A genetic and demographic investigation of the Zoroastrians of Iran

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ABSTRACT

The aim of this study was to examine the Zoroastrians of Yazd, Kerman and Tehran to determine whether or not they differed from each other genetically and from the host population of Iran; to study the Parsis and Iranis - Zoroastrians who had migrated to India in the 7th Century A.D., and compare the results with those of neighbouring Indian populations. It was hoped to obtain a large number of samples in order to make accurate comparisons, but, owing to the contemporary complex political situation, this proved impossible.

Attempts were made to explain the variants in terms of present day demographic theories but were hampered by the paucity of published data.

Blood, serum and isoenzyme group examinations were made. Serological and electrophoretic techniques were used to determine ABo, MNSs, Rh, Kell, Duffy, KP, haptoglobin, adenylate kinase, acid phosphatase, esterase D and phosphoglucomutase factors in a total of 469 Zoroastrians.

Demographic features of contemporary Zoroastrians were studied and the results compared with those of Iranians and Parsis. (No demographic data was available for the Iranis of India.) This revealed that the fertility ratio of the Zoroastrians is lower and present day infant mortality higher than those for the latter groups.

Serological test results together with the demographic findings suggest that the long practise of consanquinial marriage may account for the differences which we can observe today.

A GENETIC AND DEMOGRAPHIC INVESTIGATION OF THE ZOROASTRIANS OF IRAN

By

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To My Wife

And

NONA And MONA

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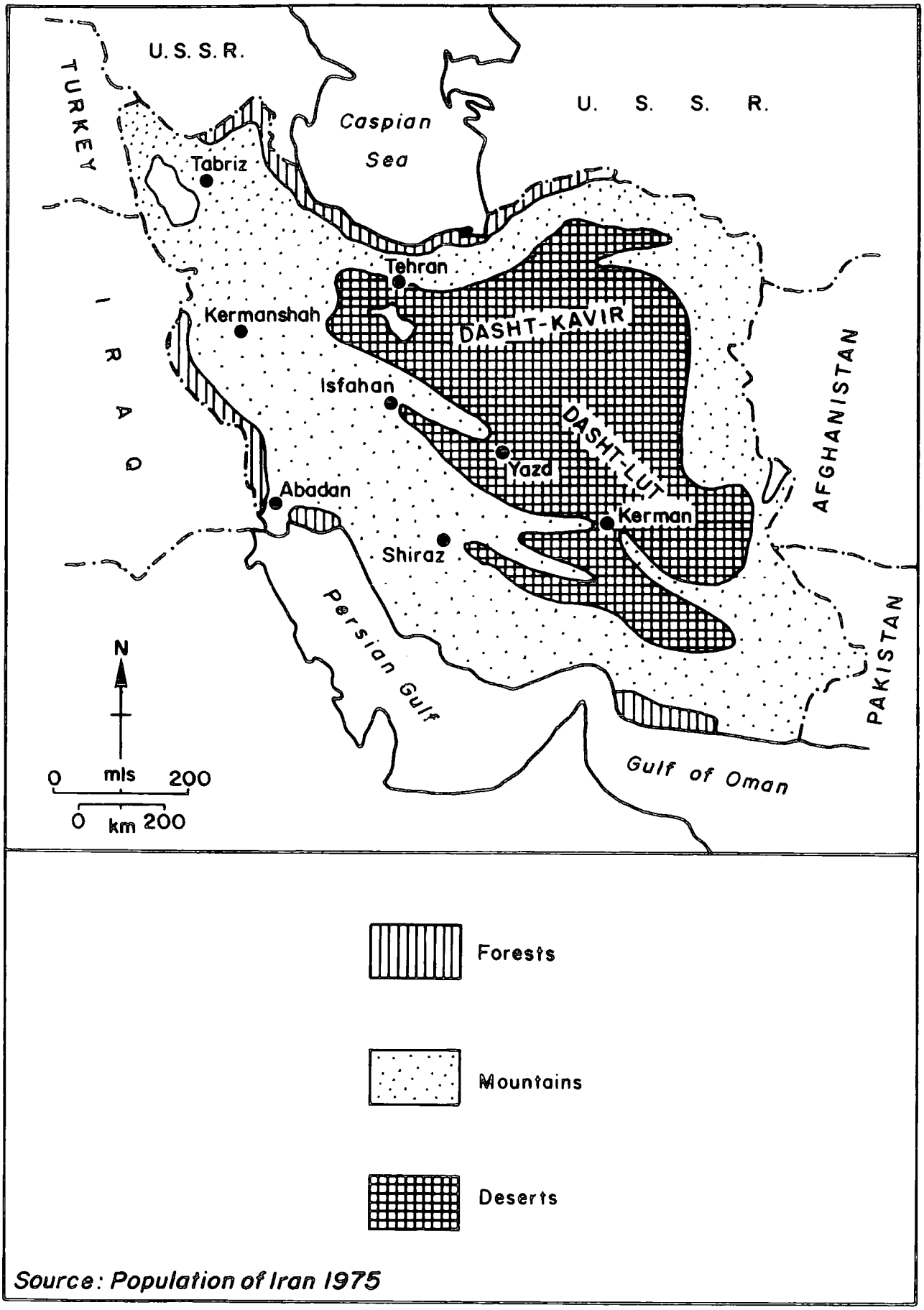
Fig 1·1 PRINCIPAL GEOGRAPHIC REGIONS OF IRAN



Source: Population of Iran 1975

CONTENTS

INTRODUCTION

There are obvious phenotypic differences between human populations throughout the world. Physical characteristics, such as the head and face measurements, variations in skin colour, hair type and body build, have been the basis for racial classification for a long time. With the help of archaeologists, historians and linguists, we have been able to build up a picture of the early migrations of man over the earth's surface. Although obvious phenotypic features distinguish one population from another, it is also recognised that genotypic factors, such as blood group gene frequencies, differ from population to population.

It is evident that regional differences have biological significance and the functioning of the physical organism towards its environment is determined by the genes responses. Physical anthropologists are devoted to the understanding of these differences and their biological significance.

The study of population structure can show the interrelationship of biological and cultural variation with reference to a variety of models. Since the genetic structure of a population refers to the distribution and relationship of gene and genotype frequencies, it is ultimately a reflection of the population's mating structure (Yasuda and Morton 1967). In studies of population structure, the effect of barriers to gene flow, which create a subdivided population, are of major importance. These barriers may be geographic and/or cultural in nature.

Man has complex rules about marriage and mating which can affect the amount of inbreeding in any population. In some small groups, the prohibition of mating with a close relative may force a man to seek a bride from another community, thus expanding the gene pool.

Many thousands of years ago the movement of both large and small groups of people and their consequent admixture have made it difficult for any clear classification of human types to be made. In fact, much of today's research into human population variation seems to emphasise the need to examine the various factors contributing to human diversity.

The ABo blood groups were discovered at the beginning of the century (Landsteiner 1900), their Mendelian inheritance indicated in 1910 by Von Dungern and Hirszfeld. Hirszfeld and Hirszfeld (1919), introduced the distribution of human blood groups as a new basis of classification. An enormous mass of information has accumulated since then on the distribution of ABo blood groups, the results of which were collected by Mourant et al (1954 and 1976) whose investigations suggested their variation in frequency differed from one population to another (Sunderland 1973, Papiha 1979). Sunderland (1973), considers that, ".... from an anthropological viewpoint the most interesting matter is that the distribution of the A, B and o genes is extremely variable among the world's people".

Distribution of other genetical characters such as MNS, Rh and taster reactions to phenylthiocarbamide and the later discovered blood groups are still being studied. These characters are susceptible to accurate statistical analysis. Their mode of inheritance is by Mendelian laws.

Apart from blood group systems, the new biochemical markers such as serum proteins, red cell isoenzymes and haemoglobins are of great importance in anthropological research. Their frequencies change slowly and the mode of inheritance is relatively simple. Surveys from various parts of the world have shown that most of these markers are polymorphic, that is, most of them occur in two or more forms, maintaining a frequency of greater than one per cent and less than ninety nine per cent.

It is not possible to carry out controlled breeding experiments on human populations. Even if there were no moral objections, the practical difficulties would make it very hard to study such an experiment. For example, the lengths of human generations would mean that the project would take many years even if a small population were studied. At the present time, the only practicable means of piecing together the possible reasons for human population variation, is to study the demographic history of a population, together with a detailed census of the existing generations and a survey of genetic markers, such as the blood group systems. The latter can provide very useful information on the differentiation of human populations.

CHAPTER 1 INTRODUCTION TO IRAN

1.1 GEOGRAPHY

1.1.1 PHYSICAL FEATURES

Iran is a large country with a total area of 628,000 square miles (1,645,000 square kilometres) and is located in between 44-63°E and 25-40°N. It extends about 700 miles from North to South and 900 miles from East to West, its longest borders being with Russia in the North and Iraq in the West, but it also shares frontiers with Turkey in the North-west and Afghanistan and Pakistan in the East and South-east respectively. Iran's southern border runs along the Coast of the Persian Gulf and the Sea of Oman. The country can be divided roughly into three areas; one consists of mountains, another of deserts and the remainder of forests and woodlands. (Fig. 1.1).

It is a country of contrasting landscapes:- the lush Caspian littoral with its heavy rainfall and deep hard wood forests; the barren salty stretches of the deserts; the snow-covered mountains and the palm groves on the Persian Gulf.

Geography and climate have played a decisive role in shaping the history and the distribution of Iran's population. The shortage and/or inaccessibility of water, the ruggedness of terrain, and the extremes in climatic conditions have restricted habitation mainly to the sea coasts and the foot hills of the mountains.

Two great deserts, the Dasht-e-Lut and the Dasht-e-Kavir, in the centre of the country are among the most arid in the world, and, while an occasional oasis may be found in the Kavir, the

Lut is totally barren, supporting no life whatsoever (Sunderland 1973).

Ecologically, rivers have played an important role in the location of the cities. The country is fringed on all sides by high mountains which tend to give Iranians a sense of isolation, and are also responsible for extreme climatic conditions. The annual rainfall ranges from less than two inches in the desert areas to over sixty inches in part of the Caspian Sea area.

Two major ranges divide the country in a West-easterly direction: the Alborz range, beginning in the Caucasus, passing through Northern Iran and continuing into Afghanistan, and the second range, the Zagros, begins in Anatolia and continues right down to Baluchistan in the South-east of Iran. There are several major lakes in Iran, and the Caspian, the largest lake in the world, lying to the North, is a great inland sea.

The temperature ranges from $50^{O}C$ in parts of the desert to $-33^{O}C$ in parts of Azarbaijan and Hamadan (source, General Department of Meterology, 1974). Humidity is near zero in desert areas like Yazd and is very high along the Caspian coast and the Persian Gulf.

1.2 HISTORY OF IRAN

The story of Iran, before the time of King Cyrus (550-520 B.C.) is a confused patchwork of myth and legend. Archaeological excavations have revealed a long history of civilisation, the evidence being of two kinds: pottery and inscribed writings in Cuneiform script on clay tablets. The former gives a glimpse

of an early civilisation, as, e.g. Perspolis, which was built prior to 4000 B.C., at first Neolithic in character, later developing into a full Bronze Age type which was homogeneous in essential and stretching from the Syrian coast to the Indus. From the ancient writings we gain information concerning the culture of this region whose highland in the North, stretches from Anatolia across to the Iranian plateau. In these early days, the highlands had not yet been occupied by the Aryan or Indo-European peoples. These people have been tentatively called Caucasian or Caspian by Arberry (1953) in the absence of insufficient reliable evidence on the ethnic origin and relation of the people.

Knowledge of the earliest inhabitants of Iran is very fragmentary. Recent excavations in one cave at Behiston, and in the caves of Belt and Aota near Behshahr on the Caspian coast, indicate an active flint industry in the Middle Paleolithic period, as well as skeletons and skulls of the Mesolithic period. This latter material has been dated to about 10,000 B.C., by Carbon-14 method of analysing pieces of charcoal from various levels of the digging, suggested that these people were Nordic and of the same race of the Upper Paleolithic hunters of Europe (Wilber 1963). Apparently, in Post-glacial times, the shores of the Caspian constituted an important passageway of East-west movement of people, with cultural connections between Northern Afghanistan and Eastern shores of the Mediterranean. During the Upper Pleistocene and Upper Paleolithic times, Upper Paleolithic man and his culture were very widely distributed throughout South-west Asia. This Aurignaucian man wandered extensively along the Mediterranean coastal areas, the Fertile Crescent and the shore

of the Caspian (Sunderland 1968).

Toward the end of the last glacial period, those living on the fringes of the Northern Eurasian area in Iraq, Iran, Afghanistan and contiguous area had already become Mesolithic hunters, and areas like the Caspian shores of Iran might have become important avenues for human movement and migration (Sunderland 1968).

In ancient times, people of various races lived in this land, and the culture and civilisation of some of them, like the Elamites, dates as far back as 3000 years B.C. They created their capital at Susa about 130 miles North of Abadan, and for a long time they struggled to maintain their independence. Susa was sacked by the Assyrians who destroyed the Kingdom of Elam.

1.2.1 ARRIVAL OF ARYANS IN IRAN

The plateau was the scene of many invasions, but some of the strongest "tribes" to invade were Aryans. They came to the Iranian plateau from the North sometime in the middle of the second millennium B.C. (Ministry of Information 1971).

It was a branch of the race which became known as the "Indo-European" race. Many of them migrated to Central Asia and the Indus Valley about three thousand years ago while the rest remained in Iran.

The Indo-European group called themselves "Ary or Airy" meaning noble and brave, while those who assumed control of the Iranian plateau gave it the name of "Airyan" later it became Eran or Iran.

The migration of "Ary" people had taken place not later than

the middle of the second millennium B.C. This migration to the East and North of Iran continued for years (Vreeland 1957). The Medic and Pars were the two Aryan tribes who entered Iran from the Northern side of the Caspian sea and by way of the Caucasus.

In 836 B.C. the Assyrian King broughtunder subjection both tribes, who had managed to reach the vicinity of Lake Urumieh, and forced them to pay tribute to him.

The second group crossed the river Oxus and settled down in the East and North-east of Iran. In those days these people were ruled by local armies or chiefs known as "Koy" or "Kay" meaning "King".

In the "Shahnameh" of Ferdowsi (1000 A.D.), these Kings are described under the Kianian dynasty (Ministry of Information 1971).

Their domain extended up to Gorgan and Mazenderan on the one side and the Indus Valley on the other. The present Khorasan and Afghanistan formed a part of their territory. Their first King was "Kay Gobad" and last in the line was "Kay Goshtasp" who was a follower of Zoroaster.

1.2.2 THE BEGINNING OF RECORDED HISTORY

The Medic tribe gradually settled down in the region covered by Rey in the East, the Zagros mountain in the West and by the river Kura in the Caucausus in the North and North-west. This was known as the land of the Great Medes and its capital city was Hagmetane, originally called Hangmatana meaning "place of assembly" (modern Hamadan). The first Iranian government of historical importance was established in this city by

Dayaukku (Deioces) in the year 708 B.C. The Medes after forming an alliance with Babylon, destroyed Nineveh the Assyrian's capital, and created an empire over the vast territory from Southern Iran to part of Asia Minor for one and a half centuries. The Medes empire was overthrown by Cambyses, son of Cyrus the Great, in 550 B.C. giving place to the Achaemenian dynasty belonging to a Pars tribe.

1.2.3 THE ACHAEMENIAN DYNASTY

The Pars or Persians came to present Western Azarbaijan from the Caucausus and lived there for sometime. Thereafter, they started on their southward movement. They remained in Northern Khosistan and thence migrated to Fars. The name of the present province of Fars and the name Persia given to Iran by the Greeks and other European people has been taken from the name of this clan. They ruled over the vast territory for 230 years from the middle of the 6th Century B.C., to the end of the 4th Century B.C.

During this period the Aryans got an opportunity to raise the standard of their culture, assisted by the civilised and cultured people living in ancient Mesopotamia, and subsequently, to become instrumental in developing the culture of the world and to civilise other people.

In 330 B.C. Alexander of Macedonia invaded Iran and conquered its capital Perspolis. Sixty eight years after the death of Alexander, Arsacs 1, Chief of the Parthian clan living in Parthova (present Khorasan), in the East of Iran, revolted against Greek rule and declared independence in the year 257 B.C. His successor quickly brought the whole of Iran under their

control. During this period the Romans had replaced the Greeks and had extended their boundary to the frontiers of Iran. In this period Mongols attempted to invade Iran and to drive out the Aryans who had ruled this territory for centuries.

The Parthian dynasty was defeated by the Persian General - King,Ardeshir-Babekan in 226 A.D. Thus the reins of government again came into the hands of a Persian family which descended from the Achaemenians.

During the days of Parthian reign, Iran was a secular state, with feudal lords ruling over various parts of it. Provinces and cities enjoyed comparatively greater freedom though power was somewhat centralised at the capital.

The Sassanians were a religious dynasty (followers of Zoroaster) who believed in a powerful central authority.

Twenty four Kings of this dynasty ruled from 224 A.D. to 652 A.D., in which year it was overthrown by the Arab Moslems (Jackson 1928).

Towards the end of the Sassanian reign, almost all the people of Iran were dissatisfied with the government, so that Arabs, though less in number and with scanty means, soon overthrew the empire which had no spiritual base. Then started a struggle between Islam and the prevalent religion of Iran, namely Zoroastrianism.

1.3 POPULATION OF IRAN

Over the centuries, Iran's population has fluctuated considerably. Sometimes immigration has increased the population, while at

other times it has been depleted by foreign invasions, civil wars, famines, earthquakes and disasters, but after minor fluctuations the population began to grow steadily (Iran Almanac 1978).

The population has risen from an estimated 7.5 million in 1906, to 8.5 million in 1921, and to 15.0 million in 1941. By the first census, of 1956, it had reached 19.0 million, 25.8 million by the second census and 33.6 million in 1976 and nearly 36.0 million in 1980. The three national censuses held in November, 1956, 1966 and 1976, show little change in the numbers of the religious minority groups in Iran.

1.4 LANGUAGES, LINGUISTIC GROUPING

Since the Aryans first arrived in the area (see part 1.2) successive invasions of Mongols, Turkic and Semitic tribes have produced a mixture of cultural, physical and linguistic strains through centuries of intermarriages and social interaction.

In general, racial mixture is greatest in those parts of Iran which have formed the historical zones of passage for invading armies, such as Azarbaijan, Khorasan, Sistan, Khosistan and Kermanshah. The transfer of tribes and the incursion of wandering Arab groups from Iraq have also had an effect on the racial mixing within the country (Clark 1972).

The most important language in Iran is Persian, which is the official national language, spoken by nearly half of the population. Persian is an Indo-European language close to Kurdish, Urdo and the Pushtu language of Afghanistan. Various languages closely related to Persian are spoken in Gilan and Mazanderan

and by Lur and Bakhtiari tribesmen (Fig. 1.2). The Kurdish language which is also related to the Indo-European group is spoken in Kurdistan, Kermanshah and some parts of Azarbaijan. The Kurds are the fourth largest ethnic group in the Middle East and about one third of them live in Iran.

They are probably descendants of the Medean branch of the Aryan people who migrated from the Eurasian Steppes to Iran. Most of the Kurds are Sunni Moslems, whereas most Persians are Shia Moslems; though there are a number of Shia Moslem Kurds in Kermanshah.

In the Eastern part of Iran near the Afghanistan and Pakistan border there is another ethnic group, the Baluchi, who number about 500,000 in Iran and are almost all Sunni Moslems. A number of Baluchi are nomadic and semi nomadic but most of them have settled in cities, towns and villages.

The second major element of the population is composed of various Turkic-speaking ethnic groups. Beginning in Achaemenian times, nomadic Turkic peoples migrated out of Central Asia into North and North-west Iran. In the 11th Century they were united under the Seljuks and established their dominion over much of the Middle East. The Turkic speakers are concentrated in North-western Iran, where they form the great majority of the population in West and East Azarbaijan provinces. The Turkaman are another group, living in the North and North-east around Gorgan and Khorasan, and their language is related to Turkish of Iran and most of them are Sunni Moslems. Historically they are descendants of the Mongol whose leader Gengees Khan led his nomadic tribe to Iran early in the 13th Century and occupied the Northern part

of Iran. They present a markedly different appearance from other Iranians.

Assyrian Christians were estimated 20,000 in 1966, most of them in Tehran, Uromieh and Tabriz. They speak Aramaic dialects. The Armenians, according to the 1966 census, numbered 110,000 in Iran; some of them live in North western Iran in Azarbaijan and some were settled by Shah Abbas in the 16th Century outside Isfefan. Today, most of the Armenians live in Tehran; they speak their own language as well as Persian.

Arabic dialects are spoken by nearly two million people in the South of Iran namely Khosistan and also along the South Coast of Iran. There is no close linguistic relationship between Arabic and Persian. Most of the Arabic speakers are Shia Moslems.

The Zoroastrians of Iran are minority groups concentrated in Tehran, Yazd, Kerman and Isfehan, speaking Dari (a dialect spoken in Iranian palaces before Islam). This Dari dialect was spoken by Zoroaster and the "Avesta", the sacred book of Zoroastrians, has been written in this dialect and consists of forty four letters written from right to left.

1.5 POPULATION OF IRAN BY RELIGIOUS AFFILIATIONS

In 1921 of the estimated nine million population of Iran, nearly eight million belonged to the Shia faith, 800,000 to the Sunni faith, 9,000 Zoroastrians, 20,000 Jews, 43,000 Armenians and 23,000 Christians. As these figures show, the Iranian Moslems are mostly Shia, the Sunni faith being represented by a smaller number, and Shia and Sunnis combined consituted 98.0 per cent of the population in 1921 (Momeni 1975). The distribution

of Iran's population by religious affiliation, by sex and urban-rural residence, in 1956 and 1966 is given in table 1.1.

In 1956, 98.5 per cent of the total population were Moslem, and the remaining 1.5 per cent were non-Moslem. Of the non-Moslem population of 301,000, 38.2 per cent were Christians (115,000), 21.6 per cent Jews (65,000), 5.3 per cent Zoroastrians (16,000), 19.6 per cent belonged to other non-Moslem religious and 15.3 per cent (46,000) not reported.

In 1966, about 99.0 per cent of the total population were reported to be Moslem and only 1.0 per cent non-Moslem. This means a reduction of non-Moslem in 1966 as compared with 1956, by 0.5 per cent. Of the urban population in 1966, 97.3 per cent were Moslem, and 2.7 per cent were non-Moslem; of the rural population, 99.7 per cent were Moslem. Inspite of the general reduction in the proportion of non-Moslems over the 10 year period between 1956 and 1966, the proportion non-Moslems in the urban area in 1966 remained almost the same as in 1956, but it decreased in the rural areas from 1.0 per cent in 1956 to 0.3 per cent in 1966, indicating a heavy movement of the non-Moslem population including Zoroastrians from rural to urban area, or even to other countries.

TABLE 1.1 POPULATION DISTRIBUTION BY RELIGIOUS, SEX, AND URBAN-RURAL RESIDENCE BASED ON 1956 AND 1966 CENSUSES OF IRAN

1956	Iran			Urban			Rural		
	Figures in thousands			Figures in thousands			Figures in thousands		
Religious	Both Sexes	Male	% Male	Both Sexes	Male	% Male	Both Sexes	Male	% Male
Moslem	18,600	9,500	50.9	5,800	3,000	51.7	12,900	6,500	50.5
Christian	115	58	50.6	62	28	45.5	53	30	57.0
Jewish	65	33	51.3	47	23	48.9	19	11	57.1
Zoroastrian	16	7	47.7	9	4	43.9	7	4	52.8
Other religious	59	30	51.2	31	16	50.0	28	15	52.5
Not reported	46	23	50.5	18	9	49.6	28	14	51.1
1966									
Moslem	24,800	12,800	51.8	9,500	5,000	52.1	15,200	7,900	51.6
Christian (Combined figures)	149	75	50.3	128	65	50.8	20	11	55.0
Jewish	61	31	51.1	59	30	51.2	2	1	46.4
Zoroastrian	21	10.8	51.4	16.7	8.6	51.4	4.7	2.2	46.8
Other religious	77	39	51.2	57	29	51.0	20	11	51.7

Source of Information: The Population of Iran 1975

1.6 TEHRAN

The capital of Iran is Tehran; this is the largest city, with a total area of 4,027 square kilometres, and is situated in the administrative division of the Central Ostan (province). To the North and North-west lie the Elburz mountains and to the South, the desert.

Its population has increased from an estimated 120,000 to nearly 7 million in 1976:-

	Tehran Ostan	Tehran City
1860 -	120,000	
1922 -	210,000	
1939 -	540,000	
1956 -	1,600,000	1,512,082
1966 -	2,829,184	2,719,730
1976 -	6,921,000	4,496,000

According to the censuses of 1956 and 1966 the population could be divided thus:-

1956 92% Moslem; the rest - Christians, Jews, Zoroastrians and other faiths.

1966 93.9% Moslem; the rest - Christians, Jews, Zoroastrians and other faiths.

In 1956, the total number of Zoroastrians in the Tehran census district (Ostan) was 4,846, and of these 4,627 lived in Tehran city. By 1966 the numbers had increased to 9,381 in the Tehran Ostan and 8,976 in the city. There are no reliable figures for 1976, but various sources suggest that the number of Zoroastrians had risen in the Ostan to 12,000, most of whom lived in Tehran city.

1.7 YAZD

Yazd is a symbolic home for the Zoroastrians (Jackson 1906), and its historical background reaches back to the Sassanian period 220-652 A.D. (Bonine 1980). Some villages in the Yazd area also established early in Sassanid times. Therefore, Yazd has been the urban focus of this region for more than a millenium. It was established over 1,500 years ago and was a major settlement as early as late Sassanid times. During the Mongol Conquest of Persia (1220-21), Yazd was one of the few Persian cities to escape devastation. According to Bonine (1980), during the 14th Century a great expansion of new construction occurred both within the city and in the surrounding area, and many shrines, mosques, religious schools, qanats, and other structures were built. Yazd Ostan, with a total area of 56,895 square kilometres, and its capital city of Yazd had a population of 289,818 in 1956, of whom 63,502 lived in Yazd city. The population of Yazd city reached to 93,241 in 1966 and 135,978 in 1976.

96 per cent of the population in the Yazd census district were Moslems and in Yazd city it was 94 per cent.

In 1966, 97.7 per cent of the population were Moslems. According to Jackson (1906), the number of Yazdi Zoroastrians in 1903 was between 8,000 to 8,500. In 1956 their number was 6,064 in Yazd Ostan, with 4,712 in Yazd city; from 1966 census, there were 4,933 Zoroastrians in Yazd district, of which 3,866 were in Yazd city.

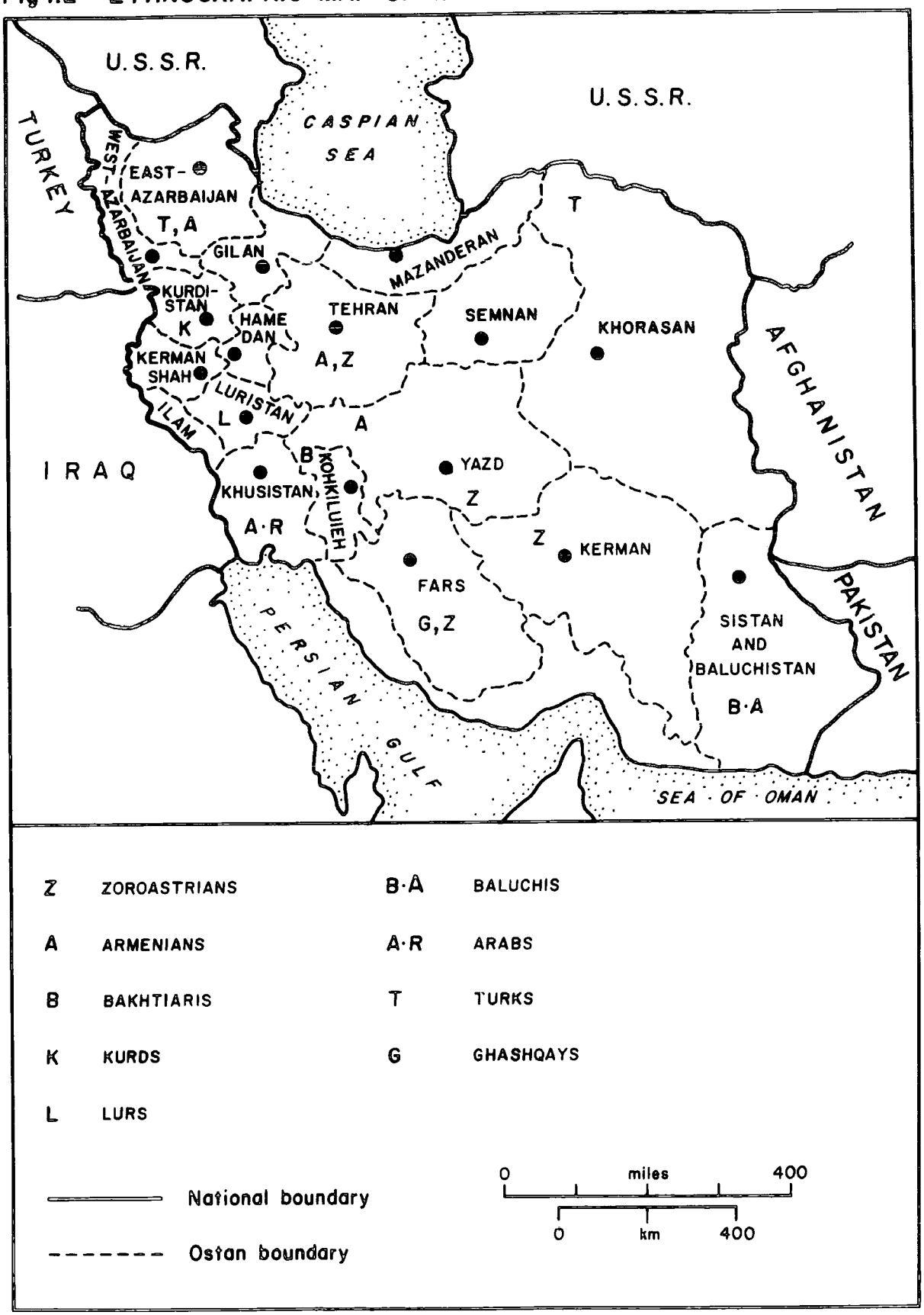
1.8 KERMAN

Kerman is the capital of Kerman Ostan or province with an area

of 60,318 square kilometres, and probably existed as a settlement in Sassanian times as a defensive outpost against the Baluchi tribes. It was sacked by Timur, the Afghans and by Nadir Shah, and was re-built during the 19th Century (Fisher 1968).

It was surrounded by deserts and Zagros Mountains on all sides. The total population of Kerman city was 62,157 in 1956, 85,404 in 1966 and 140,309 in 1976. Ninety eight per cent of the population in the Kerman province were Moslems; in Kerman city the proportion was 95 per cent. The remaining small proportion consisted of Jews, Zoroastrians, Christians and other faiths in 1956. According to 1966 census, 99.1 per cent of the population were Moslems, and the remaining 0.9 per cent were of other religious. The number of Zoroastrians in Kerman census district in 1956 was 1,857, with 1,776 in Kerman city. In 1966 there were 1,429 Zoroastrians in Kerman Ostan, with 1,369 in Kerman city.

Fig I.2 ETHNOGRAPHIC MAP OF IRAN



CHAPTER 2 ZOROASTRIANS

2.1 ZOROASTER AND ZOROASTERIANISM

The faith of Iran, which had been the state religion for more than a thousand years, was Zoroastrianism. This faith, which centred on belief in the God Ormazd, was established by the ancient Iranian Prophet, or founder, Zoroaster . It is generally considered that he was born in North-west Iran, near Lake Uromieh (West Azarbaijan) in the 6th Century B.C. (Jackson 1906 and 1928, Smith et al 1971). The religion which he founded became the faith of the Achaemenian Kings and was one of the important early religions in the world.

Most Zoroastrians today believe that Zoroaster laughed, instead of crying, at the moment of his birth. They state that ordinary men are all subject to the rules of nature, but a prophet is born quite independent of them. It is further said that a prophet is sent down to this world by God, when he sees that the people have become very sinful and wicked.

At the age of twenty or thereabouts, he withdrew from the world in order to give himself up completely to meditation. This is the period of preparation common to all great religious leaders (Jackson 1928). When he reached the age of thirty, the revelation came and he entered upon his ministry. At the age of forty-two he converted Vishtaspa, (the father of Darius), who became the protector of the faith.

The influence of the religion extended throughout Iran and even beyond its borders. He seems to have died, by violence, at the age of seventy-seven, (Jackson 1906 and 1928). According to

Mistri (1906), Arjasp, King of Turan (Tar Tary), entered Iran, and besieged Balkh, capital of Gushtasp, then entered the capital of Gushtasp. At that time Zoroaster was praying in a fire temple. A Turanian Chief entered the sacred place, and mortally stabbed Zoroaster in the back. This took place about thirty five years after Gushtasp had adopted the new faith.

Zoroastrians were persecuted when the Greeks and Romans invaded Iran. In the 6th Century A.D., invading Arab armies brought a new religion to Iran, Islam . From that time Persia adopted Islam and ceased to be Zoroastrian and only a small group remained faithful to the old religion and were persecuted for their tenacity.

They found a desert home at Yazd and Kerman in the centre of Iran, surrounded by mountains and deserts and far from frontiers and royal courts. Another group refused to be converted, and chose exile in India, finding a place of refuge in Bombay and becoming the ancestors of the present Parsis. They moved southward to the city of Ormoz on the Persian Gulf. After they had lived there for some fifteen years, they resolved to settle on the coast of India and landed on the Island of Diu. They stayed there for nineteen or twenty years until circumstances led them to push further South to Gujarat. They landed at Synjan a small town ninety four miles North of Bombay in 716 A.D., and found there a resting place among the tolerant Hindus (Jackson 1928).

They received permission to settle if they would agree to certain simple regulations, such as that they should speak the local language, their women should wear Hindu dress and they should observe Hindu social customs. These were accepted and followed.

Thus Synjan and its surrounding area became their new home. In the year 775 A.D., a second group appears to have joined these pioneers, and together they made a new community which continued for five hundred years (Fig. 2.1).

In 1315 A.D., Iranian Moslems made an attack to India, and Synjan was destroyed. The Parsis fled to the hills and kept up their ancient customs and ceremonies. When the Islamic rule relaxed and conditions changed, the Parsis returned to their former place.

In the 16th and 17th Centuries Parsis were widely distributed over Gujarat, Bombay and wherever trade offered them opportunity to develop their business interest (Sekar 1948). The Iranis are another group of Zoroastrians which migrated to India during the last 150 years. According to Sekar (1948) in the years 1920 to 1930 between 4,000 and 5,000 Zoroastrians moved to India.

By the 19th Century the number of Zoroastrians (or Gabres, as they were usually known) in Iran had fallen below 10,000 (Paul Ward 1971). In 1814, the Society for the Amelioration of the condition of the Zoroastrians in Iran gave a figure of 7,200, of whom 6,000 were in Yazd, 450 in Kerman, and 50 in Tehran. By 1892, according to the same source, the total had risen to 9,300, of whom 6,900 were in Yazd, 2,000 in Kerman, and 300 in Tehran.

Foreign observers, from the 17th Century to the end of the 19th Century, agree that the Zoroastrians suffered from both great poverty and severe discrimination. In common with other minorities, they were subject to the "Jiziya" or poll tax. Most of them seem to have earned a modest living in silk

cultivation and weaving. The Zoroastrians were forbidden to take up crafts or professions which might bring them into contact with Moslems, and were in the main restricted to farming and labouring. They had, moreover, to wear distinctive clothing, so that they could be recognised and shunned. Zoroastrian men had to have garments of cotton or wool and the women wore coloured dresses and were clearly distinguished from the rest of the community by their refusal to veil their faces.

The Zoroastrians for their part had no desire to fraternise with their oppressors, and they took deliberate measures to secure for themselves a degree of protective isolation when they adopted a dialect, incomprehensible to speakers of Persian, for their own use. This, called Dari, is spoken by all Zoroastrians. The first language of the Zoroastrian today is Dari and the second language is Persian, but in Kerman, Yazd or even Tehran, there are a number of old Zoroastrians who can not understand and speak Persian.

The growing trade between southern Iran and India during the 19th Century had some beneficial effect on the Zoroastrians; this was due to increasing contact with the highly educated parsis of Bombay. Through the efforts of the Parsis, and of those Iranis who migrated to India, the Zoroastrians were permitted to enter trade and professions.

In 1882 the annual poll tax on Zoroastrians was abolished (Boyce 1977). More important, in 1856, two schools were founded in Yazd and Kerman, and additional ones were opened later. These contacts, and the general changes in Iranian society, have enabled the small Zoroastrian community to play an increasingly

important role in the economic and cultural life of Iran. The period that followed, from the late 19th Century down to the second world war, was in many ways a golden age for the Zoroastrians. New education and new wealth and influence were put largely at the service of the faith. Many of them travelled to Bombay and then returned to Iran. In recent years material life in Iran was modernised and the old isolation of Zoroastrians, particularly in the villages, were broken into as the means of transport and communication were speeded up.

In the 19th Century, Yazd and Kerman were traditional, pre-industrial Moslem cities, and like other cities in Iran, they were divided into few residential quarters (mahalleh), in which the population of Yazd and Kerman were segregated on the bases of religion and occupation. According to Paul Ward (1971), the Zoroastrian part of Kerman was located beyond the eastern wall of the city. The precariousness of life in such a location is evidenced by the ruins of the ancient Zoroastrian part to the North of the city, which was levelled by an Afghan invasion in the 18th Century. All Zoroastrians lived within their own quarter, and were forbidden to live inside the city walls. As the result the fire temples, baths and schools of the Zoroastrians were located here. A Community Council (Anjuman), represented members in dealings with the Moslems.

In this atmosphere, the Zoroastrian community developed the characteristics of a closed, introverted, and static society.

The Tehran Zoroastrian group is relatively new, created by migrants from Yazd and Kerman during the past century (Boyce 1977), and since the 1930's it had had close contact with

Parsis in Bombay.

The Kerman Zoroastrians are as old as those in Yazd, but their number was reduced by wars in the 19th Century. In the past the whole Yazd and Kerman area was very isolated and there were no roads except for the camel caravan routes which passed across it, but progress during the last few decades has linked Yazd and Kerman to Tehran by road, rail and air, so that travel between these places takes only a few hours, whereas in the beginning of the 20th Century it could take days and some times weeks to journey from Tehran to Yazd or even Yazd to Kerman, so Yazd and Kerman remained isolated beyond the mountains and deserts.

2.2 SOME ASPECTS OF ZOROASTRIAN BELIEF

It was believed by the followers of Zoroaster that the Avestaic literature, which was originally divided into 21 sections, was written by Zoroaster himself. It contained the revelations of God, whom they called Ahura Masda, regarding heaven and earth, and subjects like astronomy, astrology, geography, philosophy, medicine, etc., were therein fully treated. Questions were put to God by the Prophet in his inspired state, and he received answers from Him.

Their faith seems to be the one thing that holds them together. They claim that the only way to be a Zoroastrian is to be born of Zoroastrian parents. The Zoroastrians' belief is in the conflict between good and evil. The light, the sun and the fire are the symbols of Ahura Masda; therefore, the sacred fire always burns in their temples, and when they pray they face the sun. Zoroastrians avoid polluting the sacred elements, fire,

water, air and earth. They believe that at the end of the appointed time the force of good will win out over evil and they also believe that fire purifies, consuming the unworthy: thus it is that Iranians (Zoroastrians and Moslems) even today seek to purify themselves on New Years day by jumping over small bonfires. Another binding custom was the disposal of the dead. Burial, defiling to the earth, was abhorrent to the Zoroastrians. Dekhmehs or tower of silence, were built outside the cities and no one but the professional bearers of the dead entered these towers. Nowadays, Zoroastrians have their own cemeteries and they cremate the dead.

2.3 MARRIAGE

According to Mistri (1906) the ancient Zoroastrians, especially those in the Sassanian period, liked to marry first cousins. The Zoroastrians of today do not marry until they are considered mature, this is usually at about fifteen years (Jackson 1906 and 1928). A Zoroastrian girl is protected by her parents, until she attains puberty which this religion is held to be at the age of 15. At this age she must be married according to the precepts of the religion. She has her own choice in the prescribed union, but she may be guided by her parents (Mistri 1906). In a Zoroastrian social circle greater respect is shown to those who have children than those without them. Zoroastrianism allows a man to select his own wife, and a woman also should not be forced to marry a man she does not like. Parents may suggest and advise but do not enforce.

According to Jackson (1928) and Mistri (1906), among Zoroastrians there is no practice of polygamy. They are strict monogamists

as a rule and polygamy is a punishable crime, but if a wife is found barren the husband is allowed to take another wife for the purpose of begetting children. Having a son is considered important because a son or sons continue the family name and because Persians and Zoroastrians possess a strong patrilineal orientation which is reflected in their descent and inheritance systems (A. Momeni 1975). Descent is traced strictly through the male line, although the inheritance of property follows the same rule, usually movable property can be passed through the female line. Marriage also is a family affair. The marriage between cousins serves to strengthen family solidarity, attach wealth to social position and increase power and influence.

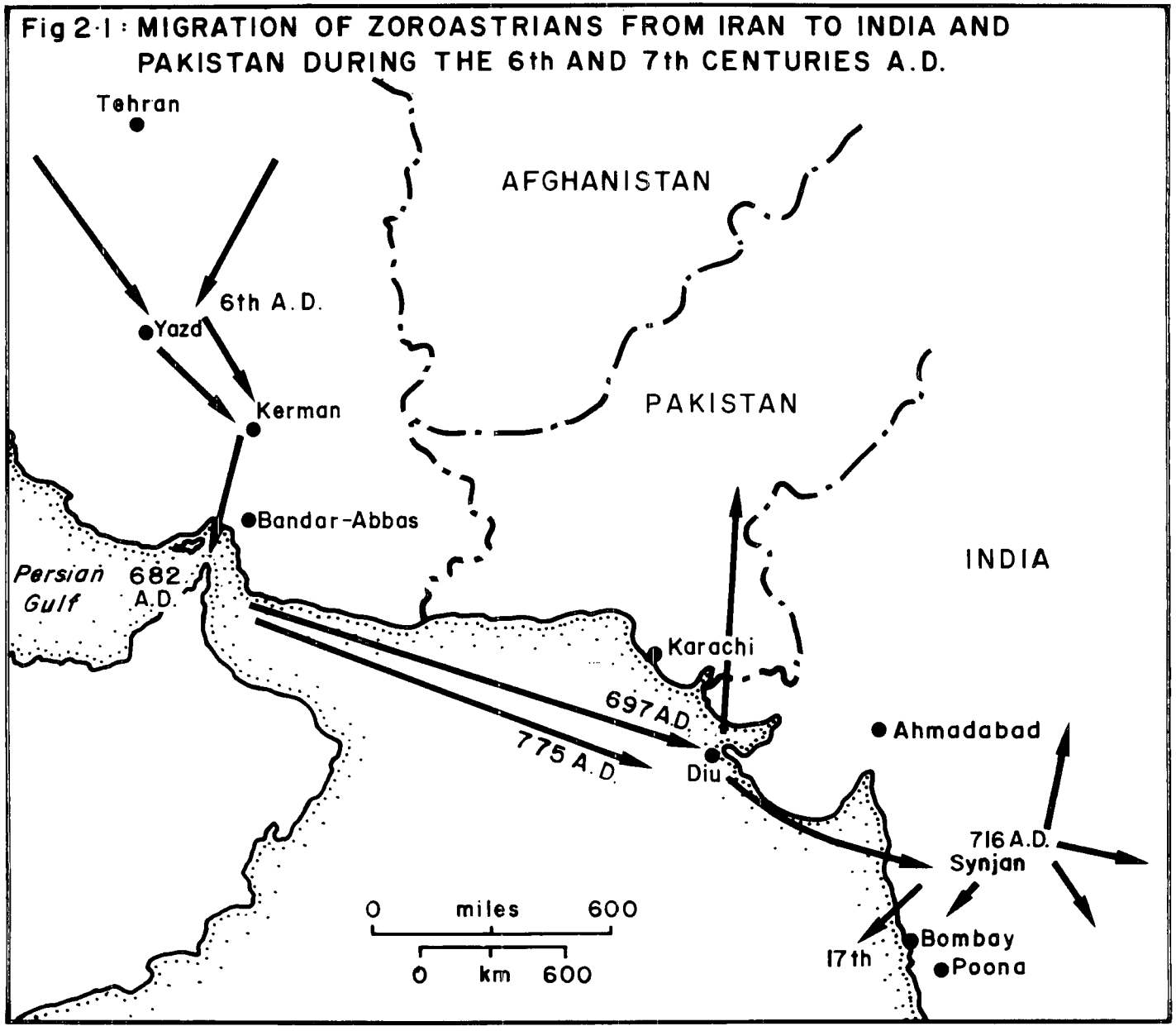


Fig 2·1 : MIGRATION OF ZOROASTRIANS FROM IRAN TO INDIA AND PAKISTAN DURING THE 6th AND 7th CENTURIES A.D.
Tehran
AFGHANISTAN
6th A.D.
Yazd
Kerman
PAKISTAN
Bandar-Abbas
INDIA
Persian Gulf
682 A.D.
Karachi
697 A.D.
775 A.D.
Ahmadabad
Diu
716 A.D.
Synjan
0 miles 600
0 km 600
17th
Bombay
Poona

CHAPTER 3 GENETIC VARIATION IN HUMAN POPULATIONS

The history of the divergence and evolution of the earlier primitive groups of man in today's complex components of race and creed is far from being fully explained or understood, but the discovery of differing blood groups by Landsteiner et al, in 1900-1901 heralded a new era of serological genetics and the number of biological markers for which population groups may be tested to determine possible affinity with others is being constantly increased.

We now recognise that the phenotype of an individual is derived from the hereditary material developing within a given environment. If environmental conditions are variable the outward manifestation of similar genetic factors may be different (the converse being equally true, but not so easily observed), the wide range of stature and weight measurements being influenced by such factors as nutrition and climate, so that our phenotype patterns are extremely variable. Practically all the blood factors are known to be almost absolutely stable in the individual, except for rare changes in pathological conditions.

Red Cell Antigens.

Since Landsteiner's work on the ABo groups, other separate blood group systems have been discovered, in all of which inheritance has been shown to conform to Mendelian principles.

The ABo blood groups of man have been intensively studied and the distributions well-mapped because of the dramatic ill-effects arising from incompatible transfusion. Remarkably, the incidence of haemolytic disease of the new born arising from ABo incompatibility is low, but some specialists are doubtful of the sensitivity of the standard

techniques used for its detection. The Rhesus group in all its complexity has received much attention in connection with haemolytic disease of the new born, whilst other systems such as Duffy, Kell and Kidd are known to incite haemolytic antibody formations but the specific conditions for this to occur are unknown.

All these serological systems and others besides, are variable in human populations. In this thesis, they will be described among the Iranian Zoroastrians and the results compared with Parsis and non-Zoroastrian groups in Iran and India.

3.1 THE POLYMORPHIC SYSTEMS

In this chapter a brief account will be given of the genetics of various polymorphic systems, which have been considered in the present study, which are introduced below.

3.2 BLOOD GROUP ANTIGENS

3.2.1 ABo BLOOD GROUP SYSTEM

The discovery of ABo blood group by Landsteiner (1900), was the beginning of a new branch of human biology. He found that there were antibodies in human serum, which in some cases agglutimated the red cells of other humans, whereas in others there was no reaction. On the basis of these reactions, he divided human beings into three distinct groups and, a year later, the existence of a fourth group, AB, was established by De Castello and Sturli (1902). The system now known as ABo was completed.

The four groups are determined by the presence or absence in the red cell of the blood group antigens, A and B, and

therefore, the blood group of the individual is either A, B, AB or o.

Red cells containing antigen A are agglutinated by anti-A, cells containing antigen B, by anti-B. Both anti-A and anti-B agglutinate AB cells, and neither of A or B react with o cells. The relationships are given in the table 3.1.

Table 3.1 The ABo blood group antigenes and antibodies

Blood groups	Antigens in red blood cells	Reaction with anti-A	Reaction with anti-B	Antibodies present in serum
O	-	-	-	anti-A and B
A	A	+	-	anti-B
B	B	-	+	anti-A
AB	A and B	+	+	- -

Bernstein (1924) showed that the A, B, o and AB blood groups, were inherited and depended on a series of three allelic genes A, B and o. The four blood groups represent six different combinations, AA, Ao, BB, Bo, oo and AB, and factor o is recessive to both A and B. The heterozygotes Ao and Bo are indistinguishable from the homozygotes AA and BB respectively. The six genotypes produced four distinguishable phenotypes (table 3.2).

Table 3.2 The ABo blood groups and their genotypes

Blood groups (phenotypes)	Genotypes
A	AA, Ao
B	BB, Bo
AB	AB
O	oo

In 1930, Thomsen et al described the subgroups of the A blood group. They reported that there were two varieties of the A antigen, A1 and A2, with a corresponding subdivision of groups A and AB, allowing them to be classified into A1, A2 and A1B and A2B respectively. The four alleles, A1, A2, B and o, with A1 being dominant to A2 and o, can produce ten different genotypes and six phenotypes - table 3.3.

Table 3.3 The A1, A2, Bo groups and their genotypes

Blood groups	Genotypes
A1	A1A1, A1A2, A1o
A2	A2A2, A2o
O	o o
B	BB, Bo
A1B	A1B
A2B	A2B

3.2.2 THE MNSs BLOOD GROUP SYSTEM

Landsteiner and Levine (1927), were the first to find a new red cell characteristic, when they absorbed anti-human-sera with various blood specimens. They called this characteristic "M"; when rabbits were immunised with red cells containing this characteristic, a specific M-antibody was frequently produced, after absorption with non-characteristic red cells. Some antisera which were absorbed with M-red cells and this led to the discovery of a second characteristic which they called "N".

The inheritance of these antigens is based on the two alleles theory. These alleles determine the M and N antigens, each

person has two of these genes, either two M, two N, or one M and one N genes. There can be four genotypes MM, MN, NM and NN, and three phenotypes M, MN and N. The existence of antigen S as reported by Walsh and Montgomery (1947) and worked out by Sanger and Race (1947). This antigen is intimately associated with the MN system. According to them the MNSs blood group system is controlled by two pairs of closely linked genes with six phenotypes and ten genotypes as are given in table 3.4.

Table 3.4 The different genotypes and phenotypes of the MNSs blood group system

Phenotypes	Genotypes
MMS	MS/MS MS/Ms
MMs	Ms/Ms
MNS	MS/NS MS/Ns Ms/NS
MNs	Ms/Ns
NNS	NS/NS NS/Ns
NNs	Ns/Ns

3.2.3 THE RHESUS BLOOD GROUP SYSTEM

In 1940, Landsteiner and Wiener discovered the rhesus factor. They reported that the serum of a rabbit which had been injected with the blood of a rhesus monkey, not only agglutinated the red cells of the monkey but also reacted with certain human blood (85 per cent of the white people). The new factor was called Rh for the first two letters of Rhesus.

The distribution of the new system was found to be the same in the ABo and MN blood groups, suggesting that the Rh, the

ABo and MN blood group systems were unrelated. The importance of incompatible transfusions as a cause of severe reactions was demonstrated by Wiener and Peters in 1940. Red cells agglutinated by anti-rhesus serum were called Rh positive and those with no reaction were distinguished as Rh negative.

Levine et al (1941), reported the existence of incompatibility between Rh negative mother and Rh positive child.

Further investigations revealed that the antigens of the Rh system and the genes responsible for them were complicated.

There are two classical hypotheses, concerning the genetics of the Rhesus system.

According the Fisher's hypothesis (cited from Race and Sanger 1962), the Rh types were determined by a series of three closely linked genes and that the occurrence of crossing-over would be very rare. They called each different antigen D, C and E. At each gene locus there are two main alternative genes, named C and c, D and d and E and e. The occurrence of the d antigen was hypothesised, but it has never been demonstrated. As only one of each pair can be carried on each chromosome, there are eight alternative rhesus gene combinations as presented below:-
CDE, CDe, cDE, CdE, cDe, cde, cdE and Cde.

The Wiener (1963) hypothesis suggested that the Rh antigens are produced by a series of multiple alleles of one gene. He postulated that a gene gives rise to an agglutinogen and this in turn possesses a number of blood factors.

3.2.4 THE KELL BLOOD SYSTEM

Coombs et al (1946), were the first to describe the Kell antigens.

Family studies in the English population showed that the antigen K was inherited as a dominant Mendelian character. With the discovery of the anti k by Levine et al (1949), it was believed that this system was controlled by a pair of genes K and k, producing three phenotypes as given in table 3.5.

Table 3.5 The phenotypes and genotypes of the Kell system

Phenotypes	Genotypes
K	KK
Kk	Kk
k	kk

In 1957, a new antigen was described by Allen and Lewis. They called the new antigen "KP^a"; K indicates that the chromosome is the same as that carrying the gene for Kell, P is for Penney, and the "a" designates the first in the new series. Family studies by them showed that the Penney system was associated with the Kell system. Later, they reported the discovery of the anti-KP^b antibody. These antigens are produced by a pair of allelomorphic genes. Their report indicates that KP^a is uncommon in all ethnic groups and has in considerable importance in the blood typing tests.

3.2.5 THE DUFFY BLOOD GROUP SYSTEM

The Duffy system was first reported by Cutbush et al (1950). The discovery started during an investigation in the serum of a patient suffering from Haemophilic disease, and had received previous blood transfusions. Family studies revealed that the antigen was inherited by means of a gene expressing itself in single and double dose, and was unrelated to the ABo, Rh, MNS and Kell blood group systems.

In 1951, Ikin et al were reported the existence of the anti-Fy^b

factor. It is supposed that the system was governed by two allelic genes, Fy^a and Fy^b. The existence of third allele reported by Sanger et al (1955). This new factor was called "Fy" was presented in the many American negroes. Further study confirmed that the Fy allele was rare in the whites (Chown et al 1965).

The phenotypes and genotypes of the Duffy system are given in table 3.6.

Table 3.6 Phenotypes and genotypes of the Duffy system

Phenotypes	Genotypes
Fy(a + b -)	Fy^aFy^a
	Fy^aFy
Fy(a + b +)	Fy^aFy^b
Fy(a - b +)	Fy^bFy^b
	Fy^bFy
Fy(a - b -)	FyFy

3.3 SERUM PROTEIN

3.3.1 HAPTOGLOBIN

Polonovski and Jayle (1938), were the first reported the plasma protein now known as haptoglobin. With the development of starch gel electrophoretic method by Smithies (1955), he reported that when human serum is subjected to electrophoresis in starch gel, haptoglobins differentiate into one of three patterns. They are HP1-1, HP2-1 and HP2-2, being the product of two allelomorphic genes, HP1 and HP2. Sera from type 1-1 shows a single band, whereas type 2-2 gives a large number of bands, all moving more slowly than those of HP1 together with a series of bands which are not of those of the HP2. Type 2-1, shows a series of bands

similar to that for HP2-2, but with a faster mobility, and one band with the same mobility as that of the HP1-1. Types Hp1-1 and HP2-2 individuals are homozygotes for HP1 and HP2 and the type HP2-1 individuals are heterozygotes.

Various sub-types have also been reported and it is said that the HP1 gene can be resolved by subtyping into two alleles HP1F and HP1S, these two together with HP2 forming a three-allelic system.

A considerable number of rare phenotypes have been found in the haptoglobin system.

3.4 RED CELL ISOENZYMES

3.4.1 PHOSPHOGLUCOMUTASE (PGM)

Spencer et al (1964) demonstrated that when red cell lysates are subjected to starch gel electrophoresis, seven different zones of PGM can be observed. Three common phenotypes are referred to as PGM1-1, PGM2-1 and PGM2-2. Family studies show that the three types are determined by two autosomal allelic genes, PGM1 and PGM2. Phenotypes PGM1-1 and PGM2-2 correspond to the homozygotes PGM^1 PGM^1 and PGM^2 PGM^2 respectively and phenotype PGM2-1 represents the heterozygote PGM^1 PGM^2. A number of rare alleles have been shown to occur at the PGM1 locus (Hopkinson and Harris, 1966). They are determined by six alleles designated as PGM_1^3, PGM_1^4, PGM_1^5, PGM_1^6, PGM_1^7 and PGM_1^8.

3.4.2 ACID PHOSPHATASE (AP)

Acid Phosphatase, was first reported to be genetically polymorphic by Hopkinson et al (1963). They demonstrated, when the haemolysates are subjected to horizontal starch-gel electrophoresis, five

distinct red cell acid phosphatase patterns appear in different individuals. They are A, BA, B, CB and CA. The sixth pattern called homozygous 'C' was reported by Lai et al (1964). In addition to the common types, two rare phenotypes RA and RB were reported by Giblett and Scott (1965), and Giblett (1967). Three co-dominant alleles, pa, pb and pc, at an autosomal locus are controlled the different types of acid phosphatase. The individuals of phenotypes A, B and C are homozygotes for the $p^a p^a$, $p^b p^b$ and $p^c p^c$ genotypes, and phenotypes BA, CA and CB represented by heterozygous genotypes $p^a p^b$, $p^a p^c$ and $p^b p^c$ respectively.

3.4.3 ADENYLATE KINASE (AK)

Fildes and Harris (1966), described the polymorphism of human red cell adenylate kinase, an enzyme which occurs in several tissues. This system is supposed to act as a catalyst in the transformation of 2-adenosine diphosphate to adenosine tri-phosphate and adenosine monophosphate within the red cell and other tissues.

They showed three distinct types of electrophoretic patterns, which are AK1-1, AK2-1 and AK2-2, genetically determined by two co-dominant autosomal alleles, AK1 and AK2. According to Fildes and Harris (1966), about 90 per cent of individuals in the English population have the AK1 phenotypes, and the AK2 is very uncommon.

Other variants such as AK3-1, AK4-1 and AK5-1 have also been reported by Bowman et al (1967), Rapley et al (1967) and Benercetti et al (1972). The AK types are independent of the other enzyme, blood and serum groups and also independent of sex.

3.4.4 ESTERASE D (ESD)

Hopkinson et al (1973), discovered a new genetic polymorphism of

human red cell esterase D. The isoenzyme esterase D is different from the red cell A, B and C esterase, which has been demonstrated by Tashian (1961 and 1969). The structural locus which determines this new esterase is independent of the loci involved in the determination of the esterase A, B and C. The esterase D isoenzymes observed in red cell lysates and other human tissues.

By the starch-gel electrophoresis, three types of esterase D isoenzyme patterns can be recognised in the haemolysates from different individuals (Hopkinson et al 1973), which are ESD1-1, ESD2-1 and ESD2-2. The three phenotypes are determined by two alleles, ESD1 and ESD2 at an autosomal locus.

Phenotypes ESD1-1 and ESD2-2 represent the homozygous genotypes ESD1 ESD1 and ESD2 ESD2 respectively, while phenotype ESD2-1 occurs in heterozygotes ESD1 ESD2. In addition to the common types, two rare variants referred to as ESD3 and ESD4 have been described by Bargagna et al (1975), Bender and Frank (1974), and Berg et al (1976), but the frequencies of their occurrence is too slight to contribute appreciably to the genetic diversity of populations (Papiha and Nahar 1977).

CHAPTER 4 MATERIALS AND METHODS

4.1 BLOOD COLLECTION

A total of 469 blood samples were collected from the Zoroastrians of Iran for the purpose of present study. These samples were obtained from three different cities (Tehran, Yazd and Kerman).

All the blood donors were healthy and were aged between twelve and ninety one, the majority of the donors being under forty five years of age. These samples were taken in several occasions during the 1979, 1980 and 1981. Another one hundred and forty samples were tested for the Abo and Rh positive and negative in Tehran, and the serums and lysates were brought to Durham by air and at dried ice temperature (-78°C). Another one hundred and forty eight fresh specimens were taken to Durham within 72 hours of their collection. The final collection of one hundred and eighty nine blood samples were tested for Abo, MN and Rh positive and negative in Iran.

For the demographic purpose, personal details regarding sex, age, occupation, birth place and the birth place of parents, number of children and information concerning the marriages were obtained from the blood donors.

4.2 METHODS

Blood received in the laboratory was immediately centrifuged for 10 minutes at 1000 RPM. A saline suspension of red cells was prepared for blood grouping. The rest of the red cells were stored at -20°C for preparing haemolysates.

The one hundred and forty eight samples were blood typed on arrival. The following is a brief summary of the three methods

employed.

A. Tile Method

This is used for the ABo system, and the sera employed were anti A, anti B and anti A + B. This test was carried out by a drop of blood cell suspension to an equal volume of the anti serum and mixing well. The red cells/serum miniature was left for a predetermined period of time and temperature. The tile was then moved gently back and forth and inspected for agglutination.

B. Tube Method

Used for M and N, and Rhesus blood group systems.
This technique involves incubating equal volumes of a 4 per cent red cell suspension (in physiological saline) and the appropriate anti-serum into precipitin tube. The cell/serum mixture was placed for a specific time at a prescribed temperature. In the case of the incomplete antibodies, a layer of 30 per cent bovine serum albumin was added as an overlay, after one and a half hours. The cells were reincubated for a further thirty minutes. It was investigated microscopically for the presence of agglutination.

C. Indirect Coombs Method

The following antisera were used - anti Fy^a, anti K, anti k, anti KPb, anti KP^a and anti S.

This technique involved incubating equal volumes of red cells with anti serum in a precipitin tube. The serum/cell mixture was placed for specific times and temperatures. After incubation, the cells were washed four times with saline. The red cells were shaken well at the end of each washing. A drop of red cells was mixed with a drop of anti-human globulin. The tile was then rocked gently for 5-10 minutes and agglutination was observed

under a strong light.

All the controls were set up at the same time and read under the same conditions.

4.3 HAEMOLYSATE PREPARATION

Haemolysates were prepared by the carbon tetracholoride method. After the red cells were thawed, a volume of carbon tetracholoride at least equal to twice the volume of cells was added and all the contents thoroughly mixed. The tubes containing the mixture were centrifuged at 3000 RPM for 20 minutes. The supernatant was placed in tubes and stored at $-20^{\circ}C$ until required for subsequent analysis.

4.4 STARCH-GEL ELECTROPHORESIS

Electrophoresis was carried out for the following red cell enzyme systems: Adenylate Kinase (AK), Esterase D (ESD), Phosphoglucomutase (PGM1), Acid Phosphatase (AP), and for the serum protein, Haptoglobin (HP).

PREPARATION OF GEL

For the preparation of each gel, 40 ml. of the required gel buffer are mixed with 3.5 gms. of 10% starch. The suspension of starch in buffer solution was heated over a gas flame. The contents were agitated by an electrical stirrer. Heating was continued until the solution became opaque and semi-solid. A vacum was applied to the flask for a few seconds to expel the air bubbles. After disconnecting the vacum, the viscous translucent solution was poured into the plastic trays. The trays were lightly smeared with liquid paraffin before pouring the gel. The gel was left to set from 2-3 hours at room temperature.

4.4.1 ADENYLATE KINASE (AK)

Thin layer gels were prepared, electrophoresis was carried out anode to cathode at constant voltage (100 mV) for 17 hours at $4^{o}C$.

The gels were stained using an agar overlay, and when the agar had set the gels were incubated for 30 minutes at $37^{o}C$ in an oven and electrophoretic bands then were read.

Tank Buffer

Citric Acid	28.72 gms
Na oH	10.6866 gms
H2o	1 litre

pH = 4.9

Gel Buffer

Succinic Acid	1.89 gms
Tris	2.226 gms
H2o	1 litre

pH = 5.0

Incubation Buffer

Tris	12.12 gms
H2o	1 litre

Adjusted to pH 8.0 with HCl

Staining

Per gel

2% Agar solution (in H2o)	10 ml
Incubation buffer	10 ml
Glucose	18 mg
Mg C12	40 mg
M.T.T.	2.5 mg
G6PDH	20 ul
ADP	4.9 mg
P.M.S.	2.5 mg
N.A.D.P.	3.1 mg
Hexokinase	20 ul

4.4.2 ESTERASE D (ESD)

The method used is that described by Koster et al (1975). The

electrophoretic conditions and procedure are given below. Before electrophoresis an aliquot of each lysate was treated with an equal volume of Clelland's reagent. Electrophoresis carried out cathode to anode for 2 hours at constant voltages (300 volts) and low ampage (5m.A.) and stained using 4-methylumbelliferyl acetate (Hopkinson et al 1963). The gels were read under U.V. light.

Gel Buffer (for 1 litre)

Tris	1.636 gms
Citric Acid	0.756 gms
Boric Acid	0.272 gms
Lithium Hydroxide	0.016 gms
Distilled water	1 litre

PH 7.4

Tank Buffer (for 4 litres)

Boric Acid	108.84 gms
Lithium Hydroxide	6.72 gms
Distilled water	4 litres

PH 7.2

4.4.3 PHOSPHOGLUCOMUTASE (PGM1)

Test for Phosphoglucomutase carried out by the method described by Spencer et al (1964). The gels were run - ve to +ve at 110 volts and 5 MA for 17 hours at $4^{O}C$.

Tank Buffer

Tris	12.11 gms
Maleic Acid	11.62 gms
E.D.T.A.	2.92 gms
$MgCl_2$	2.03 gms
NaoH	6.5 gms
Distilled water	1 litre

Adjust to pH = 7.4 with 40% NaoH

Gel Buffer

The tank buffer was diluted 1 in 15 with distilled water.

The samples were applied on cotton inserts.

After electrophoresis the gels were stained for 30-60 minutes in a 37°C oven, with the following stains:

Stain (per gel)

2% Agar Soln (in H2o)	10 ml	
Incubation buffer	10 ml	
Tris	7.28 gms	Adjust to PH 8.0 with conc. Hel. After PH ing add 20 mg of MgCl2 per 10 ml buffer.
H_2O	1 ltr	
G-1-P (containing G-1-6 diphosphate)	30 mgs	
N.A.D.P.	1.5 mgs	
P.M.S.	2.5 mgs	
M.T.T.	2.5 mgs	
G6PDH	20 ul	

4.4.4 ACID PHOSPHATASE (AP)

The method used for the acid phosphatase is that described by Hopkinson et al (1963).

Thick layer gels were prepared, and the samples applied using 3 mm Whatman paper. The electrophoresis carried out - ve to +ve at 115 volts and 40 mA for 17 hours at 4°C. The gels were then sliced and stained by placing Whatman 3 mm paper over the gel and pouring on the staining solution, and kept at 4°C. Acid phosphatase bands appeared after one hour and were read under the U.V. light.

Tank Buffer

0.41 M	Citric Acid	86.1615 g/l
	NaoH	45 g/l
	Distilled water	1 litre

adjusted to pH 6.0 with N = 40 NaoH

Gel Buffer

0.0025M Succinic Acid	0.2952 g/l
0.0046M Tris	0.5552 g/l

Staining

Methylumbelliferyl phosphate	16mgs per gel
Incubation buffer	10 ml

Incubation 0.5 Citric Acid 105 g/l; adjust to pH 5.0

4.5 SERUM PROTEINS

4.5.1 HAPTOGLOBINS (HP)

The tests for Haptoglobins were carried out using Smithies (1955a) horizontal electrophoresis method and Poulik's (1957) discontinuous buffer system.

Thick layer gels were prepared. The samples were applied using Whatman number 3 paper & electrophoresis run cathode to anode at constant current, for 17 hours at $4^{o}C$. The gels were then sliced and stained.

The bands appeared within 2 to 3 minutes.

Tank Buffer

0.06M NaoH	2.4 g/l
0.3M Boric Acid	18.55 g/l

Adjust to pH = 8.5

Staining

Glacial acetic acid	100 ml
H2o	150 ml
Leuco-malachite green	1 gm

one hand full of zinc dust, powdered.

The above ingredients were boiled in a one litre beaker until the green colour of the leuco-malachite green disappeared. The mixture was then filtered to remove the solids and stored at $4^{o}C$ until required. The above mixture was poured over the sliced gel and left for 5 minutes; the excess stain was then poured off and 10 ml of 1/10 20 valums H_2o_2 was poured onto the gel.

Dilute 20 vols H_2o_2 1 part H_2o_2 9 parts H_2o.

CHAPTER 5 RESULTS

Earlier serological studies.

Knowledge of the distribution of blood groups, serum proteins and red cell isoenzymes in Iran has been rather limited. Extensive data are only available regarding the ABo Polymorphism (Boue and Boue 1956, Motamed 1949, and Azhir 1951), but scarce respecting the blood group Polymorphisms - MNS, Rhesus, Kell and Duffy. Some frequency data have been published by Boue and Boue (1956), Nijenhuis (1964), Sunderland and Smith (1966), and Bajatzadeh and Walter (1969), but they are insufficient to explain the distribution pattern of genes for these Polymorphisms within Iran. Data regarding the serum protein (HP) were first reported by Walter and Djahanshahi (1963). Similar information about the Iranians living in different parts of Iran was reported by Bajatzadeh and Walter (1969).

Few published observations are available on the red cell enzymes in the population of Iran. Bowman and Ronaghy (1967) first studied the distribution of some isoenzymes in the Moslems of Iran.

With regard to the Zoroastrians, very little work has been done, indeed the only studies on this population are those of Boue and Boue (1956), for ABo and Rh, Bowman et al (1961), for ABo and G6PD and Bowman (1964), for haptoglobin and transferrin systems.

5.1 RESULTS

In this study the phenotype and gene frequencies for the twelve systems, ABo, MN, Ss, Duffy, Kell, KP, Rh, HP, ESD, AP, Ak and PGM, which were found in the blood samples of 469 Iranian Zoroastrians are given in table 5.1. Tables 5.2, 5.3 and 5.4, present the distribution of the systems of the Tehran, Yazd and

Kerman Zoroastrians respectively. The only published work on Iranian Zoroastrians has been by Boue and Boue (1956), Bowman and Walker (1961) and Bowman (1964).

Boue and Boue studied the Zoroastrians of Yazd and tested 233 persons for the ABo and 182 for the Rh systems. They compared their results with the Moslems of Yazd and came to the conclusion that there are similarities between these two populations.

A comparative study by Bowman and Walker (1961) of 150 Zoroastrians of Yazd and Tehran and other populations of Iran (Moslem, Armenian and tribes), showed a clear difference in the frequency of the B gene from that of the Moslem populations.

The study of Bowman (1964) of 145 Zoroastrians for Haptoglobin, compared with the Moslems of Yazd reveals a decreased frequency of HP1 in the Zoroastrians. He reported that the Zoroastrians are separable from the Moslems by the ABo blood groups and Haptoglobin, and are genetically a different breeding group from that of the present Moslem majority. This finding differs from that of Boue and Boue. On a supposed similar group they found no difference in blood groups between Zoroastrians and Moslems (Bowman et al 1961, and Sunderland et al 1966).

The results of the ABo system in the Zoroastrians of Tehran, Yazd and Kerman (tables 5.2 to 5.4) show that allele p exhibits variation, having frequencies of 0.1693, 0.2124 and 0.1576 for Tehran, Yazd and Kerman respectively. The gene q shows a range from 0.3345 in Tehran, to 0.2431 in the Yazd and 0.3016 in the Zoroastrians of Kerman. The frequency of the gene r is 0.4962 for the Zoroastrians of Tehran, whereas it is 0.5445 in the Yazd and 0.5506 in the Zoroastrians of Kerman. The frequency of the

MN blood groups and respective gene frequencies in the Tehran, Yazd and Kerman Zoroastrians are expressed in terms of three phenotypes, after testing with two antisera. Tables 5.2 to 5.4 also show the results for 66 Tehran, 51 Yazd and 28 Zoroastrians of Kerman tested with four antisera, M, N, S and s. The Kerman Zoroastrians show a higher frequency of the gene complex Ns.

The distribution of Rh types are present in the tables 5.1 to 5.4. The D negative ranges from 0.3236 to 0.3436, being 0.3269 in the Tehran, 0.3236 in the Yazd and 0.3436 in the Kerman Zoroastrians.

The three samples were pooled to give a total of 466 with the gene D negative frequency of 0.3307 (table 5.1). The results of the 66 Tehran, 51 Yazd and the 28 Zoroastrians of Kerman for the Duffy, Kell and KP systems are given in the tables 5.2 to 5.4. The Fya gene frequencies were 0.2823, 0.1835 and 0.1983 for the Zoroastrians of Tehran, Yazd and Kerman respectively, with the Fya gene frequency of 0.2078, when the three samples were pooled.

5.2 DISCUSSION

5.2.1 ABo BLOOD GROUP SYSTEM Table 5.1 to 5.6

As can be seen from the tables, the distribution of the ABo blood groups and the respective gene frequencies, after testing with anti-A, anti-B and anti-AB serum, in the Tehran, Yazd and Kerman Zoroastrians show variations. Using the chi-squared test, all three samples were found to exhibit homogenity with respect to the common ABo phenotypes. The chi-squared test shows no significant differences between the Zoroastrians of Tehran and Yazd $P > 0.20$, Tehran and Kerman $P > 0.50$ and Yazd and Kerman $P > 0.20$. The three samples were pooled to give a total number of 466 with

the B gene frequency of 0.2931, the chi-squared test showing no significant differences between these three series $X^2_8 = 9.86$, $P > 0.30$. The present study was compared with the previous data in the frequency of the B gene group, the B phenotypes frequency being 39.31% in the Zoroastrian population tested, 39.06 per cent in the Zoroastrians of Yazd tested by Boue and Boue (1956) and 46.0 per cent in the Zoroastrians of Tehran and Yazd reported by Bowman et al (1961). The chi-squared test shows no significant differences between these series. The chi-squared values are $X^2_3 = 4.45$, $P > 0.30$, $X^2_3 = 4.74$, $P > 0.30$ and $X^2_3 = 1.81$, $P > 0.70$ between the present study and the Zoroastrians of Yazd (Boue and Boue 1956), the present study and the Zoroastrians of Yazd and Tehran tested by Bowman et al (1961) and the series of Boue and Boue (1956) and samples of Bowman et al (1961) respectively.

The AB phenotype frequency in the Tehran Zoroastrians is 7.63%; 8.38% in Yazd and 10.42 per cent in the Zoroastrians of Kerman, which is the highest in these series. The three samples were pooled having a frequency of 8.80 per cent, and this value was compared with the two series tested by Boue and Boue (1956) and Bowman et al (1961), with the AB phenotype frequencies of 12.45 per cent and 11.33% respectively. These reported by Boue and Boue have the highest AB value for Iranian Zoroastrians (table 5.5). Table 5.6 presents comparative data on the Iranian Moslem populations reported by several investigators. It is obvious from the table, that all populations, except the Yazd Moslems, and the Tehran Iranians show higher frequencies of gene A than of the gene B.

According to Sunderland et al (1966) the blood group frequencies of the Shia in Yazd show marked similarities to European values,

but with characteristic differences typical of South-West Asia. In this investigation, the 466 Zoroastrians of Iran tested for the ABo system showed a higher frequency of the gene B than that found in the non-Zoroastrians, but this value of 0.2931 is lower than that of 0.3473 of Bowman et al (1961), tested on 150 Zoroastrians. The chi-squared test shows significant differences between present study and the Iranian Moslems of Nijenhuis (1966), $X_3^2 = 29.48$, $P < 0.01$, Tehran Iranian of Motamed (1949), $X_3^2 = 44.73$, $P < 0.01$, Tehran Iranians of Boue and Boue (1956), $X_3^2 = 61.34$, $P < 0.01$, Tehran Moslems of Azhir (1951), $X_3^2 = 88.65$, $P < 0.01$, and the Iranians of Bajatzadeh (1969), $X_3^2 = 67.01$, $P < 0.01$, whereas there are no significant differences between the present study and the Moslems of Yazd reported by Sunderland et al (1966), and Boue and Boue (1956), $X_3^2 = 4.37$, $P > 0.30$, and $X_3^2 = 3.75$, $P > 0.30$ respectively.

Comparing the Zoroastrians of Kerman with a small number of Kerman's Moslems tested by Beckett (1950), the B phenotype frequency was 41.0 per cent for Zoroastrians and 20.0 per cent for the Moslems (table 5.7). The chi-squared test shows a significant difference between these two samples, $X_3^2 = 13.87$, $P < 0.01$. Table 5.8 presents the distribution of the ABo blood group system in the Zoroastrians of Yazd and the Shia Moslems of Yazd reported by Sunderland et al (1966), and Boue and Boue (1956). No significant differences were observed between these series.

Table 5.9 presents comparative data on the Tehran Iranians tested for the ABo system. There are significant differences between the Zoroastrians of Tehran and the Tehran Iranian samples tested by Boue and Boue (1956), and Azhir (1951), $X_3^2 = 13.21$, $P < 0.01$, and $X_3^2 = 18.5$, $P < 0.01$ respectively.

5.2.2 THE MNSs BLOOD GROUP SYSTEM

The distribution of the MN blood groups for the present study have been summarised in the tables 5.1 to 5.4. This system has not been studied previously in the Zoroastrians of Iran, and is presented for the first time in this study. According to Mourant (1963), the frequency of the M gene is above 60 per cent in the Iranian population, and further investigations by Bajatzadeh et al (1969), Nijenhuis (1964) and Sawhney (1975), revealed that it varied between 56 to 67 per cent for the total population including the Armenian and Kurds.

The M gene frequency is 0.6261 in Tehran, 0.6298 in Yazd and 0.6542 in the Zoroastrians of Kerman. When these three samples are pooled, to give a total number of 334 with an M gene frequency of 64 per cent, this lies within the postulated range for Iranian populations.

The chi-squared test show no differences between these three series. Comparing the present series with the other Iranian samples (table 5.10), significant differences between the present study and the series reported by Bajatzadeh (1969), $X^2_3 = 7.4$, $P < 0.05$, whereas there are no significant differences between the present series and the other Iranian populations tested by Nijenhuis (1964), Boue and Boue (1956), Sunderland et al (1966), and Sawhney (1975). There are, also, no differences between the Zoroastrians of Yazd and the Moslems of Yazd reported by Sunderland et al (1966), and between the Zoroastrians of Tehran and Tehran Moslems tested by Boue and Boue (1956).

Some 145 samples out of the 466 were tested with four antisera, and exhibit MNSs phenotypes consistent with those found in the

Tehran series of Sawhney (1975) and the Yazdi Moslems of Sunderland et al (1966). The gene complexes do not show much variability (table 5.11). The frequency of the gene MS in the Tehran series of Sawhney is slightly higher than the present series and of the Yazd Moslems studied by Sunderland. The frequency of NS is close to the other published series. The gene complex Ns in the present study has a lower frequency than that found in the series tested by Sunderland et al (1966) and Sawhney (1975).

The chi-squared test shows no significant differences between these series. Tables 5.2 to 5.4 present the distribution of the MNSs blood group system in the Zoroastrians of Tehran, Yazd and Kerman. It can be seen from the tables that the phenotype MS in the Kerman sample is lower than in the Tehran and Yazd Zoroastrians, and the Ms phenotype in the Zoroastrians of Tehran in higher than the Yazd and Kerman series. The phenotype NS values are similar to each other with a frequency of 3 per cent. The frequency of phenotype MNS is 4.55 per cent in Tehran and 3.92 per cent in Yazd and is absent in the Zoroastrians of Kerman. The frequency of the gene complex Ms does not show much variability. The frequency of the MS gene in the Tehran Zoroastrians is close to that of Yazd and both are higher than in the Kerman series. These differences may be explained by taking into consideration that the sample size in these three Zoroastrian populations is small, so that chance effects may have some influence on these differences.

5.2.3 THE Rh BLOOD GROUP TYPES

Table 5.12 presents the distribution of the Rh system in this study, the Zoroastrians of Yazd and Tehran tested by Boue and

Boue (1956), and six Iranian populations reported by several authors. It is seen that there are 6 per cent Rh negative in the Zoroastrians reported by Boue and Boue, whereas it is approximately 11 per cent in the present study. The Rh negative frequency in the Zoroastrians reported by Boue and Boue (1956) is similar to that of the Yazd Moslems which they tested.

The Rh negative phenotype frequency of the present study is close to the Iranian Moslems, Yazd Moslems and the Iranians reported by Nijenhuis (1964), Sunderland et al (1966) and Sawhney (1975). As regards the frequency of the gene d, it is found that most of the Iranian population results, including the present study, lie within the range of 30-40%. Only the Zoroastrians of Boue and Boue with 0.2458 and the Yazd Moslems of Boue and Boue (1956) with 0.2627 of the gene d, differ from this range. No statistical differences were observed between the present study and the other series. Tables 5.2 to 5.4 present the distributions of the Rh phenotypes and respective gene frequencies of the Zoroastrians of Tehran, Yazd and Kerman. It is obvious from the tables that the Zoroastrians from three different locations are similar, with the Rh negative phenotype frequencies between 10-11 per cent.

The d gene frequency in the Zoroastrians of Kerman is slightly higher (0.3436) than in the Tehran and Yazd Zoroastrians (0.3269 and 0.3236 respectively). The chi-squared tests show no significant differences between these series.

Comparing the Zoroastrians of Yazd (present study), with the Zoroastrians of Yazd and Tehran reported by Boue and Boué (1956), there are 10.47% Rh negative in the present study, which is 3.5% higher than the report by Boue and Boue. No statistically

significant differences was observed, $X_1^2 = 2.39$, $P > 0.20$.

A comparison of the present series of Yazd and the Moslems of Yazd reported by Boue and Boue (1956), and Sunderland et al (1966), show no significant differences. The gene d frequency in the Zoroastrians of Yazd is 0.3236, which is higher than that of the Yazd Moslems reported by Boue and Boue with 0.2627 and lower than the two series of Sunderland et al with 0.3496 and 0.3817.

5.2.4 THE DUFFY SYSTEM

No examination of the Zoroastrians of Iran has hitherto been made for this system. Table 5.13 shows the distribution of the Duffy blood group system in the present study and the Iranians for comparison.

145 Zoroastrians were tested with one antisera, Fya. In this study the Fy(a+) frequency of 0.2078 is much lower than in the Iranians. Sunderland et al (1966) recorded a Fya frequency of 0.2497 for 151 Shia Moslems tested in Yazdi populations. Bajatzadeh (1969) found a Fya frequency of 0.446 among Iranians tested, and Nijenhuis reported a frequency of 0.43 for 348 Iranian Moslems. The chi-squared test showed significant differences between the present study and each of the Iranian samples. Tables 5.2 to 5.4 present the distribution of the Fy system in the Zoroastrians of Tehran, Yazd and Kerman. A surprisingly very low Fya gene frequency exists in the Zoroastrian populations. The Zoroastrians of Yazd with 0.1835 have a lower Fya frequency than those of Tehran and Kerman. The chi-squared test shows no significant differences between these series.

5.2.5 EXAMINATIONS OF THE KELL BLOOD SYSTEM

Table 5.14 presents the distribution of the Kell blood group system in the 145 Zoroastrians, tested with anti K, and k sera, and in Iranians. No previous work has been done on the Zoroastrians regarding the Kell blood group system. Data summarised in table 5.14 shows that the frequency of the gene K in the Iranian population varies between 2 and 5 per cent. In this study the figure is 2.5 per cent. The chi-squared test show significant differences between present series and the Iranians. The distribution of the Kell blood group system for the Zoroastrians of Tehran, Yazd and Kerman are in the tables 5.2 to 5.4. As can be seen from the tables, a small number of 66 Zoroastrians in Tehran, 51 in Yazd and 28 Zoroastrians in Kerman have been tested for the Kell system. The K gene frequency is 4.5 per cent in Tehran, 0.98 in Yazd and is absent in the Zoroastrians of Kerman; this may be due to the small sample size. No statistical difference was observed between these populations.

5.2.6 KP BLOOD GROUP EXAMINATIONS

No published data on KP blood group are available for the Zoroastrians of Iran or for other Iranian populations.

Tables 5.1 to 5.4 present the distribution of the KP system in the present study. The very small Zoroastrian groups of 66 from Tehran,51 from Yazd and 28 from Kerman have been tested with anti KPa and KPb sera, and exhibit a high gene frequency of KPb = 1 for the Zoroastrians of Tehran and Kerman, with a KPb gene frequency of 0.9902 for the Zoroastrians of Yazd. The chi-squared test shows no significant difference between these series.

The three samples were pooled giving a total number of 145 in the

following frequencies; KPa = 0.0034 and 0.9966 = KPb.

5.3 SERUM PROTEIN

The distribution of the haptoglobin groups phenotypes and gene frequencies in the present study are given in the table 5.1 to 5.4

Table 5.15 shows the distribution of the HP groups and respective gene frequencies in the Zoroastrians of Yazd and Tehran reported by Bowman (1964), and some published data from Iranian populations, for comparison.

The gene frequencies in the combined sample of Tehran, Yazd and Kerman in the present study are: HP1 = 0.2470 and HP2 = 0.7530.

No rare phenotype was observed in this study.

5.4 DISCUSSION

5.4.1 HAPTOGLOBIN

World values for the HP1 gene range from 0.07 to 0.89 (Kirk 1961). According to the table 5.15 the HP1 gene frequency in the Iranian population ranges between 0.14 for Northern Gorgan (Kirk et al 1977) and 0.35 for Shiraz (Walter et al 1963). The frequency of the HP1 gene in the present study is higher than those of Northern Iran and lower than those for other parts of the country. The HP1 values are found to be lower in the North, 0.14 to 0.25 (Kirk et al 1977), North west (0.27), Centre (0.286), and East (0.29) of Iran as reported by Bajatzadeh and Walter (1968). Similar low values were reported by Bajatzadeh and Walter (1969) in the North western (0.276), Central (0.263) and Eastern (0.249) parts of Iran. By contrast, slightly higher frequencies are found in Tehran (0.319),

Bajatzadeh and Walter (1968) and among Kurds in North west Iran (0.32) reported by Lehmann et al (1973). (See also Miyashita (1975).

Regarding the HP2 gene frequency, it is higher in the Zoroastrian population (0.75 in the present study) and 0.81 in the subjects of Bowman (1964). The statistical analysis shows that there are signficant differences between the present study and the Tehran Iranians and the Iranian populations tested by Bajatzadeh et al

(1968 and 1969), and the Shiraz Iranians of Walter et al (1963). $X_3^2 = 8.32$, $P < 0.02$, $X_2^2 = 6.80$, $P < 0.05$ and $X_2^2 = 8.09$, $P < 0.02$ respectively, but no significant differences between the present series and Tehran and Isfehan Iranians (Sawhney 1975), Iranian Moslems and the Zoroastrians of Bowman (1964). Comparing the Zoroastrians of Tehran, Yazd and Kerman, the Tehran Zoroastrians have the highest HP1 gene frequency (0.2716), and the Zoroastrians of Yazd with 0.2191 are found to have the lowest in the series tested. There are no significant differences between these three series. Also no significant differences occur between Zoroastrians of Tehran, Yazd and Kerman, and the Zoroastrians of Tehran and Yazd reported by Bowman (1964).

5.5 RED CELL ISOENZYMES

Tables 5.1 to 5.4 present the results of the red cell isoenzymes in the present study.

No published data are available for the red cell isoenzymes in the Zoroastrians of Iran.

Tables 5.16 to 5.18 show the distribution of the red cell isoenzymes phenotypes and respective gene frequencies in some Iranian populations found in the publications.

5.6 DISCUSSION

5.6.1 ACID PHOSPHATASE

Blood samples of the Zoroastrians of Tehran (125), Yazd (99) and Kerman (53) were tested for the AP system. The frequency of the gene Pa is 0.30 in the Zoroastrians of Tehran, 0.2425 in Yazd, and 0.3490 in the Zoroastrians of Kerman. The frequency of the

gene Pb exhibits a variation of 6 per cent between Tehran and Yazd, and 9 per cent between the Yazd and Kerman Zoroastrians. The Pc allele occurred in four heterozygotes CB in the Zoroastrians of Tehran and three heterozygotes in the Zoroastrians of Yazd (two CB and one CA). All the three samples show an absence of phenotype CC. The Pc gene frequency is 0.016 in the Zoroastrians of Tehran and 0.015 in the Zoroastrians of Yazd. The chi-squared test shows no significant differences between these series. The three samples were pooled gave a total number of 277, with a frequency of 0.288 for Pa gene, 0.698 and 0.0126 for the Pb and Pc genes respectively.

A comparative study of the present series with other Iranian populations tested for the AP system, shows that Pb is the most common of the three major alleles in each Iranian population reported. Its frequency ranges from 0.534 in Northern Gorgan to 0.721 in the Tavalesh and Astara (Kirk et al 1977). The Pa allele ranges from 0.271 to 0.455. The present values of Pa = 0.288 and Pb = 0.698 are within the range of variation.

Table 5.16 reveals that the Pc gene is present in all Iranian populations, except in two small series in Northern Iran (Kirk et al 1977), the highest frequency being 0.030 in Iranians from different parts of the country tested by Walter et al (1968). In the present study the allele Pc is 0.0126, which is comparable with the Isfehan Iranians of Sawhney (1975) and the Kurds of Lehmann (1973). There is statistically significant difference between the Zoroastrians of Iran and the Iranians studied by Walter et al (1968), $X^2 = 24.0$, P 0.01, but no differences between the present study and Tehran, and the Isfehan Iranians (Sawhney 1975), $X^2 = 8.1$, P 0.20, $X^2 = 1.55$, P 0.95. According to Walter et al (1968), Iranians are characterised by a lower Pa frequency than Caucasoids, on the other hand, by a higher Pb frequency. The Pc frequency of

Iranians does not differ obviously from the Caucasoid.

5.6.2 PHOSPHOGLUCOMUTASE

Other data on the distribution of phosphoglucomutase on the Iranian populations and that of the present study are summarised in the table 5.17. Most of the world's population are polymorphic at the PGM1 locus. The gene frequency of PGM_1^1 in the Iranians shows similarities to Middle East and European values. The frequencies of PGM_1^1 in the Iranian population lie between 0.68 to 0.75 and the frequency of PGM_1^2 ranges from 0.23 to 0.31. The values of 0.75 (PGM_1^1) and 0.25 (PGM_1^2) observed in this investigation are within the range.

A rare variant (6-1) was observed at the PGM1 locus in the Isfehan Iranian populations by Sawhney (1975). No rare variant at the PGM2 locus has, so far, been found in the Iranian populations.

The gene frequency of PGM1 obtained by Farhud et al (1973) in the Tehran Iranians is similar to that in neighbouring populations of Iraqi Jews and Turks. It is lower than that obtained for the Zoroastrians in the present study and those of the Tehran Iranians and Isfehan Iranians reported by Sawhney (1975). There are no statistically significant differences between the present study and those of other series.

In the case of the Zoroastrian samples, the gene frequency of PGM1 in Kerman was 0.7885, 0.738 in Tehran and 0.745 in the Yazd. With regard to the PGM_1^2, the Kerman Zoroastrians have a lower gene frequency than that of the other two groups. The chi-squared test shows no significant difference between these series and there are no significant differences between the Zoroastrians of

Tehran, Yazd and Kerman, with the Iranians tested by Farhud et al (1973), Tehran and Isfehan Iranians reported by Sawhney (1975).

5.6.3 ADENYLATE KINASE

Table 5.18 shows the distribution of the AK phenotypes and the respective gene frequencies. The only other studies of this polymorphism in the Iranian populations are the Tehran, and Isfehan Iranians of Sawhney (1975), and the Iranian Moslems of Bowman et al (1967). Sawhney found frequencies of 0.0536 and 0.0422 for the allele AK2 in 168 Tehran and 83 Isfehan Iranians respectively, while Bowman and Ronaghy (1967) reported a value of 0.0497 among Iranian Moslems. These values are similar to those found in the present study for the Zoroastrians of Iran (0.069). No significant differences were found between these series.

Regarding to the Zoroastrians of Tehran, Yazd and Kerman, the highest AK2 allele frequency was observed among the Zoroastrians of Kerman (0.0961), which is even higher than that of the Kurdish series of Lehman et al (1973), with the AK2 gene frequency of 0.0762. The chi-squared test shows no significant differences between the Zoroastrian populations tested.

It can be seen from the table, that no phenotype 2.2 was found in the Iranian samples or in the Zoroastrians of Tehran.

According to Bhasin et al (1972), the frequency of the AK2 gene in European populations ranges from 0.015 to 0.056 and the values for the Middle East lie between 0.0252 to 0.0687 (Tills et al 1970 a). The present value of 0.0691 is within the Middle East range.

5.6.4 ESTERASE D

Esterase D is a relatively new polymorphic system, so that knowledge of the allele frequencies in different populations is, as yet, limited. They have not been studied in the population of Iran. The known heterogenity of the populations of Iran suggested that a search for variants there would be more rewarding than in a more homogenous population, so that the present study was under-taken in samples from the three different Zoroastrian groups in Iran.

The number of ESD phenotypes observed and the gene frequencies are given in tables 5.1 to 5.4, for each sample and for the total. As in most of the populations so far studied, ESD is the common allele with frequencies ranging from 0.80 to 0.84 in the three samples. In the total Zoroastrians' sample, its frequency is 0.82, which is lower than the general frequencies in Europe of 0.88 (Koster et al 1975), and in Negroes of 0.90 (Hopkinson et al 1973 and Welch et al 1974), but similar to that (0.79) in a sample of Iraq (Papiha et al 1976), 0.83 of Gujarat (Papiha et al 1981), 0.80 and 0.79 of Kuwait and Panjab respectively (Cartwright et al 1976), and higher than a sample of Asiatic Indians analysed in England with the gene frequency of 0.77 (Hopkinson et al 1973), Assam of 0.72 (Benkmann et al 1974), Nepal of 0.64 (Welch et al 1974), and East Nepal of 0.61 (Cartwright et al 1976). In the three Zoroastrian samples there are no significant differences.

CONCLUSION

The results obtained from the present study and other published data for the Zoroastrians of Iran, provide a basis for the establishment of a relationship between these groups.

The serological results do not reveal significant differences between the Zoroastrians of Tehran, Yazd and Kerman.

Some of the blood systems in the present study which have been described in this chapter, show striking similarities. Concerning the ABo system, it is seen that the two previous studies of the Zoroastrians of Iran showed a higher frequency of the gene B, and the present sample confirmed this tendency. The Zoroastrians are separable from Moslems, with the exception of those of Yazd, in terms of the ABo blood groups. This is regardless of whether some of the Zoroastrians were later converted to Islam and have not interbred freely since.

This is the first time that the frequency distributions of allelic genes controlling the M, S, Fya, KP^a, K, pa, ED1, PGM1 and AK1 antigens has been presented for the Zoroastrians of Iran.

Regarding the Duffy, and Kell systems, the Zoroastrians are significantly different from Iranian Moslems.

Of the serum protein system, the haptoglobin polymorphism has been investigated. No major differences were revealed between the Zoroastrians of Tehran, Yazd and Kerman and statistical analysis did not demonstrate any difference between the present study and the Zoroastrians of Iran tested by Bowman (1964), with respect to the HP phenotypes frequency. The Iranian Moslems differ significantly from the Zoroastrians in respect of the HP system.

A relatively high HP1 gene frequency exists in Iranian populations. Among the four red cell enzymes studied, all were found to be polymorphic in the Zoroastrians of Iran.

Iranian populations with a relatively high frequency of the gene Pc are similar to the Europeans, whereas the comparatively high Pb frequency in the Iranian populations may be due to Mongoloid influence. The Zoroastrians with a low frequency of Pc and Pa differ from Caucasoids and Iranians. They believe that they were untouched by the Mongol invasions of the 13th and 14th centuries.

The only two places where the Zoroastrians succeeded in maintaining themselves in any numbers were in and around Yazd and Kerman, where they migrated after the Arabs invaded Iran in the 7th Century. Due to their remote situation in the deserts they were out of touch with the rest of the country and its people and were able to keep their religious observances and beliefs. As their beliefs and religious practises were different from those of the Moslems, closed communities developed in Yazd and Kerman, and restrictions were placed on them, for example, they were forbidden to marry with Moslems. In time they became an inbred society and preserved a gene pool, with a little gene flow into or from the Moslem communities.

Table 5.1 THE ZOROASTRIANS OF IRAN PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
ABo	A	113	24.25	P = 0.1798
	B	186	39.91	q = 0.2931
	AB	41	8.80	r = 0.5271
	O	126	27.04	
	Total	466		
MN	MM	131	39.22	m = 0.6392
	NN	38	11.38	n = 0.3608
	MN	165	49.40	
	Total	334		
Ss	SS	35	24.14	S = 0.3896
	ss	67	46.21	s = 0.6104
	Ss	43	29.65	
	Total	145		
Fy	Fy(a+)	54	37.24	Fya = 0.2078
	Fy(a-)	91	62.76	Fyb + Fy = 0.7922
	Total	145		
KP	KPa	0	0.0	KPa = 0.0034
	KPb	144	99.31	KPb = 0.9966
	KPa, b	1	0.69	
	Total	145		
MNSs	MMSS	25	17.24	MS = 0.2912 NS = 0.0798 Ms = 0.4076 Ns = 0.2214
	MMSs	24	16.55	
	MMss	30	20.69	
	MNSS	5	3.45	
	MNSs	15	10.34	
	MNss	29	20.0	
	NNSS	5	3.45	
	NNSs	4	2.76	
	NNss	8	5.52	
	Total	145		

Table 5.1 Contd. THE ZOROASTRIAN OF IRAN PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
Kell	K	0	0.0	K = 0.0255
	k	138	95.17	k = 0.9745
	Kk	7	4.83	
	Total	145		
Rh	D+	415	89.06	D = 0.6693
	D-	51	10.94	d = 0.3307
	Total	466		
AP	A	18	6.50	Pa = 0.2888
	BA	123	44.40	Pb = 0.6985
	B	129	46.57	Pc = 0.0127
	CB	6	2.17	
	CA	1	0.36	
	Total	277		
ESD	1.1	191	68.46	ED1 = 0.8208
	2.1	76	27.24	ED2 = 0.1792
	2.2	12	4.30	
	Total	297		
PGM	1.1	155	55.76	PGM1 = 0.750
	2.1	107	38.49	PGM2 = 0.250
	2.2	16	5.75	
	Total	278		
AK	1.1	239	86.91	AK = 0.9309
	2.1	34	12.36	AK_1 = 0.0691
	2.2	2	0.73	AK_2
	Total	275		
HP	1.1	17	6.72	HP1 = 0.2470
	2.1	91	35.97	HP2 = 0.7530
	2.2	145	57.31	
	Total	253		

Table 5.2 THE ZOROASTRIANS OF TEHRAN PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
ABo	A	30	22.90	P = 0.1693
	B	62	47.33	q = 0.3345
	AB	10	7.63	r = 0.4962
	o	29	22.14	
	Total	131		
MN	MM	43	36.14	m = 0.6261
	MN	63	52.94	n = 0.3739
	NN	13	10.92	
	Total	119		
Rh	D+	117	89.31	D = 0.6731
	D-	14	10.69	d = 0.3269
	Total	131		
Fy	Fy(a+)	32	48.49	Fya = 0.2823
	Fy(a-)	34	51.51	Fyb + Fy = 0.7177
	Total	66		
Kell	K+	0	0.0	K+ = 0.0455
	K-	60	90.91	K- = 0.9545
	K+ K-	6	9.09	
	Total	66		
KP	KPa	0	0.0	KPa = 0.00
	KPb	66	100.0	KPb = 1.00
	KPa KPb	0	0.0	
	Total	66		

Table 5.2 Contd. THE ZOROASTRIANS OF TEHRAN PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
MNSs	MS	13	19.70	MS = 0.3150
	Ms	17	25.75	Ms = 0.4426
	NS	2	3.03	NS = 0.0790
	Ns	2	3.03	Ns = 0.1634
	MNS	3	4.55	
	MNs	13	19.70	
	MSs	9	13.64	
	NSs	1	1.51	
	MNSs	6	9.09	
	Total	66		
HP	HP1.1	8	6.90	HP1 = 0.2716
	HP2.1	47	40.52	HP2 = 0.7284
	HP2.2	61	52.58	
	Total	116		
ESD	1.1	81	64.28	ED1 = 0.8015
	2.1	40	31.75	ED2 = 0.1985
	2.2	5	3.97	
	Total	126		
PGM	1.1	70	55.55	PGM1 = 0.7380
	2.1	46	36.51	PGM2 = 0.2620
	2.2	10	7.94	
	Total	126		
AK	1.1	109	87.9	AK1 = 0.9395
	2.1	15	12.1	AK2 = 0.0605
	2.2	0	0.0	
	Total	124		
AP	A	9	7.2	Pa = 0.300
	BA	57	45.6	Pb = 0.684
	B	55	44.0	Pc = 0.016
	CB	4	3.2	
	CA	0	0.0	
	Total	125		

Table 5.3 THE ZOROASTRIANS OF YAZD PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
ABo	A	56	29.32	P = 0.2124
	B	65	34.03	q = 0.2431
	AB	16	8.38	r = 0.5445
	o	54	28.27	
	Total	191		
MN	MM	49	37.40	m = 0.6298
	MN	67	51.15	n = 0.3702
	NN	15	11.45	
	Total	131		
Rh	D+	171	89.53	D = 0.6764
	D-	20	10.47	d = 0.3236
	Total	191		
Fy	Fy(a+)	17	33.33	FYa = 0.1835
	Fy(a-)	34	66.67	Fyb + Fy = 0.8165
	Total	51		
Kell	K+	0	0.0	
	K-	50	98.09	K = 0.0098
	K+ K-	1	1.96	k = 0.9902
	Total	51		
KP	KPa	0	0.0	KPa = 0.0098
	KPb	50	98.04	Kpb = 0.9902
	KPa Kpb	1	1.96	
	Total	51		

Table 5.3 Contd. THE ZOROASTRIANS OF YAZD PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
MNSs	MS	9	17.65	MS = 0.3456
	Ms	8	15.69	Ms = 0.3505
	NS	2	3.92	NS = 0.1054
	Ns	4	7.84	Ns = 0.1985
	MNS	2	3.92	
	MNs	6	11.76	
	MSs	12	23.53	
	NSs	3	5.88	
	MNSs	5	9.81	
	Total	51		
HP	1.1	7	7.86	HP1 = 0.2191
	2.1	25	28.09	HP2 = 0.7809
	2.2	57	64.05	
	Total	89		
ESD	1.1	72	72.00	ED1 = 0.830
	2.1	22	22.00	ED2 = 0.170
	2.2	6	6.00	
	Total	100		
PGM	1.1	54	54.00	PGM1 = 0.745
	2.1	41	41.00	PGM2 = 0.255
	2.2	5	5.00	
	Total	100		
AK	1.1	87	87.88	AK1 = 0.9345
	2.1	11	11.11	AK2 = 0.0655
	2.2	1	1.01	
	Total	99		
AP	A	6	6.07	
	BA	35	35.35	Pa = 0.2425
	B	55	55.55	Pb = 0.7423
	CB	2	2.02	Pc = 0.0152
	CA	1	1.01	
	Total	99		

Table 5.4 THE ZOROASTRIANS OF KERMAN PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
ABo	A	27	18.75	P = 0.1578
	B	59	40.97	q = 0.3016
	AB	15	10.42	r = 0.5406
	o	43	29.86	
	Total	144		
MN	MM	39	41.49	m = 0.6542
	MN	45	47.87	n = 0.3458
	NN	10	10.64	
	Total	94		
Rh	D+	127	88.19	D = 0.6564
	D-	17	11.81	d = 0.3436
	Total	144		
Fy	Fy(a+)	10	35.72	Fya = 0.1983
	Fy(a-)	18	64.28	Fyb + Fy = 0.8017
	Total	28		
Kell	K+	0	0.00	K = 0.00
	K-	28	100.00	k = 1.00
	K+ K-	0	0.0	
	Total	28		
KP	KPa	0	0.00	KPa = 0.00
	KPb	28	100.00	KPb = 1.00
	KPa KPb	0	0.00	
	Total	28		

Table 5.4 Contd. THE ZOROASTRIANS OF KERMAN PHENOTYPES AND GENE FREQUENCIES (PRESENT STUDY)

Blood Group Systems	Phenotypes	No.	%	Gene Frequencies
MNSs	MS	3	10.71	MS = 0.2130
	Ms	5	17.86	Ms = 0.4298
	NS	1	3.57	NS = 0.0549
	Ns	2	7.14	Ns = 0.3023
	MNS	0	0.00	
	MNs	10	35.72	
	MSs	3	10.71	
	NSs	0	0.00	
	MNSs	4	14.29	
	Total	28		
HP	1.1	2	4.17	HP1 = 0.2396
	2.1	19	39.58	HP2 = 0.7604
	2.2	27	56.25	
	Total	43		
ESD	1.1	38	71.70	ED1 = 0.8490
	2.1	14	26.41	ED2 = 0.1510
	2.2	1	1.89	
	Total	53		
PGM	1.1	31	59.62	PGM1 = 0.7885
	2.1	20	38.46	PGM2 = 0.2115
	2.2	1	1.92	
	Total	52		
AK	1.1	43	82.69	Ak1 = 0.9038
	2.1	8	15.39	AK2 = 0.0962
	2.2	1	1.92	
	Total	52		
AP	A	3	5.66	
	BA	31	58.49	Pa = 0.3490
	B	19	35.85	Pb = 0.6510
	CB	0	0.00	Pc = 0.00
	CA	0	0.00	
	Total	53		

Table 5.5 PHENOTYPES AND GENE FREQUENCIES OF ZOROASTRIANS OF IRAN AND OTHER PUBLISHED DATA

Blood Group Types		Phenotypes						Gene Frequencies			
		Zoroastrians of Iran Present Study		Zoroastrians of Iran Boue and Boue (1956)		Zoroastrians of Iran Bowman et al (1961)		Present Study		Boue and Boue	Bowman et al
		No.	%	No.	%	No.	%				
ABo	A	113	24.25	44	18.88	25	16.67	p	0.1798	0.1536	0.1521
	B	186	39.91	91	39.06	69	46.00	q	0.2931	0.2872	0.3473
	AB	41	8.80	29	12.45	17	11.33	r	0.5271	0.5590	0.5006
	o	126	27.04	69	29.61	39	26.00				
Total		466		233		150					
Rh	D+	415	89.06	171	93.96	-	-	D	0.6693	0.7542	-
	D-	51	10.94	11	6.04	-	-	d	0.3307	0.2458	-
Total		466		182							
						Bowman 1964					
HP	1.1	17	6.72	-	-	6	4.14	HP1	0.2470	-	0.1900
	2.1	91	35.97	-	-	43	29.65	HP2	0.7530	-	0.8100
	2.2	145	57.31	-	-	96	66.21				
Total		253				145					

Table 5.6 ABo BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES OF ZOROASTRIANS OF IRAN AND IRANIAN MOSLEMS

Population	Author	Number	Phenotypes				Gene Frequencies		
			0	A	B	AB	P	q	r
Iranians	Bajatzadeh et al 1969	565	225 39.82	203 35.93	114 20.18	23 4.07	0.2380	0.1440	0.6180
Persians (Tehran)	Motamed 1949	565	230 40.71	173 30.62	133 23.54	29 5.13	0.1993	0.1561	0.6180
Tehran Moslems	Azhir 1951	10,000	3789 37.89	3327 33.27	2224 22.24	660 6.60	0.2250	0.1567	0.6183
Tehran	Boue and Boue 1956	3049	1063 34.86	1036 33.98	721 23.65	229 7.51	0.2356	0.1707	0.5937
Iranian	Nijenhuis 1964	348	148 42.5	91 26.1	86 24.7	23 6.7	0.180	0.171	0.650
Tehran Iranians	Sawhney 1975	99	44 44.44	23 23.23	26 26.26	6 6.06	0.1565	0.1748	0.6687
Yazd Moslems	Sunderland et al 1966	307	96 31.27	81 26.38	100 32.57	30 9.77	0.2009	0.2406	0.5585
Zoroastrians Iran	Present Study	466	126 27.04	113 24.25	186 39.91	41 8.80	0.1798	0.2931	0.5271

Table 5.7 ABo PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF KERMAN AND MOSLEMS OF KERMAN FOR COMPARISON

Population	Author	Number	Phenotypes				Gene Frequencies		
			O	A	B	AB	P	q	r
Kerman Moslems	Beckett 1950	40	23 57.50	7 17.50	8 20.00	2 5.00	0.1090	0.1235	0.7675
Zoroastrians (Kerman)	Present Study	144	43 29.86	27 18.75	59 40.97	15 10.42	0.1578	0.3016	0.5406

Table 5.8 ABo PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF YAZD AND MOSLEMS OF YAZD FOR COMPARISON

Population	Author	Number	Phenotypes				Gene Frequencies		
			O	A	B	AB	P	q	r
Moslems (Yazd)	Sunderland et al 1966	151	49 32.45	40 26.49	48 31.79	14 9.27	0.1985	0.2322	0.5693
Moslems (Yazd)	Sunderland et al 1966	307	96 31.27	81 26.38	100 32.57	30 9.77	0.2009	0.2406	0.5585
Zoroastrians (Yazd)	Present Study	191	54 28.27	56 29.32	65 34.03	16 8.38	0.2124	0.2431	0.5445
Moslems (Yazd)	Boue and Boue 1956	258	82 31.78	57 22.10	90 34.88	29 11.24	0.1714	0.2544	0.5741

Table 5.9 ABo BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF TEHRAN AND NON-ZOROASTRIANS OF TEHRAN

Population	Author	Number	Phenotypes				Gene Frequencies		
			O	A	B	AB	P	q	r
Moslems (Tehran)	Azhir 1951	10,000	3789 37.89	3327 33.27	2224 22.24	660 6.60	0.2250	0.1567	0.6183
Iranians (Tehran)	Boue and Boue 1956	3049	1063 34.86	1036 33.98	721 23.65	229 7.51	0.2356	0.1707	0.5937
Zoroastrians (Tehran)	Present Study	131	29 22.14	30 22.90	62 47.33	10 7.63	0.1693	0.3345	0.4962

Table 5.10 MN BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES OF ZOROASTRIANS OF IRAN AND IRANIAN MOSLEMS

Population	Author	Number	Phenotypes			Gene Frequencies	
			MM	MN	NN	m	n
Zoroastrians (Iran)	Present Study	334	131 39.22	165 49.40	38 11.38	0.6392	0.3608
Tehran Moslems	Boue and Boue 1956	256	104 40.63	117 45.70	35 13.67	0.6348	0.3652
Iranians	Bajatzadeh et al 1969	520	222 42.69	213 40.96	85 16.35	0.6317	0.3683
Tehran Iranians	Sawhney 1975	58	24 41.38	25 43.10	9 15.52	0.6293	0.3707
Iranians	Nijenhuis 1964	348	128 36.8	181 52.0	39 11.2	0.6280	0.3720
Moslems (Yazd)	Sunderland et al 1966	151	57 37.75	75 49.67	19 12.58	0.6258	0.3742

Table 5.11 MNSs BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES OF ZOROASTRIANS OF IRAN AND IRANIAN MOSLEMS

Population	Author	Number	Phenotypes									Gene Frequencies			
			MSS	MSs	Mss	MNSS	MNSs	MNss	NSS	NSs	Nss	MS	Ms	NS	Ns
Zoroastrians of Iran	Present Study	145	25 17.24	24 16.55	30 20.69	5 3.45	15 10.34	29 20.0	5 3.45	4 2.76	8 5.52	0.2912	0.4076	0.0798	0.221
Tehran Iranians	Sawhney 1975	137	18 13.14	19 13.87	23 16.79	9 6.57	32 23.36	21 15.33	2 1.46	4 2.92	9 6.57	0.3187	0.3455	0.0938	0.24
Yazd Moslems	Sunderland et al 1966	151	10 6.62	25 16.55	22 14.57	10 6.62	30 19.87	35 23.18	3 1.99	4 2.65	12 7.95	0.2497	0.3761	0.0990	0.27

Table 5.12 Rh PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes		Gene Frequencies	
			D+	D-	D	d
Zoroastrians (Yazd)	Boue and Boue 1956	182	171 93.96	11 6.04	0.7542	0.2458
Moslems (Yazd)	Boue and Boue 1956	145	135 93.10	10 6.90	0.7373	0.2627
Iranian Moslems	Nijenhuis 1964	348	315 90.52	33 9.48	0.6921	0.3079
Zoroastrians (Iran)	Present Study	466	415 89.06	51 10.94	0.6693	0.3307
Moslems (Yazd)	Sunderland et al 1966	270	237 87.78	33 12.22	0.6504	0.3496
Iranians	Sawhney 1975	306	268 87.58	38 12.42	0.6476	0.3524
Moslems (Yazd)	Sunderland et al 1966	151	129 85.43	22 14.57	0.6183	0.3817
Iranians	Bajatzadeh et al 1969	530	443 83.58	87 16.42	0.5950	0.4050

Table 5.13 DUFFY BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes		Gene Frequencies	
			Fy(a+)	Fy(a-)	Fya	Fyb + Fy
Tehran Moslems	Boue and Boue 1956	135	111 82.22	24 17.78	0.5784	0.4216
Iranians	Bajatzadeh et al 1969	459	318 69.3	141 30.7	0.4460	0.5540
Iranian Moslems	Nijenhuis 1964	348	235 67.5	113 32.5	0.4300	0.5700
Moslems (Yazd)	Sunderland et al 1966	151	66 43.71	85 56.29	0.2497	0.7503
Zoroastrians (Iran)	Present Study	145	54 37.24	91 62.76	0.2078	0.7922

Table 5.14 KELL BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes			Gene Frequencies	
			K	k	Kk	K	k
Iranians	Sawhney 1975	307	0 0.0	294 95.77	13 4.23	0.0214	0.9786
Zoroastrians (Iran)	Present Study	145	0 0.0	138 95.17	7 4.83	0.0255	0.9745
Iranian Moslems	Nijenhuis 1964	302	0 0.0	283 93.7	19 6.3	0.032	0.968
Iranians	Bajatzadeh et al 1969	507	0 0.0	474 93.5	33 6.5	0.033	0.967
Moslems (Yazd)	Sunderland et al 1966	142	0 0.0	129 90.85	13 9.15	0.0469	0.9531

Table 5.15 HAPTOGLOBIN PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes			Gene Frequencies	
			1.1	2.1	2.2	HP1	HP2
Shiraz	Walter et al 1963	97	12 12.4	45 46.4	40 41.2	0.3560	0.6440
Iranian (Tehran)	Bajatzadeh et al 1968	305	43 14.1	109 35.7	153 50.2	0.3195	0.6805
Iranians	Bajatzadeh et al 1968	1020	123 12.0	376 36.9	521 51.1	0.3045	0.6955
Isfehan Iranians	Sawhney 1975	89	6 6.74	42 47.19	41 46.07	0.3034	0.6966
Iranian (Tehran)	Sawhney 1975	186	19 10.22	71 38.17	96 51.61	0.2930	0.7070
Iranian Moslems	Bowman 1964	429	34 7.92	176 41.03	219 51.05	0.2844	0.7156
Zoroastrians (Iran)	Present Study	253	17 6.72	91 35.97	145 57.31	0.2470	0.7530
Zoroastrians (Iran)	Bowman 1964	145	6 4.14	43 29.65	96 66.21	0.1900	0.8100

Table 5.16 AP PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes					Gene Frequencies		
			A	BA	B	CB	CA	Pa	Pb	Pc
Zoroastrians (Iran)	Present Study	277	18 6.50	123 44.40	129 46.57	6 2.17	1 0.36	0.2888	0.6985	0.0127
Iranians (Isfehan)	Sawhney 1975	71	6 7.79	30 38.96	39 50.65	2 2.60	0 0.0	0.2727	0.7143	0.013
Iranians (Tehran)	Sawhney 1975	161	21 13.04	68 42.24	65 40.37	7 4.35	0 0.0	0.3416	0.6367	0.0217
Iranians	Walter et al 1968	449	61 13.6	137 30.5	223 49.7	15 3.3	13 2.9	0.3040	0.6660	0.0300

Table 5.16 (cont.) AP PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes					Gene Frequencies		
			A	BA	B	CB	CA	Pa	Pb	Pc
Kurds (Marivan and Baneh)	Lehmann et al 1973	77	8 10.39	35 45.45	32 41.56	0 0.0	2 2.6	0.3441	0.6429	0.0130
Kurds (Sanandaj and Bijar)	Lehmann et al 1973	105	13 12.38	41 39.04	48 45.71	3 2.86	0 0.0	0.3190	0.6667	0.0143
Gonbad	Kirk et al 1977	155	24 15.5	65 41.9	59 38.1	5 3.2	2 1.3	0.371	0.606	0.023
Northern Gorgan	Kirk et al 1977	51	8 18.2	24 54.5	11 25.0	1 2.3	0 0.0	0.455	0.534	0.011
Southern Gorgan, Behshar, Sari	Kirk et al 1977	53	7 13.2	26 49.1	20 37.7	0 0.0	0 0.0	0.377	0.623	0.00
Bobol, Shahi, Amol	Kirk et al 1977	64	3 4.7	31 48.4	30 46.9	0 0.0	0 0.0	0.289	0.711	0.00
Shasavar, Rudsar, Rudbar, Rasht, Pahlavi	Kirk et al 1977	86	8 9.3	44 51.1	30 34.9	3 3.5	1 1.2	0.355	0.622	0.023
Tavalesh, Astara	Kirk et al 1977	61	5 8.2	23 37.7	32 52.5	1 1.6	0 0.0	0.271	0.721	0.008

Table 5.17 PGM1 PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes			Gene Frequencies		
			1.1	2.1	2.2	PGM1	PGM2	
Iranians (Tehran)	Sawhney 1975	165	101 61.21	50 30.30	14 8.48	0.7636	0.2364	
Iranians (Isfehan)	Sawhney 1975	86	50 58.14	28 32.56	7 8.14	0.7500	0.2442	6 - 1 = 1
Zoroastrians (Iran)	Present Study	278	155 55.76	107 38.49	16 5.75	0.7500	0.2500	
Iranians	Farhud et al 1973	127	61 48.03	52 40.94	14 11.02	0.6850	0.3150	

$1.16\ PGM_1^6 = 0.0058$

Table 5.18 AK PHENOTYPES AND GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN AND NON-ZOROASTRIANS OF IRAN

Population	Author	Number	Phenotypes			Gene Frequencies	
			1.1	2.1	2.2	AK1	AK2
Iranians (Isfehan)	Sawhney 1975	83	76 91.57	7 8.43	0 0.0	0.9578	0.0422
Moslems (Iran)	Bowman et al 1967	322	290 90.06	32 9.94	0 0.0	0.9503	0.0497
Iranians (Tehran)	Sawhney 1975	168	150 89.29	18 10.71	0 0.0	0.9464	0.0536
Zoroastrians (Iran)	Present Study	275	239 86.91	34 12.36	2 0.73	0.9309	0.0691

CHAPTER 6
COMPARATIVE STUDIES OF THE ZOROASTRIANS OF IRAN AND THE PARSIS OF INDIA

6.1 INTRODUCTION

A comparison of the blood groups of the Zoroastrians and those of other indigenous Iranians indicated disparity and clearly splits the data into two separate groups, Zoroastrians on the one hand and other indigenous people on the other.

A comparison of the blood group of the Parsis with those of South West Indian populations leave no doubt that the Parsis, who have been living in Indian for many centuries, belong to the Indo-Aryan group. Investigations concerning the morphological measurement of the people of India were begun during the latter half of the last century. Comprehensive studies on the subject were undertaken by Risley (1915) and Guha (1931), both of whom studied a large number of individuals comprising several different groups. However, investigations concerning genetical traits have been few in India in comparison with some other countries.

The problem of study of genetical variations in India is highly complex, because the large heterogenous population of India is divided into numerous endogamous groups. These endogamous groups which have been isolated from each other for centuries form the framework of the caste system. Members are forbidden by social law to marry outside their own group.

According to Sanghvi et al (1949), Sanghvi (1953), and Vyas et al (1958), the origin and evolution of a large majority of these groups has no recorded history. Some of these groups have remained socially isolated for a hundred generations or more. In many

states, the different populations on occasion speak the same language and may have altogether different social customs (Baxi 1966). Preliminary studies carried out on Indians of their genetic Polymorphic systems started in the early decades of this century with the ABo blood groups (Hirszfeld 1919). At present most of the data on the blood groups are restricted to the ABo, Rhesus and MN systems. Knowledge about the other systems like Duffy, Kell, etc., is still deficient.

Later research carried out by Saughvi reported striking genetical differences among the endogamous groups, and suggested that it may be of great interest to examine other such isolated groups who could contribute to a better understanding of Polymorphism in the Indian sub-continent. In recent years information regarding the other systems such as haemoglobin types and isoenzyme systems has been published for different populations in India (Das et al 1970), Blake et al (1970, 1971), Das et al (1978), Papiha et al (1981).

However, studies conducted on various Indian populations, including some Parsis and Iranis of South West India, are limited, and information about the frequency distribution of various genetic parameters is scanty, not only among the Parsis, but also within other groups.

6.2 PREVIOUS STUDIES ON THE PARSI COMMUNITY

The first study on the Parsi community has started by Macfarlane (1942), who tested one hundred blood samples in Calcutta, for the ABo blood group system. He compared the Parsis' blood group distribution with those of Bengali Brahmins and with some data from Mosul and Iran. The sample of Iranians in Samarkand showed a higher percentage of group B than the Parsis, and he found that

the Parsis formed a racial island of Near Eastern type of blood group distribution.

Majumdar et al (1948), studied the Parsis from Gujarat and tested 200 persons for ABo types. He reported that the Parsis are approaching the Hindu castes more with respect to the q value. He also revealed that the Parsis are a mixed stock with a high incidence of B group, and that is probably due to the fact that their sample from the Parsis contained more blood from Parsi children belonging to poor parents. Majumdar indicated that the Parsis are mixed stock. The high class Parsis are inbred, but the poorer section is certainly outbreeding. In 1954 Sanghvi et al undertook a study of the distribution of ABo, MN and Rh blood groups among Parsis, Christians and Marathas from India, with samples of 200 persons from each group. He showed that there were no significant differences in the distribution of ABo and MN blood groups in the three groups, but the frequency of the Rh negatives among the Marathas was significantly lower than in Indian Christians, and the Parsis. They also undertook a study of the frequency of Consanguineous marriages among the Parsis and Marathas and found a very high rate of such marriages.

In a comparative study Sirsat (1956) examined 200 Parsis and 200 Iranis from Bombay for two genetical characters, ABo and Rh. He found no significant difference between these groups for the ABo system, but a significant difference in the Rh system. He compared his results with Iranians of Iran and found no differences. In his discussion he noted that, while no other major assertion is possible on the evidence of one genetic trait alone, it can be said that in this genetic trait, the Parsis and Iranis show a similarity of distribution to the people of their country of

origin, Persia.

The study by Moten et al (1956) of 103 Parsis born in Bombay or Karachi, for the ABo and Rhesus systems, compares them with the Moslems of Karachi and reveals that the increased frequencies of the gene B in the Parsis of Karachi showed a closer similarity in the ABo distribution to the Indian pattern that to the Iranian pattern reported by Libman and quoted in Boyd (1939), and the results also were significantly different from those obtained by Macfarlane (1942) among a group of 100 Parsis living in Calcutta.

The 214 Parsis from Bombay, who were examined by Baxi et al (1963) for the ABo and Rh systems, showed a similarity with the Parsis reported by Sanghvi (1954).

A comparative study of 2,282 Parsis and 200 Iranis from Bombay, tested for ABo and Rh systems, was carried out by Undevia (1969). He showed that the Parsis have ABo blood group gene frequencies similar to those of occupational caste groups in Western India, but the Iranis have a much higher frequency of the B gene than either Parsis or Iranis sampled in Iran. Regarding the Rh system, he reported that the RY (CdE) gene frequency in the Parsis (0.7%) was the highest in the world. He explained that the 'founder' effect may have been important in elevating the frequency of RY, particularly in the isolated communities established by the Parsis after the initial migration.

Other recent work on Parsis have been reported by Undevia et al (1972 and 1973), and Mutalik et al (1974).

The distribution of some enzyme group and serum protein systems among the Parsis and Iranis was studied by Undevia et al (1972

and 1973). A total of 418 Parsis and 48 Iranis were sampled in Bombay and tested for the red cell enzyme systems. They showed that there were marked differences between Parsis and Iranis for the frequency of alleles in the acid phosphatase system, but the two populations were similar in the frequency of the alleles in the phosphoglucomutase and adenylate kinase systems. They typed two series of serum samples from 611 Parsis and 113 Iranis for haptoglobin, and found significant differences between the two populations and came to the conclusion that these differences suggested that the Parsi and Irani populations showed evolutionary divergence.

6.3 BLOOD GROUP SYSTEMS

The results for different blood group systems (phenotypes and gene frequencies) of the Zoroastrians of Iran and the Moslems of Iran are compared with those of the Parsis, Iranis and the Marathis are given in tables 6.1 to 6.5.

6.4 DISCUSSION

6.4.1 THE ABo BLOOD GROUP SYSTEM

Table 6.1 presents the published figures for the distribution of the ABo blood groups, and the respective gene frequencies in the Parsis and Iranis. The gene frequency distribution in the Parsis reveals a preponderance of the gene r with a frequency of 55-65 per cent.

The frequency of q varies between 12 and 27 per cent and that of P between 16 and 21 per cent. The A gene frequency is higher in the Parsis of Calcutta tested by Macfarlane (1942), the lowest

value being found in the Parsis of Bombay tested by Baxi et al (1963).

Comparing the Parsis' sample with the 200 Iranis tested by Undevia (1969), Iranis exhibit a relatively low frequency of the gene r (42 per cent) and a high value of gene q (36 per cent).

In general, the B blood group, as is common throughout India, is relatively frequent, though variable. Most of the Parsis are living in the Western part of India and the B gene frequency in the Western India ranges from 10 to 40 per cent (Saha et al 1976). The data on the Marathas of Western India were chosen for the purpose of comparative study from Sanghvi (1954). He tested 858 persons for the ABo blood group, and found a B gene frequency of 0.1973, which is within the range for the western parts of India.

Table 6.1 presents the distribution of the ABo blood groups in the present study, other Zoroastrians of Iran tested by Boue and Boue (1956) and by Bowman et al (1961).

It is seen from the table that all the populations tested for the ABo blood group exhibit a higher frequency of gene B than gene A, the only exception being the Parsis of Calcutta reported by Macfarlane (1942), with a higher value of the gene A. The differences between the distributions of the ABo blood groups in the present study, Parsis of Calcutta (Macfarlane 1942), Parsis of Bombay (Sanghvi 1954), Parsis of Bombay (Undevia 1969), Parsis of Bombay (Baxi et al 1963) and the Iranis of Bombay (Undevia 1969), yield: $X_3^2 = 21.21$, $P < 0.01$, $X_3^2 = 19.3$, $P < 0.01$, $X_3^2 = 11.4$, $P < 0.01$, and $X_3^2 = 20.1$, $P < 0.01$, whereas the difference between the present study, Parsis of Bombay (Majumdar 1948), Parsis, Iranis (Sirsat 1956), Parsis of Bombay (Mutalik 1974), and the

Parsis of Karachi (Moten et al 1956), are $X_3^2 = 1.36$, $P > 0.80$, $X_3^2 = 6.0$, $P > 0.20$, $X_3^2 = 0.64$, $P > 0.90$, $X_3^2 = 9.4$, $P > 0.50$, $X_3^2 = 1.89$, $P > 0.70$, and $X_3^2 = 4.45$, $P > 0.30$ respectively are not significant. This apparent anomaly has been explained by the effect of isolation and intermarriage between close blood relations (Wiener 1943).

Table 6.2 presents the distribution of the ABo blood group in this study of the Zoroastrians, Moslems of Iran, Parsis, Iranis and non-Zoroastrians from West India (Marathis), for comparison. It can be seen from the table, that Marathis with 25.5 and Iranian Moslems with 24.7 per cent of the blood group B have lower frequencies than those of the Zoroastrians, Parsis and Iranis of India. Regarding to the blood group A, the Marathis with 32 per cent and Iranian Moslems with 26 per cent have higher frequencies than the present study, Parsis and Iranis. Statistical analysis shows significant differences between the five series.

6.4.2 THE MN BLOOD GROUP SYSTEM

In the Indian sub-continent a higher frequency of the M gene and a relatively low frequency of the N gene have been reported by several investigators (A. E. Mourant 1963). He suggests that the frequency of the M gene is above 60 per cent in nearly every Indian population tested, and is below 60 per cent in the Mediterranean area. In the Marathis sample reported by Sanghvi (1954), the value of 0.60 is in the range of Indian populations, which is lower than the values of 0.64 in the present study and 0.63 in the Iranian Moslems tested by Bajatzadeh and Walter (1969). The M gene frequency in the Parsis is 58 per cent which is somewhat lower than the present study, table 6.3. The chi-squared test show significant differences between

Moslems, Parsis and the Marathis, but no difference between Parsis and Marathis was observed.

6.4.3 THE Rh BLOOD GROUP SYSTEM

The striking similarity of the distribution of the Rh types in the populations of India and Southern Europe is well known. Rh negatives range from 6 to 10 per cent in the Northern Indian populations, (Papiha 1972 , Bird et al 1956), and 1.5 to 12 per cent in Western India, (Sanghvi et al 1949 and 1954). The frequency of the Rh negative type in the various parts of Iran ranges from 5 to 14 per cent. The present study with 11.0, Parsis of Baxi (1963), with 10.2 and Iranis of Sirsat (1956), with a frequency of 6.5 per cent are all within these ranges.

The Rh negative incidence reported as 1.5 per cent among Marathas (Western India), by Sanghvi (1954 and 1949), is much lower than the figures for the Parsis, Iranis and the Zoroastrians (tables 6.4 and 6.5).

The d gene frequencies lie within the range 0.25 and 0.35 in the Parsi populations, which are close to the range of the Zoroastrians of Iran (0.24 to 0.33), and Iranis with the values of 0.255 and 0.3082. The chi-squared test shows significant differences between the Marathis, Iranis, Parsis, Iranian Moslems and the present study. The incidence of Rh negatives in the Kerman Zoroastrians is slighly higher than those of the Tehran and Yazd Zoroastrians. They are also characterised by a higher value of the frequency of the gene d (0.34) than are the Iranian Moslems, Parsis, Iranis and Marathis, the only exception being the Parsis tested by Sirsat (1956), with a d gene frequency of 0.35.

6.5 SERUM PROTEIN

Table 6.6 presents the distribution of the haptoglobin phenotypes and respective gene frequencies in the Parsis, Iranis of Bombay, Zoroastrians of Iran reported by Bowman (1961), and the present study. No rare phenotypes were found, but 1.15 per cent of the Parsis and 3.54 per cent of the Irani samples were phenotypically HPo-o. Table 6.7 shows the distribution of the haptoglobin groups and the gene frequencies in the present study, Iranian Moslems, Parsis, Iranis of Bombay and the Marathas of Western India for comparison.

6.6 DISCUSSION

6.6.1 HAPTOGLOBIN

Extensive studies on the distribution of the haptoglobin types in many populations of the world have been carried out since the work of Smithies (1955). These studies have further revealed that while the HP1 frequency was highest among the African negroes, it appeared to be quite low in Asiatic Indians (Giblett 1960, Kirk 1968).

According to Kirk (1968), world values for the HP1 gene frequency range from 0.07 (Irulas, S. I.), to 0.89 (Colorado, C. A.). Baxi and Camoens (1969), Blake et al (1971), Sunderland et al (1976), and Das et al (1978), reported HP1 gene frequencies of 11 to 28 per cent in Northern India.

In most studies, populations in South and South West India are characterised by low values of the HP 1 allele, an exception being Toda, reported by Kirk and Lai (1961), and Saha et al (1976).

The HP1 gene frequency in the South and South west ranges from 0.05 for the Naickers (Ananthakrishnan 1972), to 0.37 (Kirk and Lai 1961). Baxi and Camoens (1969), showed the value of the HP1 of 0.1165 for the Marathi (table 7.7). The Parsis have frequencies of 0.10 to 0.13, which are similar to the Marathi and the populations of South and South west India, but differ considerably from the Iranis of Bombay with a frequency of 0.2156. The Iranis are close to the Zoroastrians of Iran in respect of the HP1 gene frequency. The Iranian Moslems (Bowman 1964) have a higher HP1 gene frequency (0.2844) than those of the Zoroastrians, Parsis, Iranis and the Marathis.

The similarity between Zoroastrians and Iranis in respect of the HP1 gene frequency are not surprising in view of their non-Indian origin and limited admixture with the populations among whom they live. Their most striking characteristic, the high frequency of HP2 allele, is in fact characteristic of the Zoroastrians, and there is considerable evidence that they migrated to India in the 19th Century from Iran.

Statistical analysis suggests that there are significant differences between the present study and the Parsis tested by Undevia et al (1973), and Baxi and Camoens (1969), $X^2 = 33.8$, $P<0.01$, and $X^2 = 14.1$, $P<0.01$ respectively. There is also a difference between the present study and that of the Iranis of Undevia et al (1973), but the difference is not greater than those of the Parsis, $X^2 = 10.3$, $P<0.02$.

6.7 RED CELL ISOENZYMES

The results of different isoenzyme systems are given in tables 6.8, 6.10 and 6.12.

The tables show the distribution of acid phosphates, phosphoglucomutase, and adenylate kinase phenotypes and respective gene frequencies in the present study, the Parsis and the Iranis of Bombay. Unfortunately, no adequate data are available in respect of the red cell isoenzyme systems in the Parsis and Iranis.

Table 6.9, 6.11 and 6.13 present for the comparison the distribution of different isoenzyme systems in the present study, Iranian Moslems, Parsis, Iranis and the Marathis of West India.

6.8 DISCUSSION

6.8.1 ACID PHOSPHATASE Tables 6.8 and 6.9

Three alleles exist in many populations to control the phenotypic expression of red cell acid phosphatase. In all tribal Indian populations only two alleles are present in the red cell acid phosphatase system, Pa and Pb, and the former has a frequency range of 20-40 per cent (Saha et al 1976, Singh 1973 and Mukherjee et al 1974). A few cases of individuals heterozygous for the Pc allele have been reported in non-tribals (Hopkinson 1968 and Goedde et al 1972), with the highest Pc gene for an Indian sample of 0.047. Blake et al (1970), tested samples of 399 Marathis and 442 Gujaratis. They reported that no phenotypes containing the Pc allele were found among the Marathis and only 4 persons among the Gujaratis tested were of phenotype Pc. In the Parsis of Bombay tested by Undevia et al (1972), the Pc gene is absent and 2 persons among 48 Iranis tested by Undevia et al (1972), were of phenotype Pc. This gives a Pc frequency of 0.0208 for Iranis, a figure lower than that reported by Blake et al (1970). In the Zoroastrians of Iran (present study), the Pc allele occurred in seven

heterozygotes, six CB and one CA. The chi-squared test shows significant differences between the Zoroastrians of Iran and Parsis, Iranis and Iranian Moslems: $X^2_4 = 30.8$, $P < 0.01$, $X^2_5 = 14.06$, $P < 0.05$ and $X^2_4 = 24.001$, $P < 0.01$ respectively and also there is a significant difference between the Parsis and the Iranis, $X^2_3 = 26.07$, $P < 0.01$. As can be seen from the above figures the differences between the present result and the Parsis, and between the Iranian Moslems and the present results, are greater than between the present series and the Iranis.

6.8.2 ADENYLATE KINASE Tables 6.10 and 6.11

The three phenotypes AK1.1, 2.1 and 2.2 are controlled by two autosomal codominant alleles AK1 and AK2. The AK2 allele has a high frequency in Indian populations compared with those in other parts of the world (Mukerjee et al 1974, Singh 1973 and Saha et al 1976). The AK2 gene has a frequency of 0.05 in European populations but is rare in black Africans (Hopkinson 1968). The highest frequencies of AK2 hitherto reported (0.15 and 0.14), are among Indian populations (Papiha 1979, Saha et al 1976). According to Papiha (1979), the AK2 gene in Indian urban populations shows high frequencies as compared with tribal populations (Urban ranges 9.16% and tribal ranges 3.8%).

The AK2 gene frequencies among 4 endogamous groups in the Panjab reported by Singh et al (1974b) range from 0.085 to 0.107, which are compatible with the general pattern of distribution of this marker in the populations of the India. The 352 Marathis tested by Blake et al (1970), with an AK2 gene frequency of 0.09, have values similar to those found in the other parts of India. In Iranian populations the AK2 gene has a frequency of 0.04 to 0.076

(Bowman et al 1967, Lehman et al 1973, and Sawhney 1975), which are lower than Indian values.

In the present study, the AK2 gene in the Zoroastrians of Tehran and Yazd is lower (0.06 and 0.065 respectively) than that of the Kerman Zoroastrians (0.096), which is even higher than the Iranian Moslems' value. The Parsis with an AK2 frequency of 0.067 have a frequency similar to that found in the Zoroastrians of Iran (pooled data = 0.069). Low values of AK2 have been found in the 48 Iranis of Bombay (0.02) reported by Undevia et al (1972). In the Middle East (Tills et al 1970), the frequencies range from 0.025 to 0.69. Both the Parsi and Irani values fall within this range.

6.8.3 PHOSPHOGLUCOMUTASE Table 6.12 and 6.13

Two separate gene loci, PGM1 and PGM2, control the phosphoglucomutase activity, detectable in the red cell lysates. At the first locus, PGM_1^1 and PGM_1^2 have a universal distribution, though their frequency varies from one population to another (Hopkinson 1968). Singh et al (1974b) investigated 4 endogamous groups in the Panjab (North West India), and found no statistically significant differences among those groups regarding the distribution of PGM1. The frequencies of the PGM_1^1 gene reported by them ranges from 0.70 to 0.75. Saha et al (1976), reported PGM_1^1 values, ranging from 0.442 to 0.792 in South West India. Das et al (1970), reported a PGM_1^1 frequency of 0.70 for Bengalis. In the Northern India, PGM_1^1 ranges from 0.634 among the Rajput to 0.793 among 63 members of the Vaish caste (Blake et al 1971). Blake et al (1970) tested 352 Marathis and 296 Gujaratis for the PGM1 system, the PGM_1^1 gene having a value of 0.649 in the

Marathi and 0.69 in the Gujarati samples. He reported that there was no signficiant difference between these populations and that of the Bengalis tested by Das et al (1970). Undevia et al (1972), tested 401 Parsis and 46 Iranis from Bombay. The PGM_1^1 frequency in Parsis is 0.7369 and 0.7065 in the Iranis. These values lie within the range for PGM_1^1 found in other Indian populations. No rare phenotypes were observed by them in either series.

The frequency of the gene PGM_1^1 in the present study (pooled samples), 0.75, is much higher than in Iranian Moslems (0.62), and Marathis (0.64), but is relatively similar to those of the Parsis and Iranis. Statistical analysis shows that the difference between the present series and the Parsis is less than the difference between the present series and the Iranis, $X^2 = 0.58$ and $X^2 = 6.0$ respectively. Chi-squared tests show no signficant differences between the Iranian Moslems and the Zoroastrians of Tehran, Yazd and Kerman, but the difference is much higher between the Iranian Moslems and the Zoroastrians of Kerman, $P > 0.50$, $P > 0.30$ and $P > 0.20$ respectively.

6.8.4 PHOSPHOGLUCOMUTASE ISOELECTRIC FOCUSING SUB-TYPES

A total of 243 red cell samples from the Zoroastrians of Iran (present study) were sub-typed for the red cell enzyme phosphoglucomutase locus 1 and the phenotype and the respective gene frequencies were calculated by Papiha et al (1982).

Table 6.14 presents the distribution of the phosphoglucomutase sub-types in the Zoroastrians of Tehran, Yazd, Kerman and the pooled samples.

Recent investigations of phosphoglucomutase, by means of isoelectric

focusing in Polyacrylamide, have been reported by Bark et al (1976) and Sutton et al (1978). They suggested that the complex of red cell PGM isoenzyme pattern shown the existance of 4 alleles at PGM1 locus, namely, PGM_1^{1+}, PGM_1^{1-}. PGM_1^{2+} and PGM_1^{2-}.

The three main phenotypes of PGM observed by starch-gel electrophoresis PGM1.1, PGM2.1 and PGM2.2 have been attributed to the occurrence of 2 common alleles PGM_1^1 and PGM_1^2 at the PGM1 locus. Bark et al (1976), Spencer et al (1964), Welch et al (1978) and Carter et al (1979).

The PGM1.1 phenotype as determined by starch-gel electrophoresis (Spencer et al 1964), is observed to occur as three phenotypes by isoelectric focusing, which are PGM_1 1+1+, PGM_1 1+1- and PGM_1 1-1-.

The PGM2.1 phenotype on starch-gels could be one of 4 four possible phenotypes PGM_1^{1+2+}, PGM_1^{1-2+}, PGM_1^{1-2-} and PGM_1^{1+2-}.

The PGM, 2 could be one of the three phenotypes on isoelectric focusing (PGM_1^{2+2+}, PGM_1^{2+2-} and PGM_1^{2-2-}).

The families analysed by Bark et al (1976), Welch et al (1978), and Carter et al (1979) suggest that these sub alleles follow Mendelian inheritance.

243 Zoroastrian samples were sub-typed for PGM locus 1 using the LKB 2117 multiphor system (Papiha et al 1982).

Carter et al (1979) carried out a study of PGM sub-types on 4 populations and showed a PGM_{1+}^{1-} gene frequencies of 0.132 in Northern European, 0.153 in Newfoundland, 0.126 in Negroes of England and 0.096 in the Asians living in London.

According to Welch et al (1978), the PGM_{1+}^{1-} gene frequency ranges from 0.101 to 0.150 in European countries, 0.132 in Negroes and 0.053 to 0.102 in Middle Eastern countries.

According to Papiha et al (1982), the PGM_1^{1+} gene frequency in the African samples have shown exceptionally high value (69-80 per cent), compared with the Europeans (60-69 per cent). The frequency of the allele PGM_1^{1+} in the Asians is 0.537, which is lower than those of the European and African values (Carter et al 1979). The frequencies of the PGM_1^{1+} allele in the Zoroastrians of Iran ranges from 0.658 for Kerman, 0.666 for Tehran and 0.687 for the Zoroastrians of Yazd. The samples were pooled and gave a frequency of PGM_1^{1+} of 0.67, which is in the range for the European values.

6.8.5 GROUP SPECIFIC COMPONENT Table 6.15

236 serum samples for the Zoroastrians of Iran were subjected by Papiha et al (1982), and the phenotypes and gene frequencies were calculated.

Family studies by Constans (1977), reveals the existance of two codominant Gc1 sub-types, which are called Gc^{1F} (1F, fast) and Gc^{1S} (1S, slow).

The three main phenotypes of Gc by electrophoretic are Gc1.1, Gc2.1 and Gc2.2, which are products of two common alleles, Gc1 and Gc2 (Mourant et al 1978). The usual Gc1.1 phenotype is observed to occur as three phenotypes Gc^{1F-1S}, Gc^{1F-1F} and Gc^{1S-1S}; the association of Gc^{1S} and Gc^{1F} sub-types with the Gc2 gene provides two additional Gc2-1F and Gc2-1S phenotypes (Constans 1977). The analysis of the three common Gc types by

immunofication isoelectro-focusing permits the distinction of six sub-types called Gc1F-1F, Gc1F-1S, Gc-1S-1S, Gc2-1F, Gc2-1S and Gc2-2. It is assumed that they are genetically determined by three alleles, named Gc^{1F}, Gc^{1S}, and Gc^{2}. They can be explained by the existence of three Codominant alleles named Gc^{1F}, Gc^{1S}, and Gc^{2} (Constans et al 1978).

Constants (1977), studied three populations in different countries and found a Gc^{1F} frequency of 0.077 in Western Pyrenean Valley (France), 0.584 in Pygmies and 0.231 in Bolivians.

According to Papiha et al (1982), the Gc^{1F} allele ranges from 22-28 per cent in the Iraq and Israel.

The frequency of Gc^{1F} allele in the Zoroastrians of Iran (present investigation) ranges from 0.1358 in Yazd, to 0.1530 in Kerman and 0.144 in the pooled samples, which is lower than the Middle Eastern values of 22-28 per cent. The Group Specific Component for the common alleles, Gc1 and Gc2 has been studied in the Iranian populations by Walter et al (1963) Bajatzadeh et al (1968 and 1969), and Farhud et al (1978); the frequency of the Gc1 gene in these populations ranges from 0.646 (Bajatzadeh et al 1969), to 0.766 (Walter et al 1963). The Zoroastrians value of 0.773 is higher than those of the Iranians and within the range for the Europeans.

6.9 GENETIC DISTANCE

6.9.1 INTRODUCTION

The study of genetic relationships between populations in Iran, either on the broad basis of comparisons across the sub-continent, or at the local level, is still in its infancy. To enable such comparison to be effected, sufficient data has to be available. This can be approached in two ways: firstly, by comparing the distribution of specific markers, such as blood group distribution, or, secondly, by using composite indices of genetic distance based on information from a number of genetic loci. Utilising the second approach in order to assess the relationships between

populations, several measures of genetic distance are now in common use.

Those distance coefficients which make use of gene frequency results may appropriately be designated as 'genetic distances' (Constandse-Westermann 1972). If two populations have precisely the same gene frequencies they will be considered to be at zero 'distance' apart. The greater the distance between the gene frequencies the greater the distance (C. A. B. Smith 1977). Genetic distance is used for two reasons: Firstly, to reduce a complicated mass of data to easily manageable and visuable form. The study of variation in gene frequency at a single locus is comparatively easy. The difficulty of comprehending such variation at a large number of loci increases very rapidly, and it is necessary to have some composite measure to suggest relationships between population based on all the characteristics under consideration. This is the rationale for having a measure of genetic distance (Sanghvi and Balakrishnan 1972), and secondly to try to reconstruct something of the evolutionary history of the populations concerned (Smith 1977). In countries with several different populations, social distance is of great interest. Caste, class, culture and religion influence mate selection. Religious isolate and their postulates form sub-populations of the larger population in which they live. The Zoroastrians are a good example.

Most genetic distances are calculated from qualitative traits, which have been developed mostly over the last ten years. A massive amount of information about the different populations has been gathered and studied using other methods.

According to Constandse-Westermann (1972), the coefficients which

can be calculated from qualitative data (gene frequencies) may be divided into four categories.

The first category including those coefficients based on squared differences between percentages of frequency values, initially reported by Spuhler (1954). The second category includes those distance coefficients based on the same principles as X^2, namely GS^2 considered by Edwards and Cavalli-Sforza (1972), and DK^2, which can be considered as a transition to a coefficient belonging to the third category.

The third category includes the coefficient by which the differences in frequency values between populations are expressed in terms of the elements of the pooled dispersion matrix of all investigated groups.

The fourth category contains those distance coefficients whose calculation is based on the angular transformation of the original percentages of frequencies; this category was used in the present study for calculation of distance coefficient.

Edwards (1971) suggested that the angular transformation provides a measure of distance, which has some advantages over other measures, namely, that the angular transformation, being non-linear, standardises the variances and takes care of the correlations by reducing the number of dimensions and gives a better estimate of large distances.

The genetic distance E is strictly comparable between different sets of data based on information from the same loci.

6.9.2 RESULTS

10 Iranian and Indian groups selected for consideration in this

chapter were chosen on the basis of variability of gene frequency information on fifteen alleles from six loci.

The following loci and alleles are considered: the ABo locus with three alleles A, B and o; the Rh locus with two alleles D positive and D negative; haptoglobin locus with two loci HP1 and HP2; adenylate kinase locus with two alleles AK1 and AK2; Phosphoglucomutase locus with two alleles PGM1 and PGM2, and acid phosphatase locus with three alleles Pa, Pb and Pc.

The gene frequencies of the ten populations belonging to various linguistic groups are given in table 6.16. Three of these, the Zoroastrians of Iran, Iranian Moslems and Iranian Kurds are represented for three different religious and linguistic groups. The Kurds are mainly in the North West and West of the country, and the Iranian Moslems belong to several parts of Iran. The Parsis and Iranis have a common ancestry in Iran but they migrated later to Western India, and each of the other three Indian groups belong to Kunbi from the South, which are agriculturalists by profession and are widely distributed in Gujarat and practice endogamy, (Papiha et al 1981). The Panjabis are from the North and the Marathis from the West of India, and are largely cultivators and also endogamous.

The method employed here for distance coefficient in Edwards and Cavalli-Sforza's 'new E^2'.

The statistic E^2 is calculated from the formula:

$$E^2 = 8 \frac{1 - \sum_{K=1}^{S_J + 1} \sqrt{P1JK \cdot P2JK}}{\left(1 + \sum_{K=1}^{S_J + 1} \sqrt{\frac{P1JK}{S_J + 1}}\right)\left(1 + \sum_{K=1}^{S_J + 1} \sqrt{\frac{P2JK}{S_J + 1}}\right)}$$

Where P1JK is the frequency of the Kth class of the Jth character in the ith population

S_J is the number of classes minus one.

The E^2 distance for the ten populations from Iran and India were examined on the basis of this formula, the gene frequencies data was analysed using the Fortran program.

The output from the program consisted of:

1. A data input reprint
2. Individual E^2 values for each locus separately
3. The total E^2 values
4. The standardised E^2 value.

An overall E^2 value can be obtained by adding the squared distances from the different loci.

For comparative purposes, the influence of the number of alleles on the total squared value should be neutralised by dividing the total result by $\sum_{J=1}^{r} S_J$ (Constandse-Westermann 1972).

6.9.3 CODING FOR GENETIC DISTANCE

1 - Zoroastrians of Tehran

2 - Zoroastrians of Yazd

3 - Zoroastrians of Kerman

4 - Iranian Moslems

5 - Parsis

6 - Iranis

7 - West Indians

8 - South Indians

9 - North Indians

10 - Iranian Kurds.

6.10 DISCUSSION

The Zoroastrians of Tehran, Yazd and Kerman have been compared with the Iranian Moslems, Parsis, Iranians, populations of West, South and North India and the Iranian Kurds.

Table 6.17 presents data matrices of genetic distances produced using Edwards E^2 statistic. The results show that the genetic distance between the Zoroastrians of Tehran and Yazd was less than the distance between the Zoroastrians of Yazd and Kerman, and the Zoroastrians of Tehran and Kerman (Fig. 6.1). As has been pointed out in Chapter 5, the statistical analysis suggested that in most systems tested, the differences between the Zoroastrians of Tehran and Kerman were greater than the differences between the Zoroastrians of Tehran and Yazd.

According to Ward (1971), a small group of the Zoroastrians in Kerman, under high social pressure, developed the characteristics of a closed, introverted, and strict society and practised endogamy within their own community. Moreover, most of the Zoroastrians in Tehran migrated there from Yazd.

The Iranis of India showed a closer relationship with both the Zoroastrians of Tehran and Yazd than with the Zoroastrians of Kerman. Due to the growing trade between Iran and India during the 19th Century, many Zoroastrians from Tehran and especially from Yazd migrated to India, and are now known as Iranis.

The results show that the genetic distance between the Parsis of Western India and the Zoroastrians of Iran is less than the distance between the Parsis and the Marathis of West India. Two unexpected results were the relatively close relationship between the Parsis and the populations of South and North India, and between the Zoroastrians of Iran and the population of North India. There are no satisfactory explanations for these, since the Parsis were known to have settled mainly in Western India, but according to Smith (1977), two populations may be similar, with small genetic distance, if they are recently descended from a common ancestral population which later split. But conceivably there might be other reasons for the similarity, for example, the result of selective forces bringing their gene frequencies nearer together. A changed natural selection based on a changed genetical composition will cause a loss of genetical equilibrium of the population. Gene frequencies will shift in various directions from the initial intermediate values.

The close relationship between the Moslems of Iran and the Iranian Kurds suggests that they share the major part of their genetic constitutions. Nijenhuis (1964) suggested it may be dangerous to conclude from the blood group gene frequencies that the Iranians are a population composed of two main components, one Bachtiari-like and one Kurdish-like, influenced by some less important intermixing, in the first place because of the heterogenity,

probably occurring in the populations. If in relatively small numbers such heterogenity is already obvious, this would mean that the differences between the various components composing a population are relatively strong.

Consequently, it must be doubted whether an arbitary composition of a small collection of individuals will indeed provide a good average for blood group frequency values of the ethnic group concerned.

CONCLUSION

The distributions of the different allelic genes in some of the blood groups, serum protein and red cell isoenzymes obtained from the Iranian Zoroastrians are described, and the results have been compared with those of the Parsis and Iranis. In selecting ethnic groups appropriate for population genetical comparison, the Indian Parsis and Iranis were used, due to Iran being their probable place of origin; the Marathi of West India to make comparisons with the Parsis and Iranis and the Moslem Iranians to provide a control sample for Iran.

For the ABo blood groups, the more frequent occurrence of group B than that of A in Asia has been known for a long time. Analysis of the ABo blood group system in the different populations presented in this chapter show significant variation. The Marathis appear to have a high frequency of gene A, whereas it is considerably lower in the other populations. The incidence of the B gene is relatively low in the Indian Moslems and very high in the Iranians. In general a high incidence of the gene B exists in the Iranian Zoroastrians, Parsis and Iranis. The frequency of the o gene is higher in Iranian Moslems and considerably lower in the Iranis. All the Zoroastrian populations studied to date show a high frequency of the gene B.

The MN gene frequencies show little variation among the four populations. (Iranis are excluded, because of the lack of available data). The gene M constitutes the dominant gene for approximately two thirds of the total of the Iranian Zoroastrians and Iranian Moslems but among the Parsis and Marathis there is a marked departure from this situation, the M gene having a frequency of 0.585 and 0.60, respectively. By contrast, the Zoroastrians and

the Iranian Moslems have a high frequency of the gene M, well above 60 per cent, which is higher than the Mediterranean values.

In the Rhesus system, the Rh negative allele varies in frequency from 0.245 in a sample of Zoroastrians tested by Boue and Boue (1956), to 0.353 among the Parsis reported by Sirsat (1956).

The gene d does not exhibit much variation between the Zoroastrians of Iran, Iranian Moslems and the Parsis. Its frequency is lower in the Iranis, but by contrast the Marathis differ greatly in having a low frequency of the gene d.

Among the serum protein systems, the HP1 frequency is higher in the Iranian Moslems, the Zoroastrians have a frequency lower than that of the Iranian Moslems and it starts to decline in the Parsis and Marathis respectively. The Iranians have a similar gene frequency to the Zoroastrians of Iran, whereas the Parsis have a markedly lower HP1 gene frequency.

In the red cell enzyme systems, it is observed that in the case of acid phosphatase, the Parsis and Iranis differ markedly from each other. The Parsis and Marathis show an absence of the Pc allele, but it is present in the Zoroastrians, Iranian Moslems and the Iranis. With regard to the frequency distribution of the three alleles Pa, Pb and Pc, all the five populations show much variation. In the adenylate kinase system, the AK2 gene frequency is high in the Marathis and low in all the other groups. In the Phosphoglucomutase system, the Marathis have a higher PGM_1^2 frequency and show the presence of PGM_1^6.

Parsis are closer to the Zoroastrians than to the Iranis in respect to the PGM_1^1 and PGM_1^2 alleles. It should be noted that

the sample size for the Iranis is small, especially in the case of the red cell enzyme systems. A large sample of Iranis would have been desirable to make a more adequate comparison with the Parsis and Zoroastrians of Iran than has been possible in the present study.

Comparative studies using Edwards and Cavalli-Sforza's (new E^2) statistic, have shown that the Iranis are close to the Zoroastrians of Iran, and the distance between the Parsis and the Zoroastrians is less than the distance between the Parsis and Marathis.

In broad terms, therefore, the analysis of genetic markers in samples of blood elucidates the question of relationship between these populations based on historical reference.

It is known historically that the Zoroastrians of Iran have practiced endogamy since the Arab Conquest in the 7th Century. From what has been stated in the former chapters, under the high pressures of the new faith, they began to migrate to remote places such as Yazd and Kerman and the surrounding areas, in order to keep up their ancient religion. They were forbidden to marry outside their own group. Some of them migrated further, to India, but it is not known whether they brought women with them or took them from the neighbouring people in India. The high value of the gene B in the Iranian Zoroastrians appears to be due to the fact that the Zoroastrians were reservoirs of the B gene.

The Parsis represent an unusually well-defined link between the Zoroastrians and those of the Indians among whom they lived for centuries. Biologically, it appears from the results presented in this study that the Parsis have ABo blood group gene frequencies relatively similar to those of the occupational caste

group in Western India, but the Iranis have a much higher frequency of the gene B than either the Parsis or the Zoroastrians of Iran. The Irani community is small, and follows the same religion - Zoroastrianism. The high incidence of the B gene in this group may be due to the founder effect.

There are some differences in both phenotypic and gene frequency distributions for a number of systems between the Zoroastrians of Tehran, Yazd and Kerman. The populations sampled in these series have long been separated by deserts, mountains and lack of connecting roads, and these natural barriers, no doubt, have affected to some extent the blood group systems within the Yazd and Kerman Zoroastrians. The present generation of Tehran Zoroastrians are descendents of migrants, who at the beginning of this century did not build permanent community in Tehran. One marker in particular suggests that the Zoroastrian genes are present among the Iranis, even though the relative value of Pc allele in the acid phosphatase system in the Iranis is higher than the Zoroastrians. Furthermore, it reveals the absence of this allele in the Marathis and Parsis. For the Parsis there are genes which suggest firstly, that they have interbred with neighbouring groups among whom they live, and secondly, that they have derived genes from non-Zoroastrian groups at some time in the past, for example, the HP1 gene, with a high frequency in the Iranian Zoroastrians and the Iranian Moslems, and markedly low frequency in the Parsis and Marathis.

From the pattern of the gene frequencies found among the Zoroastrians, Parsis, and the Iranis in contrast with that of other Iranian and Indian populations (non-Zoroastrians), it is possible to suggest the type of genetic structure the ancestral

Zoroastrians may have had. In the ABo blood group the incidence of the B gene was high, with o probably predominating. In the MN system, the gene M predominated over N, and for Rh groups the allele d was present with a relatively high frequency. In the red cell enzyme systems, Pb predominated and Pc was present in the acid phosphatase system. For adenylate kinase system, the AK2 gene was present and in the Phosphoglucomutase system only PGM_1^1 and PGM_1^2 were present, and variants in all other systems were rare or absent. If these assumptions are correct, the resulting pattern would not be very dissimilar from that of the Iranian Moslems, regarding a number of blood group systems. These may be attributed to the fact that the Zoroastrians of Iran once have been part of a large population in Iran which was later converted to Islam. However, the Iranian Moslems suffered from incursions of various Turanian people (the Mongols, Seljuk, Turks and Tartars), leading to the introduction of new genetic characteristics.

Table 6.1 ABo BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS OF INDIA

Population	Author	Number	Phenotypes				Gene Frequencies		
			O	A	B	AB	P	q	r
Parsis (Calcutta)	Macfarlane 1942	100	43 43.00%	33 33.00%	18 18.00%	6 6.00%	0.216	0.125	0.656
Parsis (Bombay and Poona)	Mutalik et al 1974	162	59 36.42%	46 28.39%	45 27.78%	12 7.41%	0.199	0.195	0.606
Parsis (Bombay)	Sanghvi et al 1954	200	82 41.00%	44 22.00%	57 28.5%	17 8.5%	0.165	0.205	0.630
Parsis (Bombay)	Undevia 1969	2282	834 36.55%	551 24.15%	711 31.15%	186 8.15%	0.1769	0.2207	0.6024
Parsis (Bombay)	Baxi et al 1963	214	84 39.25%	45 21.03%	65 30.37%	20 9.35%	0.1643	0.2218	0.6139
Parsis (Karachi)	Moten et al 1956	103	32 31.0%	26 25.0%	34 33.0%	11 11.0%	0.20	0.25	0.55
Parsis (Bombay)	Majumdar et al 1948	231	70 30.30%	54 23.38%	84 36.36%	23 9.96%	0.183	0.267	0.550

Table 6.1 Contd. ABo BLOOD GROUP PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS OF INDIA

Population	Author	Number	Phenotypes				Gene Frequencies		
			O	A	B	AB	P	q	r
Iranis (Bombay)	Sirsat 1956	200	60 30.0%	47 23.5%	77 38.5%	16 8.0%	0.1734	0.2701	0.5565
Parsis (Bombay)	Sirsat 1956	200	73 36.5%	43 21.5%	68 34.0%	16 8.0%	0.1970	0.2782	0.5247
Zoroastrians (Iran)	Boue and Boue 1956	233	69 29.61%	44 18.88%	91 39.06%	29 12.45%	0.1536	0.2872	0.5590
Zoroastrians (Iran)	Present Study	466	126 27.04%	113 24.25%	186 39.91%	41 8.80%	0.1798	0.2931	0.5271
Zoroastrians (Iran)	Bowman et al 1961	150	39 26.0%	25 16.67%	69 46.0%	17 11.33%	0.1521	0.3473	0.5006
Iranis (Bombay)	Undevia 1969	200	42 21.0%	37 18.5%	81 40.5%	40 20.0%	0.2109	0.3630	0.4261

Table 6.2 ABo BLOOD GROUP PHENOTYPES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Types		Zoroastrians of Iran		Moslems of Iran		Parsis		Iranis		Marathis (West India)	
		No	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Nijenhuis 1964		Undevia 1969		Undevia 1969		Sanghvi 1954	
ABo	O	126	27.04	148	42.5	834	36.55	42	21.00	278	32.4
	A	113	24.25	91	26.1	551	24.15	37	18.5	274	31.93
	B	186	39.91	86	24.7	711	31.15	81	40.5	219	25.52
	AB	41	8.80	23	6.7	186	8.15	40	20.00	87	10.14
TOTAL		466		348		2282		200		858	

Table 6.2 Contd. ABo BLOOD GROUP GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group		Zoroastrians of Iran	Iranian Moslem	Parsis	Iranis	Marathis
ABo	p	0.1798	0.1800	0.1769	0.2109	0.2382
	q	0.2931	0.1710	0.2207	0.3630	0.1973
	r	0.5271	0.6500	0.6024	0.4261	0.5645

Table 6.3 MN BLOOD GROUP PHENOTYPES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Systems		Zoroastrians of Iran		Iranian Moslems		Parsis		Iranis		Marathis (West India)	
		No.	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Bajatzadeh 1969		Sanghvi 1954				Sanghvi 1954	
MN	M	131	39.2	222	42.69	75	37.50	No data		73	36.5
	MN	165	49.40	213	40.96	84	42.0	available		94	47.0
	N	38	11.38	85	16.35	41	20.50			33	16.5
TOTAL		334		520		200				200	

Table 6.3 Contd. MN BLOOD GROUP GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Systems		Present Study	Iranian Moslem	Parsis	Iranis	Marathis
MN	m	0.6392	0.6317	0.5850	-	0.600
	n	0.3608	0.3683	0.4150	-	0.400

Table 6.4 RHESUS PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS FROM INDIA

Population	Author	Number	Phenotypes		Gene Frequencies	
			D+	D−	D	d
Zoroastrians (Iran)	Boue and Boue 1956	182	171 93.96	11 6.04	0.7542	0.2458
Iranis (Bombay)	Sirsat 1956	200	187 93.5	13 6.5	0.7450	0.2550
Parsis (Bombay)	Sanghvi 1954	200	184 92.0	16 8.0	0.7172	0.2828
Iranis (Bombay)	Undevia 1969	200	181 90.5	19 9.5	0.6918	0.3082
Parsis (Bombay)	Baxi et al 1963	214	192 89.72	22 10.28	0.6794	0.3206
Parsis (Karachi)	Moten et al 1956	103	92 89.32	11 10.68	0.6732	0.3268
Zoroastrians (Iran)	Present Study	466	415 89.06	51 10.94	0.6693	0.3307

Table 6.4 Contd. RHESUS PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS FROM INDIA

Population	Author	Number	Phenotypes		Gene Frequencies	
			D+	D-	D	d
Parsis (Bombay)	Undevia 1969	2282	2026 88.78	256 11.22	0.6650	0.3350
Parsis (Bombay)	Sirsat 1956	200	175 87.5	25 12.5	0.6465	0.3535

Table 6.5 Rh BLOOD GROUP PHENOTYPES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group System		Zoroastrians of Iran		Iranian Moslems		Parsis		Iranis		Marathis (West India)	
		No.	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Nijenhuis 1964		Undevia 1969		Sirsat 1956		Sanghvi 1954	
Rh	D+	415	89.06	315	90.52	2026	88.78	187	93.5	197	98.5
	D-	51	10.94	33	9.48	256	11.22	13	6.5	3	1.5
TOTAL		466		348		2282		200		200	

Table 6.5 Contd. Rh BLOOD GROUP GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group System		Present Study	Iranian Moslems	Parsis	Iranis	Marathis
Rh	D	0.6693	0.6921	0.6650	0.7450	0.8775
	d	0.3307	0.3079	0.3350	0.2550	0.1225

Table 6.6 HP PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS FROM INDIA

Population	Author	Number	Phenotypes				Gene Frequencies	
			1.1	2.1	2.2	0.0	HP1	HP2
Parsis (Bombay)	Baxi et al 1969	30	0 0.0	6 20.0	23 76.67	1 0.0333	0.1034	0.8966
Parsis (Bombay)	Undevia et al 1973	611	10 1.64	146 23.90	448 73.32	7 1.15	0.1374	0.8626
Zoroastrians (Iran)	Bowman 1964	145	6 4.14	43 29.65	96 66.21	0 0.0	0.19	0.81
Iranis (Bombay)	Undevia et al 1973	113	4 3.54	39 34.51	66 58.41	4 3.54	0.2156	0.7844
Zoroastrians (Iran)	Present Study	253	17 6.72	91 35.97	145 57.31	0 0.0	0.2470	0.7530

Table 6.7 HAPTOGLOBIN PHENOTYPE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Zoroastrians of Iran		Iranian Moslems		Parsis		Iranis		Marathis (West India)	
		No.	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Bowman 1964		Undevia 1973 et al		Undevia 1973 et al		Baxi 1969 et al	
HP	1.1	17	6.72	34	7.92	10	1.64	4	3.54	8	1.61
	2.1	91	35.97	176	41.03	146	23.90	39	34.51	97	19.52
	2.2	145	57.31	219	51.05	448	73.32	66	58.41	380	76.46
	0.0	0	0.0	0	0.0	7	1.15	4	3.54	12	2.41
TOTAL		253		429		611		113		497	

Table 6.7 Contd. HAPTOGLOBIN GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Present Study	Iranian Moslems	Parsis	Iranis	Marathis
HP	HP1	0.2470	0.2844	0.1374	0.2156	0.1165
	HP2	0.7530	0.7156	0.8626	0.7844	0.8835

Table 6.8 ACID PHOSPHATASE PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS OF INDIA

Population	Author	Number	Phenotypes						Gene Frequencies		
			A	BA	B	CB	C	CA	Pa	Pb	Pc
Parsis (Bombay)	Undevia et al 1972	418	76 18.18	186 44.50	156 77.32	0 0.0	0 0.0	0 0.0	0.4043	0.5957	0.00
Zoroastrians (Iran)	Present Study	277	18 6.50	123 44.40	129 46.57	6 2.17	0 0.0	1 0.36	0.2888	0.6985	0.0127
Iranis (Bombay)	Undevia et al 1972	48	2 4.17	18 37.50	26 54.16	2 4.17	0 0.0	0 0.0	0.2292	0.7500	0.0208

Table 6.9 ACID PHOSPHATASE PHENOTYPE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Zoroastrians of Iran		Iranian Moslems		Parsis		Iranis		Marathis (West India)	
		No.	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Walter et al 1968		Undevia et al 1972		Undevia et al 1972		Blake et al 1970	
AP	A	18	6.50	61	13.6	76	18.18	2	4.17	28	7.02
	BA	123	44.40	137	30.5	186	44.50	18	37.50	164	41.10
	B	129	46.57	223	49.7	156	37.32	26	54.16	207	51.88
	CB	6	2.17	15	3.3	0	0.0	2	4.17	0	0.0
	CA	1	0.36	13	2.9	0	0.0	0	0.0	0	0.0
	C	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL		277		449		418		48		399	

Table 6.9 Contd. ACID PHOSPHATASE GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Present Study	Iranian Moslems	Parsis	Iranis	Marathis
	Pa	0.2888	0.304	0.4043	0.2292	0.2757
AP	Pb	0.6985	0.666	0.5957	0.750	0.7243
	Pc	0.0127	0.030	0.00	0.0208	0.00

Table 6.10 ADENYLATE KINASE PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS OF INDIA

Population	Author	Number	Phenotypes			Gene Frequencies	
			1.1	2.1	2.2	AK1	AK2
Iranis (Bombay)	Undevia et al 1972	48	46 95.83	2 4.17	0 0.0	0.9792	0.0208
Parsis (Bombay)	Undevia et al 1972	418	363 86.84	54 12.92	1 0.24	0.9330	0.0670
Zoroastrians (Iran)	Present Study	275	239 86.91	34 12.36	2 0.73	0.9309	0.0691

Table 6.11 ADENYLATE KINASE PHENOTYPE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Zoroastrians of Iran		Iranian Moslems		Parsis		Iranis		Marathis (West India)	
		No.	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Bowman et al 1967		Undevia et al 1972		Undevia et al 1972		Blake et al 1970	
AK	1.1	239	86.91	290	90.06	363	86.84	46	95.83	292	82.95
	2.1	34	12.36	32	9.94	54	12.92	2	4.17	56	15.91
	2.2	2	0.73	0	0.0	1	0.24	0	0.0	4	1.14
TOTAL		275		322		418		48		352	

Table 6.11 Contd. ADENYLATE KINASE GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Present Study	Iranian Moslems	Parsis	Iranis	Marathis
AK	AK1	0.9309	0.9503	0.9330	0.9792	0.9091
	AK2	0.0691	0.0497	0.0670	0.0208	0.0909

Table 6.12 PHOSPHOGLUCOMUTASE PHENOTYPES AND GENE FREQUENCIES IN THE ZOROASTRIANS OF IRAN, PARSIS AND IRANIS OF INDIA

Population	Author	Number	Phenotypes			Gene Frequencies	
			1.1	2.1	2.2	PGM_1^1	PGM_1^2
Zoroastrians (Iran)	Present Study	278	155 55.76	107 38.49	16 5.75	0.750	0.250
Parsis (Bombay)	Undevia et al 1972	401	219 54.61	153 38.16	29 7.23	0.7369	0.2631
Iranis (Bombay)	Undevia et al 1972	46	26 56.52	13 28.26	7 15.22	0.7065	0.2935

Table 6.13 PHOSPHOGLUCOMUTASE PHENOTYPE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, NON-ZOROASTRIANS FROM INDIA, PARSIS AND IRANIS.

Blood Group Type		Zoroastrians of Iran		Iranian Moslems		Parsis		Iranis		Marathis (West India)	
		No.	%	No.	%	No.	%	No.	%	No.	%
		Present Study		Farhud 1973 et al		Undevia et al 1972		Undevia et al 1972		Blake et al 1970	
PGM	1.1	155	55.76	61	48.03	219	54.61	26	56.52	150	42.61
	2.1	107	38.49	52	40.94	153	38.16	13	28.26	156	44.32
	2.2	16	5.75	14	11.03	29	7.23	7	15.22	45	12.78
	6.1	0	0.0	0	0.0	0	0.0	0	0.0	1	0.28
TOTAL		278		127		401		46		352	

Table 6.13 Contd. PHOSPHOGLUCOMUTASE GENE FREQUENCIES OF THE ZOROASTRIANS OF IRAN, IRANIAN MOSLEMS, PARSIS, IRANIS AND NON-ZOROASTRIANS FROM INDIA

Blood Group Type		Present Study	Iranian Moslems	Parsis	Iranis	Marathis
PGM	PGM_1^1	0.750	0.6850	0.7369	0.7065	0.6491
	PGM_1^2	0.250	0.3150	0.2631	0.2935	0.3494
	PGM_1^6	0.00	0.00	0.00	0.00	0.0014

Table 6.14 DISTRIBUTION OF THE PGM1 SUB-TYPES IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY)

Population	Number	Phenotypes										Gene Frequencies			
		1+1+	1+1-	1-1-	1+2+	1-2+	1+2-	1-2-	2+2+	2+2-	2-2-	PGM_1^{1+}	PGM_1^{1-}	PGM_1^{2+}	PGM_1^{2-}
Tehran Zoroastrians	114	51 44.75	11 9.65	2 1.76	33 28.95	1 0.88	6 5.26	0 0.0	7 6.14	3 2.63	0 0.0	0.6667	0.0703	0.2237	0.0395
Yazd Zoroastrians	88	40 45.45	7 7.95	0 0.0	26 29.55	2 2.27	8 9.1	0 0.0	1 1.14	4 4.54	0 0.0	0.6874	0.0511	0.1933	0.0682
Kerman Zoroastrians	41	18 43.9	4 9.76	2 4.88	9 21.95	1 2.44	5 12.19	1 2.44	0 0.0	1 2.44	0 0.0	0.6584	0.1220	0.1342	0.0854
Zoroastrians of Iran (pooled)	243	109 44.86	22 9.05	4 1.65	68 27.98	4 1.65	19 7.82	1 0.41	8 3.29	8 3.29	0 0.0	0.6720	0.0720	0.1980	0.0580

Table 6.15 DISTRIBUTION OF GROUP SPECIFIC COMPONENT (Gc) IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY)

Population	Number	Phenotypes						Gene Frequencies		
		1S-1S	1S-1F	1F-1F	2-1S	2-1F	2-2	Gc^{1S}	Gc^{1F}	Gc^{2}
Tehran Zoroastrians	106	45 42.45	19 17.92	3 2.83	22 20.76	6 5.66	11 10.38	0.6179	0.1462	0.2359
Yazd Zoroastrians	81	37 45.68	15 18.52	2 2.47	20 24.69	3 3.70	4 4.94	0.6728	0.1358	0.1914
Kerman Zoroastrians	49	17 34.7	9 18.37	2 4.08	14 28.57	2 4.08	5 10.20	0.5817	0.1530	0.2653
Zoroastrians of Iran (pooled)	236	99 41.95	43 18.22	7 2.97	56 23.73	11 4.66	20 8.47	0.6290	0.1440	0.2270

Table 6.16 GENE FREQUENCIES FOR 10 IRANIAN AND INDIAN GROUPS

Groups	A	B	o	D	d	HP1	HP2	AK1	AK2	PGM1	PGM2	Pa	Pb	Pc
1. Tehran Zoroastrians	0.1693	0.3345	0.4962	0.6731	0.3269	0.2716	0.7284	0.9395	0.0605	0.7381	0.2619	0.30	0.684	0.016
2. Yazd Zoroastrians	0.2124	0.2431	0.5445	0.6764	0.3236	0.2191	0.7809	0.9345	0.0655	0.745	0.255	0.2425	0.7423	0.0152
3. Kerman Zoroastrians	0.1578	0.3016	0.5406	0.6564	0.3436	0.2396	0.7604	0.9038	0.0962	0.7885	0.2115	0.3490	0.6510	0.00
4. Iranian Moslems	0.180	0.171	0.650	0.6921	0.3079	0.2843	0.7157	0.9503	0.0497	0.6850	0.3150	0.304	0.666	0.030
5. Parsis	0.1769	0.2207	0.6024	0.6794	0.3206	0.1374	0.8626	0.9330	0.0670	0.7369	0.2631	0.4043	0.5957	0.00
6. Iranis	0.2109	0.3630	0.4261	0.7450	0.2550	0.2156	0.7844	0.9792	0.0208	0.7065	0.2935	0.2292	0.750	0.0208
7. Marathis (W.I)	0.2382	0.1973	0.5645	0.8775	0.1225	0.1165	0.8835	0.9091	0.0909	0.6491	0.3494	0.2757	0.7243	0.00
8. Kunbis (S.I)	0.162	0.249	0.589	0.7542	0.2458	0.157	0.843	0.918	0.082	0.665	0.326	0.274	0.713	0.013
9. Panjabi (N.I)	0.163	0.2604	0.5766	0.7197	0.2803	0.2204	0.7796	0.9177	0.0823	0.7044	0.2965	0.3217	0.6687	0.0096
10. Kurds-Iran	0.2312	0.1841	0.5847	0.645	0.355	0.2667	0.7333	0.9238	0.0762	0.6857	0.3143	0.3190	0.6667	0.0143

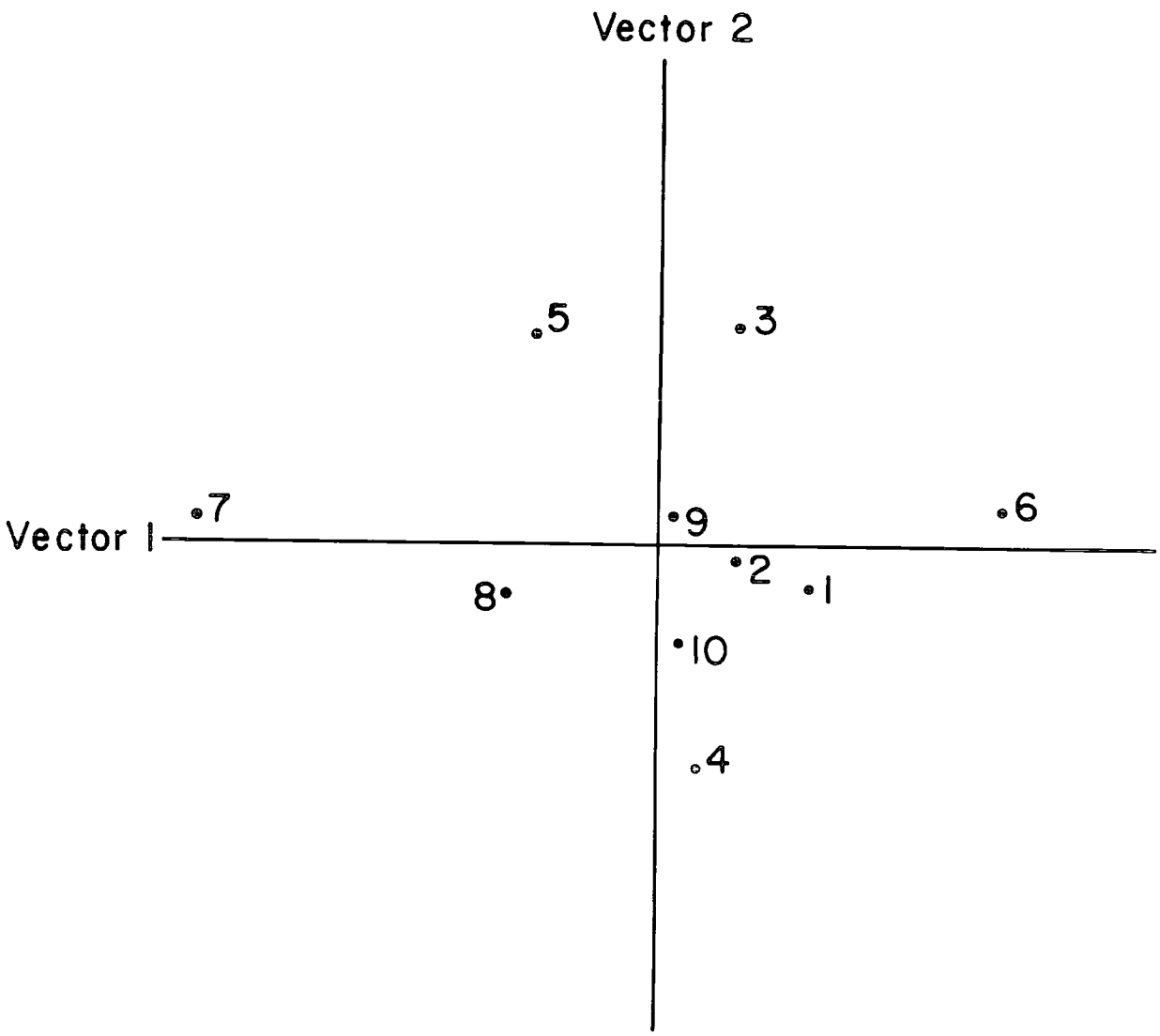
$PGM_1^6 = 0.0014$

$PGM_1^6 = 0.009$

Table 6.17 MATRIX OF EDWARDS E^2 DISTANCES, BASED ON SIX LOCI, BETWEEN TEN POPULATIONS

	1 Tehran	2 Yazd	3 Kerman	4 Iranian Moslems	5 Parsis	6 Iranis	7 Marathis	8 Kunbis	9 Panjabis	10 Kurds
1 Tehran	1.000									
2 Yazd	0.00223									
3 Kerman	0.00388	0.00541								
4 Iranian Moslems	0.00530	0.00391	0.01039							
5 Parsis	0.00882	0.00759	0.00441	0.01011						
6 Iranis	0.00428	0.00489	0.01260	0.01013	0.01490					
7 Marathis	0.01915	0.01394	0.01814	0.01795	0.01194	0.01684				
8 Kunbis	0.00670	0.00448	0.00917	0.00687	0.0071	0.00838	0.00698			
9 Panjabis	0.00217	0.00218	0.00358	0.00352	0.00434	0.0709	0.01072	0.00272		
10 Kurds	0.00426	0.00266	0.00673	0.00170	0.00717	0.01045	0.01640	0.00660	0.00264	1.000

Fig. 6-1 NMMS Plot of E^2 Distance Matrix



CHAPTER 7 DEMOGRAPHY

7.1 INTRODUCTION

Demography focuses upon changes in the size, distribution and composition of populations of which fertility, mortality and migration are the primary processes.

The complexity of a population's cultural responses to structure, kinship, marriage and religion influences its ultimate size.

Any population will increase either by live births and/or by immigration and will decrease by death or emigration, but, in a small community, occasional or periodic variations in the death rate due to natural disasters and epidemic diseases exercise a severe limiting factor on population growth.

One of the major tasks of the demographers is to project the future size of the population under consideration, because most countries are concerned with the change in population size. In a small population, several effects can ensue to bring about the elimination of one or more alleles and the eventual fixation in the population of another, purely through random processes.

Inbreeding in a small population becomes important and apparently random breeding ceases to be genetically random. Many studies of small populations have involved geographical or social isolates. Migration is a process which can unite small populations.

The population of a place at any time reflects its social and economic history. The techniques of demography can be used to describe the population in terms of its age, sex and social class distribution, as well as the rates of vital events of birth,

death and relative fertility. Demographic information has been used in a variety of ways to explore questions of human genetics and has been characterised by the determined efforts of different workers to interpret the data and to make it meaningful.

Most important social, structural and biological variables display differences in sub-groups of populations.

It is important to determine whether the changes in the number and/or distribution of the sub-groups are due to restriction of marriage partners, migration of young adults of breeding age, or to a change in the economic situation of the area, thus making it possible to alter the standard of living and consequently affect population numbers.

7.2 POPULATION DISTRIBUTION

The shift of population from one area to another or differential migration that will change not only the population's distribution but its genetic structure. Genetic structure is determined not only by the amount of gene flow into a population but also by the size of the geographical area over which the genes are flowing.

In this chapter, the population distribution of the Zoroastrians of Iran will be considered, examining certain features of Zoroastrian population, and comparing them with the total population of Iran and the Parsis of India. The study may also be viewed as the study of the quality of the Zoroastrian population. However, the quality and the range of its variability is appreciated only when the quality of one population is compared with the quality of another population. For example, the age, products of birth,

death and migration of different populations vary widely.

7.3 AGE STRUCTURE OF THE ZOROASTRIANS IN IRAN

The age structure of a population is determined by the manner in which the community has reacted through generations to a number of factors, such as mortality, fertility, diseases, migration and religious toleration. The distribution of the population of Zoroastrians in Iran by age and sex in 1956 and 1966 are given in tables 7.1 to 7.2; tables 7.3 to 7.5 also show the distributions of Tehran, Yazd and Kerman Zoroastrians by age and sex in 1966.

The total Zoroastrian population in 1956 was 16,000, of which 4,846 were in Tehran, 6,064 in Yazd and 1,857 in Kerman. The increase in the size of the population between 1956 and 1966 is 5,000; the reason for this very high increase will be discussed later. It is difficult to observe the change in the size of each age group over time (10 years), because the distribution of the Zoroastrians by age are not available in the 1956 census.

The age structure of the population affects the proportion married, and the proportion married in turn influences fertility and, indirectly, mortality and migration. A population with a high proportion of aged individuals will find its finances heavily burdened with demands for measures such as poor relief and old age pensions. With a high proportion of children, Society will be required to meet additional needs for facilities for education, school, medical help, etc. To the demographer, a knowledge of the age structure is a good measure of the biological health of the people, their anxiety to survive in the face of the stress and strain of an increasingly competitive world. The population distribution in Iran by age and sex is given in tables 7.6 to

7.7. An inspection of the tables shows an increase in the size of each age group in 1966 as compared with 1956. In 1956, 32.6 per cent of the total population were under 10 years and 49.7 per cent were under 20 years of age. The corresponding figures for 1966 were 34.1 and 54.6 respectively, appreciably higher than those for 1956.

Of the male population in 1956, 32.2 per cent were under 10, and 49.7 per cent under 20; the figures for 1966 were 34.2 and 54.7 respectively, higher than those in 1956. Of the female population in 1956, 32.9 per cent were under 10 years, and 49.6 per cent were under 20 years of age, which are lower than the corresponding figures for 1966, namely, 34.1 per cent under 10, and 54.6 per cent under 20. According to the above figures, the age structure of Iran's population changed considerably between the two censuses. It became somewhat younger in 1966 as compared with that in 1956. As a result the productive population (20-64 years) declined from 46.3 per cent in 1956 to 41.8 per cent in 1966; for the male population,this proportion declined from 46.4 to 41.3. The proportion of the population aged 65 years and over, did not change appreciably over the 10 years period between the two censuses. Comparing the above figures with the distribution of the Zoroastrians in 1966, about 17 per cent of the population were under 10 years and 37 per cent under 20, which are lower than the corresponding figures for both 1956 and 1966 for Iran as a whole. Of the female Zoroastrians in 1966, 16.7 per cent were under 10, and 36.6 per cent under 20 years of age, and of the male population, 17.4 per cent were under 10, and 37.4 per cent were under 20 years, which are lower than the corresponding figures for the Iran males and females in both 1956 and 1966.

The proportion of 20 to 64 year old Zoroastrians obtained from the 1966 Census were 56.1 for female and 54.5 for the males, which are much higher than those figures for Iran. The percentages of the Zoroastrians' population aged 65 years and over was 7.7 for both sexes, comparatively higher than those values for Iran as a whole in 1956 and 1966.

Tables 7.3 to 7.5 show the distribution of the Zoroastrians by sex and age in Tehran, Yazd and Kerman in 1966. The age structure of the Zoroastrians in these cities indicated that 20.6 per cent of the Zoroastrians in Tehran were under 10 years of age; the percentages of the Zoroastrians in Yazd and Kerman under 10 years were 19.6 and 20.2 respectively. The population under 20 years in Tehran were 39.5 per cent, 43.3 per cent in Yazd and 41.3 per cent in Kerman. It can be seen from these figures that the proportion of the Zoroastrians of Yazd under 20 years were slightly higher than those of the Tehran and Kerman. The proportion of 20 to 64 years of age in the Zoroastrians of Tehran were 54.5 for both sexes which is much higher than those of Yazd and Kerman. The percentages of the Zoroastrians aged 65 years and over was 6.0 for Tehran, 10.6 for Yazd, and 8.4 per cent for Kerman, the value for Yazd being considerably higher than those of the Tehran and Kerman.

7.4 A COMPARISON OF THE AGE STRUCTURE IN THE ZOROASTRIANS OF IRAN AND THE PARSIS OF INDIA

The age structure of the Parsis in India between 1901 to 1931 has been reported by Sekar (1948). According to Sekar, in 1901, 32 per cent of the population were under 15 years of age and in 1931 this figure was reduced to 27.2 (table 7.8). The population of age range 15-45 did not vary much between 1901 to 1931, being 50.0 per cent in 1901, and 50.6 per cent in 1931. The population

over 45 years of age increased from 18 per cent in 1901 to 22.2 per cent in 1931. Comparing the above figures with the Zoroastrians of Iran in 1966, no difference was observed in the age group 0-14 between the Zoroastrians of Iran for both sexes and Parsis in 1931. The proportion of the age group 15-45 in the Parsis was 5 per cent higher than those of the Zoroastrians, and the proportion of over 45 years of age was higher in the Zoroastrians of Iran (26.87).

Table 7.9 presents the population distribution by sex and age in the present study. According to this table, the population under 15 years of age, 29.87, is higher than those for the Zoroastrian population in 1966 and the Parsis in 1931; the Zoroastrians aged 15-45 years, in the present study is 47 per cent, which is slightly higher than that of the Zoroastrians in 1966 and lower than that of the Parsis. From the changes in the age structure as given by the figures in table 7.9 for the present study, it is clear that the Zoroastrian population is getting younger. In 1966, 26.87 per cent of the population was over 45 years of age, whereas in the present study, 23 per cent is over that age.

7.5 DISTRIBUTION OF THE ZOROASTRIANS BY SEX

In 1956 there were 103.6 males for every 100 females in Iran; the sex ratio for the Zoroastrians in the same year was 91.0. The sex ratio in 1966 was higher than that in 1956. It was 107.3 for the whole country and 103 for the Zoroastrians. In the present study there are 105 males for every 100 females, and the sex ratio of the Parsis reported by Sekar (1948) was 104.0. World wide samples have shown that at birth, boys are more numerous than girls. Experience has also shown that an initial excess of boys

is balanced, later in life, by a higher mortality among males than females (Cavalli-Sforza and Bodmer, 1971), thus leading to an expected ratio of about 100, with some variation allowed for differential migration, differential mortality rates by sex, and errors of enumeration. A sex ratio of 105 or more indicates excess males, and a ratio less than 96 indicates excess females. The sex imbalance among the Zoroastrians may be due to differential migration by sex and age especially in 1956, due to migration of the Zoroastrian young men into India looking for better jobs.

In 1966 there were 95 males for every 100 females in the Zoroastrians of Tehran; the sex ratios for the Zoroastrians of Yazd and Kerman were 88 and 91 respectively. According to these figures there were shortages of males in the three groups, but there was no shortage of males in the Zoroastrians of Iran as a whole in 1966. As indicated before, the main reason for this anomaly was migration, either to other cities or to another country; the reason for migration was to find a job or education.

Education has become an important key to social advancement. At this time, a modest education could open the way to employment in government agencies and to higher social status. As new sources of wealth became common, social mobility increased, and many lower class families could afford to educate their children. Education was regarded as a primary symbol of social position and an effective aid to social mobility. The goal of most students is to attend better schools elsewhere; they are not available in their own city. Another reason for the sex imbalance in the Zoroastrians may be differential mortality by sex, but there is no evidence so far.

According to table 7.2, the percentages of the Zoroastrian males

in the age groups 0-4, 5-9, 10-14 and 15-19 are slightly higher than those of the females, whereas the proportion of the male population aged 20-44 is slightly lower than that of the females. The relatively higher difference is at the age 20-24. Of the total Zoroastrian population in 1956, 47.7 per cent were male and 52.3 per cent female, and in 1966, 50.7 per cent was male and 49.3 female, and in the present study, the proportion of males is 51.1 and that of females is 48.9. There is no information available regarding the births and deaths of the Zoroastrian population in Iran. In the absence of these two factors, it is difficult to understand directly the nature of the demographic changes that are occurring in the Zoroastrians' community, but from the distribution of the Zoroastrian population by age and sex in 1966 and in the present study, the population in the age group 0-45 increased, and the proportion of persons over 45 years of age decreased in the present study. The sex ratio increased from 103 in 1966 to 105 in the present study. The social implications of this trend in age structure deserve careful consideration. With a large proportion of aged men and women in the society, the unproductive proportion is increased and its maintenance will throw a greater financial burden on those in the productive age group. This could result in people regulating their family size for economic reasons and consequently reducing the overall birth rate. In some cases, the responsibility for looking after the old in the family tends to postpone marriage. A reduction in birth rate will normally be the result of the diminution or postponement of marriages of the proportion of women in the reproductive age group.

7.6 FERTILITY

Of the three components of population growth, (fertility,

mortality and migration), fertility is the most important. This is especially true in countries where mortality has dropped to its lowest level. Infant mortality is almost universally declining, and it is anticipated that most countries will in the next few decades attain a low mortality level, leaving fertility as the most important variable for population change.

Because of the lack of birth registration of the Zoroastrians in Iran, the calculation of direct measures of fertility based on registration data is not possible. Instead, another measure commonly used by demographers, namely, the fertility ratio (Eaton and Mayer 1953), which is defined as the number of children under the five years per 100 women of age 15-49, is employed. Because the fertility ratio is usually calculated in situations where data needed for the calculation of direct measures of fertility are missing, it is useful in cases where there is no adequate registration of birth, such as the Zoroastrians. The ratio is, in fact, a measure of effective fertility after the bulk of infant and child mortality has occurred. That is, based on survivors only, and serves best as a relative measure (B. Bonne 1963).

In the Zoroastrian population of the 1966 census, the fertility ratio was found to be 31.0 and in the present study it is 35.0. The fertility ratios were 86.7 and 91.5 for Iran in 1956 and 1966 respectively. These indicate a very low fertility ratio in the Zoroastrians of Iran. According to Momeni (1975), the increase in the fertility ratio in Iran is more probably accounted for by a decrease in mortality and the consequent increase in the survival rate among the population under five. In the Parsis' communities the birth rate was reduced from 1901 to 1931; it was 24.6 in 1901, 19.0 in 1931 and even lower in 1941 (16.6).

7.7 ZOROASTRIANS AND THEIR FAMILY SIZE

Tables 7.10 and 7.11 present the distribution of the Zoroastrians in Tehran, Yazd and Kerman and their respective family size. Of the 1,396 Zoroastrians studied, it can be seen that 605 live in Tehran, 498 in Yazd and 293 in Kerman. Unmarried persons of both sexes, 39.2 per cent live in Tehran, 13.1 per cent in Yazd and 10.2 per cent in Kerman.

It is of great interest that the number of childless couples in Tehran, 31.5 per cent, is much greater than in the other two cities - Yazd 21.5 per cent and Kerman 15.7 per cent.

With regard to the family size shown in table 7.11, large families occur in Yazd and Kerman. The probable reason is that these people adhere more strongly to traditional religious values than in Tehran.

The cost of living in Tehran is high and the increased frequencies of small family size in Tehran reflects a growing desire on the part of the Zoroastrians to have a higher standard of living. Unless the income is large enough to allow an adequate standard of living, a large family is likely to be avoided. The need to increase the family income is reflected in the number of women employed. The employment of women outside the home could account for their desire to restrict their family size. Table 7.12 presents the distribution of various occupations in which the Zoroastrians in the present study are engaged. As can be seen from the table, the percentages of students are 23.39 and 23.31 for boys and girls respectively, 53.36 per cent of the males are involved in various occupations, and the corresponding figure for the females is 28.3 -these two figures include those who

have been retired, but who receive pensions from the government. 48.39 per cent of the females including the girls at the age group 0-6 stay at home, while the percentage of Zoroastrian males who are looking for a job, or those who are not able to work, is 23.25. The table also reveals that most Zoroastrian men are involved in private businesses or work for the Government.

7.8 MARITAL STATUS OF THE ZOROASTRIANS

In a study of demographic change in a population, the analysis of marital status is very important, because marriage results, in most areas, in the birth of legal offspring. Divorce and widowhood cause a breakdown in the family structure and reduce the possible number of further children in the original family. Thus, any change in the marriage rate has a direct effect on the fertility rate and consequently on population growth. Therefore, age at marriage and the proportion married are very important in any demographic study. In Iran the age of marriage is low and the proportion married is very high in the age group 15-19 for males and females (tables 7.13 and 7.14). There are many reasons for early marriage in Iran. Briefly, these are:

1. Religious factors - Islamic religious teachings have been highly conducive to marriage, particularly early marriage (Momeni 1975).
2. Economic poverty or the inability of parents to maintain daughters for a long time. This is mainly due to the fact that hitherto, girls were totally dependent on their parents prior to marriage, but in recent years this has been changing.
3. Social and political factors - on the farms and especially among many of the Iranian tribes and minority groups, the people betroth their children in childhood, which has both

social and political consequences; it creates friendship bondages and primary social relationships between the families involved.

4. Traditional factors - according to Kirk (1965), these factors affect the institution of marriage in the Islamic nations such as Iran. In general, the Iranian men put great emphasis on virginity and, thus, are inclined to marry very young girls.

The average age at marriage among the Zoroastrians of Iran is not available but the percentage of married females and males in the different age groups of the present study is given in table 7.15. The percentage of married Parsis in India in 1931 is presented in table 7.16. According to Sekar (1948), in 1901 24 per cent of the women in the age group 15-19 years were married, whereas in 1931 the corresponding figure was 18 per cent. In the age group 20-24 the proportion of married women was reduced from 55 in 1901, to 35 per cent in 1931. Even in the age groups 25-29 and 30-34, the percentage of married women was lower in 1931 than in 1901. Sekar also reported on the percentage of married males. In 1901, nearly 25 per cent of the males in the age groups 20-24 were married, and in 1931 the figure was 14 per cent. In the age groups 30-34 the proportion of married men was 70 and in 1931 it was 58 per cent.

In the present study, only 8 per cent of the females in the age groups of 15-19 were married; this figure is very low compared with those of the Parsis in 1931, and the Iranian population in 1956 and 1966. The percentages of married females increases from 42 per cent in the age groups 20-24, to 85 per cent in the age groups25-29 and to 91.8 per cent in the age groups 30-34. The

proportion of married women for Iran, in 1956, was 91 per cent in the age groups 25-34, and 94.7 per cent in the age groups 30-34 in 1966. The age at which men marry does not have such a strong influence on the reproductive capacity of the community as it does in the case of women. It also reflects strongly the social attitude towards married life. Table 7.15 gives the percentage of married males in the different age groups in the present study. In the age groups 15-19 only 1.6 per cent of the males are married, which is lower than those of the Parsis in 1931 and the Iranian population in 1956 and 1966. The proportion of married men in the age groups 20-24 is 11.5, and for the age groups 25-29 the value is 68.75, which is lower than the values for the Iranians in both 1956 and 1966, but higher than those of the Parsis in 1931. The highest percentage for married males is in the age groups 40-44 (84.3), which is still lower than the corresponding figure for Iran in 1966. In the present investigation 297 families were interviewed and their marital status is shown in tables 7.17 to 7.18. According to the tables, of the total of 111 Tehran married females, 75 women married Tehran males, 31 Yazd males and only 5 females married Kerman men. Of the 116 Yazd married women, 46 marriages occurred with Tehran males, 63 with Yazd and 7 Kerman males, and of the 70 Kerman married females, 19 married Tehran males, 20 married Yazd males and 31 married Kerman males.

67.5 per cent of Tehran females preferred to marry Tehran males and only 4.5 per cent of them married Kerman males. 54.3 per cent of the Yazd females married Yazd males and 6 per cent married Kerman men, and 44 per cent of the Kerman females married within Kerman, 27 per cent to Tehran and 28.5 per cent married to Yazd. According to the above figures most of the females show a

preference for Tehran males.

In old Zoroastrian families it was the custom for a husband to bring his wife to live among his own paternal kinsmen. This generally meant living in the same household or compound as his father and married brothers, but in some cases it may just have involved residing in the same city. So the wife is removed from a close association her family to live among her husband's relatives which may have been previously unknown to her. Most contemporary Zoroastrian married men prefer to set up independent households.

Young Zoroastrian men, seeking employment or better jobs have migrated to Tehran, after leaving their parents behind. They delay marriage until after they complete their education or military service, and also the high costs of arranging a marriage, including gifts for the bride and in some cases for her parents, expenses for the wedding ceremonies, and the marriage payment, can be the reason for the delaying marriage or/and decline in the number of early marriages. Most of the young Zoroastrian men from Yazd and Kerman who came to Tehran, after finding a job, and making reasonable income, usually marry Tehran Zoroastrian females.

Table 7.19 shows the percentage of the three types of first cousin marriages. Type I is the marriage between children of two brothers, type II is the marriage between children of a brother and his sister, and type III indicates marriages between the children of two sisters in the Zoroastrians of Tehran, Yazd and Kerman in the present study. It is interesting to note that in these three groups, all the three types of first cousin marriages are common, but the rate of marriages are significantly different.

The total percentage of first cousin marriages for the Tehran Zoroastrians is 13.51, and the Kerman Zoroastrians with 20.0 per cent have the highest frequency. Among the three types of first cousin marriage,type II, which is related to the marriage between children of a brother and his sister, is more common in the Zoroastrians of Iran. The table also reveals that the frequency of first cousin marriages in the Zoroastrians of Tehran is less than those of the Zoroastrians of Yazd and Kerman. Comparing the results of the present study with that of the Parsis reported by Sanghvi et al (1956), the Parsis have a frequency of first cousin marriage of 13.5 per cent which is lower than the value for the Zoroastrians of Iran (17.17). According to Sanghvi et al (1956), the rate of first cousin marriages in the Parsis' population decreased from 28.7 per cent during 1901-1930, to 13.5 per cent in 1955, indicating that the last generation showed almost half the rate found in the previous generation in this century.

According to Moezi (1967), endogamy is relatively high in rural and tribal areas in Iran; the reasons he has given, were:

a) Geographical and communication factors: long distances and transportation difficulties between villages.
b) Economic and political factors: endogamy is common, because family relationships will be strengthened by such marriages.
c) Traditional and religious factors: religious orders and as well as customs and traditions encourage marriages between close relatives.

He pointed out that it would be expected that the socio-economic changes of recent years would bring about a decline in endogamy. The rate of endogamous marriages in rural areas of Iran was 33.0 per cent (Moezi 1967), which is higher than the

figure for the Zoroastrians of Iran (17.17). Moezi (1967) also indicated that in recent years the percentage of cousin marriages declined from 33.0 per cent to 22.0 per cent and this decline of 11.0 per cent indicates an increasing trend toward exogamy.

Table 7.20 presents the frequency of Consanguineous marriages in the present study. The rates of Consanguineous marriage in the three groups of Zoroastrians varied from 14.4 to 27.0 per cent. The frequency is low in the Tehran Zoroastrians. The two groups of the Zoroastrians (Yazd and Kerman), practise high rates of Consanguineous marriages, Yazd 22.4 and Kerman 27.14.

The rate of first cousin marriages once removed in the Zoroastrians of Tehran is 0.9; the rate is high in the Zoroastrians of Yazd (2.59), and even higher in the Kerman. The frequency of second cousin marriages in the Zoroastrians of Yazd is 0.86, and 2.85 in Kerman. Second cousin marriages seems to be uncommon in the Tehran Zoroastrians.

In contrast to the report of Sanghvi et al (1956), the Parsis showed a rate of 18 per cent of Consanguineous marriages, which is lower than the value for the Zoroastrians of Iran (total), of 20.54 (table 7.20).

The coefficient of inbreeding was calculated for first cousin and other kinds of Consanguineous marriages. The average inbreeding coefficient (Fa), for each group of the Zoroastrians and for the total samples were calculated and are presented in table 7.21.

The coefficient of first cousin marriages in all three groups of Zoroastrians and for the total samples are significantly higher than those of the other kinds (first cousin once removed and second

cousin) of related marriages. The values of the coefficient inbreeding (F), and the mean coefficient (Fa), in the Zoroastrians of Tehran are much lower than those of the Zoroastrians of Yazd and Kerman.

Comparing the present results with the Parsis of India reported by Sanghvi et al (1956), the coefficient of inbreeding in the first cousin marriages is lower than the value for other sorts of related marriages. The average coefficient of inbreeding in the Parsis was 0.019. In another report, Sanghvi (1966) he gave a coefficient value of 0.01 for the Parsis, which shows a decline in inbreeding among them. These two values of 0.01 and 0.019 are in the ranges of the present study (0.011 to 0.021).

7.9 INFANT MORTALITY

No completely reliable mortality data are available for the Zoroastrians or even Iran as a whole. Therefore, no data has been found for the purpose of comparison. According to Momeni (1975), due to better sanitation and significantly better medical care, infant mortality in Tehran is much lower than in any other part of the country. Since 1956 infant and child mortality and old-age mortality have been substantially reduced in Iran in general, and in Tehran in particular. Infants being most sensitive to adverse environmental factors, the infant mortality rate is a good index of the health conditions in a population.

The Parsi infant mortality rates for the year 1925 was over 150 per 1,000 live births; in 1940 the rate was reduced to 95 and in 1944 the infant mortality rate was reduced to 68 per 1,000 live births (Sekar 1948).

The infant mortality rate in the present study is given in table 7.22. According to this table, 76 out of 111 Zoroastrian women in Tehran have given birth to 157 children, of whom 11 died at birth. 220 children were born to 91 Zoroastrian females in Yazd and 201 of them survived. The number of surviving children from 59 Zoroastrian women from Kerman was 123 and the number dead was 15. According to this table, the death rates in these three groups are 7.0 for the Zoroastrians of Tehran, 8.6 and 11.0 per cent for the Zoroastrians of Yazd and Kerman respectively.

There were 9 miscarriages reported for Zoroastrian women in Iran, of whom 4 occurred in Tehran, 2 in Yazd and 3 in Kerman, but the duration of the pregnancy when the miscarriages occurred was not given. Figures are not available for abortions.

Table 7.23 shows the rates of infant mortality in the Consangouineous and unrelated marriages in the present study. It can be seen that the mortality in the Consanguineous marriages is significantly higher than that in the unrelated marriages. Comparing the rates of mortality in the Consanguineous with those of unrelated marriages in the present study, the percentages for Consanguineous marriages for the Zoroastrians of Tehran, Yazd and Kerman are much higher than those of the corresponding figures for the unrelated marriages. Again, Kerman with a mortality frequency for unrelated marriages of 9.4 has the highest value in the three groups of Zoroastrians. Regarding the infant mortality, the chi-squared test shows significant difference between the Consanguineous and unrelated marriages in the Zoroastrians of Iran, $\chi^2_1 = 4.52$, $P < 0.05$. Comparing these results with those of infant mortality in France and Japan (Sanghvi 1966b and 1973), the frequencies of mortality in the Consanguineous marriages (first cousin only),

in France was 8.86 per cent and 6.57 in Japan, whereas in the unrelated marriages the values were 4.54 and 4.66 respectively. The rates of mortality in the inbred and unrelated Zoroastrians are much higher than those reported by Sanghvi (1966b and 1973) for France and Japan. The percentage of mortality in the Consanguineous marriages in the Kerman Zoroastrians is much higher than those of the Zoroastrians of Yazd and Tehran, the data being pooled giving a value of 12.9 which is higher than those frequencies reported for France and Japan.

CONCLUSION

There are today about 30,000 Zoroastrians, in a country of nearly 36 million people, who trace their ancestry over a period of more than 2,500 years, that is from the Achemenian period. The Zoroastrians are now divided into three major groups, living in different geographical parts of Iran, namely, Tehran, Yazd and Kerman. They have remained isolated and endogamous in Yazd and Kerman and in recent centuries nearly one third of them have migrated gradually to Tehran. Therefore, the Zoroastrians of Tehran are descendants of those who have lived in Yazd and Kerman for centuries. The Zoroastrian number has increased by 31.2 per cent, whereas the corresponding figure for the Iranians proper is 32.3 per cent.

One of the most outstanding characteristics, so often cited in the literature, is the very low age of marriage of Iranian, including Zoroastrian women (Jackson 1928, Kirk 1965 and Momeni 1975). Ages of 16, 15 and some times even 14 years are referred to as 'a girl's age at marriage'. However, the data presented in this study, as shown in table 7.15, reveals that, although the majority of women are married by the time that they reach 34 years and the men by 40 years of age, 50% of all married women, do not marry until they are between the ages of 24 and 34 years of age, which is significantly higher than the 'girl's age at marriage' referred to above. In comparing the Iran women as a whole with the Zoroastrian women, (see tables 7.14 and 7.15) a marked contrast is seen between the two groups. By the age of 24 years, 85% of all Iranian women are married compared with only 42% of Zoroastrian women.

An increase in the age at marriage diminishes the number of years left for child bearing and may, therefore, serve as a means for

lowering the birth rate. The Zoroastrians delay their marriages to a more advanced age, which could account for the marked reduction in the fertility of their women. On the other hand the main justification for having a small family may be one of economic stringency. Although the economic position of the Zoroastrian community remains a subject for further study, the occupations undertaken by them in 1980 is shown in table 7.12.

Social values do not remain static. The age at marriages, proportion married at a young age, the strength of marital bonds, the keeness for family life, and desired family size are determined from time to time by both economic and social factors and are difficult to prophesy. Comparison of the 1956 figures with those of 1966 show a significant difference in the sex ratio; in 1966 the number of males increased, as compared with 1956, and if the 1966 figure is compared with that of the present study, there is again an increase in the number of males over females. Before 1956 many Zoroastrian males emigrated mostly to India, to seek work, but in the next decade because of better opportunities for employment in Iran this was greatly reduced and this trend has continued.

The evidence regarding fertility of the Zoroastrians indicates that the fertility ratio 35% for the present study is small, when compared with Iranian and Algerian Moslems (63.1), the United States (42.3), the Hutterites (69.9), and the Papago with a fertility ratio of 51.7. Infant mortality among the Zoroastrians ranges from 7 to 11%, when comparing it with other countries given by United Nations in 1967, cited by De Jong (1972), South and Central Asia is seen to range from 5.6 to 14.2%, the South West Asia 2.5 to 16.1% and 1.2 to 8.6 % in European countries.

It can be seen that the Zoroastrians are within the range for the Asian figures and higher than those of European countries. It is difficult to decide if this is a biological problem, since there is no other data available on the infant and child mortalities of the Zoroastrian populations. Comparing the three groups of the Zoroastrians from Tehran, Yazd and Kerman, the frequency of infant mortality in the Kerman Zoroastrians was much higher than those of the Tehran and Yazd. The occurrence of marriage between relatives among the Zoroastrians has been known for a long time but data presented in this study is the first attempt to provide some information for this community. Since they are restricted from marrying outsiders, they can not be very strict about Consanguinity, especially as their numbers are limited.

The identification of spouse relationship in this study was based on information obtained by interviewing Zoroastrians. This included obtaining the names of the husband, his wife and their parents. Thus, it was possible to trace the different degrees of Consanguinity.

A comparison between cousin marriages in the Zoroastrians of Tehran, Yazd and Kerman showed a higher percentage of first cousin marriages in the Zoroastrians of Kerman. There was also a higher percentage of Consanguineous marriages in addition to first cousins, than in those of the Tehran and Yazd Zoroastrians. The coefficient of inbreeding among the Zoroastrians was high and varied from 0.011 to 0.021. In all those groups first cousin marriages were of all the possible types. The rate of mortality was increased in the offspring of Consanguineous marriages as compared with those of unrelated parents. The present investigation,

however, gave very limited scope for a comparison. Populations such as the Zoroastrians, whose levels of inbreeding are very high, and where this custom has been prevalent for more than two thousand years, present a very complex situation. The effect of inbreeding on morbidity and early mortality have been pointed out by several investigators (Sanghvi 1966b, Cavalli-Sforza, and Bodmer 1971, Sanghvi 1973 and Bodmer and Cavalli-Sforza 1976). Consanguineous marriages reduce the frequency of heterozygotes in the population and distribute them to the two homozygotes. If the frequency of two alleles at a locus is equal, inbreeding has equal effect on both homozygotes. This balance progressively changes as the frequency of one of the alleles gets smaller and smaller. The inbreeding effect is most pronounced on homozygotes which are determined by very rare genes. In a population where inbreeding is high and the gene pool contains certain recessive genes, a number of individuals may be affected by recessive disorders which are rarely found in large populations.

Information concerning the occurrence and degree of Consanguineous marriages in the Zoroastrian population was not available before the present investigation. Whether the rate of Consanguineous marriages in this population is increasing or decreasing is a matter for further study.

According to an eminent authority on the Zoroastrians (Shahmirzadi), after 1966 a large group of Iranis (recent Zoroastrians who migrated to India), arrived in Iran, where they found permanent homes; since then they have been marrying other Zoroastrians of Iran as there are no restrictions. A general increase in the total number of Zoroastrians in 1966 may be explained by these immigrations.

Consanguineous marriages and genetic drift are similarly affected by common factors, population size and migration (Cavalli-Sforza and Bodmer 1971). A small population encourages Consanguineous marriage because after a few generations most prospective marriage partners will also be relatives. Immigration, on the other hand, tends to decrease the frequency of Consanguineous marriage by introducing new partners who are not relatives.

Before comparing the results for the genetic and demographic studies, it is necessary to point out that in the serology survey blood specimens were taken only from one third of the total sample.

It is interesting to consider the evidence presented by the demographic studies. The relationship between cultural and genetic inheritance has been discussed by Cavalli-Sforza and Feldman (1973), who suggested that 'cultural diffusion' from parent to child may show a great resemblance to biological inheritance. Analysis of demographic data has shown that cultural differences exist between the Zoroastrian populations, especially in age at marriage and family size. The results of this survey of contemporary demographic data suggests evidence of a break down of this cultural diffusion in the Zoroastrians of Tehran. The results of the genetic studies support the evidence shown by the demographic data which suggests that the genetic pool of the Tehran Zoroastrians differs slightly from those of the Yazd and Kerman Zoroastrians, as does the cultural pool.

The genetic evidence suggests that possibly all the present day Zoroastrians have the same origin. Historical events caused these people to separate and new communities were formed. Factors such as mortality, morbidity at different age groups, uncommon diseases, fertility and Consanguineous marriages may have been

selective agents in the past and may have shaped many of the differences we can observe today. For the Zoroastrian population to survive and increase its numbers, its reproductive rate must be increased and more children reach physical maturity and procreate. The average age at marriage is high and the family size is small. If an increase in family size without a corresponding increase in family income occurs, this will, no doubt, be detrimental to the health of the community. It is for the Zoroastrians themselves to formulate social and population policies to encourage intermarriage between different unrelated Zoroastrians. The difficulties in formulating conclusions from the material collected in this study are primarily the lack of previous data for the Zoroastrians - in particular there are no figures available for infant mortality and morbidity at different ages; confirmed figures for miscarriages and still births; the incidence of congenital diseases, and male and female fertility. Insufficient data is published on family attitudes to the number of desired offspring or even birth control. This leads on conveniently to the consideration of possible further research.

Obviously, one possibility would be to add to the samples already collected and investigation of the traits, already indicated, on a larger scale. Another useful approach would be to investigate abnormal and common diseases in this population which might be due to inbreeding.

One of the most common inborn errors of metabolism is the deficiency of the enzyme 21-hydroxylase from the adrenal cortex, occurring in 1 in 10,000 births. The incidence is increased in the offspring of Consanguineous marriages and more than one sib may be affected (Passmore et al 1974). In the salt-losing form

of the 21-hydroxylase deficiency, hypotension and water and salt depletion occur soon after birth. It would be interesting to see whether there is any adaptation with the environment (desert areas, high temperature, large amount of salt and lack of water), where they have lived for centuries.

In a period when rapid changes are occurring in the world due to social and economic conditions, it is important to study minor population groups, such as the Zoroastrians, before they become indistinguishable from the major populations of their respective countries.

TABLE 7-1 The distribution of Zoroastrian Populations in Iran by Sex in 1956

Group	Both Sexes	Male	Female
Tehran	4846	2596	2250
Yazd	6064	2642	3422
Kerman	1857	837	1020
Other Cities	3233	1557	1676
Total	16000	7632	8368

Source of information: Iranian Census 1956.

TABLE 7.2 TOTAL ZOROASTRIAN POPULATIONS IN IRAN BY SEX AND AGE IN 1966.

Age Groups	Male	%	Female	%	Both Sexes	%
0 - 4	887	8.18	822	7.79	1709	7.98
5 - 9	999	9.21	944	8.94	1943	9.08
10 - 14	1149	10.59	1100	10.42	2249	10.51
15 - 19	1018	9.39	999	9.46	2017	9.43
20 - 24	922	8.50	986	9.34	1908	8.92
25 - 29	790	7.28	788	7.46	1578	7.37
30 - 34	746	6.88	722	6.84	1468	6.86
35 - 39	598	5.51	572	5.42	1170	5.47
40 - 44	817	7.53	789	7.48	1606	7.51
45 - 49	633	5.85	664	6.29	1297	6.06
50 - 54	662	6.11	605	5.73	1267	5.92
55 - 59	463	4.27	432	4.1	895	4.18
60 - 64	278	2.56	366	3.47	644	3.01
65 and over	883	8.14	766	7.26	1649	7.70
TOTAL	10845		10555		21400	

Source of information : Iranian Census 1966

TABLE 7.3 ZOROASTRIAN POPULATIONS IN TEHRAN BY AGE AND SEXES IN 1966.

Age Groups	Male	%	Female	%	Both Sexes	%
0 - 4	419	9.22	492	10.34	911	9.79
5 - 9	512	11.27	496	10.42	1008	10.84
10 - 14	451	9.93	453	9.52	904	9.72
15 - 19	405	8.91	446	9.37	815	9.16
20 - 24	354	7.79	444	9.33	798	8.58
25 - 29	326	7.18	372	7.82	698	7.51
30 - 34	378	8.32	388	8.15	766	8.23
35 - 39	399	8.78	344	7.24	743	7.99
40 - 44	342	7.53	311	6.53	653	7.03
45 - 49	267	5.88	214	4.50	481	5.17
50 - 54	161	3.54	229	4.81	390	4.19
55 - 59	109	2.40	132	2.77	241	2.59
60 - 64	138	3.04	162	3.40	300	3.22
65 and over	282	6.21	276	5.80	558	6.0
TOTAL	4543		4759		9302	

Source of information : Iranian Census 1966

TABLE 7.4 ZOROASTRIAN POPULATIONS OF YAZD BY AGE AND SEXES IN 1966

Age Groups	Male	%	Female	%	Both Sexes	%
0 - 4	213	9.22	206	7.86	419	8.49
5 - 9	277	11.98	270	10.30	547	11.09
10 - 14	333	14.41	311	11.86	644	13.05
15 - 19	272	11.76	256	9.77	528	10.7
20 - 24	106	4.58	168	6.42	274	5.55
25 - 29	77	3.33	122	4.66	199	4.04
30 - 34	106	4.58	157	5.99	263	5.33
35 - 39	71	3.07	165	6.29	236	4.78
40 - 44	133	5.75	173	6.61	306	6.21
45 - 49	121	5.24	145	5.53	266	5.39
50 - 54	99	4.28	187	7.13	286	5.81
55 - 59	69	2.98	102	3.89	171	3.47
60 - 64	139	6.02	129	4.92	268	5.43
65 and over	296	12.8	230	8.77	526	10.66
TOTAL	2312		2621		4933	

Source of information : Iranian Census 1966

TABLE 7.5 ZOROASTRIAN POPULATIONS OF KERMAN BY AGE AND SEXES IN 1966

Age Groups	Male	%	Female	%	Both Sexes	%
0 - 4	63	9.25	71	9.49	134	9.38
5 - 9	80	11.75	74	9.89	154	10.78
10 - 14	92	13.51	91	12.16	183	12.81
15 - 19	61	8.96	58	7.76	119	8.32
20 - 24	34	4.99	37	4.94	71	4.97
25 - 29	28	4.11	33	4.41	61	4.27
30 - 34	32	4.7	51	6.82	83	5.80
35 - 39	47	6.90	62	8.29	109	7.63
40 - 44	45	6.61	62	8.29	107	7.48
45 - 49	48	7.05	51	6.82	99	6.93
50 - 54	32	4.7	40	5.36	72	5.04
55 - 59	22	3.23	32	4.28	54	3.78
60 - 64	37	5.43	26	3.47	63	4.41
65 and over	60	8.81	60	8.02	120	8.40
TOTAL	681		748		1429	

Source of information : Iranian Census 1966

TABLE 7.6 POPULATION OF IRAN BY AGE AND SEX IN 1956 (Per cent)

Age groups	Male	Female	Both Sexes
0 - 4	17.5	17.8	17.7
5 - 9	14.7	15.1	14.9
10 - 14	10.1	9.1	9.6
15 - 19	7.4	7.6	7.5
20 - 24	7.3	8.6	7.9
25 - 29	7.7	8.4	8.0
30 - 34	7.3	7.3	7.3
35 - 39	6.0	5.4	5.7
40 - 44	5.0	4.1	4.6
45 - 49	4.2	4.0	4.1
50 - 54	3.5	3.5	3.5
55 - 59	3.0	2.8	2.9
60 - 64	2.4	2.2	2.3
65 and over	4.1	3.8	3.9

Total Population 19,954,704.

Sources: 1956 Iranian Census Volume 1.

TABLE 7.7 POPULATION OF IRAN BY AGE AND SEX IN 1966 (Per Cent)

Age Groups	Male	Female	Both Sexes
0 - 4	17.8	17.6	17.7
5 - 9	16.4	16.4	16.4
10 - 14	12.3	11.8	12.0
15 - 19	8.2	8.8	8.5
20 - 24	6.1	7.4	6.7
25 - 29	6.2	7.0	6.6
30 - 34	6.7	6.7	6.7
35 - 39	5.9	5.4	5.7
40 - 44	5.7	4.8	5.3
45 - 49	3.7	3.0	3.4
50 - 54	2.9	3.1	3.0
55 - 59	1.7	1.7	1.7
60 - 64	2.7	2.7	2.7
65 and over	4.0	3.7	3.9

Total Population 25,078,923.

Sources: 1966 Iranian Census Volume 168.

TABLE 7.8 THE PERCENTAGE OF PARSI POPULATION IN THE VARIOUS AGE GROUPS IN INDIA FROM 1901 to 1931

Age Groups	1901	1911	1921	1931
0 - 4	9.5	8.8	7.9	8.5
5 - 14	22.5	20.0	19.2	18.7
15 - 44	50.0	52.0	51.3	50.6
46 - 59	12.0	12.7	14.4	15.2
60 +	6.0	6.8	7.2	7.0

Source: C. C. Sekar 1948

TABLE 7.9 ZOROASTRIAN POPULATIONS IN THE PRESENT STUDY BY AGE AND SEXES

Age Groups	Male	%	Female	%	Both Sexes	%
0 - 4	52	7.28	68	9.97	120	8.60
5 - 9	69	9.66	73	10.7	142	10.17
10 - 14	80	11.21	75	11.0	155	11.10
15 - 19	63	8.82	62	9.09	125	8.95
20 - 24	61	8.54	50	7.33	111	7.95
25 - 29	64	8.96	57	8.36	121	8.67
30 - 34	57	7.98	49	7.18	106	7.59
35 - 39	55	7.71	48	7.04	103	7.38
40 - 44	51	7.14	40	5.87	91	6.52
45 - 49	50	7.0	40	5.87	90	6.45
50 - 54	46	6.44	37	5.42	83	5.95
55 - 59	35	4.90	43	6.30	78	5.59
60 - 64	18	2.52	22	3.23	40	2.86
65 - 69	11	1.55	15	2.20	26	1.86
70 and over	2	0.29	3	0.44	5	0.36
TOTAL	714		682		1396	

TABLE 7.10 DISTRIBUTION OF ZOROASTRIAN RESIDENTS (PRESENT STUDY) OF TEHRAN, YAZD AND KERMAN ACCORDING TO THEIR BIRTH PLACES.

RESIDENCE	TOTAL	Place of Birth			
		Tehran	Yazd	Kerman	Other Places
Tehran	605	439	91	63	12
Yazd	498	64	385	41	8
Kerman	293	25	83	176	9

TABLE 7.11 SIZE OF FAMILY IN THE ZOROASTRIANS OF IRAN (Present Study)

GROUP	NO. COUPLES	NO CHILD	ONE CHILD	TWO CHILDREN	THREE CHILDREN	FOUR CHILDREN	INDIVIDUALS	TOTAL NUMBER
Tehran	111	35	29	26	19	2	237	605
		31.5%	26.1%	23.5%	14.1%	1.8%		
Yazd	116	25	27	25	32	7	65	498
		21.5%	23.3%	21.5%	27.6%	6.1%		
Kerman	70	11	22	16	15	6	30	293
		15.7%	31.4%	22.8%	21.5%	8.6%		

TABLE 7.12 THE NUMBER OF ZOROASTRIANS INVOLVED IN THE VARIOUS OCCUPATIONS IN IRAN (Present Study)

Occupation	Males		Females		Both Sexes	
	N	%	N	%	N	%
Students	167	23.39	159	23.31	326	23.35
Government Employees	124	17.36	72	10.56	196	14.0
Lawyers	3	0.42	---	-----	3	0.21
Doctors	5	0.70	1	0.15	6	0.43
Army Officers	5	0.70	---	----	5	0.36
Gardeners	21	2.94	---	----	21	1.50
Private Businesses	172	24.1	---	-----	172	12.32
Traders	2	0.28	---	----	2	0.14
Manufacturers	1	0.14	---	----	1	0.07
Engineers	9	1.26	1	0.15	10	0.72
Private Jobs	11	3.92	95	13.93	106	7.59
Retired	28	1.54	7	1.03	35	2.51
Nurses	---	-----	17	2.49	17	1.21
Total Population	714		682		1396	

TABLE 7.13 MARITAL STATUS BY AGE OF THE MALE AND FEMALE POPULATIONS 15 YEARS OF AGE AND OVER FOR IRAN IN 1956.

Age	Married Males	Married Females
15 - 19	6.2	40.0
20 - 24	31.4	82.1
25 - 34	76.6	91.0
35 - 44	91.8	87.7
45 - 54	92.1	69.2
55 - 64	89.8	46.9
65 and over	81.0	26.2
Not reported	41.0	54.6

Source : Momeni 1975

TABLE 7.14 MARITAL STATUS BY AGE OF THE MALE AND FEMALE POPULATIONS 15 YEARS OF AGE AND OVER FOR IRAN AS A WHOLE IN 1966.

Age	Married Males	Married Females
15 - 19	4.2	44.9
20 - 24	30.1	84.8
25 - 29	71.7	94.0
30 - 34	89.5	94.7
35 - 39	94.4	93.2
40 - 44	95.7	88.1
45 - 49	95.7	81.4
50 - 54	94.0	67.1
55 - 59	93.9	61.6
60 - 64	91.4	42.4
65 and over	85.5	26.4

Source : Momeni 1975

TABLE 7.15 MARITAL STATUS BY AGE AND SEXES OF THE ZOROASTRIANS OF IRAN (PRESENT STUDY) 15 YEARS OF AGE AND OVER.

Age	Married Males N	%	Married Females N	%
15 - 19	1	1.59	5	8.06
20 - 24	7	11.47	21	42.0
25 - 29	44	68.75	49	85.96
30 - 34	46	80.70	45	91.8
35 - 39	45	81.82	42	87.5
40 - 44	43	84.31	32	80.0
45 - 49	41	82.0	30	75.0
50 - 54	35	76.08	27	72.97
55 - 59	27	77.14	30	69.76
60 - 64	5	27.77	11	50.0
65 and over	3	23.1	5	27.7
TOTAL	297		297	

TABLE 7.16 THE PERCENTAGE OF MARRIED FEMALE AND MALES OF THE PARSIS OF INDIA 1931.

Age group	Females	Males
15 - 19	18.0	7.0
20 - 24	35.0	14.0
25 - 29	66.0	43.0
30 - 34	72.0	58.0
35 - 44	74.0	78.0
45 +	49.0	——

Source of information; C.C. Sekar 1948.

TABLE 7.19 FREQUENCY (IN%) OF THE THREE TYPES OF FIRST COUSIN MARRIAGE IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY).

Group	Total No. of Marriages	Type I	Type II	Type III	Total of Types I-III
Tehran	111	5 4.5	7 6.31	3 2.7	15 13.51
Yazd	116	5 4.3	11 9.48	6 5.17	22 18.95
Kerman	70	4 5.71	6 8.57	4 5.71	14 20.0
Total	297	14 4.71	24 8.08	13 4.38	51 17.17

TABLE 7.20 FREQUENCY (IN %) OF THE CONSANGUINEOUS MARRIAGES IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY), AND THE PARSIS OF INDIA FOR COMPARISON.

Groups	Total No. of Marriages	First Cousins	First Cousin once Removed	Second Cousin	Total Cousin Marriages
Tehran	111	15 13.51	1 0.9	---	16 14.41
Yazd	116	22 18.95	3 2.59	1 0.86	26 22.4
Kerman	70	14 20.0	3 4.28	2 2.85	19 27.14
Parsis	578	78 13.5	16 2.8	10 1.7	109 18.0

TABLE 7.17 GEOGRAPHICAL DISTRIBUTION OF MARITAL STATUS OF THE ZOROASTRIANS OF IRAN IN THE PRESENT STUDY.

Place / Sex	Tehran Male	Yazd Male	Kerman Male	Total Females
Tehran Female	75 (25.25%)	31 (10.44%)	5 1.68%	111
Yazd Female	46 15.49%	63 21.21	7 2.35	116
Kerman Female	19 6.40%	20 6.74	31 10.43	70
Total Males	140	114	43	297

TABLE 7.18 GEOGRAPHICAL DISTRIBUTION OF MARITAL STATUS OF THE ZOROASTRIANS OF IRAN MARRYING WITHIN THE COMMUNITY.

Place / Sex	Tehran Male	Yazd Male	Kerman Male	Total Females
Tehran Female	75 67.57	31 27.93	5 4.50	111 100.0
Yazd Female	46 39.66	63 54.31	7 6.03	116 100.0
Kerman Female	19 27.14	20 28.57	31 44.29	70 100.0

TABLE 7.21 INBREEDING COEFFICIENT IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY) AND PARSIS OF INDIA FOR COMPARISON.

Groups	Number of matings	F. in First Cousin Marriages	F. in Others related Marriages	Average Inbreeding Coefficient (Fa)
Tehran	111	0.0084	0.0028	0.011
Yazd	116	0.012	0.0093	0.021
Kerman	70	0.012	0.0058	0.018
Pooled data	297	0.011	0.006	0.017
Parsis of India	578	0.0084	0.11	0.019

TABLE 7.22 INFANT MORTALITY IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY)

Group	No. of Women	Total children born	No. of Surviving	No. of Dead	Mortality rate %
Tehran	76	157	146	11	7.0
Yazd	91	220	201	19	8.6
Kerman	59	138	123	15	11.0

TABLE 7.23 EFFECT OF INBREEDING ON THE INFANT MORTALITY IN THE ZOROASTRIANS OF IRAN (PRESENT STUDY) AND OTHER POPULATIONS.

Group	Consanguineous Marriages					Unrelated Marriages				
	No. Women	No. Children born	No. Children Survive	No. Dead	%	No. Women	No. Children born	No. Children Survive	No. Dead	%
Tehran	16	31	28	3	9.68	60	126	118	8	6.3
Yazd	26	74	64	10	13.5	65	148	139	9	6.1
Kerman	19	42	36	6	14.3	40	96	87	9	9.4
Pooled Data	61	147	128	19	12.9	165	368	342	26	7.0
France †	—	982	895	87	8.86	—	4010	3828	182	4.54
Japan †	—	822	768	54	6.57	—	17331	16523	808	4.66

† Quoted from Sanghvi (1966).

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