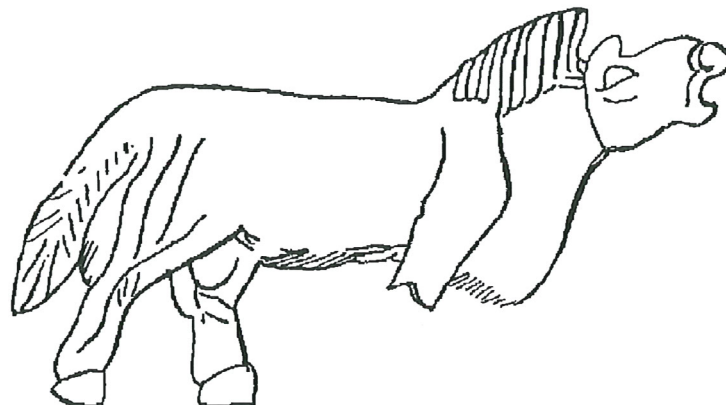


# ARCHAEOZOOLOGY OF THE NEAR EAST IV B

Proceedings of the fourth international symposium on the  
archaeozoology of southwestern Asia and adjacent areas

edited by

**M. Mashkour, A.M. Choyke, H. Buitenhuis and F. Poplin**



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Przewalski from Susa (nacre – mother of pearl)

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# THE SECONDARY PRODUCTS REVOLUTION? CHANGES IN ANIMAL MANAGEMENT FROM THE FOURTH TO THE FIFTH MILLENNIUM, AT ARJOUNE, SYRIA

Caroline Grigson<sup>1</sup>

## Abstract

This study uses the faunal material from the site of Arjouné in Syria dated to the fifth and fourth millennia to test Sherratt's hypothesis that the Late Neolithic and Chalcolithic periods saw the initiation of the use of animals for milk, wool and traction: a "Secondary Products Revolution".

Comparison of the ageing patterns of the sheep and goats in the fifth and fourth millennia at Arjouné with each other, and with patterns established at earlier sites in the Middle East, shows an increasing dependence on older animals. This seems to indicate a gradual shift in emphasis from a meat strategy in the earliest periods, to one maximizing milk and meat in the Late Neolithic, followed by another, aimed at wool, milk and meat, in the Chalcolithic. Additional evidence is the increase in the proportion of sheep, cattle and equids, kept in Chalcolithic. This suggests that the process involved a gradual shift in emphasis rather than a sudden revolution. Nevertheless it was a change that was to revolutionize the economic system, paving the way to greater productivity and heralding the establishment of the earliest towns at the beginning of the Bronze Age.

## Résumé

Cette étude se base sur les vestiges fauniques du site d'Arjouné en Syrie daté du 5<sup>e</sup> et du 4<sup>e</sup> millénaires afin de tester l'hypothèse de Sherratt sur la période néolithique et chalcolithique où l'utilisation des animaux pour l'exploitation du lait, de la laine et la traction fut initiée, soit une «Révolution des produits secondaires».

La comparaison des structures d'âges d'abattage des moutons et des chèvres durant le 5<sup>e</sup> et le 4<sup>e</sup> millénaires à Arjouné entre elles avec les autres schémas d'abattage existant sur les sites plus récents au Proche-Orient montre une préférence croissante pour les animaux plus âgés. Cette tendance semble indiquer une évolution graduelle allant d'une stratégie basée sur la production de la viande durant les premières périodes à une stratégie qui privilégie la production du lait et de la viande au Néolithique final, suivie d'une stratégie recherchant la production de la laine, du lait et de la viande au Chalcolithique. L'augmentation des taux de représentation du mouton, du bœuf et de équidés au Chalcolithique vient en outre étayer cette hypothèse. Cela suggère un processus graduel et non une révolution. Cependant, ce changement devait révolutionner le système économique global, préparant le terrain à des moyens de production plus vastes et annonçant l'établissement des premières villes au début de l'âge du Bronze.

**Key Words:** Sheep, Goats, Husbandry, Syria, Neolithic, Chalcolithic, "Secondary Products Revolution"

**Mots Clés:** Mouton, Chèvre, élevage, Syrie, Néolithique, Chalcolithique, "Révolution des produits secondaires"

## Introduction

Arjouné is one of the few archaeological sites in the Levant in which well-dated material from both the fifth and fourth millennia bc has been excavated. Its faunal remains therefore present an ideal opportunity to test Sherratt's (1981, 1983) hypothesis, based largely on pictorial evidence, that the advent of the Chalcolithic in the fourth millennium saw the initiation of the use of animals for their secondary products (milk, wool and traction). The present paper is extracted from a much larger and

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Table 1. Numbers of faunal remains identified and unidentified, at Arjoune

Millennium Trench	5th V, VII	4th VI
domestic goat <i>Capra hircus</i>	72	3
domestic sheep <i>Ovis aries</i>	46	14
sheep/goat	693	145
sheep/goat/gazelle	68	3
domestic pig <i>Sus scrofa</i>	308	88
domestic ox <i>Bos taurus</i>	261	90
domestic dog <i>Canis familiaris</i>	10	0
uncertain canid	1	0
hare <i>Lepus capensis</i>	3	0
cat <i>Felis</i> sp	1	0
gazelle <i>Gazella</i> sp.	9	9
red deer <i>Cervus elaphus</i>	1	*1
deer <i>Cervus elaphus?</i>	0	4
equid <i>Equus asinus/hemionus</i>	8	18
equid <i>Equus asinus/hemionus?</i>	1	2
bird unidentified species	0	2
tortoise <i>Testudo graeca</i>	1	9
land crab <i>Potamon potamias</i>	2	0
<b>total no. bones identified</b>	<b>1485</b>	<b>387</b>
total no. unidentified fragments	7054	1568
<b>TOTAL NOS. OF BONES</b>	<b>8539</b>	<b>*1956</b>
* + 3 unattached antler fragments		

The numbers are of "bone finds", i.e. paired elements and bone fragments of the same skull, limb, foot or bone count as one.

filled with occupation debris - pottery of various Late Neolithic and Chalcolithic types, chipped flint (Unger-Hamilton 1981), charred grain and some incised pebble figurines (Parr, forthcoming). In addition the fifth millennium trenches yielded some Halafian sherds, two animal figurines, some pendants, carved stone astragali and sherd discs, and the fourth millennium trench had some ground-stone objects and a contemporary human skeleton. In the present study the cultures of the fifth millennium are called Late Pottery Neolithic and those of the fourth millennium Chalcolithic, but some authorities (Moore 1982 and Gilead 1988) designate the entire period as Chalcolithic.

### The fauna of Arjoune

As can be seen from Table 1 although a wide range of mammals is represented at Arjoune the vast majority of the faunal remains from Arjoune are of domestic animals. As it is the domestic economy which is the subject of the present paper, it is necessary to demonstrate that the cattle, pigs, sheep and goats were definitely domestic, and the equids were possibly so.

more detailed study assessing the entire assemblage from Arjoune in the context of what is known about the archaeozoology of the Middle East, which has been awaiting publication since 1989 (Grigson, forthcoming).

### The Site

Arjoune lies on the flood plain of the River Orontes, just east of the Beqa' Gap in northern Syria, between the modern Lake of Homs to the north and the Bronze Age-Iron Age site of Tell Nebi Mend to the south. It is in the area in which the Syrian steppe gives way to the Mediterranean region and the present rainfall is 400-600mm a year.

The site consists of ill-defined areas of occupation, close to one another, on a low terrace beside the Orontes. Ten trenches were cut into the mound under the overall supervision of Peter Parr of the London Institute of Archaeology. The trenches that we are concerned with here are no. V, excavated by Lee Marfoe in 1979 (Marfoe, Copeland and Parr 1981), and nos. VI and VII (excavated by Carl Phillips in 1981 and 1982).

Trenches V and VII have been dated to the fifth millennium by radiocarbon, the range of uncalibrated dates is: 4810+/-100 to 4490+/-90 bc. Trench VI is fourth millennium: its dates range from 3860+/-80 to 2780+/-100 bc.

All three trenches consisted of man-made hollows in the terrace material, which were

## **Establishing domestic status**

The most commonly used criterion for establishing whether or not large mammals had undergone domestication is a diminution in size when compared with the wild forbears. This certainly happened during the Holocene to cattle, pigs, sheep and goats, although the problem with equids is more complicated. Various methods have been utilised, but most involve comparisons with a standard animal.

### ***Cattle***

In comparing the sizes of cattle in the Middle East at various periods Grigson (1986) followed Buitenhuis (1985) in using the complete skeleton of an aurochs cow as the standard animal for the comparison of sizes of wild and domestic cattle in the Levant, and concluded that cattle were domesticated in the area during the sixth millennium.

Figure 1C is a log ratio diagram of the sizes of the Arjouné cattle bones compared with those from earlier millennia (Figs. 1A and B) and shows clearly that they were smaller than those of both wild and domestic cattle of the preceding millennia and therefore represent small, domestic animals.

### ***Pigs***

The comparisons of the size of pigs utilize the standard established by Payne and Bull (1988) from a group of modern wild boar in Turkey. Log ratio plots of the pig measurements from Arjouné confirm that the pigs there were domestic (Figs. 2A and B).

### ***Goats***

Uerpmann (1979) calculated the means from a male and female wild goat and used them as a standard for comparison of the size of goats of various periods. He showed that there was a small size change between the goats of what he calls the Proto-neolithic (8th millennium bc) and the Early Neolithic (about 7000 bc), which is definite enough to show that the goats in the Early Neolithic sites had already undergone the morphological changes associated with domestication. There was a further reduction in the size of goats in the Pottery Neolithic of the sixth and fifth millennia. Figure 3 shows the size of the goats from Arjouné compared with those plotted on Uerpmann's histograms. Although the size range of the Arjouné goats is slightly narrower, presumably because of the smaller sample size, the mean is almost identical to that of his Pottery Neolithic range. So it would seem that the Arjouné goats are of the normal size for domestic goats of the Pottery Neolithic in the Middle East.

### ***Sheep***

Uerpmann (1979) used a wild female sheep as a standard for comparison of the size of sheep of various periods. He showed that there was a size change between the sheep of what he calls the Proto-neolithic (8th millennium bc) and the Early Neolithic (about 7000 bc). The diminution is definite enough to show that the sheep in the Early Neolithic sites had already undergone morphological changes associated with domestication. Uerpmann found that this was followed by a further reduction in the size of sheep in the Pottery Neolithic in the sixth and fifth millennia. In the subsequent Chalcolithic, or Late Pottery Neolithic of Amuq (levels D-G) there was a slight recovery in size. Figure 4 shows the size of the sheep from Arjouné compared with some of Uerpmann's histograms. The mean size of the Arjouné sheep is a little larger than that of Uerpmann's Chalcolithic (= Late Pottery Neolithic, *plus* Chalcolithic) range from the Amuq. The differences are probably not significant, so it would seem that the Arjouné sheep are normal size for domestic sheep of the Late Pottery Neolithic/Chalcolithic in the northern Levant.

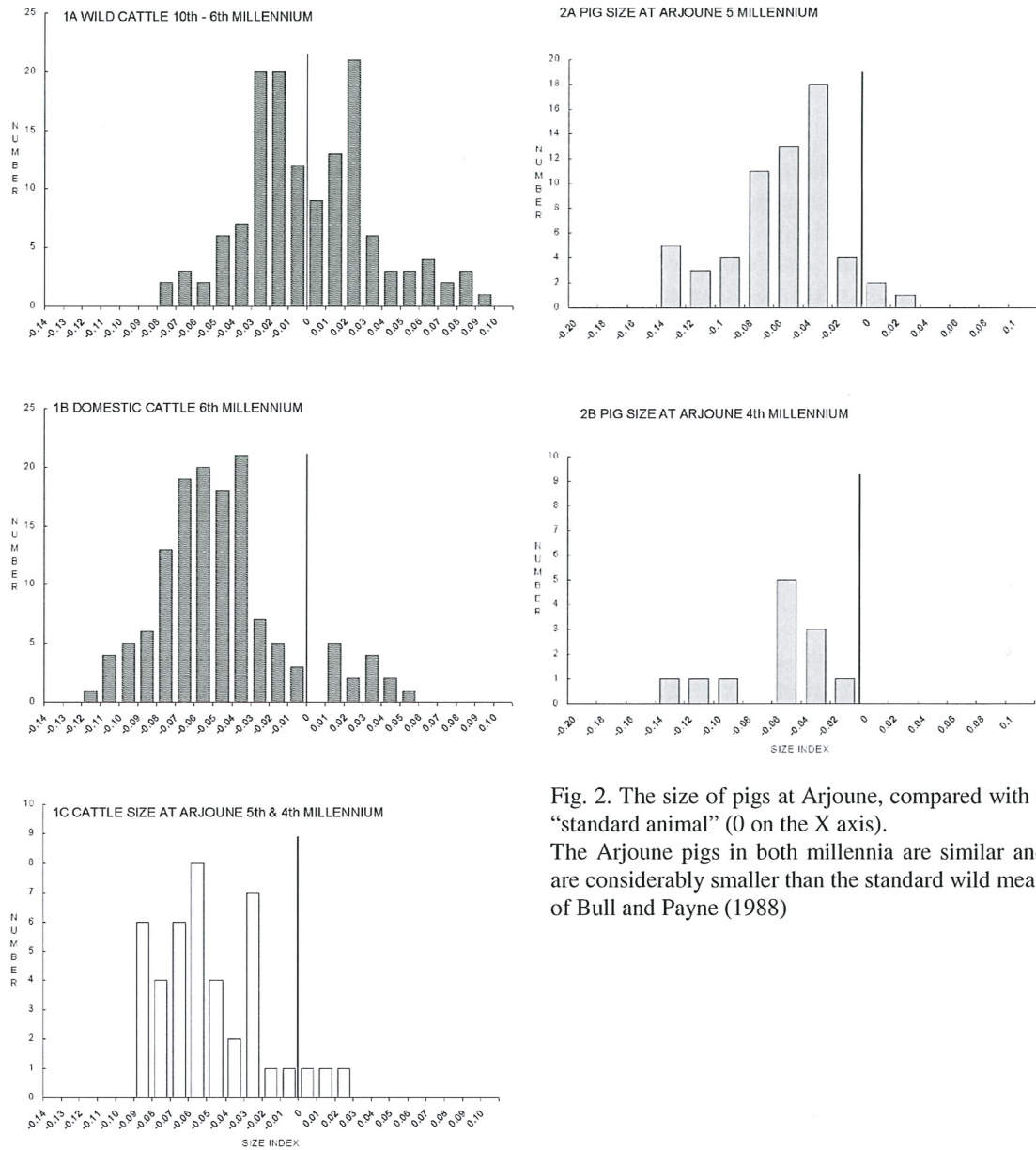


Fig. 1. The size of cattle at Arjone, compared with that of other cattle remains from the Levant, using a “standard animal” (0 on the X axis). The cattle remains from Arjone and from the 6th mill. BC are smaller than the standard and are undoubtedly from domestic animals. Data for Figures 1A and 1B and method are from Grigson (1989); standard animal from Buitenhuis (1985)

Fig. 2. The size of pigs at Arjone, compared with a “standard animal” (0 on the X axis). The Arjone pigs in both millennia are similar and are considerably smaller than the standard wild mean of Bull and Payne (1988)

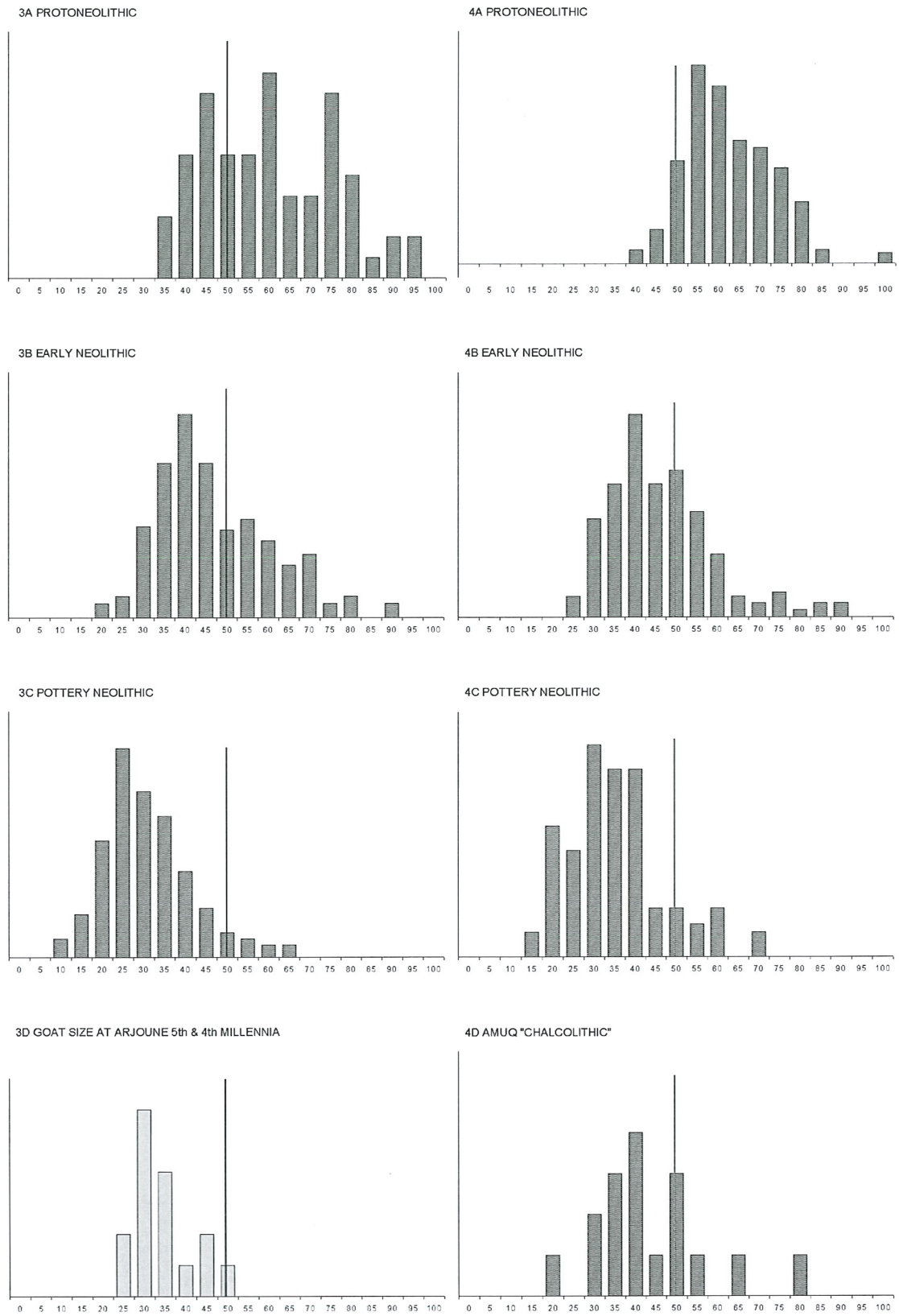
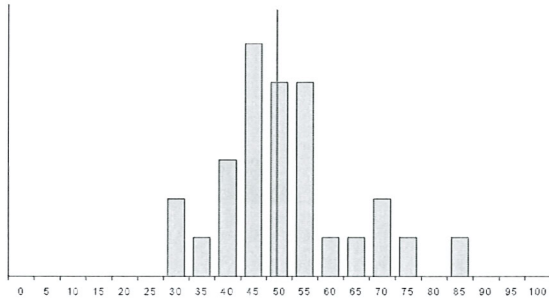


Fig. 3. The size of goats at Arjoun and other Holocene sites, compared with a 'standard animal' (50 on the X axis). Note the similarity between Arjoun with a mean value of 31.9 (n=16) and the Pottery Neolithic

Fig. 4. see next page  
Data for the figures, standard animal and method from Uerpmann(1979)



See also previous page.

Fig. 4. The size of sheep at Arjoun and other Holocene sites, compared with a 'standard animal' (50 on the X axis). Note the similarity between Arjoun (n=28) and the 'Chalcolithic' of the Amuq in the 5th millennium.

**Equids**

On the basis of size and dental morphology it is clear that the Arjoun equid remains are not of horses (*Equus caballus*), so they must be from the other equid species known in the Holocene in the Middle East - onagers (*E. hemionus*), or wild or domestic asses (*E. africanus* or *E. asinus*).

Figure 5 is a metrical analysis, based on the work of Uerpmann (1982, 1986) at Shams ed-Din at about 5000 bc, Ducos (1978, 1986) at Mureybit, and Payne (1988) at Tell Rubeidheh (fourth millennium), it shows that the size ranges from all these sites overlap (Grigson 1993). However the Rubeidheh equids are significantly larger than the others, and as they have been confidently identified as domestic donkey on morphological grounds, it seems likely that size (or rather stoutness, as most of the measurements used are of bone width) may be a criterion for distinguishing domestic donkeys from the local wild equids, which were probably onagers, not the progenitors of domestic donkeys. Unfortunately the four useable equid measurements from Arjoun fall in the area of overlap. However evidence for the presence of domestic donkeys in other sites in the fourth millennium (Epstein 1985; Grigson 1987, 1995), suggests that those of the same period at Arjoun may also have been domestic, as does the increase in the numbers of equid remains from the fifth to the fourth millennium, shown in Table 1 and Figure 13 (below).

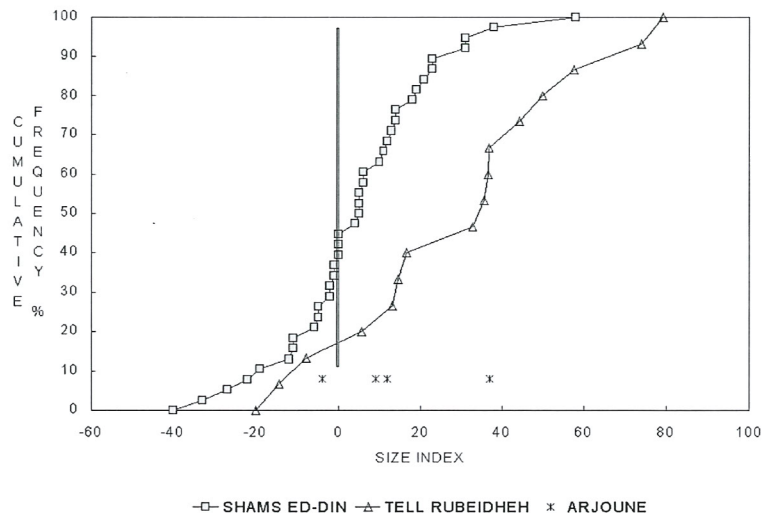


Fig. 5. The size of equids at Arjoun compared with that at Shams ed-Din and Rubeidheh, compared with a standard animal (=0). The Rubeidheh equids which are larger than the others, are domestic donkeys. The four measurements from Arjoun fall in the area of overlap with Shams ed-Din. Method from Uerpmann (1982, 1986), using the mean measurements from Mureybit as a standard (Ducos 1978, 1986); data from Shams ed-Din (c. 5000 bc) from Uerpmann (1982, 1986), and from Rubeidheh (4th millennium bc) from Payne (1988)

## Animal management at Arjouné

Having established that the cattle, pigs, sheep and goats at Arjouné were domestic and that the equids were probably so, at least in the fourth millennium, it is necessary to discuss how the animals were managed, that is, how was herd security maintained (Redding 1984), which animal products were utilized and whether there were any changes between the fifth and fourth millennia. The most useful criteria are demographic, that is the relative numbers of the sexes and the ages at which animals were slaughtered.

### Cattle

The only bones from the fifth millennium that could be sexed on non-metrical grounds were a male and a female pelvis (using the method of Grigson 1982). However the log ratio diagram (Fig. 6A), which uses only sexually dimorphic measurements, has a strong skew to the left, indicating reliance on smaller animals: probably cows.

The fourth millennium material also included a male and a female pelvis and again the log ratio diagram is skewed to the left (Fig. 6B).

Ageing patterns for cattle could only be established for the fifth millennium as the bone and tooth

sample for the fourth millennium was too small. The fusion data for the cattle long bones from the fifth millennium at Arjouné are set out in Table 2. Although too few to yield any definite information, they suggest that about a third of the animals had been killed by the age of 24-30 months and that at least four animals survived beyond three years, two of these being older than 3½.

There were 35 loose teeth, or sets of teeth, from the fifth millennium that could be roughly aged. In most cases only "less than" or "more than" ages could be established, however using Ellenburger and Baum's figures for late-maturing cattle and Higham's for wear (see Grigson 1982), it is clear that about 7 of these teeth were from animals younger than 2¼ years and 23 were from older animals. That is, about a quarter of the cattle were killed before maturity.

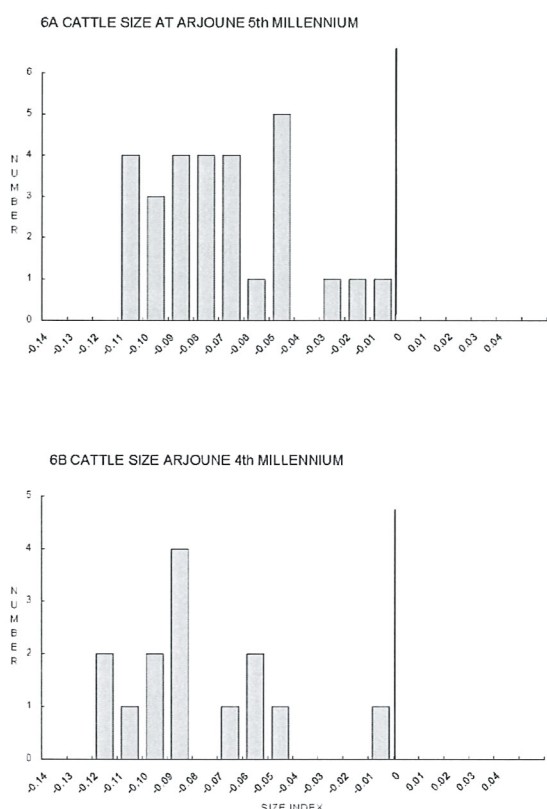


Fig. 6. The size of cattle at Arjouné in the 5th and 4th millennia, using a 'standard animal' (0 on the X axis) to show sexual dimorphism.

The cattle remains from the two periods are much the same size and the mean log ratios are identical (0.089). The skew to the left in both graphs suggests a predominance of females.

Table 2. Cattle fusion data at Arjouné

5th millennium		
Age	Unfused	Fused
7-10 months	2	8
12-18 months	4	12
c18 months	0	22
24-30 months	2	4
c.30 months	6	5
c36 months	0	2
42-48 months	3	2
<b>TOTAL</b>	<b>17</b>	<b>55</b>

Although not agreeing in detail, the two estimates of age at Arjoune suggest that between two thirds and three quarters of the cattle in the fifth millennium were kept into maturity and that most of these were cows. As a third or a quarter of the animals were killed when young, presumably for meat, before they were old enough for breeding or milking, these figures imply a generalized policy allowing for meat and breeding, probably with some milk production, rather than a specialized dairying strategy.

Although in most parts of the Middle East cattle do not yield enough milk to make dairying feasible, this is not true of the area around Arjoune: to this day the cattle graze in the lush water meadows bordering the Orontes and the cows are milked in the fields in the morning and evening.

### *Pigs*

Pigs' jaws are easy to sex, provided that the sexually dimorphic canine is present, and so are pelvises. In the male pelvis the blade of the ilium and ischium above the acetabulum is much higher, and has much more marked vertical ridges, than in the females. Table 3 shows that there were more adult female than male pigs at Arjoune.

An unusually high number of ageable pigs' jaws survives from the fifth millennium at Arjoune so it is possible to analyze them in some detail. Bull and Payne (1982) have produced extremely useful, illustrated descriptions of the eruption and wear of wild pigs' teeth in present-day Turkey. In their age group (1) (7-11 months) the first permanent molar has erupted, wear is usually advanced enough to show the dentine, and the second molar is visible in its crypt. In group (2) (19-23 months) the second molar has erupted and is usually worn to the dentine, and the third molar is either visible in its crypt or is beginning to erupt. In group (3) (31-35 months) the third molar has erupted and may be slightly worn or worn through to the dentine. In older animals tooth wear becomes increasingly severe.

The fifth millennium pigs' jaws also fall into three main groups (see Fig. 7 and Table 4). In the first, the first molar is either erupting, or has just erupted and shows slight wear. Eleven of the jaws in this age group are from animals aged about 5-6 months, one is a little younger and one a little older. All seem to be younger than those in Bull and Payne's group (1). In the second group, the second molar is erupting or has erupted and shows slight wear. In the comparison of the entire dentition with Bull and Payne's illustrations sixteen of the Arjoune jaws are between their groups (1) and (2), three overlap with group (2) and one was probably from group (2), but could be slightly younger. The remaining five jaws all overlap with age group (3) but could equally be intermediate between groups (2) and (3). Thus there is a definite clustering of the ageable pigs' jaws at 5-6 months, 14-18 months, and, less definitely, at 28-33 months. If one assumes that early domestic pigs, like the wild pigs of the Middle East today, gave birth to one litter a year, in March (Harrison 1968; Hatt 1959), the ageing data suggest that in the fifth millennium most of the pigs at Arjoune were killed between May and October. A similar pattern is shown by the 17 pigs' jaws in the fourth millennium, and again the ageing of the third group is less definite.

Table 3. Sexually dimorphic pig bones at Arjoune

Bone	5th Millennium		4th Millennium	
	male	female	male	female
Upper & lower canines	0	15	0	1
Pelvis, acetabulum	1	7	1?	1 (+2?)
<b>TOTAL</b>	<b>1</b>	<b>22</b>	<b>1?</b>	<b>2+(2?)</b>

Table 4. Age at death of pigs at Arjoune

	5th Millennium	4th Millennium
1st year	16	6
2nd year	23	6
3rd year	8	4
older	2	0
<b>TOTAL</b>	<b>49</b>	<b>16</b>

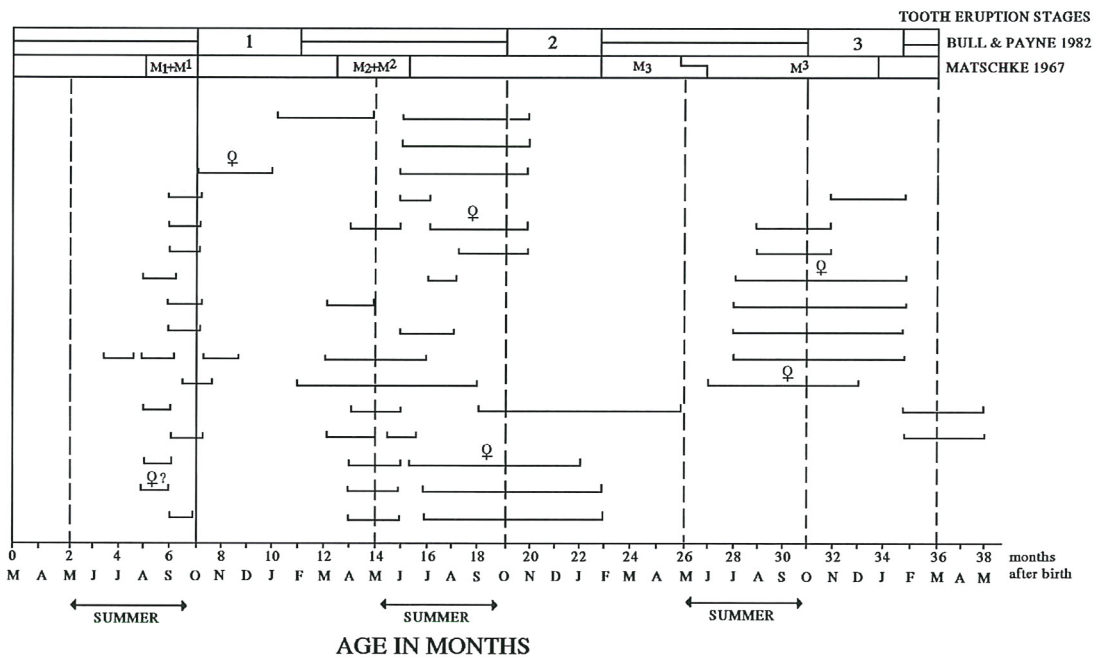


Fig. 7. The age of pigs at Arjoune in the 5th millenniumbc. The ages at death based on tooth wear and eruption in the upper and lower jaws. Each horizontal line represents the estimated age span of each ageable jaw (excluding pairs). Most of them are at stages in between those observed by Bull and Payne (1982) for modern wild boar killed in Turkey in the winter months. This suggests a pattern of summer slaughter at Arjoune

In both the fifth and the fourth millennia about one third of the animals were killed in their first year and about one third to one half in their second (Table 4). The pig bones that could be sexed were all from animals aged one year or more and most of them were female. Probably the animals killed in the first year were mostly males, while most of the females were kept until their second year for breeding, and some animals probably of both sexes, survived a year or two longer.

The pigs seem to have been killed in the summer. This may represent a deliberate culling policy, or a deliberate culling policy combined with seasonal occupation of the site. The most probable explanation is that herds of sows, piglets and one or two boars were kept close to Arjoune where they could feed and wallow on the flood plain of the Orontes. In winter they were probably driven elsewhere for mating, and to avoid the winter or spring floods of the river, returning with their young early in the following summer.

### *Sheep and Goats*

It is quite easy to determine both species and sex from complete pelvis of adult sheep and goats, and although damage can make specific identification difficult or impossible, provided that the acetabulum is complete, sexing is usually possible (Lemppenau 1964). On this basis Boessneck and von den Driesch (1979) were able to show that at Fikirtepe in Turkey the majority of both adult sheep and goats were female.

In the fifth millennium there was one pelvis of an adult male goat, one of an adult male (?sheep), and of the 10 others which can only be classified as adult sheep/goat, 9 are of females. The atlas and axis are strongly dimorphic in size and their sex is usually obvious even when they are unmeasurable. On this basis there was one male axis and three female axes of sheep/goat. In addition there was one male(?) and one female sheep astragalus. These results suggest that females outnumber males in the fifth millennium,

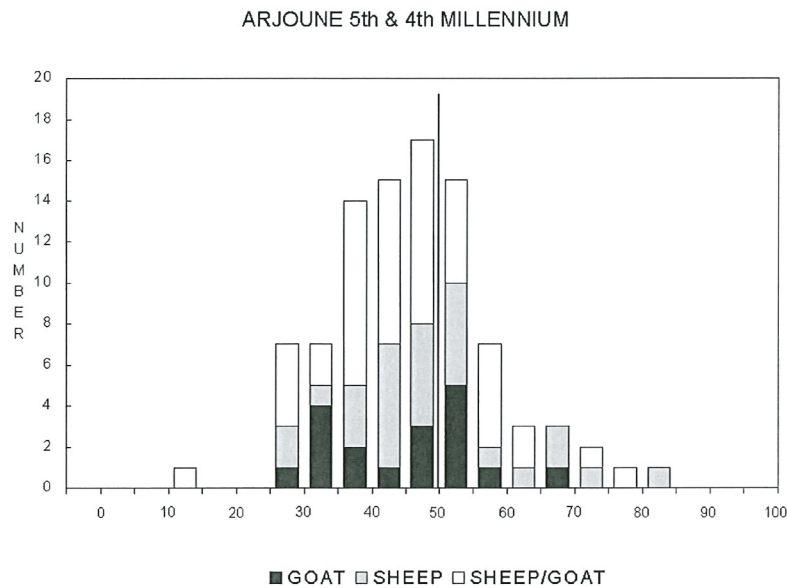


Fig. 8. The size of the Arjoun sheep and goats compared with one another and with that of the 'standard sheep'. The adult sheep and goats at Arjoun seem to be of much the same size and the skew to the left in each graph suggests a concentration on females. Standard animal and method from Uerpman (1979)

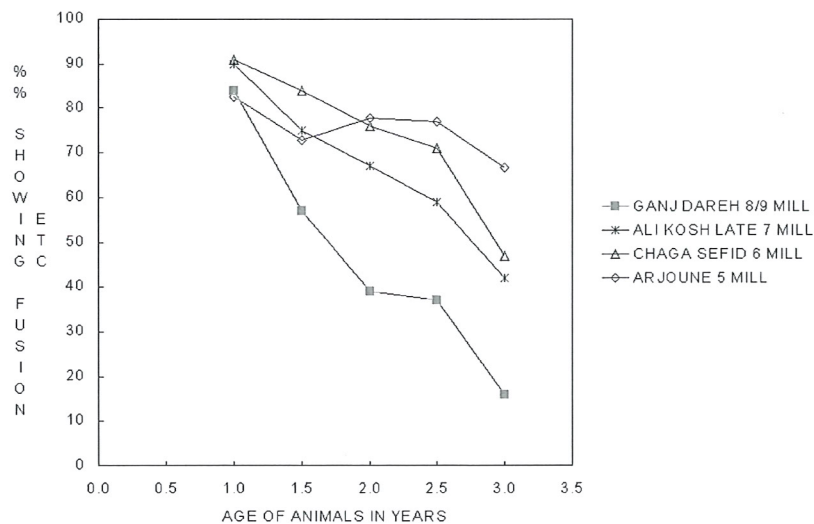


Fig. 9. Survivorship curves of sheep and goats at Arjoun in the 5th millennium bc compared with those of other sites. The earlier samples have been chosen for their large size. There is an upward shift over time. Although the Arjoun sample is rather small it seems nearer to the 6th millennium bc Chaga Sefid curve than to earlier ones. Data from Ganj Dareh, n=10372 (Hesse 1975), Ali Kosh phase at Ali Kosh, n=1465 (Hole *et al.* 1969) and Chaga Sefid, n=1614 (Wheeler-Pires-Ferreira 1975/6/7)

In the fourth millennium the results are less clear, probably because of the smaller sample size; but all the bones that can be sexed on the basis of size, morphology or both, are of sheep: one female astragalus, two male metacarpals and two female metatarsals.

Plots of sheep and goat measurements from sites of the sixth and fifth millennia, such as Fikirtepe (Boessneck and von den Driesch 1979), tend to be concentrated at the smaller end of the size range with just a few larger animals represented on the right. This skewedness is true of sheep/goat bones in general and of both sheep and goat bones where these can be separated. The obvious explanation confirmed by the results of sexing the pelvic bones at this site, is that the majority of the bones were from adult females.

A histogram comparing the sizes of sheep, goat and sheep/goat bones at Arjoune with the standard sheep is shown in Fig. 8. The pattern of distribution of the combined samples from the fifth and fourth millennia at Arjoune is so similar to that from Fikirtepe that it is safe to say that females probably outnumbered males at Arjoune as well. This is a very common pattern in prehistoric samples of domestic animal bones, and suggests that males were mostly slaughtered when young (see below).

Survivorship curves, based largely or entirely on the state of fusion of long bones or on wear and eruption of mandibular teeth, can be constructed to illustrate demographic patterns. Those based on long bone fusion have to be used with caution as the criteria used for the timing of epiphyseal fusion are not universally agreed upon. Theoretically survivorship curves should fall with age, whereas sometimes they rise at two years (data based on the fusion of the distal tibia). Other difficulties include the facts that the less dense, younger bone may have been differentially destroyed, and most survivorship curves based on long bones span only the ages from birth to about 3½ years.

Despite all these difficulties, comparisons of survivorship curves for sheep and goats from different sites do yield interesting information, in particular the contrast in the Deh Luran Plain sites in Iran reported on by Hole, Flannery and Neely (1969), between the eighth-seventh millennium and the sixth millennium. Hesse (1978) showed that the curve at the very early site of Ganj Dareh in Iran is very close to that at the earliest phase at Deh Luran. Other sixth millennium sites in Iran - Tepe Tulai and Chagha Sefid (Wheeler-Pires-Ferreira 1975/6/7) are close to those of the same period at Deh Luran; that is the individual animals in these later sites were living to a greater age than those in the earlier sites. Data from the sites with the largest samples are plotted in Fig. 9.

There were too few ageable long bones of sheep and goats from the fourth millennium to allow the construction of a survivorship curve, but the curve from the fifth, where there were scarcely any neonatal sheep/goat bones, seems to belong with those of later sites (Fig. 9). The obvious interpretation is that in the earlier sites most sheep and goats were being killed when young, that is raised for meat, with a few older animals for reproduction. In the later sites more animals were kept to an older age in order to obtain their secondary products (milk, wool and hair). However it should be remembered that the curves only go up to 3½ years and differences after this age may be more critical for determining the use made of the animals.

Survivorship curves based on tooth eruption and wear could be constructed for both the fifth and the fourth millennia at Arjoune. 51 sheep/goat mandibles, or tooth sets containing two or more lower teeth from the fifth millennium were aged according to the criteria of Payne (1973) and the resultant age distributions are plotted in the form of histograms in Fig. 10A and B and as survivorship curves in Fig. 11B and C.

Theoretical curves for survivorship under different production regimes have been modelled by Payne and these have been added to the graph (Fig. 11A). They are:

1. meat production, in which there is a high mortality of males at 2-3 years and only a few males reach adult life;
2. specialized milk production, in which there is a high mortality of males at 6-9 months, and only a few males reach adult life; from three years onwards these two curves are identical; and
3. specialized wool production, in which emphasis is on older animals of both sexes and most males are castrated and kept in a separate flock from the females and their young.

At first sight the top end of the fifth millennium curve at Arjoune (Fig. 11B) bears little resemblance to any of the modelled curves. However the bone element analysis showed that there has been a great deal

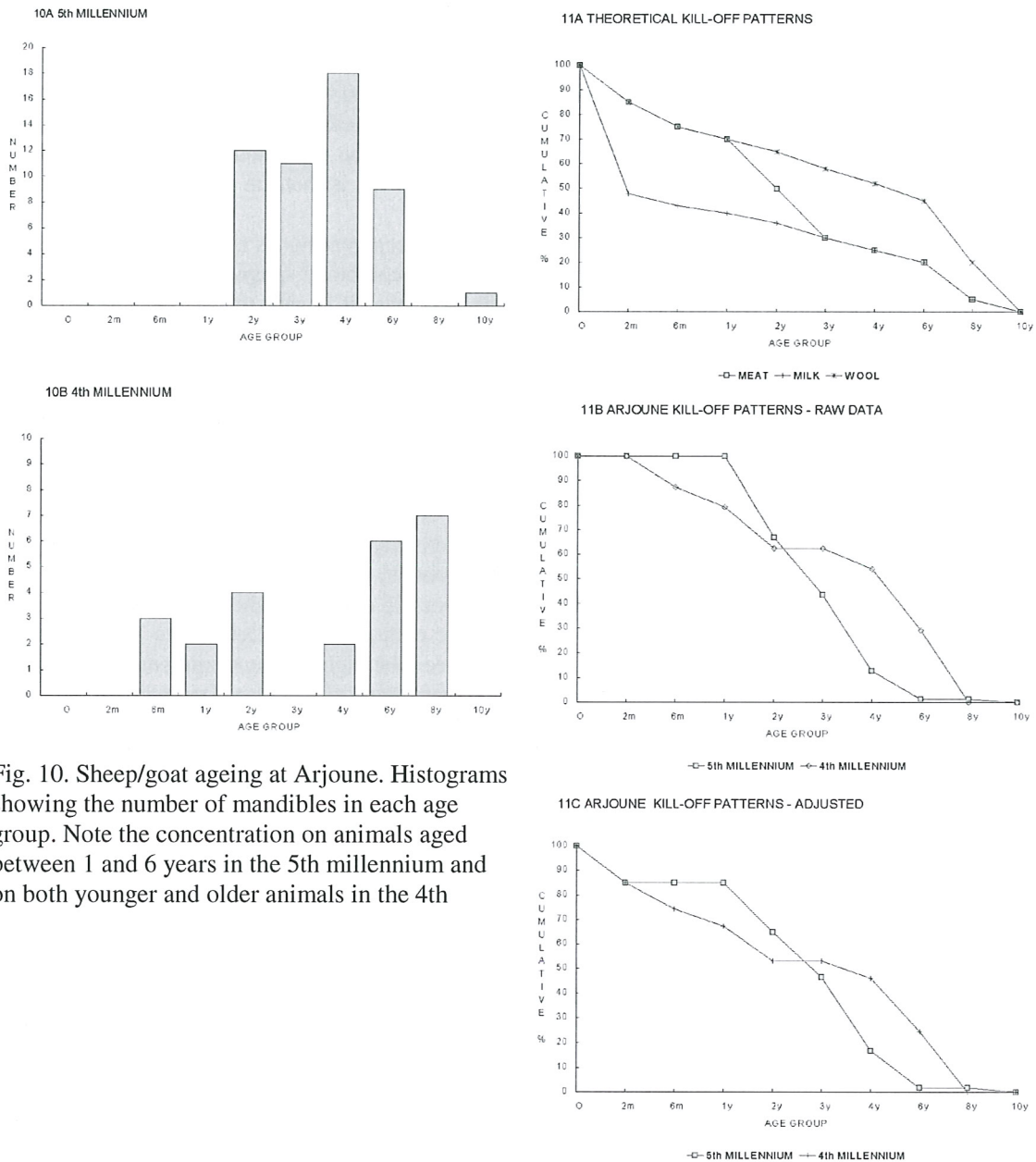


Fig. 10. Sheep/goat ageing at Arjoun. Histograms showing the number of mandibles in each age group. Note the concentration on animals aged between 1 and 6 years in the 5th millennium and on both younger and older animals in the 4th

To the right: Fig. 11. Ageing in sheep and goats.  
 A= theoretical kill-off patterns for sheep and goats devised by Payne (1973) for maximizing different products: meat, milk, or wool.  
 B= The raw mandibular ageing data from Arjoun arranged in the same way.  
 C= The mandibular ageing data from Arjoun adjusted to allow for 15% perinatal mortality and for in situ destruction of the bones of young animals (see text).  
 Note that in (B) the curve for the 5th millennium is closest to Payne's meat curve, whereas that in the 4th millennium is closer to the milk curve.

of *in situ* destruction of bone at Arjoune and that this was correlated with bone density as calculated by Binford and Bertram (1977). The resulting bone element survival graph (Fig. 12) implied a rate of destruction of the mandibles aged 6 months of about 85%, and of about 80% at the age of 1 year -7 months. If the survivorship curves from Arjoune are adjusted to allow for these differences, and, if like Payne, one assumes a 15% perinatal mortality, they come to resemble two of Payne's curves quite closely (Fig. 11C).

Payne however, points out that flocks in subsistence economies are unlikely to be kept for milk or wool alone. When both milk and meat are required (but when meat is relatively more important) his strategy (A) might be followed, and similarly in strategy (B) the slaughtered animals would still be eaten. I suspect therefore that in crude terms the age expectancy in a purely meat strategy would have a slightly younger emphasis than that illustrated by Payne's model (A). This view gains some support from the survivorship curves above, however crudely they express it (see Fig. 11). It also seems likely that in a specialized milk economy there would be a slightly higher proportion of animals aged three years or more (mostly females of course).

Thus in unspecialized economies one can postulate three stages, each involving an increase in life expectancy, from meat production (which would still allow the use of other animal products such as skins), to meat + milk, to meat + milk + wool. The adjusted fifth millennium curve (Fig. 11C) is closest to Payne's model (A), which as I have suggested above probably implies a meat *and* milk strategy in which meat production predominates.

The survivorship curve for the fourth millennium sheep and goats at Arjoune is markedly different from that of the fifth millennium and the difference is statistically highly significant ( $p < 0.005$ ). Figures 10A and B and 11C show that the main difference is the higher number of mandibles in the fifth millennium in the 2, 3 and 4 year age groups; this makes the curve at the fourth millennium resemble Payne's B curve, which suggests a greater reliance on milk than on meat. However the fourth millennium sample has a higher number of mandibles in the 6-8 year age groups, suggesting a strategy in which some animals were kept into old age, as in Payne's C category (specialized wool production), though much less marked.

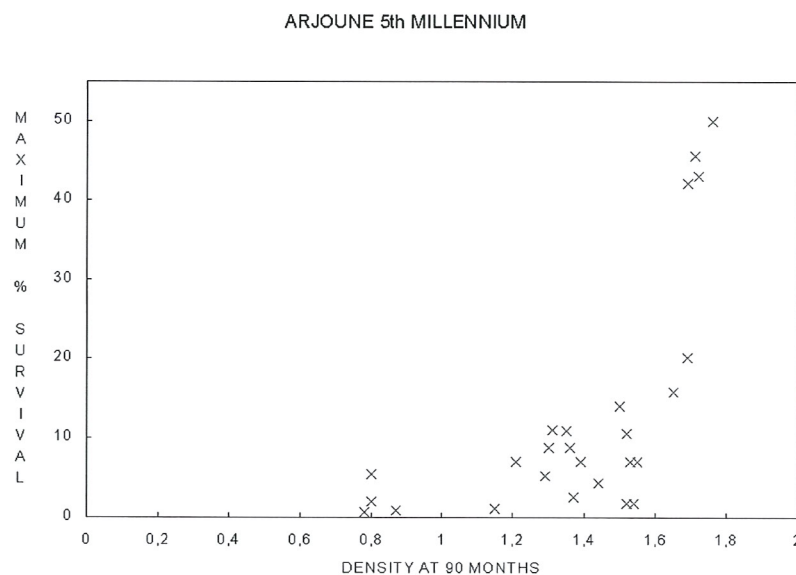


Fig. 12. The survival of sheep and goat bones at Arjoune in the 5th millennium bc. There is a correlation between the number of each element surviving and its density, as calculated by Binford and Bertram (1977). The coefficient of correlation  $r = 0.64$ , which is significant at 1% level.

The analysis of the age structure of the sheep and goat herds at Arjouné and other sites suggests a gradual shift in emphasis, from the utilization of meat in the earlier sites, to meat and some milk at Arjouné in the fifth millennium, with the addition of wool at Arjouné in the fourth millennium. None of these strategies could be described as specialized. Davis (1983) found a similar change in ageing patterns, which he interpreted as reflecting an increase in the use of secondary products in his study of the faunal remains from Neolithic and Chalcolithic sites in the Kermanshar Valley in Iran.

### Ungulate proportions

As well as demographic differences between the two millennia there are also significant changes in the relative numbers of domestic ungulates (Fig. 13), which may also relate to changing strategies of animal management.

Figure 13 shows that the proportion of cattle increased over time. A possible explanation is that in the fourth millennium cattle provided meat previously supplied by goats, whose numbers had decreased, but they may also have been used increasingly for draft, though there is no direct evidence to support this notion. The same may also be true of equids as their share of the ungulates from 1% in the fifth millennium to 6% in the fourth.

The continuing presence of a high proportion of pigs suggests a lush environment in the vicinity of Arjouné, as indeed there is to this day along the banks of the River Orontes. Although there seems to have been a seasonal pattern to the slaughter of pigs, perhaps implying a degree of seasonal movement, pigs are not a component of pastoral nomadism. This together with the evidence for the cultivation of many plant crops, suggests that the inhabitants of Arjouné were sedentary, or virtually sedentary, farmers.

A significant difference is a higher proportion of sheep in the fourth millennium, particularly when compared with goats, which suffered a marked decline in numbers. In the fifth millennium sheep comprised 39% of the bones identified as definitely sheep and goat, but in the fourth millennium this had risen to 82%. This provides some confirmation of the idea the wool was being utilized to a greater degree in the fourth than in the fifth millennium at Arjouné. Davis (1983) found similar, though not identical, contrasts in the faunal spectra from Neolithic and Chalcolithic sites in the Kermanshar Valley, which he attributed to the introduction of woolly sheep. This does not mean that hair and wool fibres were not used prior to the Chalcolithic, merely that there was no herding strategy designed to maximize fibre production.

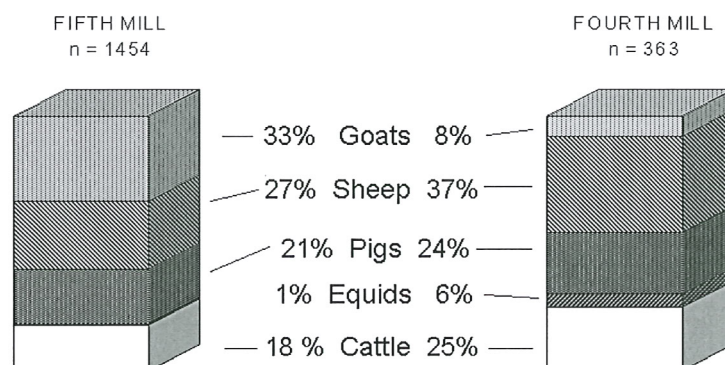


Fig. 13. The domestic ungulate proportions at Arjouné. The decline in numbers of goats from the 5th to the 4th millennium is accompanied by an increase in all other species, particularly sheep

## Conclusions

As already mentioned, Sherratt (1981, 1983) postulated that the Late Neolithic and Chalcolithic periods saw the initiation of the use of animals for milk, wool and traction: a "Secondary Products Revolution" analogous to the "Neolithic Revolution" of preceding millennia. The concept of a revolution has been strongly criticized by Chapman (1983) who pointed out that the innovations of the "Revolution" are dispersed over at least two millennia in both the Middle East and Europe.

Comparison of the ageing patterns of the sheep and goats in the fifth and fourth millennia at Arjoune with each other, and with patterns established at earlier sites in the Middle East, shows an increasing dependence on older animals. This seems to indicate a gradual shift in emphasis from a meat strategy in the earliest periods, to one maximizing milk and meat in the Late Neolithic and to another aimed at wool, milk and meat in the Chalcolithic. Additional evidence is the increase in the proportion of sheep kept in Chalcolithic.

The evidence from Arjoune does support the Sherratt's notion of the introduction of the utilization of secondary products, but it also suggests that, as Chapman argued, the process of their introduction was a gradual shift in emphasis and not a sudden revolution. Nevertheless it was a change that was to revolutionize the economic system of the fifth and fourth millennia, paving the way to greater productivity and heralding the establishment of the earliest towns at the beginning of the Bronze Age - the so-called "Urban Revolution".

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