± 0.03 | 0.7 ± 0.1 | 2.5 ± 0.4 |
| | F | 7 | 127.6 ± 23.6 | 7 | 28.6 ± 6.4 | 10 | 8.0 ± 0.66 | 4.1 ± 0.6 | 0.4 ± 0.07 | 0.7 ± 0.10 | 2.8 ± 0.9 |
| 15–30 | M | 12 | 127.1 ± 29.5 | 12 | 24.4 ± 6.9 | 16 | 7.9 ± 0.47 | 4.5 ± 0.6 | 0.4 ± 0.09 | 0.6 ± 0.1 | 2.4 ± 0.6 |
| | F | 15 | 164.9 ± 47.2 | 15 | 34.9 ± 14.1 | 17 | 8.0 ± 0.87 | 4.0 ± 0.7 | 0.5 ± 0.1 | 0.8 ± 0.2 | 2.7 ± 0.8 |
| 31– | M | 2 | 153.0 | 2 | 37.0 | 2 | 7.95 | 3.9 | 0.5 | 0.9 | 2.6 |
| | F | 4 | 163.8 | 4 | 32.3 | 5 | 8.8 ± 0.46 | 4.2 ± 1.0 | 0.5 ± 0.2 | 0.8 ± 0.2 | 3.4 ± 1.0 |

| Age range | Sex | Leukocyte types | | | | | | Hemoglobins | |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | PMN | Lymphocytes | Monocytes | Eosinophils | Basophils | No. | g/100 ml |
| 0–14 | M | 13 | 33.9 ± 7.5 | 38.0 ± 11.5 | 5.0 ± 3.5 | 23.1 ± 8.8 | 0.08 | 15 | 11.4 ± 1.0 |
| | F | 18 | 37.7 ± 14.9 | 44.3 ± 17.3 | 5.9 ± 5.4 | 12.0 ± 10.5 | 0.06 | 19 | 10.7 ± 1.4 |
| 15–30 | M | 16 | 46.8 ± 14.0 | 28.9 ± 10.6 | 7.2 ± 4.7 | 16.7 ± 9.8 | 0.44 | 17 | 13.1 ± 1.1 |
| | F | 19 | 47.6 ± 16.6 | 31.7 ± 10.8 | 4.8 ± 1.9 | 15.6 ± 10.2 | 0.21 | 18 | 10.8 ± 1.7 |
| 31– | M | 3 | 41.7 | 29.3 | 5.7 | 23.3 | 0 | 3 | 13.4 |
| | F | 6 | 49.3 ± 8.1 | 31.3 ± 2.8 | 6.0 ± 3.3 | 12.2 ± 7.1 | 1.17 | 5 | 11.8 ± 0.8 |

1958; Kritchevsky, 1958). Although the fraction of cholesterol which is esterified is often used as an index of liver function, we hesitate to do so here because of the low total cholesterol.

*Plasma Protein*

Total plasma proteins were determined by means of a modified biuret reaction, using a Technicon Auto-analyzer as recommended in the *Technicon Methods Manual.* The relative proportions of the various types of protein were determined by the paper electrophoresis method, employing a Spinco Model RB for electrophoresis and a Spinco Analytrol B for quantification and following the procedures outlined in the *Spinco Instruction Manual.* The proportions of the various types of protein have all been converted to absolute values. The minor $\alpha_1$ component did not always separate sufficiently to be distinguished from the albumin and has therefore been combined with the albumin in the quantitative studies. Where separation was clear, it constituted on the average only 2–4 per cent of the total. Similarly, the overlap of fibrinogen with $\gamma$-globulin made quantification of the former difficult, and the two have been combined. Through the courtesy of Dr. J. A. Penner, fibrinogen determinations were performed on six specimens by the method of Ratnoff and Menzie (1951). These specimens were selected solely on the basis of whether, after all the other determinations, there was sufficient plasma left for fibrinogen studies. The six values obtained were 152, 164, 234, 257, 330, and 421 mg/100 ml. The average of these values is 260 mg/100 ml. These values are well within the range for normal Caucasians. From this we conclude that roughly 90 per cent of the value obtained for the fibrinogen-plus-$\gamma$-fraction is contributed by the $\gamma$-globulin.

The findings are summarized in table 30. Total proteins, by European and American standards, are relatively high. Albumin values are similar to, but perhaps slightly lower than, those encountered in well-nourished Caucasian groups. The high total protein values are due to elevated $\gamma$-globulin. Similar elevations in the $\gamma$-globulin fraction, with relatively smaller depressions of the albumin and normal or elevated total plasma proteins (by Caucasian standards), have been encountered in many indigenous populations living under tropical and subtropical conditions (references in Bakker, Bliek and Luyken, 1957; Luyken, van Dam-Bakker and de Grott, 1958; Powell, 1958; Aretas, 1959; Queval and Pellissier, 1959; Sonnet and Michaux, 1959; Bronte-Stewart *et al.*, 1960; Bronte-Stewart *et al.*, 1961; Curtain, Gajdusek and Zigas, 1961; and Couvée, 1962a). Again, relatively few studies have been carried out on hunters and gatherers with as little agriculture as the Xavantes. However, Arens and Brock (1954) and Bronte-Stewart *et al.* (1960) encountered values almost identical to those reported here among the Bushmen of southwest Africa, except that in our series we did not observe the males to have higher total and $\gamma$-globulin values than the females as did Bronte-Stewart *et al.* (1960). Luyken, Luyken-Koning and Oosterhuis (1960) also report similar total protein values among 33 Trios and Oayana Indians of Surinam ($7.9 \pm 0.7$ g/100 ml), although the $\gamma$-globulin values appear somewhat lower ($1.6 \pm 0.3$

g/100 ml). Finally, Curnow (1957) and Wilkinson *et al.* (1958) have reported somewhat lower total proteins and definitely lower γ-globulins among Australian aborigines, although in the case of the two groups studied by the latter investigators, there was evidence of departure from the original dietary pattern, either through governmental supplements or lowered intake because of range restrictions.

The Xavantes thus illustrate a phenomenon which has provoked a good deal of comment, namely, the occurrence of normal or slightly depressed albumin but elevated γ-globulin fractions in tropical populations, many of whom (but not the Xavantes) appear to have poor nutritional status. It remains to be seen whether this will be a general finding in hunters and gatherers. The occurrence of the antibodies in the γ-globulin fraction, the tendency of these differences from European patterns to disappear with residence in Europe (Schofield, 1957), as well as the fact that newborn Africans show approximately the same pattern of plasma proteins as newborn Europeans (Symul, 1950; Jelliffe, 1953; Close, 1955; Thompson, 1956) suggest that this is primarily a response to repeated infections and parasitization, complicated to some extent, in some groups, by low animal protein intake and hepatic dysfunction (Symul, 1950; see also Arens and Brock, 1954; Powell, 1958; Joubert, 1959; Bronte-Stewart *et al.*, 1961). However, it is not clear yet whether racial factors play a role. In the United States, normal young Indian and Negro males have shown significantly lower albumin but higher γ-globulin values than normal young Caucasian males (Klein, Cummings and Hammarsten, 1962; Danowski, Tinsman and Moses, 1963). It may be questioned whether the disease experience of these three groups are identical, but the response of the Indians to an antigenic challenge may start from a different baseline than that of the Caucasians. Some evidence on this point should stem from observations on Caucasian or part Caucasian groups living under the same or similar conditions to the indigenous tropical populations mentioned above. The data are conflicting. Curtain, Gajdusek and Zigas (1961) observed among a group of 44 "half-caste Indian-Caucasian people living under primitive conditions in the Iquitos region of Peru (upper Amazon). . . serum protein levels much closer to the values reported for normal Europeans than to those of any of the Melanesian groups" (i.e., serum proteins of 7.1 ± 0.1 g/100 ml, γ-globulin of 1.3 ± 0.3 g/100 ml). They write, "These people live under conditions similar to those of lowland Melanesians, particularly with respect to hygiene, nutrition, climate, clothing, and parasitic infestation. The differences in the serum protein patterns between this group and the Melanesians may therefore be racial difference." On the other hand, Arroyave, *et al.* (1960) report relatively high serum proteins, with all of the electrophoretic fractions contributing proportionately, in a village population in Panama of mixed Caucasian, Negro, and Indian ancestery.

*Hemoglobin*

Hemoglobin values were determined with a colorimeter which had been recently calibrated. The values shown in table 29 are obviously low by our Western standards. However, they are similar to those reported in New Guinea natives (Oomen, 1961; Couvée, 1962a), although definitely lower than those reported in Australian aborigines (Davis and Pitney, 1957; Casley-Smith, 1960) or African Bushmen (Bronte-Stewart *et al.*, 1960). At all ages, the values for females are below those for males.

*Blood Films*

Field conditions did not permit routine determinations of the number of leukocytes per cmm of blood. However, thin blood films were obtained for differential leukocyte counts. At the time of these counts, a rough estimate was made of the leukocyte density; as is apparent from table 29, most counts were thought to be in the normal range. The results of differential leukocyte counts are given in tables 29 and 30. The striking feature is the marked increase in eosinophils coupled with a decrease in neutrophils, presumably due to intestinal parasitism. Unfortunately, stool studies were not carried out, but Sadock de Freitas (1955), in the only other medical survey of this group, reported finding in stools the ova of *Trichuris trichiura, Necator americanus, Enterobius vermicularis,* and *Ascaris lumbricoides;* no data are given on number of individuals surveyed. Similar differential counts have been reported in other primitive groups, although the eosinophil levels observed in the Xavante tend to be higher than those encountered in Australian aborigines (Breinl and Priestley, 1917; Casley-Smith, 1959b) or in the heavily parasitized Akikuyu and Masai of Kenya (Orr and Gilks, 1931) or the natives of New Guinea (Breinl and Priestley, 1917; Couvée, 1962a), these latter two groups representing primitive agriculturalists and pastoralists. Since in parasitic disease eosinophilia is especially marked during tissue invasion (cf. Smit, 1962), the findings in the Xavantes may indicate a relatively high "body burden" of some parasite, whose identity is now unknown.

Approximately one third of the blood films were thought to exhibit erythrocyte characteristics such as aniso- and poikilocytosis, hypochromia, and basophilic stippling well beyond the normal range. There is thus in the appearance of the erythrocytes substantiation of the relatively low hemoglobin values reported earlier. A problem for the future is how possible inadequacies of dietary iron may combine with chronic blood loss due to intestinal parasitism, menstruation, and childbearing to produce the observed picture.

## IX. HEALTH OF THE XAVANTES: ANTIBODY STUDIES AND EXAMINATIONS FOR MALARIA AND FILARIASIS

In addition to their contribution towards defining the disease pressures under which primitive man evolved, attempts to depict the disease profiles of such groups as the Xavante are absolutely necessary for the full realization of some goals of population genetics. Thus, one of the long-range objectives of studies such as the present is an evaluation of the biological role of the various genetic polymorphisms. Collection of significant quantities of data is difficult, and it is unlikely that any single effort will yield data adequate to test for the existence of associations of the magnitude likely to be encountered. Pooling of information will be necessary, but first it will be necessary to have accurate information on the disease patterns of the populations concerned.

It is not enough to know that the infant mortality is the same in two populations; some insight into the possible causes of this as well as adult mortality is necessary.

It is now possible to test serum or plasma for the occurrence of approximately 100 different kinds of antibodies to pathogens. The tests employed depend on the facilities available, since few if any laboratories are equipped to evaluate all known antibodies. Opinion varies as to what tests are most significant, since time and serum are both limited. The determinations reported in this section represent only a fraction of those possible, but they do include a number of very important causes of mortality and morbidity, some long endemic and some possibly reflecting contacts with non-Indians. It is intended that these antibody studies will in part offset the great difficulty in obtaining meaningful medical histories from the Xavantes, as well as the lack of reports by trained medical observers in the past.

*Treponemal Studies*

In an effort to assess the prevalence of treponemal infections, all plasmas were subjected to the V.D.R.L. Slide Quantitative Flocculation Test, as described in *Laboratory Procedures for Modern Syphilis Serology* (Communicable Disease Center, 1961). An effort was also made to conduct parallel T.P.I. tests, as described in *Serology Evaluation: Research Assembly, 1956–1957* (Communicable Disease Center, 1957; see also Wheeler, 1961). Unfortunately, many of these latter tests were deemed unsatisfactory because of apparent nonspecific toxicity of the sera as well as frequent bacterial contamination. Among the 63 specimens, there are five scored as WR(++) or (+++) and one R (table 31). A total of 18 T.P.I. tests were readable, four of which gave a WR (++) or stronger reaction. None was definitely positive. Thus, taken in conjunction with the absence of clinical evidence of yaws, it would appear that this group is entirely free of treponemal infections, the few reactive V.D.R.L.'s probably being false positives. Schaad (1960) recorded only one positive serological test for syphilis (exact test not stated) among 26 Oayana and Trios Indians of Surinam. This may be taken as additional evidence that the Indians of South as well as North America were free of syphilis prior to the advent of Europeans. The cause for the V.D.R.L. "false positives" is unclear as it is in general. It is noteworthy that the fibrinogen-plus-$\gamma$-globulin levels of the six individuals with positive V.D.R.L. tests average 2.66 g/100 ml, i.e., they do not differ significantly from the general population.

*Malariasis and Filariasis*

The blood films obtained for the leukocyte and erythrocyte studies were also read for the presence of malaria parasites. Among 76 thin films, *Plasmoium falciparum* was seen once and *P. malariae* twice. All three of the positive films were from women; two of the three had been examined and found to have marked splenomegaly. No filaria were seen, but inasmuch as all blood films were prepared between the hours of 9:00 A.M. and 5:00 P.M., this is an observation of dubious value. Schaad (1960) also failed to record filaria in smears from 51 Oayana and 71 Trios Indians, but he, too, made his preparations in the daytime. On the basis of the known difficulty of finding malaria parasites in thin films when thick films are positive, plus the frequency of splenomegaly in the women, we are inclined to suspect that malaria is a more significant disease in this community than our limited findings would suggest. It is important to obtain better data on this question in future studies.

It is not known whether malaria is a disease of great antiquity in the New World or whether the peoples who entered the American Continent at the latitude of the Bering Straits were free of these parasites, the infection of their descendants first developing following contacts with Caucasians and Negroes after the third discovery of the New World (Boyd, 1949; Gabaldon, 1949). Should the introduction of malaria be relatively recently in the historical sense, then a number of observations (e.g., infant mortality, hemoglobin levels) are suspect as indicators of the true state of affairs in the pre-Columbian Xavante.

*Pertussis*

Inasmuch as it is anticipated that both the techniques and the results of the remaining antibody studies will be presented elsewhere by Drs. Gordon C. Brown and Warren C. Eveland, a minimum of detail will be given here. All the sera were not subjected to the same studies, primarily because of the limited supply of serum available and the fact that some blood specimens yielded more serum than others. The rather extensive use of fluorescent antibody techniques reflects an effort to extract maximum information from the limited blood available.

The presence of antibodies to *Bordetella pertussis* was investigated with two techniques, one the rapid, small volume technique for determining agglutinating activity (cf. Kendrick, Eldering, and Bradford, in press), the other an indirect fluorescent antibody (F. A.) technique. A rapid diagnostic F. A. technique has recently been described from the laboratory making the determinations; this involves the identification of unknown bacteria by known, labeled antiserum (Kendrick, Eldering and Eveland, 1961). The indirect F. A. technique employed in the present studies differs in that known bacteria were subjected to the action of the serum to be tested, after which the bacteria were exposed to the action of a labeled rabbit anti-human globulin. Fluorescence was graded as 0, 2, 3, or 4+, the latter three being considered as positive reactions. Table 31 records the observations as + or −. Agglutination titers were determined, beginning at a 1/10 dilution; reactions at titers of 1/10 or greater are recorded as +. The *B. pertussis* strain employed was number 10-536 from the collection of the Michigan Department of Health (Grand Rapids Branch). This is a strain regularly employed in the preparation of reference agglutinating suspensions.

Table 31 indicates that 15 of 33 individuals tested ($45.5 \pm 8.7$ per cent) were positive by the agglutination technique and 42 of 62 ($67.7 \pm 5.9$ per cent) by the F. A. technique. The reasons for the discrepancies between the

TABLE 31. A SUMMARY OF THE STUDIES ON MALARIA AND ANTIBODIES TO CERTAIN INFECTIOUS AGENTS

Where there is no entry there was insufficient plasma for the determinations.

| | | | | | | | | | Polio | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Est. | | | Pertussis | | Measles | I | | II | | III | | Influenza (H.A.I.) | | Salmonella (F.A.) | | | |
| Individual no. | Parents | Sex | age (years) | Malaria | VDRL[1] | F.A. | Aggl. | (F.A.) | Neut. | F.A. | Neut. | F.A. | Neut. | F.A. | $A_2$ | B | A | B | C-2 | D |
| II 10 | I 4, 3 | M | 26 | — | NR | + | | | — | + | + | + | — | + | — | — | — | — | + | — |
| 29 | I 9, 10 | F | 50 | — | NR | + | + | + | — | + | + | — | — | + | — | — | — | — | — | — |
| 33 | I 13, 14 | M | 60 | — | NR | + | | + | + | + | + | + | — | + | — | — | — | — | + | — |
| 38 | I 11, 12 | F | 40 | — | | | | | | | | | | | | | | | | |
| 42 | I 13, 14 | F | 65 | — | NR | — | | + | + | — | + | — | — | + | | — | — | — | + | — |
| 52 | I 20, 19 | F | 48 | — | NR | — | — | + | — | + | + | + | — | — | — | — | — | — | + | + |
| 60 | I 20, 21 | M | 39 | — | WR(±) | — | | + | + | — | + | — | + | + | | — | — | + | + | — |
| 61 | | F | 18 | — | NR | + | | + | + | + | + | + | + | + | | — | + | + | + | — |
| 63 | I 22, 23 | M | 17 | — | NR | + | + | | + | + | + | + | — | + | — | — | — | + | — | + |
| III 6 | II 12, 13 | M | 12 | — | WR(±) | + | | | + | + | + | — | + | — | — | + | — | + | + | + |
| 8 | II 15, 16 | F | 10 | — | WR(±) | + | + | | + | + | + | + | — | + | — | + | — | — | — | + |
| 17 | II 18, 17 | F | 40 | — | NR | + | — | | + | + | — | — | — | — | — | — | + | + | + | + |
| 18 | II 18, 17 | M | 35 | — | R (undil.) | + | + | + | + | + | — | + | — | + | | — | + | + | + | + |
| 22 | II 33, 23 | F | 12 | — | NR | + | — | | + | + | + | + | — | + | — | — | + | + | + | + |
| 27 | II 33, 25 | F | 15 | — | NR | + | + | | + | + | + | — | — | + | — | — | + | + | + | + |
| 29 | II 33, 27 | M | 21 | — | NR | + | | — | + | + | + | + | + | + | | — | + | + | + | + |
| 30 | II 33, 27 | M | 17 | — | NR | + | | + | + | + | + | + | + | + | | — | — | — | + | — |
| 32 | II 33, 28 | M | 27 | — | NR | + | | + | + | + | + | + | — | + | | — | — | — | + | — |
| 38 | II 33, 29 | M | 28 | — | NR | + | | + | + | + | + | + | — | + | — | — | + | — | + | — |
| 41 | II 33, 29 | F | 27 | — | NR | + | + | + | — | + | + | + | — | — | — | — | + | — | + | + |
| 42 | II 33, 29 | M | 21 | — | WR(+++) | + | | — | + | — | + | — | — | + | | — | + | + | + | + |
| 43 | II 33, 29 | M | 19 | — | NR | + | | — | + | — | — | + | + | — | | — | — | — | + | — |
| 44 | II 33, 29 | M | 17 | — | WR(±) | — | + | + | + | + | + | + | — | + | — | — | + | — | + | — |
| 45 | II 33, 29 | F | 18 | — | NR | + | + | | + | + | + | + | + | — | — | — | + | — | + | + |
| 46 | II 33, 29 | M | 10 | — | | | | | | | | | | | | | | | | |
| 47 | II 34, 30 | F | 26 | — | NR | + | + | | | + | | — | | + | — | — | — | + | + | + |
| 48 | II 34, 30 | M | 20 | — | WR(±) | + | | + | + | + | — | + | + | + | | — | — | — | — | — |
| 49 | II 34, 30 | F | 17 | *P. mal.* | NR | — | | | + | + | + | — | — | + | — | — | + | + | — | — |
| 50 | II 34, 30 | F | 9 | — | NR | — | — | | — | + | + | + | — | + | — | — | — | + | + | — |
| 51 | II 34, 30 | M | 10 | — | NR | — | + | | — | + | + | + | — | + | — | — | — | + | + | + |
| 52 | II 31, 32 | F | 20 | — | NR | + | | + | | — | | + | | — | | — | + | + | + | + |
| 53 | II 31, 32 | M | 22 | — | WR(++) | + | | + | + | + | + | + | + | + | | + | + | + | + | + |
| 59 | II 39, 38 | F | 17 | — | | | | | | | | | | | | | | | | |
| 60 | | M | 21 | — | WR(±) | + | + | + | + | + | + | + | + | + | | — | + | + | + | + |
| 64 | | F | 15 | — | WR(++) | — | — | + | + | + | — | + | — | + | — | — | — | + | + | + |
| 68 | II 39, 41 | F | 26 | — | NR | + | + | + | + | + | + | + | — | + | — | — | + | — | + | + |
| 69 | II 39, 41 | F | 20 | — | NR | + | — | + | + | + | + | + | + | + | — | + | — | + | + | + |
| 70 | II 39, 41 | F | 17 | — | NR | + | | + | + | + | + | + | + | + | — | + | + | + | + | + |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 73 | II 45, 44 | F | 12 | — | NR | + | + | + | + | + | + | — | — | + | | + | + | + | + | + |
| | 75 | II 45, 52 | M | 10 | — | NR | — | | | + | + | + | + | + | + | | — | + | + | + | + |
| | 77 | | F | 14 | — | NR | — | — | + | — | + | + | + | + | + | — | — | — | — | + | + |
| | 79 | I 16, 17 | F | 18 | — | NR | + | | + | + | + | + | + | + | + | | — | — | — | + | + |
| | 80 | I 16, 17 | F | 17 | — | NR | + | — | | — | + | + | + | + | + | — | — | — | + | + | + |
| | 82 | II 45, 52 | M | 28 | | NR | + | — | + | + | — | + | — | + | — | — | — | + | + | + | + |
| | 83 | II 45, 52 | F | 32 | — | WR(±) | + | | + | + | + | — | + | — | + | | — | — | — | + | + |
| | 89 | II 46, 47 | M | 40 | — | WR(±) | + | | | | + | | — | | + | | — | + | + | + | — |
| | 92 | II 48, 49 | F | 10 | — | WR(+) | + | + | | — | + | — | + | — | + | — | — | + | + | + | + |
| | 96 | II 50, 51 | F | 15 | — | NR | — | | — | + | + | + | — | + | + | — | — | — | — | — | — |
| | 97 | II 50,51 | F | 17 | — | NR | + | — | + | + | + | + | + | + | + | — | — | + | — | + | — |
| | 99 | II 60,61 | F | 2 | — | | | | | | | | | | | | | | | | |
| | 100 | II 60, 62 | F | 15 | — | NR | + | — | — | — | + | + | + | — | + | — | — | + | + | + | — |
| | 101 | II 60, 62 | M | 21 | — | NR | — | | + | + | + | + | + | + | + | — | + | + | + | + | + |
| | 107 | II 65, III 90 | M | 17 | — | | | | | + | + | + | + | — | + | | — | + | + | + | — |
| IV | 1 | III 9, 83 | F | <1 | — | | | | | | | | | | | | | | | | |
| | 2 | III 2, 17 | F | 7 | — | | | | | | | | | | | | | | | | |
| | 3 | III 2, 17 | M | 10 | — | NR | — | | | + | + | + | + | — | + | | — | — | + | + | — |
| | 4 | III 2, 17 | M | 9 | — | NR | — | | | + | + | + | + | + | + | | — | — | + | + | + |
| | 5 | III 16, 17 | F | 20 | — | NR | + | + | | + | + | + | + | + | + | — | — | — | + | + | + |
| | 9 | III 38, 52 | F | <1 | — | | | | | | | | | | | | | | | | |
| | 11 | II 60, III 41 | M | 7 | — | WR(++) | + | — | | + | + | + | + | + | + | — | — | — | — | — | + |
| | 14 | II 59, III 47 | F | 11 | *P. mal.* | NR | + | — | + | — | + | + | + | — | + | — | — | — | — | + | — |
| | 15 | II 58, III 47 | M | 2 | — | | | | | | | | | | | | | | | | |
| | 16 | III 48, 100 | F | <1 | — | | | | | | | | | | | | | | | | |
| | 19 | III 54, IV 5 | F | <1 | — | | | | | | | | | | | | | | | | |
| | 20 | III 60, 59 | F | 2 | — | | | | | | | | | | | | | | | | |
| | 21 | III 60, 59 | F | <1 | — | | | | | | | | | | | | | | | | |
| | 22 | III 18, 68 | M | 4 | — | NR | — | — | | — | + | + | + | + | + | — | — | + | + | + | + |
| | 23 | III 18, 68 | M | 1 | — | | | | | | | | | | | | | | | | |
| | 24 | III 18, 69 | F | 5 | | WR(±) | + | | — | — | + | + | + | + | + | | — | — | — | + | + |
| | 25 | III 18, 69 | M | 2 | | | | | | | | | | | | | | | | | |
| | 26 | III 72, 71 | F | 17 | *P. fal.* | NR | — | — | | — | + | + | + | — | + | — | — | — | — | + | + |
| | 30 | III 72, 71 | F | 20 | — | WR(++) | + | | + | + | + | + | — | — | — | | + | — | + | — | + |
| | 31 | III 78, 79 | F | 2 | — | | | | | | | | | | | | | | | | |
| | 32 | III 82, 97 | M | 5 | — | NR | | | | | | | | | | | | | | | |
| | 33 | III 82, 97 | M | <1 | — | | | | | | | | | | | | | | | | |
| | 34 | III 84, 83 | M | 17 | — | NR | + | | + | + | + | + | + | + | + | | — | — | + | + | + |
| | 36 | III 84, 83 | F | 18 | — | NR | — | — | + | + | + | + | + | — | + | — | — | + | — | + | — |
| | 38 | III 86, 87 | M | 9 | — | NR | — | | | + | — | + | — | + | — | | — | — | + | — | + |
| | 39 | III 89, 90 | M | 8 | — | WR(±) | — | — | | + | + | + | + | + | + | — | — | — | + | + | — |
| | 41 | III 89, 90 | F | 3 | | WR(±) | — | — | | — | + | + | + | + | + | — | — | — | — | + | + |

[1]NR, nonreactive (negative test); WR(±), very weak reaction and difficult to distinguish from artifact; WR(+), weak reaction and difficult to distinguish from artifact; WR(++) or (+++), weak reactions that were greater than serum artifacts and probably valid; R, reactive (positive test).

results of the two tests will be discussed in detail in another paper. Aside from technical considerations, it is entirely possible that the two approaches are measuring different types of antibodies. Somewhat similar discrepancies between the results of two serologic procedures, one of which entails the use of F. A., have recently been reported with reference to scrub typhus by Bozeman and Elisberg (1963). Snyder *et al.* (1962) have drawn attention to discrepancies between tissue culture neutralization and complement fixation tests for measles antibodies. If persons who are positive by either technique are considered to be positive, then 24 of 33 individuals (72.7 ± 7.8 per cent) have evidence of previous infection with *B. pertussis.* With respect to age, and considering the 0–14 and 15–30 age groups employed previously, there were 11 negatives among 20 tests (F. A. technique) at the 0–14 level, and 6 of 33 at the 15–30 level ($\chi^2$ [corrected for continuity] = 6.15, d.f. = 1, 0.01 > $P$ > 0.001). For the agglutination tests, the corresponding figures are 9/14 and 7/15 ($\chi^2$ [corrected for continuity] = 0.34, d.f. = 1, 0.70 > $P$ > 0.50). The fact that only three of the 0–14 group are five years of age or below seriously limits the conclusions to be drawn. However, the F. A. studies do suggest an age effect.

*Salmonella*

The presence of antibodies against four strains of *Salmonella,* as designated in table 31, was tested by the F. A. technique. Parallel tests for agglutinating antibody were not performed, because the studies on pertussis just described had adequately validated the F. A. techniques as applied here. The results are summarized in table 31. Of 63 individuals tested, 28 (44.4 ± 6.3 per cent) were considered positive for antibodies to group A (represented by S. *paratyphi* A), 37 (58.7 ± 6.2 per cent) for antibodies to group B (represented by S. *typhimurium*), 54 (85.7 ± 4.4 per cent) for antibodies to group $C_2$ (represented by S. *newport*), and 40 (63.5 ± 6.1 per cent) for antibodies to group D (represented by S. *anatum*). Considering reactions to all four types together, there were 29 negative reactions in 80 tests in the younger (0–14) group, while for the adult (15–30) group, there were 47 negatives among 136 tests ($\chi^2$ = 0.01, d.f. = 1, 0.95 > $P$ > 0.90). The absence of any suggestion of an age effect indicates an early exposure to the antigenic agent.

*Poliomyelitis*

The presence of antibodies to poliomyelitis types I, II, and III was studied by both virus neutralization tests and fluorescent antibody techniques, employing procedures recently described by Riggs and Brown (1962a, 1962b). The F. A. tests were conducted at a dilution of 1:10, and, although recorded as −, 3, or 4+, again are presented as + or −. Neutralization studies began at a dilution of 1:8. Any serum not reacting at this dilution was recorded as −, sera reacting at this or greater dilution were recorded as +. In addition to the tests recorded in the table, studies of antibody avidity according to the techniques of Sabin (1957) were made on six randomly selected specimens. All six specimens were positive for antibodies to all three types of poliomyelitis, providing additional confirmation of the validity of the findings. Again the percentage of positive reactors is striking. The significance of the discrepancies between the results of the two tests will be discussed in another paper. If we regard reaction to either test as evidence for exposure to the strain concerned, all of the 60 persons tested with both techniques have antibodies to type I, 59 ($98.3 \pm 1.7$ per cent) to type II, and 56 ($93.3 \pm 3.2$ per cent) to type III. The four negative persons were aged 20, 27, 40 (negative for II and III), and 48. The poliomyelitis antibodies appear to be acquired during the first decade of life; this is in keeping with the observations on "high-antibody-frequency" populations of Paul *et al.*, 1952; Paul and Horstmann, 1955; Lie-Khing-Ting, 1960; and Reinhard, 1963.

*Measles*

Measles antibodies were determined by F. A. techniques similar to those described for poliomyelitis (Riggs and Brown, 1962a, 1962b). Brown's unpublished observations have demonstrated a satisfactory correlation between the results of F. A. and neutralization tests for measles antibody similar to those already reported for poliomyelitis. Studies were carried out at a 1:10 dilution. Of 37 specimens tested, 31 ($83.8 \pm 6.0$ per cent) were positive. Again the age breakdown is interesting: The six negatives are aged 5, 15, 15, 19, 21, and 21 years; the youngest positive is 11. There is a paucity of tests on children below the age of 10; consequently little can be said regarding age trends except that there is no striking "cut-off" point among the older age groups.

*Influenza*

The presence of antibodies to types B and $A_2$ (Asian) influenza was determined by the hemagglutination inhibition technique (Committee on Standard Serological Procedures in Influenza Studies, 1950). Only 8 of 63 ($12.7 \pm 4.2$ per cent) persons were positive for antibodies to strain B, and none of 38 persons tested for type $A_2$. The age distribution of the positives is puzzling, all ranging between an estimated 10 to 22 years. We cannot identify a clear cut-off point as age decreases, but it seems noteworthy that no one over the age of 22 possesses demonstrable antibodies. The alleged sensitivity of the Indian to influenza would certainly lead to the expectation that the virus, once introduced into the village, would have infected a higher proportion of older individuals. It is pertinent in this connection that studies employing pooled serum specimens from inhabitants of the State of Michigan have shown some evidence that antibody titers diminish with age (Davenport, Hennessy and Francis, 1953), suggesting that the proportion of positive tests might diminish in older people. However, it seems unlikely this phenomenon provides the entire explanation of our observation.

*Summary of the Antibody Studies*

Even from these limited studies, a number of provocative facts emerge. Before considering these, some potential technical problems should be noted. Some of the techniques employed in this section are relatively new, and experience with persons with elevated gamma globulin levels is limited. Quite possibly, the precise percentages of positive findings will in time be modified. In particular, we are concerned about the absence of clear-cut age trends in instances where these might reasonably have been expected. For the total material, of 254 tests performed on individuals 0–14 years of age, 107 (42.1 per cent) were negative; of 337 tests on persons 15–30 years old, 146 (43.3 per cent) were negative; and of 106 tests on persons 31 or older, 49 (46.2 per cent) were negative. Furthermore, it must also be recognized that even where well-established serological survey techniques are employed, many problems of interpretation remain.

Three aspects of the present studies seem noteworthy. First, there is a relatively high frequency of positive tests for measles and pertussis antibodies, the prevalence of the measles antibody being comparable to that encountered in Iceland, Guatemala, or Morocco (Black, 1962). We can find no other studies of the frequency of antibodies against pertussis in primitive people, but a similar high frequency of persons positive for measles antibodies has been reported among a variety of "Australasian" indigenes (Adels, Francis and Gajdusek, 1962; Adels and Gajdusek, 1963). These findings may provide a clue to the possible recent decrease in the size of the group, although again we emphasize that the limited demographic data are consistent with an expanding population. On the other hand, we cannot exclude the possibility that these diseases have been endemic among the Xavantes and neighboring Indian groups for a considerable period of time. The epidemiological characteristics of isolated groups such as this are poorly defined. These groups should have a high proportion of persons lacking immunity to specific diseases. There is no doubt that when an outsider introduces an agent of disease not endemic in such a group, it often finds fertile soil—and the outsider reports this observation when he returns to civilization. Whether the contacts of Indian groups with one another also precipitate outbursts of disease is not known. And whether these contacts, resulting in a "snake-like pattern of progression" (cf. Adels and Gajdusek, 1963), are sufficient to maintain the endemicity of such diseases as pertussis and measles in these isolated groups is also inadequately documented. One of the reasons given for the hostility of the Xavante towards the Carajá was the Xavante claim that the Carajá brought them sickness.

Secondly, there is a very high frequency of antibodies to all three types of poliomyelitis virus, as well as to members of the *Salmonella* group. This has been frequently observed among tropical populations living at low economic levels (cf. Paul *et al.*, 1952; Paul and Horstmann, 1955), but there is still a dearth of information on the indigenous primitive groups of these and more temperate regions. Gajdusek and Rogers (1955) have recorded high frequencies of antibodies to polio among the Tarahumara Indians of Northwestern Mexico, and Reinhard (1963) has summarized and extended the data on the prevalence of poliomyelitis antibodies among the native populations of Alaska. A similar very high frequency of antibodies against all three types of poliomyelitis virus was observed in New Guinea natives by van

Tongeren, Wilterdink and Timmers (1960). With respect to the salmonelloses, Gajdusek and Rogers (1955) have also recorded a high frequency of individuals with antibodies to the *Salmonella* pathogens among the Tarahumara. On the other hand, Schaad (1960) encountered only one positive reaction to the typhoid H and O and paratyphoid B antigens (all three in one individual) among 27 Oayana and Trios Indians of Surinam. The paradox of a virtual absence of paralytic poliomyelitis among such heavily infected groups as this, despite high antibody titers, is well known, but the interpretation of the observation remains under discussion. The possibility that antibodies not only to poliomyelitis but also to the salmonelloses are acquired in such a way as to minimize clinical disease has important implications. Of the utmost importance in this connection are the studies of Fox and collaborators (1959) on the Indian populations of the Peruvian Andes, indicating that for each case of typhus recognized, "between 13 and 51 infections occurred. Since, in this instance, under-reporting hardly can be invoked as an explanation, one must conclude that in the Peruvian altiplano most infections are subclinical or give rise to only trivial illness. The available data suggest that early age of infection constitutes a partial explanation for this phenomenon but genetically determined host resistance and reduced virulence of the agent may also contribute."

Finally, the low frequency of positive tests for influenza antibodies indicates that these notably epidemic respiratory diseases apparently have not involved many of the population. On the other hand, the demographic data make it clear that the eight persons positive for influenza did experience their disease while in contact with other members of the tribe. Why did the disease not spread?

In summary, the data presented represent only a first, small step in defining the disease background against which natural selection works in such groups. More extensive surveys are required. They should include tests for a wide variety of the viral antibodies already demonstrated in the non-Indian inhabitants of the Amazon valley (cf. Causey and Theiler, 1958; Gajdusek, Rogers and Bankhead, 1959; Schaeffer *et al.*, 1959). Even these limited observations raise some provocative and basic questions concerning the epidemiologic characteristics of isolated groups of this nature. The paramount question, at least from the standpoint of utilizing the data of this paper as normative for primitive populations, is the extent to which diseases such as measles, pertussis, and malaria are recent introductions. Similar studies in primitive groups at the very moment of "first recorded contact" are imperative.

## X. DISCUSSION

The first, most obvious, and least imaginative use of the data obtained in the course of this study will be to indicate the biological relationship of the Xavantes to other South American Indian tribes. Although the present studies leave much to be desired, few other South American tribes have been studied as thoroughly. Detailed comparisons must wait for the results of future studies.

Possible unusual characteristics, in comparison with the other Ge speaking Indians of Brazil, are, morphologically, the great facial breadth, the strikingly flattened parietalia, and the marked differences between the Indices of Pattern Intensity for fingers and toes, and, serologically, the Gm, the Gc, the Hp, and secretor types. As already emphasized, the tribal structure poses some interesting impediments to an evaluation of the significance of these possible differences. But, though differences exist, there are many traits in which the Xavante are very similar to neighboring groups. Of particular interest morphologically is the intra-group variability which, as best we can measure it, is not much less than that of the population of a cosmopolitan German city. Clearly, however, we are only at the beginning of a definition of the range of genetical variation between and among the remaining tribes of this region; it remains to be seen whether extremes of microdifferentiation, such as reported by Simmons, Tindale and Birdsell (1962) for the island-dwelling Australian aborigines from the Gulf of Carpentaria, will be encountered.

The real purpose of this study, however, was not to classify the Xavantes (who are barely mentioned in the *Handbook of South American Indians*) in relation to other Indian tribes but rather to contribute to the methodology of collecting and analyzing data pertaining to the population dynamics of hunting and gathering groups. It is not our intention to attempt oversimplified quantitative treatments or to generalize on the basis of so limited a study. In view of the present active interest of an increasing number of investigators in such groups, much more material should become available in the next ten years, at which time it will be possible to search for common denominators. Even then, there will be many difficulties with respect to generalization. It may be that most surviving primitive groups owe their survival either to an unusually hostile attitude to the outside world or to a retreat into harsh and/or unproductive areas, with resulting cultural impoverishment. Both these factors may be in operation simultaneously. However, before we regard all surviving hunting and gathering or neolithic communities as atypical we must consider whether a typical community ever existed. Man barely maintained his numbers for most of his existence. Therefore, expansions of one group must have been attended by contractions of another, so that even the persistent marginal groups of today must have had their counterpart in the past.

But while no attempt will be made to generalize from this scanty material, it is appropriate to direct attention to certain results which will influence the course of further work. The small effective population size, the endogamous mating pattern with a high degree of inbreeding, the practice of polygamy with a preference for sisters—these are cultural characteristics which should favor the development through drift of genetic differences between villages and tribes. Although the village structure renders the usual tests of significance of dubious value, apparent differences have been found between the Xavante and the other tribes of this region; the latter in turn differ from one another. However, as already emphasized, one can either be impressed by the similarities or by the differences among the South American tribes. In a sense, the question is not whether there are significant differences, but whether these differences are as large as might be expected considering the breeding structure. If one is impressed by the similarities, then two chief alternative, and not mutually exclusive, lines of thought are to be pursued: Either the separation of the tribes is in the genetic sense relatively recent or there are selective forces at work to stabilize these gene frenquencies. Unfortunately, it will be difficult to collect adequate data to test this latter hypothesis. An indirect approach which holds much promise is machine simulation of small populations, from the results of which one may be able to replace intuition with a range of probabilities (cf. Schull and Levin, in press).

There is no way to be certain that the over-all mating pattern of this village has not been seriously disturbed in recent years. The most obvious disturbance would be a recent decimation of the tribe. However, it should be emphasized that, both by virtue of age structure and surviving children per couple, this population appears to be at least replacing itself. The breeding pattern seems one of moderate fertility and moderate childhood mortality. The factors responsible for the moderate fertility of so many primitive peoples have been the subject of much speculation and little real inquiry. The roles of abstinence, abortifacients, oral contraceptives, suppression of ovulation by lactation, and other physiological factors all have to be defined. The evidence suggests a deep commitment on the part of the primitive peoples to the concept of population regulation and a degree of discipline in reproductive matters which, in proportion to the knowledge available, is notably deficient in civilized man today.

A long range objective of studies of this kind, as stated in the introduction, is to contribute to our understanding of the factors responsible for the evolution of differences in gene frequencies between groups. The present observations supply thought-provoking material regarding the role of three of these factors: drift (sampling), differential fertility, and differential mortality (disease pressures). This is material which will guide the development of the machine simulation of small populations.

A number of observations pertinent to the evaluation of the role of drift have already been mentioned. We regard it as fortunate that we were able to provide preliminary documentation of the biological lines along which a village split occurs, since this is a process which must have occurred frequently in the history of man. The non-randomness of this schism provides remarkable opportunities for accidents of sampling.

The evidence suggests that fertility differentials have far more genetic significance in the Xavantes than is true for civilized man today. The position of chief or head of clan is not inherited but won on the basis of a combination of attributes (prowess in hunting and war, oratory, skill in wrestling, etc.). The greater fertility of these leaders (assuming this to be a rather general pattern) must have genetic implications. Indeed, it may be that the single most dysgenic event in the history of mankind was departure from a pattern of polygamy based on leadership, ability, and initiative. And in this same vein, a development of parallel significance might be relaxation of inbreeding, with, at the new equilibrium, the consequent increase in the relative proportion of heterozygotes for undesirable traits, who themselves may often exhibit minor manifestations of the abnormalities in question.

We can make little comment on the genetic significance of the mortality and morbidity patterns encountered in this group, since we know virtually nothing about specific causes of death among the Xavante. However, it is very clear that the age structure of the population is such that most of the constitutional and degenerative diseases with which modern medicine is preoccupied probably play a very minor role. This observation provides part of the thesis that present day frequencies of some of these diseases, such as diabetes mellitus, may be explained by the fact that the genotype which ultimately manifests itself under civilized conditions as diabetes may in a group such as this actually have positive survival value for a high proportion of individuals (cf. Neel, 1962).

Physical examination reveals a group which is superficially healthy. The greater evidences of disease in the women than in the men may reflect not only the heavier physical demands on the women but also the fact that their mode of life results in greater exposures. Thus, the women, spending more time in the villages, might be more subject to the bites of malaria-carrying mosquitoes. The only agent of disease directly identified was the malaria parasite, in three persons. Since our studies were conducted at the height of the dry season, these findings provide a very minimum estimate of the impact of malaria. By inference from the eosinophilia, intestinal parasitism is common. So, by inference from the antibody studies, are viral infections. The latter studies raise some very fundamental questions concerning the epidemiological characteristics of such groups. Specifically, how has a group which appears so healthy acquired antibodies to so many pathogens?

There is a high proportion of individuals with antibodies to poliomyelitis, but there is little or no evidence for paralytic disease in the population, a paradox already recognized in many populations of low economic level. It is not clear to what extent this is due to a natural oral immunization beginning while the infant still has a passive partial immunization acquired from the mother, to the death of the more severely affected, or to the characteristics of the disease in very young children. Similar uncertainties exist concerning the manner of acquisition of certain other of the antibodies encountered in these studies. Consider first the salmonelloses. The deposits of human feces about the village, the swirling clouds of dust, the low levels of hygiene, the obvious stickiness of the ever-flowing Indian breast—all lead to a very early exposure to the *Salmonella* group of bacteria, with the possibility either of severe clinical disease and death or of subclinical or mild disease due to active immunization beginning while passive protection is still present. The literature on the transfer of antibodies by milk after the neonatal period is extensive and controversial (reviewed in Vahlquist, 1958). None of the observations to date deals with hyperimmunized populations such as the Xavante. Are these hyperimmunized mothers able to transmit significant amounts of maternal antibody to the child during the prolonged period of breast feeding, with partial neutralization or attenuation of a variety of agents of disease either in the intestinal tract (cf. Sabin and Fieldsteel, 1962) or following absorption of small amounts of unchanged maternal antibody from the intestinal tract, a phenomenon which improved serological techniques are revealing to be of more significance than earlier seemed to be the case (cf. Leissring, Anderson and Smith, 1962)? We have no data on the prevalence and etiology of diarrheal diseases among infants at this level of culture that would enable us to reach sound judgments concerning the manner of acquisition of these antibodies.

Such diseases as measles and pertussis are usually considered to be non-endemic among Indians and to run an unusually virulent course when introduced into these groups by Caucasians. Our observations regarding antibodies could be evidence for serious epidemics among the inhabitants of this village in the recent past. If so, this casts serious doubt on the validity of our demographic data as a representation of the primitive state. A final judgment on this point must await much more extensive antibody studies among Indian villages in the Mato Grosso.

Earlier, we speculated on the existence of strong selective forces tending to stabilize gene frequencies for the genetic polymorphisms studied. Difficult though the problem of amassing significant numbers might be, the future undoubtedly will bring a number of studies seeking evidence for such forces. It will be important that such studies are accompanied by adequate data on the mortality and morbidity structure of the populations concerned, since a given level of mortality may be reached in many ways, some possibly involving a given genetic system, others not.

If measles, pertussis, and malaria are relatively recent introductions to the Xavantes, in spite of which they maintain very good health, then one is forced to ascribe to "untouched" primitive man a very high level of physical fitness and resistance indeed. This inference also emerges from the papers of Abbie (1960) and Packer (1961) on the Australian aborigine. Our thinking about the health of primitive man has been influenced too much by the observations of medical missionaries and civilian administrators on demoralized and crowded agriculturalists and pastoralists. (See, for example, the report of Orr and Gilks, 1931, on the Akikuyu and Masai of Kenya.)

An obvious gross deficiency in the present study is the complete absence of data on psychological and mental attributes of the Xavante and on the relationship of intelligence to reproduction. This will be a most difficult area in which to work, but its importance will justify extraordinary efforts in future studies.

The study of the breeding structure of primitive groups is a valid objective in and of itself. But there is a further objective to such studies in that they will permit a semi-quantitative approach to a much discussed issue, namely, the relaxation in natural selection assumed to have occurred in recent years. Many of the characteristics of Xavante demography and biology which we have stressed could be inferred from other publications, most notably Krzywicki's (1934) remarkable compilation. However, the basis for the truly quantitative approach which would replace speculation with the type of data necessary for precise treatments does not exist; it is towards this goal that the present study has been directed.

## XI. SUMMARY

1. The Xavante Indians of the Brazilian Mato Grosso are a predominantly hunting and gathering tribe speaking a Ge type language. The present study was an effort not only to characterize these people from the descriptive standpoint but also to explore in some depth the methodology of defining significant biological parameters in such groups. To this end, anthropological, demographic, genetic, and medical data were collected on a Xavante village which first established peaceful relations with the Brazilians some 20 years ago and appears to be culturally intact.

2. There are three exogamous patriclans represented in most Xavante villages and these in turn are divided into named patrilineages. The chief's lineage, supported by the other lineages of his clan and by some people outside the clan, forms the dominant faction in the community. Interfactional disputes, leading to accusations of sorcery and occasional fighting, may provoke secessions of groups from the village, which then take up residence elsewhere; otherwise intervillage migration is uncommon. The ideal marriage pattern is sororal polygamy since a husband is expected to take up residence in his wife's household, but a man may marry a number of unrelated wives. First marriages are regularly between boys in their teens and girls as much as ten years younger.

3. Morphological studies of 91 Indians of both sexes and all ages included 11 measurements, a determination of skin and hair color and iris color and texture, finger and palm prints and a direct reading of toe dermatoglyphics, and five standardized photographs from which 41 qualitative or semi-qualitative traits were scored. The Xavantes can be characterized as relatively large, dolichocephalic, unusually broad-faced Indians with low foreheads, triangular-appearing heads (due to flat parietalia), large noses, and large mouths. True mongolian folds are not common. Both the coefficient of variation for metric characteristics and the Index of Variation for non-metric characteristics (as defined in the text) are for a variety of traits less than corresponding values as determined by one of the authors on the inhabitants of Hamburg, but the differences are not great. Fingerprints show high Indices of Pattern Intensity, whereas toe prints show low Indices.

4. Blood specimens were obtained from 79 persons and examined independently in two laboratories for variation with respect to the following genetically controlled systems: ABO, MNSs, Rh, Kidd, Kell, Lutheran, Duffy, Diego, P, Wright, haptoglobins, transferrins, Gm groups, group specific (Gc) component, erythrocyte nonspecific esterases, erythrocyte lactic dehydrogenases, erythrocyte glucose-6-phosphate dehydrogenase, and hemoglobin type. Secretor type was determined from saliva specimens.

Gene frequencies were computed by conventional methods after it was shown that for systems where heterozygote could be distinguished from homozygote the frequencies of the various phenotypes were in good agreement

with those predicted by the Hardy-Weinberg relationship. In keeping with the findings of others on South American Indians, the genes $I^A$ and $I^B$, $V$ (of the Rh system), $K$, and $Lu^a$ were not encountered, whereas there was a relatively high frequency of $M$, $R_1$, $R_2$, and $Di^a$. However, the $Gc^1$ gene was much less frequent than in the only other study to date, and there were no Gm (b+) individuals. The frequency of the gene $P$ appeared relatively high whereas the $Hp^1$ and $Sec$ gene frequencies were below those found in other South American Indian tribes. The findings with respect to the P trait may reflect technical problems. The population structure renders it difficult to assign errors to estimates of gene frequencies, so that precise comparisons were difficult. In general, the impression is of a retention of genetic variability in these systems no less marked then with respect to the physical traits, despite the population structure to be described below.

5. The village studied has recently undergone a schism. A pedigree was obtained which combined data on the splinter village with that on the parent village. Study of the pedigree suggests the genetic non-randomness of such schisms, with the attendant opportunity for genetic drift. Village age structure suggested a population which was replacing itself, this by virtue of an intermediate fertility and intermediate childhood mortality. No sterility was observed. Endogamy was striking; at least 50 of 56 marriages have been contracted within the village. The coefficient of inbreeding is undoubtedly relatively high; the determined value of 0.0094 is a gross underestimate. Fourteen of the 37 married males were polygamous, with the village chief, by virtue of five wives, contributing very disproportionately to the next generation. Although this may be an extreme example, the study suggests that sexual selection in the Darwinian sense may be quite strong. Effective population size appears to be of the order of 50, although this figures is subject to many qualifications, most of which should result in an even smaller number.

6. Neither the genetic systems studied nor the morphologic traits revealed any instance where the findings in a child were discordant with those in its alleged parents. In this connection, the possibility that errors in blood typings might introduce false exclusions is examined in some detail. It thus appears that the alleged mating pattern is a reasonable approximation of the true pattern.

7. Physical examination of 78 persons revealed marked differences between the sexes. Males were well-muscled, almost caries free, and, with few exceptions, without cardiac murmurs or spleno- or hepatomegaly. Females showed more caries; they often had soft apical systolic murmurs, and about one-third had hepato- or splenomegaly. Both sexes had slow pulses and low blood pressures.

8. Laboratory studies revealed relatively low hemoglobin values in both sexes, but especially in the females. Differential leukocyte counts revealed a marked eosinophilia. Total cholesterol values were low (127 ± 30 mg/100 ml in adult males, 165 ± 47 mg/100 ml in adult females). Serum protein determinations were high (7.9 ± 0.5 g/100 ml in adult males, 8.0 ± 0.9 g/100 ml in adult females), due primarily to high $\gamma$-globulin levels.

9. Serological and hematological studies concerned with an evaluation of disease pressures and epidemiologic characteristics revealed no syphilis, but malaria parasites were found in 3 out of 76 thin blood films, and a high proportion of persons had antibodies to measles, pertussis, poliomyelitis types I, II, and II, and *Salmonella* types A, B, $C_2$, and D. Antibodies to influenza strain $A_2$ were not detected, but 8 of 63 persons tested had antibodies to strain B.

10. It is pointed out that opportunities to study relatively undisturbed hunting and gathering societies are rapidly disappearing. Only from comprehensive studies much more extensive even than the present can we hope to identify and quantify the important agents of natural selection which prevailed during the first 99 per cent of man's time on earth. A preliminary discussion of some of these agents appears in the text. It is particularly urged that such studies include a characterization of disease pressures; otherwise the propriety of pooling the results of various studies, as in our efforts to define the significance of the genetic polymorphisms, will forever be in doubt.

## REFERENCES

ABBIE, A. A. 1960. Physical changes in Australian aborigines consequent upon European contact. *Oceania* 31: 140-144.

ABBIE, A. A., AND ADEY, W. R. 1953. Pigmentation in a central Australian tribe with special reference to fair-headedness. *Amer. J. Phys. Anthrop.* n.s. 11: 339–359.

ABBIE, A. A., AND SCHRODER, J. 1960. Blood pressures in Arnhem Land aborigines. *Med. J. Australia* 2: 493-496.

ADAMS, A. R. D., AND MAEGRAITH, B. G. 1960. *Clinical Tropical Diseases.* Oxford: Blackwell, 540 pp.

ADELS, B. R., FRANCIS, J. E., AND GAJDUSEK, D. C. 1962. Measles in Australasian indigenes. *Amer. J. Dis. Child.* 103: 255-260.

ADELS, B. R., AND GAJDUSEK, D. C. 1963. Survey of measles patterns in New Guinea, Micronesia, and Australia. *Amer. J. Hyg.* 77: 317-343.

AICHEL, O. 1932. Ergebnisse einer Forschungsreise nach Chile-Bolivien. *Z. Morph. Anthrop.* 31: 1-166.

ARENDS, T., AND GALLANGO, M. L. 1962. Haptoglobin and transferrin groups in Venezuela. In *Proceedings of the Eighth Congress of the International Society of Blood Transfusion*, pp. 379-382.

ARENS, L., AND BROCK, J. F. 1954. Some aspects of the serum protein pattern of Africans. *S. Afr. J. Clin. Sci.* 5: 20-34.

ARETAS, R. E. 1959. A propos des hypertrophies parotidiennes dites nutritionnelles. *Bull. Soc. Path. Exot.* 52: 404-411.

ARROYAVE, G., SCRIMSHAW, N. S., PINEDA, O., AND GUZMAN, M. 1960. Electrophoretic pattern of hyperproteinemic sera in a population group of rural Panama. *Amer. J. Trop. Med.* 9: 81-84.

BAKKER, A. W. I., BLIEK, A., AND LUYKEN, R. 1957. The serum proteins of malaria-free inhabitants of central Netherlands New Guinea. *Docum. Med. Geogr. Trop.* 9: 1-8.

BARRETT, M. J. 1953. Dental observations on Australian aborigines: Yuendumu, central Australia, 1951-52. *Australian J. Dent.* 57: 127-138.

BEST, W. R., LAYRISSE, M., AND BERMEJO, R. 1962. Blood group antigens in Aymara and Quechua speaking tribes from near Puno, Peru. *Amer. J. Phys. Anthrop.* n.s. 20: 321-329.

BIRDSELL, J. B. 1950. Some implications of the genetical concept of race in terms of spatial analysis. *Cold Spring Harbor Symp. Quant. Biol.* 15: 259-314.

Biswas, P. C. 1961. Ethno-geographic distribution of dermatoglyphs. *Second Internat. Conf. Hum. Genet.*, pp. E105-E106. (Abstract)

Black, F. L. 1962. Measles antibody prevalence in diverse populations. *Amer. J. Dis. Child.* 103: 242-249.

Blomberg, R. 1960. *Chavante; An Expedition to the Tribes of the Mato Grosso.* London: G. Allen and Unwin, 119 pp.

Boas, F. 1895. Fifth report on the Indians of British Columbia. In *The Northwestern Tribes of Canada—Tenth Report of the Committee.* Report of the Sixty-fifth Meeting of the British Association for the Advancement of Science, pp. 523-592.

Boyd, M. F. 1949. Historical review. In *Malariology,* M. F. Boyd, ed. Philadelphia: W. B. Saunders, pp. 3-25.

Boyer, S. H., Porter, I. H., and Weilbacher, R. G. 1962. Electrophoretic heterogeneity of glucose-6-phosphate dehydrogenase and its relationship to enzyme deficiency in man. *Proc. Nat. Acad. Sci.* (U. S.) 48: 1868-1876.

Bozeman, F. M., and Elisberg, B. L. 1963. Serological diagnosis of scrub typhus by indirect immunofluorescence. *Proc. Soc. Exp. Biol. Med.* 112: 568-573.

Breinl, A., and Priestley, H. 1917. Note on the "Arneth count" in healthy aboriginal children of Northern Australia. *Amer. Trop. Med. Parasit.* 10: 427-430.

Bronte-Stewart, B., Antonis, A., Rose-Innes, C., and Moudie, A. D. 1961. An interracial study on the serum protein pattern of adult men in southern Africa. *Amer. J. Clin. Nutr.* 9: 596-605.

Bronte-Stewart, B., Budtz-Olsen, O. E., Hickley, J. M., and Brock, J. F. 1960. The health and nutritional status of the Kung Bushmen of South West Africa. S. *Afr. J. Lab. Clin. Med.* 6: 187-216.

Bronte-Stewart, B., Keys, A., and Brock, J. F. 1955. Serum cholesterol, diet, and coronary heart disease. *Lancet* 2: 1103-1108.

Campbell, T. D. 1938. Observations on the teeth of the Australian aborigines. River Diamantina, South Australia. *Austrialian J. Dent.* 42: 121-125.

Campbell, T. D. 1939. Food, food values, and food habits of the Australian aborigines in relation to their dental conditions. Parts. I, II, and III. *Australian J. Dent.* 43: 1-15, 45-55, 73-87.

Campbell, T. D., and Barrett, M. J. 1953. Dental observations on Australian aborigines: A changing environment and food pattern. *Australian J. Dent.* 57: 1-6.

Carr-Saunders, A. M. 1922. *The Population Problem.* London: Oxford University Press, 516 pp.

Casley-Smith, J. R. 1959a. Blood pressures in Australian aborigines. *Med. J. Australia* 1: 627-633.

Casley-Smith, J. R. 1959b. The haematology of the central Australian aborigine. II. White and differential counts; eosinophil counts and Casoni tests. *Australian J. Exp. Biol. Med. Sci.* 37: 481-488.

Casley-Smith, J. R. 1960. The haematology of the central Australian aborigine. IV. Hemoglobin, erythrocyte counts, constants, fragilities and sedimentation rates. Effects of Europeanization. *Australian J. Exp. Biol. Med. Sci.* 38: 37-46.

Causey, O. R., and Theiler, M. 1958. Virus antibody survey on sera of residents of the Amazon valley in Brazil. *Amer. J. Trop. Med.* 7: 36-41.

Chown, B., and Lewis, M. 1953. The ABO, MNSs, P, Rh, Lutheran, Kell, Lewis, Duffy, and Kidd blood groups and the secretor status of the Blackfoot Indians of Alberta, Canada. *Amer. J. Phys. Anthrop.* n. s. 11: 369-383.

Chown, B., and Lewis, M. 1955. The blood groups and secretor genes of the Stoney and Sarcie Indians of Alberta, Canada. *Amer. J. Phys. Anthrop.* n. s. 13: 181-190.

Cleve, H., and Bearn, A. 1961. Studies on the "Group specific component" of human serum. Gene frequencies in several populations. *Amer. J. Hum. Genet.* 13: 372-378.

Close, J. 1955. Le taux des protéines sériques chez le nourrisson Africain. *Ann. Soc. Belg. Med. Trop.* 35: 129-145.

COHEN, B. M., NEEL, J. V., AND GERSHOWITZ, H. 1962. Accuracy of World War II blood typing. *Amer. J. Hum. Genet.* 14: 238-239.

Committee on Standard Serological Procedures in Influenza Studies. 1950. An agglutination-inhibition test proposed as a standard reference in influenza diagnostic studies. *J. Immun.* 65: 347-353.

Communicable Disease Center, Venereal Disease Branch, U. S. Public Health Service. 1957. *Serology Evaluation: Research Assembly, 1956-1957.* U.S.P.H.S. Publ. 650, 214 pp.

Communicable Disease Center, Venereal Disease Branch, U. S. Public Health Service. 1961. *Laboratory Procedures for Modern Syphilis Serology,* 35 pp.

CONNERTY, H. V., BRIGGS, A. R., AND EATON, E. H. 1961a. Simplified determination of the lipid components of blood serum. *Clin. Chem.* 7: 37-53.

CONNERTY, H. V., BRIGGS, A. R., AND EATON, E. H. 1961b. Simplified determination of the lipid components of blood serum. *Clin. Chem.* 7: 589-590.

COOK, R. P. (ed.). 1958. *Cholesterol.* New York: Academic Press, 542 pp.

COON, C. S. 1962. *The Origin of Races.* New York: A. A. Knopf, 724 pp.

COUVÉE, L. M. J. 1962a. The nutritional condition of the Kapauku in the central highlands of West New Guinea. *Trop. Geogr. Med.* 14: 314-324.

COUVÉE, L. M. J. 1962b. Marriage, obstetrics, and infant mortality among the Kapauku in the Central Highlands, West New Guinea. *Trop. Geogr. Med.* 14: 325-333.

COUVEÉ, L. M. J., NUGTEREN, D. H., AND LUYKEN, R. 1962. The nutritional condition of the Kapaukus in the central highlands of Netherlands New Guinea. I. Biochemical examinations. *Trop. Geogr. Med.* 14: 27-32.

COWELL, A. 1961. *The Heart of the Forest.* New York: Knopf, 238 pp.

CRAN, J. A. 1955. Notes on the teeth and gingivae of central Australian aborigines. *Australian J. Dent.* 59: 356-361.

CROW, J. F. 1958. Some possibilities for measuring selection intensities in man. *Hum. Biol.* 30: 1-13.

CUMMINS, H. 1930. Dermatoglyphics in Indians of Southern Mexico and Central America. *Amer. J. Phys. Anthrop.* 15: 123-136.

CUMMINS, H. 1941. Dermatoglyphics in North American Indians and Spanish-Americans. *Hum. Biol.* 13: 177-188.

CUMMINS, H., AND GOLDSTEIN, M. S. 1932. Dermatoglyphics in Comanche Indians. *Amer. J. Phys. Anthrop.* 17: 229-235.

CUMMINS, H., AND MIDLO, C. 1943. *Fingerprints, Palms, and Soles.* Philadelphia: Blakiston Co.

CUMMINS, H., AND STEGGERDA, M. 1935. Fingerprints in a Dutch family series. *Amer. J. Phys. Anthrop.* 20: 19-41.

CURNOW, D. H. 1957. The serum proteins of aborigines in the Warburton Range Area. *Med. J. Australia* 2: 608-609.

CURTAIN, C. C., GAJDUSEK, D. C., AND ZIGAS, V. 1961. Studies on Kuru. II. Serum proteins in natives from the Kuru region of New Guinea. *Amer. J. Trop. Med.* 10: 92-109.

DANOWSKI, T. S., TINSMAN, C. A., AND MOSES, C. 1963. Lipid and body fluid patterns in North American Negro and white prisoners. *Metabolism* 12: 117-125.

DAVENPORT, F. M., HENNESSY, A. V., AND FRANCIS, T., JR. 1953. Epidemiologic and immunologic significance of age distribution of antibody to antigenic variants of influenza virus. *J. Exp. Med.* 98: 641-656.

DAVIDSON, W. S. 1957. Health and nutrition of Warburton Range natives of central Australia. *Med. J. Australia* 2: 601-604.

D'AVILA, J. B. 1950. Anthropometry of the Indians of Brazil. In *Handbook of South American Indians,* Vol. 6, J. H. Steward, ed. Washington: U. S. Government Printing Office, pp. 71-84.

DAVIS, R. E., AND PITNEY, W. R. 1957. Some haematological observations on aborigines in the Warburton Ranges area. *Med. J. Australia* 2: 605-608.

DE LIMA, P. E. 1950. Níveis tensionais dos Indios Kalapalos e Kamaiurá. *Rev. Brasil. Med.* 7: 787-788.

ELLIS, F. R., CAWLEY, L. P., AND LASKER, G. W. 1963. Blood groups, hemoglobin types, and secretion of group-specific substance at Hacienda Cayalti, North Peru. *Hum. Biol.* 35: 26-52.

FERNANDES, J. L., JUNQUEIRA, P. C., KALMUS, H., OTTENSOOSER, F., PASQUALIN, R., AND WISHART, P. 1957. P.T.C. thresholds, colour vision and blood factors of Brazilian Indians. I. Kaingangs. *Ann. Hum. Genet.* (Lond.) 22: 16-21.

FINN, S. B. 1952. Prevalence of dental caries. In *A Survey of the Literature on Dental Caries.* National Academy of Sciences—National Research Council Publ. 225, pp. 119-173.

FOX, J. P., MONTOYA, J. A., JORDAN, M. E., CORNEJO UBILLUS, J. R., GARCIA, J. L., ESTRADA, M. A., AND GELFAND, H. M. 1959. Immunization of man against epidemic typhus by infection with avirulent *Rickettsia prowazecki* (Strain E). V. A brief review and observations during a three and one-half year period as to the occurrence of typhus among vaccinated and control populations in the Peruvian Andes. *Arch. Inst. Pasteur Tunis* 36: 449-479.

GABALDON, A. 1949. Malaria incidence in the West Indies and South America. In *Malariology,* M. F. Boyd, ed. Philadelphia: W. B. Saunders, pp. 764-787.

GAJDUSEK, D. C., AND ROGERS, N. G. 1955. Specific serum antibodies to infectious disease agents in Tarahumara Indian adolescents of northwestern Mexico. *Pediatrics* 16: 819-835.

GAJDUSEK, D. C., ROGERS, N. G., AND BANKHEAD, A. S. 1959. Serologic survey of viral and rickettsial diseases among jungle inhabitants of the Upper Amazon Basin. *Pediatrics* 23: 121-131.

GEIPEL, G. 1935. *Anleitung zur erbbiologischen Beurteilung der Finger und Handleisten.* München: J. F. Lehmann, 80 pp.

GERSHOWITZ, H. An unusual human anti-N serum. *Proc. Second Internat. Conf. Hum. Genet.* (In press.)

GIBLETT, E. R., AND BEST, W. 1961. Haptoglobin and transferrin types in Peruvian Indians. *Nature* 192: 1300-1301.

GREENBERG, J. H. 1960. The general classification of Central and South American languages. In *Men and Cultures. Selected Papers of the Fifth International Congress of Anthropological and Ethnological Sciences.* A. F. C. Wallace, ed. Philadelphia: University of Pennsylvania Press, pp. 791-794.

GREY, G. 1841. *Journals of Two Expeditions of Discovery in North-west and Western Australia, 1837-1839.* London: T. and W. Boone, 2 vols.

HART, C. W. M., AND PILLING, A. R. 1960. *The Tiwi of North Australia.* New York: Henry Holt and Co.

HEITHERSAY, G. 1959. A dental survey of the aborigines of Haast's Bluff, Central Australia. *Med. J. Australia* 1: 721-729.

HENRY, L. 1961. Some data on natural fertility. *Eugen. Quart.* 8: 81-91.

HICKS, S. C., AND MATTERS, R. F. 1933. Standard metabolism of Australian aborigines. *Australian J. Exp. Biol. Med. Sci.* 11: 177-183.

HIRSCHFELD, J. 1959. Individual precipitation patterns of normal rabbit sera. *Acta Path. Microbiol. Scand.* 46: 229-238.

HUXLEY, F. 1957. *Affable Savages.* New York: Viking Press, 287 pp.

ISHIKUNI, N., NEMOTO, H., NEEL, J. V., DREW, A. L., YANASE, T., AND MATSUMOTO, Y. S. 1960. Hosojima. *Amer. J. Hum. Genet.* 12: 67-75.

JELLIFFE, D. B. 1953. Serum proteins in the newborn African. *Docum. Med. Geog. Trop.* 5: 286-288.

JOUBERT, S. M. 1959. A comparative study of serum protein moieties in European, African and Indian adult populations of Durban, S. Africa. *J. Lab. Clin. Med.* 5: 1-15.

JUILLAN, M., AND BATS-MAILLET, Y. 1960. Cholesterolemia of the population groups of Algeria. *Arch. Inst. Pasteur Algerie* 38: 151-180.

JUNQUEIRA, P. C., KALMUS, H., AND WISHART, P. 1957. P.T.C. thresholds, colour vision, and blood factors of Brazilian Indians. II. Carajas. *Ann. Hum. Genet.* (Lond.) 22: 22-25.

KEAN, B. H. 1944. Blood pressure of the Cuna Indians. *Amer. J. Trop. Med.* 24: 341-343.

KEAN, B. H., AND HAMMILL, J. F. 1949. Anthropathology of arterial tension. *Arch. Intern. Med.* 83: 355-362.

KEITER, F. 1950. Über Zehenbeerenmuster und Kompliziertheitsindex. *Z. Morph. Anthrop.* 42: 169-183.

KEITER, F. 1954. Gesetzmässigkeiten polygener Erbmerkmale beim Menschen. *Z. Morph. Anthrop.* 46: 170-183.

KEITER, F. 1957. Vaterschaftsdiagnostik mittels "Trennlogarithmus." *Ärztl. Forsch.* 11: 537-551.

KEITER, F. 1960. Norddeutsche, Franzosen und Italiener im morphognostischen Paarvergleich. *Mitt. Anthrop. Ges. Wien* 90: 55-66.

KENDRICK, P. L., ELDERING, G., AND BRADFORD, W. L. Chapter XIV in *Diagnostic Procedures and Reagents*, 4th ed. American Public Health Association. (In press.)

KENDRICK, P. L., ELDERING, G., AND EVELAND, W. C. 1961. Fluorescent antibody techniques. *Amer. J. Dis. Child.* 101: 149-154

KIDDY, C. A., AND HOOVEN, N. W. 1961. Repeatability and standardization in cattle blood typing. *Science* 134: 615-616.

KLEIN, G. C., CUMMINGS, M. M., AND HAMMARSTEN, J. F. 1962. Differences between normal serum protein patterns of American Indian, Negro, and Caucasian subjects. *Proc. Soc. Exp. Biol. Med.* 111: 298-300.

KRITCHEVSKY, D. 1958. *Cholesterol.* New York: John Wiley and Sons, 291 pp.

KRZYWICKI, L. 1934. *Primitive Society and Its Vital Statistics.* London: MacMillan and Co. 589 pp.

LAPICCIRELLA, V., LAPICCIRELLA, R., ABBONI, F., AND LIOTTA, S. 1962. Enquête clinique, biologique et cardiographique parmi les tribus nomades de la Somalie qui se nourrissent seulement de lait. *Bull. WHO* 27: 681-697.

LASKER, G. W. 1960. Small isolated human breeding populations and their significance for the process of racial differentiation. In *Selected Papers of the Fifth International Congress of Anthropological and Ethnological Sciences, 1956,* A. F. C. Wallace, ed. Philadelphia: University of Pennsylvania Press.

LAYRISSE, M., AND WILBERT, J. 1961. Absence of the Diego antigen, a genetic characteristic of early immigrants to South America. *Science* 134: 1077-1078.

LAYRISSE, M., WILBERT, J., AND ARENDS, T. 1958. Frequency of blood group antigens in the descendants of Guayquerí Indians. *Amer. J. Phys. Anthrop.* n.s. 16: 307-318.

LAYRISSE, M., LAYRISSE, Z., AND WILBERT, J. 1962. Blood group antigen tests of the Waica Indians of Venezuela. *Southwest. J. Anthrop.* 18: 78-93.

LAYRISSE, M., LAYRISSE, Z., AND WILBERT, J. 1963. The blood groups of Northern Continental Caribs. *Hum. Biol.* 35: 140-166.

LEISSRING, J. C., ANDERSON, J. W., AND SMITH, D. W. 1962. Uptake of antibodies by the intestine of the newborn infant. *Amer. J. Dis. Child.* 103: 160-165.

LEVINE, P., KUHMICHEL, A. B., WIGOD, M., AND KOCH, E. 1951. A new blood factor, s, allelic to S. *Proc. Soc. Exp. Biol. Med.* 78: 218-220.

LIE-KHING-TING. 1960. Poliomyelitis in Indonesia. A serological survey for neutralizing antibodies against polio viruses, 1957-1959. *Trop. Geog. Med.* 12: 293-302.

LINNET-JEPSEN, P., GALATIUS-JENSEN, F., AND HAUGE, M. 1958. On the inheritance of the Gm serum group. *Acta Genet.* (Basel) 8: 164-196.

LIVINGSTONE, F. B., GERSHOWITZ, H., NEEL, J. V., ZUELZER, W. W., AND SOLOMON, M. D. 1960. The distribution of several blood group genes in Liberia, the Ivory Coast, and Upper Volta. *Amer. J. Phys. Anthrop.* n.s. 18:161-178.

LOWENSTEIN, F. W. 1961. Blood pressure in relation to age and sex in the tropics and subtropics. *Lancet* 1: 389-392.

LUYKEN, R., AND JANSEN, A. A. 1960. The cholesterol level in the blood serum of some population groups in New Guinea. *Trop. Geog. Med.* 12: 145-148.

LUYKEN, R., AND LUYKEN-KONING, F. W. 1960. Studies on the physiology of nutrition in Surinam. VI. Cholesterol content of the blood serum. *Trop. Geog. Med.* 12: 313-314.

LUYKEN, R., LUYKEN-KONING, F. W., AND OOSTERHUIS, H. K. 1960. Studies on the physiology of nutrition in Surinam. II. Serum protein levels. *Trop. Geog. Med.* 12: 233-236.

LUYKEN, R., VAN DAM-BAKKER, A. W. I., AND DE GROOT, A. P. 1958. Observations on serum proteins of inhabitants of New Guinea and the Antilles, compared with animal experiments. *Trop. Geog. Med.* 10: 385-391.

MACCLUER, J. W., AND SCHULL, W. J. 1963. On the estimation of the frequency of non-paternity. *Amer. J. Hum. Genet.* 15: 191-202.

MANN, I. 1957. Report on ophthalmic findings in Warburton Range natives of central Australia. *Med. J. Australia* 2: 610-612.

MANN, G. V., NICOL, B. M., AND STARE, F. J. 1955. The beta-lipoprotein and cholesterol concentrations in sera of Nigerians. *Brit. Med. J.* 2: 1008-1010.

MANN, I., AND TURNER, C. 1956. Colour vision in native races in Australasia. *Amer. J. Ophthal.* 41: 797-800.

MANSON-BAHR, P. H. 1960. *Manson's Tropical Diseases,* 15th ed. London: Cassell, 1177 pp.

MASON, J. A. 1950. The languages of South American Indians. In *Handbook of South American Indians,* Vol. 6. J. H. Stewart, ed. Washington: U. S. Government Printing Office, pp. 157-318.

MATTOS, R. B. 1958. Acuidade visual para longe e freqüência de discromatopsia em índios brasileiros. *Arquiv. Brasil. Oftalmol.* 21: 105-253.

MATHUR, K. S., WAHI, P. N., AND SHARMA, R. D. 1962. Studies on serum cholesterol of clinically healthy adults at Agra. *Indian J. Med. Res.* 50: 195-203

MAYBURY-LEWIS, D. *Akwe-Shavante Society.* Oxford: Clarendon Press. (In press.)

MÉNDEZ, J., TEJADA, C., AND FLORES, M. 1962. Serum lipid levels among rural Guatemalan Indians. *Amer. J. Clin. Nutr.* 10: 403-409.

MORTARA, G. 1957. *A fecundidade da mulher do Brasil.* Rio de Janeiro: I.B.G.E. Conselho Nacional de Estatística.

MURPHY, R. F. 1960. *Headhunter's Heritage.* Berkeley: University of Californa Press. 202 pp.

NAGEL, R., AND ETCHEVERRY, R. 1963. Types of haptoglobins in Araucanian Indians of Chile. *Nature* 197: 187-188.

NEEL, J. V. 1958. The study of natural selection in primitive and civilized human populations. *Hum. Biol.* 30: 43-72.

NEEL, J. V. 1962. Diabetes mellitus: a "thrifty" genotype rendered detrimental by "progress." *Amer. J. Hum. Genet.* 14: 353-362.

NEEL, J. V., AND SCHULL, W. J. 1954. *Human Heredity.* Chicago: University of Chicago Press, 361 pp.

NEWMAN, M. T. 1953. Anthropometry of the Umotina, Nambicuara, and Iranxe, with comparative data from other Northern Mato Grosso tribes. Appendix 3 in *Indian Tribes of Northern Mato Grosso, Brasil,* K. Oberg, ed. Washington: U. S. Government Printing Office.

NEWMAN, M. T. 1960. Populational analysis of finger and palm prints in highland and lowland Maya Indians. *Amer. J. Phys. Anthrop.* n.s. 18: 45-58.

NYE, L. J. 1937. Blood pressure in the Australian aboriginal. *Med. J. Australia* 2:1000-1001.

OBERG, K. 1953. *Indian Tribes of Northern Mato Grosso, Brazil.* Smithsonian Institution Institute of Social Anthropology Publ. 15. Washington: U. S. Government Printing Office, 144 pp.

OOMEN, H. A. P. C. 1961. The nutrition situation in western New Guinea. *Trop. Geog. Med.* 13: 321-335.

ORR, J. B., AND GILKS, J. L. 1931. The physique and health of two African tribes. In *Studies of Nutrition.* Great Britain, Medical Research Council Special Report Series 155. London: His Majesty's Stationery Office, p. 82.

OSBORNE, R. H. 1958. Serology in physical anthropology. *Amer. J. Phys. Anthrop.* n.s. 16: 187-195.

PACKER, A. D. 1961. The health of the Australian native. *Oceania* 32:60-70.

PARKER, W. C., AND BEARN, A. G. 1961. Haptoglobin and transferrin gene frequencies in a Navajo population: a new transferrin variant. *Science* 134: 106-108.

PAUL, J. R., AND HORSTMANN, D. M. 1955. Survey of poliomyelitis virus antibodies in French Morocco. *Amer. J. Trop. Med.* 4:512-524

PAUL, J. R., MELNICK, J. L., BARNETT, V. H., AND GOLDBLUM, N. 1952. Survey of neutralizing antibodies to poliomyelitis virus in Cairo, Egypt. *Amer. J. Hyg.* 55: 402-413.

POLLITZER, W. S., HARTMANN, R. C., MOORE, H., ROSENFIELD, R. E., SMITH, H., HAKIM, S., SCHMIDT, P. J., AND LEYSHON, W. C. 1962. Blood types of the Cherokee Indians. *Amer. J. Phys. Anthrop.* n.s. 20: 33-43.

POST, R. H. 1962a. Population differences in red and green color vision deficiency: a review, and a query on selection relaxation. *Eugen. Quart.* 9: 131-145.

POST, R. H. 1962b. Population differences in vision acuity: a review, with speculative notes on selection relaxation. *Eugen. Quart.* 9: 189-212.

POWELL, S. J. 1958. The serum protein pattern and liver function tests in the Natal African. *S. Afr. J. Lab. Clin. Med.* 4: 273-282.

PRICE, W. A. 1939. *Nutrition and Physical Degeneration.* New York: Paul B. Hoeber, 431 pp.

QUEVAL, R., AND PELISSIER, A. 1959. Contribution à l'étude électrophorétique des problèmes sériques des Africains du Tchad. *Bull. Soc. Path. Exot.* 52: 385-403.

RACE, R. R., AND SANGER, R. 1962. *Blood Groups in Man,* 4th ed. Oxford: Blackwell, 465 pp.

RANKE, K. E. 1898. Beobachtungen über Bevölkerungszustand und Bevölkerungsbewegung bei Indianern Centralbrasiliens. *Deutsch. Ges. Anthropol.* 29: 123-134.

RATNOFF, O. D., AND MENZIE, C. 1951. A new method for the determination of fibrinogen in small samples of plasma. *J. Lab. Clin. Med.* 37: 316-320.

REINHARD, K. R. 1963. Ecology of enteroviruses in the western Arctic. *J. Amer. Med. Assoc.* 183: 410-418.

RIBEIRO, D. 1957. Culturas e línguas indígenas do Brasil. *Educacão e Ciências Sociais* 2: 5-102.

RIGGS, J. L., AND BROWN, G. C. 1962a. Application of direct and indirect immunofluorescence for identification of enteroviruses and titrating their antibodies. *Proc. Soc. Exp. Biol. Med.* 110: 833-837.

RIGGS, J. L., AND BROWN, G. C. 1962b. Differentiation of active and passive poliomyelitis antibodies in human sera by indirect immunofluorescence. *J. Immun.* 89: 868-873.

SABIN, A. B. 1957. Properties of attenuated polioviruses and their behavior in human beings. *New York Acad. Sci. Special Publ.* 5: 113-137.

SABIN, A. B., AND FIELDSTEEL, A. H. 1962. Antipoliomyelitic activity of human and bovine colostrum and milk. *Pediatrics* 29: 105-115.

SADOCK DE FREITAS, A. 1955. Inquerito médico-sanitário entre os Indios Xavante. In *Report of Indian Protective Service for 1954,* M. T. Simões, ed. Rio de Janeiro: Ministerio do Agriculture.

SALLER, K., (ed.). 1956 ff. *Lehrbuch der Anthropologie in systematischer Darstellung, dritte völlig umgearbeitete und erweiterte Auflage.* Stuttgart: G. Fischer.

SALZANO, F. M. 1957. The blood groups of South American Indians. *Amer. J. Phys. Anthrop.* 15: 555-579.

SALZANO, F. M. 1961a. Studies on the Caingang Indians. I. Demography. *Hum. Biol.* 33: 110-130.

SALZANO, F. M. 1961b. Studies on the Caingang Indians. III. Blood groups. *Amer. J. Phys. Anthrop.* n.s. 19: 391-404.

SALZANO, F. M., AND SUTTON, H. E. 1963. Haptoglobin and transferrin types in southern Brazilian Indians. *Acta Genet. Stat. Med.* 13: 1-8.

SCHAAD, J. D. G. 1960. Epidemiological observations in bush Negroes and Amerindians in Surinam. *Trop. Geog. Med.* 12: 38-46.

SCHAEFFER, M., GAJDUSEK, D. C., LEMA, A. B., AND EICHENWALD, H. 1959. Epidemic jungle fevers among Okinawan colonists in the Bolivian rain forests. I. Epidemiology. *Amer. J. Trop. Med.* 8: 372-396.

SCHOFIELD, F. D. 1957. The serum protein patterns of West Africans in Britain. *Trans. Roy. Soc. Trop. Med. Hyg.* 51: 332-337.

SCHULL, W. J., AND LEVIN, B. R. Monte Carlo simulation: some uses in the genetic study of primitive man. In *Proceedings of the Symposium on Stochastic Models in Medicine and Biology*, J. Gurland, ed. (In press.)

SCHWARTZ, C. J., AND CASLEY-SMITH, J. R. 1958. Serum cholesterol levels in atherosclerotic subjects and in the Australian aborigines. *Med. J. Australia* 2: 84-86.

SCRIMSHAW, N. S., MENDEZ, J., FLORES, M., GUZMAN, M. A., AND DE LEON, R. 1961. Diet and serum cholesterol levels among the "Black Caribs" of Guatemala. *Amer. J. Clin. Nutr.* 9: 206-210.

SHAPER, A. G., AND JONES, R. W. 1959. Serum-cholesterol, diet, and coronary heart disease in Africans and Asians in Uganda. *Lancet* 2: 534-537.

SHARP, R. L. 1940. An Australian aboriginal population. *Hum. Biol.* 12: 481-507.

SIMMONS, R. T., TINDALE, N. B., AND BIRDSELL, J. B. 1962. A blood group genetical survey in Australian aborigines of Betinck, Morington and Forsyth Islands, Gulf of Carpentaria. *Amer. J. Phys. Anthrop.* n.s. 20: 303-320.

SMIT, A. M. 1962. *Over eosinofilie bij worminfecties en eosinofiele meningitis.* Amsterdam: Klein offset Drukkerig, 135 pp.

SMITHIES, O. 1959. Zone electrophoresis in starch gels and its application to studies of serum proteins. In *Advances in Protein Chemistry*, Vol. 14, pp. 65-113.

SNYDER, M. J., MCCRUMB, F. R., BIGBEE, T., SCHLUEDERBERG, A. E., AND TOGO, Y. 1962. Observations on the seroepidemiology of measles. *Amer J. Dis. Child.* 103: 250-251.

SONNET, J., AND MICHAUX, J. L. 1959. Considérations sur l'hyperglobulinémie du Bantou normal. *Ann. Soc. Belg. Med. Trop.* 39: 495-505.

STEGGERDA, M. 1950. Anthropometry of South American Indians. In *Handbook of South American Indians*, Vol. 6. J. H. Steward, ed. Washington: U. S. Government Printing Office, pp. 57-69.

STEINBERG, A. G., STAUFFER, R., AND FUDENBERG, H. 1960. Distribution of $Gm^a$ and Gm-like among Javanese, Djuka Negroes, and Oyana and Carib Indians. *Nature* 184: 324-325 .

STEINBERG, A. G., STAUFFER, R., BLUMBERG, B. S., AND FUDENBERG, H. 1961. Gm phenotypes and genotypes in U. S. whites and Negroes; in American Indians and Eskimos; in Africans; and in Micronesians. *Amer. J. Hum. Genet.* 13: 205-213.

STEWARD, J. H. (ed.) 1946-1950. *Handbook of South American Indians.* Washington: U. S. Government Printing Office, 7 vols.

SUTTON, H. E., MATSON, G. A., ROBINSON, A. R., AND KOUCKY, R. W. 1960. Distribution of haptoglobin, transferrin, and hemoglobin types among Indians of Southern Mexico and Guatemala. *Amer. J. Hum. Genet.* 12: 338-347.

SYMUL, F. 1950. Étude des protéines sériques des indigènes d'un centre extra-coutumier: Léopoldville. *Ann. Soc. Belg. Med. Trop.* 30: 295-311.

TABRAH, F. L. 1962. Absence of dental caries in a Nigerian bush village. *Science* 138: 38-39.

TASHIAN, R. E. 1961. Multiple forms of esterases from human erythrocytes. *Proc. Soc. Exp. Biol. Med.* 108:364-366.

THOMPSON, M. D. 1956. The serum protein pattern of African infants in Uganda. *Trans. Roy. Soc. Trop. Med. Hyg.* 50: 77-81.

TINDALE, M. B. 1953. Tribal and intertribal marriage among the Australian aborigines. *Hum. Biol.* 25: 169-190.

VAN DONGEN, R., DAVIVONGS, V., AND ABBIE, A. A. 1962. Aboriginal blood pressures at Beswick, south-western Arnhem Land, and correlation with physical dimensions. *Med. J. Australia* 2: 286-289.

VAN TONGEREN, H. A. E., WILTERDINK, J. B., AND TIMMERS, W. C. 1960. Neutralizing antibodies to the viruses of poliomyelitis, dengue types 1 and 2, Murray Valley and Japanese B encephalitis in Papuan populations of Netherlands New Guinea. *Trop. Geog. Med.* 12: 208-215.

VESELL, E. S., AND BEARN, A. G. 1962. Variations in the lactic dehydrogenase of vertebrate erythrocytes. *J. Gen. Physiol.* 45: 553-565.

VAHLQUIST, BO. 1958. The transfer of antibodies from mother to offspring. *Advances Pediat.* 10: 305-338.

WARMER, P., BEECH, M., AND CASLEY-SMITH, J. R. 1957. Observations on serum antibodies in aborigines of the Northern Territory. *Med. J. Australia* 2: 857-858.

WHEELER, A. H. 1961. The effects of specific antibody on the morphology of Treponemes. In *Twelfth Annual Symposium on Recent Advances in the Study of Venereal Diseases.* (Abstract)

WILDER, H. H. 1922. Racial differences in palm and sole configuration. Palm and sole prints of Japanese and Chinese. *Amer. J. Phys. Anthrop.* 5: 143-206.

WILKINSON, G. K., DAY, A. J., PETERS, J. A., AND CASLEY-SMITH, J. R. 1958. Serum proteins of some central and South Australian aborigines. *Med. J. Australia* 2: 158-160.

WRIGHT, S. 1940. Breeding structure of populations in relation to speciation. *Amer. Natur.* 74: 232-248.