Hypotheses and Estimators for the Demographic Interpretation of the Chalcolithic Population from Mehrgarh, Pakistan
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Source: *East and West*, Vol. 39, No. 1/4 (December 1989), pp. 11-42
Published by: Istituto Italiano per l'Africa e l'Oriente (IsIAO)
Stable URL: https://www.jstor.org/stable/29756889

# Hypotheses and Estimators for the Demographic Interpretation of the Chalcolithic Population from Mehrgarh, Pakistan

by Pascal Sellier

Rather paradoxical thought processes in oriental archaeology, more especially intense as pre-urban civilizations are concerned, led a presumed 'demographic pressure' to be so much put forward that it became a hackneyed argument for many hasty explanations, whereas, all too often, the only direct reference to the populations under study, namely the skeletons, was quite ignored. Although gradually disappearing, this inexplicable disregard is still rather well illustrated by the half page dedicated to burials in the recent and voluminous publication on Jarmo (Braidwood 1983). The almost complete lack of anthropological data is so common in the treatment of cemeteries (Tobler 1950, for instance) that some authors could do nothing but stress the serious limitations thus imposed for any subsequent analysis (Forest 1983).

Not only is there never any evidence (least of all figures) given for the so much alleged demographic pressure, which means that one never gets beyond truisms and tautological reasoning, but also this often becomes a sort of myth, able to explain all the rest. At all events, I am amongst those who do not see why this should be considered as a specific causality (Hassan 1981) instead of studying interrelationships between different factors (demographic, social, economic, environmental...) or analysing structural changes. It has already been stressed that, at any rate, this 'pressure' could never have been explosive (this is a post-industrial-revolution phenomenon): a natural growth rate $t = 0.1$ or $0.2\%$ already seems definitely high to many authors (Hassan 1981: 161; Masset 1980, 1985; Oates 1980: 311-12). Anyway it is for the supporters of this demographic pressure to prove it (Oates 1980: 312), and that would not be sufficient to sustain a dynamic interpretation of a population. It should also be pointed out how much this concept refers to rather outdated Malthusian or Darwinian models (Petersen 1975: 229-30; Binford 1968: 272) now disputed by numerous demographers (Bideau 1983, for instance) who insist on the existence within populations of autoregulatory processes, sometimes even social ones (Oates 1980; Masset 1980). It is therefore necessary to turn away from these assertions and the imposing demographic pictures based on them (Hassan 1981 is a recent example) in order to go back to concrete facts.

Non-demographic approaches have nonetheless been used to try to study these phenomena according to the area of sites, the number of dwelling units and especially the population density. But we cannot ever hope to employ the accurate ethnological models (Casteel 1979; Hassan 1981) based on data that cannot be approached by archaeological methodology (caloric needs, functional areas, biomass, detailed food resources, etc.). More elementary assessments, like the population density according to the area of the site (or part of it), are usable in archaeology only at the cost of controversial hypotheses (Oates 1980: 307) and are surely not transferable from one site to another or from one region to another (Kramer 1980). In order to appreciate how unpredictable this is, it is enough to note how wide the variability of the population density can be: from 3 to 300 capita per sq.m. (Hassan 1981: 29 ff.). Kramer (1980) has drawn attention to the limits of the ethno-archaeological procedure in this field rather than to its applications, and his conclusions exhort to cautiousness; sometimes the complexity of the problems even leads to a sort of naïve presentation of data which are in no way demographic (Aurenche 1981). It will be enlightening enough to ponder over the poor correlation coefficient between the population density and the occupied area ($r = 0.62!$), calculated by Hassan (1981: 67) by making a careful selection among the only rural sites from Kramer (1980) in an already circumscribed area.

If it seems too early, or too hazardous, to deduce any precise extrapolation from this, that does not detract from the ethno-archaeological procedure which has at times given some pertinent but limited results for general population questions; however, such an approach can only indirectly treat of actual demographic parameters. It seems to me therefore, as Masset has recently sustained (Masset 1980), that basic demographic information can only be obtained from analysis of the deceased populations themselves, that is from their skeletons.

The question of palaeodemography has also caused heated debates (Bocquet & Masset 1982, 1985; Van Gerven & Armelagos 1983) and the justified prudence and pessimism expressed by these first authors on the subject should be remembered. The lack of realism in the models proposed is often striking when compared with historical data (Petersen 1975) or with standard life-tables (Ledermann 1969), besides the blind confidence of authors in some astonishing results (Angel 1969 determines the sex of all the children, including infants; Hassan 1981: 112-13, presents without comment an infant death rate of 50 per 1000 in an Epipalaeolithic population; to cite but a few instances). There was indeed cause for severe criticism of the methods and the hopes of palaeodemography but without necessarily prohibiting the use of its experiences (Bocquet & Masset 1985); that palaeodemography is not demography has merely to be known.

If some cautiousness or even some pessimism is needed, it is nevertheless true that the palaeodemographic analysis of funerary series provides data which no other source can (Masset & Parzysz 1985) and those will be even surer since hypotheses are more explicit and more fully discussed and since interpretations and estimations, as well as their margins of error, are more correctly measurable. According to skeletal analysis and through examination of a few simple data, almost exclusively limited to the age of the immature individuals (non-adults) and to elementary archaeological information, we would like to show, from the graveyard of the Mehrgarh Chalcolithic site (MR2), that it is possible to define a working framework rigorous enough to control each of its stages and to open up new perspectives for research and discussion by proposing some demographic estimates.

## The Chalcolithic Cemetery of Mehrgarh

### *Period III and Site MR2*

The archaeological site of Mehrgarh, in Pakistani Baluchistan, represents a particularly long chronological sequence, from the 7th to the 3rd millennium B.C., which has been divided into seven main periods, from the pre-ceramic Neolithic to the Bronze Age (Jarrige & Lechevallier 1979; Jarrige 1985). The MR2 zone is the largest area extending over about 75 hectares and corresponds to period III, the Chalcolithic one, dating from the end of the 5th millennium to the beginning of the 4th millennium B.C. (Jarrige 1981, 1984; Samzun 1988). A total area of about 3000 sq.m., divided into several sectors, has been excavated and different types of remains have been exposed: mud-brick buildings (dwelling and storage units), specialized craftsmanship areas and a cemetery, accidentally discovered in 1982, which has been subjected to two excavation campaigns and has already been presented (Samzun & Sellier 1983, 1985).

The 3rd period belongs to the general framework of a farming society (agriculture and animal husbandry) also showing, compared with the earlier periods, important changes in its techno-economic status: mass production of pottery (mainly wheel-turned), metallurgy, bow-drill technique and diversification of agriculture (Samzun 1988; Jarrige 1981, 1984). In view of those innovations and also of the great extent of the site and the existence of large storage buildings, the archaeological hypothesis is that of an extensive population undergoing a process of fairly continuous demographic growth (Jarrige 1985). This outlines very briefly the scope of the Chalcolithic phase to which the MR2 graveyard belongs (the only cemetery discovered in this area apart from a few isolated burials).

### *The MR2 Graveyard*

To the west of the S1C and R5J buildings, it has been possible to excavate an area of about 144 sq.m., covering three distinct zones (fig. 1), which yielded a total of 99 individuals. This does not represent the total number of individuals in this area as it could not be thoroughly excavated (cf. *infra*).

The general characteristics of this cemetery, as far as the burial practices and the grave goods are concerned, having already been described (Samzun & Sellier 1983, 1985), we shall only refer to them briefly. Out of the 99 individuals, 84 are in strict anatomical connection while 15 of them are totally dislocated skeletons or only portions of skeleton. Those 15 examples represent genuine secondary burials (re-inhumations: Duday & Sellier 1990) with even, at times, a gathering of the bones into bundles (fig. 6, no. 51) or a handling of the corpses, such as cranium no. 72 whose face is nested inside the two parietal bones that are fitted into each other (fig. 7). In general, the individuals in anatomical connection are laid in a standard position and orientation (fig. 5 and 6): east-west, skull eastwards, in left lateral decubitus, with the lower limbs flexed or hyperflexed (fig. 5). Most of the bodies (2/3) are buried individually while the others are generally placed in pairs; in this case, they are simultaneous inhumations and very often at least one of them is a secondary burial. Two cases are unusual: the association of four specimens (two complete and connected, no. 24A and no. 25A, plus two cranial fragments, no. 24B and no. 25B) and a multiple burial (northern corner of square S1A), only a portion of which could be excavated, equivalent to a quadrant, and containing so far six connected skeletons (figs. 2, 3 and 4). The grave goods (when present) are very stereotyped, being only ornaments of white steatite beads with, occasionally, beads or pendants made of semi-precious stone, apart from three deposits: one copper/bronze compartmented seal and two pottery vessels.

### *General Perspectives and Overview*

The biological information gathered from these 99 humans remains will form the basis of the analysis together with other related archaeological data about the distribution of the burials within the three excavated sectors (fig. 1): central sector (fig. 2), north-eastern sector (fig. 3) and southern sector (fig. 4). Our argument (schematized in table 6) can be broken up into different steps so that each new inference (with the relevant discussion) depends on one or several hypotheses as well as on some of the previous deductions. It is therefore a sequenced and hierarchically organized system which proceeds by successive accumulations. At the end of our analysis we shall recapitulate the main hypotheses. Starting from crude descriptive or quantitative data, we first propose to estimate the sex ratio of the adults and the age distribution among the non-adults; this will be discussed in order to propose the identification of some codification in the funerary practices (correlations with grave goods and burial customs) together with the detection of an important bias within the non-adult sample (age group of the newborn and very young children) and its interpretation. The second stage, the central one, estimates some of the essential demographic parameters and this leads to a quantification of the under-representation of the youngest age-group of the children, thus allowing to calculate corrected figures; these will ultimately serve

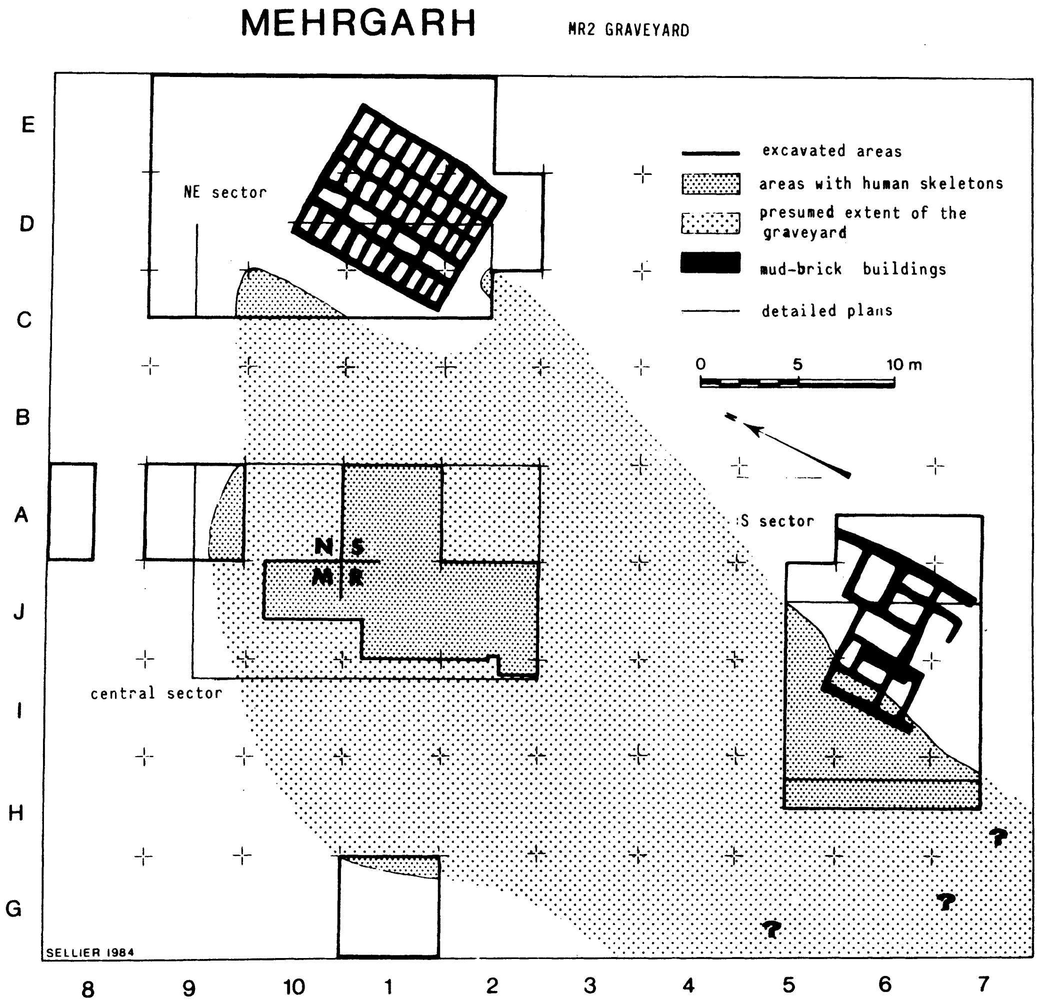


Fig. 1 - Excavated areas from MR2 graveyard and presumed extent of the graveyard.

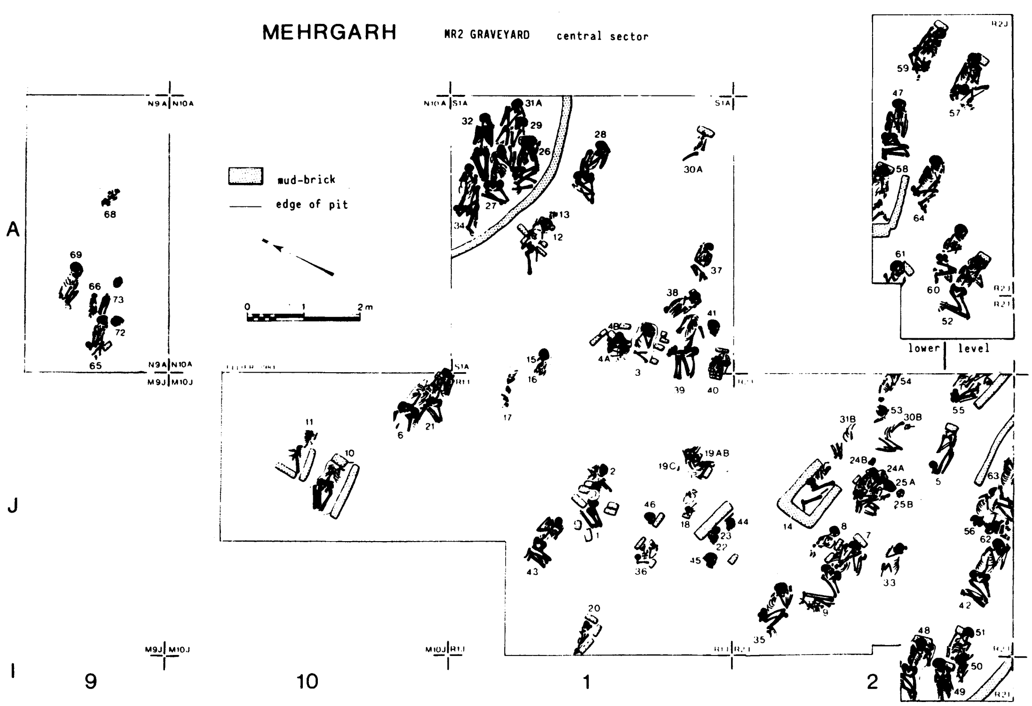


Fig. 2 - Central sector of the MR2 graveyard with, to the right, the R2J sounding.

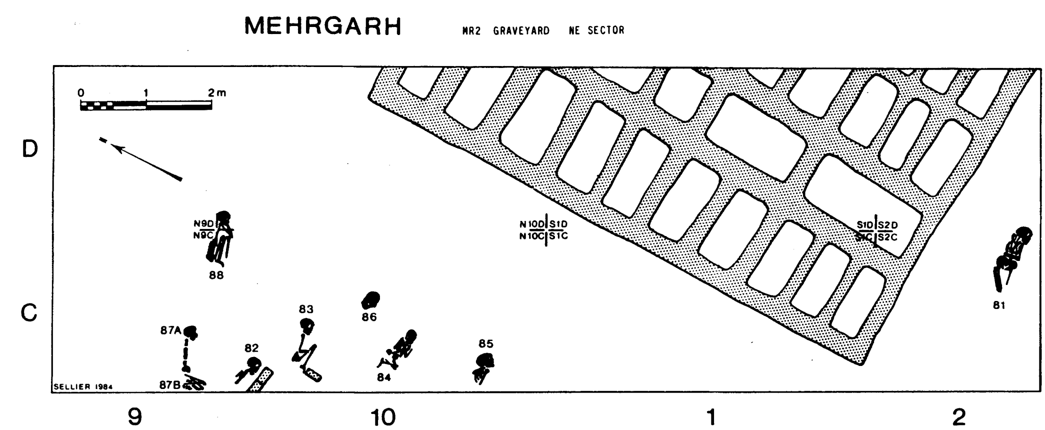


Fig. 3 - North-East sector of the MR2 graveyard, near S1C building.

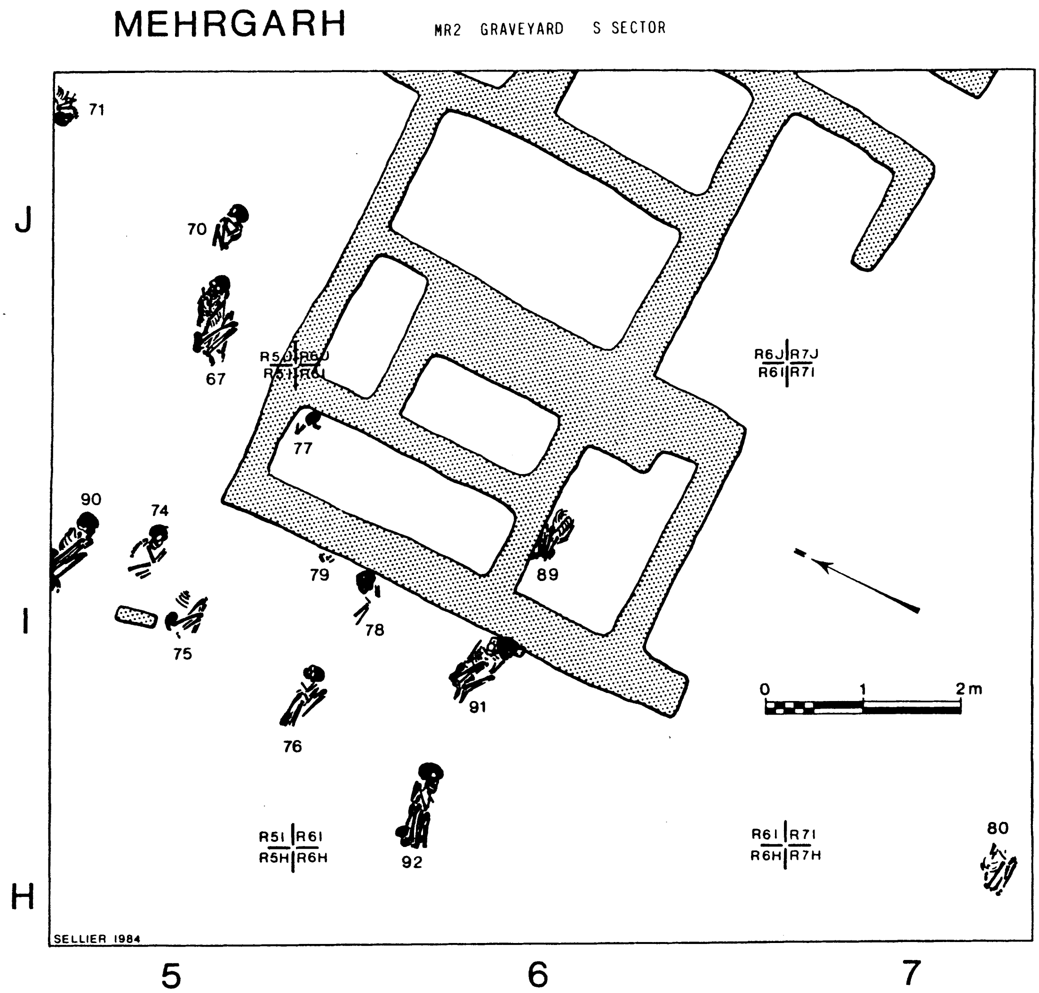


Fig. 4 - South sector of the MR2 graveyard, near R5J building.

to make an evaluation of the living population size (corresponding to the length of the burial period). This requires some formalization in the definitions and symbols used which, whether standard or our own, may not necessarily be familiar to the reader and are therefore shown in table 1. Finally this will appear as an adaptation of the work made by Acsádi & Nemeskéri (1957) and by Donat & Ullrich (1971), thanks to the use of Bocquet and Masset's demographic estimators (Bocquet & Masset 1977; Bocquet 1979; Masset & Parzysz 1985).

## 1. The Total Number of Buried Individuals

### *Sex of the Adults and Age of the non-Adults*

We have already developed the first stage of our analysis (Samzun & Sellier 1983, 1985) and explained the criteria used to determine the sex of the adults and the age of the non-adults (Samzun & Sellier 1985). We indeed chose to begin by limiting the study to these two categories; without otherwise changing the basis of our approach, this avoids the major difficulty of determining the ages of the adults (Acsádi & Nemeskéri 1970; Masset 1980, 1982) and, moreover, of producing the general age distribution of the population (which cannot be obtained by mere addition of the individual ages: Masset 1982). The results are shown in table 2; so these are the total numbers of the specimens *buried* within the excavated area, without judging what the representativeness of these figures might be compared with the number of the *dead* among the total living population having used the graveyard (cf. *infra*). According to our symbols (cf. table 1), they are D0-2, D0-5, D5-9,.... D0-$\omega$ ($\omega$ being the term of human life). We can also point out that the D0-2 category counts only children under one year of age, which therefore gives D0-1 = 3 and D1-2 = 0.

Apart from the specific choice of certain criteria (which everyone agrees on) and of special age groups (particularly in relation to the subsequent use of demographic estimators and to possible comparisons), the basic hypothesis (hypothesis no. 1, cf. table 6) is therefore the diachronic permanency of biological phenomena, specially child growth (teeth calcification and eruption, development and fusion of centres of ossification), since the relation between each developmental stage and age groups rests on reference to known, i.e. modern, pupulations (skeletal series with corresponding registers of births and deaths do not predate the 19th century), which date anyway from several millennia later than our Chalcolithic sample. As regards a biological phenomenon among the same species and apart from identifiable pathological problems (rickets, ... etc.), the hypothesis can be seen as quite acceptable, even though the diet of the population does influence child growth; however, discrepancies could not be very large (Acsádi & Nemeskéri 1970: 104-13) and even the most critical authors agree on the reliability of these criteria (Bocquet & Masset 1977: 66, 1982: 324; Masset 1976a: 89, 1980: 338), unlike those linked to senescence which are not so well correlated

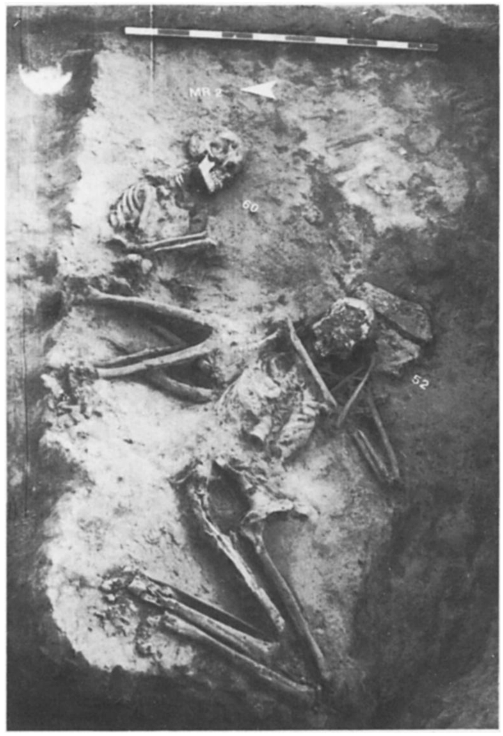


Fig. 5 - Specimens no. 60 and no. 52 (standard position).

with age (Masset 1982; Bocquet & Masset 1982, 1985) and which can sometimes be evolving in the course of centuries, like the synostosis of the cranial sutures (Masset & Castro e Almeida 1981). Further tests would in fact be possible in order to confirm this point (study of the ratio skeletal age / dental age, comparison between buried population whose diet can be known from other data: archaeological context, analysis of trace elements Sr/Ca). It must already be pointed out that future calculations will be exclusively based on the child age group D5-14 and the total number of adults D20-$\omega$.

*Discriminating Funerary Practices*

A first step of analysis (Samzun & Sellier 1983, 1985) allows comparison of the distribution (table 1) of the female adults (28), the male adults (20) and the non-adults (26 per 73 adults) with, on the one hand, the burial practices already defined (Sellier 1985): primary burials in strict anatomical connection (fig. 5 and 6) and genuine secondary burials (Duday & Sellier 1990) which correspond to the re-inhumation either of dislocated incomplete skeletons (fig. 6: no. 51) or of cranial fragments with occasional manipulation of the bones (fig. 7); and comparison, on the other hand, with the

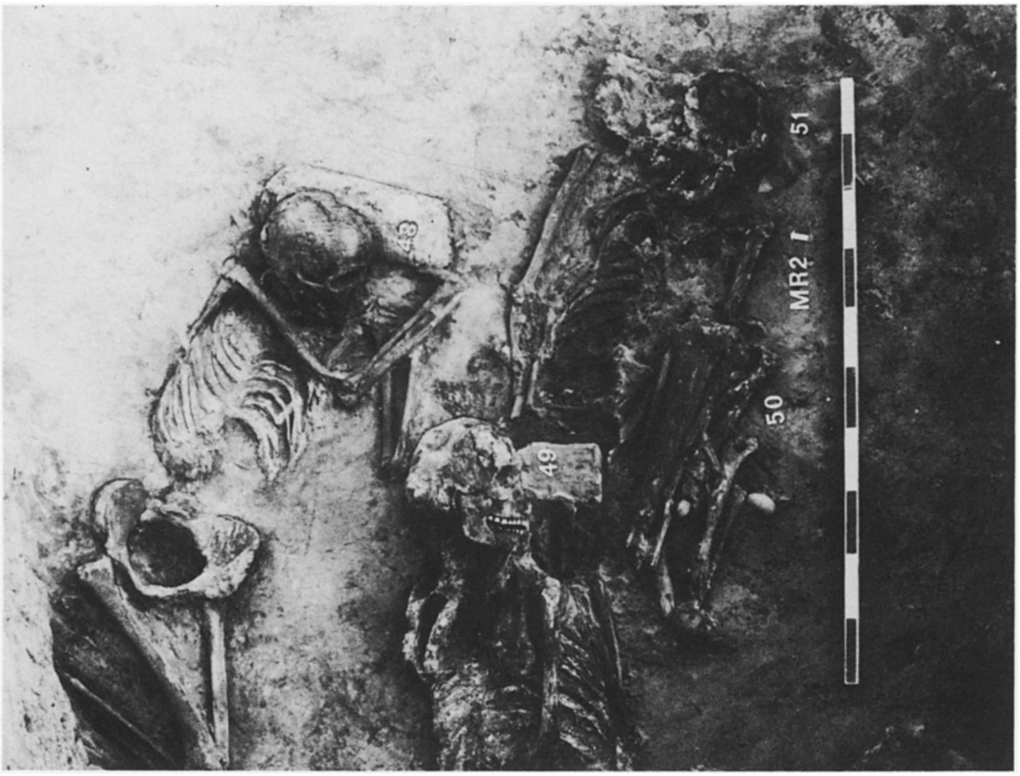


Fig. 6 - Specimens no. 48 (standard position), no. 49 (ventral decubitus, grave having cut into the next two), no. 50 (dorsal decubitus) and no. 51 (secondary burial with bundle-like gathering of bones).


Fig. 7 - Specimen no. 72: disconnected child cranium with intentional manipulation; the face is nested inside the two parietal bones that are fitted into each other (to the right).

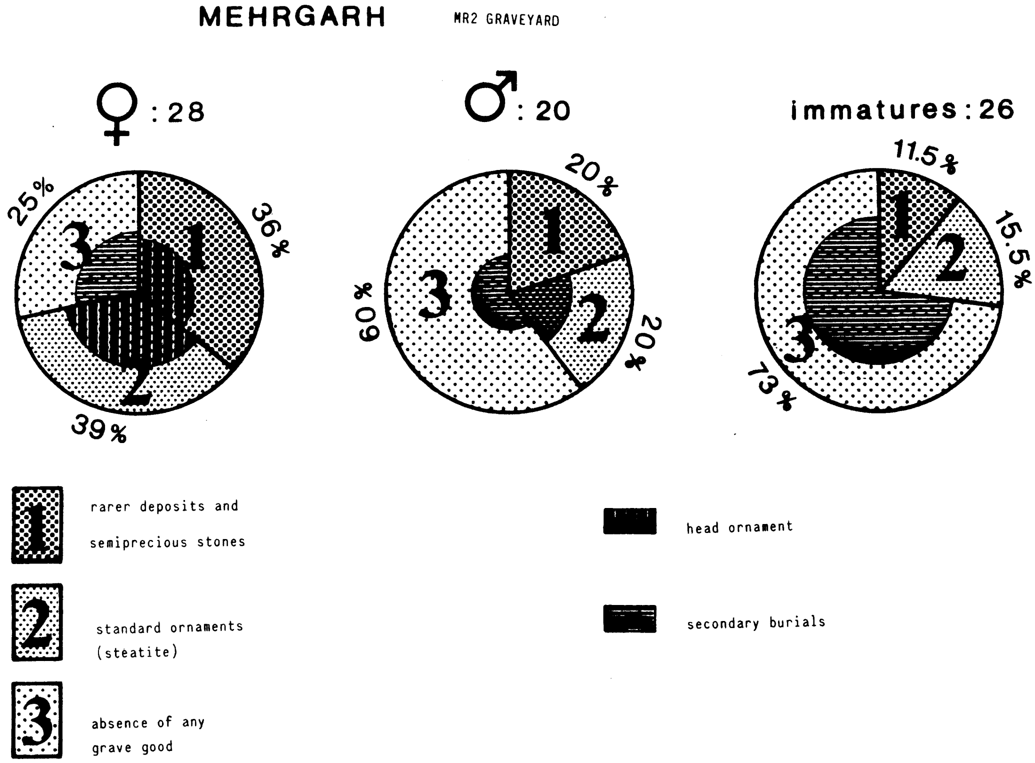


Fig. 8 - Discriminating distribution of grave goods and burial practices according to age (adults/non-adults) and sex (of the adults); Class 1 = rarer deposits and semiprecious stones; Class 2 = standard ornaments (steatite beads); Class 3 = absence of any grave good.

distribution of the grave goods classified into three general categories: Class 1 comprises the unusual objects (the only two pottery vessels and one compartmented seal) together with the ornaments including beads or pendants of semi-precious stone; Class 2 contains 'standard' objects, namely the ornaments only made of white steatite beads (whatever size or shape), while Class 3 is characterized by the total lack of any grave goods.

I have shown (Samzun & Sellier 1985) a discriminating distribution of statistical significance (Chi-squared tests at level $p \leq 0.05$) for both the grave goods and the burial practices (fig. 8): the secondary burials (dislocations) mainly concern the children (27% as against 11% of the adults) and are, as a whole, the most lacking in grave goods (97% being in Class 3, as against 55% of the connected skeletons). The females possess the few head ornaments (6 cases) and chiefly occupy Class 1 (36%) and Class 2 (39%), whereas children are but rarely represented there (respectively 11.5% and 15.5%, as against 73% in Class 3). The males have an intermediate status (20% in

Class 1, 20% in Class 2 and 60% in Class 3). It is clear that these correlations do not describe all the complexity of a social organization but they nevertheless reveal to some degree the codification of the funerary practices according to sex and age.

*Ratio non-Adults/Adults*

The distribution of non-adults requires another more purely demographic discussion. The overall number of non-adults compared with the total number of the buried individuals (N = D0-ω = 99) is extremely low; whether this proportion non-adults/adults is expressed by the ratio $\frac{\text{D0-14}}{\text{D0-}\omega}$ (23%) or by $\frac{\text{D0-20}}{\text{D0-}\omega}$ (26%) makes little difference; for a population in which a low life expectancy at birth ($e_0^{\circ}$) and a high mortality rate (m) would be expected, the number of non-adults seems amazingly low by comparison with either historical data or with data from the standard life-tables or even from archaeological cemeteries where the children seem to be all present. Ledermann's standard life-tables (network 103), either by estimation (Ledermann 1969: 28) or by interpolation (*ibid.*: 150-51), relate a probability of death under 14 ${}_{14}q_0$ = 230 p.1000 to a life expectancy at birth close to 48 years which is much too high for our sample. Kurth has already pointed out that demographic results of many archaeological cemeteries do not correspond to what would be expected from a biological-statistical point of view (Kurth 1963: 12) and historical comparisons give high $\frac{\text{D0-20}}{\text{D0-}\omega}$ ratios: Kurth (1963) puts forward a value of 60%; for Southern Austria, the proportion was 54% in 1829 and still 46.3% in 1900 (Donat & Ullrich 1971: 239); in France from 50 to 62% according to some parish registers dating from the age of Louis XIV (Masset 1976a: 86); and so many other examples could be cited. Furthermore some archaeological series give quite plausible proportions for non-adults: around 40-50% for most of the medieval sites from Hungary and Czechoslovakia (Acsádi & Nemeskéri 1970: 238-55), 61.8% at Westerhus (Sweden) in the 12th-13th centuries (Gejvall 1960) and, in still older cemeteries, 58% at Lerna (middle Bronze Age, Greece; Angel 1969: 429), 38% at Khirokitia (Neolithic, Greece; Acsádi & Nemeskéri 1970: 188) and, for two Epipalaeolithic examples from North Africa where non-adults seem to be well represented, 57% at Taforalt and 59% at Columnata (Bocquet & Masset 1977). Once more we could give other numerous examples, but also refer to a large number of archaeological graveyards where, as at Mehrgarh, the number of non-adults is amazingly low (Bocquet & Masset 1977; Masset 1976a; Sellier 1987a). In fact, a close relation does exist between the life expectancy at birth $e_0^{\circ}$ and the probability of death under 14 ${}_{14}q_0$ (Acsádi & Nemeskéri 1970: 238, table 83) so that a margin can be suggested in which the non-adult ratio could be considered as realistic: according to the authors, 36 to 50% (Acsádi & Nemeskéri 1970: 238) or 45 to 60% (Donat &

Ullrich 1971: 241). It is clear that our 23% ratio denotes a strong bias within our overall number of non-adults.

## *Under-representation of the Age-Group 0-5 Years*

It is possible to go further by showing that this bias selectively affects certain age-groups, namely those of the youngest children. D0-1 and D1-5 (with 3 and 5 individuals respectively) give absolutely incredible infant and under-five probabilities of death: ${}_1q_0$ = 30 per 1000 and ${}_5q_0$ = 81 per 1000. Turning back to our comparisons, it will be found in Ledermann's standard life-tables that an infant death rate of 30 per 1000 would correspond to a life expectancy at birth ($e_0^\circ$) of 69 years (Ledermann 1969: 24, network 102) to 71 years (*ibid.*, network 100, from interpolation in the tables: 96-97; or from the formula: 51-52) and a mortality rate under 5 years of 81 per 1000 corresponds to $e_0^\circ$ = 60-62 years (*ibid.*, network 101: 28; network 100: 51-52 and 93). The historical data are of the same order as, for instance in France under the Ancien Regime, ${}_1q_0$ = 250 to 300 per 1000 and ${}_4q_1$ = 250 per 1000, and therefore ${}_5q_0$ = more than 430 per 1000 (Masset 1976a: 85). Some archaeological cemeteries give equally important figures: ${}_1q_0$ = 359 per 1000 and ${}_5q_0$ = 487 per 1000 at Lerna (Angel 1969; see the reservations expressed by Bocquet & Masset 1977: 82-83), ${}_1q_0$ = 242 and ${}_5q_0$ = 445 per 1000 at Taforalt and ${}_1q_0$ = 267 per 1000 at Columnata. The obvious conclusion to be drawn is that a considerable bias affects the sample of children under 5. Let us add that the number of the older children can be considered as normal and this can be verified by the ratio $\frac{\text{D5-10}}{\text{D10-15}} = 1.5$ (compare with Masset 1973: 337; Bocquet & Masset 1979: 67) and we shall see later that the correction proposed for D0-1 and D1-5 will be enough to bring the overall ratio of the immature specimens $\frac{\text{D0-20}}{\text{D0-}\omega}$ up to a value (56%) that is consistent with the above-mentioned data.

## *Discussion of the Conclusions*

We must therefore introduce an absolutely basic distinction, that Donat & Ullrich (1971) have already pointed out, between the number of the *buried* specimens (symbol D) and the number of the *dead* (symbol d) corresponding to the whole population living during the burial period (when the graveyard was in use). So it must be concluded that d0-5 $\neq$ D0-5 (and *a fortiori* d0-1 $\neq$ D0-1) whereas the number of older children (over 5) and adults has to be regarded as satisfactory (Donat & Ullrich 1971: 245), that is d5-$\omega$ = D5-$\omega$. This requires a few comments. Without any data about the age of the adults, but with a sex ratio males/females which must be considered as balanced (Samzun & Sellier 1985), we have no means of detecting an under-representation of a particular group within D20-ω; the hypothesis of an unbiased overall number of adults is nevertheless perfectly acceptable since the question is only about the non-adults/adults ratio and this only will be used in the following. Furthermore it is also clear that the under-representation of the age-group D0-5 definitely prevents us from calculating any other demographic parameter which is largely dependent upon it, such as life expectancy at birth $e^{\circ}_{0}$ (that explains questionable results reached by some palaeodemographers), unless other sources of information are used (cf. *infra*). Lastly, the major hypothesis (hypothesis no. 2) which the previous deductions (based on comparisons) made use of is that of the existence of an 'archaic mortality pattern' (concerning societies prior to the 19th- and 20th-century industrial revolution and to the demographic changes that went with it). It will be discussed later, when it is again referred to as a basic hypothesis for the use of the demographic estimators.

### *Interpretation of the 0-5 Years Bias*

The evidence of the biased number D0-5 gives rise to the two subsequent questions: first, can the under-representation of the children under 5 be assessed and therefore can the figure d0-5 be estimated, and secondly, how can such a large bias be accounted for? Our further developments will be to answer the first question; as for the second one, it concerns quite a number of cemeteries, especially protohistorical ones, and has already been seriously discussed (Masset 1976a; Acsádi & Nemeskéri 1970).

However convenient and hackneyed it may be (Vallois 1960; Angel 1969; still recently put forward without examination by Peterson 1975 and Hassan 1981: 96), the argument that skeletons of young children specially tend to 'spontaneously disappear into the soil' (Riquet 1966 quoted by Masset 1976a: 80) or to mysteriously dissolve is clearly unsatisfactory (Masset 1976a: 80-83; Acsádi & Nemeskéri 1970: 238). From a biological point of view, one can neither explain why, although children's skeletons are largely cartilaginous, the *ossified* elements should disappear more often than those of adults and older children (Masset 1976a: 80), nor why there should be such a mass destruction only for specimens under a specific age, nor why it would also affect the dental elements as well as the grave deposits. Moreover, Masset (1973) has succeded in showing that the preservation of bones in the soil has little to do with the age at death of the subjects.

Another cause of destruction, this time authentic, could be the lesser depth of children's graves, even shallower for infants and newborn babies. This has been evidenced in some cemeteries and, often, there is indeed a sort of relation between the age (and thus the stature) of the child and the depth of the grave (Acsádi & Nemeskéri 1970: 239). That can in fact explain the preponderant destruction of the graves of the youngest because of subsequent ploughing or erosion. This could seem possible at Mehrgarh where, in MR2 site, the skeletons are nowadays very close to the surface, but the facts exclude this explanation since the lower (and thus the more protected) burial levels are more greatly lacking in children, and not the reverse. It can also be noticed that, within the other graveyards of Mehrgarh, one earlier (MR3, Neolithic dating from the 6th-7th millennia) and the other later than MR2 (MR1, Bronze *c.* 3000 B.C.), a fair number of young children, infants and newborns are well preserved (Sellier 1987b), while the conditions of burial and erosion are quite similar to those of the MR2 Chalcolithic site.

There is only one explanation left, then: an intentional selection of the buried individuals according to age, a phenomenon already attested in other sites (Masset 1976a; Sellier 1987a). So the newborn and the young children (under 5) were almost totally excluded from the cemetery (at least from the 144 sq.m. excavated in three separate areas, cf. fig. 1), which was therefore reserved for older children, adolescents and adults. The youngest must have been buried elsewhere or received special treatment. This gives further evidence for the codification of funerary practices, which is also supported by the data from the MR1 cemetery, dating from about one millennium later, which, on the contrary, provides only newborn babies (or foetuses) and very young children; the cemetery which should contain the older children and adults of the same period has never been discovered (it has probably been destroyed). This reversed image thus confirms a practice already identified at the Chalcolithic period in the MR2 cemetery.

## 2. Paleodemographic Estimators

If we wish now to calculate some major demographic parameters, and especially the actual number of the deceased d0-ω, we must consider the bias noticed in the D0-5 number, on which the life expectancy at birth and the mortality rate are widely dependent, and which directly affects the ${}_1q_0$ and ${}_5q_0$ probabilities of death (under 1 and 5 years). The methods proposed up to now to solve the child bias problem are not satisfactory: they proceed by fixing *a priori* some rates or some coefficients, quite arbitrarily chosen within a rather wide margin which can be considered as reasonable (according to the historical data mentioned above). Standard life-tables (Ledermann 1969) can be used by taking into account either a low life expectancy at birth $e_0^{\circ}$ or a high probability of death ${}_1q_0$, ${}_5q_0$ or ${}_{15}q_0$ (but always arbitrary), according to the entry chosen in the tables (networks 100 to 103). One can adopt a given mortality rate (Gelvall 1960: m = 40 to 50 per 1000 according to death rates known in Sweden from 1749 to 1809), or a minimum non-adult ratio (for instance, Donat & Ullrich 1971: ${}_{15}q_0 = \dfrac{d0\text{-}15}{d0\text{-}\omega} = 45\%$) and distribute the surplus (d0-15 — D0-15) among the different age-groups in proportion to the buried individuals (with, for those authors, a minimum of 20% for ${}_1q_0 = \dfrac{d0\text{-}1}{d0\text{-}\omega}$); this anyway is somewhat more logical than Angel's obscure calculation (Angel 1969), aslo used without examination by Voigt (1983), which leads to the single correction of D0-1 according to d0-1 = D0-1 + (D15-ω — D0-15), with the postulate d0-15 = D15-ω (or ${}_{15}q_0$ = 50%). Whatever figures are proposed, explicit or not, they all are arbitrary within a group of possible solutions and none of them allows to measure a confidence interval by giving a standard error (which necessarily depends also on the original number N = D0-ω).

## *Principle of the Demographic Estimators*

Thus we have used the demographic estimators proposed by Bocquet and Masset (Bocquet & Masset 1977; Bocquet 1979; Masset 1980; Masset & Parzysz 1985) which are independent of the biased effective D0-5 since they all refer to a single ratio $x = \dfrac{D5\text{-}14}{D20\text{-}\omega}$ ; and we have already concluded that these age groups were satisfactorily represented within our sample. These estimators are based on mathematical regressions of different demographic parameters according to the x ratio (these are curvilinear relations); the estimators are f(x) equations which give the standard error due to the method and also the coefficient of correlation of each variable to the ratio $x = \dfrac{D5\text{-}14}{D20\text{-}\omega}$ (Bocquet & Masset 1977: 85; Bocquet 1979: 265). These coefficients are quite satisfactory, since for the life expectancy at birth ($e_0^\circ$), for the infant probability of death (${}_1q_0$), for the probability of death under 5 years (${}_5q_0$), for the crude death rate (m) and for the overall general fertility rate (${}_{35}F_{15}$), they are respectively r = 0.941, 0.841, 0.775, 0.918 and 0.969. The basis of the regressions are 40 life-tables from the 17th to the beginning of the 20th century (more than half of them are prior to the 20th century) about what is called 'pre-Jennerian' populations among which infant and infectious diseases were not controlled (with therefore a pre-industrial revolution or 'archaic' mortality pattern), which is not the case for the standard life-tables based on modern populations (even if underprivileged).

## *Review and Discussion of the Hypotheses*

This method is based on hypotheses which have been clearly stated by their authors (Bocquet & Masset 1977) and even severely criticised by them (Bocquet & Masset 1982: 326-29) but it is worth while to review them briefly and moreover to stress the conditions for using the demographic estimators, which are less explicit. The necessary hypotheses are three and are of a different nature (table 6): the existence of an archaic mortality pattern (hypothesis no. 2) which we have already referred to in the previous stage, the obligation to treat the population as a stationary one (hypothesis no. 3) and, lastly, the span of female fertile life (hypothesis no. 1A), which is of minor importance and linked to hypothesis no. 1.

The regressions used are indeed based on 40 known life-tables (only 30 for ${}_{35}F_{15}$ because of technical problems: Bocquet 1979: 265) concerning past populations with low life-expectancies and thus high infant death rates (Europe, America and Asia from the 19th to the 20th centuries, and Europe from the 17th to the 18th centuries). Therefore this assumes that, even for quite dissimilar populations, biological necessities do exist, which does not allow any demographic structure. It is a classic argument in historical demographic studies and there is a lot of evidence to support it (Bocquet & Masset 1979: 67). In fact, there is actually some consistency among the demographic parameters of all Primates, including modern Man (Bocquet & Masset 1982: 329), and even of placentary mammals in general (Bocquet & Masset 1977: 67). Hypothesis no. 2 (existence of an unvarying archaic mortality pattern) allows us to increase the scope of the correlations discovered in pre-industrial populations, relatively close to our own, as far as populations dated from several millennia earlier. A similar principle rules the comparative procedure criticised above, which consists in choosing an *a priori* value for demographic parameters within a 'plausible' margin, but here the method does not fix arbitrarily any value and allows us to calculate the coefficients of correlation as well as the confidence intervals of the estimations. In addition it should be noted that this latter depends both on standard error of estimation due to the method (given by the authors with the equations) and on the size of the overall number of buried specimens $N = D0\text{-}\omega$ (Bocquet & Masset 1977; Masset & Parzysz 1985).

Thus a first limit for the use of the estimators becomes clear: if N is smaller than 50 individuals the accuracy of the estimates will be delusive (Masset 1980: 339). Other conditions directly ensue from hypothesis no. 2 and from the reference to recent populations which are all farming groups whose subsistence is based on agriculture and animal husbandry (Bocquet & Masset 1977: 79). Our protohistoric population has necessarily to fit into this framework too, and to square with the original demographic conditions, that is $x = \dfrac{D5\text{-}14}{D20\text{-}\omega}$ within the margin 0.100 to 0.300 (Bocquet 1979: 266) and the ratio $\dfrac{D5\text{-}9}{D10\text{-}14}$ of the order of 1.5-2.0 which is a characteristic of early pre-Jennerian populations (Bocquet & Masset 1977: 67), prior to the discovery of the smallpox vaccine (and, of course, of other knowledge for the prevention of infant mortality). When established, these four conditions support the higher validity of hypothesis no. 2: $N > 50$, $0.100 < x < 0.300$, $\dfrac{D5\text{-}9}{D10\text{-}14}$ around

1.5-2.0, and farming economy.

So some reference populations are indeed more reliable and less inconvenient to use than others and we saw that those of the estimators are satisfactory. Nevertheless, the unavoidable use of reference populations introduces one drawback of the same nature as the systematic errors in the determination of the age of adults: to some extent, the reference populations impose their own demographic structure on the prehistoric sample (Bocquet & Masset 1982: 329). It means that a certain amount of information is inevitably lost and that mostly the deviations from the standard will be significant (rather than the similarities); it also ensues that, as long as the same method is used, comparisons between cemeteries will remain pertinent, especially if discrepancies are noticed (Masset 1976b: 128).

At present we have no means of knowing the natural growth rate ($t = n - m$) of the buried populations except by one demographic estimator (Bocquet & Masset 1977: 70) depending on the above x ratio and on the oldest adults age-group D60-ω, which is almost impossible to determine accurately (except, perhaps, by Masset's method which is the only one to take into account the possible existence of very old adults and to determine the overall age distribution independently of the individual ages: Masset 1982). Even if it cannot be very important (Masset 1980; Hassan 1981) during a long period (if $t = 2\%$, the population doubles in size every 35 years, and is multiplied by nearly 150 in a thousand years if $t = 0.5\%$), it is yet a very severe hypothesis to consider the population as stationary (hypothesis no. 3) and thus to assume that $t = 0$, which automatically makes $m = n$, and consequently $R_0 = 1$ (crude reproduction rate).

Unsatisfactory as it may be, this hypothesis is absolutely unavoidable. Therefore any dynamic study of the population becomes impossible, and this acts as if all the situations were artificially possible, which limits the conclusions; moreover a new bias is then created (moderate but unverifiable as long as t is not known) in comparison with estimators which would take the growth rate into account (and which exist: Bocquet & Masset 1977). But this hypothesis is a real handicap only in the case of cemeteries with very short periods of use (then the variations of t may be quite significant); otherwise, the fluctuations of t more or less cancel each other, and the longer the burial period is, the more realistic the hypothesis $t = 0$ becomes (Bocquet & Masset 1977: 72). Anyway this kind of neutral hypothesis allows us to calculate demographic parameters in order to obtain, if not always exact figures, at least trends which may be compared with others.

The last point (hypothesis no. 1A) is rather a convenience for the calculation of $_{35}F_{15}$ and DF than a hypothesis properly speaking: a span of female fertile life of 35 years, from 15 to 50 years of age. Somehow it ensues from hypothesis no. 1 (existence of a diachronic biological permanency) and does not deserve further discussion. Anyway a deviation of a few years would not be of much consequence and most authors agree about this figure (for instance Hassan 1981: 129-30: from 15-18 to 44-47 years).

*Results*

The results of the computations through the demographic estimators, according to the ratio $x = \dfrac{D5\text{-}14}{D20\text{-}\omega}$, in the MR2 cemetery are given in table 3. First, it will be noticed that our sample corresponds to the four 'conditions of use' which have been mentioned above: the population indeed appears to have a farming economy, which is evidenced by the archaeological data and moreover by the faunal and macro-vegetal remains (Jarrige & Lechevallier 1979; Jarrige 1981, 1984); $x = 0.205$ is in the correct maring, as well as $\dfrac{D5\text{-}9}{D10\text{-}15} = 1.5$, and N is large enough ($N = 99$). Of course, the confidence intervals take into account both the reliability of the method and the standard error linked to the size of the sample N (Bouville, 1980, totally forgot the second, which gives the wrong impression of a fantastic accuracy of his estimations). For the computations of confidence intervals, we followed the heavier but more accurate method used by Bocquet & Masset (1977: 76-77) because a simpler method, proposed by Masset & Parzysz (1985) and proceeding by successive interpolations, leads to even larger margins. It will be noticed that anyway the accuracy of the results is not so good ($\pm 1$ S.D. corresponding only to a level $p = 33\%$ whereas $\pm 2$ S.D. is needed for $p = 5\%$). Even so these estimates provide valuable information and are in fact the only reliable ones in spite of the infant bias within our sample. The demographic parameters thus obtained are quite consistent with either the standard life-tables (Ledermann 1969) or the known data about the 'archaic mortality', and are also less disastrous (for $e_0^\circ$ and the mortality) and less exuberant (for DF) than in some palaeodemographic 'wild imaginings' (Masset & Parzysz 1985: 152): a life expectancy at birth of around 23 years, an infant probability of death of 284 per 1000 (instead of 30 per 1000 as D0-1 would first indicate), a probability of death under 5 years of 452 per 1000 (and not 80 per 1000, according to D0-5), a crude death rate of 42 per 1000 (necessarily equal to the birth rate since hypothesis no. 3 states $t = 0$), an overall general fertility rate (annual) of 165 per 1000 and a rather high total fertility rate of almost 6 children per female.

*Comparisons*

These estimates can be compared with the results obtained, with the same method, from MR3 Mehrgarh Neolithic graveyard (Sellier 1987b) and from other cemeteries (Bocquet & Masset 1977: 80-81; Bocquet 1979: 267). One cannot take into account a few sites (Lerna, Montigny-Esbly, Sopronköhida) where there seem to be additional difficulties about age determination or an under-representation of adults; but our results are consistent with those from other sites, especially from Taforalt and Columnata (Mesolithic, Northern Africa) and from French Neolithic sites. By contrast, at Roaix (Bouville 1980: 88), a Chalcolithic hypogeum from southern France, the results are much different (with the same Bocquet and Masset's method): much more favourable in the lower burial level ($e^{\circ}_0$ around 35 years and moderate probabilities of death $_1q_0$ and $_5q_0$), with N = 58 (close to the minimum), and unbelievably pessimistic in the upper layer (for instance life expectancy at birth between 1 and 13 years!); it is supposed to be a 'war stratum' (*ibid.*: 89), which the estimates cannot confirm since their amazing figures only come from the ratio $x = \frac{D5\text{-}14}{D20\text{-}\omega} = 0.770$, which is huge and much too far over the maximum limit for using this method. Therefore one should only comment on this biased ratio and not on any estimated values: the adults (D20-$\omega$) are under-represented (which is not so consistent with a 'war stratum') or the children (D5-14) are over-numerous.

I also used these demographic estimators on the data from Ra's al-Hamra (Oman, *c.* 3500 B.C.) provided by A. Coppa and R. Macchiarelli at the Rome conference (IsMEO, 4-7 July 1984), which only refers to 73 specimens whereas the total buried population subsequently amounts to nearly 200, after the last excavation season (Santini 1985; Biagi et al. 1984). Based on the ratio x = 0.167, the results show slightly more favourable demographic conditions than in MR2 (still using the hypothesis t = 0):

$$\hat{e}^{\circ}_0 = 27.24 \pm 6.35 \qquad \hat{m} = 0.0372 \pm 0.0076$$
$$_1\hat{q}_0 = 0.263 \pm 0.040 \qquad _{35}\hat{F}_{15} = 0.148 \pm 0.030$$
$$_5\hat{q}_0 = 0.410 \pm 0.085 \qquad \hat{DF} = 5.18 \pm 1.06$$

This is not only more coherent but also much more realistic than $e^{\circ}_0 = 21$ years calculated by the anthropologists (due to the classic systematic error in ageing adults, which makes them considerably younger than they should be: no one would have reached the age of 46 and 3/4 would have been under 35 years of age), curiously associated to probabilities of death $_1q_0 = 0.118$ and $_5q_0 = 0.200$, both much too low.

## 3. Total Number of the Dead and Estimation of the Average Size of Population

### *Corrected Data: Total Number of the Dead*

Let us return to the MR2 cemetery at Mehrgarh since, with the estimates $_1\hat{q}_0$ and $_5\hat{q}_0$ (not depending on D0-5), we can now correct the youngest age-group figures biased by the selection of the *buried* (D0-1 and D0-5) by calculating the number of the *dead* within these age-groups, d0-1 and d0-5, corresponding to the original population of the young children and infants. If d0-$\omega$ represents the overall deceased population (and therefore comprises the youngest children, infants and newborn babies excluded from the cemetery), the relation is: d0-5 = d0-$\omega$ . ($_5\hat{q}_0$). All the dead individuals over 5 years having been buried (cf. *supra*): d0-$\omega$ = d0-5 + d5-$\omega$ = d0-5 + D5-$\omega$, which finally gives d0-5 = $\frac{\text{D5-}\omega\ .\ ({}_5\hat{q}_0)}{1 - {}_5\hat{q}_0}$ and d0-$\omega$ = $\frac{\text{D5-}\omega}{1 - {}_5\hat{q}_0}$ and consequently for the infants under 1 year: d0-1 = d0-$\omega$ ($_1\hat{q}_0$).

In this way we obtain the corrected size of the youngest age groups (table 4): 47 infants under 1 year old (and not only 3), which means that 93.6% of the dead within this age group are missing in the cemetery, and, on the whole, 75 children under 5 years of age (and not only 8), thus corresponding to a bias of 89.3%. So the original number of the dead should have been 166, which signifies that the overall bias in D0-$\omega$ is of 40.4%.

It will be noticed that these corrections, only concerning the age group 0-5 years, are enough to raise the ratio $\frac{\text{d0-20}}{\text{d0-}\omega}$ up to 56%, which is then consistent with the comparative data mentioned above. The confidence interval of our corrected data can thus be calculated by taking the extreme values $\pm 1$ S.D., $_5\hat{q}_0^+$ and $_5\hat{q}_0^-$; the overall sample of the dead d0-$\omega$ is thus contained between 148 and 188 individuals (at the level p = 33%). So we finally have a not purely arbitrary method to estimate this gap between the number of the buried and that of the deceased, justifiably underlined by some palaeodemographers (Nemeskéri 1962; Donat & Ullrich 1971).

## *Extension of the Cemetery*

Our corrected number d0-$\omega$ = 166 only represents the number of the deceased corresponding to the area actually excavated in MR2, about 144 sq.m. (Samzun & Sellier 1985). But this is not the whole area of the cemetery which must be estimated for further interpretation (Nemeskéri 1962). The excavated zones (fig. 1) have revealed, in several places, clearly demarcated boundaries of the graveyard, beyond which no skeleton can be found. There is such a boundary to the North-East near the S1C building, another North-West of the central sector, one also to the East of the South sector and, lastly, one to the West (revealed by a small sounding). So the plausible extension of the cemetery can be figured (fig. 1) by joining those boundary lines. Doing so, we use another hypothesis (table 6: hypothesis no. 4) about the homogeneousness of burials in the graveyard, that is the absence of any gap within the whole burial area thus determined. This appears to be quite satisfactory considering such a specialized area, to the West of a sort of ring of buildings (Samzun & Sellier 1985: 94, fig. 3), where the burial density is very high in the excavated zones (figs. 2, 3 and 4). It will also be noticed that this overall burial area is not limited to the South-West for no boundary could be found there. The total area of the cemetery S = 800 sq.m. is thus a minimum figure since the graveyard might extend much farther in this direction.

*Burial Density*

The general density of burials over the excavated 144 sq.m. is 0.87 specimen per sq.m., including 26 extra specimens simply spotted from the surface but not excavated (making a total of 125). In fact the excavation was not managed in the same way over the whole graveyard area and some sectors have not been explored deeply enough. Only one sounding of 14 sq.m., in R2J-R2I (fig. 2), reached the virgin soil and clearly showed both the actual depth of the burial stratum and the overall density of inhumations which is 1.7 specimens per sq.m. (since this sounding counted 24 specimens).

With one more hypothesis (table 6: hypothesis no. 5), that the burial density is the same throughout the cemetery, we can estimate Dtot, the total number of the individuals *buried* within the S area. This proposition is quite acceptable because there is no reason why the R2J sector should be a special one and because the density of burials is indeed very high in the other sectors, even in those much less deeply excavated (as for instance the portion of multiple burial in square S1A). Anyway we saw that the S area is an absolute minimum and Dtot = 1.7 × 800 = 1360 must be considered as an under-estimate.

*Total Number of Deceased*

We previously saw that the total number of the *deceased* from our population is definitely not equal to the number of individuals *buried* and that more than 89% of the children under 5 years of age are missing. It is therefore necessary to estimate the total number of the dead, dtot, corresponding to our 1360 buried individuals. Since we estimated the deceased/buried ratio $\frac{\text{d0-}\omega}{\text{D0-}\omega} = 1.68$ (table 4) within the excavated area, it can be assumed for the S area that $\text{dtot} = \text{Dtot} \cdot \frac{\text{d0-}\omega}{\text{D0-}\omega}$. This is based on hypothesis no. 6 (table 6): the lack of children under 5 is homogeneous throughout the whole graveyard. It is a sort of extension of hypothesis no. 5 about the burial density which mostly referred to the only individuals over 5 years old. As the under-representation of the D0-5 specimens is not a random phenomenon but a genuine funerary practice, an intentional selection of the buried, hypothesis no. 6 is satisfactory unless one would assume that there could be a specialized zone for infants and youngest children somewhere in the very middle of the S area, among their elders' burials. This is highly unlikely because the MR1 later site, which has been extensively excavated and which revealed (in a reversed image) the same division newborn-infants-youngest children/older children-adolescents-adults, definitely shows that the isolation of the burial of the youngest is complete. So, according to d0-ω estimate and its confidence interval, it is easy to calculate that dtot = 2280 ± 270, which is the overall number of the dead related to the minimum burial area, S, of 800 sq.m.

*Length of the Burial Period and Size of the Living Population*

It is indeed the overall number of the *dead* (and not of the buried individuals) which must be used as a basis for the estimation of the average size of population, P (Nemeskéri 1962; Acsádi & Nemeskéri 1970; Donat & Ullrich 1971). For this estimation of P, I shall use the formula proposed by Acsádi & Nemeskéri (1957; also used by these authors in 1970: 65-67) the reliability of which has been evidenced by Donat & Ullrich (1971: 237). P is related to dtot, the overall number of the dead, $e_0^\circ$, the life expectancy at birth, and T, the period during which the graveyard was in use: $P = k + \frac{e_0^\circ \cdot (dtot)}{T}$ ; k is a correction factor, approximately 10 per cent of T (Acsádi & Nemeskéri 1957, 1970) and not 10 per cent of the whole ratio (Donat & Ullrich 1971: 237; these authors noticed this mistake in Table 9 from Acsádi & Nemeskéri themselves, 1970: 67). With the approximation $m = \frac{1}{e_0^\circ}$ (true if t = 0, cf. hypothesis no. 3), this formula is indeed quite similar to that by Gejvall (1960) who overlooked the correction factor k and used m instead of $e_0^\circ$ but did not however stress the distinction between the buried (Dtot) and the deceased (dtot).

Therefore, in order to determine P, the length of the burial period T must be estimated. As a first step, we know that this graveyard corresponds to a precise phase within period III of Mehrgarh, the second one (reviewed in Samzun & Sellier 1985), and that phase III-2 could hardly have exceeded 300 years (A. Samzun: personal communication).

Further, five different arguments all give evidence for a relatively short burial period (hypothesis no. 7). The uniformity of the grave goods and of the funerary practices is a rather poor argument which does not bring much more than the attribution of the cemetery to the single phase III-2. The stratigraphic study is more informative since it shows (in the R2J sounding) the homogeneity and the thinness of the burial stratum: 75 cm. thick at the most, in which there are no discernible separated layers (in fig. 2, the 'lower level' is nothing but a drawing convenience); even if nothing is known about the original depth of the graves, this is a strong argument in favour of a short period of time. Furthermore, the specimens have often been gathered by two, exceptionally by four or even more in the multiple burial; these are most probably simultaneous inhumations (Samzun & Sellier 1985), which also points to a short burial period. It is also noticeable that the number of dislocations generally increases with the length of the burial period, surely in the ossuaries (Uberlaker 1974: 66-67), but here also since it gives evidence of corpse manipulation. This ratio is very low since the graveyard counts only 15% of complete dislocations (out of 99 excavated specimens). The fact that several graves have been cut into by later ones testifies to some degree of relative chronology within the cemetery and would seem to argue against a short burial period (thus grave no. 3 is later than nos. 4A-4B, no. 63 later than nos. 52 and 62, no. 65 later than no. 73 and lastly no. 49 later than nos. 50 and 51); the digging of those new graves (at the same level as the others) cut straight into the earlier skeletons (fig. 6), but without moving their bones or disturbing their connections. So this gives evidence of the permanence of most of the ligamentary connections and of the incomplete body-tissue decomposition at the time the later burials took place, and this is a last argument in favour of a short period during which the graveyard was in use.

Despite all these indications, it is still quite difficult to assign a precise figure of the length of the burial period, even if short (hypothesis no. 7). I would put forward something like 50 years and suggest 100 years as a maximum (these lengths are thus underlined in table 5) but, in order to leave the question open to discussion, I have also calculated P for shorter and longer burial periods. Table 5 gives, with the average figures, the confidence intervals according to ${}_5\hat{q}_0$ and $\hat{e}^{\circ}_0$; the higher value ${}_5\hat{q}_0^{+}$, corresponding to dtot$^{+}$, must be then associated to $\hat{e}^{\circ -}_0$ (the lowest life expectancy at birth corresponding to the highest probability of death under 5 years).

Considering our arguments about the length of the burial period, a living population size (average during that period of time, considering that deaths and births counterbalance each other under the stationary population hypothesis) from 500 to 1000 people is a satisfactory rough estimate. When compared with the figures presented by Aurenche (1981: 93), which are nothing but assertions, the basic hypotheses of which are not even mentioned, we would face a rather medium size or even scattered population, considering the 75-hectare overall area of the MR2 Chalcolithic site. Compared with more cautious but also far-off figures from early Mesoamerica farming settlements around 1000 B.C. (Hassan 1981: 93, table 6.10), our estimate is close to the maximum population size of the regional centres ('nucleated centers') opposed to small rural groups. The representativeness of the excavated zones must also be taken into account, in regard to the overall 75-hectare area of the period III site; the total area so far excavated is about 3000 sq.m. (Samzun 1988), that is 0.4% of the whole area of the Chalcolithic site and the presumed extent of the graveyard (S, cf. *supra*) thus corresponds to only 0.1%. This shows how little representative our estimate is (which is a minimum, let us insist), in regard to the whole period III site; it is very likely that there are other graveyards on the site, even for III-b phase only.

## Overview and Perspectives

Initially clearly anthropobiological, this work leads us to new interpretations and to perspectives of both anthropological and archaeological nature. So it can offer much more than a simple catalogue of sex and age of the skeletons, since we have been able to identify an unsuspected complexity among the funerary practices which are codified at three levels: discriminating distribution of the grave goods, particularities of the practice of secondary burial and existence of a specialized zone from which newborn babies, infants and young children are excluded. A synthesis of the processes followed by Acsádi & Nemeskéri (1957, 1970), by Donat & Ullrich (1971) and by Bocquet & Masset (1977) allows us to have direct access to some demographic parameters, to estimate the bias in the buried sample and, lastly, to suggest some figures for the living population size related to the graveyard.

We attempted to expound our interpretative process as clearly as possible (table 6) by pointing out hypotheses often unexpressed in archaeological literature. It is indeed more than a mere succession of inferences which are often vague relations not necessarily taking into account the arguments on the hypotheses to be weighed or the conclusions to be drawn. Through calculation of precise estimates, the confidence intervals of which are known, we can relate our interpretations to a probability model as well as to hierarchized hypotheses, and sometimes suggest alternative propositions.

Throughout the interpretation, we have introduced seven hypotheses not equally significant (table 6). We shall not refer again to their reliability nor to their necessity that have already been fully discussed. We only wish to remark that hypotheses no. 1, no. 2 and no. 1A are of the same order and are related to biological factors, the non-chronological nature of which can be easily acceptable. Hypotheses no. 4, no. 5, no. 6 and no. 7 belong to a different category, since they concern extrapolations from the archaeological data (from a non-extensive excavation). We have chosen to leave open hypothesis no. 7 by proposing several lengths for the burial period, but the other three hypotheses could also be re-evaluated if new data were to come after further excavation. So these hypotheses are less general and less theoretical than the first ones and could be, to a certain extent, revised. Lastly, hypothesis no. 3 (stationary population) stands alone and appears to be the more questionable. It is convenient because it is neutral and it is anyway essential to the successive estimations, although difficult to verify (unless by T which makes it more acceptable as it increases).

Our conclusions finally lead towards new perspectives. Later on, our estimates might be compared with other anthropological data, such as scars of parturition (for DF), the age distribution of the adults (for $\mathring{e}_0$) and the oldest age-group D60-$\omega$ (to estimate the growth rate t). Comparison with archaeological data from outside the cemetery is another possibility and should suggest a new research strategy to go on studying such a complex and extended site as MR2. This would include a better evaluation of the nutritional status of the Mehrgarh Chalcolithic population as well as of its food storage capacities and an attempt to analyse more extensively this 75-hectare area. Although one can hardly hope to sort out the whole compound sequence, with possible movements, desertions and reoccupations of all or parts of the site, perhaps it might be possible at least to locate, on the overall MR2 site, chronological as well as functional areas (habitation, storage, specialized craftsmanship) and (why not?) discover new burial grounds.

ACKNOWLEDGEMENTS

I wish to thank J.-F. Jarrige, Director of the French Archaeological Mission in Pakistan, and the Department of Archaeology of Pakistan, without whom the two excavation campaigns of the MR2 graveyard would not have taken place; A. Samzun who was in charge of the excavation of the Chalcolithic site, and who also kindly translated for me the German references; and especially A. Fetizon, S. Thiebault and G. Tosello who so largely contributed to the efficiency and success of the field work in far from easy conditions.

Written in 1985, this paper was read at the conference held in Rome (IsMEO, 4-7 July 1984), *Archeologia protostorica dell'Asia Media: due esperienze a confronto.* Drawings and photographs are by the author.

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Table 1 - *Symbols and definitions*

| | | |
|---|---|---|
| $D_{a\text{-}b}$ | : | number of observed skeletons from age a to age b; it is the *number of the buried* within the *excavated* area; specially: $D_{0\text{-}1}$, $D_{0\text{-}5}$, $D_{5\text{-}14}$, $D_{20\text{-}\omega}$. |
| $x = \dfrac{D_{5\text{-}14}}{D_{20\text{-}\omega}}$ | : | basis for computation through demographic estimators of the type $y = f(x)$. |
| $N = D_{0\text{-}\omega}$ | : | total number of the uncovered buried specimens. |
| $D_{tot} =$ | : | overal number of the *buried* within the whole area S of the graveyard (excavated or not). |
| $d_{a\text{-}b}$ | : | actual number of the dead from age a to age b; it is the unbiased *number of the deceased*. If all specimens in the a-b age-group are buried in the graveyard, then $d_{a\text{-}b} = D_{a\text{-}b}$; otherwise $d_{a\text{-}b} = D_{a\text{-}b}$ + bias. |
| $d_{tot}$ | : | overall number of the *dead* among the whole population during length T (buried or not within the graveyard). |
| $\hat{\ }$ | : | estimated data; specially: $\hat{e}^{\circ}_0$, ${}_1\hat{q}_0$, ${}_5\hat{q}_0$, $\hat{m}$. |
| t | : | natural growth rate (annual); without migration $t = n\text{-}m$; if stationary population, $t = 0$. |
| ${}_{35}F_{15}$ | : | overall general fertility rate (annual); average annual number of born alive children/number of female from 15 to 50 (15 + 35) years of age. |
| DF | : | total fertility rate; average number of born alive children per female during her whole fertile life (15 to 50 years old if not dead before); $DF = 35\ ({}_{35}F_{15})$. |
| $e^{\circ}_0$ | : | life expectancy at birth (average age at death). |
| ${}_bq_a$ | : | probability of death between age a and age a + b; number of dead between a and a + b/living population of age a. Specially ${}_1q_0$ = infant probability of death (before 1 year of age); ${}_5q_0$ = probability of death from birth to 5 years of age. |
| m | : | crude death rate (annual). |
| n | : | crude birth rate (annual). |
| P | : | average size of living population (throughout the T period of time). |
| T | : | period of time during which the graveyard has been in use (burial period). |
| S | : | overall burial area (excavated or not). |

Table 2 - *Mehrgarh, MR2 graveyard: Sex distribution of the adults and age distribution of the immatures (non-adults); N = 99 specimens*

| ADULTS : 73 (73.7%) | | | IMMATURES : 26 (26.3%) | | | | | |
|---|---|---|---|---|---|---|---|---|
| ♀ | ♂ | ⚥? | 0-2 | 2-5 | 5-9 | 9-12 | 12-14 | 14-18 |
| 28 | 20 | 25 | 3 | 5 | 9 | 5 | 1 | 3 |
| 38% | 28% | 34% | 11.5% | 19% | 35% | 19% | 4% | 11.5% |

Table 3 - *Mehrgarh, MR2 graveyard: Estimates of demographic parameters (Bocquet & Masset's method)*

$$\hat{e}^{\circ}_{0} = 23.67 \pm 4.78$$

$$_{1}\hat{q}_{0} = 0.284 \pm 0.029$$

$$_{5}\hat{q}_{0} = 0.452 \pm 0.064$$

$$\hat{m} = \hat{n} = 0.0421 \pm 0.0067$$

$$_{35}\hat{F}_{15} = 0.165 \pm 0.021$$

$$\widehat{DF} = 5.79 \pm 0.74$$

$$N = 99$$

$$\frac{D_{5-9}}{D_{10-15}} = 1.5$$

$$\frac{D_{5-14}}{D_{20-\omega}} = 0.205$$

$e^{\circ}_{0}$ = life expectancy at birth.
$_{1}q_{0}$ = infant probability of death.
$_{5}q_{0}$ = probability of death under 5 years of age.
n = crude birth rate.
m = crude death rate.
$_{35}F_{15}$ = overall general fertility rate (annual).
DF = total fertility rate (per female).

Table 4 - *Number of the buried individuals (D) and of the deceased (d, corrected data) and estimates of the bias for the under-1-year group, the under-5-years group and the whole population (0-ω)*

| | 0-1 | 0-5 | $0\text{-}\omega$ | $\frac{0\text{-}20}{0\text{-}\omega}$ |
|---|---|---|---|---|
| D | 3 (3%) | 8 (8%) | 99 | 26% |
| d | 47 (28%) | 75 (45%) | 166 | 56% |
| d/D | 15.67 | 9.37 | 1.68 | |
| $\frac{d-D}{D}$ | 93.6% | 89.3% | 40.4% | |

$$d_{5-\omega} = D_{5-\omega} = 91.$$

Table 5 - *Different estimates of the minimum population size (P) according to the length of the burial period T (in years); the basic burial density is: 1.7 specimens per sq.m.*

| T (in years) | P (mini) |
|---|---|
| 25 | 2161 ±186 |
| 50 | 1084 ±93 |
| 100 | 550 ±46 |
| 300 | 210 ±15 |
| 500 | 158 ±9 |

burial density = 1.7 specimens / m2

$$S = 800 \text{ m2}$$

$$D_{5-\omega} = d_{5-\omega} = 91.$$

$$D_{tot} = 1360.$$

$$d_{tot} = D_{tot} \cdot \frac{d_{0-\omega}}{D_{0-\omega}} = 2280 \pm 270.$$

Table 6 - *General diagram of the overall interpretative process with relations between data, hypotheses, discussions and conclusions (which can be used as new hypotheses for next steps)*