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SUMMARY

During 1995-1999, excavations took place on a Roman burial site in Tiel (Gelderland, The Netherlands), first by the State Service for Archaeological Investigation (ROB) and later by the Hendrik Brunsting Stichting (HBS) of the Free University of Amsterdam (AIVU). Approximately 400 graves were unearthed, including graves containing no human remains. The 191 graves with burnt bones contained the cremated remains of 199 individuals, consisting of 44 males, 47 females, 56 non-adults, 39 adults of indeterminable sex and 13 individuals of unknown sex and age. In nine graves the remains of two individuals had been interred. For the determination of sex and age the recommendations of the Workshop of European Anthropologists (WEA) and Brothwell (1980) were used. For 164 remains thin microscopic sections were made to establish age at death more accurately. Consequently, for those graves containing only a few fragments of cremated remains, an estimation of age could still be determined microscopically. Histological inspection revealed pseudopathological changes due to fungal invasion. Until now such changes have not been reported for cremated remains. True pathological changes could be demonstrated in 41 individuals, varying from antemortem tooth loss to healed fractures and benign tumours. Apart from the cremated human bones, animal remains were found in 98 graves. In 73 of the cases these remains had accompanied the dead on the pyre. In 25 cases the animal remains were unburnt (Groot, 2000). Unfortunately, not every grave has yet been dated one by one. As a result the demographic reconstruction was applied to the entire life span of the burial site, *i.e.* from the middle of the first century AD until the middle of the third century AD.

KEY WORDS

Roman, burial, cremations, sex and age determination, histological age determination, pathology, fungal invasion.

INTRODUCTION

In the summer of 1991, during surveys in the municipality of Tiel (Gelderland), amateur archaeologists[1] came across what appeared to be the remains of a Roman burial site. Potsherds and the remains of cremated human bones had been brought to the surface by ploughing. The amateur archaeologists estimated the size of the site as no more than one hectare. The municipality of Tiel had planned a major building expansion in the same area. In 1995, the State Service for Archaeological Investigation (ROB) carried out a small-scale excavation in order to establish the extent of preservation of the graves. Most of them turned out to be reasonably well preserved. The decision was then made to excavate the site completely because it might turn out to be the best-preserved Roman burial site in The Netherlands. In 1996 the Archaeological Institute of the Free University of Amsterdam (AIVU) took over the project from the ROB, and carried out three consecutive summer campaigns, ending in 1999. Excavations are still (December 2000) in progress but have moved on to the settlement to the southeast of the burial site. Presently the work is carried out by the 'Hendrik Brunsting Stichting' (HBS), the excavation division of the AIVU. The extent of the burial site turned out to be much larger than originally thought, *i.e.* between five and six hectares (Figure 1).

So far, approximately 400 graves had been excavated[2]. Apart from the graves, traces were found of round and square ditches originally dug around the graves to make a small mound over the burials. These ditches had filled up naturally over the years. Only 191 graves contained cremated bones. These remains were buried after a certain 'ritual' had been performed. After the deceased had been cremated on a pyre, sometimes together with pottery, personal belongings and in some cases a piece of meat, the residue was either raked together and put in a hole dug for this purpose, or the bone fragments were separated from the other remains and buried. In some cases these remains were supplemented with unburnt plates, dishes and a piece of meat, put next to the human remains in a hole and covered with soil.

The main objective of our study was to establish sex and age at death of the individuals. Furthermore we tried to determine if a relationship existed between the sex of the deceased and the shape of the surrounding ditches. Haalebos (1990) suggested that the difference between round and square ditches could be related to the sex of the buried person. Out of the 400 graves, 191 contained cremated human remains. Although 198 graves were examined, seven animal refuse pits will not be considered as graves (Groot, 2000), and consequently not taken into account for further calculations. Originally, only 61 graves were examined (van den Bos, 1998). These graves were selected for two reasons. Firstly, they were supposed to contain enough material in order to determine sex and age at death. Secondly, they represented equal numbers of graves with a round, a square or no surrounding ditch at all.

The archaeological results of the excavation will only be incorporated in this study insofar as they are useful for the understanding of the anthropological data. Unfortunately, not all graves have yet been dated one by one. As a result the demographic reconstruction was applied to the entire life span of the burial site, *i.e.* from the middle of the first century AD until the middle of the third century AD.

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[1] Members of the association 'Beoefenaren Archeologie Tiel en Omstreken' (BATO).
[2] Including the round and square ditches containing no central burial.

MATERIAL AND METHODS

The contents of the graves were sieved with running water through mazes with a width of 10, 2.5 and 1mm. The bone fragments were separated from the other remains and left to dry. Then they were sieved again, but this time without water and using sieves with round holes of 10 and 3mm. The remains on each sieve were weighed. This was done to establish the rate of intactness according to Maat (1997). The rate of intactness was calculated by dividing the weight of the remains larger than 10mm by the overall weight of the remains larger than 3mm. The result might vary from zero, meaning that all the remains passed the 10mm sieve, to one, meaning that none of the remains passed the 10mm sieve. After examining the remains of 118 Merovingian graves from Wageningen, Maat (1997) suggested that a search for and analysis of cremated adults was most rewarding if the cremations contained a weight of over 150 grams of fragments larger than 10mm, regardless of their rate of intactness. For the non-adults[3] Maat (1997) suggested a weight of the remains on the 10mm sieve under 150 grams, together with a rate of intactness less than 0.6. For our study the complete and unselected remains from all the 191 graves were examined to test the approach developed by Maat for its usefulness on different types of sites. There could be a difference in nature of the state of the remains between sites. The cremated remains from Wageningen were for instance deposited in earthenware containers, whereas the material from Tiel, except for two cases, was buried directly in the ground. Such differences in burial tradition might result in a different fragmentation of the cremated remains. Therefore, not only the remains on the 10mm sieve but also the remains passing the 10mm sieve were examined. The remains passing the 3mm sieve were discarded because of extreme fragmentation and contamination with dirt and gravel.

The temperature reached during cremation can be established by means of studying the colour and texture of the cremated remains (Holck, 1996). The colour of the fragments may vary from light brown, when a combustion temperature of approximately 200°C is reached, to old white (circa 800°C).

For the determination of sex and age we used most but not all recommendations of the Workshop of European Anthropologists (WEA) and Brothwell (1981). The fragmentary state of the cremated remains was a limiting factor to the interpretation of the morphology. Therefore, those parts relevant for the determination of sex, if present, were selected and used to establish a 'positive sex determination' (male/female), a 'possible sex determination' (male?/female?) or an 'unreliable sex determination' (male??/female??).

Criteria:

Male/female	At least three sex characteristics were present, and the robustness of the bone fragments confirmed the diagnosis.
Male?/female?	Only one or two sex characteristics were present, but these were not convincing.
Male??/female??	The determination was unreliable and depended only on the robustness of the bone fragments.

[3] In our study someone younger than 20 years of age.

For non-adult individuals a distinction between the sexes could not be made because of similar bone features. The age of a non-adult could be established either by means of dental development, or from the age of twelve years on by means of the status of epiphyseal fusion of long bones.

In addition a possible age of each individual was established by means of bone histology. During life, the structure of bone tissue is subject to change due to modelling, replacement and remodelling. Between the age of 30 and 40 years this process of bone resorption and synthesis is in balance (Hoedemaeker, 1991). As one grows older, relative resorption starts to dominate. During the ageing process the original quantity of (interstitial) lamellar tissue decreases, whereas the number of Haversian systems (osteons) and osteon fragments increases. For our study a qualitative age determination was used after Herrmann et al. (1998)[4]. For proper comparison selected pieces of femoral shaft from the excavated remains were used. If these were not available and other long bone samples were used, the histological age determination might differ somewhat because age related remodelling need not be similar in different parts of the skeleton. Nevertheless, an assessment whether an individual was young or old could still be made.

According to the method of Frost (1958), modified by Maat et al. (2000), a microscopic transverse section of the midshaft of one of the long bones, preferably the femur, was made. First the sample was dripped with Cyanolit® in order to prevent chipping during sawing. Then a slice of approximately 2-3 cm was sawn off transversally to the shaft axis with an iron or fret saw. The slice was subsequently ground on one side only on wet waterproof sandpaper (3M®) of successively 220 mesh and 1200 mesh which had been attached to a grinding or glass plate with Vaseline®. When the slice had reached the required smoothness, which could be observed by means of a dissection microscope, it was cleaned with running distilled water and brushed underwater with a soft brush after which the slice was left to dry. When fully dried the slice was glued with its smooth side to an object glass with Cyanolit® and dried under light pressure. Then the other side of the slice was ground first on dry sandpaper (3M®, 80 mesh) until a thickness of about 0.1mm was obtained. Next, this side of the section was ground again on wet sandpaper (220, 1200 mesh) to a thickness of 20-30 micron. Afterwards the section was rinsed again with running distilled water and cleaned underwater with a soft brush. The thin section was dried and covered by Entellan® and a glass coverslip, which had been cleaned in xylene. After drying the section could be examined under a light microscope with or without a polarisation filter.

Insofar present, pathological changes to the bone were examined according to Ortner and Putschar (1985) and recorded.

Laarman (ROB) and Groot (2000) had studied the animal remains found between the human bone fragments. Their results were summarised and discussed here only briefly for the understanding of the physical anthropological data.

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[4] The reference collection of Barge's Anthropologica, *i.e.* the Rilland-Bath collection and the results of Herrmann et al. (1989) were used.

RESULTS

The distribution of weight

The total weight for each grave of bone fragments larger than 3mm varied from 0.1g to 1540g with an average weight of 381g (Figure 2)[5]. The distribution of the weight of the material that stayed on the 10mm sieve (0-1091g, mean weight: 192g) differed from the distribution of the total weight as shown in Figure 3. The average total weight (of remains larger than 3mm) of all male individuals was 938g, and that of all female individuals 676g. The results with respect to weight are summarised in Table 1. Figure 4 shows the distribution of the total weight of the male individuals including the 'possible' and 'unreliable sex determinations'. Out of 30 males the remains of 15 weighed more than 1000g whereas out of the 30 female individuals only the remains of three individuals weighed more than 1000g (Figure 5)[6]. The remains of the three 'possible' males weighed less than 800g (Figure 4). The remains of the eight 'possible' females weighed less than 900g (Figure 5). The fragments larger than 3mm of the non-adults weighed never more than the category 500-600g (Figure 6), with an average weight of 100g (Table 1). The average total weight (of remains larger than 3mm) of the double adult interments was 1376g (Table 1). The average total weight (of remains larger than 3mm) of the double interments containing the remains of an adult together with those of a non-adult was 545g (Table 1). The remains of the seven adult individuals who were found in graves together with a non-adult were the ones in the lowest weight classes of Figure 7. The two double adult interments were situated at the higher end of Figure 7. The remains of the individuals for whom only a sex determination was not possible had an average total weight (of remains larger than 3mm) of 139g (Table 1). The individuals for whom age and sex could not be established had an average total weight (of remains larger than 3mm) of 35g (Table 1). In most graves hardly any vertebral fragments could be identified.

Rate of intactness related to the possibility of sex- and age determination

The rate of intactness was calculated for 189 graves[7]. Figure 8 shows the rate of intactness as function of the weight of the burnt remains larger than 10mm. The vertical line at 150g represents the sectioning line Maat (1997) suggested in his study for all cremated remains from Wageningen. Of the adult individuals, 63 met the requirement that their portion of fragments larger than 10mm weighed more than 150gr.

Out of these 63 adult individuals the sex of 53 could be determined with certainty while in seven of them a 'possible' sex could be established. For two individuals only an 'unreliable' sex determination could be given. For one adult individual sex could not be determined at all. Of the adult individuals, 76 fell on the left side of the line. Out of these 76, the sex of seven could still be given unequivocally, and for five the sex determination was 'possible' while the outcome for six individuals was 'unreliable'. The sex of 58 individuals could not be determined at all.

[5] From 189 graves. The two graves that got mixed up accidentally not included.
[6] Only single interments have been taken into account for these calculations.
[7] The remains of one adult and one non-adult are not taken into account for these calculations because the remains have accidentally been mixed up.

According to the sectioning line of Maat (1997) in Figure 9 it should be rewarding to determine the age of 63 individuals macroscopically[8]. In fact, only for 51 the age at death could be diagnosed. A total of 76 individuals fell on the left side of the line. Of these an estimation of age could still be given for 14 individuals. For 25 individuals it could only be established that they were adults.

Table 2 summarises the loss of demographic information with respect to cremations of adults in case only the cremations with a weight of more than 150 grams on the 10mm sieve had been examined. Such a criterion would have selected 48 of 60 possible cases of sex determination (80%), and 45 of 55 possible age determinations (82%). Table 3 shows whether analysis of the selected remains would have altered the sex distribution compared to the analysis of the complete collection. The numbers in Table 2 and Table 3 do not correspond with the results in the text because in these tables only the remains of adults with a 'positive' sex determination or no sex determination at all were used. The 'probable' and 'unreliable' sex determinations were omitted.

Of the 41 non-adults identified macroscopically[9], 34 fit the requirements of a weight on the 10mm sieve less than 150g, and a rate of intactness under 0.6 (83%).

Temperature
Almost all the bone fragments from the Roman burial site in Tiel had a whitish colour. Occasionally bone fragments were found which were dark grey, bluish and sometimes even black. A whitish colour indicated a combustion temperature of about 800^{0}C (Holck, 1996). The condition of the artefacts that accompanied the deceased produced other indicators of the temperature reached during the cremation process. Tin-bronze alloys and glass had melted, which occurred at temperatures between 750^{0}C and 900^{0}C (Wahl and Kokabi, 1988; Holck, 1996). A final indicator for the combustion temperature was the histology of the bone tissue itself. The texture of osteons was still intact. Holck (1996) stated that if a temperature above 900^{0}C was reached it would have been destroyed.

General demography
Within the 191 graves that have been examined[10] a total of 199 individuals were found. Nine graves contained the remains of two individuals. In three cases the remains of a female and a non-adult were buried together. Three males were buried together with a non-adult. In one case an adult of 'unknown' sex was probably buried with an infant. In the other two the remains of a male and a female were found. The general results with respect to the sex and age at death distribution are shown in Figure 10.

Sex distribution of adults
The sex of 70 adult individuals could be determined with certainty ('positive'), while in 12 a 'possible' and in nine an 'unreliable' sex determination was achieved. Table 4 summarises the occurrence of the main sex features used for the sex determination. The 70 individuals consisted of 35 males (18% of the total number of individuals) and 35 females (18% of the

[8] Histological methods of age determination may establish an age of an individual even when only a few grams of fragments remain.
[9] Seven non-adults could only be identified by means of histological age determination. In this paragraph they are included in the group of 57 individuals for whom sex could not be determined.
[10] In this case the two graves which accidentally got mixed up will be used for the demographics.

total number of individuals), the adult individuals from the double interments (five females and five males) included. The 12 'possible' determinations consisted of four males and eight females. Five males and four females belonged to the 'unreliable' sex determination class. For 52 individuals the sex could not be established.

Age distribution

The morphological age at death determination for cremated remains of adults depended in most cases on the degree of endocranial suture obliteration. In spite of the high temperatures reached by the fire, sutures of the vault were usually reasonably well preserved. Of the total number of 199 individuals 56 were non-adult and 113 adult. The results are summarised in Figure 11. The individuals for whom could only be said that they were adult (N = 45) were omitted in Figure 11 but shown in Figure 12 where a distinction was made between male and female. Apart from the seven non-adults who were interred with an adult, 49 other non-adults were found[11]. The non-adults make up 28% of the total number of 199 individuals. Figure 13 shows the age distribution of the non-adults in five years intervals.

Because the age categories of 20-40, 30-60 and 40-80 years overlap and thus result in an inconsistency, we also applied the demographic analysis method of Acsádi and Nemeskéri (1970) whereby the age diagnoses of all 199 individuals were equally assigned to their related age intervals of five years (Figure 14). For instance, when four individuals morphologically fell into the interval 20-40 years, one each was assigned to the (sub) intervals 20-25, 25-30, 30-35, 35-40 years. If only one individual fell into the interval 20-40 years then 0.25 individual was assigned to each five years interval. In the case of the adult individuals for whom no age could be established the assignment occurred over all five years intervals from 20 to 80. Figure 15 shows the distribution of the relative number of deaths over intervals of five years, separately for males and females. As suggested by Acsádi and Nemeskéri (1970), the males with a 'possible' sex determination were used in the calculations as if they had been diagnosed as certain males. The same goes for the 'possible' females. As also suggested by Acsádi and Nemeskéri (1970), the non-adults were equally divided over the males and females. The same was done for Figures 16-18. Using the distribution of intervals of five years, the relative number of deaths (dx) could be calculated as shown in Table 5[12] and Figure 15, where a distinction was made between males and females. As in Figure 14, a peak showed up in the categories 0-5 and 35-40 years. In the age class 20-25 years the females seemed to have a higher peak than the males. From the same distribution the relative number of survivors (lx) in any interval could also be calculated as shown in Figure 16. A distinction was made between males and females. Starting-point was that at time of birth the number of survivors was 100%. By subtracting the relative number of dead (dx) for each interval from the original percentage and using the outcome for the next interval a curve resulted as shown in Figure 16. The life expectancy in years (ex) could be calculated by dividing the total number of years of life left at a given time for the entire population (Tx) by the total number of individuals living at that time (Lx). Figure 17 shows the distribution of life expectancy for both males and females. It declined over the years with a slight peak between 60-65 years for the males. Finally the probability of death (qx) was calculated as the quotient in any interval from the relative number of dead (dx) and the relative number of survivors (lx). Figure 18 shows the probability of death for males and females separately. They both had a peak between 55-60 years, although the females had a slightly higher peak in this interval.

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[11] Including the seven non-adults only recognised by means of histological age determination.

[12] Table 6 and Table 7 show the calculations for males and females separately.

Histological age determination
Differences between young and old individuals could be clearly seen in the micrographs of thin sections (Figures 19, 20 and 21). Figure 19 shows a thin transverse section of the femur shaft of an individual between 7 and 12 years old. The density of osteons was very low if compared to Figure 20, which was of the femur shaft of an individual between 40 and 50 years old. In three cases the histological age determination differed considerably from the macroscopic morphological age determination. In two cases an adult age was given macroscopically, while microscopically a non-adult age was diagnosed. For the third individual the opposite was the case.

General pathology
In some instances changes could be demonstrated which were caused by diseases or mechanical trauma. The number of individuals showing such changes was 41, i.e. 21% of the total number of inspected individuals. The pathological condition of one individual could not be identified due to the fragmentary state of the bone.

Traumas (mechanical)
Three individuals showed signs of healed fractures of various bones. One male individual (20-40 years) had a healed fracture of the tibia shaft. Another male individual (30-60 years) showed a fractured and poorly healed metacarpal bone. The third male individual (30-40 years) suffered from more severe injuries although the fractures had healed. He showed a healed impression fracture of one of his vertebral bodies and an infected fracture of his femur and tibia.

Spondylolysis (separation of the vertebral arch from the vertebral body)
One female individual between 20 and 40 years showed this stress/ fatigue fracture in one of her vertebrae in her lower spine.

Enthesopathies (isolated ossifications of connective tissue)
An enthesopathy is believed to be a tissue response to local mechanical strain. One female individual between 20 and 40 years showed a solitary ossification of the patellar ligament, which is also called 'patellar tufting'.

Periostitis (inflamed periosteum)
In eight cases (three females between 30 and 40 years, one between 40 and 50 years, one between 40 and 60 years, two males between 35 and 45 years, and one individual for whom sex could not be established between 40 and 60 years) a non-specific superficial bone inflammation was found in one of their long bones. Two individuals of which the sex could not be established, one between 20 and 25 years and the other between 15 and 20 years showed periostitis of the vault. The above mentioned male individual between 30 and 40 years with several fractures showed signs of periostitis of the cranial vault as well.

Osteomyelitis (entire bone infection)
Osteomyelitis, an infection of the entire bone caused by pyogenic bacteria, was found in five individuals. Two female individuals between 20 and 40 and between 50 and 60 years showed osteomyelitis of their skull. One female between 30 and 40 years and one male between 20 and 40 years showed osteomyelitis of several long bones. One female individual between 40 and 60 years showed signs of osteomyelitis of her big toe.

Purulent arthritis (bacterial joint infection)
The above mentioned male individual between 30 and 40 years with several fractures also showed a purulent arthritis of one of his hip joints.

Tumours
For two individuals a benign tumour could be demonstrated. One infant of seven to twelve years old had a chondroma, a benign cartilaginous tumour of its tibia. The other individual (a male between 50 and 60 years) had an osteoma (a benign osseous tumour) on the cranial vault.

Nutrition deficiencies
Two young individuals between 0 and 5 and between 15 and 20 years suffered from a general chronic nutritional deficiency (cachexia) which could be demonstrated by histological analysis. With respect to their age they showed too many extremely wide Haversian canals in the cortical layer of their long bones.

Degenerative arthropathies (degenerative joint affections)
Two individuals (one male and one female both between 40 and 60 years) showed signs of vertebral osteophytosis (degenerative intervertebral disc disease). The female individual also suffered from peripheral osteoarthritis (joint cartilage degeneration).

Diffuse Idiopathic Skeletal Hyperostosis (DISH)
Four individuals (one male between 20 and 40 years and one between 35 and 45 years, one female between 60-80 years and one individual between 20 and 40 years for whom sex could not be established) showed signs of DISH. This disease, previously known as Forestier's disease results in the systematic and ongoing ossification of connective tissue and cartilage of various parts of the body. Muscle attachments and ligaments are especially affected.

Osteoporosis (bone loss by age or by lack of use)
In microscopic sections used for the histological age determination (Figure 21), severe osteoporosis was discovered in seven individuals: five females between 20 and 40, 30 and 40, 30 and 50, 40 and 60 and between 50 and 60 years, in one male individual between 40 and 60 years and in one young individual between 15-20 years. Osteoporosis manifests itself as a decrease in the volume of bone tissue, and in a decrease of its architecture and strength.

Teeth and jaws
Seven individuals (two females between 20 and 40 years, one between 30 and 40 years, two males between 40 and 60 years, and two individuals for whom sex could not be established, one between 20 and 40, the other between 40 and 60 years) showed alveolar bone resorption due to antemortem tooth loss. In three cases (one female between 30 and 40 years, one male between 35 and 45 years and one individual for whom sex could not be established between 40 and 60 years) carious lesions could be demonstrated. One male individual between 40 and 60 years showed chronic periodontitis (an inflammation of tooth attachment tissue) and changes from a torus maxillaris *i.e.,* bony outgrowths along the inner side of sockets of the upper jaw.

Pseudo pathology
Histological examination established the presence of so called *pseudo-pathological* changes *i.e.,* tape-like focal destruction tunnels extending from the periosteal-/ endosteal surfaces and

from the Haversian canals, and `popped` osteocyt lacunae (Figure 22). They were found in 84 cases of the 164 microscopically inspected cremations (51%).

Animal bones

Animal bones were frequently found among the burnt human bones[13]. In 91 graves animal remains were found. Out of these 91 graves, 25 contained a total number of 44 fragments of unburnt animal bones. Most of the fragments could not be identified beyond being mammalian (39.2%). Amongst the identified species were cow, pig, sheep or goat, chicken and geese.

Females seem to have been accompanied in more or less the same frequency by animal remains as the males, 57% and 68% respectively.

Structures surrounding the graves

The results from the sex determinations were used to sort out a possible difference between males and females with respect to the way they were interred after being cremated. There seemed to be no difference in the way men and women were interred within round or square structures. The cremated remains of fourteen males were buried within a round ditch, ten were placed within a square one. The remains of 13 females were buried in the center of a round ditch, and a same number had been placed within a square one.

The remains of the non-adults appeared to have been interred within the smallest structures of the burial site, *i.e.* smaller than five metres in diameter and twice as often within square features as in round ones.

DISCUSSION

In this paper we described the results of the excavation of a Roman burial site in Tiel. The major objectives of this study were to determine the age at death and sex of the cremated individuals. Furthermore we tried to establish a relationship between the sex of the deceased and the shape of the surrounding ditches.

The remains in general

The size of the cremated remains varied from waste to pieces with a length of several centimetres. The total weight of the remains varied between 0.1 and 1540 grams. After experimentally (under laboratory conditions) cremating a corpse weighing around 70 kg the remains amount to approximately 2700 grams for males and 1840 grams for females (Holck, 1996). In none of the cases from Tiel did the remains amount to these averages as suggested by Holck (1997). Many archaeologists regard the deposition of the burnt remains in a separate pit after a cremation to be part of a ritual where only a small amount of the total remains of the original pyre were collected and buried (Wahl and Kokabi, 1988). Consequently fewer burnt bones are found than could be expected from a complete cremation of an adult.

[13] After separating them from the human bones, the animal remains from 26 graves were sent to F. Laarman of the ROB, for determination of species. M. Groot (2000) examined the remaining animal fragments.

A second explanation for the small amount of remains from Tiel is the fact that from the Middle Ages on, the fields had been ploughed, bringing parts of the remains to the surface, and consequently diminishing the amount of surviving remains.

A third explanation for the fact that the burnt remains do not amount to the averages found by Holck (1997), is that because females usually contain more body fat than males the fire will reach higher temperatures for a longer time during the cremation. Consequently, their less robust bones become even more brittle and will deteriorate faster in the soil so that fewer bone fragments survived. Indeed, in the case of Tiel many of the pits dug for the burnt remains were too large for the amount of burnt remains found in them. Could it be that originally these pits contained more burnt bone fragments, but that deterioration of these brittle bones resulted in a pit with less fragments as originally deposited?

The small amount of remains of a child's cremation was usually ascribed to the fragile state of its fragments, which then decay when buried (Wahl and Kokabi, 1988; Bridger, 1996; Mays, 1998). Because of the fragile state of infant bone its mass should decrease considerably during cremation. Holck (1997) however showed in experiments that this was not necessarily the case. The opposite might even be true. The bodies of infants contain relatively little fat and much water so that their cremation takes up to three times as long as that of an adult. If an infant's cremation was not complete, biological decay after burial would have affected the bone more than it would have done if the cremation had been complete, since in the latter case the bone fragments would have hardened. Holck (1996) suggested that because an infant cremation might have taken more time and would have needed much more wood, infants might have been cremated together with an adult on purpose. The adult body fat would guarantee complete cremation of the infant. Hence, possibly, a practical reason for our finds of mixed adult and non-adult remains in several graves.

The remains after cremation

The size of the fragments depends on the temperature of the fire, as well as on the way the pyre was built, the way in which the fire was extinguished (for instance by rain), the way in which the remains were collected after cremation, and finally the way in which they had been interred (Wahl and Kokabi, 1988). The temperature reached during cremation can be established by means of the colour of the cremated remains. Recently Holck (1996) analysed the changes in shape, size and colour of bone during cremation. For a complete cremation of an average person of 70 Kg, approximately 140 Kg of wood was needed (Holck, 1996). Under ideal conditions, not taking into account rain, snow, frost or wind (McKinley in Roberts, 1989), a cremation fire would have to last at least eight hours to lay bare the skeleton (Holck, 1996; Wahl and Kokabi, 1988). In the open air a cremation could and probably did take much longer, because keeping a fire at a constant temperature between 800^{0}C and 900^{0}C is difficult, if not impossible. That a temperature between 800^{0}C and 900^{0}C was often reached was indicated by the colour of the bone fragments, which were mostly bluish white. The colour might vary from light brown (when a temperature of approximately 200^{0}C was reached) to chalk white (around 800^{0}C). When these high temperatures were reached, the bone not only turned white but also it also shrunk up to 30% in size, deformed, developed cracks and fragmentised. During the cremation several pieces of bone must have burst because of the heat and would have landed outside the center of the fire. These fragments did not endure the highest temperatures, consequently they turned light brown, black and blue.

Melted bronze and glass objects were found between the remains in several graves. It corroborated that temperatures were reached between 750 and 900°C (Wahl and Kokabi, 1988; Holck, 1996). Furthermore, we found that the texture of osteons was still intact, consequently a temperature above 900°C had never been reached.

Depending on the temperature of the fire, remains are rather brittle directly after cremation (Stiner et al., 1995). They will feel rather solid when excavated because burnt bone fragments take up fluid from the soil (Wahl, 1982). The good preservation of the cremated remains results from its burnt state. Calcium phosphate in burnt bone is more stable than that in unburnt bone (Herrmann et al., 1990). Frost and water influence the fragmentation of the buried remains (Herrmann et al., 1990). After water has entered the bone, little cracks occur. Whenever cremated bones are found together, they appear to be reasonably well preserved with occasionally larger fragments. When the material is collected and sieved these larger fragments often fall into smaller pieces. This influences the rate of intactness. The way in which relatives had selected the bone fragments from the remains of the pyre might also have contributed to the size of the fragments (Wahl and Kokabi, 1988). When only a few burnt bones were found in the grave, the relatives might have made a (symbolic) selection so that only the larger parts ended up in a grave separate from the remains of the pyre (Wahl and Kokabi, 1988). The remains of the pyre, often referred to as 'Brandgruber Gräber', should therefore not be considered as proper graves, but rather as refuse pits.

Weight

The average weight of the remains of males was 35%, and that of females 37% of the expected experimental average weight of remains after cremation by Holck: 2700g and 1840g respectively. In the studies from Vorst in Germany (Bridger, 1996) and Stettfeld in Germany (Wahl and Kokabi, 1988) these percentages came respectively to 31% (males at Vorst), 26% (females at Vorst), 28% (males at Stettfeld), and 29% (females at Stettfeld). In comparison with other Roman burial sites in Germany (see Wahl and Kokabi, 1988) the material from Tiel tended slightly towards a higher average weight. Perhaps the remains were sorted out more carefully after cremation, and later during excavation.

The remains of the non-adults weighed less than 100g (average). But this data was hard to interpret since we discovered some of the very young non-adults due to the application of the microscopic age determination method.

If compared to single burials, the average weight of the double adult interments was as expected rather high: 1375g.

Rate of Intactness related to the possibility of sex- and age determination

The criteria as suggested by Maat (1997) seemed adequate for the material from Tiel. For adult individuals it seemed most rewarding to make an attempt to determine sex- and/or age of a cremation if its fragments larger than 10mm weighed more than 150 gram, regardless of the rate of intactness. The sex distribution of the cremated population would not have been altered if only the thus selected remains would have been studied. A selection before determination would have rendered unnecessary the analysis of 34 out of 83 cases (41%). Table 3 demonstrates that analysis of the selected remains would not have altered the sex distribution compared to the analysis of the complete collection.

The remains of 39 out of 41 non-adults met Maat's (1997) requirements for non-adults too (weight $\leq$ 150 g and rate of intactness < 0.6). Another five non-adults were interred together with an adult. Still we would like to observe that the remains of two youngsters weighed between 150 and 300 grams. The weight of the infants younger than 5 years should not be more than 150g, as Maat (1997) suggested for all non-adults. The advantage of the application of criteria as suggested by Maat (1997) would be that the anthropological research effort on cremated remains would become more efficient and 'cost-effective'. The procedure eliminates those remains, which would yield no satisfactory results concerning sex determination. But, since in our case the 65 macroscopically settled age determinations could be extended with another 99 diagnoses by microscopic analyses, the determination of age by means of macroscopic criteria alone would have been too sparing. Only a few small bone fragments were already sufficient for a microscopic age diagnosis.

Demography

Sex

We chose not to use metrical methods as suggested by WEA (1980), Brothwell (1980) and Herrmann et al. (1990) for establishing sex because metrical methods are problematic even when applied to complete and unbent skeletons, let alone when only a few fragments have survived the fire. Defined landmarks are harder to pin down. Landmarks used for measurements are usually unreliable in cremated material since most fragments are distorted and shrunken. In addition errors of measurement are more serious because a mistake of only 1mm on a short distance measurement may affect the outcome substantially. Sex determinations may be influenced not only by subjectivity of the researcher, but also by shrinkage of the bone tissue due to the cremation process. If for instance the cremated remains of a male with a fragile bone texture would be examined, the final sex diagnosis might be 'female' by mere decrease in size since sex determination results may also be assessed by bone robustness. Male bones are thicker and thus better withstand the heat of the fire and later fragmentation.

As might be expected from other demographic studies (Acsádi and Nemeskéri, 1970; Waldron, 1994), we found only a very small difference between the number of males and females[14]: 44 males and 47 females. When the ratio males/females differs greatly from one to one, part of the population might be missing due to selective migration or war. In many wars males are buried far from home (Acsádi and Nemeskéri, 1970). In our population this did not seem to have been the case.

Age distribution of adults

The age distribution at the time of death showed a slight peak between 20 and 25 years of age and a substantial peak between 35 and 40 years (Figure 14). These peaks were often ascribed to maternal perinatal death. In this case however the number of males and females dying in these age categories was approximately equal, allowing room for speculation. When the life expectancy table made by Ulpianus in the third century AD is consulted it seems unlikely that ages at death above 60 years were reached at all (in: Acsádi and Nemeskéri, 1970). Both in our study, and according to Ulpianus average life expectancy at birth was 30 years. But that

[14] Including the 'possible' and 'unreliable' sex determinations.

low expectancy was mainly due to the high perinatal death rate of children of those days. At the age of twenty years calculated life expectancy was still another twenty years, resulting in an age at death of ca. 40-45 years. This was almost similar to life expectancy in Roman Valkenburg (Lonneé and Maat, 1998) and in the late medieval period of Western Europe (Onisto et al., 1998) as well as seen these days in developing countries (Waldron, 1994). As can be expected from a pre-industrial population (Acsádi and Nemeskéri, 1970), the end of the curve in Figure 16 declines rapidly because the number of individuals reaching a high age decreased dramatically.

Age distribution of non-adults

Fifty-six non-adults have been found in our study (28% of the total number of individuals). The number of non-adults appeared to be what might be expected in case of a pre-industrial population (Acsádi and Nemeskéri, 1970; Brothwell, 1994; Waldron, 1994). According to Plinius (Nat. Hist. 7,16,72) infants younger than one year were not a official member of the population, and were consequently not to be cremated and buried in the official burial place. Acsádi and Nemeskéri (1970) suggesed that the death rate in the first years of life was the highest, because of the life conditions under which infants were growing up during the Roman period. Wahl and Kokabi (1988) estimated that in prehistoric societies between 45 and 60% of children died during their first years of life. This seemed to have been the case for Tiel as well.

But, since the above mentioned burial conditions might not be the sole reason for the relative shortage of youngsters if compared to Wahl and Kokabi (1988), it could not be excluded that our number of died youngsters was realistic. Life at rural Tiel might not have been that bad!

Demography according to Acsádi and Nemeskéri (1970)

Using the 'relative' numbers of deaths/survivors in the demographic analysis according to Acsádi and Nemeskéri (1970), the 199 individuals from Tiel could be distributed over age intervals of five years. This seemed to give a more realistic representation than the more common direct representation where age categories of 20-40, 30-60 and 40-80 years overlap, consequently giving an inconsistency. The danger with the former method is however, that the representation may become too smoothly distributed over the age intervals. Consequently, a possible small and characteristic under- or over- representation in one or more age at death intervals would become overlooked. Even taking this into consideration, females in our study still tended to show a slight peak in the 20-25 year age at death interval. It might have been due to maternity mortality (Figure 15).

Pathology

In comparison with Nijmegen, which is also a city in the province of Gelderland in The Netherlands (Ruys in: Haalebos, 1990; 5.85%), and with Vorst in Germany (Bridger, 1996; 0%), Tiel showed a rather high frequency of pathologic changes (21% of the individuals). Was this the result of less fragmentation and better preservation of our material? We do not think so. But we did pay special attention to the detection of pathological changes. It seemed unlikely that the farmers from Tiel were less healthy than their neighbours in Nijmegen.

The male individual between 30 and 40 years who had collected quite a few mechanical traumas must have been seriously invalidated at that time.

So far only two cases of vertebral osteoarthritis were found in the material from Tiel. This is rather surprising since this affection has been reported to be relatively common in an average rural society of the Roman period (Lonneé and Maat, 1998; Hillson, 1996). Certainly the lack of this affection in our sample was due to the severe fragmentation and almost lack of vertebral material.

Fungal invasion

Since all organic components should have been burnt out of cremated bones (Mays, 1998), cremated bone tissue should no longer be affected by (be attractive for) fungi or bacteria after burial. This is probably one of the reasons why burnt bone survives better in the ground than unburnt bone. Nevertheless, we discovered unequivocal microscopic signs of fungal attack in half of the samples! So far, fungus has only been reported in unburnt bone (Hackett, 1981; Piepenbrink, 1986). Could this mean that our samples had been buried and thus been subject to decomposition for rather a long time before being burnt on the pyre? Was such a 'ritual' practised during the Roman Period? Or could there be another reason to explain the presence of fungal invasion? A tentative comparison could be made with a death ritual, which is still practised, on Bali in Indonesia. To give relatives time to save sufficient money for a proper cremation feast, the dead are temporarily inhumated for a few months or even for several years. When enough money is saved by the relatives, the deceased or at least what remains of him or her is dug up and cremated during an exuberant feast (personal communication Mrs van den Bos-Talling; Wahl and Kokabi, 1988). But it does not seem very likely that a similar practice existed throughout the Roman Period since no indications (*e.g.* from antique literature) were ever mentioned to corroborate this hypothesis.

Alternatively, the fungus may have entered the cremated bone fragments because of a nutritious piece of animal meat that originally had been interred as a gift together with the cremated remains. In 25 graves (13%) unburnt animal remains were found. In addition a realistic possibility exists that in many more graves pieces of meat had originally been interred together with the human remains, but that these pieces of meat left no traces since they were boneless. Consequently juices and putrefaction fluids from the meat would be absorbed by the dry cremated bone, making it attractive for the fungi.

Animal remains

In 46% of the 199 investigated graves from Tiel animal remains were found (25 unburnt and 66 burnt). In Nijmegen for instance only 9% (Thijssen in: Haalebos, 1990) and in Vorst in Germany only 1% of the graves (Bridger, 1996) showed animal remains. In the area where Tiel is situated, cultural emphasis might have laid on cremating animal remains together with those of the deceased as a gift for the dead or on adding fresh meat afterwards for the same reason. Females seemed to have been accompanied in more or less the same frequency by animal remains as the males, 57% and 68% respectively.

Structures surrounding the graves

Haalebos (1990) suggested that males were interred within round and females within square structures. For Tiel this could not be attested. The question what these structures could possibly mean stayed unanswered. Still it seemed quite obvious that the remains of the non-adults were buried within the smallest structures of the burial site.

CONCLUSION

From the approximately 400 graves unearthed, only 191 contained the burnt human remains of 199 individuals, including 44 males, 47 females and 56 non-adults. In nine graves the remains of more than one individual were deposited. An estimation of age at death could not only be made by means of macroscopic methods, but also by microscopic methods. The latter method was even applicable in case cremations consisted of only a few fragments of burnt bone. True pathological changes could be established in 41 individuals

Apart from personal belongings, the deceased were accompanied by foodstuff, as well on the pyre as in the final grave. In 91 graves the remains contained animal bones.

The demographic reconstruction appeared to be representative for a rural community during the Roman period. Unfortunately the graves had not yet been dated one by one, so nothing could be said about the number of living individuals at any given time, or the possible over- or under-representation of a sex or age class during a certain part of that period. Still we could conclude that the average age at death of males and females over twenty years of age was 40-45 years. Furthermore an equal number of males and females had been buried.

The microscopic fungal invasion, which we found in many specimens, seemed to confirm that the cremated remains of the dead had been interred together with a fresh piece of foodstuff (meat).

From the investigation of the graves from the Roman burial site in Tiel, it could not be established that from the middle of the first century AD until the middle of the third century AD, a clear sex difference existed between the interments within round or square ditches.

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FIGURES

Figure 1: Map of the burial site. The round and square features represent the ditches originally dug around the graves.

Figure 2: Distribution of the total weight of cremated bones of each grave; N = 199.

Figure 3: Distribution of the total weight of cremated bones of each grave (black), and the weight of the remains on the 10mm sieve (white) over classes of 100g. N = 199.

Figure 4: Distribution of the total weight of cremated bones of males (white), males for whom a sex determination was doubtful (gray), and males for whom a sex determination was unreliable (black), divided over increasing intervals of 100g. N = 38.

Figure 5: Distribution of the total weight of cremated bones of females (white), females for whom a sex determination was doubtful (gray), and females for whom a sex determination was unreliable (black), divided over increasing intervals of 100g. N = 42.

Figure 6: Distribution of the total weight of the burnt remains from the graves containing non-adult individuals, divided over increasing intervals of 100g. N = 41.

Figure 7: Distribution of the total weight of the burnt remains from the double interment graves, two adults (white), adult + non-adult (black), divided over increasing intervals of 100g. N = 9.

Figure 8: Intactness rate plotted against weight of the remains that stayed behind on the 10mm sieve in order to determine the possibility of determination of sex. ▲ = positive sex determination;◊ = 'possible' sex determination; ♦ = unreliable sex determination; - = sex determination not possible; o = non-adults; ■ = two adults; □ = adult and non-adult. The vertical lines are the sectioning lines suggested by Maat (1997).

Figure 9: Intactness rate plotted against weight of the remains that stayed behind on the 10mm sieve in order to determine the possibility of determination of age. ▲ = age determinable of adults; - = age determination of adults not possible; o = non-adults; □ = adults of unknown age; ◊ = two adults of unknown age; X = adult (of unknown age) and non-adult; + = adult (known age) and non-adult. The vertical lines are the sectioning lines suggested by Maat (1997).

Figure 10: Distribution of the number of individuals divided over the classes: male, female, as well as over the age at death classes: adult, 20-40 years, 30-60 years, and 40-80 years. N = 91.

Figure 11: Distribution of the number of individuals divided over the age at death classes: non-adult, 20-40 years, 30-60 years and 40-80 years. N = 124.

Figure 12: Distribution of the number of male and female individuals divided over the age at death classes: adult, 20-40years, 30-60 years and 40-80 years. N = 70.

Figure 13: Distribution of the number of non-adult individuals over five year age at death intervals. N = 56.

Figure 14: Distribution of the relative number of deaths in 5 year intervals. Calculation as proposed by the demographic analysis after Acsádi and Nemeskéri (1970). N = 199.

Figure 15: Distribution of the relative number of deaths (dx) in 5 year intervals, for males and females. N = 199.

Figure 16: Distribution of the relative number of survivors (lx) in 5 year intervals, for males and females. N = 199.

Figure 17: Distribution of the relative life expectancy in years (ex) in 5 year intervals, for males and females; N = 199.

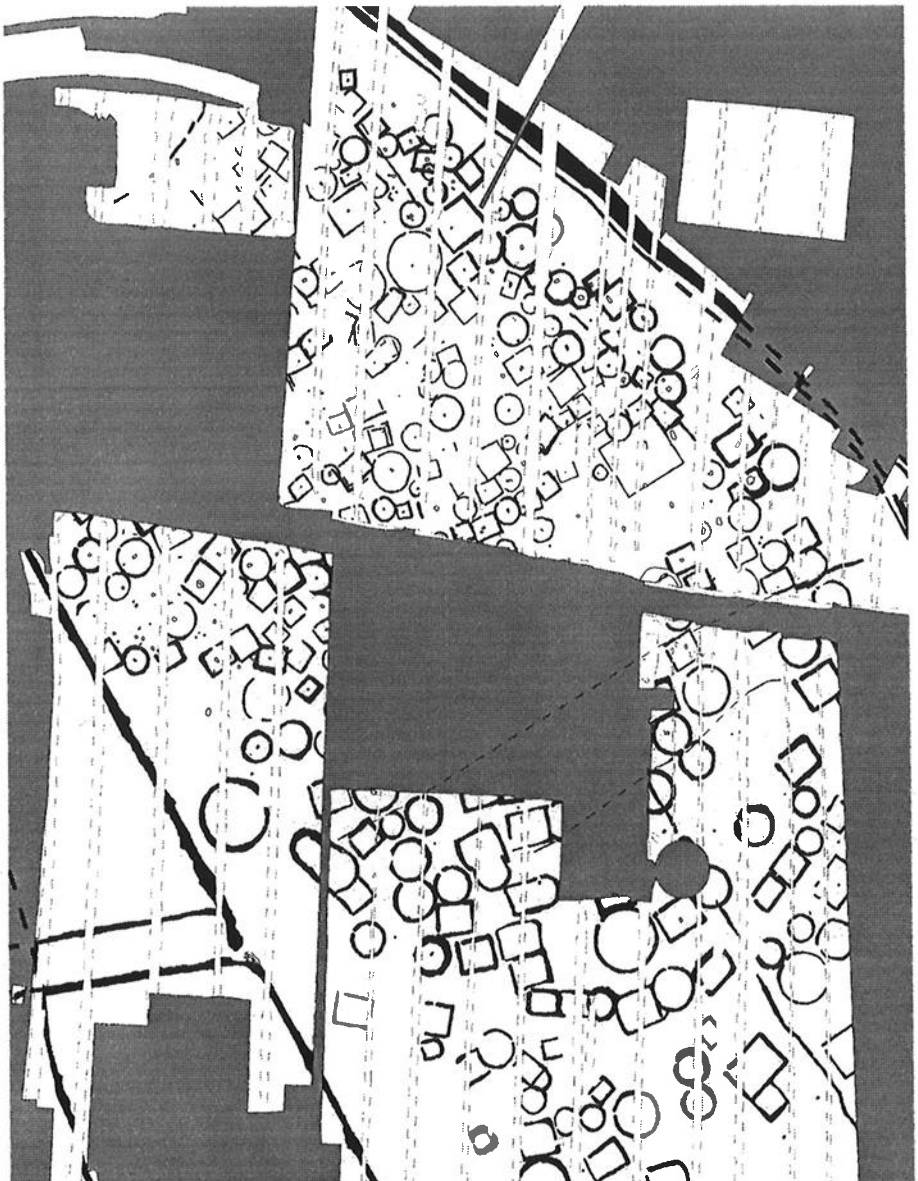
Figure 18: The distribution of the relative probability of death (qx) for males and females, in 5 year intervals. N = 199.

Figure 19: Micrograph of the subperiosteal area of a transverse section of the femur shaft from an individual between 7-12 years old. Only few osteons (1) are visible between the parallel interstitial lamellae (2). Magnification: 100x Leica DMRB, unpolarized light with blue filter, Minolta 8/10x.

Figure 20: Micrograph of the subperiosteal area of a transverse section of the femur shaft from an individual between 40-50 years, in addition to Figure 19 showing signs of osteoporosis. 1 = osteon of normal dimension; 2 = wide Haversian canals. Magnification: 100x, Leica DMRB, Minolta 28/10x.

Figure 21: Micrograph of the subperiosteal area of a transverse section of the femur shaft from an individual between 50-60 years old. Many osteons are visible. Hardly any parallel interstitial lamellae are left over. 1 = periosteal surface; 2 = osteons of the second generation; 3 = osteons of the first generation; 4 = Haversian canal. Magnification:100x, Leica DMRB, unpolarized light with blue-filter, Minolta 28/10x.

Figure 22: Micrograph of the subperiosteal area of a transverse section of the femur shaft from an individual between 30-50 years old. Shown are the tape-like tunnels from fungi and the popped osteocyt lacunae. Magnification: 100x, Leica DMRB, unpolarized light with blue filter, Minolta 28/10x.



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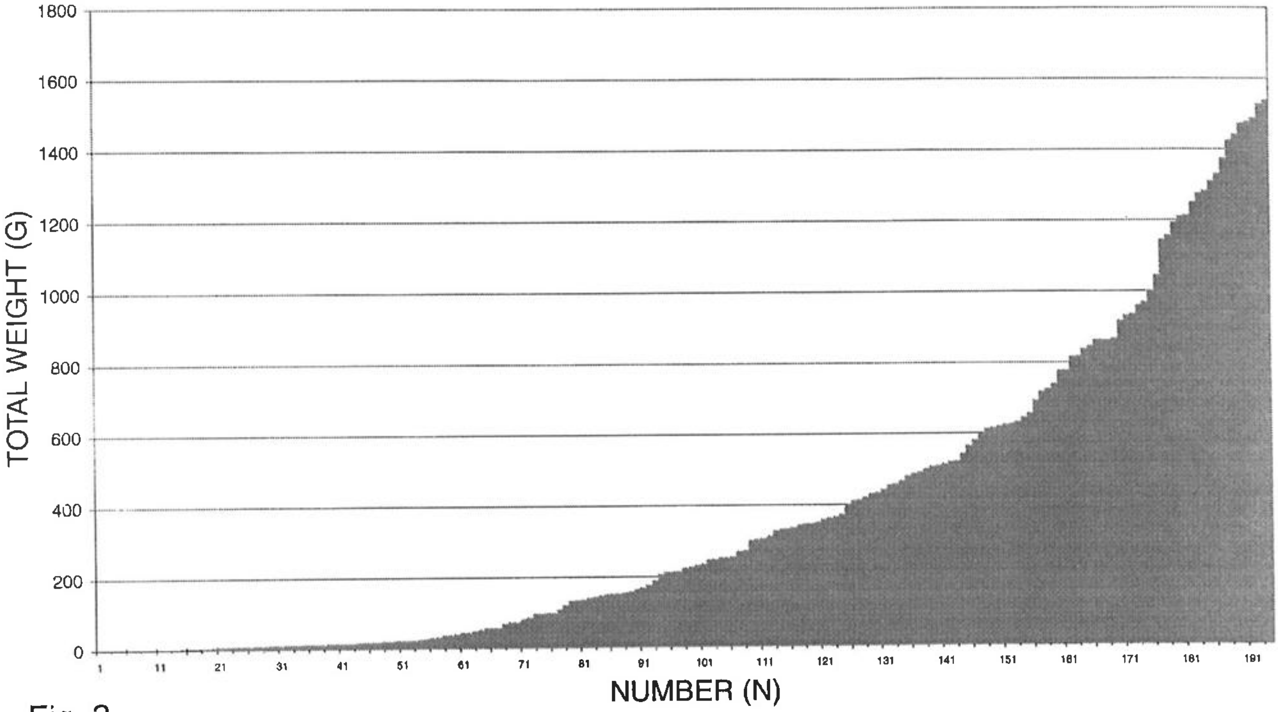
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1400
1200
1000
800
600
400
200
0
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11
21
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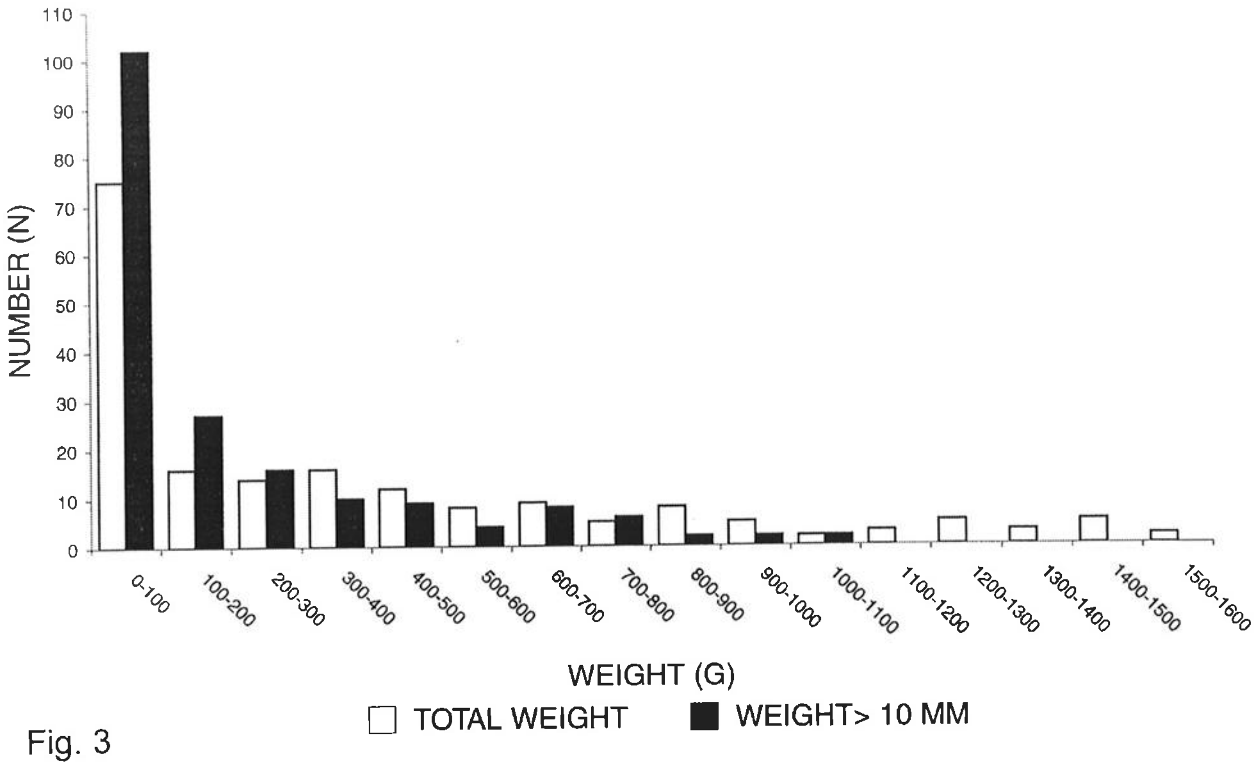
61
71
81
91
101
111
121
131
141
151
161
171
181
191
NUMBER (N)

Fig. 2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700-800
800-900
900-1000
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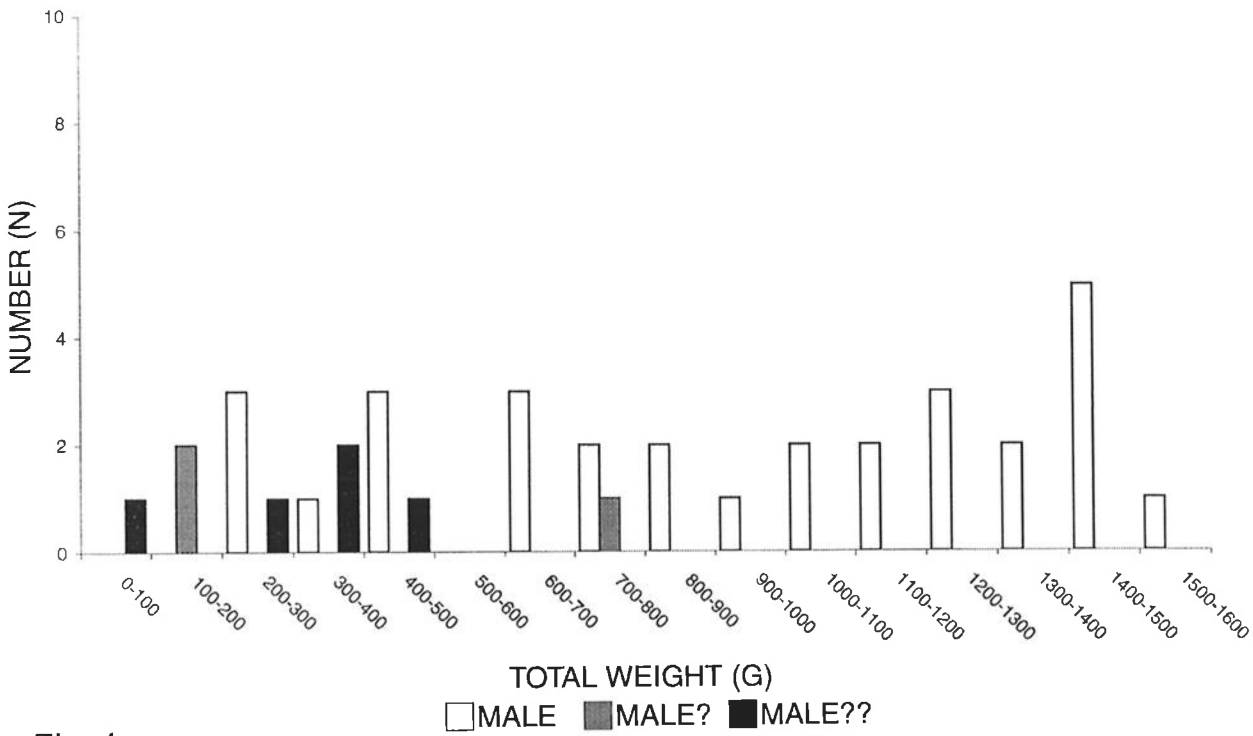
Fig. 3



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800-900
900-1000
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1300-1400
1400-1500
1500-1600
TOTAL WEIGHT (G)
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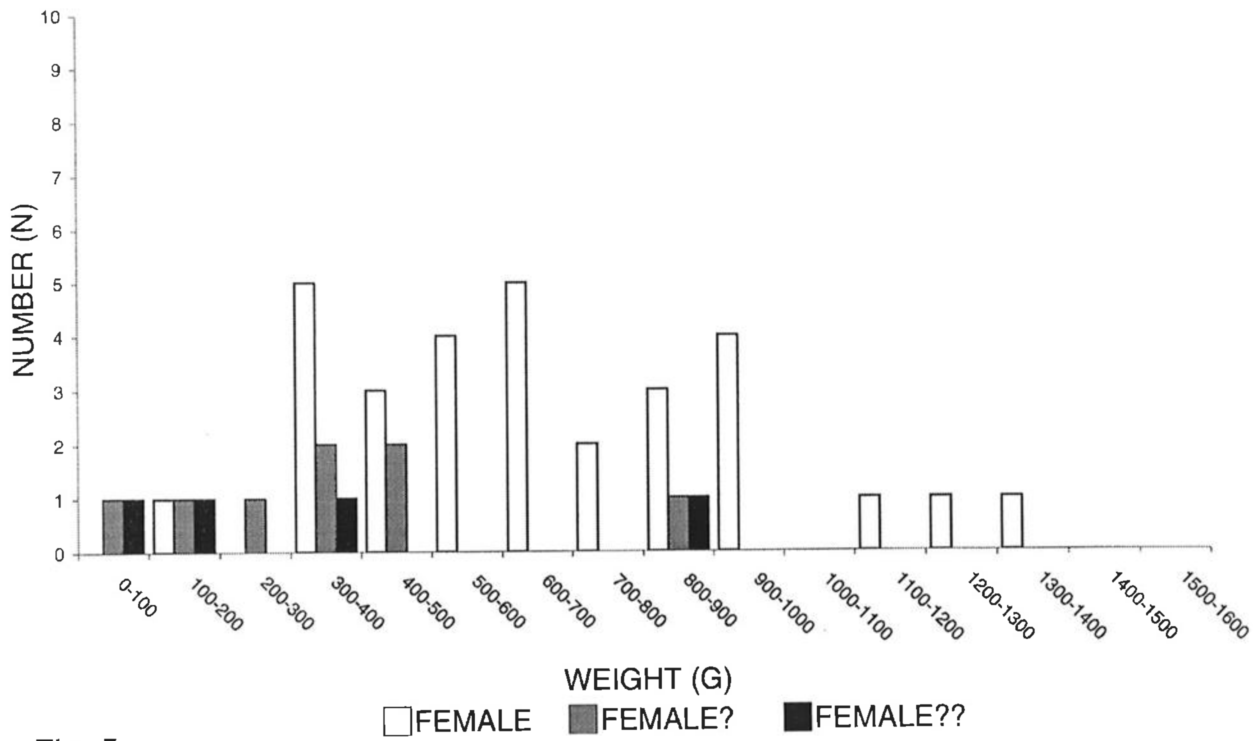
MALE?
MALE??

Fig. 4



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800-900
900-1000
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WEIGHT (G)
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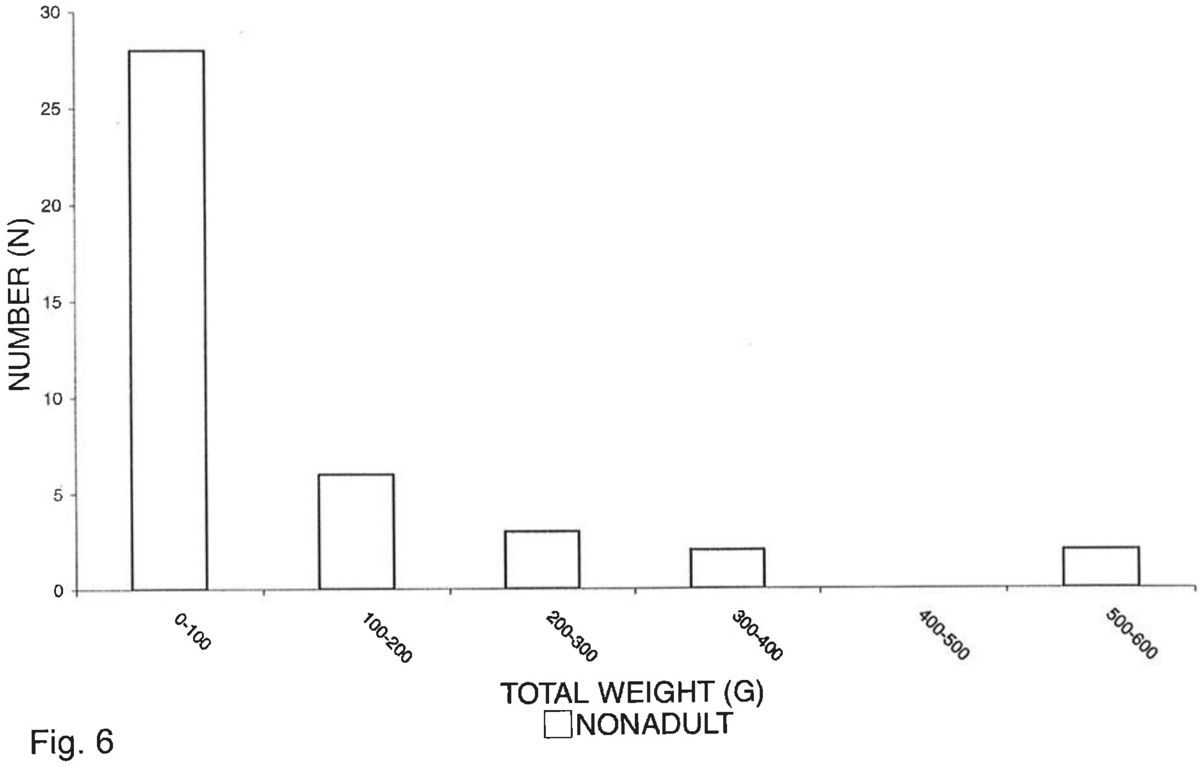
FEMALE?
FEMALE??

Fig. 5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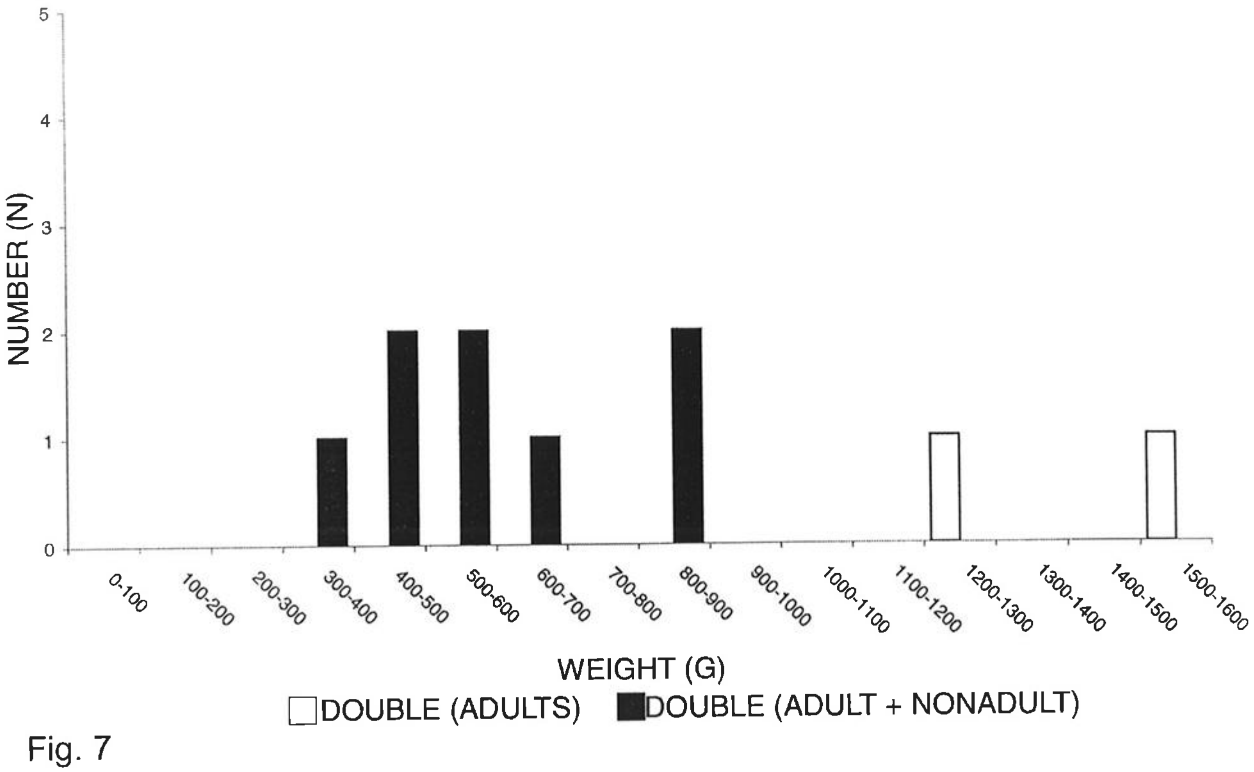
NONADULT

Fig. 6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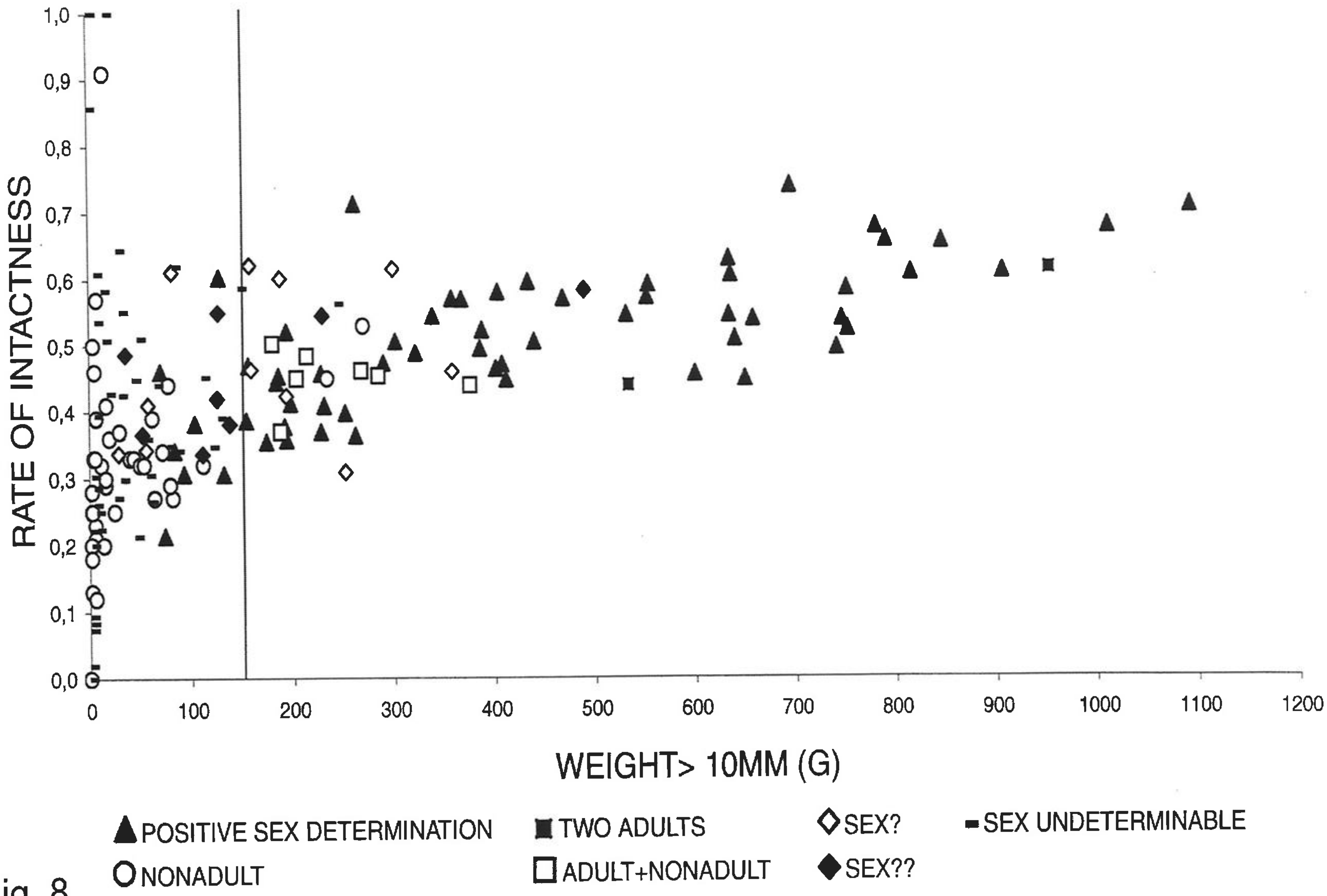
3
4
5
0-100
100-200
200-300
300-400
400-500
500-600
600-700
700-800
800-900
900-1000
1000-1100
1100-1200
1200-1300
1300-1400
1400-1500
1500-1600
WEIGHT (G)
DOUBLE (ADULTS)
DOUBLE (ADULT + NONADULT)

Fig. 7



1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
RATE OF INTACTNESS
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
WEIGHT> 10MM (G)
POSITIVE SEX DETERMINATION
TWO ADULTS
SEX?
SEX UNDETERMINABLE
NONADULT
ADULT+NONADULT
SEX??

Fig. 8

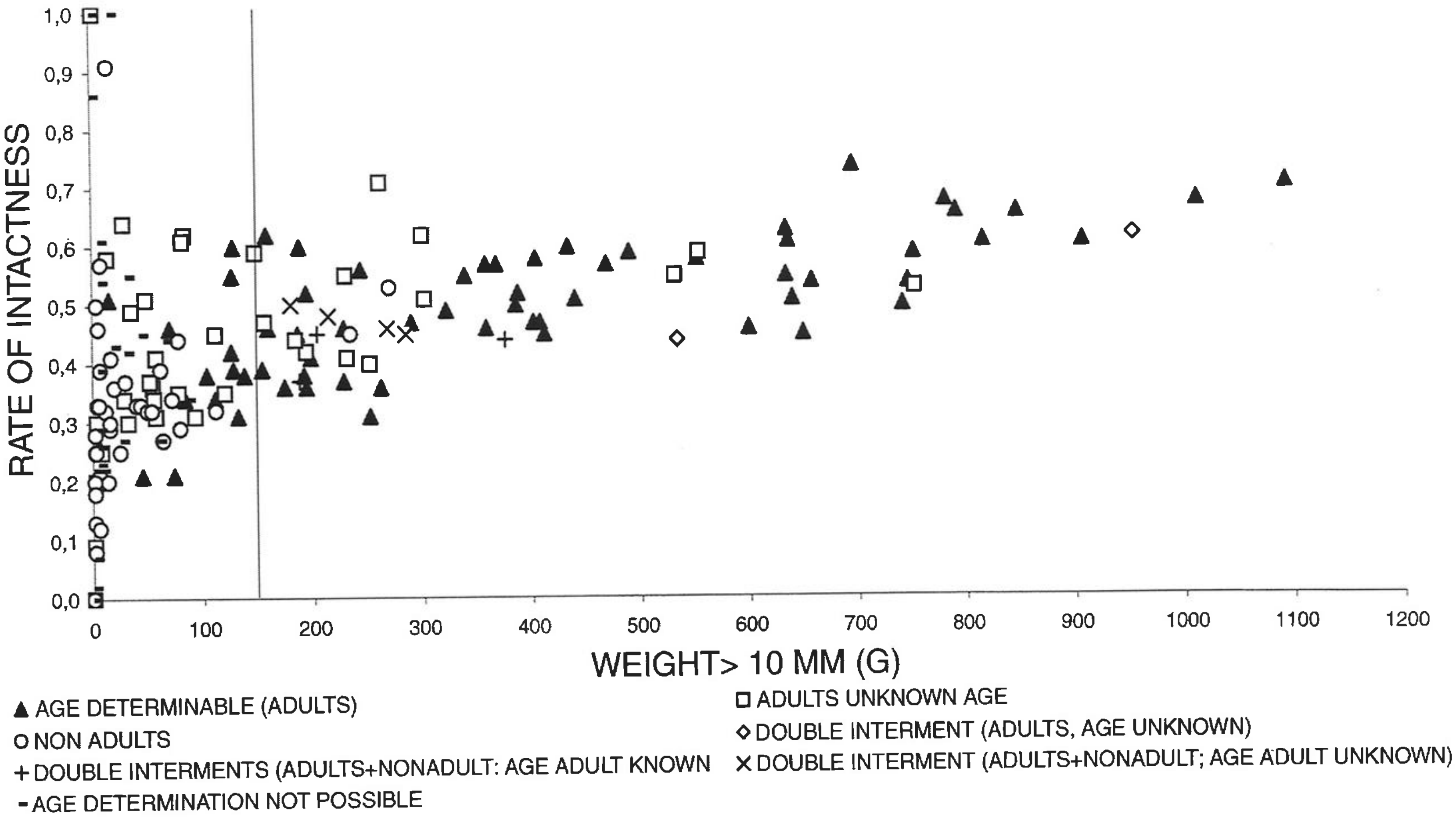

RATE OF INTACTNESS
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
WEIGHT> 10 MM (G)
AGE DETERMINABLE (ADULTS)
NON ADULTS
DOUBLE INTERMENTS (ADULTS+NONADULT: AGE ADULT KNOWN
AGE DETERMINATION NOT POSSIBLE
ADULTS UNKNOWN AGE
DOUBLE INTERMENT (ADULTS, AGE UNKNOWN)
DOUBLE INTERMENT (ADULTS+NONADULT; AGE ADULT UNKNOWN)

Fig. 9


14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
NUMBER (N)
male
male?
male??
female
female?
female??
SEX
ADULT OF UNKNOWN AGE
20-40 YEARS
30-60 YEARS
40-80 YEARS

Fig. 10

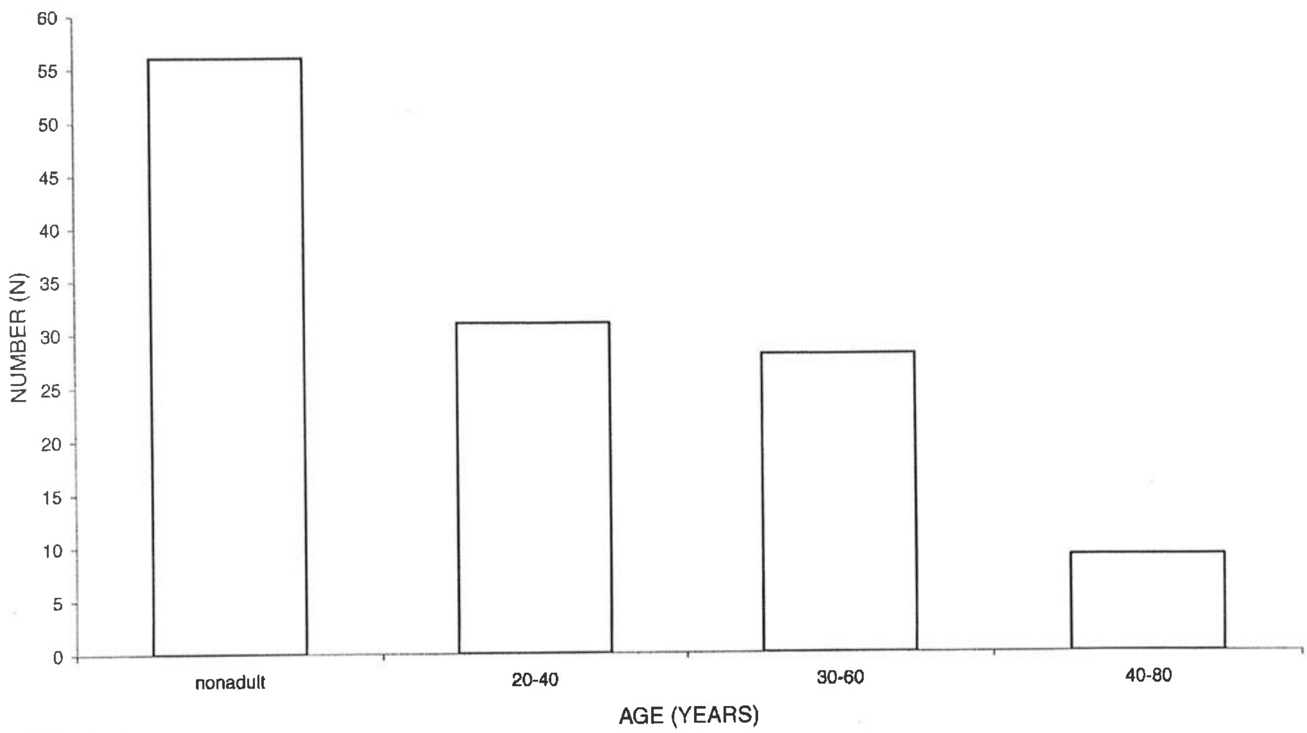

60
55
50
45
40
35
30
25
20
15
10
5
0
NUMBER (N)
nonadult
20-40
30-60
40-80
AGE (YEARS)

Fig. 11

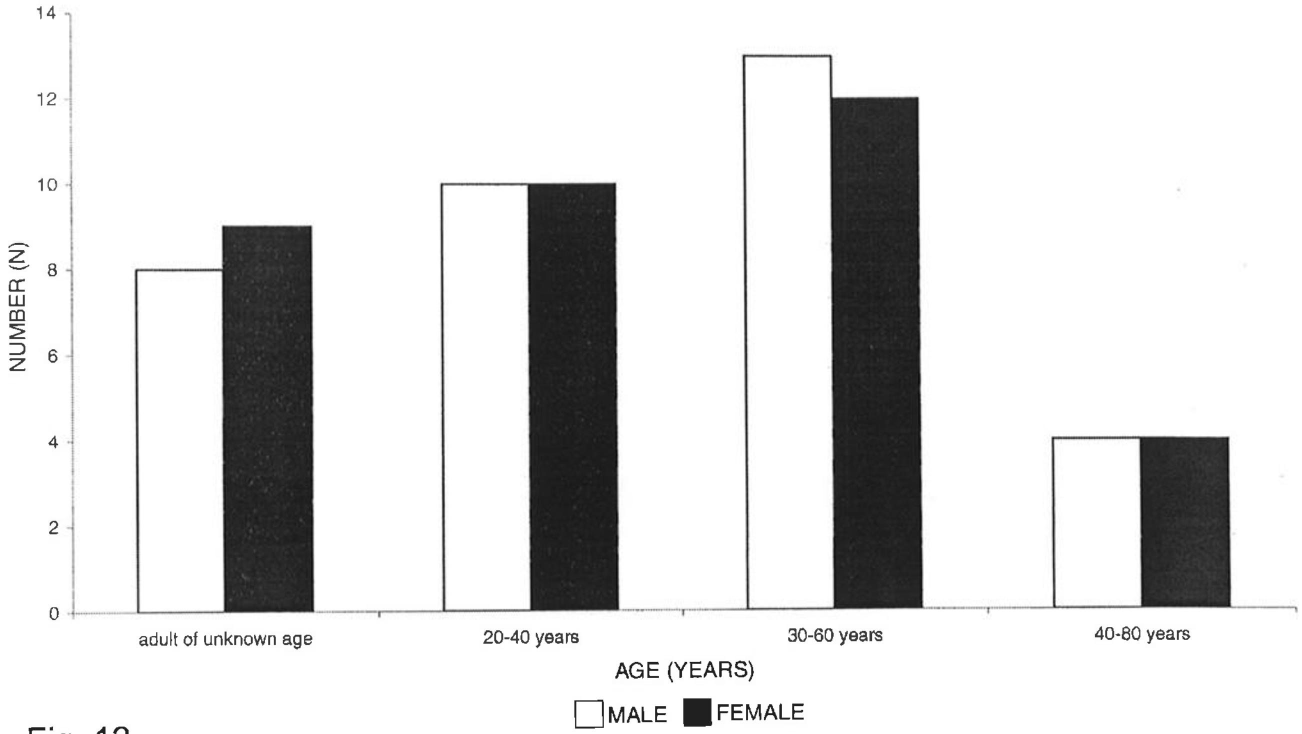

14
12
10
8
6
4
2
0
NUMBER (N)
adult of unknown age
20-40 years
30-60 years
40-80 years
AGE (YEARS)
MALE
FEMALE

Fig. 12

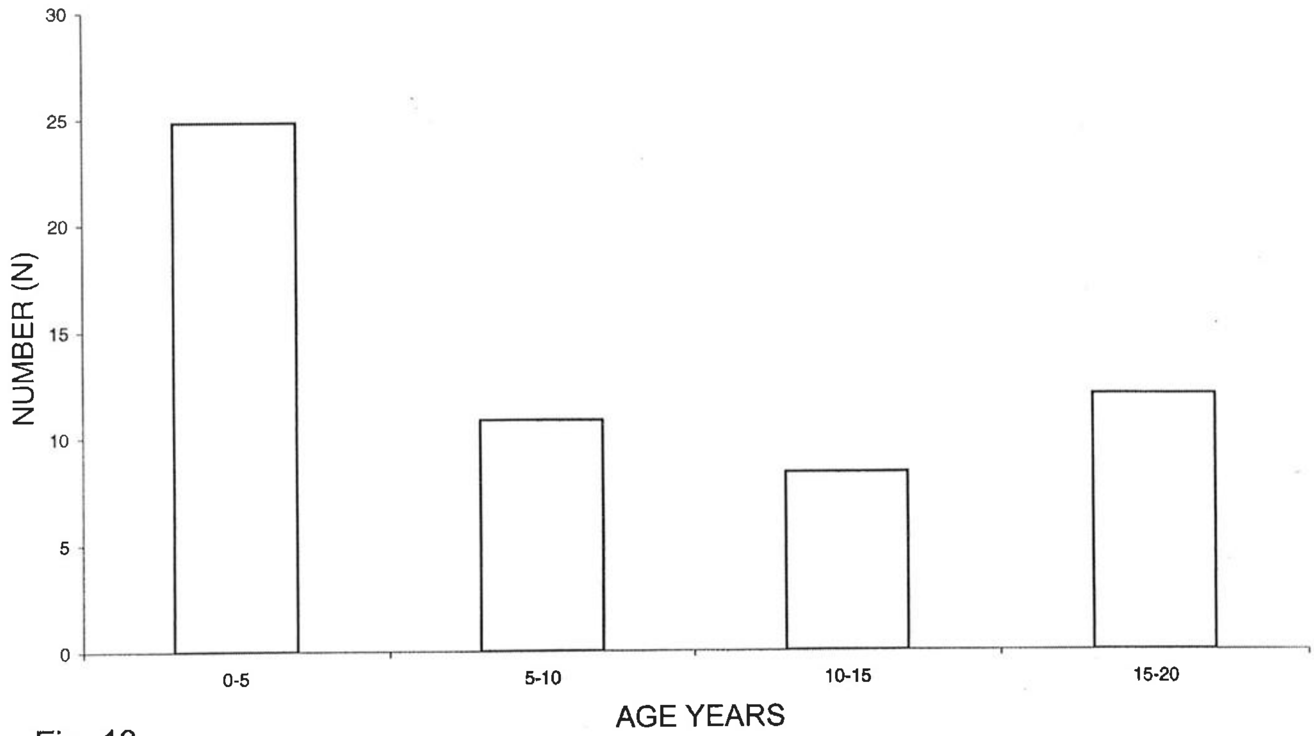

30
25
20
15
10
5
0
NUMBER (N)
0-5
5-10
10-15
15-20
AGE YEARS

Fig. 13

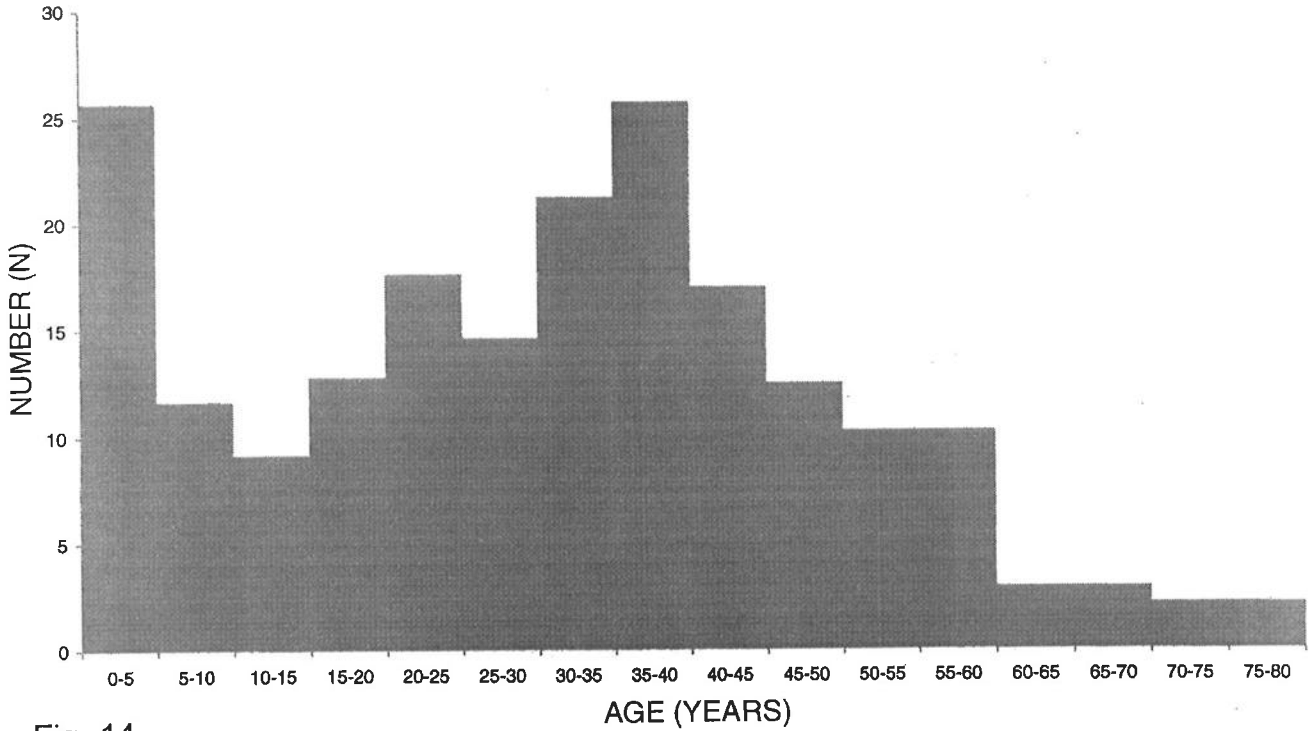

30
25
20
15
10
5
0
NUMBER (N)
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
AGE (YEARS)

Fig. 14

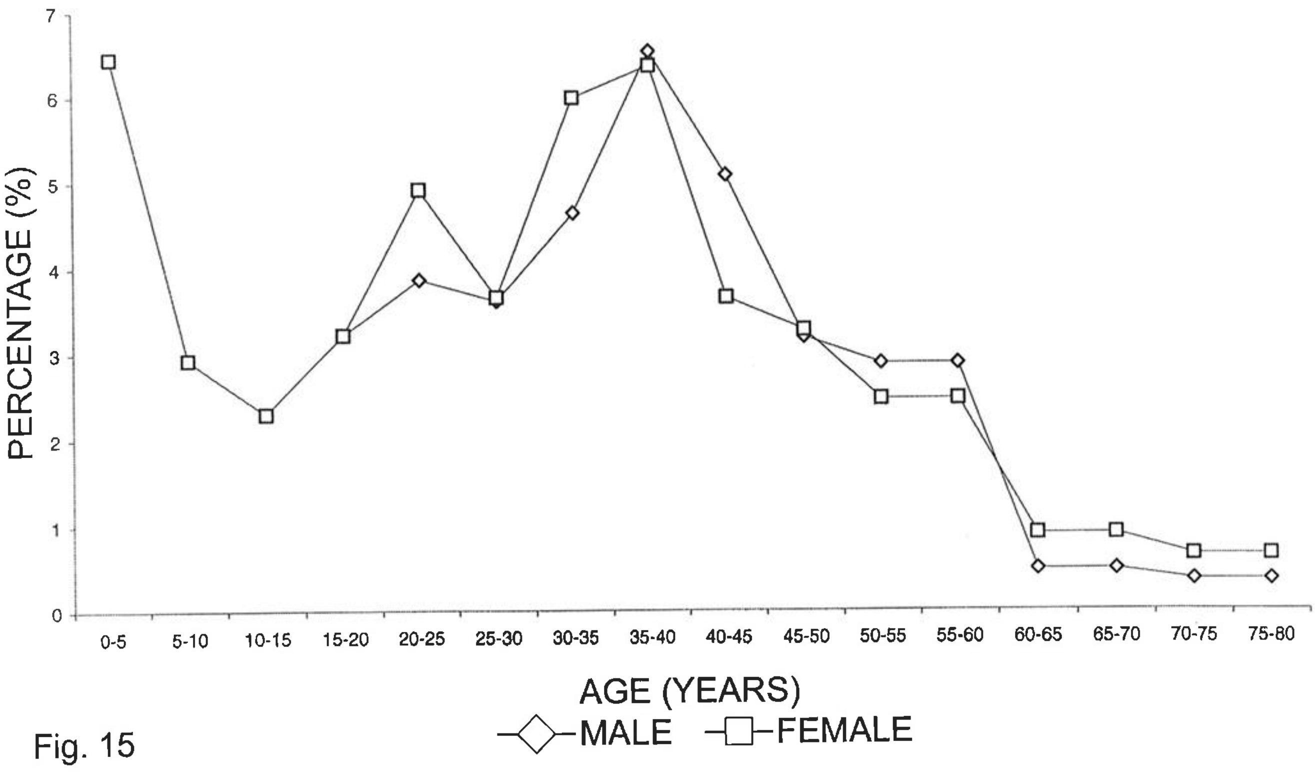

7
6
5
4
3
2
1
0
PERCENTAGE (%)
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
AGE (YEARS)
MALE
FEMALE

Fig. 15

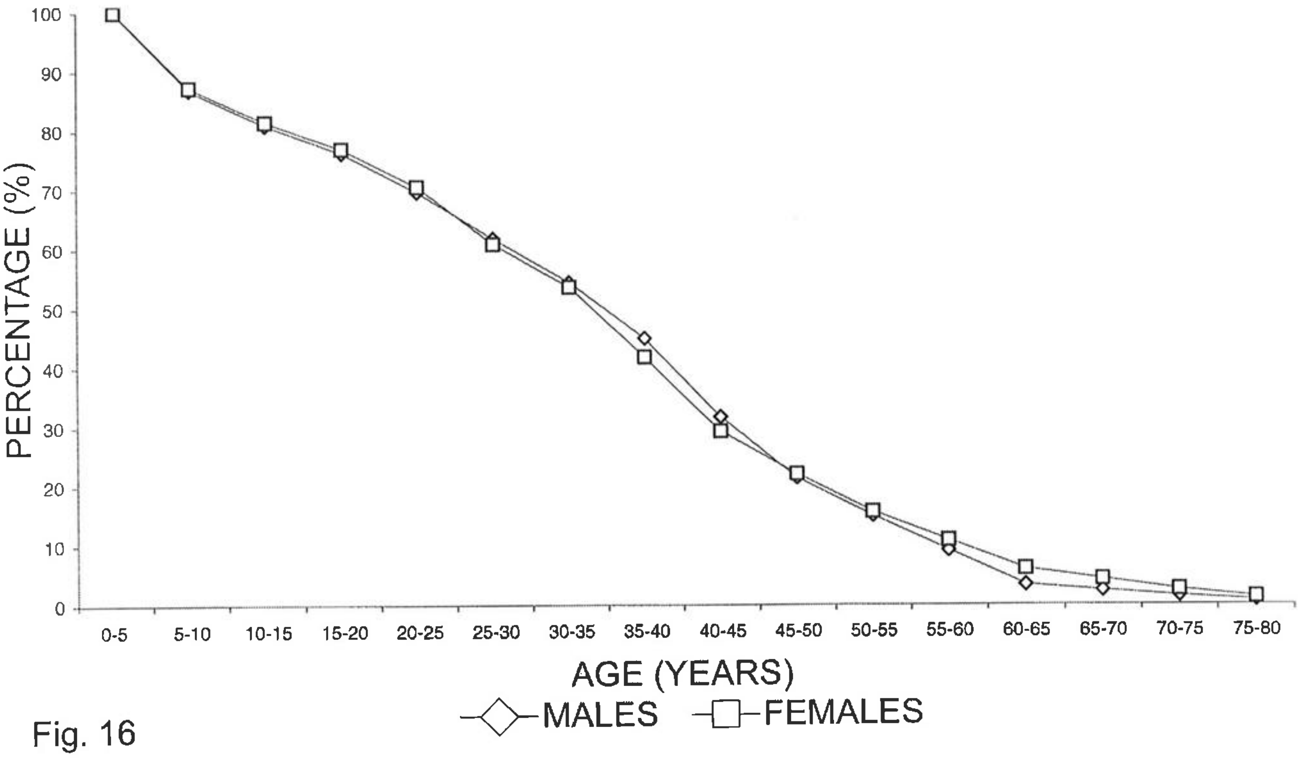

100
90
80
70
60
50
40
30
20
10
0
PERCENTAGE (%)
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
AGE (YEARS)
MALES
FEMALES

Fig. 16

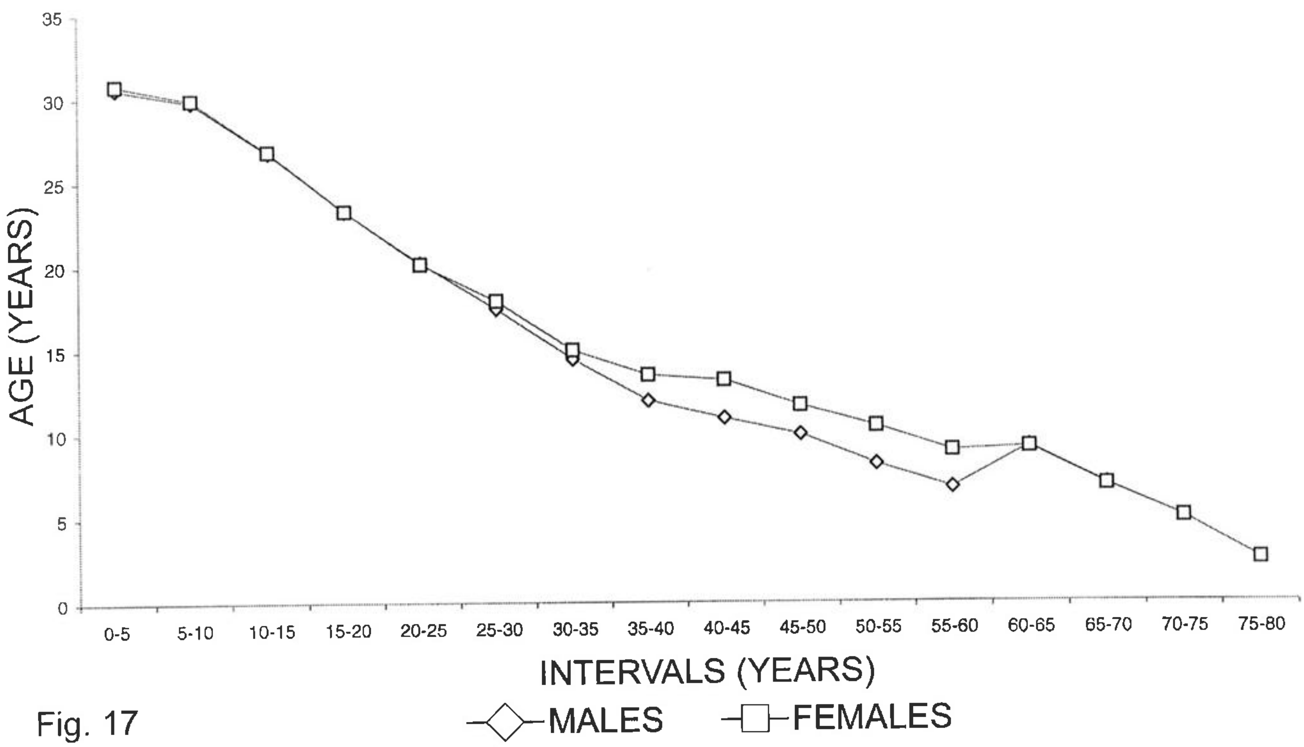
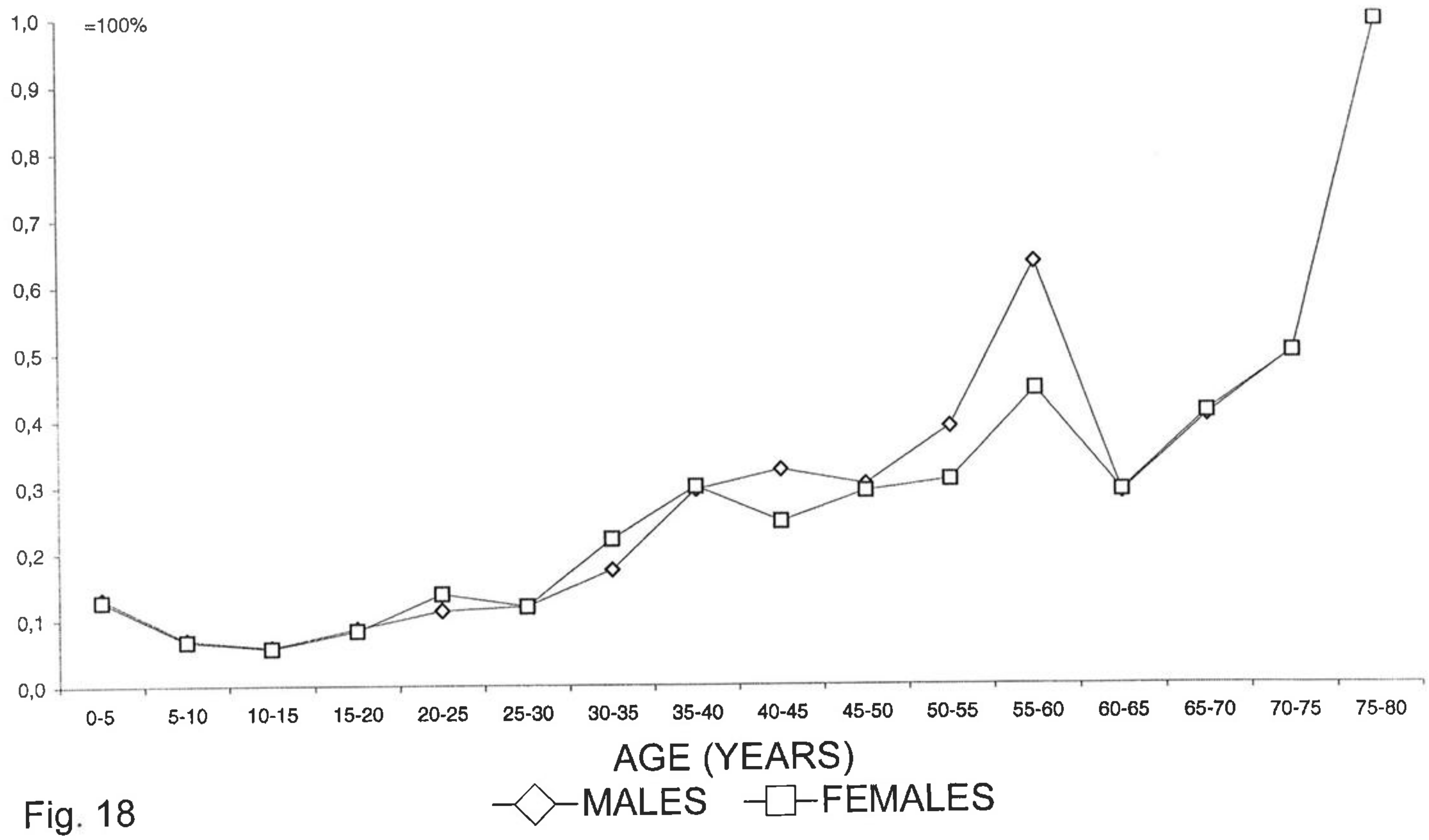
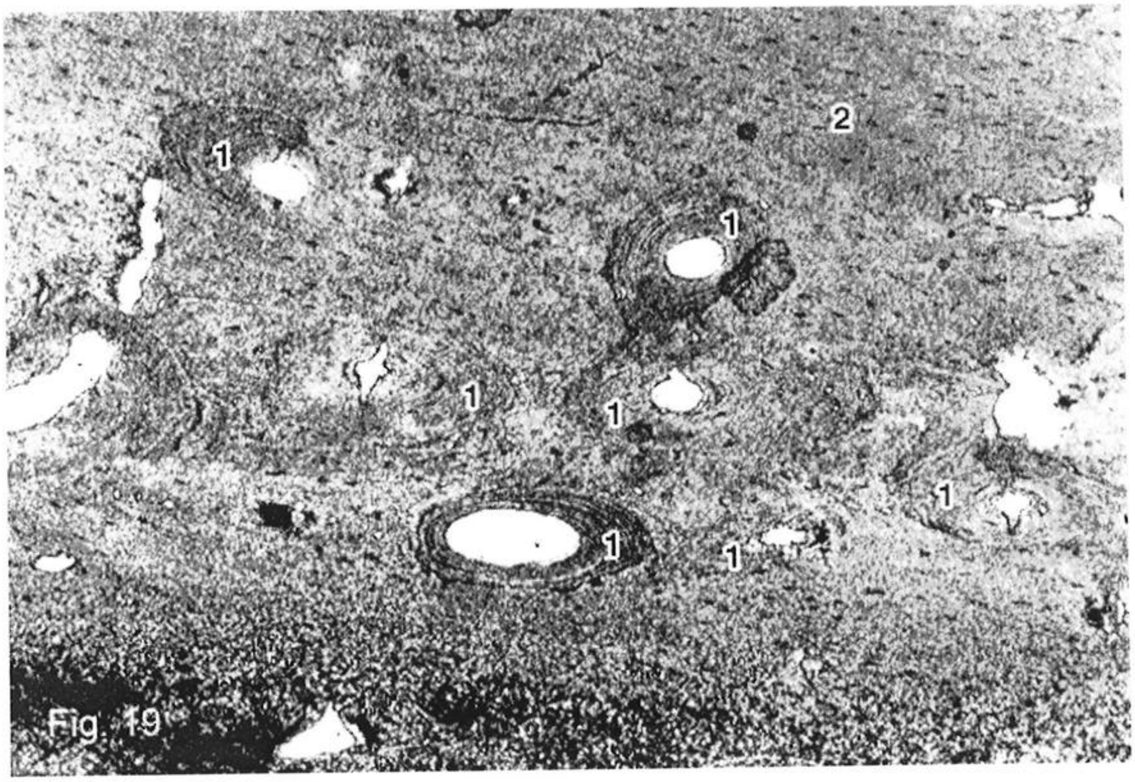

35
30
25
20
15
10
5
0
AGE (YEARS)
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
INTERVALS (YEARS)
MALES
FEMALES

Fig. 17

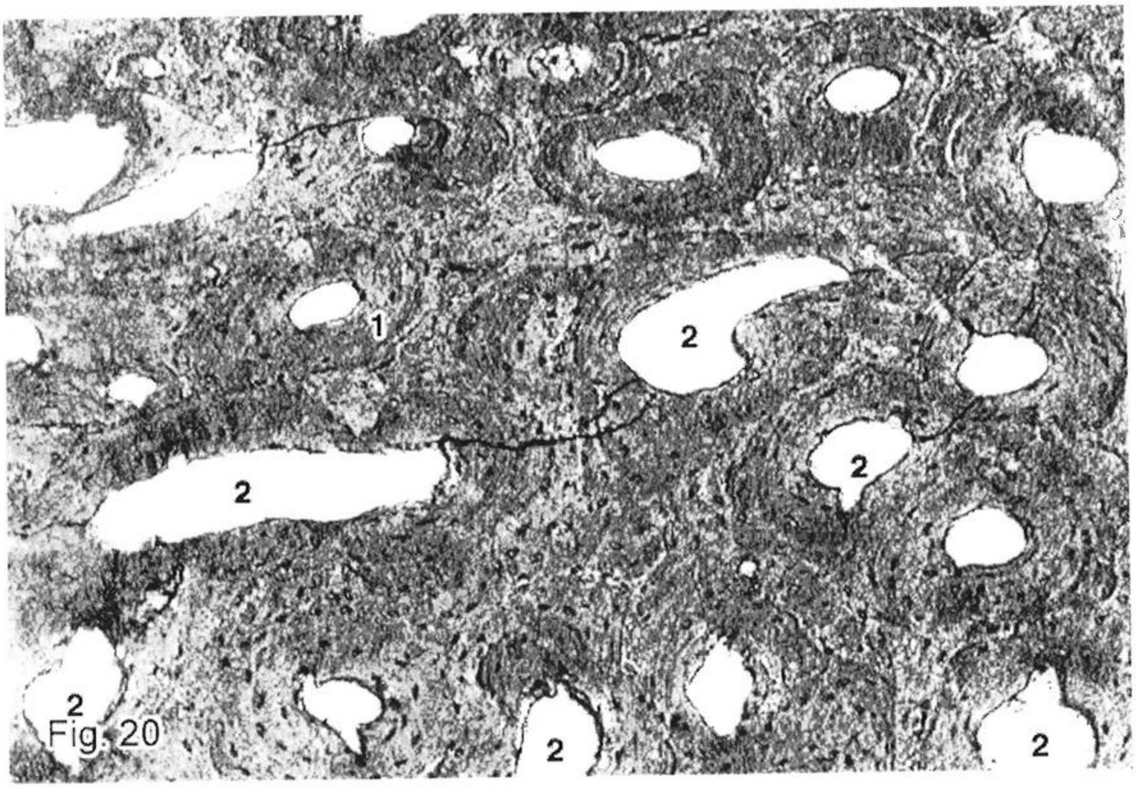


1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
=100%
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65-70
70-75
75-80
AGE (YEARS)
MALES
FEMALES

Fig. 18



1
2
1
1
1
1
1
1
1
Fig. 19



1
2
2
2
2
Fig. 20
2
2

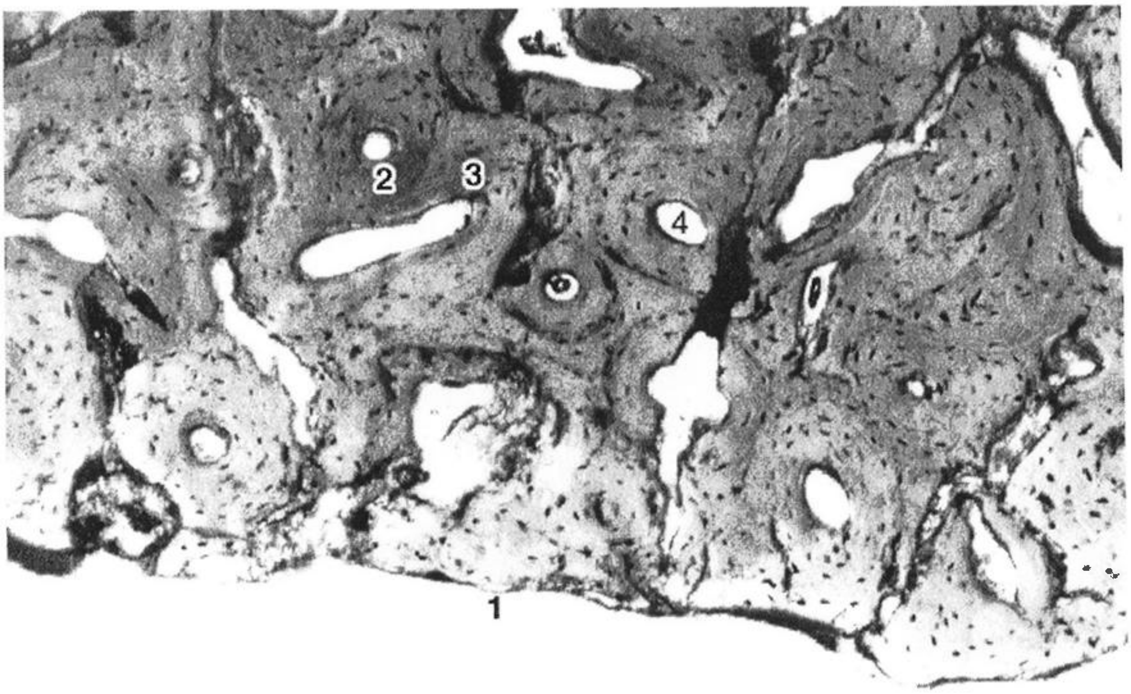


Fig. 21

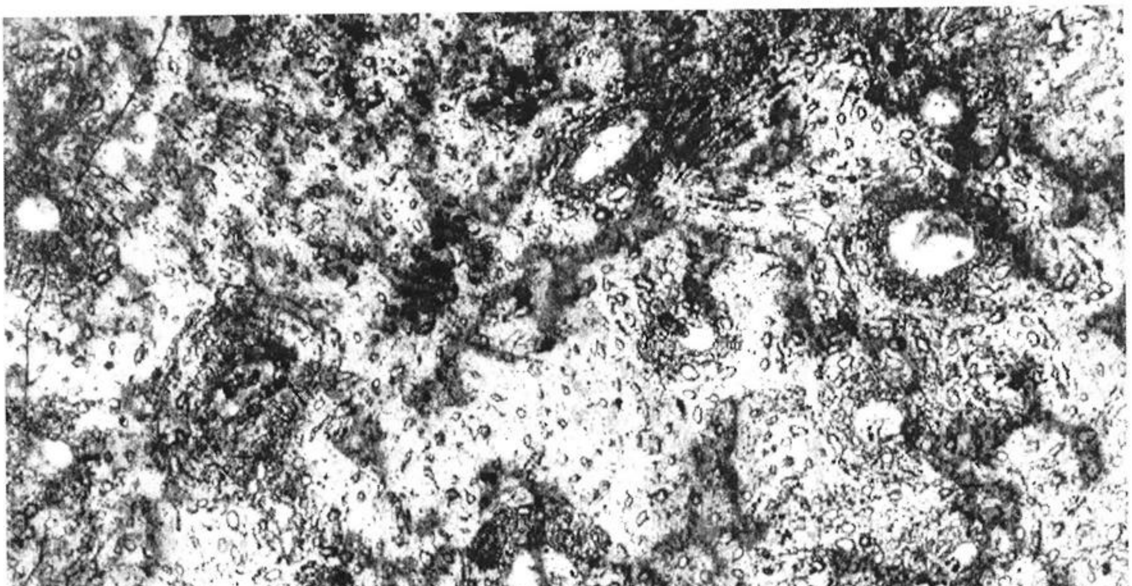


Fig. 22

Table 1. Distribution of the number of individuals per sex category with their average weight and variation (g = grams)

	Number	Average (g)	Variation (g)
Male	30 (35)	938.2	212-1529
'Male?'	4	360.2	140-777
'Male??'	5	277.5	74-420.5
Female	30 (35)	675.7	152-1375
'Female?'	8	361.1	86-816
'Female??'	4	332.0	16-837
Nonadults	42 (49)	99.6	2-518
Double: adults	2	1375.5	1211-1540
Double: adult + non-adult	7	544.7	442-846
Adults, sex unknown	21 (22)	138.9	3-432
Indeterminable	37	35.0	0.1-252
Total	**199**	**380.9**	**0.1-1540**

The individuals from the category "Double interments" were equally distributed over the category 'Male', 'Female', 'Adult', and 'Non-adult' and expressed between brackets. The seven 'non-adults' determined by histological means were not included. They were represented in the category 'Indeterminable'.

Table 2. Sex and age of adults of the complete collection of cremations.

	Sex determinable	Sex not determinable	Total
Age determinable	50 (44)	5 (1)	55 (45)
Age not determinable	10 (4)	18 (0)	28 (4)
Total	60 (48)	23 (1)	83 (49)

( ) = cremations selected for more than 150 grams of fragments larger than 10mm.

Table 3 Sex distribution of adults.

	Males	Females	Total
All individuals	30	30	60
Portions >10mm and >150g	27	27	54

g = grams

Table 4. Use of sex features which produced a positive sex determination. N = 91.

Sex feature	N
Linea aspera	1
Sulcus supramastoidea	1
Glabella	2
Sulcus supramastoidea	2
Dens axis	3
Pars petrosa ossis temporalis	3
Os zygomaticum	10
Processus mastoideus	13
Protuberantia occipitalis externa	21
Tuberculum marginale	23
Linea nuchae	25
Orbita	27
Processus zygomaticus	27
Crista supramastoidea	31
Meatus acusticus internus	38

Table 5. Table of age at death according to Acsádi and Némeskeri (1970). Overall. Age in years. N = 199.

Age, x	Dx	dx	lx	qx	Lx	Tx	ex
0- 5	25.6	12.9	100	0.13	467.8	3067.9	30.7
5-10	11.6	5.9	87.1	0.07	420.9	2600.1	29.9
10-15	9.1	4.6	81.3	0.06	394.8	2179.2	26.8
15-20	12.8	6.4	76.7	0.08	367.2	1784.4	23.3
20-25	17.6	8.9	70.2	0.13	329.0	1417.1	20.2
25-30	14.6	7.4	61.4	0.12	288.4	1088.2	17.7
30-35	21.3	10.7	54.0	0.20	243.2	799.7	14.8
35-40	25.8	13.0	43.3	0.30	184.0	556.5	12.9
40-45	17.1	8.6	30.3	0.28	130.2	372.5	12.3
45-50	12.6	6.3	21.7	0.29	92.9	242.3	11.1
50-55	10.3	5.2	15.4	0.34	64.2	149.4	9.7
55-60	10.3	5.2	10.3	0.51	38.3	85.2	8.3
60-65	2.9	1.5	5.1	0.29	21.7	46.9	9.3
65-70	2.9	1.5	3.6	0.40	14.4	25.2	7.0
70-75	2.1	1.1	2.2	0.50	8.1	10.8	0.1
75-80	2.1	1.1	1.1	1.00	2.7	2.7	0.0
Total	199				3068		

x age interval
Dx number of deaths
dx relative number of deaths (%)
lx relative number of survivors (%)
qx probability of death
Lx total number of years lived
Tx the total number of years of life left
ex life expectancy

Table 6. Table of age at death according to Acsádi and Némeskeri (1970). Males. Age in years. N = 98.

Age, x	Dx	dx	lx	qx	Lx	Tx	ex
0- 5	12.8	13.1	100	0.13	467.3	3056.2	30.6
5-10	5.8	5.9	86.9	0.07	419.7	2588.9	29.8
10-15	4.6	4.7	81.0	0.06	393.2	2169.2	26.8
15-20	6.4	6.5	76.3	0.09	365.2	1776.0	23.3
20-25	7.7	7.9	67.8	0.11	329.2	1410.8	20.2
25-30	7.2	7.3	61.9	0.12	291.2	1081.5	17.5
30-35	9.2	9.4	54.6	0.17	249.3	790.3	14.5
35-40	13.0	13.3	45.1	0.29	192.6	541.0	12.0
40-45	10.1	10.3	31.9	0.32	133.6	348.4	10.9
45-50	6.4	6.5	21.6	0.30	91.6	214.8	10.0
50-55	5.7	5.9	15.1	0.39	60.7	123.2	8.2
55-60	5.7	5.9	9.2	0.64	31.4	62.5	6.8
60-65	0.9	1.0	3.4	0.29	14.4	31.0	9.2
65-70	0.9	1.0	2.4	0.40	9.5	16.7	7.0
70-75	0.7	0.7	1.4	0.50	5.3	7.1	0.1
75-80	0,7	0.7	0.7	1.00	1.8	1.8	0.0
Total	98				3056		

x age interval
Dx number of deaths
dx relative number of deaths (%)
lx relative number of survivors (%)
qx probability of death
Lx total number of years lived
Tx the total number of years of life left
ex life expectancy

Table 7. Table of age at death according to Acsádi and Némeskeri (1970). Females. Age in years. N = 101.

Age, x	Dx	dx	lx	qx	Lx	Tx	ex
0- 5	12.8	1.3	100	0.13	468.3	3079.1	30.8
5-10	5.8	5.8	87,3	0.07	422.1	2610.9	29.9
10-15	4.6	4.5	81,5	0.06	396.4	2188.8	26.8
15-20	6.4	6.3	77,0	0.08	369.2	1792.4	23.3
20-25	9.8	9.7	70,7	0.14	329.1	1423.2	20.1
25-30	7.3	7.2	61.0	0.12	286.9	1094.1	17.9
30-35	11.9	11.8	53,8	0.22	239.4	807.2	15.0
35-40	12.7	12.5	42.0	0.30	178.6	567.8	13.5
40-45	7.3	7.2	29,5	0.24	129.2	389.2	13.2
45-50	6.5	6.5	22,3	0.29	95.1	256.0	11.7
50-55	4.9	4.9	15,8	0.31	66.8	164.9	10.5
55-60	4.9	4.9	10,9	0.44	42.5	98.1	9.0
60-65	1.8	1.8	6,1	0.29	25.9	55.7	9.2
65-70	1.8	1.8	4,3	0.41	17.1	29.8	6.9
70-75	1.3	1.3	2,5	0.50	9.5	12.7	5.0
75-80	1.3	1.3	1,3	1.00	3.2	3.2	2.5
Total	101				3079		

x age interval
Dx number of deaths
dx relative number of deaths (%)
lx relative number of survivors (%)
qx probability of death
Lx total number of years lived
Tx the total number of years of life left
ex life expectancy

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