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PALAEOPATHOLOGY IN ARCHAEOLOGICAL FAUNAL REMAINS

A NEW APPROACH

by

Kathleen Mary Clark

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ABSTRACT

FACULTY OF ARTS

ARCHAEOLOGY

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PALAEOPATHOLOGY IN ARCHAEOLOGICAL FAUNAL REMAINS

by Kathleen Mary Clark

Gross pathological lesions have been noted in the literature on non-human archaeological animal remains since the mid 19th century. In the last 20 years the accumulation of research into human skeletal remains has engendered a dynamic palaeopathological science producing highly valid insights into the condition of people of antiquity. These advances in the understanding of osteological abnormality have, however, been seen to be of limited application to animal bone because of the nature of the primary material. The data on which the discipline of palaeopathology relies is derived from the burial of bodies. The remains available to the archaeozoologist are predominantly the highly selected residues of human consumption.

The biological principles governing the presentation of pathological lesions are, however, consistent. This thesis therefore seeks to explore the potential for understanding and quantifying pathology in animal remains, basing the research on the concept of treating the assemblage as the fundamental body of evidence.

An essential precept of this approach is to demonstrate the incidence of certain selected pathologies within natural populations of specified mammals, and to define this incidence within the comparative material in a manner which is applicable to fragmentary archaeological remains. The potential indicated by the work on defined populations is then explored within actual archaeological assemblages.

The sub-families selected for this thesis are the Caninae and the Bovidae, represented here by the genera Canis, Vulpes and Ovis, with a restricted contribution from Bos in the archaeological case studies. The retrievable pathological data from both comparative and archaeological sources is described and quantified, and the implications discussed.

The results suggest that, for each species under consideration, pathology should be regarded as a quantifiable variable within the assemblage. Consequently, it is demonstrated that a pathological profile may be a practical method of assessing the range of extrinsic stresses imposed on, and experienced by, the animals represented within the archaeological assemblage.

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PREFACE

Palaeopathology is an undisputed growth area in archaeological investigation. In the last two decades an expertise has developed around the recognition that archaeological bone reflects the activity of life, and not just the deposition of the dead. The potential of the field was foreseen in the first quarter of this century, but it is with the excavation of cemeteries from the late 1960's onwards that individuals or groups of skeletons could be differentiated by the action of disease, trauma, birth defect or occupational stress.

In the last ten years the expertise and resources have developed, refined and polarised to the extent that there are now exclusive professional journals, dedicated post-graduate courses, and forensic credibility. This last activity has undoubtedly made a major contribution to making past inconveniences and distresses accessible in the present. Human palaeopathology has made it possible to identify with and understand the stiff knees, swollen arthritic hands, or inflexible and aching backs of our own predecessors. And indeed, the trivialities of health should perhaps concern the archaeologist more than they do, given that any society is a reflection of how well its individual components feel. In archaeological material the range of fitness may be very wide, and may well reflect the attitude of the healthy to the less fit.

These comments do, of course, only relate to human remains. For animal bone the question of pathology has virtually no recourse to the kind of data recoverable from human cemeteries. Death will have occurred prematurely in the majority of cases, and the carcase will have undergone multiple stages of dispersal and disintegration. There will, however, be no difference in life in the reaction of bone to age, trauma, infection, or the manifestation of congenital abnormality.

This thesis presents an argument, and a series of case studies to support it, for the consideration of pathology in animal remains as a quantifiable entity. Chapter 1 presents a summary of current

opinion in the area of animal palaeopathology. Chapter 2 discusses the biological theory pertinent to the identification of osteological anomalies in archaeological material. Two chapters, 4 and 6, will put forward the the case for using comparitive material to gain an insight into the pathological load borne by populations of animals under identifiable environental conditions. The application of this approach to archaeological material is illustrated in Chapters 5 and 7.

This thesis has, as its focus, variation in joint morphology which encompasses both pathological arthropathies and the visible adaptations made by the skeleton at the points of articulation. This is the area of osteological variation where the dynamics producing pre-depositional variability operate to leave consistent visible traces within species. To date archaeological interest has been almost exclusively in specimens where mechanical function is disrupted through disease or trauma. The current study explores the wider implications of group variation, and the levels of incidence of pathological lesions within this variation.

It would be spurious, however, to undertake a purely orthopaedic investigation without consideration of other pathological anomalies that are evident in both comparative and archaeological remains. Skeletal material can only produce testimony to a fraction of the stresses borne by the body, and much bone anomaly will be a secondary response to forces acting within the soft tissue. Nevertheless, it is essential that pathology is viewed as a cumulative process rather than a "memorial event", even within the restricted material available to the archaeozoologist. In the case studies undertaken in this thesis, therefore, analysis and discussion is extended to cover all observed abnormality.

CHAPTER 1

THE CURRENT STATUS OF PALAEOPATHOLOGY WITHIN THE DISCIPLINE OF ARCHAEOZOOLOGY

Amongst archaeozoologists currently engaged in the analysis of faunal assemblages they will be few, if any, who do not use the work by Baker and Brothwell (Baker & Brothwell 1980) as their initial, and usually sole, recourse for the reporting of their pathological observations. This publication therefore not only raised the profile of disease recognition in animal remains, but indirectly imposed a standardisation of reporting and description which is of immense value in those reports which include pathological description. The relevance of minor or intermittent pathology is not, however, a universally accepted maxim. The absence of notes on pathology in animal bone reports cannot be relied upon to indicate an absence of pathology in those assemblages.

Additionally, as discussed more fully later in this chapter, Baker and Brothwell did not propose their book as a definitive catalogue of pathological anomalies against which archaeozoologists could match their observed lesions and produce an archaeological 'fact'. Their preface makes this quite clear:

> "The authors aim to draw attention to animal pathology in the archaeological field, and to compare modern and ancient disease. They are unable to go into great detail about the inferences which may be drawn from it, and indeed, until a great deal more pathology is published in excavation reports and elsewhere it will not be possible to do this in any systematic way. However, the study of ancient disease does present the promise of adding another facet to the expanding field of environmental archaeology." (Baker & Brothwell 1980)

This sentiment is reiterated throughout their work. However, their clarity of description, supported by their photographic illustration, renders the book a highly accessible reference for workers who perceive the need to give some account of their anomalous specimens. The subsequent uniformity of description which has resulted since 1980 is an enormously constructive development. What has not

occurred, however, is a development of the ideas put forward and argued in the book within the archaeozoological discipline.

This lack of a forward momentum which should have been initiated by such a seminal work is unlikely to lie with the observational abilities of archaeozoological workers. It is more likely that the relevance of lesions and deviation is not generally perceived beyond the interest in an individual animal. Faunal analysis is, on the whole, concerned with the exploitation of species, and factors relating sporadically to unreconstructible individuals are not particularly useful.

Here we encounter the major contention concerning the applicability of pathological analysis to animal remains, and it is this contention which appears to dictate the current state of affairs. The precursory events surrounding the deposition of the animal bone relate to human choice or exigency, and activity. This choice and activity is assumed to correlate with the quantitative degree of species recovered. Faunal analysis therefore bases its results and conclusions on the relative representation of species, and the variation observable within species such as size, sex ratio and age distribution. Disease and abnormality are assumed to be characteristics contained within individuals and, as the individual animal is rarely visible in archaeological assemblages, anomalies are frequently considered of minimal relevance, and if they are reported it is in very general terms and very often without reference to context or period. However, it is also the case that in some assemblages the recovered lesions are described in some detail, but again without any consideration of the contextual information. In both these circumstances, the pathological observations are isolated from the primary data within which they are derived, and the abnormalities assume a significance greater than the individuals in which they originate.

At this point another relevant issue should be addressed. There is an incongruous coyness amongst archaeozoologists with regard to pathological manifestations. It is somehow assumed that if an abnormality is not easily recognised and identified (invariably

through Baker & Brothwell) the faunal analyst is unqualified to undertake a description. If the abnormality is not gross, or is not obviously repeated in the whole assemblage, and particularly if funding does not allow for further referral to a veterinarian or a palaeopathologist, these lesions are lost. The loss is not considered important because the lack of that particular fragment in the analysis of the assemblage is not material.

This timidity to address the degree of osteological abnormality in faunal assemblages is certainly discrepant, but it invokes a rather deeper consideration of the basis of faunal analysis. Workers who have no experience, qualification or practical understanding in the field of live animal husbandry produce reports which purport to identify agricultural systems, economies, and social structures of the past, based on animal residues. They do this routinely without recourse to agriculturalists or livestock specialists. But they are very reluctant to take on the side issue of the condition of these animals because they consider this field to be the prerogative of veterinarians. This is neither logical, realistic nor useful archaeologically. If archaeozoologists are prepared to take on, without question, the all important task of identifiying human motivation in the utilisation of animals, they should accept the responsibility of understanding the condition of those animals.

In a detailed discussion of agent identification and analogical and ampliative inference, Gifford-Gonzalez (1991) reiterates the conclusions of Mayr (1982) and Flannery (1986) regarding the probabilistic nature of biological generalisations and the propensity of unique features to emerge at different levels of organisation. Simple causal models derived from lower (or higher) hierarchical levels may be irrelevant or insufficient at the level of relationships we actually need to study. For a discipline dependent on analogical inference, this probabilistic nature of determination in biological systems has to be addressed within any study schema - in Gifford-Gonzalez' view by invoking forensic strategies where

> ". . . independent lines of evidence, derived from distinct systems of causation, can be mobilised to challenge and/or support

one another, leading to more strongly warranted inferences regarding the past life relations that produced certain configurations of material in our sites".

This may improve the apparent soundness of analogical inference, but it still tends to disallow the indeterminate stochastic event, notwithstanding that

> "stochastic processes, even though making predictions probabilistic (or impossible) rather than absolute, are just as causal as deterministic processes." (Mayr 1982 quoted in Flannery 1986, 513).

Binford (1978, 454) emphasises the potential for irregularity in the archaeological record brought about by human judgement operating in circumstances which cannot possibly be identified.

> "Judgements are made by men in terms of evaluations regarding the situation of the moment relative to some desired end. . . . The execution of decisions stemming from judgements results in situationally variable behaviour. This potential for behavioural flexibility, the capacity for rational assessment resulting in flexible strategy plans, is one of the fundamental characteristics of human behaviour. Those who would equate patterning the archaeological record with "culture" would deny this property to man. If the patterning is a simple reflection of "preprogrammed designs for living", then rational behaviour and the regular use of judgement are denied."

The question of modelling "rational" decisions is discussed by Trigger (1991). His antithesis to modern reconstruction of prehistoric perception is founded in the inability of archaeologists to demonstrate that their understanding corresponds to that of the people under study. But if, as he says, behavioural interpretations should be made on the basis of modelling the types of rational decisions that prehistoric peoples could have made in the light of their understanding of the world, and human beings never adapt to the real world but only to the world as they perceive it to be, then there would appear to be some circularity of argument. The identification of that perception underlies all else, a state which remains an undemonstrable concept unless validated by arguments based on material generated within that concept – the ubiquitous

closed system. Returning to Gifford-Gonzalez' proposals then, there is a problem with invoking "forensic evidence". If we do accept Flannery's (1986) proposition that archaeology and anthropology, like biology, are precluded from "laws" and should focus on "concepts", forensic-type approaches are inappropriate in that they are, by definition, concerned with the elucidation of laws. They require an underlying basis of agreed proofs against which to operate, and these proofs cannot exist.

Trigger (1991) does acknowledge the discrepancies, although the proposed remedy seems insufficient for the complaint:

> "What archaeologists need is a more complete understanding, not of how they know but of what there is to know, which in this case means about the nature of human behaviour. Without a general understanding of what kind of behaviour has produced the archaeological record, archaeologists, regardless of their epistemological sophistication, will remain exceedingly vulnerable to having their behavioural interpretations of archaeological data distorted by their own subjectivity."

This understanding, he believes, will be achieved through a synthesis of the ecological determinism of processual archaeology and the historical particularism which identifies cultural tradition.

It is not within the brief of this thesis to develop these lines of thought as they pertain to faunal remains studies as a whole. But within the particular topic under consideration - the assessment of remanent pathology, and especially joint morphology and the incidence and development of joint conditions in animals in antiquity - a dichotomy exists which has to be addressed at this broader level. If a domesticate is a product of gene pool modification through human manipulation (Brothwell 1975) then there is an argument for classing it as an artefact (Uerpmann 1972), whereas any reactive manifestation within its joints is an ecofact, in that it is a biological response to an environmental stimulus, regardless of the degree, if any, of human involvement in that stimulus provided there is no intent to modify. The analogy that springs to mind is that of the trapped grain carbonised during pot firing. However, such an analogy is superficial in that the grain's existence is independent of the pot,

and may itself be a result of genetic modification through human selection. Equally, joint modification may be a result of particular conformation selectly directly, or indirectly through its association with desirable traits.

It is human intent, and the perceived consequences of judgement that define the domesticate; accident, disease, age, misadventure, neglect, climate or condition can modify joint structure. But additionally joint structure can be a consequence - and possibly a perceived consequence - of an unrelated human intention. There are osteological anomalies that may be artefactual - polling or docking, for instance, or the distortions produced in humans by head or foot binding. And there may be as yet unrecognised practices which will have modified living bone intentionally, but have produced remains indistinguishable from those resulting from unintentional injury or degeneration. Uerpmann (1972) takes the view that, for domesticated animals, no adaptational changes can be attributed to environmental determinism, in that these animals would have been introduced into the environment by man and therefore the main influences are cultural and economic. This view must also accept then that injury, disease or modification must also arise from cultural or economic circumstance.

It can be argued that the need to see, rather than the need to know about, human intervention in animal remodelling has resulted/a lack of explicit terms of reference for animal palaeopathology. And indeed, as a sub-discipline it appears to be a reluctant participator in the archaeozoological activity in general because of the paucity of its data, and an unwelcome appendage to palaeopathology because of its all too obvious shortcomings when subjected to human palaeopathological methodology. Its minimal interest is exemplified by Rackham (1983, 253). He defines the following as the major categories of archaeozoological observation:

Stratigraphy and spatial distribution
Identification and quantification of species
Sex of animals from which the bones derive
Age of animals from which the bones derive

and adds:

> "Apart from minor specific anomalies such as pathology, and ignoring for the moment the major problems such as contamination and derived material, these categories encompass the maximum recordable and deducible information of relevance in an economic reconstruction."

And it is clear that as long as pathology remains specific, i.e. unrelated to the normal variation, it also remains minor and unassimilable.

The advances made in the study of human palaeopathology both in techniques and interpretation have engendered two broad areas of opinion on the practicality and value of such studies on faunal remains. While there is agreement that any osteological material may be susceptible to physical analysis, the incomparability of depositional circumstances appears to render the animal bone assemblage inaccessible in terms of data interpretation. This point is iterated very clearly by Rogers et al (1987, 183):

> "We stress the futility of trying to arrive at any sensible conclusion from the examination of single joints, or single groups of joints, or single skeletal elements. . . . Even when dealing with partial skeletons, all the available material should be examined and clear mention made of those elements which are missing".

Except for the infrequent whole animal burial, or some death assemblages, the animal bone assemblage rarely achieves even the single group and often has a high proportion of partial joints. Clearly therefore, if an argument is to be presented on the validity of study of archaeological animal arthropathies, a departure from the aims and methodologies of human palaeopathology has to be stated.

The potential for animal palaeopathology had, however, been recognised by Siegel some 10 years earlier:

> "The importance of human diseases in terms of their diverse ramifications has been recorded widely; no less important is the impact of animal disease today, and in the past too. Indeed, at least some of this information clearly is retrievable from the archaeological record." (Siegel 1976, 376)

And in 1980, Baker and Brothwell commented that

> "Within the framework of zooarchaeology remarkably little attention has been given to aspects of animal health and disease in relation to human societies. . . A broader treatment is needed, giving information relevant to the proper interpretation of vertebrate abnormality as found on archaeological sites, the prospects for finding other as yet undescribed conditions, and the ways in which aspects of veterinary studies are relevant within a maturing science of archaeology". (Baker & Brothwell 1980, 1)

Fourteen years on this "broader treatment" is still awaited, although few animal bone reports published in that time do not refer to Baker & Brothwell 1980.. However, it is possible that two inhibitory factors to progress might be seen in the comments quoted above. It is perhaps counterproductive for archaeological science to consider itself, and present itself to others, as a "promising infant" – while some areas have obviously been more successful than others the discipline has to acknowledge that it is adult. The second point is the implicit assumption that veterinary study is the only analytical method applicable to osteological variation; this has to be questioned, and much of the validity of the work presented here relies on the premise that veterinary opinion is relevant, but should not be exclusive.

The current and traditional approach to osteological anomaly in archaeological assemblages relies on the development of veterinary hypotheses relating to the incidence of clinical disease. This approach has been succinctly and repeatedly defined by Baker:

> "There are a number of bone diseases and abnormalities that are related to the specific use to which animals are put, both currently and in the recent past, and the hypothesis is put forward that evidence for such diseases in past populations indicates that the animals in question may have been used this

way. However it should be strongly stressed that the majority of these disease processes have multiple causes, and while use may be the most common, others are possible. In practice what this means is that too much weight should not be given to individual instances of disease, interesting as these are in their own right, and that for use-associated disease to be put forward in the archaeological context a relatively high incidence of that disease should be found. This in turn means that hypotheses as to use can only be strongly made from archaeological sites producing large amounts of bone." (Baker 1983, 253)

These statements are incontrovertible in the context of veterinary interest, that is the diagnosis of clinical disease in the individual. And it is an attractive strategy to the archaeological worker - because modern diagnosis depends on the presence of a predetermined set of manifestations it can equally be applied to ancient bone so long as that set is recognised. Hence the current call amongst workers for the picture dictionary of type lesions, with the seemingly unavoidable consequence of casting the remainder of the sample as an homogenous norm. This is not a new demand; as Harcourt notes (Harcourt 1971a) a reference collection of comparative material with known diagnoses would be useful, but such material is scarce because modern therapy checks conditions quickly, and if it fails the animal is normally despatched before mature lesions develop. Again, this is a preoccupation with only one aspect of the problem. Indeed, archaeological animals may frequently die or be slaughtered before a condition is mature and knowledge of immature and sub-clinical manifestations could yield as much, if not more, information than the interesting, but detached, gross presentation.

Articular variation exists because osteogenic dynamics, while conforming to biological rules, vary in their degree from individual to individual through compensatory response to intrinsic or extrinsic stimuli. In most populations it would be expected that a minor portion of this variation would be anomalous compared with the normal distribution of some defined and relevant morphological variable, a minority within this anomalous group would be pathological, and a smaller fraction still would be deemed clinical. Although virtually all faunal remains are an artificially isolated part of a larger scenario, it seems arguable whether the archaeological

clinical lesion should remain in isolation from the larger arthropathic reality.

It is probably useful to state some general definitions here. Joint variation is the term used to express deviation from some standard, and although it will include arthropathy it is not exclusively anomalous. Arthropathic specimens are anomalous but not necessarily pathological, that is diseased. A pathological specimen exhibits lesions which indicate the presence of a disease which is, or has the potential to be, a clinical condition.

One fact and two assumptions also need to be stated. The fact is that arthropathies conform to defined biological concepts. The assumptions are, firstly, that joint variation is a response to stimuli, but initiation and degree may be related to a predisposition (for example genetically determined poor conformation). And secondly that a sub-clinical manifestation is unlikely to represent cause of death but may be indirectly implicated if it is age-related or associated with a clinical condition.

If it is accepted then that functional modification and protopathology might be worthy of further investigation, the reasons why there has been so little interest on the part of workers need some clarification.

The size and fragmentary nature of animal bone assemblages precludes the kind of detailed examination required to identify abnormalities associated with the early stages of disease conditions. Thus, most lesions observed are mature and the bones clearly deviant from the normal - for example the obvious healed fracture, ankylosed joint, grooved and eburnated articular surface. However, the possibility, even likelihood, must exist that for every advanced osteological lesion observed there are others in the developmental stage.

When lesions are reported they are treated as discrete and particular phenomena. But any further consideration is invariably in general terms, and this reflects the traditional need to get directly to a

diagnosis, aetiology, and interpretation. The arthropathies are a prime example – commonly designated as arthritis and deemed to signify age or draught use. Neither of these presumptions necessarily follow from the presence of the lesion, nor even from a reliable diagnosis. "Recovery of ankylosed joints from an archaeological excavation is an indication that the animals on location were used for heavy agronomical or draught purposes" (Alur 1975, 411) typifies such statements.

The situation is further exacerbated by the variation in reporting procedures that occurs according to the professional field of the observer; at the most straightforward level this means those who are veterinary practitioners and those who are not. For those who are not, recourse to veterinary opinion is only feasible for specimens which they, the archaeological workers, have already identified. In the absence therefore of standardised methodology and observation, the pathological status of the assemblage relies solely on that initial identification. It is this major deficit in methodology which lends such weight to the idea of published reference collections of lesions. The difficulty seems to be, however, that this is a partial answer to only one of many possible questions. And the fact that far too few questions are asked of or about animal palaeopathology is largely due to this preoccupation with the gross, gruesome and grisly; furthermore, the questions that do actually arise rarely go beyond those where answers can only be subjective – how much pain was the creature in; is this lesion indicative of deliberate cruelty.

These are of course valid considerations, but taken outside the profile of the whole sample that validity diminishes to undefined curiosity.

Returning to an earlier point, however, this should not diminish the validity of the random event. For example, healed fractures in ribs of a dog will invite conjecture about cruelty (blow from object wielded by human) or accident (blow from horse's hoof). Such conjecture is interesting, and inevitable, but the improbability of it progressing to any substantive statement curtails its value. The

important thing is that the event was survived and healing followed. This has more relevance for considerations regarding circumstance and attitude than the irreconcilable surmise of intent or accident. The conjecture, however, has more narrative potential.

Even where documentary evidence exists for specific conditions, conjecture can still occur over intent. When Aristotle set down remedies for flatulence, diarrhoea and insomnia in elephants (Thompson 1910), was his concern with the comfort of the animal or the humans responsible for it?

For the moment, within the terms of this paper, the overlying problem is that of methodological theory - should this requirement for narrative remain a factor within an approach designed to be accommodated in current faunal reporting procedures. And if so, how is the process of analogy to be operated if the argument is upheld that the discrete archaeological lesion and the modern disease diagnosis are not the only, or even the most important, analogues.

Archaeological faunal remains constitute unsatisfactory source material for the assessment of disease amongst individuals, in the way that human remains are susceptible to palaeopathological technique. This point was raised earlier with regard to the comments of Rogers et al (1987). At this level deductive argument is likely to be inappropriate to animal remains; the truth of a premise (modern diagnosis) may not unconditionally guarantee the truth of the archaeological conclusion. And the inductive process of analogy, whilst allowing degrees of strength of inference, must also be suspect:

> "Arguments by analogy proceed from particular to particular, and although such arguments are often misused, some are quite strong. To set up an analogy is to describe relevant similarities between A and B which make it likely that some other characteristic is the same, and therefore license the move from a premise to a conclusion." (Kelley & Hanen 1988, 45)

While the relevant similarities between an archaeological and a modern pathological lesion can clearly be described, in many cases it will be invalid to claim similarity between other characteristics on the basis

of the association of these characteristics in the modern animal. The assumption cannot be upheld in the absence of other factors relating to the archaeological individual. Degenerative joint disease is a very common, and simple, case in point. Degeneration can be initiated by ageing processes within the tissues, repeated minor trauma and stresses, or compensatory malalignment in response to injury or disease elsewhere in the body (Chapter 2 gives a more detailed discussion of these processes). The associated characteristics are different in each case, and without additional information on the archaeological individual no further analogy between modern and ancient animal is justified. This is, of course, reiterating the opinion of Rogers et al. However, the departure from that line of thinking, and an inherent theme in this research design, is that it may be the choice of analogues which is inappropriate, not necessarily the principle of analogy. If the level of comparison is moved from the specific (pathological lesion and individual animal) to the collective (osteological variation and archaeological or modern sample), we begin to move away from the impossible constraint of considering only those ancillary factors directly bearing on a defined disease within a single organism.

As an application of middle range theory, this would appear to be remarkably uncontentious.

Although the collective approach is equally appropriate to human palaeopathology, the availability of individuals and the researchers' natural interest in, and identification with, members of their own species have developed areas of concern rather different to those of the archaeozoologist. Nevertheless, Steinbock (1976, ix) stressed the need for a wider strategy in human studies in a comment which anticipated the current concern in faunal work:

> "The term palaeopathology was popularized if not invented by Sir Marc Armand Ruffer at the turn of this century while working with the extensive collections of Egyptian mummies and skeletons. With few exceptions, the literature since then has consisted of short reports describing isolated specimens of bone pathology. The specimens are often regarded as interesting curios without attempting to interpret the significance of such osseous lesions in the populations

> presented by the individuals. More recently an epidemiological or population approach has been utilized to study the skeletal pathology of ancient human populations, and this provides much more meaningful information.. . . Reports of isolated pathological specimens have little meaning unless placed in their archaeological and epidemiological context. Studies of such conditions as osteoarthritis, and dental disease are practically worthless unless an epidemiologic approach is employed."

The interests prevailing currently amongst human palaeopathologists are, however, probably more in line with the opinion of Manchester:

> "The abstract study of disease, itself part of the archaeological discipline, is not concerned solely with humanity as a whole. Human society consists of individuals and the quality of their separate lives influences the material and cultural prosperity of society. The widespread community diseases may seriously affect material prosperity, as did for example the Byzantine plague in the reign of Justinian. Individual disease creates stress, both psychological and economic, within family or larger groups and so may diminish the cultural and economic development of a community. A physically or mentally handicapped individual may be dependent upon his fellows for his welfare, from birth. Such material interdependence is considered essential in our contemporary Western society. To what extent was the handicapped Anglo-Saxon farmer or Palaeolithic hunter cared for by his kinsmen? Such and similar questions for distant antiquity can only be answered from a knowledge of the diseases of the time, their overall incidence and their individual severity." (Manchester 1983, 2)

These questions are not directly transferrable to archaeozoology. Animal plagues are certainly known to have affected material prosperity (Dun 1851); they may well have been common but will be a rarity in the archaeological record. Material interdependence between man and animal is expressed archaeologically in the consumption residue - species, age, sex, size; disabling lesions in domesticates can indicate either kindness, cruelty, ignorance or indifference. And whilst it seems accepted that human relationships can be explored within burial data, it is not rational to assume even the existence of relationships between man and his food in the same way.

Notwithstanding the somewhat ambivalent nature of modern attitudes to animals, there is a tendency to project into the past the arrogation that man must always have been aware of the parallelism of pain and distress in himself and other mammals.

If, then, Steinbock's appraisal of the collective approach is considered compatible with the views expressed here regarding osteological variation in faunal remains, the problem arises that epidemiology in its true sense (factors affecting a community at any one time) is not an option directly available to the faunal analyst. Cemetery material is susceptible to assessment as a sample of its source population in a way that animal assemblages, as consumption residues consequent upon choice and/or availability, are not. Data obtained from an assemblage will only reflect an unspecified fraction of the consumed portion (also unspecifiable) of a population. What is important therefore is the comparability between assemblages. And what is essential is that the methodology to do this is evolved within groups of material in which the biases of consumption, deposition, taphonomy and retrieval are either removed or quantified, and where the environmental and human factors are directly assessable. This means investigating large samples of defined modern material using techniques available for archaeozoological analysis.

This approach appears, at first sight, to conform to the forensic strategy discussed at the beginning of the chapter - "independent lines of evidence derived from distinct systems of causation . ." But this is not quite the case. At the present time it seems quite inappropriate to cite causation of osteological variation and extrapolate back, until there is a strong foundation of information regarding this variability within groups of animals. At present this foundation in archaeology seems shaky, and it is the investigation of the potential for building a stronger base which is the aim of this research.

CHAPTER 2

BIOLOGICAL PRINCIPLES UNDERLYING THE DEVELOPMENT OF ARCHAEOLOGICALLY VISIBLE LESIONS

This chapter outlines the biological principles and dynamics involved in the development of those skeletal lesions which are known to be visible in archaeological material. It is set out in four main subsections, and these define an overall classification which is adhered to throughout the four case studies of Chapters 4, 5, 6 and 7. Chapter 3, "Materials and Methodologies", includes the explanation of the assignment of anomalies within this classification. The concern of the current chapter is to define the osteological axioms responsible for the development of reactive lesions, congenital deviations or environmental adaptations.

Archaeological bone is overwhelmingly the most common find attributable directly to a once living body, and is one of the largest categories of material recovered in excavation. Living bone is a constantly dynamic medium, whose adaptive and reparative abilities are repeatedly called upon to maintain an equilibrium of structure within which the animal organism can continue to function. These abilities are considerable, but they rely on a principle of osteogenic reciprocity. In the timescale of the individual, what is lost, missing, or damaged must be replaced, either at the site of deprivation by the development of new bone, or elsewhere (albeit in close proximity) by some compensatory structure appropriate to the demands being made. This activity leads to the formation of the bony anomalies - lesions - which are recognisable in archaeological material where the repair and compensation has not made a perfect reconstitution of the original morphology. Over the period of species evolution, repeated demands may result in a genetic restructure wherein the osteological adaptations are reproduced sufficiently often to define a new "normality". In the potentially enormous, but often highly variable, timescale between individual adaptation and the derivation of a new normality there is a vast range of pathological, but viable, diversity. Archaeozoologists are, on the whole, most happy when dealing with the broad timespans of species evolution, domestication, or the

consistent appearance of selected 'types'. They recognise, but are less comfortable with, the manifestations of osteological adaptation within the individual animal but justifiably seek recourse in modern veterinary and zoological opinion. The aggregation of archaeological data on the minuteae of pathological reparation and adaptation within dated samples of animal remains is, however, an area which is repeatedly ignored.

Human demands on animals are only constrained by the degree to which the animal can adapt to those demands and still be viable in terms of economic or social value. If fecundity is paramount, arthropathies may be manifold before sterility renders the animal uneconomic. Draught animals may support extensive compensatory arthopathies without noticeable effects on their performance. This has been noted particularly by Bellars and Godsal in the British Antarctic Survey sledge dogs (Bellars & Godsal 1969). Selective breeding for any trait may be accompanied by an unconscious selection of congenital peculiarity. Environmental or nutritional stresses may produce skeletal changes through mineral deficiencies, and disease originating anywhere in the body may involve the skeleton at some stage during its progression.

Over and above these recognised circumstances surrounding modern exploited animals, any number of economic, social or environmental factors which are not relevant, or even experienced, in modern animal husbandry may have been brought to bear on the domesticates of antiquity; and an unknown incidence or permutation of such factors could produce stresses which express as osteological anomalies. It therefore follows that archaeozoologists should be prepared to report all variation whether or not they are able to assign a degree of relevance to it. As long as we rely only on relevance apparent in modern material - human and non-human, medical and veterinary - we will at best be reporting on the limited evidence of single bodies. What we should be working towards is collating a body of evidence which assists in the understanding of the human-animal relationship at any period and under any circumstances, be they economic, social,

environmental or, and this is probably the highest hurdle to be negotiated by a palaeopathologist, indeterminate.

It is the necessity to encompass the indeterminate, or at least the undetermined, which has engendered the five major categories of data recording used in this thesis - infective, arthropathic, traumatic, soft tissue ossification, and congenitally abnormal manifestations. None of these categories is deemed to be exclusive; their inter-relationship within any individual, sample or population is accepted. What this thesis hopes to demonstrate is that the observation of these manifestations leads naturally to the consideration of the anomaly pattern as a whole. The body of pathological evidence we are be able to extract from the skeletal remains in butchery waste, kitchen middens, rubbish dumps, or discrete burial has to be presentable in a standardised form. We have to produce pathological data in a manner which relates to the conventional profiles of species representation, age, sex, and type where applicable.

The core of this thesis is anomalous variation in joint morphology, and this is discussed at some length in the next section of this chapter.

THE STRUCTURE, FUNCTION AND ADAPTATION OF DIARTHROID JOINTS

This section is concerned with the morphology, mechanical function and internal dynamics of joints. Its aim is to demonstrate an important underlying principle of the research design - that within the constraints of genetic imposition, joints are not consistent replicas of a structural design but exhibit a range of acquired variation under normal functional activity. Depending on the rate or degree of compensatory response, however, abnormal circumstances may not produce abnormal deformations or pathological lesions in bone, particularly where death by other causes has curtailed the progress of osteological adjustment. Where pathological lesions are apparent, the affected joints should be considered alongside those which do not exhibit gross malformation. For any group of joints therefore the range of variation consequent upon reparative and

degenerative dynamics is likely to be more informative than discrete observations of structural disfunction.
Joints can be broadly classified as:

Synarthroses	immoveable joints
Amphiarthroses	partially moveable joints
Diarthroses	freely moveable joints

Synarthroses are a residual of embryonic development when articulating elements are joined by solid articular discs.
Synarthroses have no movement function. Those articulations derived from cartilage bone are joined by hyaline cartilage, and those derived from membrane bone are united by fibrous tissue. Many synarthroses disappear when skeletal growth is complete (synchondrosis), e.g. the epiphysial cartilage between diaphysis and epiphysis in a long bone. On maturity, ossification extends from the diaphysial side and the epiphysis becomes fused or synostosed with the diaphysis.

Amphiarthroses are permanent, and permit some movement, but are not involved in the growth of articulations. There are broadly two types - syndesmoses, which are bone surfaces joined by fibrous tissue as in the human inferior tibio-fibular joint, and symphyses where the opposing articulating surfaces are covered with hyaline cartilage, and these cartilaginous areas are then united by fibrous tissue or fibrocartilage. The intervertebral joint and the inter-pubic joint are both symphyses; the fibro-cartilage in the intervertebral joint has thickened to form an elastic disc; the pubic symphysis often has a simple vertical cavity in the centre of the fibro-cartilage which can expand in the female in the later stages of pregnancy.

Diarthroses are the joints which are the concern of this study. Here the articulating surfaces are covered by thin hyaline or articular cartilage. The whole joint is contained within a capsule of fibrous tissue within which, other than the articulating surfaces, the joint is lined with fine synovial membrane overlying subsynovial connective tissue. Where the synovial membrane undergoes transition to the periosteum and cartilage margin it is well vascularised, and this

vascularity is possibly related to the membrane's high proliferative abilities in this area (Jubb & Kennedy 1970). It is here that erosion, lipping or osteophyte formation occur in arthritis and arthropathy.

Within the membrane is contained the synovial fluid which appears as a thin film over the articular surface and the membrane; this fluid acts as lubricant, and its viscosity varies from joint to joint according to the mechanical demands on the structure. It may also serve as nutrient supply to the avascular articular cartilage (Le Gros Clark 1965).

The fibrous capsule often undergoes localised thickening forming bands or ligaments. These structures not only assist in maintaining proximity and congruence of the articular surfaces but are also involved in directional restraint. The fibrous tissue of the capsule is sometimes interrupted, as on the anterior aspect of the stifle joint where it is partly replaced by the quadriceps tendon (Jubb & Kennedy 1970). The fibres of capsules and ligaments are conjoined to bone by attachment to the periosteum and by mineralised fibres extending into the bone as penetrating Sharpey's fibres.
Diarthroses are described in terms of the actions they perform by direct muscular action, although some of them are capable of restricted movement in other directions by manipulation, thus giving some measure of protection in cases of sudden stress. The following classification of diarthroid joints is that described by Le Gros Clark:

> Enarthrosis (ball and socket joint) in which a spheroidal articular surface fits into a corresponding concavity. In no case are the articular surfaces completely spherical in curvature; the radius of curvature is not identical in all diameters, so that they are to a slight extent ellipsoidal. Movement is allowed in all directions – flexion, extension, abduction, adduction and rotation. The composite movement (excluding rotation) is circumduction.
>
> Condylarthrosis (condyloid joint) in which the articular surfaces are more conspicuously ellipsoid, and which allows flexion, extension, abduction, adduction, but not rotation.

Saddle-shaped joint (joint of reciprocal reception). The articulating surfaces are each concavo-convex in opposite directions. Like a condyloid joint, it allows flexion, extension, abduction and adduction, but the curvature of the articular surfaces also permits a light rotation. These joints combine considerable strength with relatively free mobility - an example is the carpo-metacarpal joint of the human thumb.

Ginglymus (hinge joint). This only allows movement about a transverse axis, i.e. flexion and tension. The articular surfaces are trochlear or pulley-like in shape.

Trochoid (pivot joint) which allows movement about a longitudinal axis (rotation). An example is the joint between the first cervical vertebra and the odontoid process of the second. The articulation consists of a peg or disc fitting within an osseo-ligamentous ring.

Arthrosis (plane joint) in which the only movement is a slight degree of gliding of one articular surface over the other. Movement is further limited by a tight fibrous capsule and frequently also by inter-osseous ligaments joining the opposed surfaces of the articulating bones. The articular surfaces are approximately flat, or show a slight degree of curvature. Examples are found in the human intercarpal and intertarsal joints.

In hyaline cartilage, essentially a persistence of the embryonic tissue which is the basis for ossification, the cells are evenly distributed throughout the matrix, rounder in the centre of a cartilaginous structure and flattening towards the periphery. The translucent matrix is a sulphated mucopolysaccharide protein with both high pressure resistance and elasticity, containing collagenous fibrils whose disposition and alignment is dictated by that of the cartilage cells and the tensional requirements of the cartilaginous structure. With age, these collagenous fibrils increase within the intercellular matrix, transforming the hyaline cartilage into fibrocartilage.

Articular hyaline cartilage, unlike other sites such as the larynx, trachea and bronchi, is not enclosed in a perichondrium (connective tissue sheath).

Fibrocartilage can also occur at the periphery of a joint surface where it serves to enlarge the cavity and prevent fracture of the margin.

Some diarthrodial joints have intra-articular discs or menisci which are plates of fibrocartilage or dense fibrous tissue lying between articular cartilages. In some articulations, for example the mandibular, they can separate the joint into two discrete synovial cavities. In others, as in the knee, the menisci are less complete. Here they act as shock absorbers and, by their elasticity, adapt their curvature to reduce incongruity between the femoral condyles and the tibia.

Collagenous fibres, as the basis of fibrous tissue, are considered to grow in response to tensile forces (Le Gros Clark 1965) and to orientate themselves in the direction of the stress. Intrinsic articular ligaments therefore, which become differentiated within the fibrous tissue of the joint capsule, are likely to be a developmental response to the tensile forces involved in the normal joint movement, particularly as these capsular ligaments become fully differentiated only after birth.

Ligaments have very low elastic properties and to all intents and purposes may be considered non-extensible. Their normal condition is to be taut when the joint is in the position of maximum stability - that is when the joint surfaces are at maximum congruence when the joint is in full extension. The degree of joint looseness is dictated by the laxity of the capsule as a whole, and this in turn is directly related to the possible range of movement of the articulation. In the elbow joint, for instance, the capsule is lax anteriorly and posteriorly and stronger medially and laterally where the well differentiated collateral ligaments have developed, and these ligaments remain taut over the whole range of extension and flexion. In contrast, the human shoulder joint, which is not weight bearing and has a wide range of movement, has a capsule which is consistently loose over its whole area.

Because the restraining influence of ligaments decreases with flexion in joints with more than one degree of freedom, it is the reciprocal contraction and relaxation of muscle which is the main mechanism for sustaining joint stability by maintaining contact between articular

surfaces at all positions of flexion. Where there is a wide range of movement which would be inhibited by strong ligamentous development, and again the human shoulder is a good example, there are groups of muscles whose purpose is to limit movement, not promote it.

In the majority of cases the archaeological animal joint will be represented by only one of the two bony components of the original diarthrosis. It may be a complete articular surface on an otherwise fragmentary bone, or it may itself be incomplete as an epiphyseal fragment. Only in very rare circumstances will there be any soft tissue adhesions. The periosteum will be absent, as will all cartilaginous structures including many where pathological ossification may have been initiated. Beyond identification to species and age status (juvenile or adult) there is unlikely to be any supporting evidence as to sex, stature, nutritional plane, or association with disease, archaeologically visible or not.

What is left and available for analysis is a part of "a compression member whose tension members have rotted away" (Currey 1984). Its functional meaning as a joint can only be expressed in terms of the absent tension members. However, its meaning as a unit of morphological variation is defined by association with other such units. Chapter 1 considered the philosophical validity of such an application for faunal assemblages; here it is necessary to look at how this variation occurs.

Joint physiology

Mammalian structure is constantly subjected to applied adaptational demands. And it is the manifestations and degree of adaptational response which define what is the standard state at any point in time and within any specified group. The evolution of the mammalian skeleton, complex and innovative though it is, may not have produced a structural framework that is in complete harmony with the normal, and natural, demands placed upon it. In his demonstration of the adaptive structure of bone, Currey concludes:

"The close relationship between load and strength must mean that the build of the bones is actually determined by the forces imposed during locomotion. This statement does not distinguish between determination over evolutionary time and determination during a lifetime. It is probable that the build of bones is roughly established by the genes of an animal, but the precise relationship between build and imposed load is established during life. There is much evidence that the build of a bone can be altered by loads imposed on it, so it is not the case that animals have a particular build of their bones and simply limit their own locomotory activity to what their bones are capable of bearing, though obviously elephants do not behave like month-old lambs." (Currey 1984, 238)

But, when considering certain joint structures, he concedes the difficulty in appreciating the evolutionary logic:

"Being a zoologist schooled in the belief that animals are optimally designed by natural selection, I must admit to regarding the knee with some disquiet: it seems marvellously designed to make the best of a bad job. The elbow, with its snug-fitting trochlear notch seems so stable compared with the knee, with its more or less planoconvex articulations held rather desperately together by ligaments; yet the hand is able to rotate much more than the foot. It cannot be argued simply that the knee is weight-bearing while the elbow is not, because in many mammals the fore-limbs bear more static load than the hind limbs, and yet the knees of nearly all land mammals are rather similar, as are the elbows . . .

I give a possible reason for the difference here, but I have little faith in its truth. The ankle joints of nearly all mammals are simple hinges. The tibia and fibula are bound together, and only one degree of freedom is permitted. The mechanical simplicity of the joint is made necessary by the large loads it has to exert during acceleration and running. Although the forelimbs bear more of the static load of the body, the hind limbs can thrust through the centre of gravity of the body without producing large upsetting turning moments; this the forelimbs cannot do. Nevertheless, the hind foot must be capable of accommodating to irregularities in the ground and to changes in direction. The tibia must, therefore, be capable of rotating about its own long axis. This requires two degrees of freedom. But it is not possible to have two degrees of freedom and with large angular excursions and at the same time have the stability of a shaft rotating in a trough, which is essentially what the elbow joint is." (Currey 1984, 166)

Loads are applied to bone either through joints or via the fibrous tissue attached to them, and thus bone can be viewed as the "passive" recipient of mechanical activity. Its cellular content is not involved with mechanical function, and as its structure is fundamentally collagen fibres sustained within an inorganically reinforced matrix, some similarities can be seen between the skeleton and inanimate supporting structures. However, unlike inanimate material, bone has the ability to modify its own structure in response to the deformatory loads imposed on it, although such modifications will normally be within a genetically imposed template. Thus, in very general terms, loads applied through specific activities will generate a compensatory response in the cellular content in the bone which will alter density, organisation, mass or morphology. In normal functional circumstances the cells' activity is directed to sustaining maximum efficiency of the bone - minimum addition of bone tissue to maintain stability and competence.

Lanyon (1982, 280) summarises three contexts which apply during normal functional activity:

> "Customary **intermittent deformation** may be influential in determining and maintaining skeletal structure. This is the immediate consequence of functional activity. It may also be responsible for initiating, influencing or controlling the structural changes which ensure that the skeleton becomes, and remains, suitable for its customary mechanical function.
>
> Customary intermittent deformation may be the cause of **skeletal deterioration** and structural failure. When parts of the skeleton are not maintained in an adequate mechanical state, damage and deterioration occurs under loads and strains which could normally be withstood without adverse effect. The manifestation of the damage depends upon the location and nature of the mismatch between structure and function. This may become apparent, as in osteoporosis, by the collapse of vertebrae or fatigue failure of femoral necks or, as in osteoarthrosis, by subchondral bone sclerosis and erosion of articular cartilage.
>
> Customary intermittent deformation is a reflection of customary **loading**. Each part of the skeleton is loaded in a particular characteristic fashion."

Abnormality, therefore, arises where the balance between structure and function is disrupted, and such maladjustment can arise through inappropriate mechanical activity as well as antipathetic physical or biochemical conditions. However, the important point is that remodelling will occur where mechanical activity is entirely appropriate to the function of the limb – within the bounds of genetic determination every normal bone will display some degree of remodelling which, through the intermediary of the "customary intermittent deformation" will reflect the normal, customary loading. For even in bone that is fully in equilibrium with the applied mechanical activity and where no changes in mass or morphology are required to maintain efficiency of function, constant repair is required to the matrix of large trabeculae and cortical bone. This internal remodelling is done by the formation of secondary osteones which continually replace damaged tissue and which, because tissue damage occurs predominantly at the sites of greatest stress, appear commonly at the point of fibrous insertions.

Tendon and ligament insertions occur through the medium of the periosteum. At these insertions the perforating fibres of Sharpey (fibrous bundles which run through the periosteum into the underlying bone where they become calcified) are concentrated so that the tendon or ligament appears to continue into the bone. There is however a transition zone at the insertion; cartilage cells are arranged in columns in the fibrous tissue of the tendon or ligament to form fibrocartilage, under which is a plate of calcified cartilage extending into the area of true bone. Tension or damage at the point of insertion can raise the periosteum away from the underlying bone, stimulating osteoblastic activity and causing new growth from the bone into the fibrocartilage of the attachment. This phenomenon has been noted in the third phalanx of modern draught animals, and explored as a possible indicator of prehistoric ploughing at the site of Ban Chiang in south east Asia (Higham et al 1981).

In the joints of long bones, the synovial cartilage is underlain by a thin layer of subchondral cortical bone. Beneath this, extending through the epiphysis and merging with the compact cortical bone of

the shaft, is cancellous bone which, in the foetal animal, is a random three-dimensional lattice. The orientation of the lattice into trabecular tracts only takes place after functional activity commences. In Lanyon's opinion this orientation is a response to the uneven strains imposed on a random structure:

> "If trabeculae are arranged in the same direction as function stress trajectories, then they will be subjected to axial tension or axial compression. However, if trabeculae are arranged at an angle to these trajectories they will also be loaded in bending and this will produce an uneven amount of strain on their different surfaces. Rather than considering that pure tension or compression strain encourages bone formation, it is more likely that an uneven strain pattern stimulates preferential deposition and removal of bone tissue until an alignment is reached where trabecular bending is eliminated, or at least minimized, during functional loading. When this situation has been achieved the trabeculae will have assumed a trajectorial arrangement. Different bones are subjected to different patterns of loading depending upon their position and the nature of the animal's various activities.
> Cancellous bone is protected from many morphologic influences likely to arise purely from having to occupy a particular position in a limb or having to be a particular overall shape." (Lanyon 1982, 282)

Most long bones broaden to some degree as the articulation is approached, and these expansions are mainly occupied by cancellous bone. The overlying subchondral cortical bone is very thin and non-compliant; the articular cartilage is very compliant having a very low modulus of elasticity and tensile strength (Currey 1984), but it too is very thin. The impact-absorbing capabilities of articular cartilage are thus very limited - experiments on cattle phalanges showed that removal of the cartilage increased the peak force by 9%, but removal of the cancellous bone and part of the compact bone increased it by a further 31% (Radin et al 1973). Cancellous bone is more compliant than compact bone, and it is the cancellous bone which contributes the highest degree of impact attenuation of the joint. This is important not only in reducing the stresses involved in the transfer of loads from one bone to another, but also to prevent damage to the lubricating cartilage. Because in normal functional activity joint surfaces are rarely completely congruent, much of the time load is

actually focused on an area much smaller than that of the whole facet. If there was no compliance in the subchondral bone, the weak cartilage would split; if the deformation was too great, the joint would not function efficiently.

When compensatory response fails to accommodate imposed stresses, structural changes of either degenerative or proliferative nature can occur which would be considered as disease conditions, and therefore strictly pathological. The following arthropathies are those which might be visible in the limb bones of domesticates in archaeological assemblages (J. Baker pers. comm.). They certainly do not cover all the conditions which might occur in the limbs, and they are presented here in very broad terms. It should also be reiterated here that in every case bone lesions are always secondary to soft tissue involvement.

Degenerative osteoarthrosis

Functional overload can be invoked by inappropriate subchondral bone remodelling, incompetent ligamentous support or inadequacy of joint congruity. If sustained, the mechanical disfunction can initiate the condition of degenerative osteoarthrosis.

This condition is so common amongst older people and animals that it tends to be regarded as normal. However, ageing of joints often progresses slowly enough that functional compensation is allowed; strictly speaking where more rapid progression occurs, resulting in pain, locomotor disturbances and lameness, it is regarded as pathological. As cartilage ages it loses elasticity and any attrition can lead to macroscopic lesions on the articular surfaces. It is the response of the cartilage and the subchondral bone to the initial lesions which dictate the subsequent course of the condition (Lanyon 1982).

Disruption of the articular surface can lead to the development of clefts in the cartilage, and if the underlying layer of calcified cartilage is fractured, callus may form in the cleft and in the adjacent bone. The cartilage may become separated and eroded,

exposing the subchondral epiphyseal bone. The vulnerability of ageing cartilage to such degeneration lies in its apparent reparative inadequacies, as described by Le Gros Clark:

> "From the point of view of its reparative power and of its reactions to irritants, articular cartilage may be divided into central and peripheral areas. The latter are in immediate proximity to the vascular synovial membrane through which they can derive nutriment more readily than the central areas. They are therefore able to react much more vigorously when exposed to injury. It has been shown that an experimental lesion in the peripheral areas is followed by the active formation of new cartilage. This is partly the result of proliferation of the cartilage cells themselves, and partly due to the proliferation and metaplasia of the cells of the synovial membrane, which is immediately adjacent. An incision in the central articular area, on the other hand, is followed by no formation of new cartilage of normal type - the lesion is simply repaired by the deposition of fibrous tissue or by only a partly chondrified matrix. In certain types of chronic arthritis, also, the central cartilage may succumb to toxic influences to the extent that it becomes entirely eroded from the surface of the bone, while the peripheral areas respond by active growth, producing a characteristic "lipping" of the articular margin."
> (Le Gros Clark 1965, 173)

Once initiated therefore, degenerative osteoarthrosis can become a self-perpetuating condition in the absence of reparative ability. Lanyon outlines two possible sequences for the induction of the degenerative spiral:

> "One hypothesis is that the initial lesion is in the cartilage and, as this degenerates and loses its shock-absorbing capability, the underlying bone is comparatively overloaded and responds by the trabeculae becoming thickened, more contiguous, and more mineralised. The increased stiffness that results leads to further cartilaginous damage and eventual eburnation of the joint surface. The alternative, but not mutually exclusive, hypothesis is that the subchondral bone, which is after all the principal shock absorber, becomes stiffer first, possibly as a direct response to a high or increased level of intermittent stress.
>
> The natural response of the subchondral trabeculae to high stress would be to remodel, thicken, and become more contiguous, thus presenting a stronger but stiffer structure. This adaptive response, which at least in the

> first instance protects bone tissue from deleterious mechanical damage, so overloads the cartilage that progressive degeneration becomes inevitable."
> (Lanyon 1982, 301)

He does however put forward the view that the absolute level of cartilage load may be less important than the variations in subchondral compliance, in that cartilage is more likely to crack and tear over areas of higher compression where the subchondral deformation is reduced. He notes that the almost invariable finding of fibrillation at the junction of loaded and unloaded areas of joint surfaces is consistent with lesions being related to the stress gradients within the subchondral bone.

Stiffening is not only related to primary remodelling consequent upon increased load, but also the secondary reparative changes due to the healing of subchondral trabecular fractures, and an increased incidence of fracture could be expected where the bone was reacting too slowly to accommodate changes in mechanical circumstances.

Greenough (1981) describes the degenerative progression as observed in modern dairy cattle. The hyaline cartilage becomes dry, dull, yellowish and slightly granular in appearance. Small clefts and fissures appear and progress to splitting and fibrillation of the cartilage - pieces of cartilage, or cartilage with bone, may detach to form corpra libra (joint mice). Continued erosion will expose the subchondral bone which becomes eburnated and possibly grooved. Loss of cartilage and bone increases the malalignment and malfunction, leading to extension of the injuries. Improper joint movement stimulates development of perichondral cartilage which ossifies to the characteristic exostoses or osteophytes. The density of bone adjacent to the eroded cartilage and bone eburnation is modified.

Osteochondritis dissecans

Modern veterinary literature recognises this condition primarily as one affecting the larger breeds of dog, particularly the Great Dane, and of calcium-deficient pigs (Jubb & Kennedy 1970), and it has also

been noted in immature horses (Morgan 1972). The condition was first described, and the nomenclature ascribed, as a disease of man by Konig and Paget in 1870 (Roebuck 1964). Veterinary sources consider the most likely initiator to be trauma, particularly that invoked by a shearing stress; however, in the case of osteochondritis dissecans, veterinary opinion does not distinguish between a discrete incidence of articular stress and a clinical response to repeated pressures.

In skeletal material, the macroscopic evidence of the condition is a small circular depression in the articular surface. The depression is a result of the detachment of a thickened plaque of articular cartilage from the subchondral bone. The degree of resorption and reparative osteogenesis is variable, but if high it may render the manifestation invisible in an archaeological specimen, or make it indistinguishable from post-mortem pseudopathological change. Baker and Brothwell (1980) consider that radiographic examination will verify its presence by identifying an underlying local sclerosis with a generalised osteoporosis of the remainder of the epiphysis.

Jubb & Kennedy (1970) consider that depression of the articular surface and tapering areas of radiolucency into the epiphysis are indicative of severe lesions, and that in many cases the condition may only be detected in thin, slab radiographs of the subchondral bone.

Morgan (1972) points out the similarity of the radiological appearance of this condition with that of periarticular subchondral bone cysts in horses as described by Petterson and Reiland (Petterson & Reiland 1968). In Petterson's study the subchondral cysts occurred in the phalanges in 13 of the 14 cases, the exception being a cyst in the carpal bone. Osteochondritis dissecans is normally recognised in the head and distal condyles of the humerus and the distal condyles of the femur, although Baker and Brothwell (1980) do point out that it can affect any joint. In the study by Roebuck (Roebuck 1964) the condition was found in the femoral condyle, proximal tibia, patella, talus, femoral head and capitellum.

Although Jubb and Kennedy (1970) note that there is no widespread awareness of the disease in animals, they cite trauma as the precipitating factor. However, in Roebuck's work with human patients (Roebuck 1964), in which species dissecans is considered a common lesion, he isolates five aetiological theories:

a) traumatic
b) ischaemic
c) constitutional
d) hereditary
e) attributed to epiphyseal growth

In his discussion of these he questions the validity of trauma as the initiating factor although conceding that trauma may be influential in determining the site, stage and type of lesion. He quotes quantitative experimental work done by Buchner and Reiger who found that a force of 614 kg was required to fracture the femoral condyle by pressure of the patella, which is clinically unacceptable. However, he does also draw attention to the observations of Fairbank and Smillie that the screw-home movement of the knee joint in the last degrees of extension causes the medial condyle of the femur to impinge upon the tibial spine, an occurrence they consider to support their observations that there is a high incidence of long tibial spine being associated with osteochondritis dissecans. Jubb and Kennedy (1970) state that the humeral lesion in animals occurs where the articular cartilage is subject to compression by the posterior rim of the glenoid when the joint is in full extension, and in the case of pigs a local compression with probable shearing component causes trabecular fractures in the subchondral bone.

The ischaemic nature of the free body and of the bed from which it derives is a consistent factor, suggesting that the blood supply to the bone is adversely affected by persistent minor traumata, as in the case of Kienbock's Disease of the carpal navicular in operators of pneumatic tools. A fatigue fracture may then occur with subsequent osteochondritis dissecans.

Roebuck's observations on his own cases and those of others lead him to invoke strongly the hereditary, constitutional and epiphyseal

growth factors. On the other hand, Clanton and Delee (1982) oppose this view and cite the work done by Petrie in which no definite genetic aetiology was found – in a study of the first-degree relatives of 34 patients suffering from osteochondritis dissecans, only one was found to exhibit the condition.

The constitutional factor does not appear to be well established beyond a possible association with endocrine dwarfism (White 1957). However, the very high incidence of the condition in the age group most likely to experience widespread endocrine imbalance cannot be ignored.

Irregularities in epiphyseal ossification in juveniles, with persistence of osseous islets susceptible to trauma in early maturity, have been suggested as underlying causes (Caffey et al, quoted in Roebuck 1964).

In the archaeological literature, Wells (1974) points out the common occurrence of the condition in Romano-British and Anglo-Saxon human material (up to 5% in some cemeteries), with 95% of the lesions occurring in the knee and foot, and the remainder in the elbow and wrist. He considered this consistent with trauma or stress being major factors in the aetiology; heavy agricultural work on foot produces a principal line of force directed through the big toe, the first cuneiform, the navicular, the head and trochlear surface of the talus to the distal articular surface of the tibia (Wells 1974). He further suggested that those sites in the wrist and elbow may be a consequence of "restraining restive oxen or guiding clay-choked ploughs", and considered the relative rarity of the condition in the Bronze Age to be a reflection of a pastoral way of life wherein demands on the lower limbs are confined to " a leisurely daily amble". In the absence of evidence relating to familial association in the communities from which the specimens are derived it appears somewhat simplistic to disregard the possible genetic factor, particularly as Wells himself points out that in his archaeological material osteochondritis and osteoarthritis rarely occur in the same joint, whereas in modern joints one is likely to arise from the other.

It would seem reasonable to expect a proportion of stress-induced osteochondritis to initiate a degenerative osteoarthritis where stress is persistent, as in the case of non-mechanised agricultural work.

Ringbone

This condition is not clearly defined in the veterinary literature. Baker (Baker & Brothwell 1980) states that it can be taken to mean any bony exostoses affecting the interphalangeal joints, or indeed any bony enlargement in this area. Some authors are more specific in their definition; Smith et al (1972) describe it as a condition of the second, or less commonly the first, phalanx. Cohrs (1967) says that it can involve the equine coffin bone (3rd phalanx) and Jubb and Kennedy (1970) describe it as a degenerative arthropathy of any interphalangeal joint.

Today ringbone is only recorded as a disease of the horse and is associated with working animals. However, Baker (Baker & Brothwell 1980) considers that it is likely to have occurred in draught cattle, and that as lesions are found in archaeological specimens which are in all respects the same as ringbone in the horse, it may be assumed that it was present in these cattle.

There are two forms of ringbone - articular and periarticular. Articular ringbone is a chronic ankylosing arthrosis, destruction of the articular cartilage being followed by union of the joint. The subchondral bone is atrophic. Periarticular ringbone is the more common condition - this results from inflammation of the ligamentous apparatus and periosteum. The reaction to the irritation caused by mechanical trauma causes exostoses formation which again may lead to union of the joint.

Ringbone is a condition which is unanimously accepted as a manifestation of repeated minor stress. Cohrs does suggest that excessively straight posture may predispose towards the disease, and that an excessively low rim to the proximal articular surface of the 2nd phalanx will facilitate a greater degree of sliding, twisting and

lateral movement which in turn renders the first interphalangeal joint susceptible to the arthrosis.

Spavin

Cohrs (1967) defines spavin as follows:

> "Spavin *Arthropathia deformans et ankylopoietica tarsi* is a chronic, deforming condition of the distal and medial parts of the tarsal joint, leading to ankylosis. It is the most frequent pathological joint condition in horses. It also occurs in cattle, particularly draught cattle. A similar condition is seen less frequently in the carpal joint (*Arthropathia deformans et ankylopoietica carpi*)."

In the live animal spavin occurs in several different forms. Jack spavin is the severe condition, high spavin affects the proximal tarsal bones, occult spavin produces a limited degree of exostosis, and blood and bog spavin produce no changes in bone at all and would not therefore be detected in an archaeological sample.

It seems generally agreed in the literature (Baker & Brothwell 1980; Smith et al 1972) that it is the development of the exostoses leading to ankylosis that is the major feature of the condition, and that the articular surfaces may be relatively unaffected.

Smith et al (1972) note that although the lesion may be small it is a serious and stubborn cause of lameness. Once ankylosis is complete, however, the animal may be fit for light work, exhibiting a stiffness of gait rather than pain-induced lameness.

Until recently the aetiology of spavin has been considered to lie mainly in repeated shock and concussion, with the possibility of an hereditary predisposition, and it has been considered a disease of the working animal. Goldberg (1918) concluded that spavin was caused by infection, and term should be used to indicate any inflammation of the hock joint leading to ankylosis.

However, a detailed study of the occurrence of spavin amongst a Swedish dairy herd of different breeds (Holmberg & Reiland 1984)

calls traditional views into question. The relevant points can be summarised as follows:

a) Of a live sample of 169 animals over the age of 18 months, tied up on concrete from the age of 3 months, 31% exhibited clinical signs of spavin. Radiographic investigation increased this incidence to 37%; changes were seen before 24 months and severity increased with age.

b) Post-mortem examination was performed on 17 of these animals culled for reasons of infertility or low milk production in their first, second or third lactations (24-48 months). Of these, 7 had been diagnosed radiographically with spavin. Morphological examination increased the incidence to 13.

c) A control group of 33 loose-housed animals had a 21% incidence of spavin on radiographic investigation.

d) Fusion did not occur before the age of 4 years. The distinctive stiffness of gait was associated only with cases of fusion.

e) Of the three breeds investigated - Swedish Red, Friesian and Jersey - the small Jersey breed had the highest incidence of spavin (50% as compared with 20% for the Friesian). However, within the breed groups two youngstock feeding regimes were applied - high and low intensity - and within the Jersey group alone the incidence of spavin was differentiated between the two regimes (71% incidence with high intensity, 25% with low).

f) In a subsample of 32 tied cows, with offspring of mean age 3 years, an inherited predisposition for spavin was noted. 11 dams had radiographically diagnosed spavin, and 64% of their offspring were affected. Of the remaining 21 dams, spavin was diagnosed in 19% of the offspring. In the untied control sample, 5 of the 7 affected animals were closely related.

Spavin is a common condition today, and well represented in the archaeological record. Baker & Brothwell (1980) note 26 cases from 12 sites. A classic specimen has occurred in the sample of sheep metatarsals recovered from North Ronaldsay.

Septic arthritis

Suppurative, or purulent, arthritis is always caused by bacterial infection, and it is the pyogenic, i.e. pus-forming, bacteria which cause bone changes identifiable in archaeological material. Infection

may be primary where bacterial access is gained through penetrating wounds, or secondary by extension of a pyogenic focus following a minor injury, or metastatic spread.

The following are the principal causative bacteria according to species. The susceptible age group for each host is indicated - it can be seen that, with the exception of pig, susceptibility decreases with age. The most common manifestation of septic arthritis is pyosepticaemia neonatorum ("joint ill") which results from infection of the umbilicus at birth.

Species	Bacillus	Age
Sheep	*Erysipelothrix rhusiopathiae*	Lamb
	Streptococcus spp.	"
	Haemophilus agni	"
	Staphylococcus spp.	"
	Escherichia coli	"
	Pasteurella	"
	Mycoplasma spp.	Adult
Pig	*Streptococcus spp.*	Neonate
	Erysipelothrix rhusiopathiae	Adult
	Haemophilus spp.	"
	Corynebacterium pyogenes	"
	Salmonella spp.	"
	Mycoplasma spp.	"
	Brucella suis	"
	Escherichia coli	"
Cattle	*Streptococcus spp.*	Neonate
	Escherichia coli	"
	Corynebacterium pyogenes	All ages
	Salmonella spp.	"
Horse	*Shigella equirulis*	Neonate
	Streptococcus spp.	"
	Escherichia coli	"
	Klebsiella genitalium	"
	Corynebacterium equi	"
	Salmonella spp.	> 6 months

The condition usually begins with an inflammation of the synovial membrane. This becomes swollen and infiltrated by polymorphonuclear leucocytes (Smith & Gault 1938). (These cells are characterised by a lobulated nucleus. They have a marked capacity for ingesting and destroying bacteria, and in local infections they emigrate freely from the blood vessels into inflamed tissues and become actively engaged in destroying the infective agent.) The inflammation extends to the articular surface which can become soft and eroded. The bone may be exposed through destruction of the

cartilage, and a suppurative osteitis may ensue. The capsule may rupture and the infection diffuse into the surrounding soft tissues and may extend to the skin surface. If the infection is overcome by cellular activity, the subsequent healing will result in varying degrees of disability. If only soft tissue has been involved disability will be caused by fibrous adhesions. However, if the bone has been affected a bony ankylosis can result through osteoblastic activity and the development of dense subchondral trabeculae.

TRAUMA

The standard definition is "any bodily injury or wound" (Collins English Dictionary 1979) but for archaeological purposes trauma represents a group of lesions which are only visible where they affect bone, and the visibility of these effects are not necessarily concommitant with the severity of the injury. The proliferation which accompanies the partially healed, infected, unreduced and comminuted fracture of a long bone may be highly visible and grossly anomalous, but the soft tissue ossification of a ligament with articular exostosis consequent upon a prolonged series of minor shocks might be as illuminating when visible as a developing condition over a sample or series of samples.

Traumatic lesions are the most common in osteological material after mechanically induced joint anomalies, and can be summarised as follows:

a) A complete or partial break in any bone (fracture).

b) The abnormal displacement of a bone in relation to another (dislocation).

c) A disruption in the normal blood or nerve supply (haemotoma, embolism).

d) Any artificially induced change in shape or contour.

Fracture

This is the result of any event which causes a complete or partial break in the continuity of a bone. In juveniles, the concussive or percussive events which might cause such breaks in adults may

result in greenstick fractures, where the high collagenous content causes the bone to bend with the stress and only partially breach. These injuries are recognisable where the reunion has taken place at an eccentric angle or where the animal has died within weeks of the damage. In the main, however, greenstick injuries which have been surmounted are not readily visible in archaeological material.

In adult bone which is fully mineralised bone trauma can be expressed basically in seven ways, although any fracture can demonstrate multiple expressions.

a) Transverse. A clean break in the horizontal plane.

b) Oblique. A clear break but angular to the horizontal plane.

c) Spiral. A concentric detachment, often caused by a torsion stress.

d) Impact. The breakage caused by the force of one bone upon another.

e) Torsion. A break caused by strain, where the strain in a ligament is strong enough at its attachment to fracture the anchoring bone.

f) Comminuted. Bone is fractured in multiple planes, and bone fragments are liberated.

g) Compression. A bone is subjected to force on two opposing planes, and compresses to absorb the stress.

Some fractures occur because the bone is already weakened or stressed by another pathological or metabolic condition (pathological fractures). These can occur in association with such conditions as osteoporosis, osteomalacia or neoplasia. Compound fractures are those where the broken bone perforates the skin; the bone and surrounding soft tissue is then immediately exposed to possible infection.

The recognition of fracture in archaeological bone relies on the survival of the individual for a sufficient period for some healing to occur. Some fractures may heal so well, without distortion, that they will only become evident in x-ray.

When bone breaks, not only is the collagenous and mineralised matrix fractured, but the blood vessels around the site of the fracture are ruptured. These blood vessels occur throughout the section of the bone - in the Haversian system of the cortex, in the marrow and also in the periosteum. It is the disruption of the vascular system which initiates the repair process.

Within hours of the injury there will be evidence of reactive and reparative activity, but this will involve soft tissue. Within days there may be a sufficient accumulation of new bone cells for a survived fracture to be recognisable in the bone alone, but for this to be visible in archaeological material would require very well preserved bone. It is likely that fractures sustained within a week or two of demise would be indistinguishable from post-mortem or point of death damage in ancient buried specimens using the naked eye or low magnification microscopy.

The time taken for full healing to take place depends of course on the size of the bone, the degree of displacement that has taken place and whether there has been any reduction (repositioning the opposing fracture surfaces), the ability to immobilise the damaged element, and the presence or absence of infection. In archaeological material it is often the visible operation of these factors that gives the greatest insight into the post-traumatic life and circumstances of the animal.

The natural course of fracture repair can be summarised as follows.

1. The blood escaping from the ruptured blood vessels accumulates within and around the fracture site, and as the blood flow ceases as the vessels seal, the haematoma coagulates. When the blood flow ceases the bone and periosteal cells at the site of fracture die. The haematoma then becomes the focus of cellular invasion (Tortora & Anagnostakos 1990).

2. Either side of the fracture site the periosteum will be torn and as it pulls away from the bone the sub-periosteal osteogenic layer is

stimulated to form new cells which start to bridge the fracture. Internally, similar activity is initiated in the endosteum and in the bone marrow, with the cell growth directed towards the fracture. These first calli consist of fibrous connective tissue, and within days this becomes mineralised into woven bone.

3. The accumulation of new bone cells forms a collar externally around the fracture, and this external callus is then replaced by trabeculae. A trabecular structure also develops within the marrow cavity.

4. Dead fragments are slowly resorbed by osteoclastic action and the woven bone is converted to lamellar bone. If the bone is in the correct orientation and has been immobilised this remodelling may eventually remove any trace of the fracture (White & Folkens 1991). X-rays may indicate old fracture lines, but for archaeological animal bone it is a smooth thickening of the bone surface which is most usually suggestive of a well healed fracture. These distentions are often more easily felt than seen, particularly in the long bones, and initial identification is often tactile rather than visual.

Well healed fractures in the limbs of wild gibbons, with little shortening of the affected bones, have been noted and illustrated by Schulz (Schulz 1939, 1967). A possible healed fracture, without displacement, of the left fourth metatarsal of the extinct *Macropus titan* has been reported by Horton and Samuel (Horton & Samuel 1978). As Siegel comments (Siegel 1976) the presence of good fracture repairs with little distortion in wild animals should warn against claiming splints or other intervention where such repairs are found in domesticates. Equally, the converse argument ought to be recognised; the presence of malunited, possibly infected, poorly healed fractures may not indicate absence of some sort of attention. This possibility is not always fully considered even amongst some human palaeopathologists:

> "In order to avoid the irritation of renewed bleeding, injury to the young granulation tissue, the penetration of soft tissue between the ends of the broken bone, the

> dangers of inflammation, infection, and the like, it is best to ensure the immobility of the injured part, but in prehistoric times men did not know this. Thus in ancient times a fracture often led to the creation of a pseudarthrosis, or false joint, between the broken parts of the bone which had not succeeded in uniting." (Zivanovic 1982)

This is an extraordinary dismissal of the observational power, with regard to their limbs, of people, some of whom have demonstrated their skill in successful trephination since the Neolithic. Fracture infection, malunion and pseudarthroses, particularly of the femoral head, occur in all periods (Manchester 1983) including our own. The optimum repair of a limb bone will take several weeks' full immobilisation – for the lower limbs particularly this may well not be possible and to ensure survival a compromise on the degree of disability may have been accepted. This is of course speculation, but it is still the basis of the modern treatment of potentially fatal conditions such as osteosarcoma or diabetic gangrene.

With animal bone it seems entirely reasonable to expect that survival, at least for a short period, is not necessarily obviated by malunion of a fracture. Quadrupeds, particularly digitigrade, are able to move reasonably efficiently on three legs and thus minimise stresses on a damaged limb or foot.

Hyperostosis and discrete osteophytic outgrowths

This category embraces those bony anomalies resulting from the demands made upon the sub-periosteal osteogenic layer underlying muscle attachments. They manifest as bony developments around the site of tendon insertion, and are recognisable as smooth, bony enhancements of the natural contour of the element rather than reactive manifestations from it. In archaeologial herbivore specimens they are commonly recognisable in the proximal metapodia as a bulking of the epiphyseal proximity outwith the joint sac, and in the posterior phalanges where they can often form a distinctive flange. In this study they are differentiated from ligament strain on two bases:

a) Site of osteoblastic activity. In the majority of cases, and particularly the limb bones, the tendon attachments can be disassociated from the ligamentous.

b) Ligament strain tends to express as a more osteophytic outgrowth; ligaments are more inelastic than tendons and so their capacity for energy storage is lower. The bone at their attachments is therefore subjected to a stronger force, usually over a smaller area, with a consequent acceleration of the sub-periosteal osteoblastic layer and a more finger-like bony excrescence.

CONGENITAL ANOMALIES

The general categories visible in skeletal material are:

1. Aplasia (non-development of a skeletal component)
2. Hypoplasia (reduction in growth)
3. Hyperplasia (over-growth)
4. Dysplasia (abnormal growth).

The majority of congenital abnormalities are not compatible with survival, for example tibial hemimelia, a defect commonly encountered in Galloway cattle and caused by a simple recessive gene, which results in calves with short and bent hind legs (Alderson 1982). Similarly, spina bifida manifesta, where the non-union of the neural arch exposes the spinal cord, will be lethal (although spina bifida occulta, where simple non or partial union of the neural arch does not cause herniation or tumour in the contents of the spinal canal, may not be fatal and is visible archaeologically). Additionally, congenital susceptibility to certain conditions can also prove fatal in the longer term, as has been noted in Teeswater sheep. This breed has a susceptibility to scrapie in those animals with stronger forequarters with the consequent linkage between a defect and a desirable characteristic which can result in a rapid spread of the condition (Alderson 1982).

In archaeological material our interest will invariably be concerned with those manifestations which do not affect the viability of the

animal. As will be seen from the observations reported in the chapters dealing with case studies, the range of encountered congenital defects may be very restricted and it is clear both from these studies and other published works that congenital dental anomalies predominate. This is particularly the case in dogs where the reduction of the jaw from the ancestral species, and the slower response of tooth diminution, can result in congenital crowding of the teeth and commonly the absence of the mandibular third molar.

Amongst archaeological animals, later prehistoric and protohistoric dogs probably have the highest potential for demonstrating congenital deviation. Indeed, if we accept that the "plain dog" recognised throughout prehistory is itself a man-made species we must also accept that the characteristics of "dog" which differentiate it from wolf are preserved congenital deviations. The further differentiation in dogs that is observed from at least the later Iron Age onwards in terms of stature, robusticity, limb form and cranial morphology, in addition to the structure of the dental arcades, must also therefore indicate preserved anomalies. To paraphrase the comments of Baker and Brothwell (Baker & Brothwell 1980), a normal dachshund cannot have legs 45 cm long. In order to be a normal dachshund it has to be an achondroplastic dwarf. To extrapolate backwards, therefore, a normal plain dog has to be a congenitally modified wolf.

This line of thinking of course invokes some degree of consanguinity in the preservation of these characteristics. The term "congenital" however encompasses all traits present at birth, and although consanguinity is a common, and archaeologically useful, cause, it does not determine all the deviation that might be apparent in our material.

Johansson (Johansson 1965) summarises this problem specifically, but with useful relevance to the archaeological question.

> "What is hereditary in one case may be a phenocopy (non-inheritable change in an organism that is caused by environmental influence during development but which resembles the effects of a genetic mutation) in another. Furthermore, a hereditary disposition for malformations may

have a visible effect only under certain environmental conditions.

Several different types of achondroplasia (disproportionate dwarfism) occur in cattle. Dexter cattle are heterozygous for a partially dominant gene which in single doses is responsible for the short-legged but fully viable Dexter type. In double dose it causes extreme achondroplasia with foetuses with very short legs and heads normally aborted before the eighth month of gestation.

> Many morphological malformations give the impression of an arrestment in the foetal development at a certain stage of differentiation and growth, e.g. hare lip, cleft palate, polydactyly.

An example of such abnormality which may or may not result from hereditary factors is the condition of hemivertebrae in dogs, as described by Hoskins (Hoskins et al 1966). This pathological asymmetry results from the failure of the centres of ossification of the lateral halves of the vertebral body to unite because of the persistence of the dorsoventral septum. The vertebral body thus retains a medial cleft which tends to result in an inhibition of development of one half of the centrum. This causes a wedge-shaped vertebra, and in the live animal produces scoliosis and kinked tails. If multiple hemivertebrae occur, the spine will be obviously shortened.

Any study of pathological conditions in animals which uses dogs as demonstrable material has to address the question of congenital hip dysplasia. Archaeologically, this condition is unrecognised other than in man, and yet in the modern dog it is ubiquitous amongst the large breeds with the notable exception of the greyhound. In the modern canine it has become something of a "cause celebre" in that it is attributed to the desire of breeders of large dogs to produce animals with increasingly narrow hips which accentuate the powerfulness of the forequarters. Its absence in archaeological material has already been noted as interesting (Baker & Brothwell 1980), and the reasons for this non-appearance may be significant.

Hoskins et al (Hoskins et al 1966) describe the mechanical influences and manifestations as follows:

"Coxofemoral subluxation. The shallowness of the acetabulum, with the increased looseness of the joint, allows the femoral head to slide over the surface of the acetabulum when the joint is moved. The result of the sliding of the two surfaces of the joint on each other is increased flattening of the acetabular rim and flattening of the femoral head, with bulging of the circumference to give a mushroom-shaped femoral head. Almost without exception, arthritic changes develop in the affected joints of dogs with congenital subluxation by the time the animal is two to three years old."

Riser (Riser 1964) considers that the underlying factors are related not only to heredity, but also to local embryonic disturbances related to vascular or metabolic influence, or to intrauterine forces (malposition or hormonal influence). He also notes that congenital hip dysplasia is now a frequent abnormality in large breeds but seldom occurs in dogs that mature at less than 25 to 30lb. He also records the following opinion, which is significant archaeologically if only by its lack of application:

> "Congenital developmental dysplasia, aseptic necrosis of the femoral head (Perthe's disease), slipped epiphysis of the femoral head (epiphysiolysis), reduced and unreduced traumatic dislocations, are all forms of bone deformities of the hip which look similar and are often indistinguishable after osteoarthritis has set in, even though the patterns of development are different."

This condition has been observed in two of the fifteen modern dogs prepared as comparative material for Chapter 5, a labrador and a German shepherd. None of the comparative greyhounds exhibited such symptoms. And to quote Riser further:

> " . . . the purebred greyhound does not have this disease. All reasons why dysplasia does not occur in this breed are not known, but the greyhound does have a greater volume of pelvic muscle mass per body weight than do those breeds commonly afflicted with developmental hip dysplasia.
>
> Recent reports strongly suggest that when man controls canine breeding, he disregards the laws of gravity and biomechanics for bracing, and that hip dysplasia may result from a lack of sufficient muscle power and pull to support the hip joint adequately. Breeding dogs strictly for bench shows may have favoured a decrease in muscle mass."

The significance of congenital anomalies in archaeological animals is an area which has yet to be fully explored, in that it relies on observations of what are often minor deviations without obvious pathological implications. However, it is an area which might prove fruitful for the later and post medieval periods in particular, where selection for type is most apparent and there is the likelihood that unconscious retention of associated non-lethal characteristics occurs.

INFECTIVE LESIONS

These are visible as the change in bone structure consequent upon inflammation. The arrival of the initiating bacteria, which are essentially a foreign protein, into the bone tissue causes the white blood cells to migrate in profusion towards these organisms. These white blood cells multiply and attempt to engulf the bacteria, and in so doing the blood supply is usually disrupted. This causes the death of some portion of the tissue, which liquifies through the action of enzymes (necrosis) into pus.

The classification of infection in the living animal is straightforward; it is either specific or non-specific. Specific infection encompasses those changes which are totally due to a recognised causative agent; non-specific describes all inflammatory conditions which are not attributable to a specific organism.

In human remains of archaeological origin, specific infective lesions are essentially related to tuberculosis, leprosy, and syphilis. Whilst many other lesions of inflammatory origin can be explained by association, for example trauma, congenital predisposition or mineral deficiency, the inability to identify absolutely the causative bacteria still renders these infections as non-specific.

In archaeological animal bone, it is likely to be very rare that a specific infection will be recognised. Earlier in this chapter, in the consideration of septic arthritis, a number of bacilli were cited as being the possible agents of inflammatory reaction in joints. In bone as a whole, by far the most common bacteria causing visible bone changes are the staphylococci, the streptococci, and the haemophylous

bacteria which flourish in a blood-rich medium. These highly opportunistic organisms will produce most of the infective lesions that we see archaeologically, but are unlikely to indicate endemic health problems within an assemblage at the level of observation available to the archaeozoologist. For humans the bubonic plague, or Black Death, epitomise endemic bacterial infections, and yet these are not visible in the skeletal remains. For domesticated animals, the catastrophic "murrains" - rinderpest, redwater, foot-and-mouth - are viral infections which have virtually no predisposition to bone.

The value of infective lesions in archaeological animal bone lies in the understanding of the circumstances surrounding the infiltration of the bacteria, and the conditions under which the infection was sustained, overcome, or succumbed to. Once again, it is the cumulative evidence of comparative populations and archaeological assemblages which will provide the greatest insight, and not the occasional observation of gross affliction.

In Chapter 4 an analysis will be presented of the infective lesions observed in the limbs, and particularly the feet, of a sample of modern foxes. As will be explained in that chapter, the quality of the skeletal material is such that highly superficial reaction affecting only the periosteal layer can be brought into the analysis. However, the frequency of skeletal reaction to intrusive bacteria is demonstrated and it is in this sort of light that archaeological inflammatory lesions should be sought. In the final section of Chapter 5, where we are dealing with canid material decomposed over fifteen centuries, the relevance of opportunistic infection is still demonstrable.

For archaeological material there are three manifestations of infection which may be observable as discrete conditions.

a) Periostitis. The bacterium lands on the external surface of the bone, stimulates swelling and consequently loss of circulation. Pitting occurs, followed by new bone formation on the outer surface of the compact bone. The new bone is usually laid down in a striated and linear manner.

b) Osteomyelitis. This occurs commonly in the long bones, and particularly in the metaphyses. The bacteria settle on the inner table of the medullary cavity and cause white cell reaction and formation of pus. This destruction commonly extends outwards to form a draining sinus through which the liquified necrotic material escapes. Such draining sinuses are visible in archaeological material. However, the infection may be overcome and reparation occur which obliterates the sinuses, in which case the diagnosis of osteomyelitis depends on the recognition of the inner dead zone (the sequestrum) and the new collar of bone at the margin of the medullary cavity (the involucrum). This can only be fully achieved by radiography.

c) Osteitis. A rarer occurrence, where the infections involves the compact bone. Once established this would be very difficult to differentiate from osteomyelitis in archaeological bone.

In the overwhelming majority of cases, it is unlikely that any observed infective lesions in archaeological animal bone will indicate a 'named' disease; what is useful however is to assess the progress and degree of the inflammation in order to evaluate the condition and functional value of the animal. This is most clearly illustrated in Chapter 4 on Suburban Foxes, where the condition of the bone allows early and superficial lesions to be examined, and the assessment procedures undertaken for this thesis are explained in full there.

CHAPTER 3

STATEMENT OF MATERIALS AND METHODOLOGY

A major proposition of this thesis is that a pathological lesion, as a deviation from an accepted template of normal development, can offer levels of information and significance beyond the pure diagnosis of disease or abnormality. Before any empirical strategies or results are presented, it is necessary to expand, and indeed defend, this proposition because it does rely on the broader, and less commonly assumed, definition of "pathology". Collins English Dictionary defines the word as follows:

> **pathology.** 1. the branch of medicine concerned with the cause, origin, and nature of disease, including the changes occurring as a result of disease. 2. the manifestations of disease, esp. changes occurring in tissues or organs. 3. any variant or deviant condition from normal.

It is the third definition which, as far as this thesis is concerned, is deemed to be most useful for archaeozoology. Our assessment of what is "normal" will rarely be made on remains assignable to individuals; it will be made on groups of disarticulated elements assignable only to species. "Normality" for the archaeozoologist is a repeated distribution pattern of measurement on single elements within period and species. As standard practice, specimens which are clearly diseased or traumatised are not measured. On the other hand, bones which are not visually abnormal without the aid of microscope, x-ray or histological techniques will be included in the standard metrical analysis. The argument here is that pathological variation can be endemic in any assemblage, and indeed is likely to be where adult animals constitute any part.

Mammalian skeletons are load-bearing, shock-absorbing, multi-articulated structures, vulnerable at many points to repeated extrinsic pressures but with high regenerative abilities. Bone is usually the most dynamic item in the archaeological record, and the pathological imprints on it will reflect not only major afflictions but the continuum of adjustments made by the animal to its environment,

nutritional plane, or the demands made on it in terms of muscle power or reproduction. Additionally, selective breeding by man for any particular attribute of the animal may enhance the potential for a pathological manifestation. In short, the unmodified skeleton of an adult domestic animal is likely to be very rare, but unmodified single elements may be very common.

In archaeology the integrity of faunal analysis depends on its ability to compare assemblages, and if pathology is to be introduced into that analysis in a meaningful, replicable way it must, in the first instance, be compatible with those procedures. This is a fundamental principle in this thesis, that the production of pathological profiles on assemblages should be an integral part of the animal bone report, and not an occasional luxury dependent upon veterinary or molecular biological interest. This is not to say that such detailed examination of archaeological animal remains is not warranted, but first we must assess the areas of need in such directions. To do so, we should be able to observe, report, and quantify pathological deviation in assemblages using the facilities that are currently available, and make those findings known in such a way that pathological variation is as acceptable and comparable as data on age, sex and size.

The methodologies developed and employed for this research, therefore, are embedded within the facilities normally available to faunal analysts. Quite deliberately, no recourse has been made to x-ray, SEM, or any chemical analytical techniques. The major methodological aim has been to apply the same procedures to every specimen, group of specimens, assemblage or skeleton that has become available for study. The objectives underlying this strategy are threefold:

1. To quantify the incidence of lesions on a consistent basis of observation.

2. To express incidence in a standardised manner to facilitate comparison.

3. To appreciate levels of disease, stress, or congenital attributes between and within groups of animals associated with human societies.

In this thesis it is the compound body of evidence which is sought, rather than the discrete evidence of an individual body. For this, a procedure of examination is required which can be replicated by any worker operating within the prescribed agenda of faunal analysis.

Materials

The same techniques were carried out regardless of the origin of the material, and these origins can be summarised as follows:

i) Groups of individual skeletons processed from cadavers, but not by the writer, with histories of size, sex, age, weight, environment, and cause of death. This category is represented solely by the collection of fox skeletons produced by Professor S. Harris during the 1970's, and a full description of the collection is given in Chapter 4.

ii) Skeletons produced from cadavers by S. Hamilton-Dyer or the writer. This category is mainly represented by the comparative dog skeletons reported in Chapter 5. The bodies of these animals, which were euthanasia subjects, were donated by the RSPCA. Their size, sex, weight and type were recorded by the writer, but age was rarely known. The skeletons were prepared at the Faunal Remains Unit, Southampton. The bodies were initially boiled over two days, with subsequent dissolution of the flesh with proteolytic enzyme (Neutrase 0.5L).

iii) Disarticulated elements of a genetically isolated ancient breed, produced and deposited as skeletons in modern times. This is the sheep sample collected by the writer and described in Chapter 6.

iv) The sheep limbs from the archaeological assemblage from the Winchester Northern Suburbs, covering a period from the the 10th to the 17th century AD. This material was made available at the time the assemblage was in the Faunal Remains Unit, Southampton for full analysis.

v) The sheep limbs from the archaeological assemblage at Fiave-Carera of the Late Bronze Age. This material is held in the Department of Archaeology, University of Southampton, and is described by Gamble and Clark (Gamble & Clark 1987).

vi) Concentrations of disarticulated dog bones from Romano-British contexts at Baldock, Hertfordshire. This material is reported fully in Chapter 5.

vii) Canid material from Staines Road Farm, Middlesex, of the Late Neolithic. These remains are also described in Chapter 5.

viii) Discrete dog burials from Late Iron Age and Early Romano-British Baldock, Hertfordshire, again reported in Chapter 5.

The disparity in the sizes of samples used in this work, which range from more than 5,000 complete elements in the fox collection to less than 50 fragments from Staines Road Farm, required basic strategies which could be applied to all groups. Within these procedures, modifications or innovations were necessary or desirable to accommodate the characteristics of different species or the condition of the samples. As each sample constitutes a group of elements of a single species, any modifications applied are to the whole group.

In the case of the medieval Winchester study (Chapter 7 Part A) the relevant sample is the assemblage of sheep limb bones; the catalogue and discussion of referred pathologies from all other species, although produced under the same regime of observation, is essentially an illustration of the deficiencies of the traditional approach to animal bone pathology.

In the fields of archaeozoology, pathology, veterinary and medical science, terminology is not always consistent between, or even within, the disciplines. In this thesis, the descriptive terminology is that employed in Sissons & Grossman (Getty 1975), and measurement terms are those of von den Driesch (von den Driesch 1976).

Method of observation

All bone fragments were first assessed with the naked eye to define gross deviations. Conditions such as bowed limb bones, expanded epiphyses, unreduced or poorly healed fractures, established exostosis formation, or variation in dental formulae are more readily observable with the unaided eye than with the microscope.

Each specimen, regardless of the preliminary assessment, was then examined with binocular microscope at magnification 6x. Anomalies identified at this level were then examined at 12x or 24x. Where possible, if lesions were identified on the external surface of the bone the inner table of the cortex was examined by auroscope – this proved possible on clean, broken archaeological longbones, on all complete or almost complete skulls, in dental alveoli, and was also useful in examining larger foramina in the vicinity of lesions. However, although higher magnification and the use of the auroscope add to the definition of the lesion, it is the identifications at 6x magnification which constitute the data sets reported, analysed and discussed here. This decision is based on the practice and experience gained in the investigation of the modern suburban fox sample of over 5000 bones (the initial research enquiry); recognition of abnormality by the purely visual method was not increased above 6x magnitude, but the difference in visibility of anomalies between the naked eye and 6x magnitude is significant.

Specimens were identified to element, right and left, fused or unfused, and allocated a unique specimen number.

Measurement

Each specimen was then measured according to the conventions of Von den Driesch (1973) and additionally, in the case of *Canis*, those of Harcourt (Harcourt 1974). Where measurements have been taken outside of these conventions, this is noted.

Measurements were taken with Mitotuyo electronic callipers, with manual input to Microsoft Works Version 1.05 database. Measurements were taken to 0.01 mm in order to mitigate experimental error due to unconscious recognition of expected numbers, and the figures rounded to 0.1 mm through a spreadsheet. Ratios were also derived through spreadsheet formulae using the 0.1 mm cell values.

Metrical analysis

Metrical results and regression analysis were achieved through Quattro Plus (Borland International Inc.), and further statistical results produced with Easistat (ARC Scientific Ltd., Oxford), whose implementation of the Kolmogorov-Smirnov test is from Press et al (Press et al 1986). Where a Chi-squared test has been performed, this has been done without application of Fisher's exact test or Yates' correction.

CHAPTER 4

SUBURBAN FOXES. A CASE STUDY OF THE PATHOLOGY VISIBLE IN THE LIMB BONES OF A POPULATION OF WILD CARNIVORES

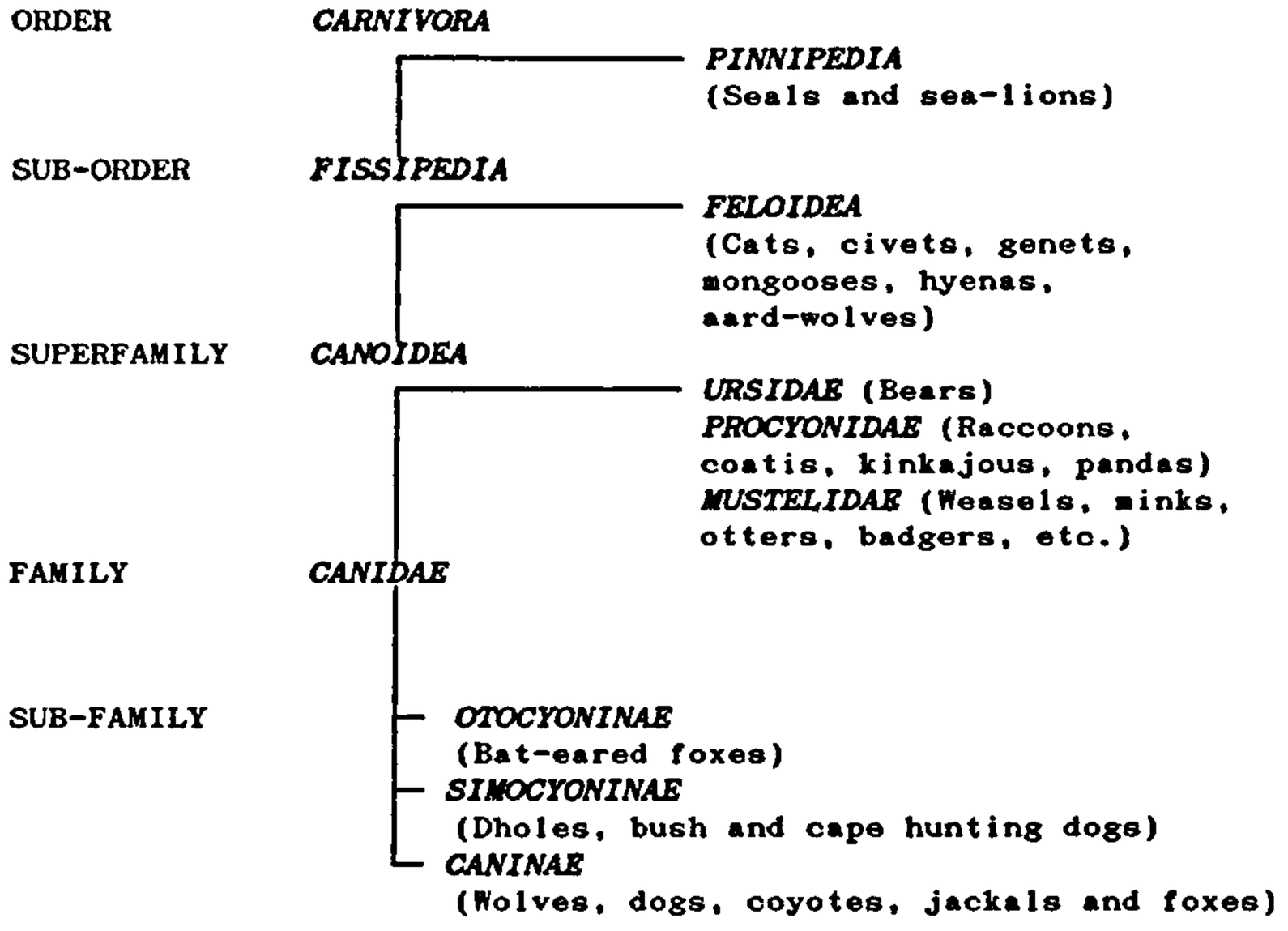
Introduction

Although carnivores comprise a relatively small proportion of faunal assemblages, the order includes the domestic dog which is the earliest known domesticated species (Cunliffe 1993). This animal is by far the most frequently occurring carnivore in the archaeological record but as a species suitable for investigation on a population basis, *Canis familiaris* is a very poor candidate. The continued specialisation of breed attributes, without the functions that originally made those attributes desirable, makes the modern dog interesting as an individual representing a possible type, but virtually useless for any study that involves looking at a sample of the population of the species. Feral dogs such as dingos would be suitable but sufficiently large collections of well provenanced, aged skeletons are unavailable. Similarly with wolves, the availability of large groups of modern skeletons is very restricted.

Some modern domestic dog material will be discussed in the next chapter where it is relevant to the archaeological dog remains investigated there. But in order to examine and illustrate the development and pattern of pathology within the dynamics of a living population it has been necessary to look at *Vulpes*, another genus within the Caninae subfamily, where a suitable sample of a defined population has become available.

The species investigated here therefore is the red fox, *Vulpes vulpes*. Its relationship to other canids is shown in the following classification.

CLASSIFICATION OF CARNIVORES AND CANIDS



GENERA OF THE CANID SUB-FAMILIES

		No. species
SUB-FAMILY	*OTOCYONINAE*	
Genus	*Otocyon* (Bat-eared foxes. Africa)	1
SUB-FAMILY	*SIMOCYONINAE*	
Genus	*Cuon* (Dholes. India)	1
	Lycaon (Cape hunting dogs. Africa)	1
	Speothos (Bush-dogs. S. America)	1
SUB-FAMILY	*CANINAE*	
Genus	*Alopex* (Arctic foxes. Circumpolar (N)	1
	Atelocynus (Zorros. S. America)	1
	Canis (Wolves, jackals, coyotes, dingos, domestic dogs. Africa, India, Asia, Europe, N. America, introduced Australia)	9
	Cerdocyon (Crab-eating foxes. S. America)	1
	Chrysocyon (Maned wolves. S. America)	1
	Dasycyon (Andes wolves. S. America)	1
	Dusicyon (Pampas foxes etc. S. America)	9
	Fennecus (Fennec foxes. N. Africa)	1
	Nyctereutes (Racoon-dogs. Asia, E.Europe)	1
	Urocyon (Grey foxes. N. America)	2
	Vulpes (Red foxes. N. America, Africa, Europe, Asia, India, introduced Australia)	10

SPECIES IN GENUS *VULPES*

Vulpes vulpes	The red fox
Vulpes bengalensis	The Bengal fox
Vulpes cana	Blandford's, or the hoary fox
Vulpes chama	The cape fox, or silver-backed fox
Vulpes corsac	The corsac fox
Vulpes ferrilata	The Tibetan sand fox
Vulpes macrotis	The kit fox
Vulpes pallida	The pale, or sand fox
Vulpes ruppelli	Ruppell's fox
Vulpes velox	The swift fox

The Harris collection

The collection skeletons of *Vulpes vulpes* was amassed in the early 1970s by Professor Steve Harris of the Department of Zoology, University of Bristol. It is derived from both accidental death and vermin control measures and is considered to constitute a representative sample of a fox population (Harris 1977a). The validity of hunting and control carcase counts as indicators of live population densities is also discussed by Englund (1980), Stubbe (1980a), Zimen (1980), Teagle (1967) and Lloyd (1980).

This particular population, dependent as it is on density of human occupation to provide residential habitats, represents a strategy of this animal which is now observable in most British cities and larger towns but which, at the beginning of the 1980's at least, was unknown throughout the rest of the species' range. Essentially therefore it exemplifies a species exploiting a new niche. At this time also, because of the need to identify accurate and viable means of rabies control, concern was expressed at the lack of studies into fox ecology (Zimen 1980, Lloyd 1980), and the difficulties in studying a species with such wide adaptive capabilities. The Harris collection may therefore reflect a geographically specific case, but it may also be typical of the kind of plastic adaptive strategies demonstrated by the species.

The distribution of *Vulpes vulpes*

Of all the canids the red fox, *Vulpes vulpes*, with its 47 recognised sub-species has the widest distribution. The antecedent species of the red fox, ***Vulpes alopecoides***, occurred contemporaneously with that of the corsac fox, ***Vulpes praecorsac*** in the early pleistocene in Europe, with the co-existence of the arctic, corsac and red fox occurring in the late pleistocene. Following the last glaciation the arctic fox, ***Alopex lagopus***, withdrew northwards with the receding ice, and ***Vulpes corsac*** to the open steppes of Russia. The red fox, ***Vulpes vulpes***, expanded to occupy a wide range of habitats in the more temperate regions. It now occurs throughout the holarctic region, except for Greenland, most arctic islands, and the drier zones of North America and North Africa (Fig. 4.1). Its appearance in Australia is the result of deliberate introduction. This enormous geographical distribution is the largest natural distribution of all mammals with the exception of humans and wolves, but it is the fox and not the wolf which has succeeded in persisting over all its range despite persecution and habitat destruction.

Whereas in Europe the wolf retained a wide presence until the close of the last century, in Britain it was eradicated by the end of the Middle Ages except for remote areas of Scotland and Ireland. While the wolf had been considered a valuable sporting animal by the nobles, its destructive capabilities on peasant livestock also rendered it a pest. With the destruction of most of its forest habitat in the Middle Ages the wolf population declined and eventually vanished, and the vacancies of sport animal and vermin were filled by the fox as the next appropriate carnivore.

As a species the fox appears far more adaptable than the wolf and is able to adopt varying strategies to exploit available environments. Unlike the wolf, which is a pack animal, the fox is a familial, creature with a matrilocal residence pattern. It has a non-specialised diet and will adapt to differing availabilities of food. It therefore only competes with other species for individual food items, and not for the overall availability.

Foxes appear at all stages of the archaeological record, and are significant on some early prehistoric sites in the Middle East (Clutton-Brock 1987, Hole et al 1969, Reed 1961,) and at Jericho were among the most commonly killed animals.

The Harris collection

In 1977 Harris published **Spinal Arthritis (*Spondylosis deformans*) in the Red Fox (*Vulpes vulpes*), with some methodology of relevance to Zooarchaeology.** This paper described observations made during research into the ecology of suburban foxes, and the data were derived from 252 carcases prepared by natural decomposition in the open air. It is this group of skeletons which has been made available for study within this thesis. The average age of the sample was 1 year 9 months, and 34.5% of the group exhibited the gross lesions of *Spondylosis deformans*.

Harris (1977, 192) comments on his results as follows:

> "That a free-living wild animal population can exhibit such a high incidence of a debilitating and presumably painful condition is both unexpected and previously unrecorded. Ever since Darwin pronounced on the origin of the species, and Spencer introduced that much quoted ecological maxim "survival of the fittest", it has been assumed that animals struggle to survive, and that weak, sickly or injured animals are eliminated from the population by inter- and intraspecific competition.
>
> The assumption that an injured animal cannot survive in the wild state has been used by archaeologists to distinguish domestic animals from those in a wild population. Stecher & Goss (1961), for instance, examined the spines from 245 equines, and found that ankylosing lesions were only present in domestic animals, and Zeuner (1963) noted that natural selection eliminates pathological types. Harcourt (1967), in a study of osteoarthritis in a Romano-British dog, argued that the degree of disability in the animal supported the view that it was a house dog, on the grounds that the condition is painful in the earlier stages and can be crippling, so that a village scavenger would have been unable to forage successfully and unable to hold its own in fights for food. However, the degree of disability seen in Harcourt's specimen was no worse than that seen in specimens collected in the present study, many of which exhibit several pathological conditions of the skeleton, and they certainly survived in the wild without obvious serious handicap."

This is an important point, and one which is relevant across the whole gamut of faunal remains and not just canids. And yet while Harcourt's argument has become an habitual citation, Harris's is quoted much more selectively.

Spondylosis deformans is a proliferative and potentially ankylosing condition of the vertebrae, the exostoses forming as a consequence of degeneration of the intervertebral disc. A clear explanation of the likely course of progression is given in Baker and Brothwell (1980, 129):

> "The consensus of opinion appears to be that the primary lesion is a focal degeneration of the annulus fibrosus which leads to the formation of major intradiscal fissures. This can progress to further damage to the already ruptured annulus with increasing amounts of necrotic debris in the disc space. Finally and gradually the disc tissue is almost totally lost and the naked bone of the ends of the vertebral bodies becomes ground and polished. The degeneration of the annulus leads to avulsion of the outermost layer of fibre, mainly ventrally or laterally. This fibre becomes necrotic and there is an attempt at healing with the formation of fibrocartilage which gradually changes to bone which unites with the vertebra at an early stage."

The literature and archaeological occurrences of *Spondylosis deformans* are also discussed by Baker and Brothwell (1980, 129), who consider that the Harris scheme of classification developed with the foxes could be applied equally well to any species.

Harris went on to investigate possible relationships between his observed levels of incidence for *Spondylosis deformans* and its development and the existence of previous traumatic injury. Previous injury was taken to be any skeletal defect or fracture caused by an accident. Soft tissue traumas could not be recorded, although they could equally affect the development of *Spondylosis deformans*, and thus the significance of the result may be reduced. Nevertheless, in his sample of 252 aged animals, he found in each age class a greater degree of severity of spondylosis in those with previous injury than

in those without. However, he points out that severely affected specimens were found without any signs of previous injury.
In a further paper (Harris 1977b) the injuries, as defined by healed fractures, were described and their causes and effects discussed. The sample size was increased to 256 animals over the age of 6 months, and 32.4% were found to have sustained and survived at least one fracture. Harris noted, qualitatively, that older animals exhibiting several separate injuries were badly affected with arthritis.

In neither of the surveys (*Spondylosis deformans* nor traumatic injury) is the claim made that the results reflect the normal situation in fox populations. In the absence of pathological reports on large samples of rural foxes it may be prudent to assume that the urban fox is more susceptible to injury by moving vehicles, broken bottles, etc; in Harris's study nearly 60% of healed fractures were recorded from the hind quarters "where most injuries might be expected to occur to an animal trying to avoid a moving vehicle".

Sample validity

The research design produced for this thesis calls for investigations on large samples which can support statistical analysis (Chapter 1). It could be argued that populations which are possibly unrepresentative are unsuitable subjects. I shall discuss this argument here, but the theme pertains equally to the case study presented in Chapter 6.

Palaeopathology, except in the very few instances where there is some preservation of soft tissue, is concerned only with those events which involve skeletal tissue. It can be applied circumstantially - as at the Peruvian site of Telarmachay where "72% of the predominantly camelid remains were from newborn animals, a fact which strongly suggests the occurrence of a high mortality from enterotoxaemia, a bacterial condition association with domestication and unsanitary corralling" (Wheeler pers. comm. quoted in Brothwell 1988). But at the level of direct osteological analysis it concerns a very restricted

array of manifestations which could result from a very wide variety of possible aetiological factors.

Palaeopathological observation, unlike modern pathology, is always a post-mortem activity, and only in the minority of cases will it indicate cause of death. For animal bone, cause of death may have minimal relevance; animals identified in food residues may invariably be assumed to have had a traumatic death inflicted on them. What palaeopathology is concerned with is the evidence indicating **survival of**, and **adaptation to**, those circumstances and events which initiated physiological disruption.

For archaeological animal bone in particular, there is limited potential for applying forensic medicine in the true meaning of that term, which is medical jurisprudence; the pathological lesion can be thought of as an **ecofact** regardless of whether or not it is consequent upon human intervention, and the information inherent in it is concerned with the reparative abilities or otherwise of the animal's physiology. Beyond this, the analytical approach proceeds to the interpretative, and justifiable interpretation depends on the accumulation of a substantial body of information on which to found a hypothesis. We can apply biological "laws" to define the development of lesions, but further than this there can be no rules, only hypotheses, without falling into sophistical argument and equifinality.

On this basis, and bearing in mind the works already cited on the ecology of this animal, distinguishing between what is and what is not a representative population within a species is irrelevant as long as the sample's integrity can be defined by acceptable parameters – geographical, age, population structure, or any justified combination of factors. To take the case of traumatic lesions in these foxes, it is the consistency of the reparative or degenerative processes of the individual across the sample which is meaningful, not the number of vehicles available to initiate those processes, because the vehicles are a constant – the same number were available to all the foxes. Indeed, the car could perhaps be viewed as an agent of natural selection. In chapter 6 this line of reasoning will be extended to a

situation where an initiating factor is hypothesised to be an independent variable which is environmentally determined.

Sample definition

For this study 178 skeletons were examined out of a total of 342 in the Harris collection. The only criteria for selection was that the limb bones were fused. The ageing technique used by Harris is based on annuli in the tooth cementum, and follows the convention that all foxes are born on 1st April. By selecting only those animals with full fusion, therefore, at the lower end of the age range the sample will reflect skeletal maturity and not age because age at fusion can vary by weeks between individuals, even those from the same litter.

Additionally, it is also necessary to be aware of the potential differences in maturation between wild and domesticated forms, and here in particular between *Canis* and *Vulpes* species.

Harris's experimental work on ageing techniques for *Vulpes vulpes* (Harris 1977) included age determination by the degree of epiphyseal closure, and he found that all ossification was complete by 29 weeks with the proximal humerus as the last closure in the limbs. He noted that his results supported the theory that epiphyses close more quickly in wild animals than in domesticated relatives. Certainly there is a difference in age at closure compared with studies on modern domestic dogs. Looking at the latest-closing epiphysis, the proximal humerus, full ossification in dogs is not achieved until at least 40 weeks (Sumner-Smith 1966). Furthermore, Sumner-Smith's investigations showed that age range for proximal humerus closure is very narrow and that closure is unlikely to occur before 40 weeks.

Table 4.1
Dogs: Published estimates of humeral epiphyseal closure

Reference	Breed	Latest closure time (weeks)
Lesbre 1897 (quoted in Getty 1975)	Not known	52
Seoudi 1948	German Shepherd Egyptian Armant	52
Bruni & Zimmerl 1951 (quoted in Getty 1975)	Not known	78
Smith 1960	Greyhound	56
Sumner-Smith 1966	29 breeds and crosses	>40
Silver 1969	Not known	60

The skeletal maturity of this sample of wild foxes, therefore, is occurring at a lower age than we should probably expect in an archaeological group of domestic dogs. This may not, however, always be the case when considering wild specimens of the *Canis* genus. Macintosh (1975) considers that the dingo *Canis dingo* exhibits the early fusing characteristic of wild canids (proximal humerus at 46 weeks), but he is comparing this with the highest figure quoted in Getty (Getty 1975) (78 weeks). Dingoes will clearly overlap with the domestic dogs reported by Sumner–Smith, but this is not surprising if they are descendants of *Canis familiaris* (Clutton-Brock 1987).

Ageing

It is not appropriate in this thesis to present a critique of age determination by epiphyseal fusion, but it is necessary to justify why one study has been used in preference to others, particularly when the standard archaeological reference (Silver 1969) will not be applied. Sumner–Smith accumulated observations from 259 animals from 29 breeds and cross-breeds to produce latitudinal data, and from 22 Greyhounds of 4 litters to produce a sequence of longitudinal data (Sumner–Smith 1966). From this he produced earliest and latest times of fusion of the limb bones, and a commonest sequence of fusion. The sample sizes, heterogenity of source, and the use of latitudinal and longitudinal data suggest that this study is the most

applicable to archaeological material, although Sumner-Smith's conclusions are highly conservative. This is, of course, only to say that modern studies may be useful for relative, and not absolute, ageing.

There appear to be no studies which measure changes in age at fusion with increasing distance from the wild state; in other words, any possible delay in maturity visible in wolves originally bred from wild individuals but maintained in captivity over several generations. For earlier prehistoric canid material, therefore, which is designated as *Canis familiaris*, even relative ageing may be highly speculative.

The population structure of the Harris collection

Returning to the foxes in this study, Fig. 4.2 shows the distribution of these 174 specimens examined by age and sex. Although the skeletally immature animals are absent, the pattern still accords well with Harris's comment on his observations on the full 342 sample:

> "There is a greater mortality rate for dog foxes in their first year, this being due to their greater activity (and hence vulnerability) while dispersing. This is counteracted by a higher mortality rate for vixens in their second year, this being due to their increased vulnerability while rearing cubs. Thereafter the rates of mortality for both sexes are equal, with a slightly greater life expectancy for dog foxes." (Harris 1975)

This reflects the matrilocality of residence of this species.

Fig. 4.3 shows the percentage of each sample within five age classes. The curves are broadly similar, but the distortion caused by the absence of the immature animals in age class 0 is apparent.

Fig. 4.4 compares the population structure of the current sample and the Harris sample with those of three other published studies which were not considered by Harris at the time of his work. Because of the discrepancy in age class 0, this class is omitted.

The sample from Hakel (Stubbe 1980) in what was the German Democratic Republic is drawn from the population of a 1300 ha.

wildlife research area. Over a study period of 15 years the average reproduction rate was calculated at 190% (range 110-265%) and a theoretical age group distribution was produced on this. In this area repeated hunting to zero level and subsequent immigration had produced an actual age distribution in favour of class 0.

The two other studies are from Sweden; from Jamtland-Harjledalen in central Sweden and Uppland-Sodermanland in northern Sweden (Englund 1980). Jamtland is predominantly coniferous forest with 10% of the land in agriculture; Uppland is again coniferous forest but with 30% in agriculture. The life curves shown in Fig. 4.4 have been calculated from the data generated over four and six years respectively. Although the juveniles are omitted from this analysis, their average contribution to the actual age distributions over the study periods is markedly lower than that of Hakel (53.2% and 51.7% for Jamtland and Uppland, where non-intensive hunting occurs, 65.3% for Hakel). It should be pointed out here that "hunting" is killing by shotgun, either for sport or vermin control.

Although in class 1 the London foxes approach the high representation of the Hakel population, the graph overall conforms well to the German and Swedish data; and certainly the deviations from the Harris plot by the subsample, as shown in Fig. 4.3, are well within the tolerances suggested in Fig. 4.4.

The pathology

The physical and metrical investigation is concerned exclusively with the limbs; the long bones, metapodia and phalanges. The gross length of each bone was measured (Von den Driesch 1976); the osteological anomalies were recorded under five headings, each category being subdivided to express degrees of severity.

1. Infective lesions:
    a) trace
    b) established
    c) mature
    d) fusion/deformation

2. Articular anomalies:

    a) articular extension
    b) eburnation
    c) grooving
    d) periarticular exostosis
    e) destruction of subchondral bone
    f) fusion/deformation of joint area
    g) remodelling
    h) depressions in subchondral bone

3. Trauma:

    a) simple
    b) complex

4. Hyperostosis:

    a) mild
    b) established
    c) severe

5. Discrete osteophytes not associated with articulations.

1. Infective lesions

The four degrees of severity can be described as follows:

Trace:	Pitting of the bone surface is visible with the aid of a microscope at x6 magnification.
Established:	Proliferation and/or pitting of the bone surface is visible with the naked eye.
Mature:	Some resolution has occurred. Woven bone is replaced with lamellar; draining sinuses may erupt in cases of osteomyelitis.
Fusion or deformation	The extent of the lesion is such that bony proliferation bridges two or more elements. This category also includes cases where distortion of the element occurs through the degree of bone destruction.

A total of 161 lesions were recorded, affecting 76 individuals. The contribution of each element is shown in Table 4.2. For the moment the phalanges are not included as they will of course over-contribute lesions in comparison to the other limb elements.

Table 4.2
Suburban foxes: infective lesions by element

Element	No. sites	No. affected individuals	No. affected bilaterally	Affected elements as % examined
Humerus	5	3	1	1.1
Radius	16	15	1	4.5
Ulna	9	9		2.5
Mcar2	6	6		1.7
Mcar3	8	7	1	2.3
Mcar4	5	4	1	1.4
Mcar5	6	5	1	1.7
Femur	10	9	1	2.8
Tibia	20	20		5.6
Mtar2	15	14		3.9
Mtar3	7	7		2.0
Mtar4	11	11		3.1
Mtar5	10	10		2.8

Therefore, although 42.3% of the foxes had some infective lesion of the limbs, the best percentage we can achieve by analysing the elements in isolation is 5.6%. Additionally, we should not expect to see lesions of category 1 (trace) in archaeological material using standard microscopy, and the relative fragility of the immature woven bone of early repair means that we may not see category 2 in poorly preserved material. What is likely to be useful, however, is to observe any relationships between what may be archaeologically visible, and what would not survive but is likely to have been present. In the case of these foxes the sample size demands that such an exercise be kept simple, and so it is the pattern of mature and deforming anomalies compared with that of the trace and established lesions which is described.

Figs. 4.5 to 4.11 show the sites of lesions, the stippled areas producing one or two cases and the black areas three or more. Fig. 4.12 illustrates the incidence of the four categories of severity across the proximal, distal and mid areas. Fig. 4.13 indicates the suggested vulnerable sites in the limbs.

Excluding the phalanges which of course give an over-representation, the points suggested in Fig. 4.12 can be summarised as follows.

a) The pattern of severity correlates reasonably well to the general distribution of infective lesions. This is particularly clear in the metapodials where the higher susceptibility of the metatarsals compared to the metacarpals is mirrored in the greater severity of the lesions. Similarly, the status of lesions in the mid and distal tibiae is established or greater.

b) Well-healed lesions (category 3) and deforming lesions (category 4) are under represented in the proximal long bones and the metacarpals, and well-healed lesions are virtually absent from the proximal and mid metatarsals.

c) Deforming lesions occur in the shaft area of all bones except the humerus, and in the metapodia in particular they are the most common category of lesion in the shaft. It is likely that many of these are the result of post-traumatic infection.

2. Hyperostosis at the sites of muscle attachment

25 animals contributed a total of 38 bones where some degree of hyperostosis was visible at sites of tendon insertion. This anomaly is defined as an area of increased bone deposition, as opposed to an osteophyte which is a discrete bony extrusion. It may be that at this level this is an unnecessary distinction; osteophytes are discussed later in this chapter and similarities in the pattern will be observed.

Figs. 4.14 to 4.17 show the sites of the anomaly, the stippled areas representing one or two lesions, and the black areas three or more.

The three degrees of severity are defined as follows. Each category would be visible in archaeological material, even with rather poor preservation and a high degree of fragmentation.

Mild	The bony protuberance is visible with the naked eye; it enhances the sculpture of the bone but does not deform it.

Established	The prominence has developed to such an extent that its morphological characteristics are different to the profile of the underlying bone.
Severe	The shape of the element itself is altered in some way by the development of the hyperostosis. Common sites are the medial and lateral supracondylar tuberosities of the femur; these are the upper attachments of the tendons of the gastrocnemius (the muscle which flexes the stifle joint and extends the tarsus).

Fig. 4.18 illustrates how the degrees of severity are distributed across the proximal, distal and mid areas of the elements.

Two animals produced bilateral anomalies, one in the femora and the other the radii. These represent 10.5% of the affected elements.

The factor found to be significant in the distribution of these anomalies is sex (Fig. 4.19), where n(normal) = 151, n(hyperostosis) = 25, $\chi^2 = 6.242$, $\rho = 0.0125$. No significance was found on the bases of weight or height. However, although dogs seem more susceptible to the hyperostosis, of the four individuals exhibiting severe anomalies, three were vixens. Additionally, maturity (animals in their first year compared with those aged 12 months or more) does not have a significant relationship across the whole sample. When applied to dogs alone, however, it does (n(normal) = 67, n(hyperostosis) = 18, $\chi^2 = 6.171$, 1df, $\rho = 0.0130$ (Fig. 4.20)).

3. Osteophytes

These discrete, finger-like projections have not been categorised by severity as they form a continuum of characteristic development.

Table 4.3
Suburban foxes: Occurrence of osteophytes by element

Element	No. lesions	Indivs. affected unilaterally	Indivs. affected bilaterally	Affected elements as % examined
Humerus	2	2	0	1.1
Radius	1	1	0	0.6
Ulna	4	3	1	2.2
Mcar2	6	5	0	2.8
Mcar3				
Mcar4	1	1	0	0.6
Mcar5	16	8	4	6.7
Femur				
Tibia	15	9	3	6.7
Mtar2				
Mtar3	1	1	0	0.6
Mtar4	1	1	0	0.6
Mtar5	5	1	2	2.2

Seven of the osteophytes of the tibia were on the proximal anterior tuberosity, the site of attachment of the patellar ligament. Fifteen of the osteophytes on the fifth metacarpal were at the site of attachment of *M. Extensor carpi ulnaris.*

As with the attachment hyperostosis dealt with previously, there is an apparent relationship between the occurrence of these osteophytes and sex, and again there was no significance when the lesions were tested against the weight or the height of the animals. Fig. 4.21 illustrates the distribution by sex; n(normal) = 142, n(osteophyte) = 34, χ^2 = 4.233, 1df, ρ= 0.0397. Once again, although this significance is not strong the males show a greater susceptibility to the condition. There is, however, an indication that maturity (in the first year, or older) is a factor across both sexes. Fig. 4.22 shows the distribution of osteophytes for animals in their first year, and the mature animals; n(normal) = 140, n(osteophyte) = 34, χ^2 = 4.901, 1df, ρ = 0.0268. If dogs only are tested then ρ = 0.0305.

If manifestations of hyperostosis and osteophytes are combined, the relationships are maintained. For sex n(normal) = 126, n(anomalous) = 52 (8 animals exhibited both forms), χ^2 = 5.538, 1df, ρ = 0.0186, and for age χ^2 = 4.900, 1df, ρ = 0.0269. Although it can be shown that there is a significant difference in weight between the male and

female subsamples (K–S = 0.5613, ρ = 0.0000), no such relationship between weight and lesions can be claimed (K–S = 0.2076, ρ = 0.1187).

4. Trauma

Traumatic lesions are defined here as being the result of fracture; the effects of sprain, dislocation, contusion, or infection following soft tissue wounds are dealt with under other headings as appropriate.

Eighteen traumatic lesions were noted, of which three were of the fibula and therefore fall outside this analysis. Twelve individuals were involved, two of them with complex fractures of the radius and ulna.

Table 4.4.
Suburban foxes: Sites of healed fractures

Element	Diaphysis			Status	Epiphysis			Status
	Prox	Dist	Mid		Prox	Dist	Mid	
Humerus			1	Complex	1			Complex
Radius	1		1	"				
Ulna	1		1	"				
Mcar2			1	"				
Femur		2		"				
Tibia		1		"				
Mtar2			1	"				
Mtar4		1		Simple				
Ph1					1			Simple
Ph2						2		"

The simple healed fractures of the phalanges were all fractures of the subchondral bone.

Harris (Harris 1977b) recorded the number of healed fractures in a subsample of 331 foxes and found 91 affected individuals. This is a higher percentage (27.5%) than reported above (6.7%); Harris however surveyed the whole skeleton and included ribs and caudal vertebrae, both of which elements are highly susceptible to fracture and heal well.

In the limb bones, Harris recorded 48 healed fractures, a lesion to examined individuals ratio of 14.5 (48/331). The present study produces this ratio at 10.1 (18/178). The major under-representation is in the tibia/fibula (Harris records 16). As the

specimen numbers of affected individuals recorded by Harris is not currently available, it is not possible to demonstrate that the subsample is biased in favour of animals without traumatic lesions in the limbs.

5. Arthropathy

A total of 6,804 bones of 171 individuals of known age make up the sample used in this study, producing 13,608 articular ends.

Fig. 4.23 shows the distribution of normal and anomalous individuals over six age classes.

"Anomalous" is defined here as an individual exhibiting one or more arthropathic manifestations in any of the 15 elements examined. An "arthropathic manifestation" is any one of the eight expressions detailed on the recording form. These in themselves may not be considered pathological lesions; here they are suggested to be anomalies with pathological potential.

The arthropathic incidence within each element group is summarised as follows:

Table 4.5
Suburban foxes: Arthropathic incidence by element

Element	Examined R	Examined L	Arthropathic	Arthropathic as % of sample
Humerus	167	165	20	6.02
Radius	161	164	14	4.31
Ulna	160	159	21	6.58
Mcar2	142	131	7	2.56
Mcar3	147	130	14	5.05
Mcar4	143	126	7	2.60
Mcar5	144	128	21	7.72
Femur	166	169	14	4.18
Tibia	171	168	17	5.01
Mtar2	149	147	10	3.38
Mtar3	149	146	13	4.41
Mtar4	148	146	15	5.10
Mtar5	146	145	11	3.78
Phalanx 1	1849		85	4.60
Phalanx 2	1038		33	3.18

Fig. 4.24 extends this summary to show the anomalies distinguished between proximal and distal articulations. The contraction of the arthropathic subsample at each stage of this initial analysis is

marked; of the 171 individuals in the group, 52.63% exhibited an arthropathic manifestation; of the 6,804 bones, 4.44% were anomalous, which diminishes by half if the sample is considered as a group of articular ends. This might be seen as discouraging, but it is still several orders of magnitude above the current archaeological level of observation. However, many of the slighter manifestations may be unobservable in archaeological material in anything less than excellent preservation. As with the infective lesions discussed previously, the point here is to demonstrate how the archaeologically visible anomalies relate to the overall pattern of the condition.

The following table shows the number of arthropathic articular ends in the subsample by age class.

Table 4.6
Suburban foxes: Arthropathic articular ends by age

Element		Age class					
		0	1	2	3	4	5+
Humerus	prox	3	1	0	0	0	2
Humerus	dist	2	3	1	3	3	2
Radius	prox	3	1	2	0	1	3
Radius	dist	2	0	0	0	0	2
Ulna	prox	4	3	4	1	4	2
Ulna	dist	0	0	1	0	0	2
Mcars	prox	5	14	1	3	3	2
Mcars	dist	7	3	2	0	4	5
Femur	prox	2	0	1	2	0	0
Femur	dist	4	1	0	2	2	0
Tibia	prox	2	1	1	2	1	1
Tibia	dist	2	4	1	0	1	1
Mtars	prox	13	3	11	0	2	7
Mtars	dist	2	3	6	0	1	1
Ph1	prox	4	11	9	0	5	12
Ph1	dist	9	14	5	1	3	10
Ph2	prox	7	6	4	2	0	1
Ph2	dist	3	5	2	0	0	3
		74	73	51	16	30	56

Therefore, the overall pattern which is reflected in the majority of the individual articular ends is of a high incidence in age groups 0 and 1, diminishing or stabilised over 2 and 3, with an increase in 4 and 5+. Given the population curve in Fig. 4.3, and the understanding that degenerative joint conditions are age-related, this pattern suggests that while the frequency of arthropathy increases amongst older animals, there is still possibly a significant

contribution from the younger age classes. This contribution can be simply expressed as follows:

Table 4.7
Suburban foxes: Arthropathic contribution by age class

Age class	No. of individuals	Arthropathic articular ends	Arthropathies per individual
0	68	74	1.1
1	64	73	1.1
2	18	51	2.8
3	10	16	1.6
4	5	30	6.0
5+	6	56	9.3

However, it is also necessary to describe and analyse, if possible, the degree of severity observable within each arthropathic instance. As stated earlier, each anomalous articular end was described in terms of occurrences of certain manifestations. The reasoning for this relies on the principle that the progression of joint degeneration is visible in the increasing number of arthropathic expressions (identifiable singular osteological deviations). For example, a specimen with periarticular exostoses, eburnation and grooving is taken to be further advanced arthropathically than one with an articular extension only. This is an alternative way of looking at progression; it is more common to score the relative severity of the complete lesion. But by looking at the accumulation of expressions, which are themselves the potential components of a pathological lesion, it is possible to extract more information from the non-pathological but still anomalous group which, on a scale of severity, would either score zero or form a single category of "mild".

The choice of categories is deliberately kept simple, but it is acknowledged that it may be oversimplified in some cases.

For instance, the "fusion" category is likely to contain advanced examples of the "periarticular exostoses" category, and should perhaps not be a discrete group in that it could appear in the analyses as a single manifestation. Where it does occur alone it could be argued that it should be treated as being at least at the level of two manifestations.

Similarly, in order to avoid the inclusion of any cases of septic arthritis, as far as is possible on visual examination only, destruction of the articular surface was only included in the analysis if accompanied by other categories, in which case it was assumed to have become progressive. This is certainly over-simplifying the situation.

Figs. 4.25 to 4.31 illustrate the distributions of the three manifestations which most frequently occur alone, and the distributions of the multiple lesions. It is coincidental in this instance that the maximum number of manifestations encountered at one joint surface was six, the same as the number of age classes. In the columns given below, the similarity to the table showing incidence by age class might give the impression that age increases to the right - this is not the case, and in the next table there is no recourse to known ageing data - or indeed to any data relating to the individual animal.

Table 4.8

Suburban foxes: Arthropathic severity by age class

Element		No. manifestations					
		1	2	3	4	5	6
Humerus	prox	5	0	0	0	1	0
Humerus	dist	10	2	0	2	0	0
Radius	prox	9	0	1	0	0	0
Radius	dist	3	0	1	0	0	0
Ulna	prox	10	2	4	2	0	0
Ulna	dist	2	0	1	0	0	0
Mcars	prox	22	3	3	0	0	0
Mcars	dist	6	11	2	0	2	0
Femur	prox	4	1	0	0	0	0
Femur	dist	7	0	1	0	1	0
Tibia	prox	3	3	1	1	0	0
Tibia	dist	1	1	3	2	1	1
Mtars	prox	23	9	4	0	0	0
Mtars	dist	11	1	1	0	0	0
Ph1	prox	25	8	3	2	2	1
Ph1	dist	32	5	3	1	2	1
Ph2	prox	6	7	4	3	0	0
Ph2	dist	6	4	2	1	0	0
		185	57	34	14	9	3

Manifestations (n = 300 articular ends)		Age class >0 (n = 104 individuals)	
1	61.6%	1	62.5%
2	19.0%	2	17.3%
3	11.3%	3	9.6%
4	4.7%	4	4.8%
5+	4.0%	5+	5.8%

These results are shown graphically in Fig. 4.32. The "Individuals in age class" curve is the same as that for the Harris sample in Fig. 4.4. The line for the number of manifestations is derived only from the group of affected articular ends - in this case 300 out of a total examined of 13,608, or 2.2%. If the remaining diarthroid surfaces (mandibular, scapular and pelvic) had been included the total examination would rise to 14,676. If the intervertebral amphiarthroses had been examined the number of articular surfaces available for investigation in this sample would be 25,534. But without actually examining skeletons in this detail it is not possible to say whether the 2.2% affectation rate would remain the same. Nevertheless, in the sample that has been analysed there is a strong similarity between the population structure and the accumulation of arthropathic anomalies.

It is, of course, the first phalanx that makes the largest contribution to the arthropathic load (13.7% proximal, 14.7% distal), and the accumulation curve for manifestations on the proximal first phalanx is very similar to that for the overall arthropathic sample (Fig. 4.33). But now the sample size is breaking down into very low numbers for the upper categories, and it is probably sensible just to observe the similarities between elemental contribution to the single manifestation category, and the percentage of animals falling into age class 1. On this basis, the proximal ulna and proximal metatarsals also give a fair reflection (62.5% and 63.9% respectively).

It is not simply the case that the "severity" of a lesion corresponds to the age of the bone in which it occurs. This is not to say that these arthropathies are not age-related - reference to Fig. 4.23 will show that they are - but it is perhaps the contribution of "lighter"

anomalies by the older animals which produces the pattern of the condition in the population as a whole.

Discussion

Table 4.9:
Suburban foxes: Number of arthropathic manifestations by age class

Age class	No. manifestations					
	1	2	3	4	5	6
0	52	14	5	2	0	1
1	46	10	9	4	4	0
2	26	11	10	2	1	1
3	7	4	3	1	1	0
4	21	7	2	0	0	0
5+	34	12	4	5	1	0

In the table above, under the definitions outlined in Chapter 2, only manifestation categories 4, 5 and 6 would qualify as pathological, or indeed anomalous. Within these there are 23 lesions, 6 of which do occur in the oldest animals, over 5 years old, but 11 are exhibited in animals under 2 years of age. In the age class for animals between 4 and 5 years there are no pathological arthropathies in the limbs. Observations of the strictly pathological, and probably clinical, exhibitions therefore not only give very fragmentary information, they also mask the dynamic of a condition developing to maturity. It is the dynamic working within the population which is the more useful concept archaeologically as long as the complexities are acknowledged.

Interaction of conditions

Although the anomalies have been described under five broad headings, these categories are not discrete or exclusive. The possibility of hyperostosis at muscle insertions and osteophytes being part of the same process has already been discussed. Pain caused by infection or trauma may cause lameness which induces arthropathic changes. Infections which are unobservable because they occur in soft tissue, or are sited in non-limb elements, may affect the status of the bone, as may the plane of nutrition, state of the teeth, demands of pregnancy or lactation. There are also overlaps in the definitions applied to each category. Hyperostosis, for example, may also be closely associated with healed infection or

minor trauma. Septic arthritis is primarily an infection, but may manifest on an opposing joint surface as a general arthropathy such as periarticular exostosis.

Age is, of course, a major parameter to be considered with any lesion. Even with temporally random events such as fracture or infection from penetrating wounds, older animals are likely to have accumulated more lesions or visibly healed sites. This has to be remembered when looking at any associations between conditions. However, in this study there are two significant relationships between categories which are relevant to archaeological investigations, whether or not the age factor is invoked.

Three categories, arthropathic, hyperostotic and osteophytic, and infective, have a significant dependence on the age of the animal, as follows.

Table 4.10
Suburban foxes: Arthropathy, hyperostosis, osteophytosis and infection by age class

Category	n(total)	n(anomalous)	K-S statistic	ρ
Arthropathic (all)	172	87	0.3586	0.0000
(>=12 months)	104	67	0.3425	0.0075
Hyperostotic/osteophytic				
(all)	174	51	0.3730	0.0001
(>=12 months)	104	37	0.4724	0.0000
Infective (all)	174	76	0.1627	0.2070
(>=12 months)	104	45	0.2791	0.0375

The infective category is, however, more weakly dependent. Looking at the relationships between the categories, a possible area of this weakness is apparent. Arthropathic lesions are strongly related to both infective, and hyperostotic/osteophytic. Infective lesions, however, are not significantly related to hyperostotic/osteophytic cases at all.

Table 4.11
Suburban foxes: Relationship of arthropathic to infective, hyperostotic and osteophytic lesions

Category 1	Category 2	n	χ^2 value	df	p
Arthropathic	Infective				
(all)	(all)	178	12.913	1	0.0003
(>=12 months)	(>=12 months)	104	8.397	1	0.0038
Arthropathic	Hyperostotic*				
(all)	(all)	178	8.012	1	0.0040
(>=12 months)	(>=12 months)	104	8.580	1	0.0034
Infective	Hyperostotic*				
(all)	(all)	178	1.601	1	0.2057
(>=12 months)	(>=12 months)	104	1.564	1	0.2111

Fig. 4.1
Foxes: Global distribution



Natural distribution of Vulpes vulpes .
(after Zimen 1980(a))

Fig. 4.2

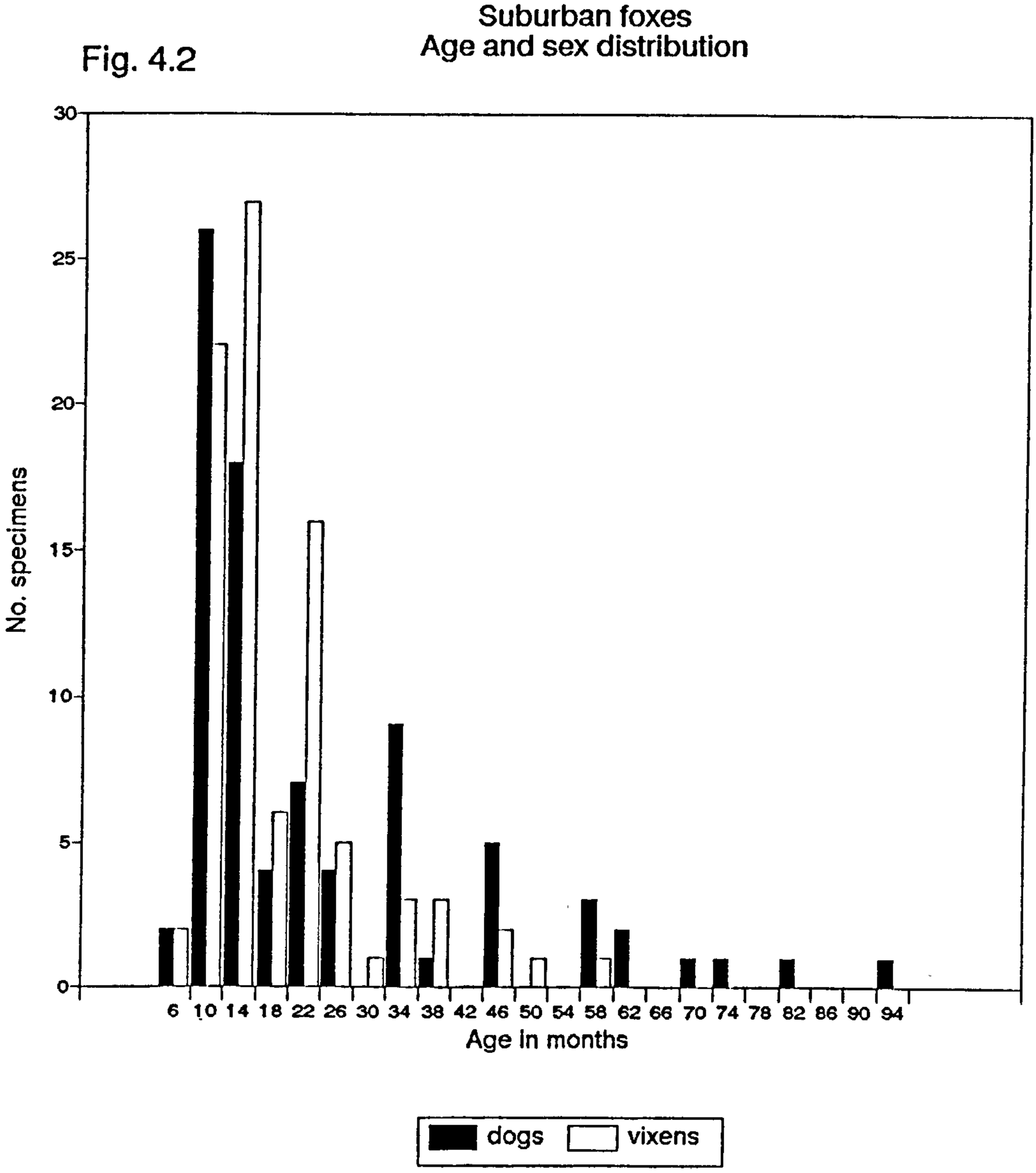

Suburban foxes
Age and sex distribution
No. specimens
30
25
20
15
10
5
0
6 10 14 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82 86 90 94
Age in months
dogs
vixens

Fig. 4.3

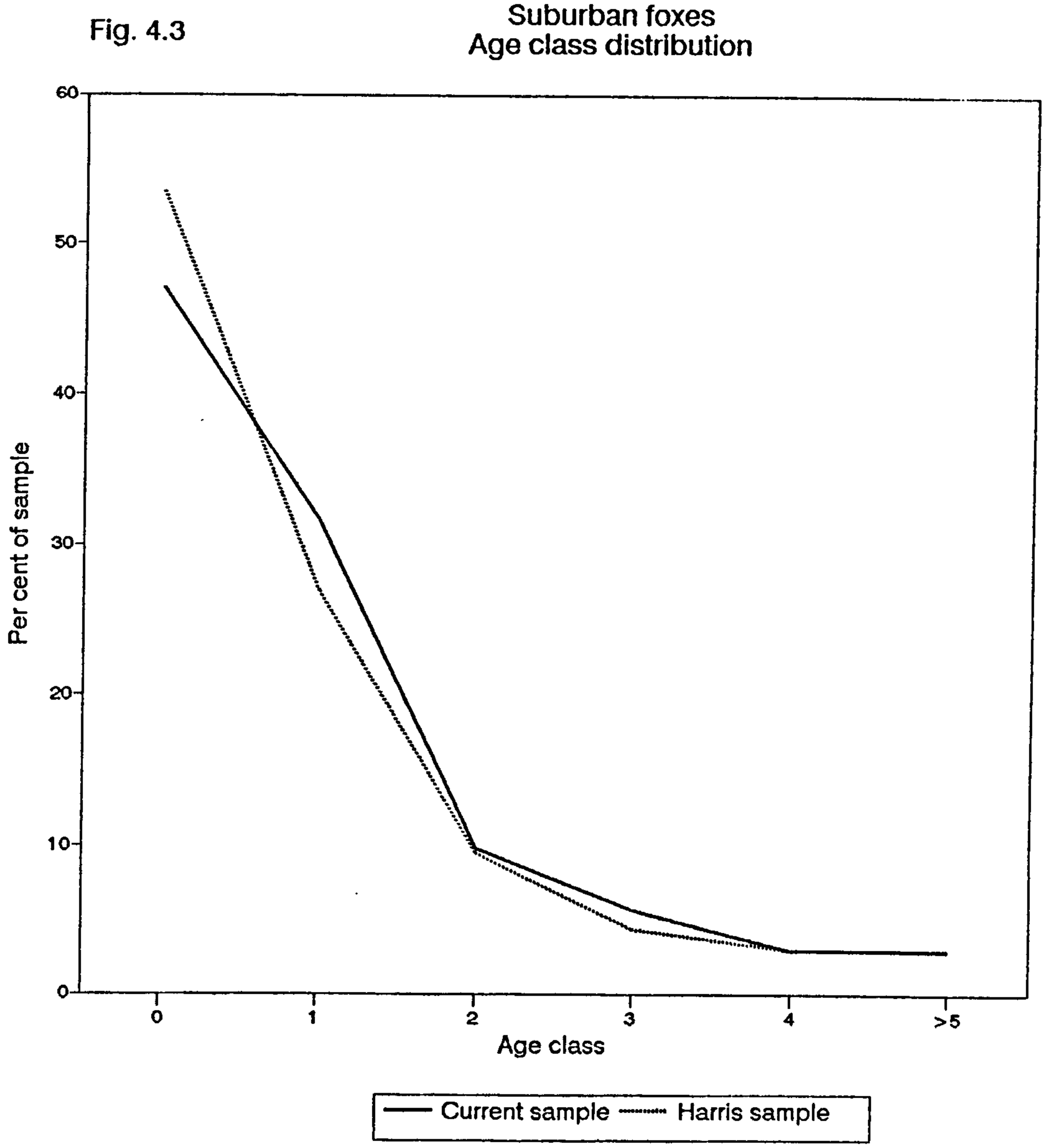

Suburban foxes
Age class distribution
Per cent of sample
60
50
40
30
20
10
0
0
1
2
3
4
>5
Age class
Current sample
Harris sample

Fig. 4.4

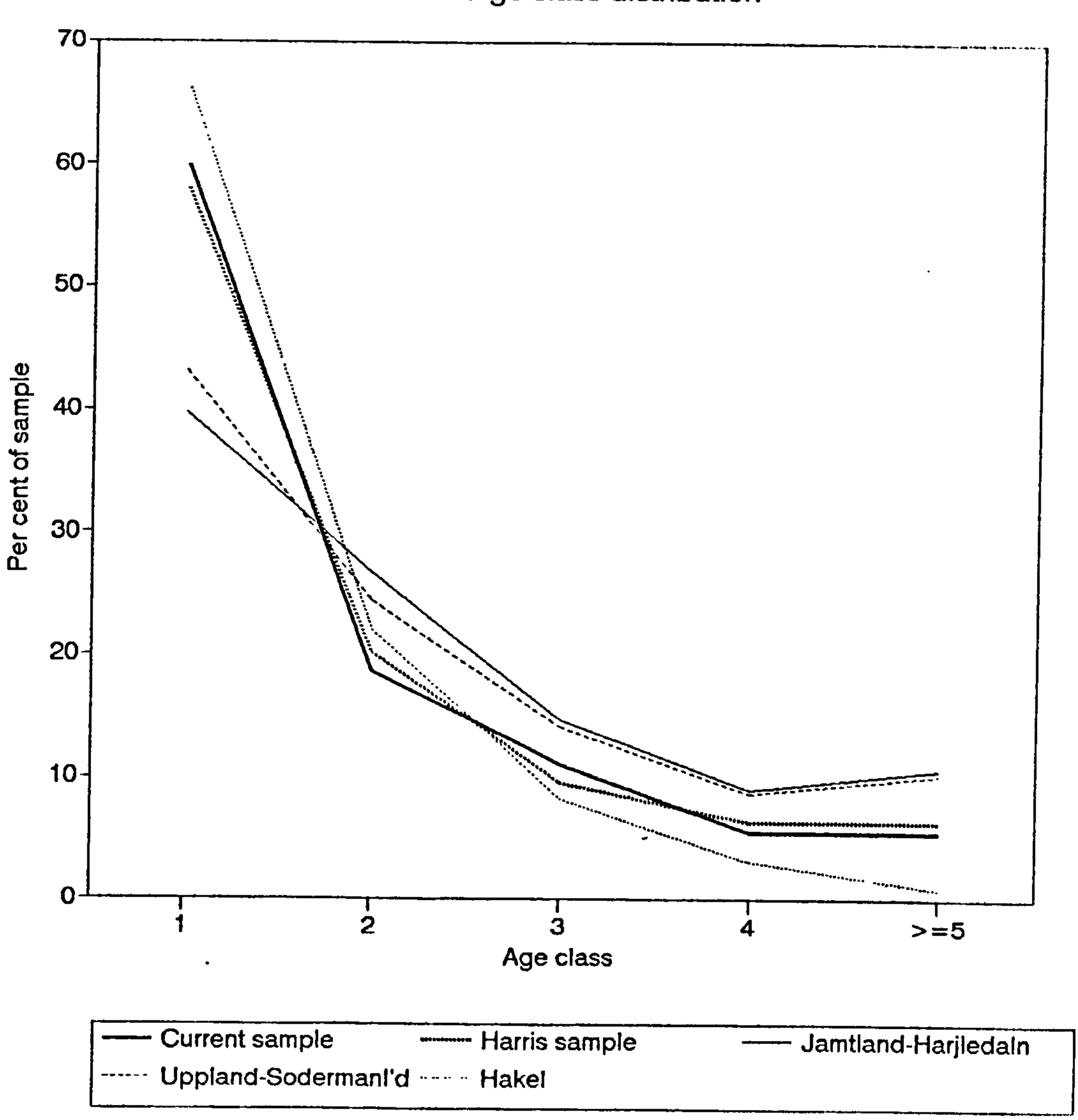
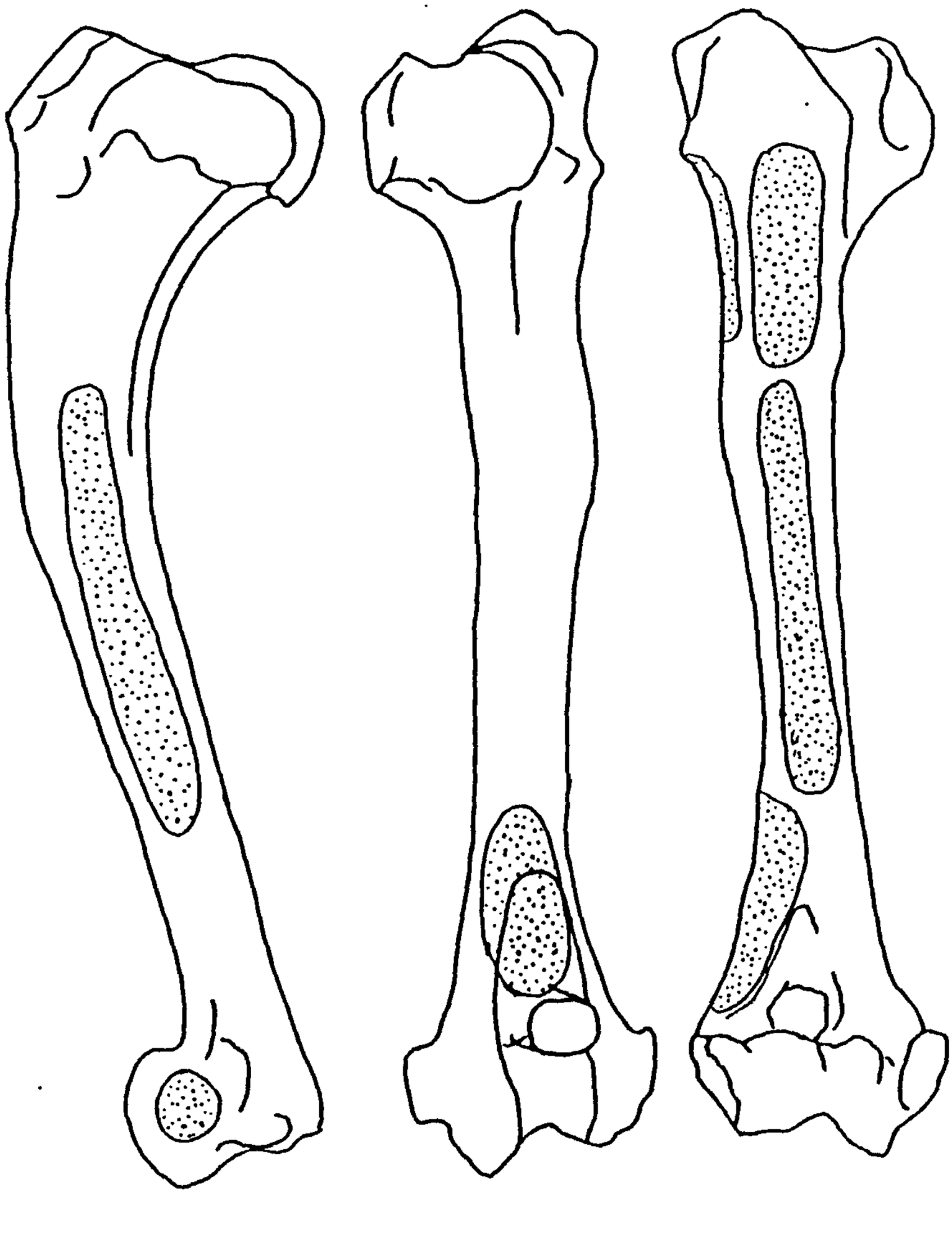

Suburban foxes
Age class distribution
Per cent of sample
70
60
50
40
30
20
10
0
1
2
3
4
>=5
Age class
Current sample
Harris sample
Jamtland-Harjledaln
Uppland-Sodermanl'd
Hakel

Fig. 4.5
Suburban foxes: Sites of infective lesions

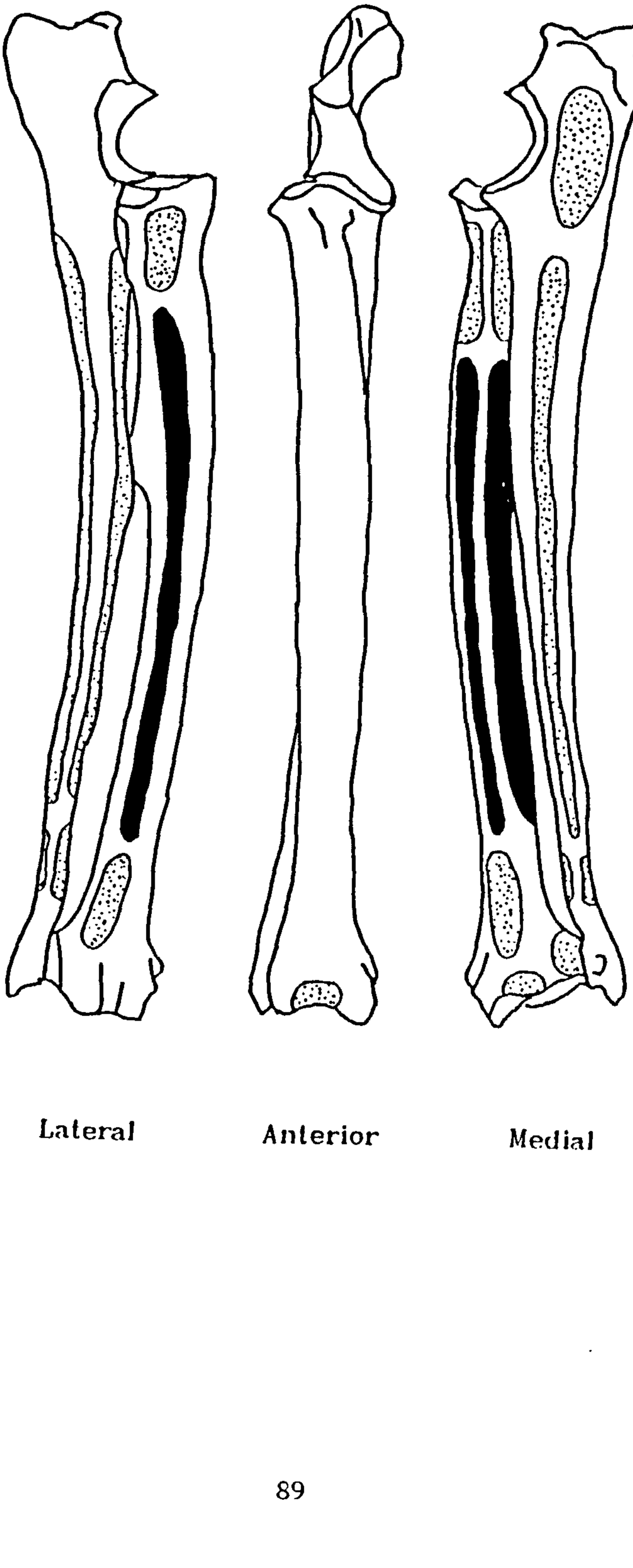
Humerus



Medial Posterior Anterior

Fig 4.6
Suburban foxes: Sites of infective lesions

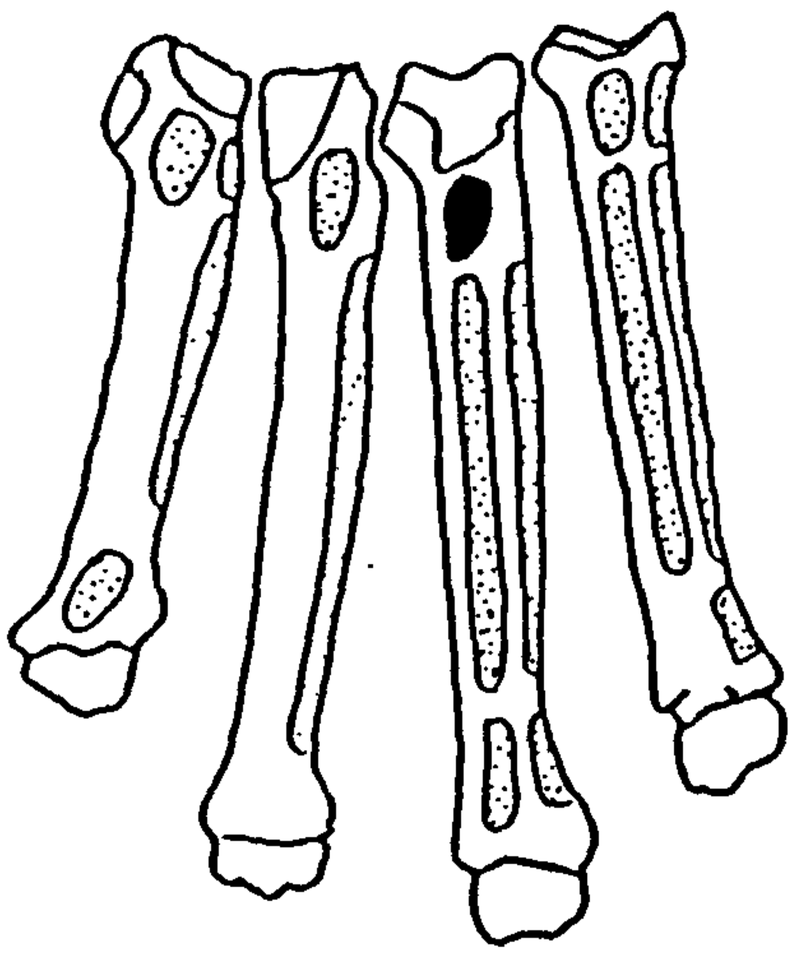
Radius and Ulna



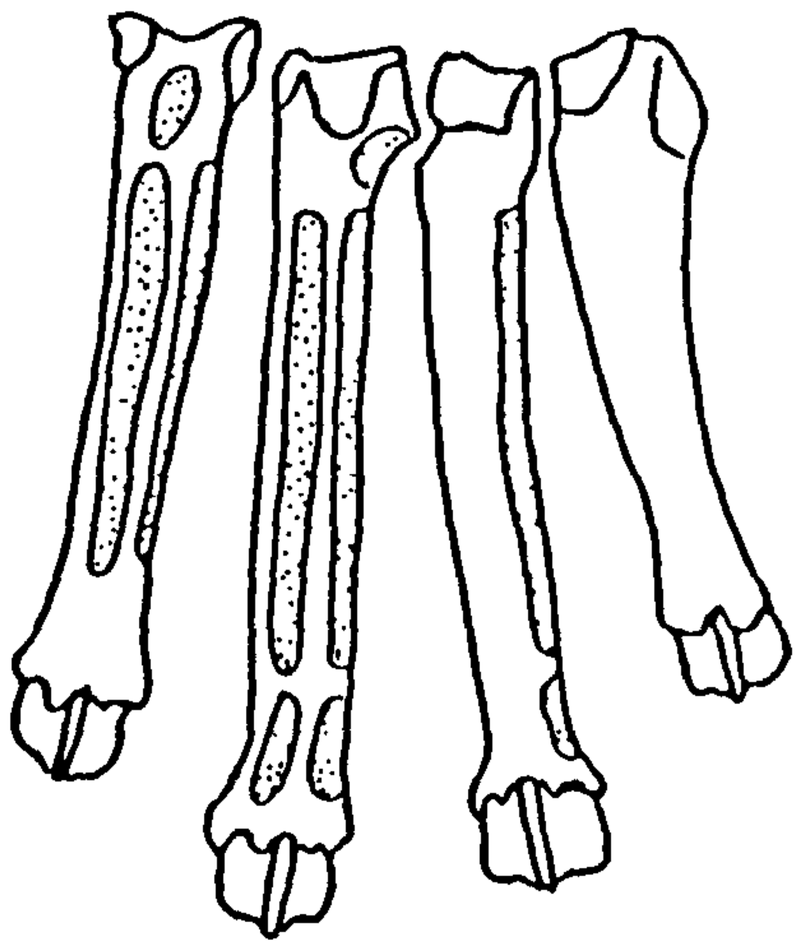
Lateral Anterior Medial

Fig. 4.7
Suburban foxes: Sites of infective lesions

Metacarpals



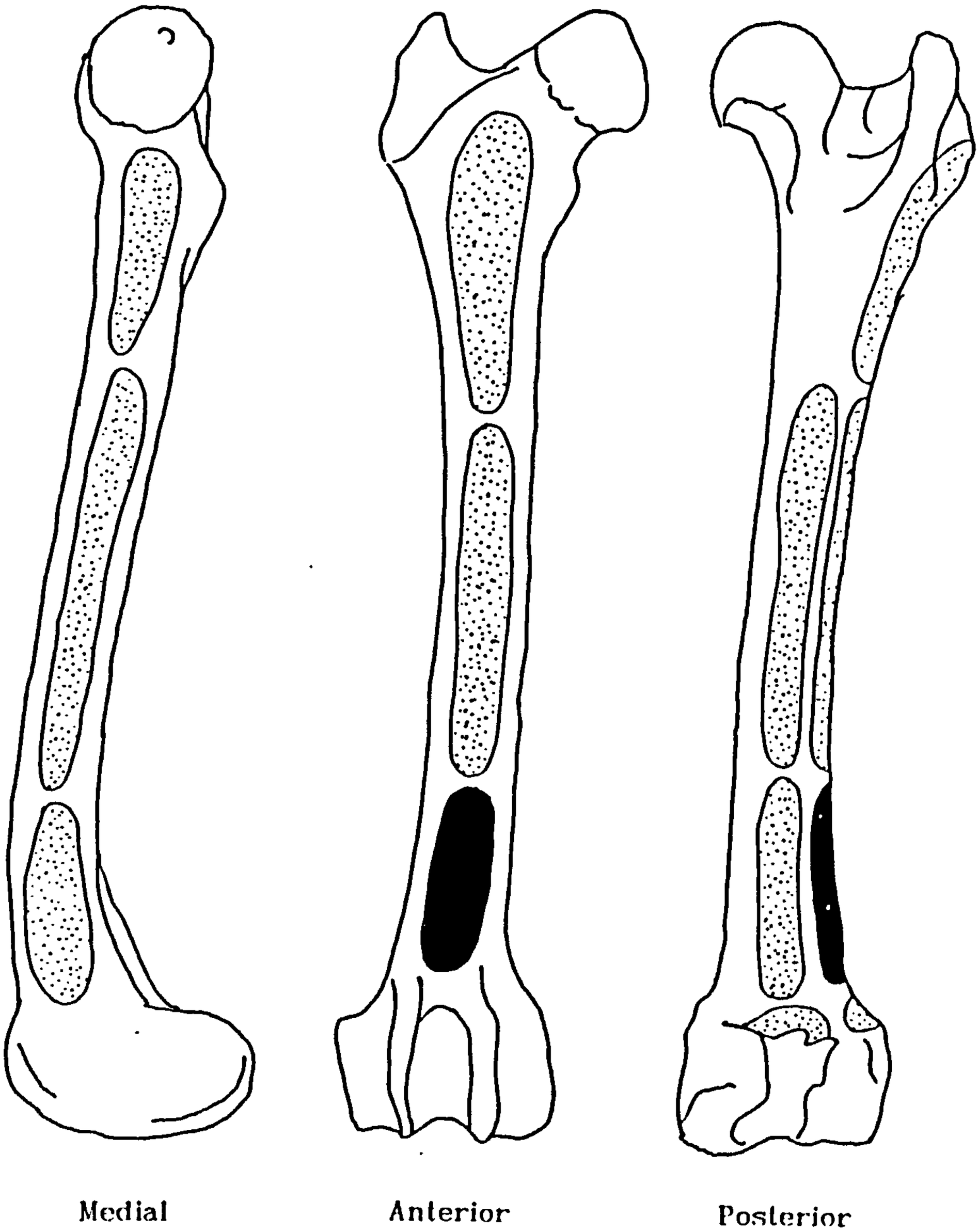
Anterior (showing
anterior + medial sites)



Posterior (showing
posterior + lateral sites)

Fig. 4.8
Suburban foxes: Sites of infective lesions

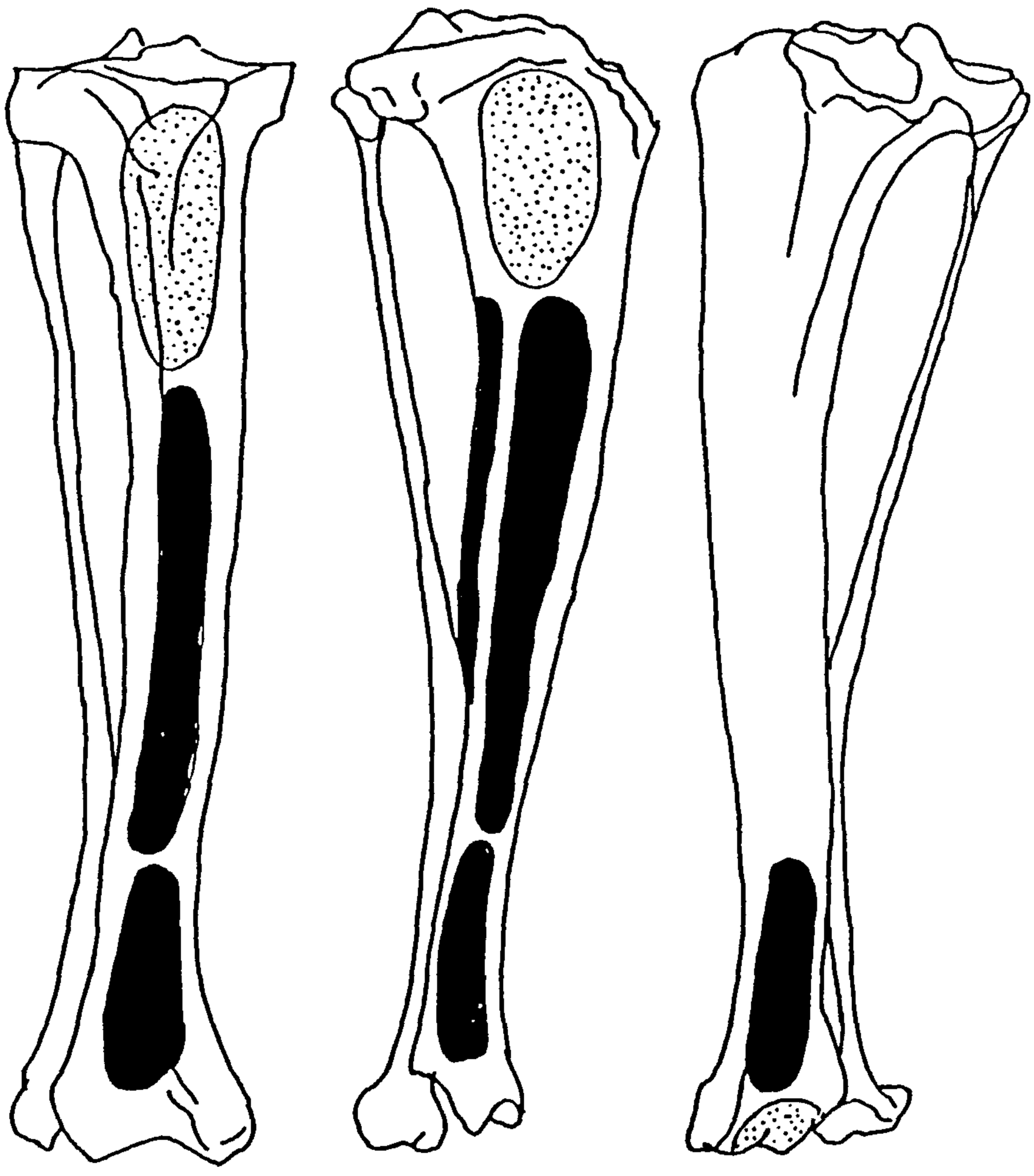
Femur



Medial Anterior Posterior

Fig. 4.9
Suburban foxes: Sites of infective lesions

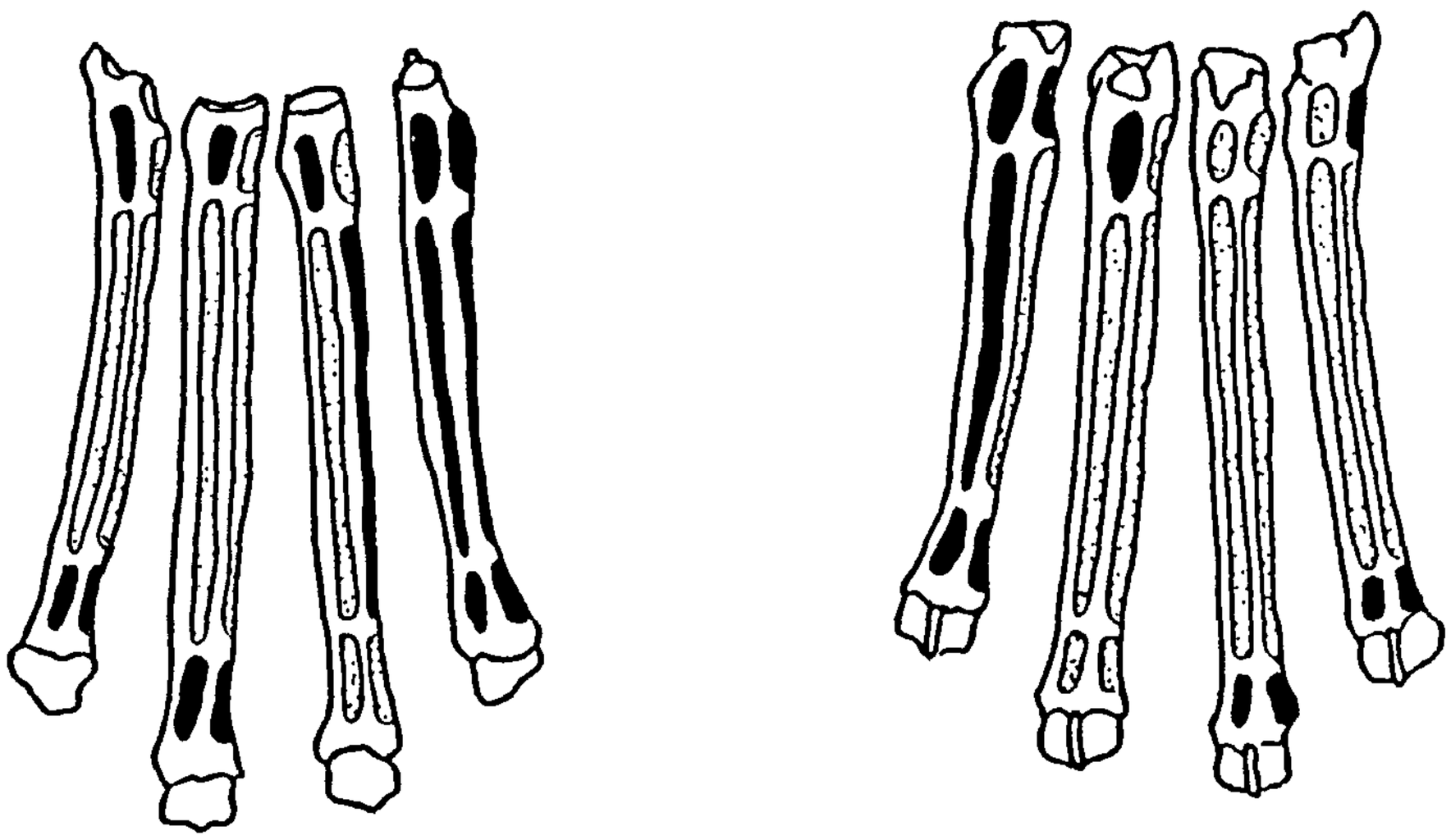
Tibia



Anterior Lateral Medial

Fig. 4.10
Suburban foxes: Sites of infective lesions

Metatarsals

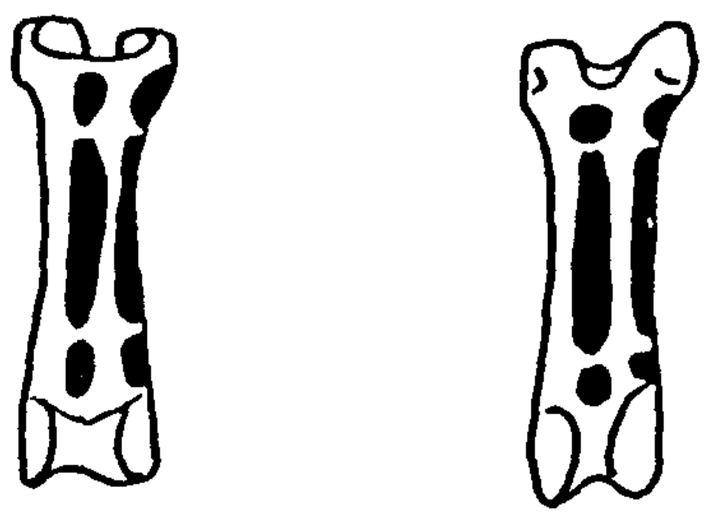


Anterior (showing
anterior + medial sites)

Posterior (showing
posterior + lateral sites)

Fig. 4.11
Suburban foxes: Sites of infective lesions

Phalanx 1



Anterior Posterior

Fig. 4.12
Suburban foxes: Infective lesions: degrees of severity

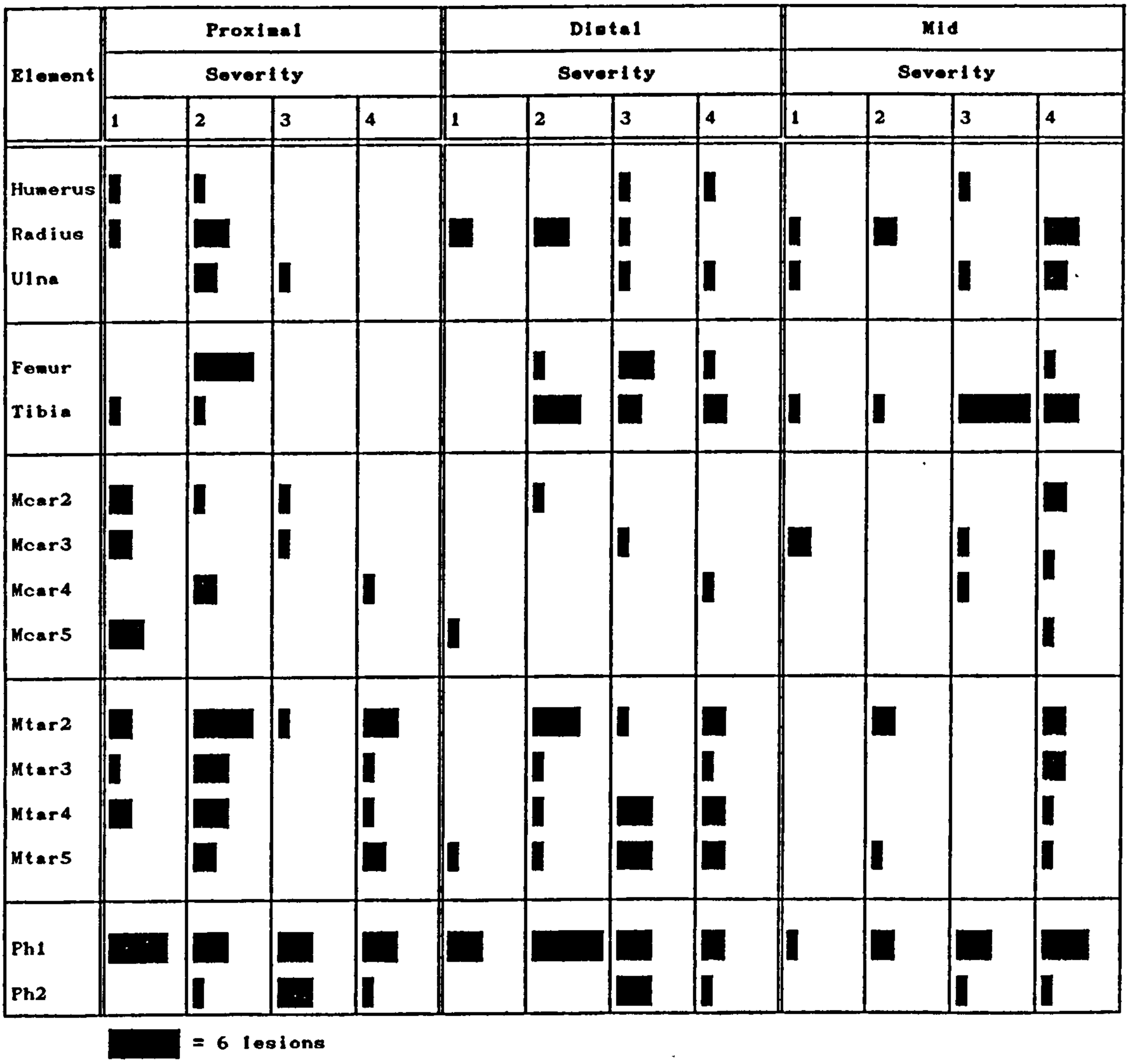


Fig. 4.13
Suburban foxes: Vulnerable sites on limbs indicated by infective lesions

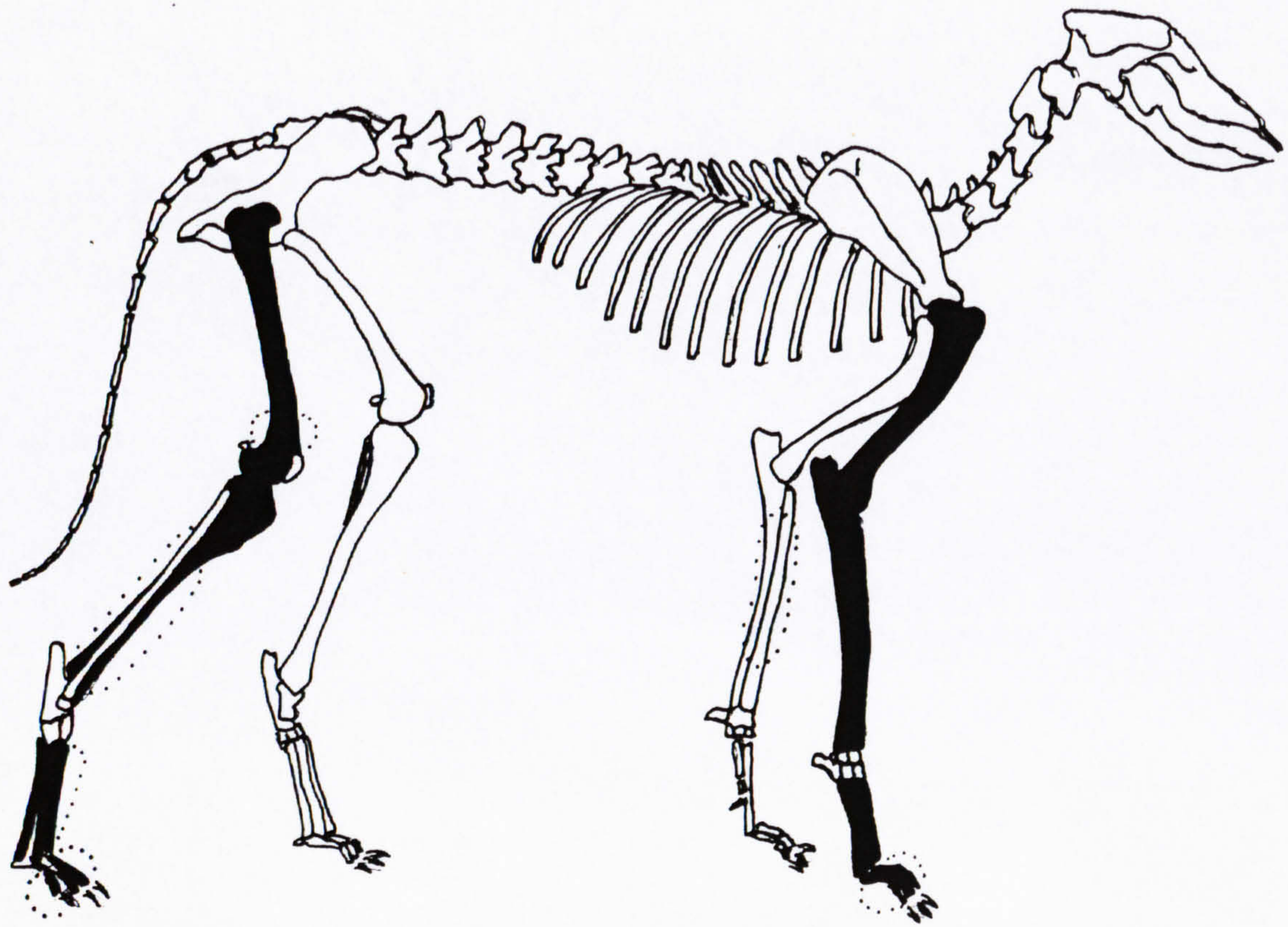
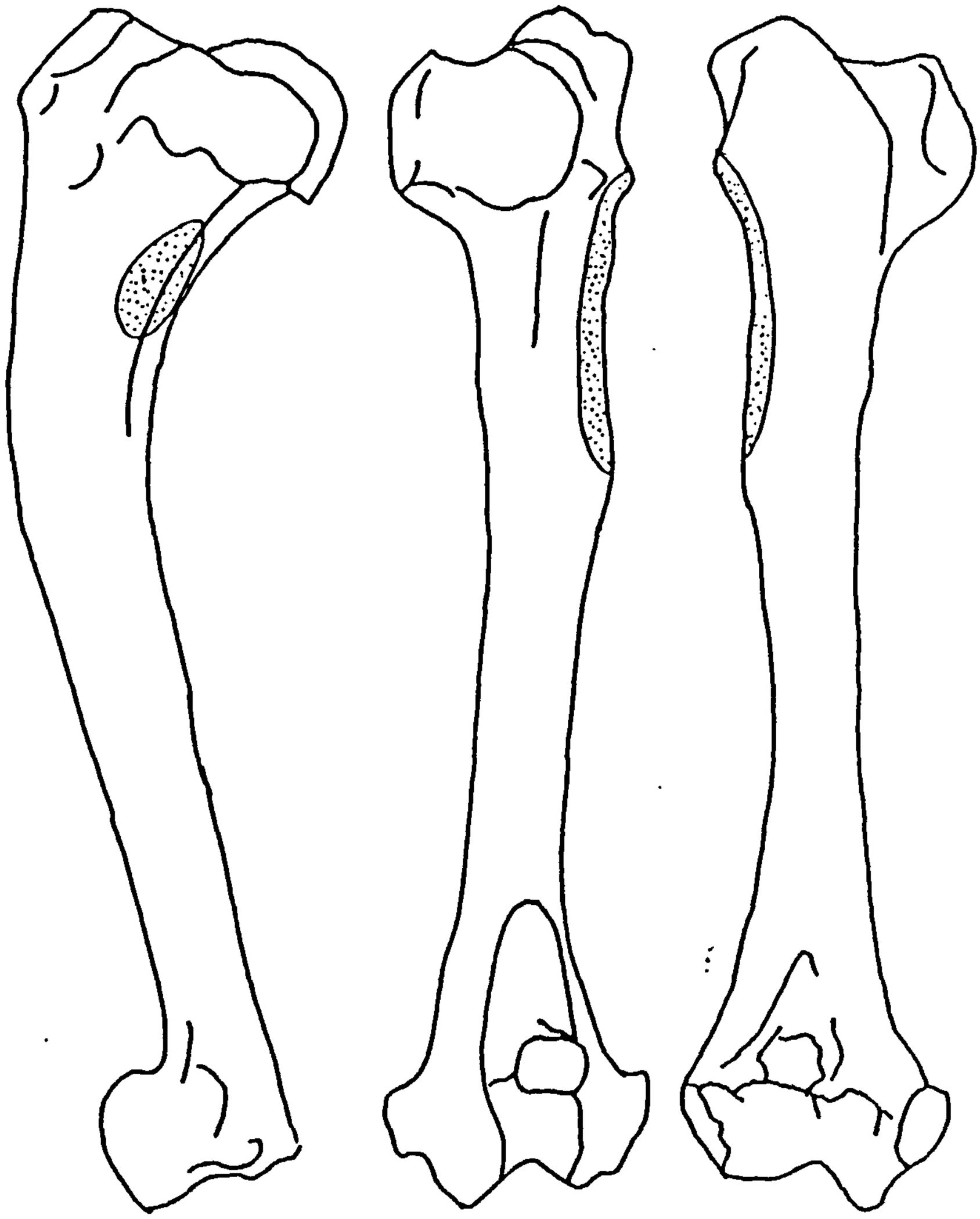


Fig 4.14
Suburban foxes: Sites of hyperostosis

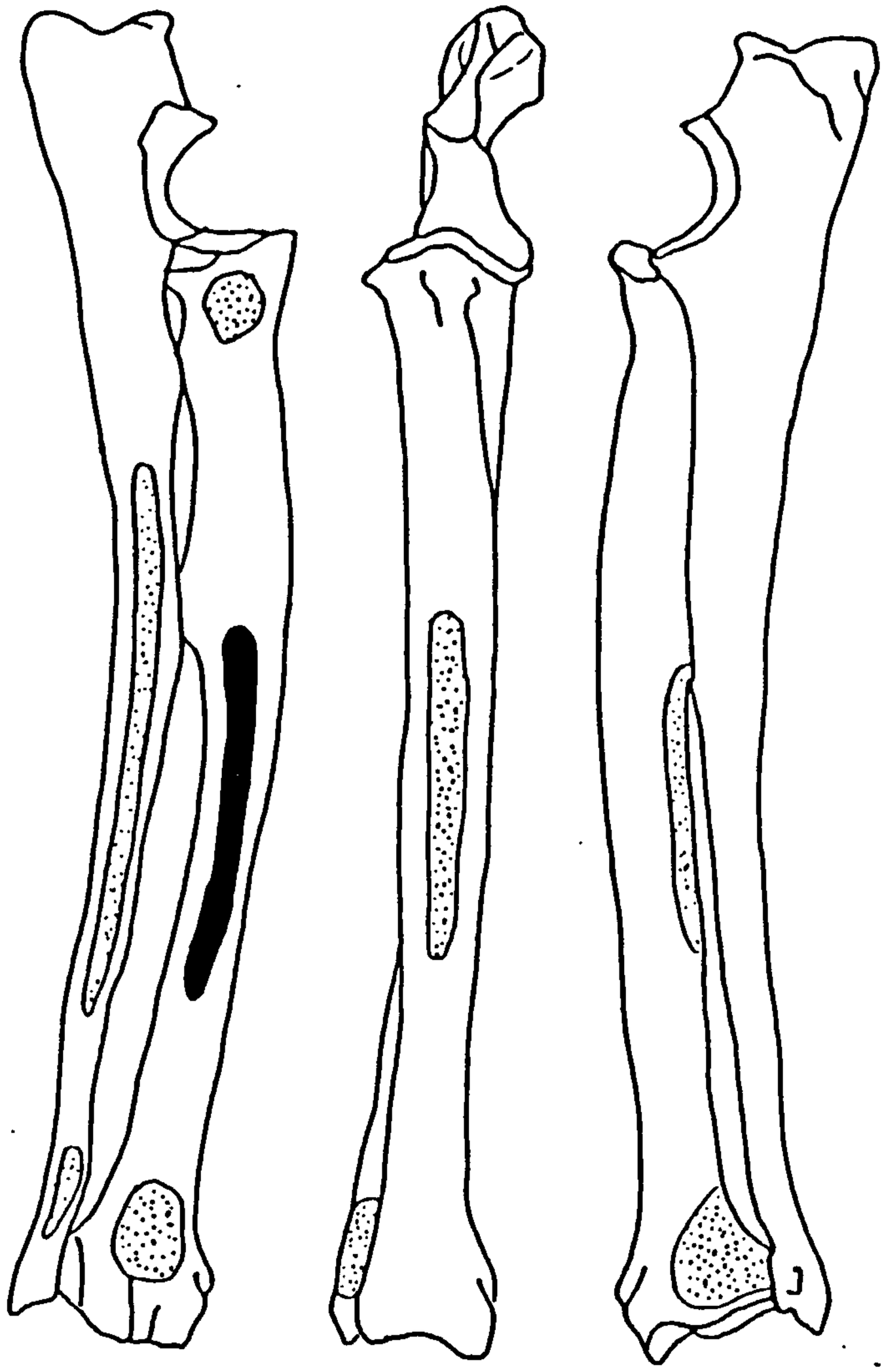
Humerus



Medial Posterior Anterior

Fig. 4.15
Suburban foxes: Sites of hyperostosis

Radius and Ulna

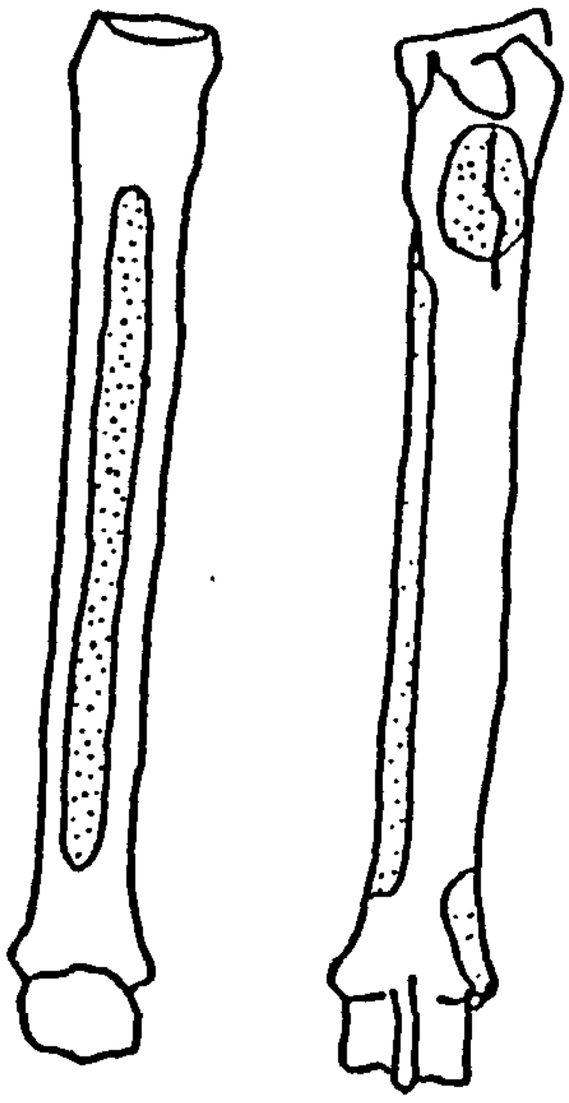


Lateral Anterior Medial

Fig. 4.16
Suburban foxes: Sites of hyperostosis

Metapodia

Metatarsal 4



Anterior Posterior

Metatarsal 5



Posterior

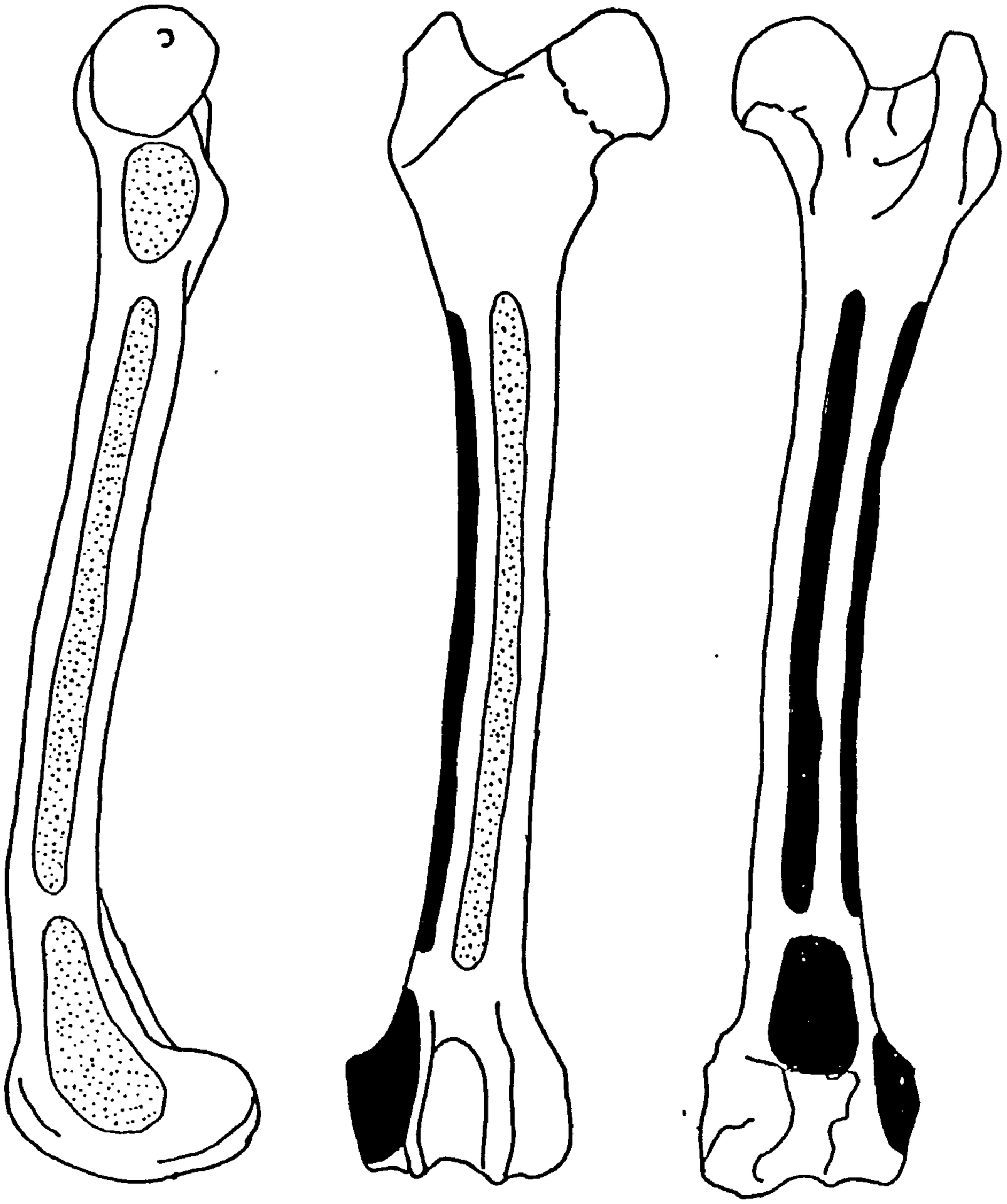
Metacarpal 2



Posterior

Fig. 4.17
Suburban foxes: Sites of hyperostosis

Femur



Medial

Anterior

Posterior

Fig. 4.18
Suburban foxes: Hyperostosis severity

Element	Proximal			Distal			Mid		
	Severity			Severity			Severity		
	1	2	3	1	2	3	1	2	3
Humerus	■	▮							
Radius		▮		▮	■		■	▮	
Ulna		▮		■			▮		
Mcar2	▮								
Mcar3									
Mcar4									
Mcar5									
Femur	▮			■	■	■	■	▮	■
Tibia									
Mtar2									
Mtar3									
Mtar4	▮	▮				▮			
Mtar5				▮					
Phl				■					

■ = 6 lesions

Fig. 4.19

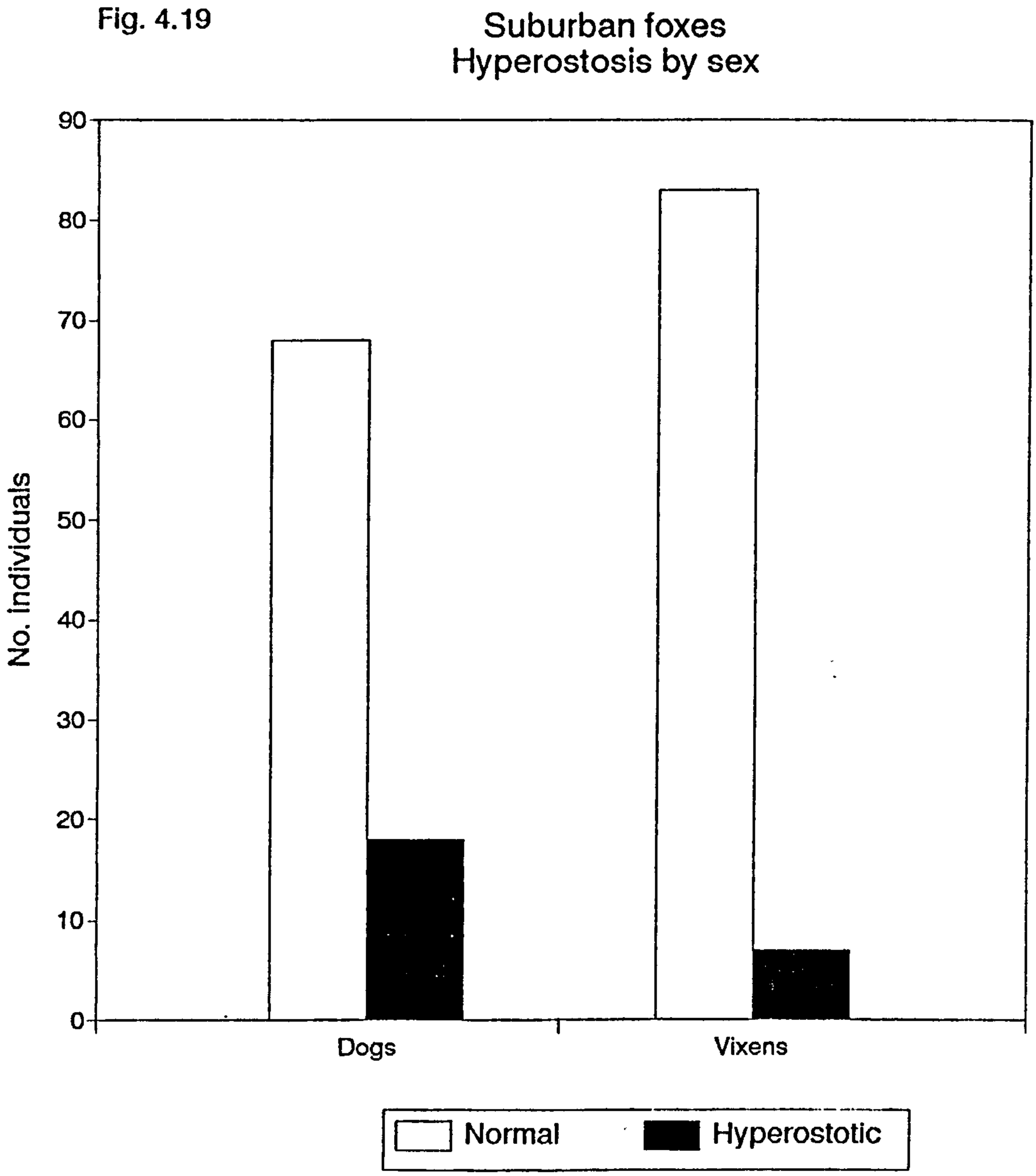

Suburban foxes
Hyperostosis by sex
No. individuals
90
80
70
60
50
40
30
20
10
0
Dogs
Vixens
Normal
Hyperostotic

Fig. 4.20

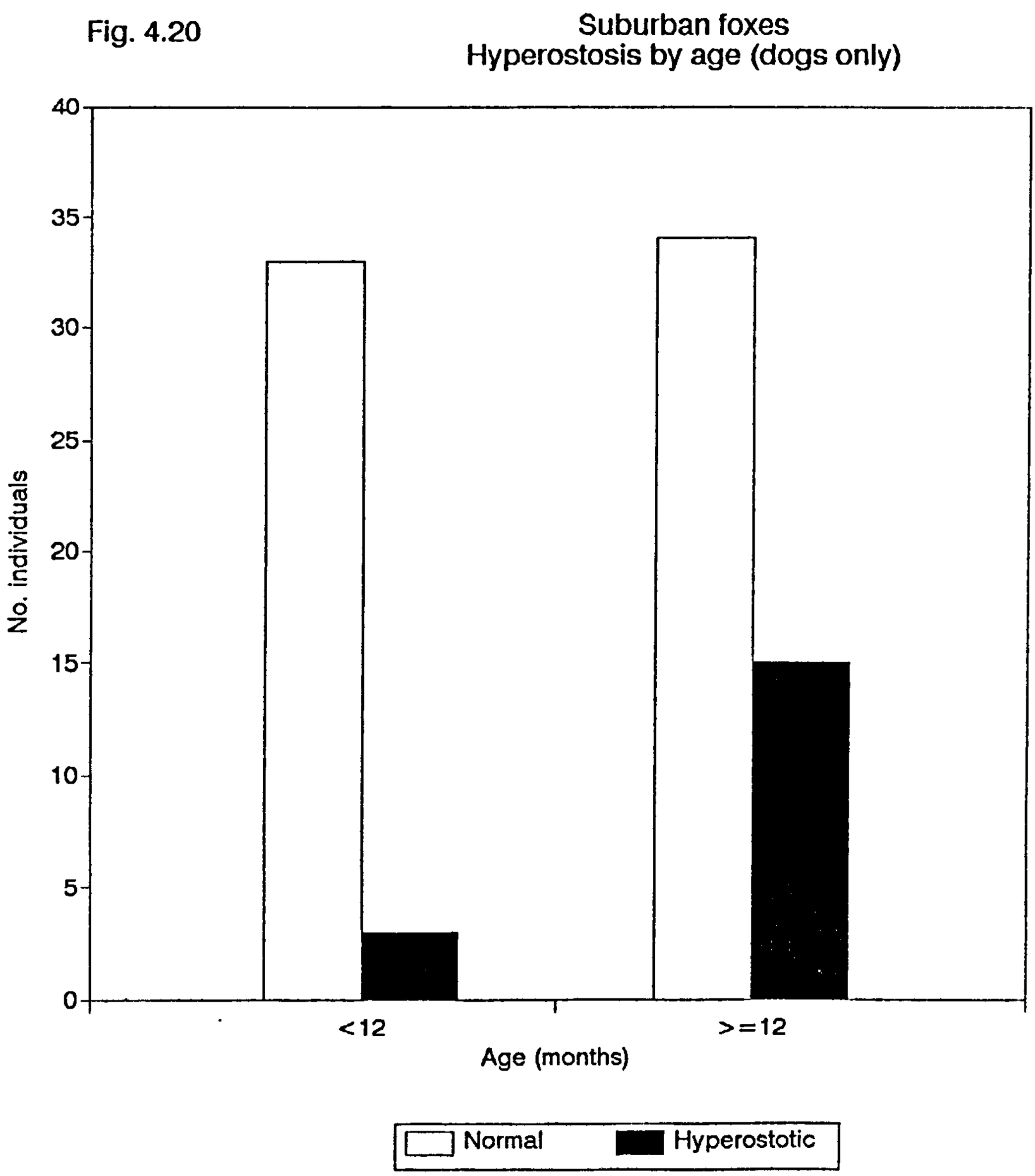

Suburban foxes
Hyperostosis by age (dogs only)
No. individuals
40
35
30
25
20
15
10
5
0
<12
>=12
Age (months)
Normal
Hyperostotic

Fig. 4.21

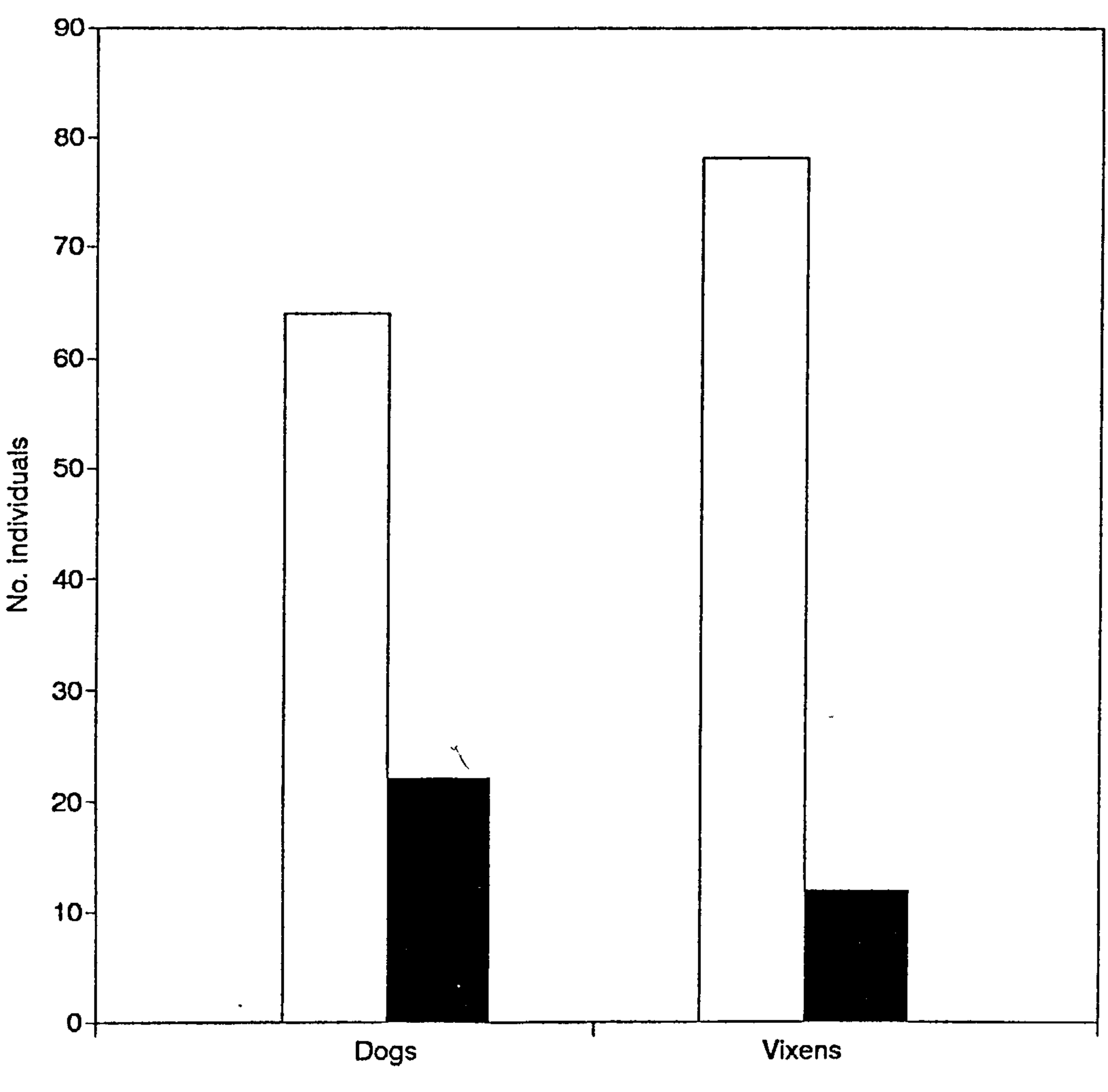

Suburban foxes
Osteophytes by sex
No. individuals
90
80
70
60
50
40
30
20
10
0
Dogs
Vixens
Normal
Osteophytic

Fig. 4.22

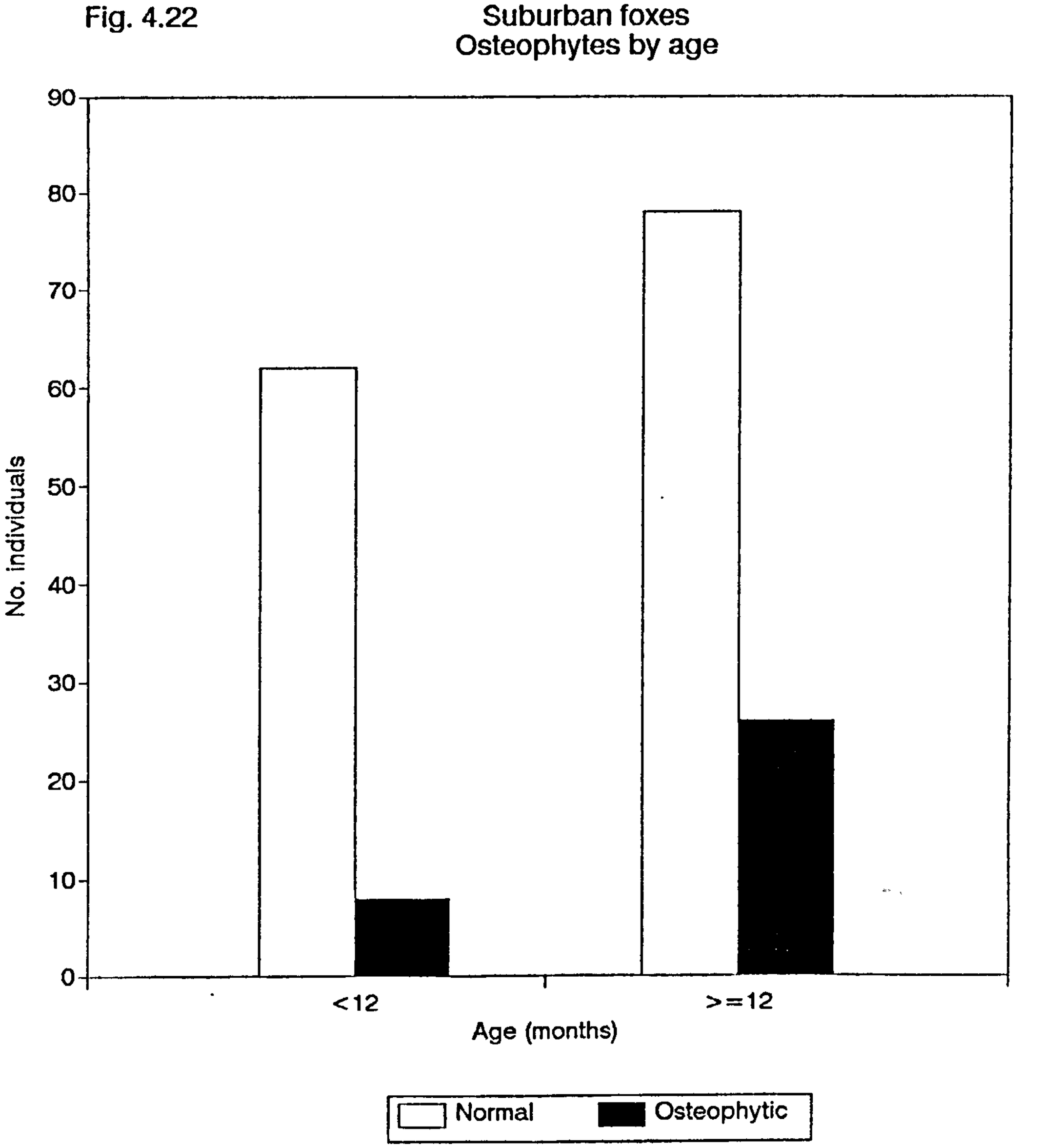

Suburban foxes
Osteophytes by age
No. individuals
90
80
70
60
50
40
30
20
10
0
<12
>=12
Age (months)
Normal
Osteophytic

fig. 4.23

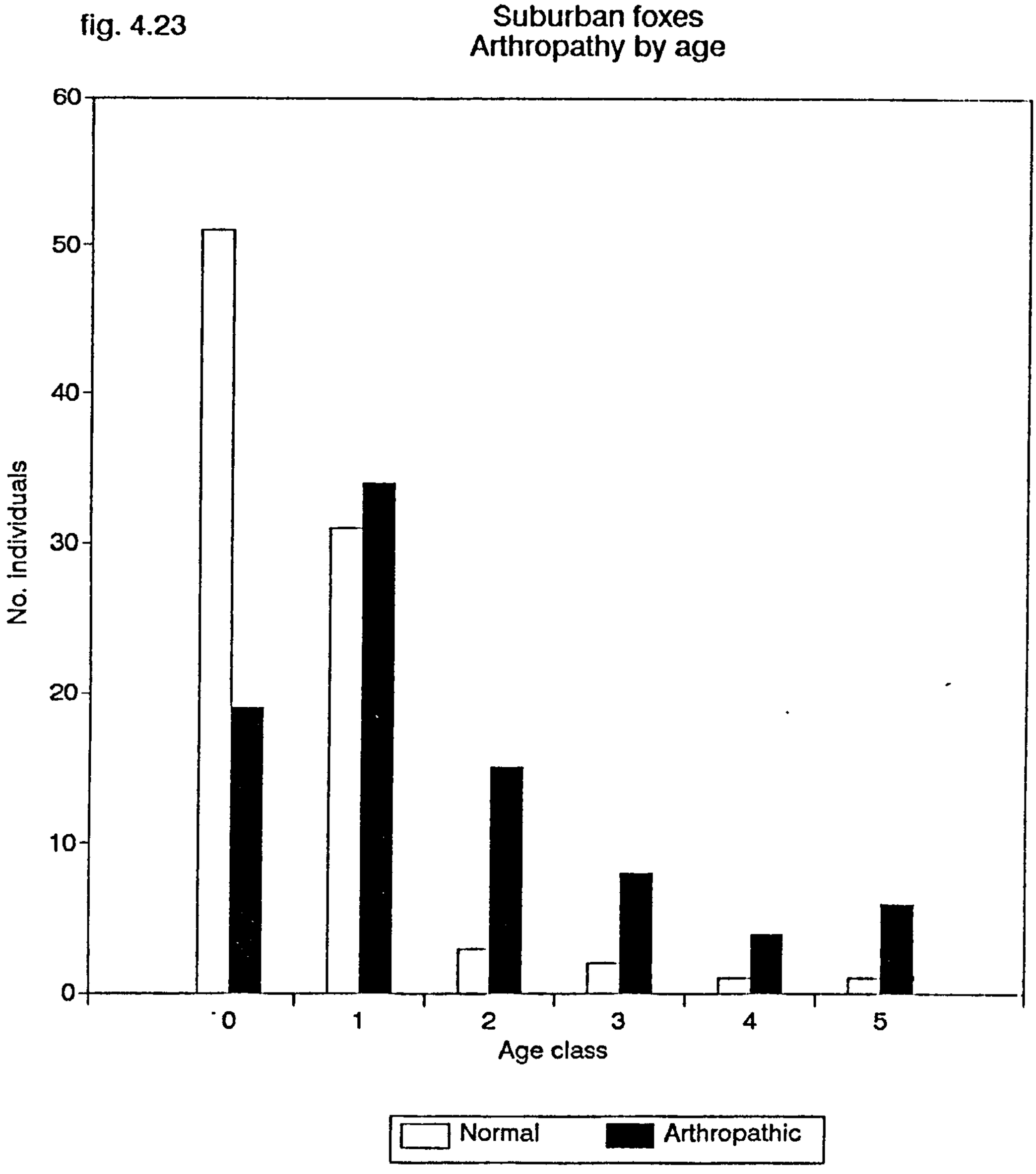

Suburban foxes
Arthropathy by age
60
50
40
30
20
10
0
No. individuals
0
1
2
3
4
5
Age class
Normal
Arthropathic

Fig. 4.24
Suburban foxes: Arthropathy by element

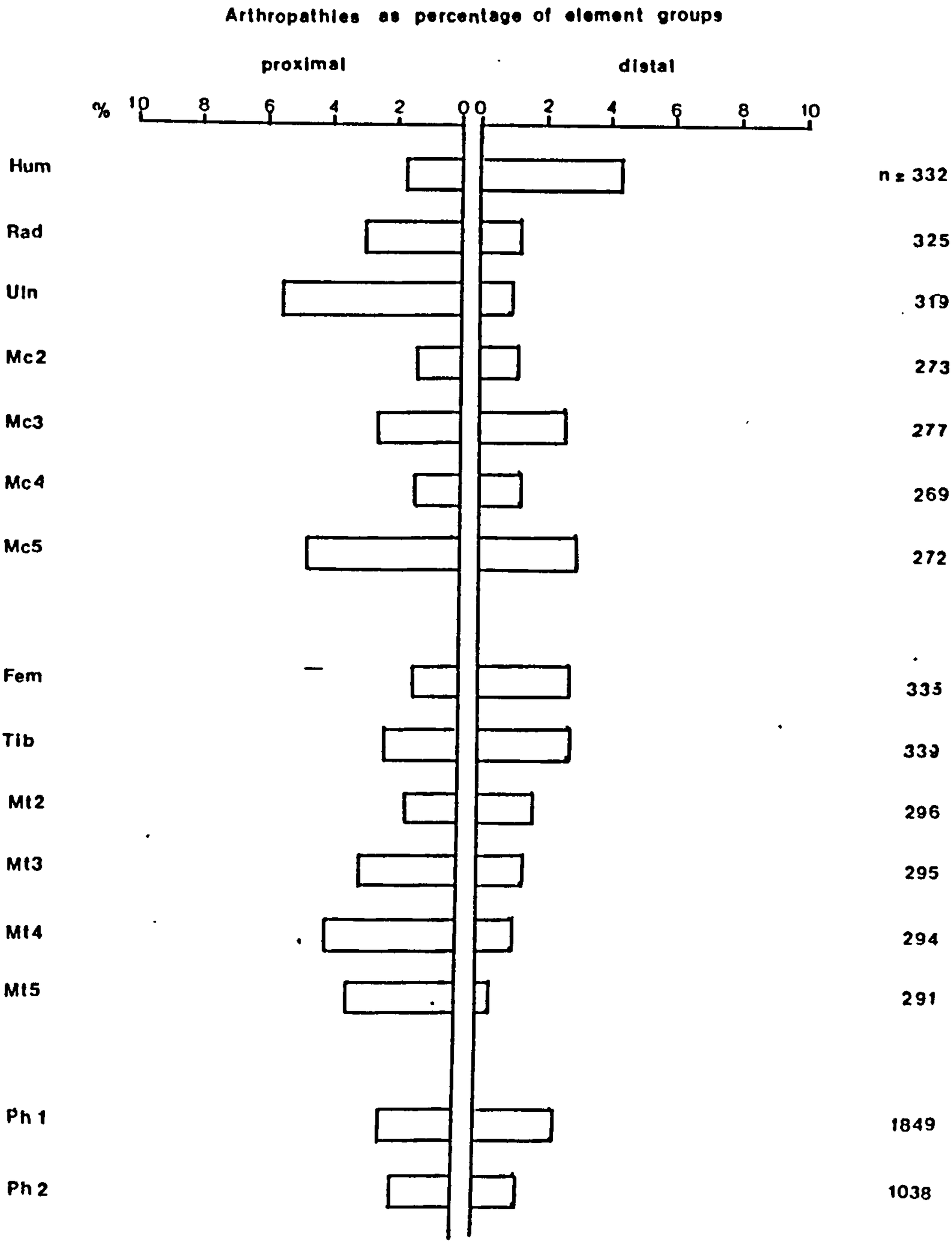


Fig. 4.25
Suburban foxes: Arthropathy: articular extension

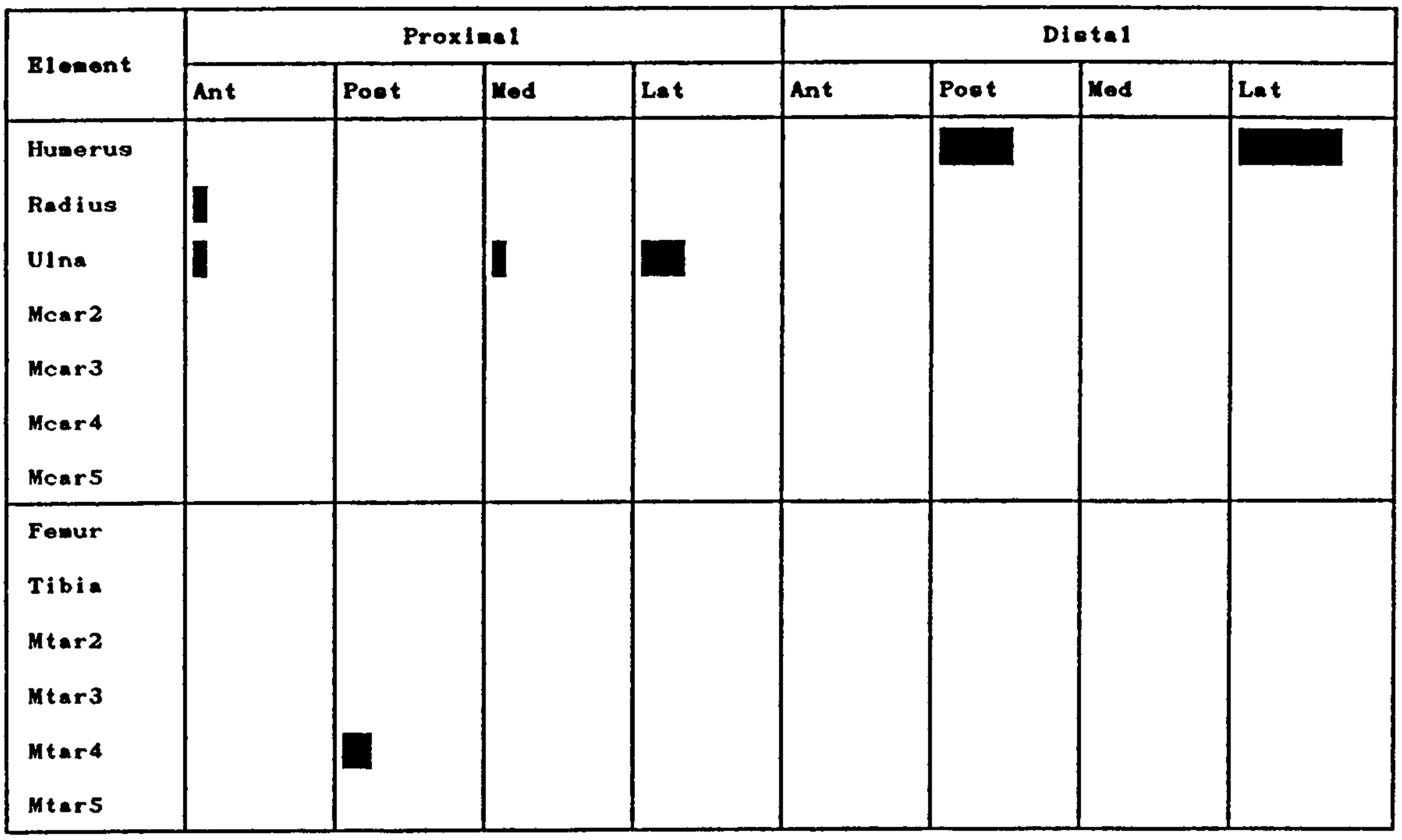


Fig. 4.26
Suburban foxes: Arthropathy: eburnation

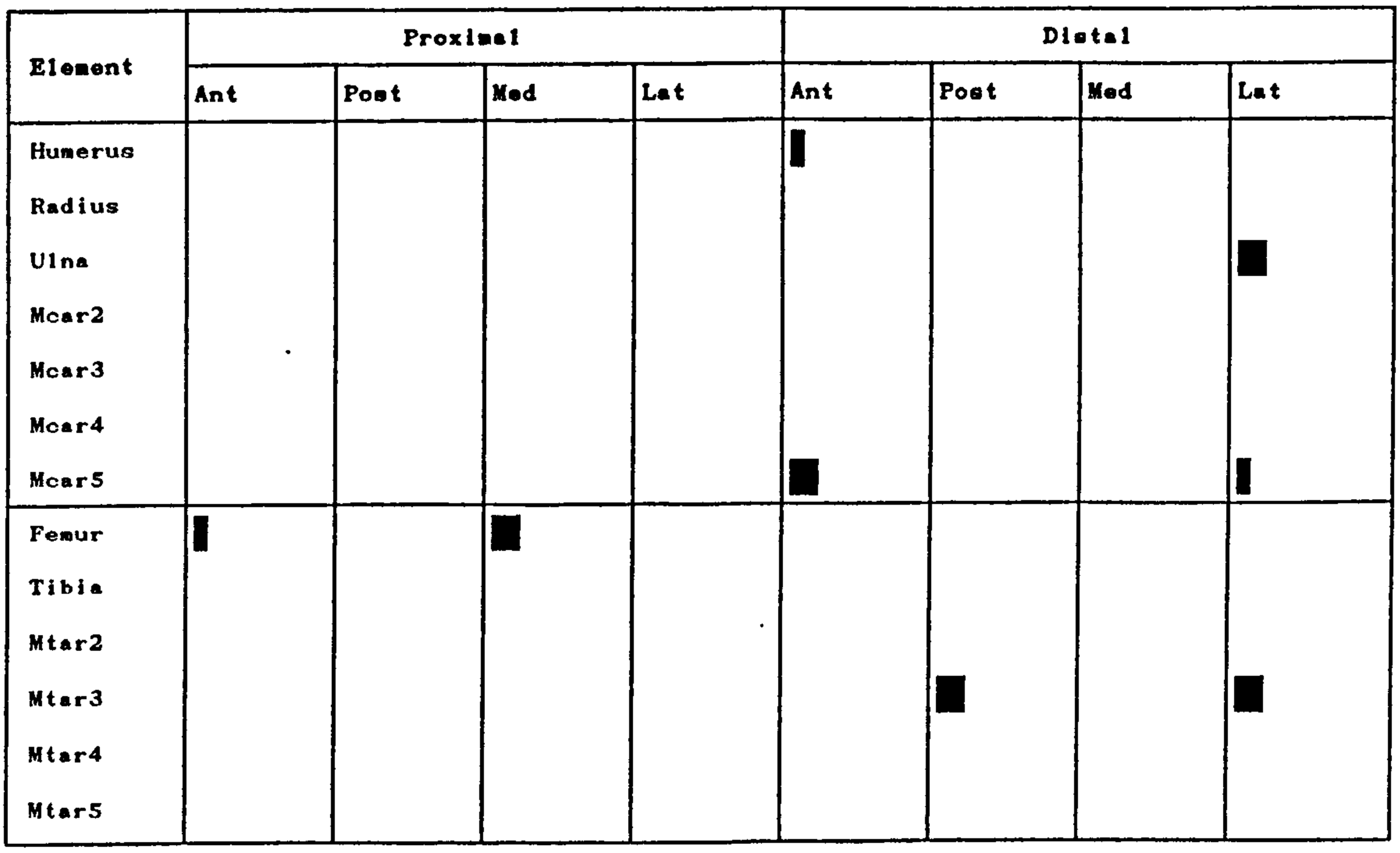


Fig. 4.27
Suburban foxes: Arthropathy: periarticular exostosis

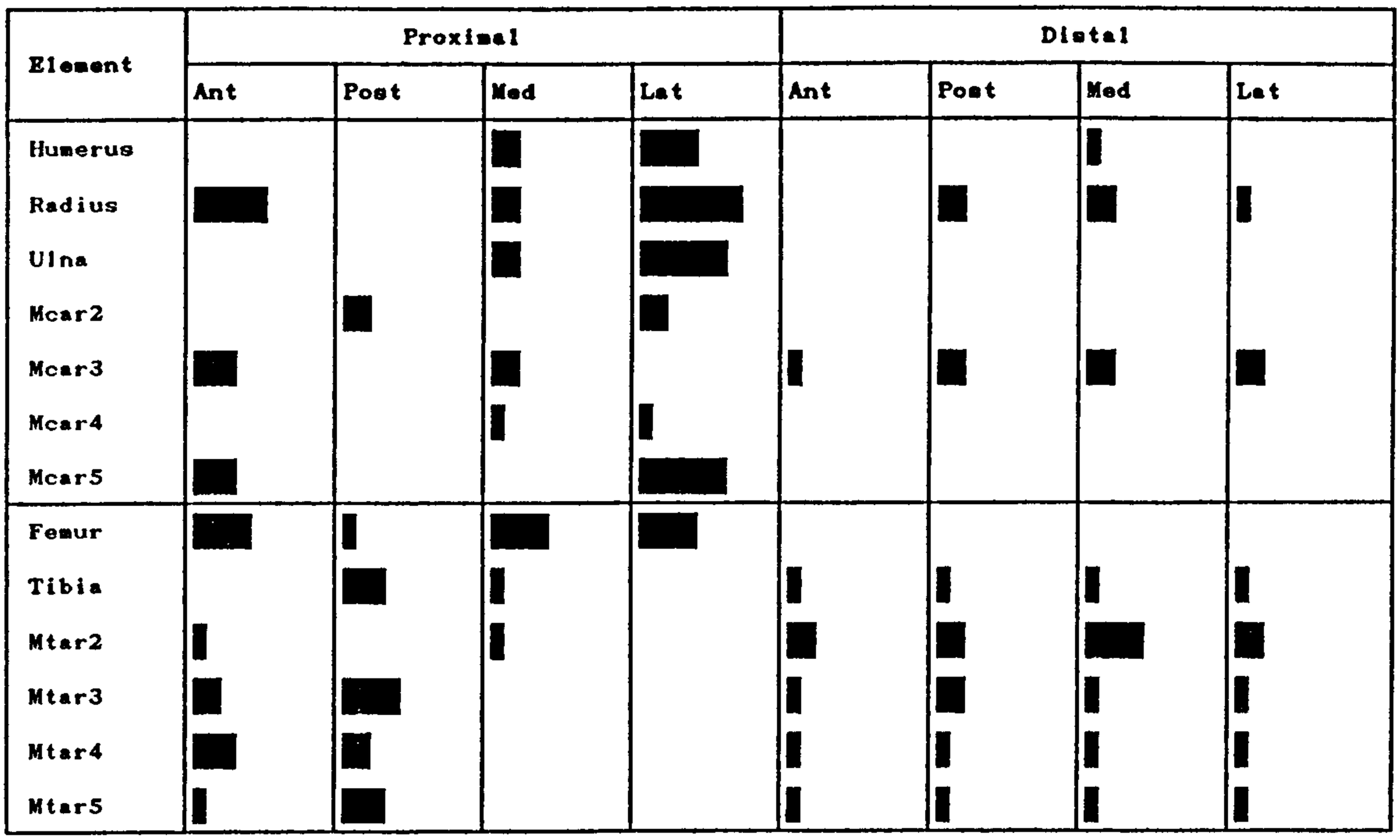


Fig. 4.28
Suburban foxes: Arthropathy: combination of two manifestations

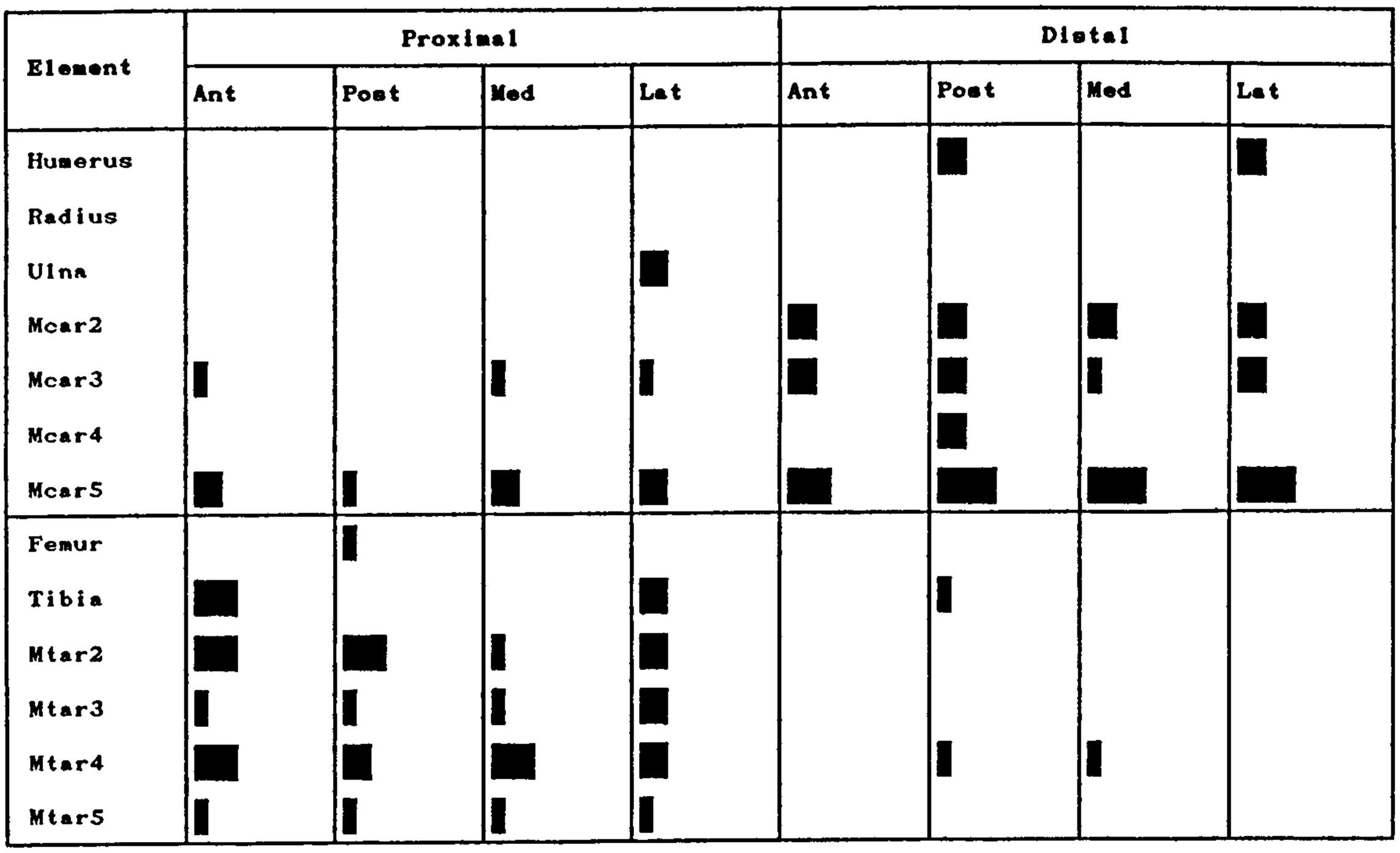


Fig. 4.29
Suburban foxes: Arthropathy: combination of three manifestations

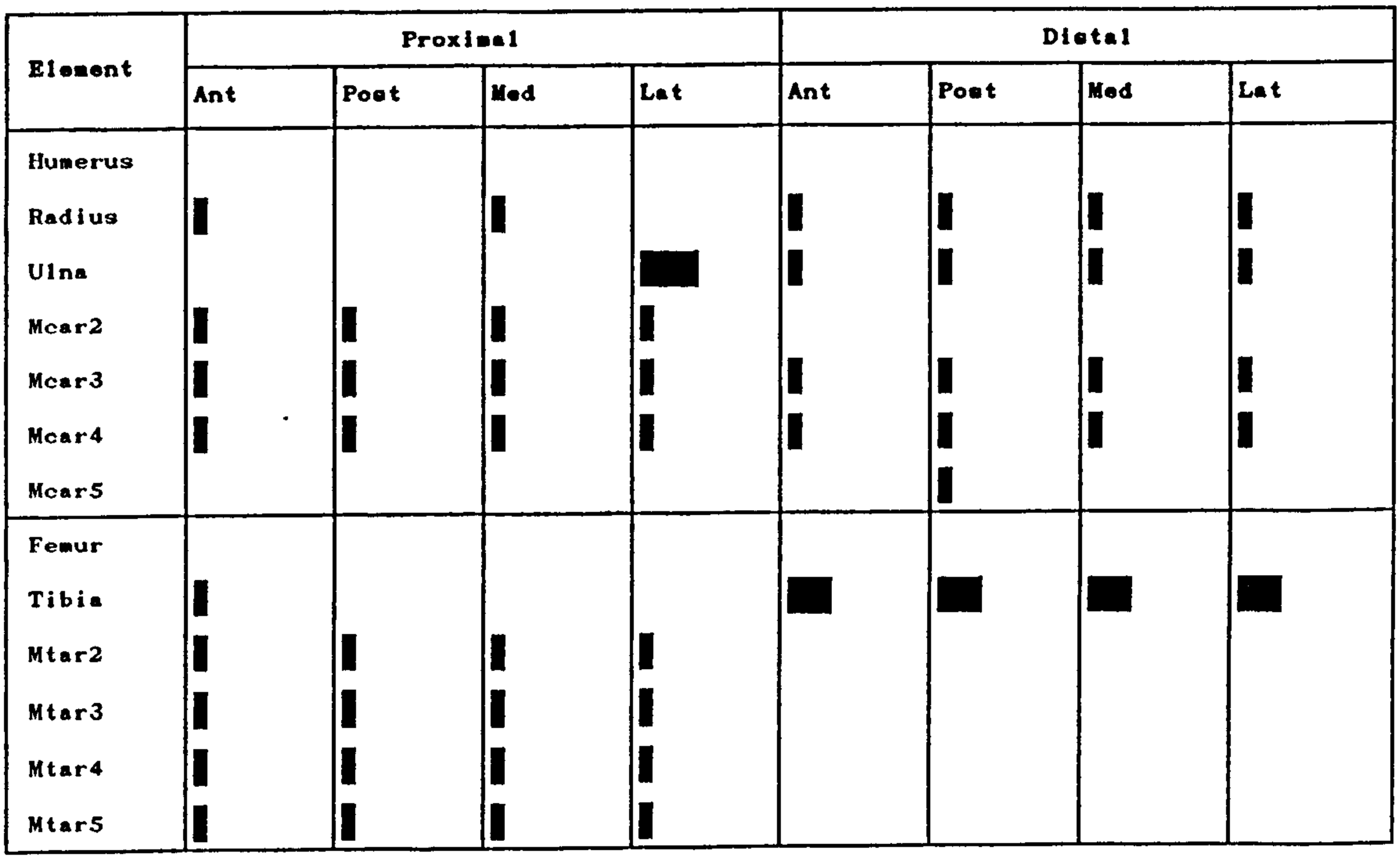


Fig. 4.30
Suburban foxes: Arthropathy: combination of four manifestations

Element	Proximal				Distal			
	Ant	Post	Med	Lat	Ant	Post	Med	Lat
Humerus					■	■	■	■
Radius								
Ulna	■	■	■	■				
Mcar2								
Mcar3								
Mcar4								
Mcar5								
Femur					■	■	■	■
Tibia	■	■	■	■	■	■	■	■
Mtar2								
Mtar3								
Mtar4								
Mtar5								

Fig. 4.31
Suburban foxes: Arthropathy: combination of 5+ manifestations

Element	Proximal				Distal			
	Ant	Post	Med	Lat	Ant	Post	Med	Lat
Humerus	■	■	■	■				
Radius								
Ulna								
Mcar2					■	■	■	■
Mcar3								
Mcar4					■	■	■	■
Mcar5								
Femur					■	■	■	■
Tibia					■	■	■	■
Mtar2								
Mtar3								
Mtar4								
Mtar5								

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Fig. 4.32

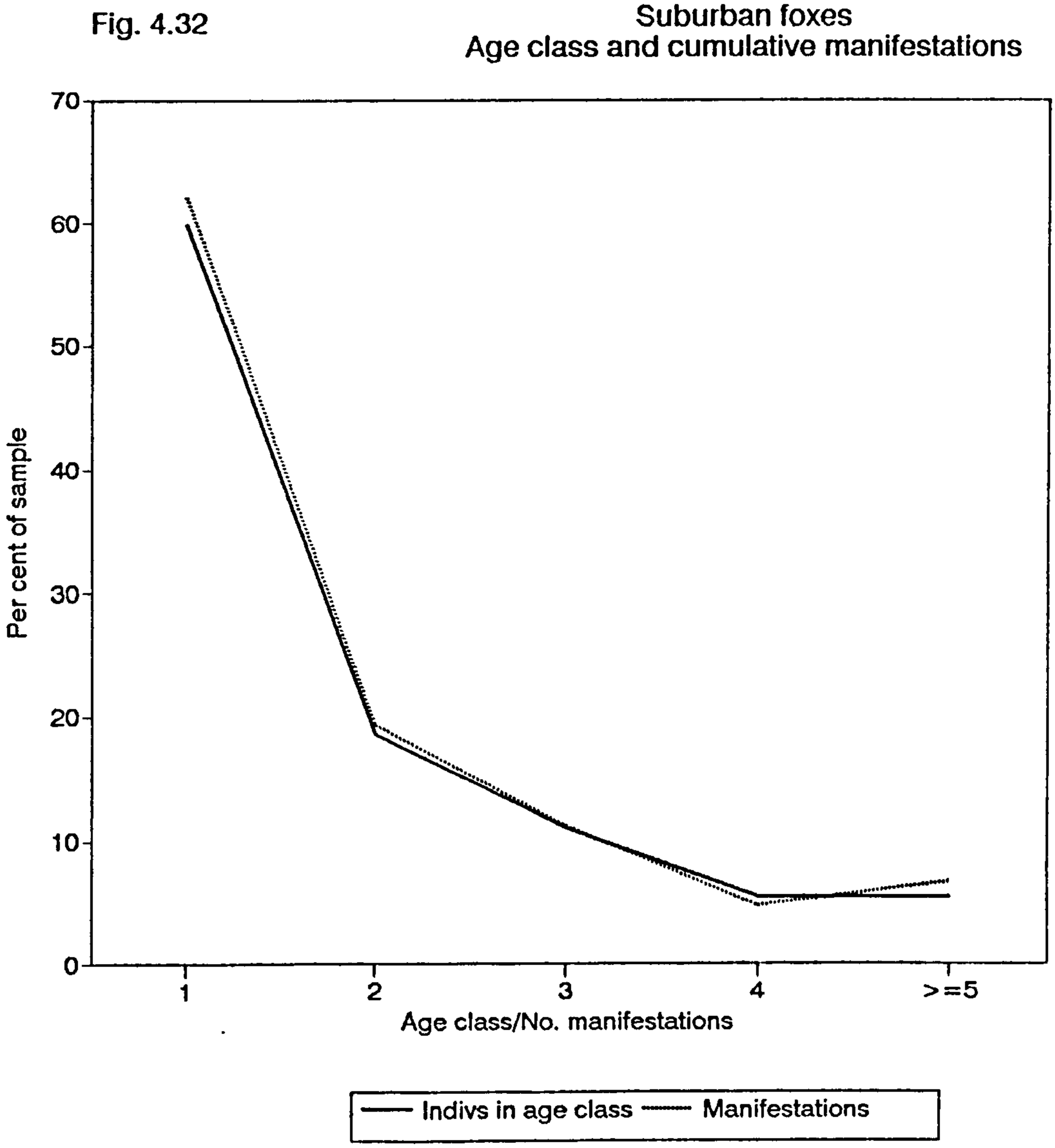
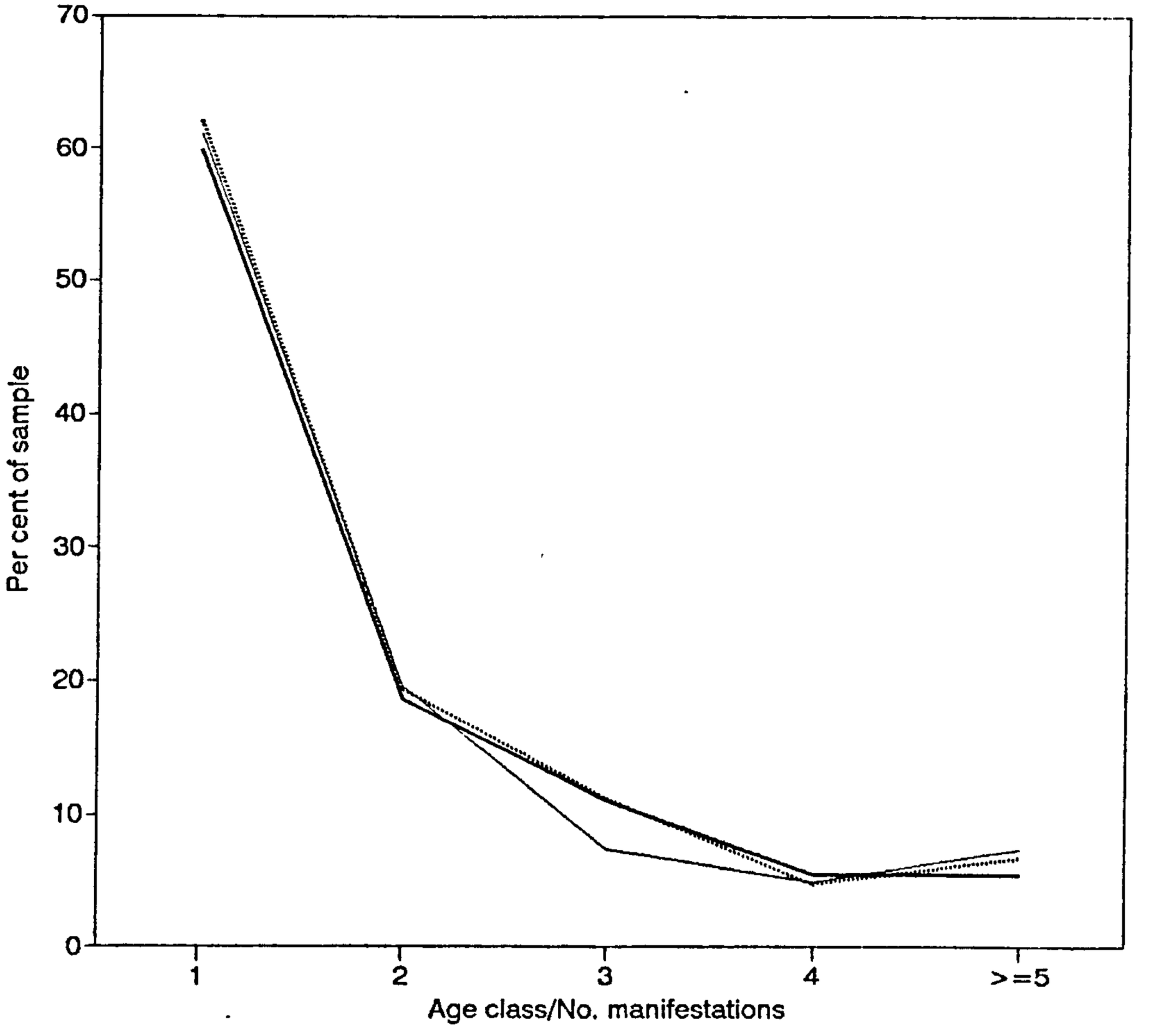

Suburban foxes
Age class and cumulative manifestations
Per cent of sample
70
60
50
40
30
20
10
0
1
2
3
4
>=5
Age class/No. manifestations
Indivs in age class
Manifestations

Fig. 4.33

Suburban foxes
Age class and cumulative manifestations





CHAPTER 5

ARCHAEOLOGICAL CANIDS

Of all domesticated species, the dog has retained its relationship with man undiminished into a modern society. The species continues to coexist successfully regardless of environmental constraints, and the dog is universally recognised as the closest and most ubiquitous companion to man. The unique social habits of wolves are now acknowledged to correlate closely with those of hunter-gatherer societies (Olsen 1985, 16). In Clutton-Brock's opinion (Clutton-Brock 1987, 34), the relationship and the power of communication between man and dog

> " . . is a biological link based on social structures and behaviour patterns that are closely similar because they evolved in both species in response to the needs of a hunting team, but which endure today and have become adapted to life in sophisticated, industrial societies."

In dogs we are encountering a probable non-food domesticate whose activity and integration within human society is difficult to define, although we ourselves have very clear ideas about what a dog is and does. Whether we think that in antiquity dogs were present on sites for their own ends, or were being exploited, or something of both, the bones available to us come from human deposition. The analysis of them is incorporated within the methodologies already in place for reporting faunal remains, and these are essentially aimed at identifying economic activity. If dog is not an economic indicator, does observed variation in the subspecies in time and space have any relevance? The nature of the deposits suggests that it might; but the nature of archaeological reporting suggests that this relevance may be seriously biased.

A difficulty with dog, as far as archaeologists are concerned, seems to be that the species cannot be seen to be contributing to the economic structure of its contemporary human society. Its remains fit uneasily into conventional analysis because of their paucity in butchery or processing debris. Its cultural significance and its

evolutionary particularities in early prehistory have been well discussed, notably by Olsen (Olsen 1985) and Clutton-Brock (Clutton-Brock 1987), but its lack of a definable economic role has rendered it obscure in the later periods when man-domesticate relationships are reckoned to have moved from the symbiotic to the exploitative.

This has been recognised, certainly since the late 1980s, by such workers as O'Connor (O'Connor 1986b, 13) and Maltby (Maltby 1987, 551). Maltby suggests that concentrations of dog remains in the 3rd to 4th century pits at Owslebury might indicate some form of population control, noteably where these concentrations are comprised of a substantial amount of neonatal or pup remains. He has suggested that such depositions might indicate that selective breeding was practised. Harcourt in 1974 demonstrated clearly that over the Romano-British period as a whole there was a significant increase in the variety of dog type, with the persisting phenomenon of what he considered to be an animal too small to serve any useful purpose, or indeed to survive without human protection (Harcourt 1974, 164).

It is, however, the recovery of complete, and often solitary, individuals which engenders the greatest interest amongst faunal analysts. Grant has argued for the deliberate killing of the dogs in the special deposits of Late Iron Age Danebury (Grant 1984, 542) an argument broadly supported by Wilson (1992). The presence of a "matched" pair of dogs (in height) in the grave of an early to mid-Iron Age human male at Dibbles Farm (Everton 1988) again suggests deliberate dispatch in order to accomplish a particular act of burial. At Late Iron Age Bramdean, Clutton-Brock (Clutton-Brock 1981) considers that three dogs from pits were deliberately buried and that these were probably herding dogs treated with affection and regard; there is evidence from this site that dogs had some special significance in the form of the perforated dog metapodials ("dogfoot pendants"). Armour-Chelou (Armour-Chelou 1987) also reports the deliberate placing of dog bodies in recognisably significant positions in the site, and notes that this type of burial is recurring in several southern Iron Age sites. It has been suggested by Ross (Ross 1968)

and rationalised by Wait (Wait 1985), that the presence of articulated dog is a significant factor in the identification of ritual shafts for both the Iron Age and the Romano-British periods. It has been shown in numerous reports that articulated dog can appear as associated with human burial (e.g. Maltby 1988), where human burial ought to be as at Lankhills (Clarke 1979), in burial with other animals, or buried alone. Whimster (Whimster 1981) has collated a dozen references to dog skeleton or skull accompaniaments to human remains for the Iron Age. Philpott (Philpott 1991) has added a similar corpus of information for the Romano-British period. Prummel (Prummel 1992) catalogues 271 dog burials from 108 cemeteries in Continental and Anglo-Saxon Europe from the 5th to the 8th century. Classical literary sources identify dog as adjunct of deity or appropriate sacrificial victim (e.g. Jenkins 1957). In Pagan Scandinavia dogs are an inevitable presence in status burial (Davidson 1967). There is no doubt that certain dogs have enjoyed ritual significance, and that this significance has mitigated towards the survival of their remains. The problem is that this significance of the few might inaccurately predict the status of all in the archaeological record.

A problem with any observations on dogs is that they are represented in very low numbers in refuse contexts In these situations their frequency, often less than one per cent, may be noted but no measurement taken. On the other hand, whole or partial skeletons appear regularly either as individual burials, burial with humans or in a human burial context, or in other circumstances which are deemed to have a ritual basis. This has engendered a tendency to report fully only those dogs which are found in some degree of articulation. It would, however, be very interesting to know if the background dogs, those who donate a few of their disarticulated and fragmented bones to the refuse assemblages, differ in any way to the animals accorded a more complete deposition.

Nevertheless, it is now a fact of the archaeological record that dog is normally recovered in some degree of articulation, or the assemblage indicates strongly that the carcases were deposited whole. So what

we may well be seeing are archaeological specialities and not representatives of a species in antiquity. In so many cases we see what was chosen to be buried, and what has been chosen to record. With other domesticates (horse is perhaps the exception) we accord them a function - post-mortem human consumption - and regardless of all the taphonomic problems that function is highly visible in the nature of the deposits and the material. Any functions that dogs might fulfill are not observable archaeologically - hunting, guarding, companions - although there is no shortage of artistic and documentary evidence illustrating these activities. And no shortage of evidence indicating the presence of dogs scavenging on sites even where their bones are absent.

This 'invisibility of function' is compounded by the accepted practice of describing the remains; it is not considered appropriate to describe the animal in terms of its similarity to modern breed types (Clutton-Brock 1987, 43), but only in the size and proportions drawn from direct measurement. Objectively, this is indisputable, but it does seem to have led to rather pedestrian observations. The increase in variation of size and shape of the domestic dog over time is a phenomenon which is inextricably bound to human attitudes. Whether or not we express this variation by direct analogy to modern breeds may be far less important than recognising and defining changes in the material available to the archaeological analyst.

For instance, calculations of the cephalic index (Getty 1975), and the snout and snout width indices (Harcourt 1974), each of which does produce a three-dimensional aspect of the head, are only possible on very intact skulls. Once again, therefore, dogs from special deposits will contribute most of the evidence for 'appearance', whereas it is equally relevant to the study of the species to understand something of the appearance of dogs with lower social profiles. To do this, it is necessary to produce metrical relationships drawn from fragmentary material; and in most cases the only way to relate these indices to morphology and dimension is by direct comparison with measurements taken from modern breeds.

In the later sections of this chapter the canid remains from four very different types of deposit will be discussed. The first is the partial skeleton, mainly cranial, of a probable individual, the second and third are complete skeletons. The fourth group comprises the fragmented remains of at least 33 dogs over the age of about 6 months, interspersed with neonatal and pup material, and recovered from four separate features and six contexts. It is this last group which requires some extension of methodologies to express the presence of types of individuals, in order that the pathology can be related to the animal group in a rational manner. It is the development of these ideas which is the subject of the following section.

EXTENDING THE POTENTIAL FOR METRICAL ANALYSIS

a) Estimated shoulder heights

In faunal analysis the definitive work for dogs is Harcourt's **The Dog in Prehistoric and Early Historic Britain** (Harcourt 1974), in which he assembles the measurements of dated dogs by period and also presents his method of assessing the shoulder height of dogs from the overall lengths of the longbones. What have come to be called "the factors of Harcourt" are now the determining assessment for archaeological dog.

Shoulder height is clearly the most useful initial expression of dog variability, both as a descriptive term to illustrate a major visual characteristic of the animal, and as an analytical tool. And Harcourt's work, which was originally an extension of the work of Koudelka (1885), founded a tradition of estimating stature which has been consistently adhered to by all workers. Dog heights can therefore be extracted from any animal bone report with confidence, or calculated from the limb bone measurements in the knowledge that the same formula will have been universally applied.

It is this consistency which has enabled the canid section of this thesis to encompass a preliminary study of dog development in the period from which the major case study in this chapter is drawn. The dog remains from the late Romano-British wells and pit at

Baldock will be analysed and described on the basis of their pathological condition later in this chapter. As groups, their composition will also be suggested in terms of variability in stature and cranial aspect, and on the question of stature their validity as a representative sample of late Romano-British dogs will be discussed. To do this it is necessary to re-examine Harcourt's results showing the increase in variability in the Romano-British period compared with the Iron Age, and to develop methods which will enable more canid material to be brought into the analysis.

What Harcourt found for the Iron Age was a fairly uniform population in the height range 40-60 cm, with a small minority of shorter dogs present. The general uniformity was echoed in the cranial material available for the period which suggested unmodified dog with broad zygomatic arches, moderate snout lengths and fairly broad muzzles.

For the Romano-British period by contrast the noticeable feature is the variability in the height of the dogs, and particularly the presence of a significant group of smaller dogs. Bow-leggedness begins to appear, and crania examined by Harcourt for this period also show an equivalent variability - in particular the presence of the small, round-headed animal.

The standard practice now is to compare archaeological dog heights with Harcourt's groups, and the standard phrase in the faunal report is " . . . using the factors of Harcourt on such and such a bone of this length, the estimated shoulder height is . . . , which is within Harcourt's range for the period".

There are two obvious problems here. The range for the Iron Age is entirely contained within that for the Romano-British period, so saying that a specimen is within Harcourt's range for Iron Age dogs implies a definitive value which is not actually there. Secondly, and possibly more important, is there really a visible interface in dog type at the beginning of the Romano-British period? Harcourt's specimens are dated no closer than the archaeological period so there

is, for the moment at least, no prospect of reworking this data further.

For any group of canids to be understood usefully in terms of their size or type, this last question has to be addressed, and it necessary to test the reproducibility of Harcourt's results. To this end, shoulder heights have been calculated from measurements of Iron Age and Romano-British dogs published since 1974. The contributing sites are shown in Tables 5.1 to 5.5.

Table 5.1
Dogs: Iron Age sites contributing measurable dog bones

Site	No. bones measured	Reference
Baldock	3	Chaplin & McCormick 1986
Balksbury Camp	6	Maltby 1982
Bramdean	2	Clutton-Brock 1981
Danebury	10	Grant 1991
Dibbles Farm	2	Everton 1988
Farmoor	1	Wilson 1979
Flagstones, Dorchester	2	Bullock & Allen 1991
Knights Enham	2	Griffith 1976
Owslebury	1	Maltby 1987
M3 Motorway Site R27	1	Griffith 1978
Skeleton Green	7	Ashdown & Evans 1981
Yarnton	3	Smith in prep.

Table 5.2
Dogs: Romano-British sites contributing measurable dog bones
Mid 1st - Mid 2nd centuries

Site	No. bones measured	Reference
Baldock	3	Chaplin & McCormick 1986
Billingsgate Buildings	2	Armitage 1978
Ditches	1	Rielly in prep.
Flagstones, Dorchester	2	Bullock & Allen 1991
Greyhound Yard, Dorchester	18	Maltby 1989
Owslebury	4	Maltby 1987
Shakenoaks Farm	1	Cram 1978
St. Magnus, London	3	Armitage 1979
Wanborough	9	Rielly in prep.

Table 5.3
Dogs: Romano-British sites contributing measurable dog bones
Mid 2nd - Mid 3rd centuries

Site	No. bones measured	Reference
Alington Avenue, Dorchester	3	Maltby 1988
Baldock	5	Chaplin & McCormick 1986
Billingsgate Buildings	1	Armitage 1978
Greyhound Yard, Dorchester	44	Maltby 1989
Owslebury	1	Maltby 1987
Shakenoaks Farm	1	Cram 1978
St. Magnus, London	1	Armitage 1979

Table 5.4
Dogs: Romano-British sites contributing measurable dog bones
Mid 3rd - Mid 4th centuries

Site	No. bones measured	Reference
Baldock	2	Chaplin & McCormick 1986
Bramdean	1	Clutton-Brock 1981
Central Criminal Ct., London	2	Armitage 1979a
Frocester Court Roman Villa	2	Noddle 1979
Greyhound Yard, Dorchester	1	Maltby 1989
Ilchester	1	Levitan 1982
Owslebury	14	Maltby 1987
Shakenoaks Farm	2	Cram 1978
St. Magnus, London	1	Armitage 1979
Winchester Northern Suburbs	11	Maltby 1987a

Table 5.5
Dogs: Romano-British sites contributing measurable dog bones
Late 4th century

Site	No. bones measured	Reference
Baldock	8	Chaplin & McCormick 1986
Caerleon Legionary Fortress	17	O'Connor 1986
Greyhound Yard, Dorchester	12	Maltby 1989
Ilchester	1	Levitan 1982
Lankhills Cenotaph	1	Clarke 1979

The distribution of the Iron Age estimated shoulder heights compared with Harcourt's humerus lengths is shown in Figs. 5.1 and 5.2. The shapes of the graphs are similar, although the post-1974 sample size is 41 individuals compared with 68.

The post-1974 Romano-British group is slightly larger - 206 individuals compared with Harcourt's 188, but the overall picture is very similar as can be seen in Figs. 5.3 and 5.4. Again, the post-

1974 data is shown as estimated shoulder height, the Harcourt data as humerus lengths.

As closer dating information is available for the post-1974 material, it is possible to begin to consider the Romano-British period in more detail. Fig. 5.5 shows the sample divided into periods with dates running from mid century to mid century, and with the dogs presented in three height categories. The choice of boundaries for date is based only on the need at this stage to divide the period into equal portions. The fact that the sample sizes are reasonably comparable is quite fortuitous. For the size categories, it is intended only to demonstrate any gross change in relationship between the larger and smaller animals. The sample sizes are, of course, insufficient for any conclusions to be drawn. However, the indications, particularly the predominance of the smaller dogs in the late 4th and early 5th centuries, are interesting enough to warrant putting forward a methodology which might enable the sample size to be increased significantly if, at some future stage, it becomes feasible to access raw metrical data.

At the other end of the timescale, Fig. 5.5 also shows the Iron Age data in the three height categories. Although it must be emphasised again that these samples are insufficient to claim a conclusion, the picture is not that of a clear interface between Iron Age and Romano-British. Indeed, Fig. 5.6, which divides the Iron Age data into Early/Middle and Late, might suggest that a horizon should be sought within the Iron Age.

Because shoulder heights are calculated from regression equations derived from the relationship of the overall length of the long bones to the stature of the animal, the ability to produce them relies entirely on the recovery of complete humeri, radii, ulnae, femora or tibiae. In this study the potential of the metapodia as predictors of shoulder height has been investigated. If the second to fourth metacarpal and metatarsals can be brought into the analysis, another 16 bones per animal become available. Additionally the metapodia probably have a better rate of survival as complete elements as their

reduced length also reduces the effects of imposed stresses in the soil. The results are presented here, and although they will be much enhanced by the incorporation of further material as it becomes available, they have been applied to these canid studies.

The skeletons of fifteen modern dogs were measured, and the estimated shoulder heights calculated using each long bone and the factors of Harcourt. The heights derived from each long bone were compatible.

Using the mean of the shoulder heights estimated from the length of each long bone as the dependent variable, regression equations were derived for each of the metapodial elements to exemplify the relationship between metapodial and estimated shoulder height. The resulting regression equations and coefficients of determination are as follows:

Table 5.6
Dogs: Calculated metapodial factors

Element	Factor	r^2
Metacarpal 2	(0.94 x GL) - 1.56	0.989
Metacarpal 3	(0.83 x GL) - 2.03	0.993
Metacarpal 4	(0.84 x GL) - 2.60	0.994
Metacarpal 5	(0.98 x GL) - 1.56	0.989
Metatarsal 2	(0.86 x GL) - 2.04	0.995
Metatarsal 3	(0.77 x GL) - 2.26	0.996
Metatarsal 4	(0.75 x GL) - 2.68	0.996
Metatarsal 5	(0.83 x GL) - 1.75	0.996

The range identified by the long bones and the heights derived from the metapodial analysis are shown in Table 5.7.

Table 5.7
Dogs: Shoulder heights derived from long bones and metapodia

Type	Shoulder height calculated from length of element									
	Lbone range	Mcar2	Mcar3	Mcar4	Mcar5	Mtar2	Mtar3	Mtar4	Mtar5	M'pod range
Greyh'd	66.9-69.1	68.3	69.7	68.5	68.9	67.5	69.2	68.3	68.5	67.5-69.2
Toy	27.4-29.6	27.6	28.4	27.6	27.5	28.2	28.5	27.9	27.6	27.6-28.5
Labrador	50.2-52.6	50.0	51.4	51.5	51.7	49.5	50.3	50.9	51.7	49.5-51.7
JR terr x	38.8-39.9	39.6	39.9	38.7	38.4	39.6	39.7	39.5	39.4	38.4-39.9
Lab x	48.2-49.0	51.7	51.4	50.0	50.2	50.8	51.0	50.2	50.0	50.0-51.7
Alsation	56.1-57.9	57.4	56.7	55.2	55.8	57.6	56.5	55.8	55.0	55.0-57.6
Greyh'd	69.0-71.5	72.3	71.6	70.1	70.9	71.5	71.6	70.7	71.8	70.1-72.3
Bord. terr	28.5-32.9	32.4	32.0	31.0	32.7	30.3	30.1	29.6	31.4	29.6-32.7
JR terr	29.5-32.4	32.7	32.6	32.4	34.0	32.3	32.1	32.4	32.7	32.1-34.0
Greyh'd	68.2-69.2	66.6	67.5	66.9	68.5	67.1	67.3	66.3	68.0	66.3-68.5
Greyh'd	72.0-73.9	74.8	75.3	74.1	74.3	72.9	73.1	72.4	72.3	72.3-75.3
Bull terr	41.1-44.0	43.6	43.8	43.0	43.6	42.1	42.8	42.3	42.4	42.1-43.8
Chinese cr	37.6-40.0	39.1	39.8	38.9	37.4	39.1	39.3	38.8	38.5	37.4-39.8
Boxer	58.5-60.1	57.6	57.6	56.6	56.4	59.4	59.4	59.2	59.9	56.4-59.9
Spaniel x	45.9-48.4	46.3	47.9	46.5	46.8	47.2	49.0	46.4	47.4	46.3-49.0

Table 5.8 applies the metapodial formulae to five archaeological skeletons from the collection of the Faunal Remains Unit, and shows the forecast height ranges predicted by the longbones and the metapodia.

Table 5.8
Dogs: Forecast shoulder heights using longbones and metapodia

Type	Shoulder height calculated from length of element									
	Lbone range	Mcar2	Mcar3	Mcar4	Mcar5	Mtar2	Mtar3	Mtar4	Mtar5	M'pod range
A94	49.4-50.9	48.1	47.2	45.6	47.1	46.3	46.0	45.8	45.0	45.0-48.1
A174	34.2-39.5	35.0	36.1	34.9	34.8	35.6	35.9	35.0	35.5	34.8-36.1
SH10	40.0-43.6	40.5	41.8	40.7	39.7	43.2	42.6	42.6	43.4	40.5-43.4
B320	47.2-49.6	48.0	48.0	47.0	46.5	48.3	48.4	48.1	47.4	46.5-48.3
B2618	29.7-32.4	28.2	28.8	28.0	26.9	28.6	29.5	28.5	29.0	26.9-29.5

A94 = Post-medieval
A174 = Iron Age
SH10 = Medieval
B320 = Late Iron Age
B2618 = Mid 1st century AD

b) Cranial morphology

As discussed earlier, the potential of cranial measurements to identify variability in canids is restricted because the conventional indices - cephalic, snout, and snout width - rely on metrical components available only in well preserved or highly intact skulls. While these indices no doubt give very good comparative standards, and Harcourt (Harcourt 1974) again illustrates their usefulness in identifying the departure from plain dog to modified dog in later prehistory, they are probably more restricted in their application than any other metrical indications. Yet in an animal which is capable of direct

facial communication with humans it is the appearance of the head of the dog which stimulates recognition and response in the human. That is not to say that when, and if, all dogs were plain dogs of even stature and robusticity they were not recognisable as individuals. The archaeologically invisible characteristics such as coat, colour, submissiveness or agression may well have been apparent. However, the emergence of the brachycephalic dog in the Romano-British period as identified by Harcourt should alert us to the potential for cranial modification in this animal. When discussing the pathological condition of representatives of this species, therefore, cranial morphology might be a useful variable in determining the "modification status" of an individual or groups of individuals. The problem is to identify variation metrically in skull fragments, and this is the theme of this section.

As in all mammals, the canid skull is made up of a number of bones interlocked along the lines of sutures. In the mature animal synchondrosis can result in the visual obliteration of these synarthroses, but they remain as susceptible planes of weakness particularly in dead bone subjected to demineralisation. In burial conditions where external matrix pressure is equal, such an adult skull may survive intact, or disintegrate only along the suture lines as the underlying support of the brain decomposes. More commonly, however, varying external pressures and changes in soil environment will cause the skull to fragment at all points of weakness, and these are classically the thinnest areas of the cranial vault, the nasal bones, the palate, and the zygomatic arches. Consequently in circumstances of prolonged diagenesis, multiple burial or poor archaeological retrieval, and often a combination of these, the planes of measurement necessary for the production of the conventional indices are lost.

In the disintegration of the cranium, nevertheless, three fragmental types appear to persist consistently, and these are the aboral maxilla, the occipital condyles and the frontal bone. The occipital condyles occur the least frequently. The aboral maxillae are frequently recovered but are vulnerable to disintegration at their aboral border

and into the alveolus of the second molar, thus prejudicing their metrical validity which relies on the extremity landmark of the aboral border of the M2 alveolus.

Greater diagnostic potential may lie with the frontal bone, an area of the canid cranium which has the advantage of increased density because of its return from the facial aspect into the orbital region. Its initial posterior disintegration plane is likely to be the tempero-frontal suture, and anteriorly the next vulnerable point is the junction of the nasal to the medial suture. It has minimal curvature and this, allied to its density, reduces susceptibility to pressure. Its primary fracture plane is the medial suture, and thus it is measurable as a hemicephalic fragment. Additionally, and importantly, it encompasses three standard measurements (von den Driesch 1976), the post-orbital constriction, the ectorbitale, and the entorbitale (the least breadth of the braincase, the greatest facial width, and the minimum width between the orbits).

Using the same sample of modern dogs as that described for the estimation of shoulder heights, no useful relationships were found between long bone length and the three cranial measurements and only the greyhounds (the only known pure bred animals in the set) group closely on a simple scattergram (Fig. 5.7).

Looking at the relationships within the frontal bone alone, however, there may be some interesting indications. Figs. 5.8, 5.9 and 5.10 illustrate how the relationship between the measurements varies with breed and type, and between modern and archaeological dogs, and wild canids. The following key relates to each of the graphs.

1	Modern fox	18	Border terrier
2	Iron age dog (Baldock)	19	Jack Russell
3	Late 1st century dog (Baldock)	20	Greyhound
4	Greyhound	21	Greyhound
5	Toy Poodle	22	English bull terrier
6	Labrador	23	Iron Age dog (Andover)
7	Saxo-Norman fox (Carisbrooke)	24	Chinese crested
8	Neolithic wolf (Shepperton)	25	Rotweiller
10	Jack Russell x Staffordshire terr.	26	Boxer
11	Labrador x	27	Timber wolf
12	Juvenile collie	29	Mid IA dog (Yarnton)
13	German Shepherd	30	Late IA dog (Yarnton)
14	12/13th century dog (Winchester)	31	Juvenile European wolf
17	Greyhound	32	Spaniel x

These graphs are, of course, indications only; ideally the wild group would be represented only by wolf as the ancestral species.

Fig. 5.8 plots the two measurements which have the strongest relationship in modern dogs - the minimum width between the orbits (entorbitale) and the width across the zygomatic processes of the frontal bone (ectorbitale). The upper and lower limits are occupied by the Boxer and the Toy Poodle, both very highly modified breeds. The wild canids occupy the line to the right of the modern dogs - where the width between the frontal zygomatic processes is relatively narrow in relation to the facial width - as do four of the five archaeological dogs included on this graph. Interestingly, the archaeological dog which approaches most closely the modern dog and lies directly on a line linking three greyhounds is from Iron Age Andover.

Fig. 5.9 shows the relationship between, again, the entorbitale breadth and the post-orbital constriction (the narrowest part of the braincase that lies immediately posterior to the temporal line). This clearly differentiates the four adult wild canids, but the juvenile wolf lies beyond the majority of the adult dogs in the region where the post-orbital constriction is markedly wider than the facial breadth. This is a typical paedomorphic characteristic, emphasising not only the size and roundness of the head but also the facial area occupied by the eyes. The three modern dogs of this sample which clearly fall into this group are the spaniel, the Jack Russell/Staffordshire cross,

and the Chinese crested, all of which have this domed head and large eyed appearance.

Fig. 5.10, which plots the post-orbital constriction in relation to the ectorbitale breadth (the width across the zygomatic processes of the frontal bone) shows a similar picture, although the excessive width of the supraorbital area of the boxer has displaced its position.

These three figures include the cranial dimensions of the first three case studies which follow. The fourth study, that of groups of canid remains from Baldock, is illustrated separately.

FOUR ARCHAEOLOGICAL CASE STUDIES

a) THE CANID REMAINS FROM THE NEOLITHIC RINGWORK AT STAINES ROAD FARM, SHEPPERTON.

This ringwork, on the southern side of the valley of the River Ash, was totally excavated in 1989 in advance of gravel extraction, having formerly been identified on aerial photographs. The ringwork is possibly associated with the adjacent habitation (or feasting) site, avenue of pits, and 'field' ditches (Jones 1990).

Canid skeletal material recovered from the ringwork was representative of at least two species, *Vulpes vulpes* (red fox) and *Canis lupus* (wolf). It is possible that *Canis familiaris* (domestic dog) is also present, but it is more likely that the bones of *Canis sp.* derive from the wolf, and probably from one individual. A minimum number of two foxes were represented.

In addition to the canid material, a pelvis of a small badger (*Meles meles*) was recovered from context H3g.

Comprehensive metrical data for all the material are shown in Table 5.9. All measurements are in millimetres, and measurement definitions follow the convention of von den Driesch (1976).

Table 5.9
Canids: Staines Road Farm metrical data

G5 A/B	Mandible	R	Length M3-P2	55.1	Fox
			Length molar row	26.8	
			Length P2-P4	27.4	
			Length carnassial alveolus	13.4	
			Length M2	9.5	
			Length M3	2.7	
			Jaw thickness below M1	6.2	
			Mandible height behind M1	14.4	
G5 A/B	Mandible	L	Length carnassial alveolus	13.8	Fox
			Jaw thickness below M1	6.3	
G9 D2	Mandible	R	Jaw thickness below M1	5.9	Fox
G11 D3	Scapula	R	Min length neck of scapula	26.6	Dog/
			Length glenoid	31.8	wolf
			Breadth glenoid	19.2	
G11 D3	Mcar V	R	Max length	60.7	Dog/
			Prox breadth	11.3	wolf
			Prox depth	12.3	
			Min diaphysis	8.3	
			Dist depth	9.5	
G11 D3	Mcar III	R	Prox breadth	9.2	Dog/
			Prox depth	12.3	wolf
			Min diaphysis	7.2	
G11 D4	Mcar II	R	Max length	60.9	Dog/
			Prox breadth	8.5	wolf
			Prox depth	11.6	
			Min diaphysis	6.9	
			Dist breadth	11.1	
			Dist depth	8.8	
G12 D3	Humerus	R	Min diaphysis	8.4	Fox
			Distal breadth	20.5	
			Distal depth	13.9	
G12 D3	Humerus	L	Distal breadth	20.4	Fox
G12 D3	Ulna	R	Depth anconeal process	14.9	Fox
			Min depth olecranon	12.0	
			Height trochlear notch	13.4	
G12 D3	Femur	R	Min diaphysis	12.1	Fox
			Dist breadth	22.3	
G12 D3	Tibia	L	Prox depth	24.3	Fox
G12 D3	Mtar II	L	Max length	57.1	Fox
			Min diaphysis	4.2	
			Prox breadth	7.5	
			Prox depth	4.0	
			Dist breadth	5.7	
			Dist depth	5.8	
G12 D3	Mtar III	L	Min diaphysis	4.7	Fox
			Prox breadth	5.8	
			Prox depth	8.5	

Table 5.9 (Cont.)

G14	Atlas		Breadth across wings	81.3	Wolf
			Breadth cranial articular surface	34.2	
			Breadth caudal articular urface	41.7	
			Length dorsal arch	19.0	
			Height	25.9	
	Cranium		Nasion-prosthion	110.2	Wolf
			Frontal midpoint-prosthion	129.2	
			Snout length	98.7	
		R	Length of cheektooth row	75.7	
		R	Aboral M3-oral C	80.7	
		R	Length molar row	19.4	
		R	Length premolar row	58.0	
		L	Length premolar row	52.8	
		R	Length carnassial alveolus	20.6	
		L	Length carnassial alveolus	20.8	
		R	Length M1	12.4	
		L	Length M1	11.9	
		R	Length M2	6.4	
		R	Length P1	6.2	
		L	Length P1	5.7	
		R	Length P2	11.9	
		L	Length P2	12.3	
		R	Length P3	13.2	
		L	Length P3	12.8	
			Least breadth skull	35.1	
			Frontal breadth	63.7	
			Least breadth between orbits	48.1	
			Greatest palatal breadth	69.2	
			Least palatal breadth	41.8	
			Breadth at canine alveoli	43.6	
		R	Inner height of orbit	30.6	
		L	Inner height of orbit	28.5	
	Mandible	L	Condylar process-infradentale	159.0	Wolf
			Angular process-infradentale	159.2	
			Angular indentation-infradentale	150.2	
			Condylar process-aboral canine	141.8	
			Angular indentation -aboral canine	134.3	
			Angular process-aboral canine	143.2	
			Aboral M3-aboral canine	91.6	
			Length M3-P1	84.4	
			Length M3-P2	78.2	
			Length molar row	38.9	
			Length P1-P4	46.1	
			Length P2-P4	40.5	
			Length carnassial alveolus	22.6	
			Length P1	4.8	
			Length P2	10.4	
			Length P3	11.5	
			Length P4	12.2	
			Jaw thickness below M1	13.4	
			Height vertical ramus	61.4	
			Height mandible behind M1	29.4	
			Height mandible between P2 and P3	23.1	
				92.2	
G14 D3/4	Vertebra (C)		Body length	32.2	Dog/ wolf
			Length cranial-caudal artic processes	42.0	
			Breadth across caudal artic processes	34.2	
			Breadth cranial articular surface	15.7	
G14 D3/4	Vertebra (T)		Body length	19.6	Dog/ wolf
			Breadth cranial articular surface	27.6	
			Breadth caudal articular surface	24.9	
			Height cranial articular surface	13.3	
			Height caudal articular surface	24.9	

Table 5.9 (Cont.)

G15 D3	Tibia	R	Min diaphysis	14.1	Dog/
			Dist breadth	24.4	wolf
			Dist depth	16.1	
G15 D3	Calcanaeum	R	Max length	46.0	Dog/ wolf
G15 D3	Scapula	L	Min length neck of scapula	14.3	Fox
			Length glenoid	16.6	
			Breadth glenoid	8.8	
G15 D3	Radius	R	Prox breadth	10.7	Fox
			Prox depth	6.8	
			Min diaphysis	7.3	
G15 D3	Mtar V	R	Min diaphysis	6.7	Dog/ wolf
G15 D3	Tibia	L	Min diaphysis	7.7	Fox
			Dist breadth	14.2	
			Dist depth	9.6	

VULPES VULPES

The mandibles of context G5 and the appendicular elements of G12 are of the correct relative proportions and may be from the same individual. In the right mandible P3 and P4 are missing and the alveoli filled, and M1 is very worn. The right ulna exhibits lipping of the proximal border of the trochlear notch. Observations on modern foxes (Chapter 5) this would suggest the animal(s) was in its third season or more at time of death.

The remains of fox limb bones in context G15 are of a very small specimen. The mandible fragment in context G9 is also of a small animal.

CANIS SP.

The skull material of context G14 was originally identified by the excavators as that of a large, possibly deformed dog (The **Independent** 11/2/90), and it is considered to be deposited in the same phase as two human burials recovered from other ditch segments. When the remains became available for this study it was clear that this would be a very large domestic dog indeed for this period (Plates 5.1 and 5.2). Metrical tests suggest that this is in fact a wolf, and the identification is based on the following four criteria:

a) The overall size of the cranium and left mandible. Data relating to Neolithic domestic dogs is restricted, but has been summarised by Harcourt (1974) and supplemented by Burleigh et al (1977) and van Wijngaarden-Bakker (1974). Conformity in size is a feature of this period, and Table 5.10 shows selected measurements for the Staines Road Farm skull and comparable Neolithic domestic dogs. The Staines Road Farm specimen is significantly larger.

Table 5.10
Dogs: Selected skull measurements of Neolithic dogs

	1	2	3	4	5	6	7	8	Reference
Easton Down	83.0	-	60.0	36.0	67.0	20.0	-	-	Harcourt 1974
Dowel Cave	85.0	55.0	64.0	39.0	71.0	21.6	-	-	" "
Maiden Castle I	-	-	61.0	-	68.0	-	-	-	" "
Maiden Castle II	-	-	64.0	-	69.0	-	-	-	" "
Windmill Hill I	87.0	-	65.0	36.0	71.0	20.8	-	-	" "
Windmill Hill II	82.0	50.0	58.0	32.0	64.0	19.7	-	-	" "
Newgrange	-	-	-	-	-	-	48.6	-	Wijngaarden-
Newgrange	-	-	-	-	-	24.0	-	42.1	Bakker 1974
Newgrange	-	-	-	-	-	21.9	-	35.2	" "
Grimes Graves	83.5	64.5	64.5	37.0	69.4	21.6	-	-	Burleigh et al 1977
Durrington Walls	-	-	-	-	-	20 to 24.0	-	-	Harcourt 1971
Staines Road Farm	110.2	69.2	75.7	43.6	84.4	22.6	58.0R 52.8L	46.1	

1 = Nasion-prosthion
2 = Maximum palatal width
3 = Maxillary cheek tooth row
4 = Width at canine alveoli
5 = Mandibular cheek tooth row
6 = Mandibular M1 length
7 = Maxillary premolar row length
8 = Mandibular premolar row length

b) The relative length of the upper carnassial (Clutton-Brock 1963). In wolves, the length of the upper carnassial exceeds the sum of the lengths of the two molars. In dogs, the summed molar lengths exceed, or are equal to, the length of the carnassial. For the Staines Road Farm specimen the carnassial length exceeds the molar length by 1.8mm.

c) The degree of crowding of teeth in the jaws. It has been shown by Degerbol (1961), Clutton-Brock (1963) and van Wijngaarden-Bakker (1974) that non-domesticated canids will have a smaller degree of tooth crowding in the jaws than domestic dogs. The formulae (Wijngaarden-Bakker 1974) for deriving the relative percentage of teeth length to tooth row length are:

$$\text{Upper jaw:} \quad \frac{(\text{Lengths P1 + P2 + P3}) \times 100}{\text{Length anterior edge P1 to anterior edge P4}}$$

$$\text{Lower jaw:} \quad \frac{(\text{Lengths P1 + P2 + P3 + P4}) \times 100}{\text{Length anterior edge P1 to anterior edge M1}}$$

The indices for the Staines Road Farm skull are:

Upper jaw (R):	79.4%
(L):	91.5%
Lower jaw (L):	86.3%

The discrepancy between right and left upper jaw is likely to be a consequence of traumatic injury and is discussed below.

Comparison with other tooth crowding indices for Neolithic domestic dogs is shown in Table 5.11.

Table 5.11
Dogs: Tooth crowding indices of Neolithic dogs

	Upper	Lower
Newgrange	107.0	
Newgrange	108.0	
Newgrange		91.0
Newgrange		101.0
Newgrange		103.0
Newgrange		101.0
Grimes Graves (est)	109.0	97.7
Staines Farm Road	79.4 R	
	91.5 L	86.3

d) Snout width index. This expresses the width of the muzzle relative to the length of the nose. Domestication, or even just captivity, produces a shortening of the facial part of the skull without a concurrent narrowing of the muzzle, and so wild canids will exhibit a narrower snout relative to the length. The index is derived from the formula:

$$\frac{\text{Breadth at canine alveoli} \times 100}{\text{Length from nasion to prosthion}}$$

For the Staines Road Farm animal the index is 39.6%, and this is compared with Neolithic domestic dogs in Table 5.12.

Table 5.12
Dogs: Snout width indices of Neolithic dogs

Easton Down	43.5
Dowel Cave	45.8
Windmill Hill I	41.4
Windmill Hill II	39.1
Grimes Graves	44.3
Staines Road Farm	39.6

Although the first three of these indications suggest that this skull is that of *Canis lupus*, it would be a small representative of that species. The absolute length of the upper carnassial is 20.8mm compared with the 23.3mm of the smallest European wolf (*Canis lupus lupus*) reported by Clutton-Brock (1963). Van Wijngaarden-Bakker (1974) has measured the lower carnassial of the smallest wolf in the British Museum (Natural History) at 29.5mm in length, substantially longer than the 22.6mm of the Staines Farm Road canid.

The snout width index is at the lower end of the scale for reported dogs, and does not clearly delineate this specimen from domesticated animals. However, the possibility exists of developmental disruption following traumatic injury which may affect the index. This is discussed more fully below.

The atlas apparently associated with the skull (see Fig. 5.11) is very close in size to that of a modern greyhound. Additionally, the other elements attributed to Dog/wolf in Table 5.9 are in the correct relative proportions, both to the atlas and each other, to have originated in the same specimen. They are also highly comparable to the corresponding elements in comparative greyhounds. Thus, although there are no complete limb bones from which to derive an estimated shoulder height according to the factors of Harcourt (1974), it is possible to suggest that the animal was of similar stature, which is in the range 65-70cm.

Harcourt's maximum estimated shoulder height for Neolithic dogs is 62cm based on a tibia length of 211mm from Nympsfield Long Barrow, reported in 1938. Excluding this specimen, the maximum height estimated by Harcourt is 49cm. Bate (Clifford 1938) has discounted the possibility of the Nympsfield bones being wolf on the grounds of size, diminution of articular ends, feeble development of sites of muscle attachment, and more rounded aspect of the bones. However, no skull material was recovered on which to base a more justified statement.

The Staines Road Farm skull is of an adult animal; all sutures are closed and the frontoparietal obliterated. The carnassials are worn, but not heavily. Observations on the incisors of coyotes (*Canis latrans*) (Gier 1957) suggest an age greater than five years.

A prominent feature of the cranium is the healed depressed fracture of the left frontal bone, medial of the zygomatic process and extending from the nasion caudally to the site of the frontoparietal suture (see Fig. 5.12). There is another traumatic lesion of the left maxilla extending from just medial of the left orbit to a point just dorsal of the infraorbital foramen. Some possible post-mortem damage has rendered the borders of this lesion indistinct.

There is a marked asymmetry of the palate and dental arcade, and it is possible that there may have been some developmental response to the disruption caused by the frontal lesion (Fig. 5.13). The teeth are closer together on the right, and there is no diastema between the right P1 and P2. The canines are asymmetric, the right one appearing to be hyperplastic.

Although the portion of the right maxilla bearing M2 is missing, there is no maxillary ante-mortem tooth loss, nor any evidence of periodontal disease. There has been some damage in life to the right I2 and left I1 resulting in ante-mortem staining of the enamel.

The left mandible is complete, but only a fragment of the right symphisis survives. The right I3 is damaged and the enamel discoloured, and the left I1 is missing with the alveolus filled.

A fragment of one of the ribs associated with the skull material (see Fig. 5.11) exhibits a healed fracture. Two other fragments of these ribs have small proliferative lesions which probably indicate periostitis, and may well have been a consequence of an overlying soft tissue traumatic injury such as bruising.

The metrical and pathological evidence suggests the possibility that this is not simply a wild specimen deposited in a ritual context. The identification of wolf is made with some confidence, but the animal is small and the snout width index, the first cranial expression to reflect human interference, would not on its own differentiate the remains from domestic dog. However, the snout width index is not necessarily indicative of domestication, merely of the maintenance of the animal in a restraining environment.

In this case, the traumatic injuries to the head, almost certainly acquired before full maturity, are associated with asymmetrical development and may well be the causal factor in the distortion. This renders the snout width index suspect. On the other hand, these traumatic lesions are in full accordance with the pattern of healed cranial fractures reported by Baker and Brothwell (Baker & Brothwell 1980, 94) in domestic dogs from the early Neolithic to the Roman period.

Although it is impossible to do other than speculate, it does seem that the evidence points to this mature animal being kept in some degree of captivity from at least sub-adulthood.

b) A DOG SKELETON RECOVERED FROM A LATE IRON AGE DITCH AT BALDOCK, HERTS

The skeleton is of a mature, male dog standing between 47 and 50 cms at the shoulder. The skull indices are comparable with those considered by Harcourt to indicate the unmodified "plain" dog:

Cephalic index	54.7
Snout index	48.8
Snout width index	40.9

The relative appearance of the upper facial area, as defined by the frontal bone, is shown on Figs. 5.8, 5.9 and 5.10 as Specimen 2.

The animal is therefore unremarkable in size and probable appearance. However, the pathology, and particularly the sequence of pathology, gives a useful insight into the life and condition of the individual.

In the axial skeleton, vertebrae T12, T13, L1 and L2 exhibited a flattening of the spinous processes, accompanied by a proliferation of disorganised bone probably indicative of infection following minor traumatic injury. The facet of the right rib tubercle of a thoracic vertebra had been subjected to some stress evidenced by a circumferential linear depression. Two left ribs each supported a small osteoma (benign button wart) of about 1mm diameter on the lateral ventral surface – these osteomata are common manifestations in older animals of all species.

In the limbs, the right ulna had a reduced healed fracture just distal of the mid shaft. The radius was not involved, and the reduction of the fracture may therefore be a consequence of the uninjured radius acting as a natural splint rather than an indication of human intervention. The left third and fourth metacarpals and the right third metacarpal had slight marginal lipping on the anterior of the distal articular surfaces. The left third metatarsal and the right fourth exhibited similar lipping, with the right fourth metatarsal also showing a groove at the attachment of the proximo–posterior tendon. These metapodial manifestations can all be attributed to the maturity of the animal. The fifth metatarsal showed some evidence of joint stress in the linear indentations on the distal anterior facet.

Two probably articulating phalanges showed lesions of degenerative osteoarthritis. The first phalanx exhibited periarticular exostoses

medially and anteriorly extending to the mid shaft, and the distal medial facet was eburnated at the distal extremity. The second phalanx also had periarticular exostoses medially and anteriorly, with destruction of the medial sector of the medial facet and eburnation of the perimeter of the destroyed area.

The cranial pathology is complex (Fig. 5.14) and probably indicates a series of traumatic injuries sustained over a period of months or years.

A recent fracture of the right and left nasal processes of the incisive extends into and across the inciso-maxillary suture. The proliferation of disorganised bone along the line of the fracture indicates an early stage of healing.

There is a non-united but ante-mortem fracture of cranial right nasal bone on line of inciso-maxillary suture.

An unhealed depression fracture of the frontal bone extends diagonally just cranial of the coronal suture. Although no healing of the fracture margins is evident, the depressed portion is overlain by a proliferation of disorganised bone which is probably a combination of healing callus and inflammatory reaction. These lesions do not continue through to the inner table, although the fracture margins are visible on the inner surface.

This latter, unhealed traumatic injury overlies on the right side a thickened area of bone just lateral of the right temporal line. This lesion probably relates to an earlier, fully healed traumatic injury.

Finally, there is a healed depressed fracture of the area over the left nasomaxillary suture just cranial of the left sinus. The nasomaxillary suture is displaced medially and now intercepts the median suture. The lateral portion of the left naso-frontal suture is also reorganised and now returns to intercept the median suture, so that the frontal bone continues as a narrow extension to meet the median suture.

The only dental anomaly is a missing P1R with the alveolus filling.

To summarise, the dog is well matured on the evidence of the teeth, the osteomata, the bilaterality of the metapodial arthropathies, and the severity of the phalangeal degenerative osteoarthritis. The arthropathic load cannot, however, be considered heavy in that relatively few joint surfaces are affected.

The sequence of fractures suggests a number of traumatic episodes. The injury to the right forelimb cannot be interpreted as it could have occurred through a variety of causes. The injuries to the lower thoracic/upper lumbar vertebrae, however, are very suggestive of a blow across the back. The sequence of cranial trauma indicates that this animal died shortly after sustaining multiple injuries to the facial part of the head. It had, however, survived previous traumatic damage to the head, and the realignment of the nasal sutures suggests that at least one of these episodes occurred in sub-adulthood.

c) A DOG INTERRED IN A DOUBLE HUMAN BURIAL AT BALDOCK, HERTS.

This is a dog burial within a human grave of the late 1st century AD. The initial inhumation was that of a man. The grave was subsequently opened for the interment of a female, at which time an arm of the man was rearranged to encompass the shoulder of the woman. At a later date the grave was again opened and the body of the dog, in an un-nailed wooden box, laid across the thighs of the female. (M. Stevenson in prep.).

The bone was in poor condition, friable and with much root damage to the surface. No baculum was recovered so sex must remain indeterminate. All the long bones were complete however, and so it is possible to determine the stature at between 30 and 32 cms. The skull was too fragmented for skull indices to be calculated; nevertheless, the fragments show the frontal and temporal bones to be very thin. The frontal bone survived intact however, and the dimensions of this bone are shown on Figs. 5.8, 5.9 and 5.10 as Specimen 3. This is certainly a very small dog.

Two congenital abnormalities suggest that this is an example of "modified" dog. The animal had the anomalous vertebral formula of C7 T12 L8 (normal configuration C7 T13 L7), and the congenital absence of both third molars.

Early arthropathic manifestations were visible in the vertebrae:

C4	Early periarticular exostosis ventral cranial face.
C5	Early periarticular exostosis ventral cranial face.
C6	Early periarticular exostosis ventral caudal face.
T5	Extension of ventral border of right caudal rib facet.
T8	Early periarticular exostosis right ventral caudal face.
L1a	Early periarticular exostosis ventral cranial face.
L4	Periarticular exostosis ventral cranial face.

Joint changes, probably indicative of age, were also seen in the bilateral articular extension of the postero-lateral articular margins of the humeri.

The right radius and ulna displayed reduced and very well healed fractures of the distal diaphyses. Although the shafts were slightly bowed laterally, the smooth reunion of this double fracture suggests that it was manually reduced, even if the limb was not immobilised as the bowing could be a result of weight-bearing.

There is asymmetry between the right and left femora in the angle between neck and shaft. The left neck is elongated and inclined dorsally to increase this angle. This may be a compensatory realignment subsequent to the fracture of the right radius and ulna.

Finally, there is a traumatic injury to the orbital part of the left frontal bone, evidenced by the partially healed fracture of the caudal part of the orbit with depression of the most ventral part of the lesion. There are no indications of inflammation, but the degree of healing suggests the injury may have been sustained within weeks of death.

The contextual, dimensional and pathological information points unreservedly to this animal being a pet. It is a very small animal.

It is mature, and possibly very mature, has clearly been cared for by the appearance of the healed limb fracture, and is buried in its own coffin in close association with a human female. The circumstances of its burial both mimic and support the apparent sentiments surrounding the interment of the two humans. This, of course, could reflect the sentiments of the person responsible for the burial rather than the occupants of the grave.

d) CONCENTRATIONS OF DOG REMAINS DEPOSITED IN THREE WELLS AND A PIT AT ROMANO-BRITISH BALDOCK

In contrast to the previous three deposits, these remains are agglomerations of the fragmented skeletons of a number of dogs. Each context is deemed by the excavator to contain a discrete deposit (M. Stevenson, pers. comm.), but each context contains more than one animal. The skeletons are disarticulated, fragmented and intermixed, but the identified components discussed here are all attributable to *Canis familiaris*.

One well (18) is dated to the late 3rd century AD, the other two (448, 557) to the late 3rd to 4th century. The pit (2254) is earlier, late 1st or early 2nd century AD. In the wells, the canid remains were recovered from depths between 10 and 14 metres. At this level much of the material lay below the modern water table and was retrieved with the assistance of divers.

It is not known whether the wells were viable or dry at the time the bodies were deposited, but in the excavation area many such wells were encountered. The shafts are sunk into the underlying chalk, and it may be that fluctuations in the water table of this highly permeable strata endowed them with a high rate of obsolescence. The good preservation of the bone, however, suggests that it has been enclosed within waterlogged conditions for much of its burial, and the depth will have ensured insulation from the environmental shock of quick drying.

Every fragment identifiable to element was examined microscopically at 6x magnification, and this is the primary level at which pathological anomalies were observed. Identified lesions were then examined at

12x magnification, and in some instances at 25x or 50x. Any measurements defined by von den Driesch (von den Driesch 1976) were recorded for all measurable fragments which were not obviously juvenile.

This is therefore a situation where the first principle of this thesis has to be applied:

> Osteological deviation, as expressed by pathological lesions, will be more obvious than the individuals contributing those anomalies, unless the assemblage is treated as the 'body'.

In other words, we should seek to define the pathology in ways which are meaningful to the assemblage; otherwise we will continue to see pathological abnormalities in terms of some unfortunate creature which cannot be fully identified through its remains, but which we will endow with an individuality because of a perceived incapacity.

In these dog remains from Baldock there is the opportunity to bridge this gap between the observable lesions and the unidentifiable individuals. We should be able to put forward a reasonable analysis of the dogs present in any of the contexts in terms of the minimum number of individuals represented, the age structure of the group, and the size range encompassed. Against this background we should be able to superimpose the pathological evidence to gain an insight into the condition and health of each group.

To deal with the ageing first, although only fragments with fused epiphyses were examined there will clearly be some continuum of relative age as dictated by the fusion sequence. Table 5.14 gives the data relating to the longbone fusion following the convention of Sumner-Smith (Sumner-Smith 1960), which is summarised below in Table 5.13.

Table 5.13
Dogs: Most common fusion sequence (Sumner–Smith 1960)

Element	Earliest time of fusion (wks)	Latest time unfused (wks)
Metacarpal	20	28
Metatarsal	20	28
Proximal ulna	20	32
Distal humerus	20	32
Proximal radius	20	32
Distal tibia	20	32
Distal femur	24	32
Distal radius	24	36
Proximal femur	24	36
Proximal tibia	24	44
Proximal humerus	40	40

Table 5.14
Dogs: Baldock assemblages: Epiphyseal fusion sequence by context

Context	Element															
	Uln P		Hum D		Rad P		Tib D		Fem D		Rad D		Fem P		Tib P		Hum P	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
18/9	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	1
18/10	-	-	2	2	-	-	2	2	1	2	-	-	-	-	-	1	-	1
18/12	5	4	7	7	6	5	6	2	6	3	5	3	4	2	5	1	3	3
18/12a	1	-	2	1	2	1	1	2	1	3	1	1	1	3	1	1	2	1
484/11	13	18	14	19	13	19	17	14	12	12	8	8	5	6	6	7	4	4
557/5	6	6	6	4	8	7	5	4	5	6	5	3	3	5	4	3	3	1
2254	2	2	1	1	1	2	-	1	1	-	1	2	1	-	-	1	1	1

With regard to the size structure of each group, the estimated shoulder heights have been calculated for each measurable longbone and metapodial. A "minimum number of individuals per stature level" has then been derived, and the probable elemental contributors set out in the tables which precede the pathological descriptions for each context.

The group is, perhaps, of sufficient size to warrant comparison with the period groups discussed earlier, and this is illustrated in Fig. 5.15.

The cranial dimensions of this Baldock material as a whole, as suggested by the morphology of the frontal bones, are produced in Figs. 5.16, 5.17 and 5.18 to compare with modern and other archaeological dogs. There is a noteable homogeneity and containment

of the relationships between each dimension. It is, of course, possible that some juvenile material may be included as it is often difficult to differentiate sub-adult and young adult cranial bone.

The pathology is described by context, with Well 18 described by layer. Each description is preceded by a table which summarises the lesions within the broad categories of age-related, inflammatory, traumatic and congenital. Tooth loss in all contexts is summarised in Table 5.27.

WELL 18 LAYER 9

No pathology was noted on the four bones from this layer. The distal humerus and proximal radius and ulna had been gnawed by dog.

WELL 18 LAYER 10

Table 5.15
Dogs: Baldock Well 18 layer 10: Estimated shoulder heights

Hum	Rad	Uln	Fem	Tib	Mc2	Mc3	Mc4	Mc5	Mt2	Mt3	Mt4	Mt5	$\bar{x}$
39.0						37.8	36.7	36.5	35.7				37.1
					51.6	52.3	51.4	51.3	52.6	53.0	50.7	50.3	51.7

Table 5.16
Dogs: Baldock Well 18 layer 10: Categories of pathological manifestations

Element	Site of lesion	Age-related	Inflammatory	Traumatic	Congenital
Vert L1	Spinous process		*	*	
Vert L2	Spinous process		*		
Vert L3	Spinous process		*		
Vert L7	Cranial	*			
Sacrum	Ventral		*		
Pelvis	Ilium, ischium		*		
Astragalus	Distal	*			
Astragalus	Distal	*			
Astragalus	Distal	*			
1st Phalanx	Distal	*			
1st Phalanx	Distal	*	*		
Mandible	M3				*
Mandible	M3				*
Mandible	P3			*	

Non-suppurative arthropathy

Manifestations are mild. Three astragali showed slight eburnation of the central distal trochlea, and one first phalanx exhibits articular

extension with remodelling of the distal articular surface. One distal tibia has fused with the distal fibula. A lumbar vertebra L7 has established lesions of spondylosis deformans which would have caused fusion with L6 (not recovered).

Inflammatory lesions

Three lumbar vertebrae, probably from the same individual as the L7 described above, exhibit lesions which are likely to be the result of post-traumatic inflammation. L1 and L3 have proliferative inflammatory lesions of the spinous process, and L2 has severe inflammation of the spinous process with gross enlargement posteriorly. It has been noted by Harris (1977) that animals with signs of previous bone trauma do show a higher incidence of spondylosis. However, the maturity of the ankylosis and the active appearance of the inflammation suggest that the onset of the spondylosis precedes the traumatic event, or may be concurrent if the post-traumatic inflammation is persistent.

A pelvis exhibits proliferation of reactive new bone at the crest of the right ilium, and also extensive bony proliferation at the dorsal ischiatic arch. There are bony extensions to right and left ischiatic spine. The dimensions of this pelvis suggest it may be of the same individual as the lumbar vertebrae discussed above.

There is an inflammatory lesion on the ventral part of the distal segment of a sacrum; this is from a smaller individual than that discussed so far. A first phalanx has an inflammatory lesion covering the distal diaphysis and epiphysis with eburnation of the medial distal trochlea.

Dental

Two articulating mandibular fragments show congenital absence of M3, and ante-mortem loss of both P2s with alveoli filled. Another larger articulating pair of mandibles had the left P3 broken above the line of the jawbone; all the teeth in this mandible were very worn. A small right mandible had lost P2 and the alveolus was filled.

WELL 18 LAYER 12

Table 5.17
Dogs: Baldock Well 18 layer 12: Estimated shoulder heights

Hum	Rad	Uln	Fem	Tib	Mc2	Mc3	Mc4	Mc5	Mt2	Mt3	Mt4	Mt5	$\bar{x}$
26.8		27.8		27.1									27.2
	28.7	29.5	28.9	29.0					31.3	31.7	31.0		30.0
31.1	31.8	31.2	33.1	30.9	34.1							32.2	32.1
					36.8	34.4	36.0						35.7
	45.6		46.6	45.1	45.6	45.2		45.3					45.6
	50.2			50.7				48.5					49.8

Table 5.18
Dogs: Baldock Well 18 layer 12: Categories of pathological manifestation

Element	Site of lesion	Age-related	Inflammatory	Traumatic	Congenital
Vert L	Spinous process			*	
Scapula	Lateral acromium		*		
Scapula	Dorsal glenoid			*	
Pelvis	Acetabulum	*			
Astragalus	Distal	*			
Radius	Diaphysis	*			*
Radius	Proximal	*			
Tibia	Distal	*			
Mcar2	Proximal		*		
Mtar3	Distal	*			
Mtar4	Proximal	*			
Mtar5	Proximal		*		
Mandible	P4, M1	*			
Mandible	P2			*	
	Condylar process		*		
Mandible	P3			*	
Cranium	Palatine process		*	*	
Cranium	P4	*			

Non-suppurative arthropathy

Again, these manifestations are mild. A third metatarsal has slight eburnation of the medial edge of the distal trochlea, and a fourth metatarsal has eburnation of the proximal portion of the facet on the proximal medial tuberosity (articulation with sesamoid bone). An astragalus has slight eburnation of the central distal trochlea and there is eburnation of the cranial lip of a right acetabulum. A radius has lipping of the medial edge of the proximal articular surface. A distal tibia and fibula have fused. A scapula has a circular depression in the dorsal portion of the glenoid, with another linear depression centrally. There is no indication of eburnation or reactive bone formation, and it is likely that these are due to an incompetence of the subchondral bone, originating either from a congenital defect or a minor stress. The dimensions of all these affected elements

indicate that they are from a small animal or animals, whose stature is unlikely to exceed about 30 cm.

Inflammatory lesions

A second metacarpal has periostitis proximo-anteriorly extending from the anterior margin of the proximal articular surface to mid-shaft. Medially, the shaft has been flattened and remodelled. A fifth metatarsal has an inflammatory lesion on the proximal epiphysis medially and anteriorly, and the medial portion of the proximal articular surface has been destroyed. Again, these metapodials will be derived from the smaller animals in the group.

An inflammation has occurred on the lateral edge of a scapular acromium. This animal is larger than those represented by the affected metapodials, and probably stood in excess of 40 cm.

Trauma

The spinous process of a lumbar vertebra has been displaced to the right without any indications of post-traumatic infection.

On a cranial fragment there is a partially healed fracture with reactive bone on the left palatine process of the maxilla, terminating caudally at the P3 alveolus. The length of the carnassial alveolus suggests that this fragment derives from one of the larger animals in the group.

Congenital

A radius is bowed, and the ossification and vascularisation of the ulnar scar suggest the animal was very mature. Its height, however, is at the lower end of the group, probably under 30 cm although precision in estimates is lower with congenital limb distortions.

Dental

A maxillary P4, and mandibular P4 and M1 were very worn, and a mandibular P3 had been broken off on the line of the jawbone. Another mandibular fragment had a P2 broken on the jawbone line with an infection of the medial extremity of the condylar process.

WELL 18 LAYER 12a

Table 5.19
Dogs: Baldock Well 18 layer 12a: Estimated shoulder heights

Hum	Rad	Uln	Fem	Tib	Mc2	Mc3	Mc4	Mc5	Mt2	Mt3	Mt4	Mt5	$\bar{x}$
	32.7		32.6 34.7	32.8			30.4				31.4	28.3	31.4 34.7

Table 5.20
Dogs: Baldock Well 18 layer 12a: Categories of pathological manifestation

Element	Site of lesion	Age-related	Inflammatory	Traumatic	Congenital
Mandible	P2			*	
	P4/M1		*		
Cranium	Caudal nasal			*	

The observable pathology from this layer is limited to two specimens. A mandible has the cranial root of P2 missing with the alveolus filled, and the caudal alveolus appearing normal. Buccally there is jawbone recession below P4/M1.

An almost complete cranium, of a slightly larger dog than the mandible described above, shows a healed depressed fracture of the whole of the caudal portion of the maxillae and nasal bones. The lesion is symmetrical and bilateral, and the depression has caused severe compression of the nasal conchae.

WELL 484 LAYER 11

Table 5.21
Dogs: Baldock Well 484 layer 11: Estimated shoulder heights

Hum	Rad	Uln	Fem	Tib	Mc2	Mc3	Mc4	Mc5	Mt2	Mt3	Mt4	Mt5	$\bar{x}$
					23.0					23.0			23.0
27.5	27.7	27.2		27.1	27.3	26.6	27.2	28.2	25.6	26.2	25.8	26.2	26.9
	29.4		28.9	29.0	30.6	30.1	29.8	28.4	28.4	29.1	30.0		29.4
	31.1			30.9	32.0	30.6	32.3	31.1		29.5		30.4	31.0
			33.1		33.1	33.9	33.5	32.0	32.0	33.6	33.1	34.1	33.2
34.5					33.7	34.2		33.6		34.4	34.1	34.1	34.1
	36.5				36.4		35.7	34.1	35.1	34.6		35.5	35.4
					37.5	36.8		35.3	36.0			36.4	36.4
					39.3			37.4					38.4
					45.9	46.0			43.9			42.5	44.6
			46.6	45.1	46.5	46.0		47.5	46.4	47.1	46.3	45.1	46.3
48.4	48.5			50.7	50.3			48.2	47.9			46.9	48.7

Table 5.22
Dogs: Baldock Well 484 layer 11: Categories of pathological manifestations

Element	Site of lesion	Age-related	Inflammatory	Traumatic	Congenital
Axis	Dens				*
Vert T3	Spinous process			*	
Vert T5	Caudal	*			
Vert T6	Postero-dorsal				*
Vert T7	Cranial & caudal	*			
Vert T8	Caudal	*			
Vert T12	Caudal	*			
Vert T13	Cranial	*		*	
Vert L1	Cranial	*		*	
Vert L2	Cranial	*			
Vert L3	Cranial	*			
Vert L6	Cranial	*			
Vert Ca	Caudal				*
Vert Ca	Cranial	*			
Vert T12	Caudal	*			
Astragalus	Distal	*			
Astragalus	Distal	*			
Radius	Diaphysis				*
Radius	Diaphysis				*
Radius	Diaphysis		*		
Radius	Distal	*			
Ulna	Distal			*	
Femur	Caput				*
Femur	Diaphysis		*	*	
Femur	Diaphysis		*	*	
Femur	Femoral neck				*
Tibia	Distal		*		
Tibia	Distal	*			
Mcar1	Proximal		*		
Mcar1	Proximal		*		
Mcar3	Proximal	*			
Mcar3	Diaphysis	*			
Mcar5	Proximal		*		
Mcar5	Distal	*			
Mcar5	Proximal		*		
Mcar5	Proximal		*		
Mcar5	Diaphysis		*		
Mtar3	Proximal		*		
Mtar3	Proximal		*		
Mtar5	Distal	*			
Metapod	Distal			*	
Metapod	Distal	*			
Metapod	Distal		*		
Metapod	Distal		*		
1st Phalanx	Distal	*			
1st Phalanx	Diaphysis		*		
1st Phalanx	Proximal	*			
1st Phalanx	Proximal	*		*	
1st Phalanx	Proximal	*			
2nd Phalanx	Distal	*			
Mandible	M1			*	
Cranium	Palate		*		

Non-suppurative arthropathy

Two astragali from two relatively small individuals have slight eburnation of the central distal trochlea. In the appendicular elements the arthropathic indications are confined to the metapodia and digits. They can all be considered early stage arthropathies - reactions to stresses without the development of clinical osteoarthritis.

A third metacarpal from a middle range dog has periarticular exostoses of the proximo-lateral facet. A fifth metacarpal from a smaller animal also has exostosis, this time associated with a swollen proximal epiphysis. Another fifth metacarpal which may well come from the same animal has eburnation of the distal sagittal ridge. A fifth metatarsal has exostosis and remodelling of the postero-lateral extremity.

A distal metapodial has slight lipping and early periarticular exostosis of the distal anterior facet. Periarticular exostoses also occurs in two proximal first phalanges and a second distal phalanx and another first phalanx has eburnation of the medial edge of the distal trochlea.

Nine vertebrae were recovered exhibiting degrees of periarticular exostoses, some with associated eburnation.

C7 Periarticular exostoses to cranial face laterally.

T5 Periarticular exostoses to caudal face laterally.

T7 Periarticular exostoses to cranial and caudal facies laterally and ventrally. Eburnation of central portion of both cranial and caudal facies.

T8 Established periarticular exostoses to caudal face ventrally with less mature exostoses laterally including rib facets. The cranial face has less mature osteophytes, mainly involving the rib facets.

T12 Established periarticular exostoses to caudal face, laterally and ventrally.

T13 Established periarticular exostoses to cranial and caudal facies ventrally.

L1 Established periarticular exostoses to cranial face ventrally.

L2 Established periarticular exostoses to cranial face, laterally and ventrally.

L6 Early periarticular exostoses to cranial face, laterally and ventrally.

Both T13 and L1 also exhibit fractures which are described under trauma.

Dimensional relationships suggests that these vertebrae may derive from one individual. The mode of growth of the osteophytes is compatible with the condition spondylosis deformans, and if one individual is involved the condition is visible from the lower cervical to the lower lumbar region, with the greatest advancement between the eighth thoracic and the mid-lumbar bodies. Adjacent vertebrae were found to articulate, but there was no evidence that the condition had progressed to the fusion stage at any intervertebral location.

A caudal vertebra has slight circumferential eburnation of the cranial face.

A distal tibia showed fusion with distal fibula, and a radius had developed an osteophyte on the postero-lateral aspect of the distal diaphysis. Both these elements were from the smallest identifiable dog in the group and the lesions confirm the animal's maturity.

Inflammatory lesions

Two bones, a distal tibia and a complete third metatarsal, from a very small animal or animals, had established infective lesions. The tibia exhibited periostitis of the distal posterior diaphysis with a 15 mm long lesion. The metatarsal had exostosis distal to and bordering the lateral groove with some resorption and remodelling of the proximal anterior face. The antero-proximal surface was finely pitted and probably indicates an infection initiated in the soft tissue of the tendon. Although it is only possible to give a rather broad approximation of shoulder height from metatarsals, it is likely that this animal or animals stood between 22 and 25 cm.

From taller dogs, but still under 35 cm, came an infected radius and two fifth metacarpals. The radius had three small areas of periostitis on the medial distal diaphysis. A metacarpal had osteomyelitis antero-laterally of the proximal diaphysis, and a post-mortem break had exposed the track of the draining sinus. The bone was swollen proximal to the mid-shaft in the latero-medial plane. The other

metacarpal also exhibited osteomyelitis of the mid-diaphysis with swelling laterally and posteriorly.

An animal which was probably in the middle size range has produced a femur with advanced osteomyelitis of the distal diaphysis. There are two draining sinuses posteriorly, and a large sinus anteriorly. All three sinuses interconnect. The medial and lateral condyles are splayed and the anterior articular surfaces are extended and remodelled. There is periarticular exostoses at the proximal margin of the trochlea.

A fifth metacarpal from a larger dog also exhibits osteomyelitis with a proliferative lesion proximo-laterally and the draining sinus anteriorly. The same dog, or another dog of similar size, has septic arthritis of the proximal articular surface of a third metatarsal. The articular surface is destroyed, and the anterior aspect has exostosis and a draining sinus.

Osteomyelitis was also found in two fragments of distal metapodia. In one the lesion extended proximally from the anterior mid-shaft with a draining sinus at the distal extremity of the lesion. In the other fragment the distal diaphysis was affected with swelling medially, laterally and posteriorly; the distal epiphysis had expanded and there was development of periarticular exostoses medially and laterally.

A second phalanx showed periostitis/osteomyelitis of the mid and distal diaphysis with thickening of the shaft particularly at the site of tendon insertion.

A cranial fragment exhibited a proliferative inflammatory lesion of the palate adjacent to P4, M1 and M2.

Trauma

Vertebrae T13 and L1 described under non-suppurative arthropathy had transverse fractures of the cranial facies, with the ventral portion of the facies depressed. These depressed portions were eburnated. There was no evidence of reactive bone at the fracture

margins. The lesions are consistent with compression fractures where the animal had some movement for a sufficient time after the trauma for the ventral facies to eburnate. The intervertebral discs were probably already incompetent as this is a common association with spondylosis deformans. The ventral osteophytes had been displaced.

A vertebra T6, from a different animal, has a curvature cranially of the dorsal part of the spinous process, and this is probably the result of a simple trauma which occurred in a young animal. A well-healed spiral fracture of the distal diaphysis of an ulna again probably occurred in a young dog.

An unreduced fracture of a proximal femur had healed with the proximal epiphysis displaced cranially. A posterior draining sinus indicates a post-traumatic osteomyelitis.

In the foot bones, a soft tissue ossification at the site of tendon insertion in a second metacarpal is probably the result of a severe sprain. A distal metapodial had a healed longitudinal fracture of the posterior sagittal ridge. A first phalanx with an expanded proximal epiphysis and extension of the proximal articular surface anteriorly has a partially healed fracture of the proximal subchondral bone medio-laterally.

Congenital

Two radii, probably from the same animal, were bowed, and one had a slightly flared distal epiphysis. It is considered that these come from an animal with congenitally bowed legs, but the presence of epiphyseal expansion may possibly suggest rickets. However, in this case it is likely that the manifestation would be bilateral.

Two femora, from different animals, presented congenital anomalies. One had an abnormality of the fovea causing it to be cresent-shaped and very deep cranially. The other had an elongated femoral neck, raising the head well above the level of the greater trochanter.

A vertebra T6 had no left posterior dorsal facet - this is a common congenital defect in dogs. A caudal vertebra had asymmetry of the cranial dorsal processes. Finally the dens of an axis was inclined dorsally.

Dental

A broken mandibular M1 with the caudal alveolus filled and the remaining cusp worn and discoloured.

WELL 557 LAYER 5

Table 5.23
Dogs: Baldock Well 557 layer 5: Estimated shoulder heights

Hum	Rad	Uln	Fem	Tib	Mc2	Mc3	Mc4	Mc5	Mt2	Mt3	Mt4	Mt5	$\bar{x}$
	29.4		30.4	30.2	28.7	28.2	28.7	27.8	28.0	28.2	28.0	28.7	28.8
			30.4			30.7	30.5		29.0	29.5	29.6	29.9	29.9
31.4			31.2					31.4				30.5	31.1
					37.0	37.3		37.3			37.6	38.5	37.5
	43.6		44.2			42.8		42.7	42.6	43.2	43.5	43.0	43.2
45.2			46.1		45.4	46.0		44.6		45.0			45.4
	52.7		53.7	49.0	51.2	51.7	51.1	51.4	50.2	50.4	48.9	49.4	50.9
			53.7	53.1							50.5		52.4

Table 5.24
Dogs: Baldock Well 557 layer 5: Categories of pathological manifestation

Element	Site of lesion	Age-related	Inflammatory	Traumatic	Congenital
Atlas	Right ala			*	
Vert C6	Cranial	*			
Vert C9	Spinous process		*	*	
Vert L2	Spinous process		*		
Sacrum	Auricular surface		*		
Scapula	Scapular neck		*		
Scapula	Glenoid			*	
Scapula	Glenoid	*			
Humerus	Distal		*		
Humerus	Proximal		*		
Radius	Diaphysis				*
Radius/ulna	Diaphysis			*	
Radius/ulna	Diaphysis			*	
Ulna	Distal	*			
Femur	Proximal	*			
Femur	Distal	*'			
Tibia	Diaphysis				*
Mcar2	Proximal	*			
Mcar2	Proximal		*		
Mcar2	Proximal		*		
Mcar3	Diaphysis	*			
Mcar3	Proximal		*		
Mcar3	Proximal	*			
Mcar5	Distal	*			
Mcar5	Proximal	*			
Metapod	Distal		*		
1st Phalanx	Proximal	*			
1st Phalanx	Proximal	*			
1st Phalanx	Proximal	*			
1st Phalanx	Distal		*	*	
2nd Phalanx	Proximal			*	
2nd Phalanx	Proximal			*	
Mandible	P2			*	
Mandible	P2			*	
Mandible	Buccal		*		
Mandible	Buccal		*		
Mandible	Buccal		*		
Mandible	P4/M1		*		
Cranium	Left frontal			*	
Cranium	Right maxilla M1		*		
Cranium	Left palate		*		
Cranium	M1		*		
	P2			*	
Cranium	M1		*		
Cranium	Right frontal			*	

Non-suppurative arthropathy

A femur of an animal standing between 46 and 48 cm had lipping of the femoral head and articular extension at the lateral border, with eburnation of the most dorsal point of the femoral head. A distal femur, possibly from the same animal, had lipping of the margins of the trochlear articular surfaces. An ulna of a dog of similar proportions showed exostoses at the distal medial border of the radio-ulnar articulation.

A sixth cervical vertebra of a middle or upper range dog exhibited lipping of the cranial articular processes, and a scapula, also from the middle or upper range, also had lipping of the articular margin and some articular extension.

Three middle range metapodials, two second and a third metacarpal, had periarticular exostoses proximally and anteriorly, the two second metacarpals also having evidence of inflammation extending into the proximal diaphyses.

From the smaller animals came a fifth metacarpal with periarticular exostosis proximally and distally.

Three first phalanges showed a similar combination of lesions - periarticular exostosis proximally with pitting at the sites of tendon insertion. A second phalanx was compressed and the proximal epiphysis was remodelled in the posterior-anterior plane.

Inflammatory lesions

A distal humerus from a medium-sized dog had proliferation and pitting between the lateral epicondyloid crest and the olecranon fossa, and a humerus from a small animal also had pitting of the bone surface, this time anterior of the teres major tuberosity.

A scapula from a middle range animal had periostitis of the medial scapular neck, and a sacrum of a larger dog had pitting of the auricular surface.

A second lumbar vertebra exhibited proliferation and pitting of the dorsal extremity of the spinous process - possibly an inflammation following trauma.

In the foot bones, a third metacarpal from a medium sized dog had lesions of osteomyelitis on the proximal epiphysis with a draining sinus anteriorly, and a further area of pitting on the proximal diaphysis. A distal metapodial had bony proliferation on the distal metaphysis medially and laterally.

A pair of articulating mandibular fragments had inflammatory lesions of the body between the canine alveolus and P2. Another mandible had a similar lesion extending on the buccal side from the post-mortem break at the canine alveolus to P4. In a further fragment the P4 and M1 alveoli were infected with resorption of bone bucally.

Cranial material produced a caudal right maxilla with pitting of the M1 alveolus and jawbone recession buccally, and a caudal left maxilla with pitting of the palate adjacent to the carnassial. A left maxilla had an inflammatory lesion of the M1 alveolus with recession of the jawbone, and a broken P2 with the caudal stump remaining. A right maxilla also had pitting of the M1 alveolus.

Trauma

There is severe traumatic injury to the foreleg of a large and a small dog. In the case of the larger animal there is a comminuted and unreduced fracture midshaft of the radius and ulna, with proliferative callus formation but not full union. The distal diaphyses are displaced posteriorly. The small dog has a comminuted fracture of the proximal diaphysis – again with proliferative callus formation but no union.

In the scapula, a medium-sized dog has fracture and detachment of the lateral edge of the articular surface with the commencement of callus formation.

The remaining lesions are in small animals, and concern at least two dogs. An atlas has the right ala extremity displaced dorsally. A ninth thoracic vertebra has a malalignment of the spinous process with pitting of the bone surface – this is probably a healed fracture with post-traumatic inflammation. A third and fifth metacarpal have soft tissue ossification mid and distal diaphysis, and the fifth metacarpal also has expansion of the proximal diaphysis and epiphysis. A first phalanx has a healed fracture with displacement medially of the distal epiphysis, and bony proliferation at the distal end with abscess formation.

In the cranial fragments was a left frontal with a traumatic lesion on the temporal line, caudal to the ectorbitale, which has produced an indentation. This is likely to be the result of a glancing blow. A fragment of a right frontal has a depressed fracture of the ectorbitale with a cyst on the orbital part of the frontal.

Congenital

A radius and tibia, possibly from the same medium-sized individual, were bowed.

Dental

Two articulating fragments of a notable shallow mandible had P2 broken in the jaw.

PIT 2254

Table 5.25
Dogs: Baldock Pit 2254: Estimated shoulder heights

Hum	Rad	Uln	Fem	Tib	Mc2	Mc3	Mc4	Mc5	Mt2	Mt3	Mt4	Mt5	$\bar{x}$
38.7	38.8	37.5		38.8	35.7	42.8							38.7
	47.0	45.7	47.2										46.6

Table 5.26
Dogs: Baldock Pit 2254: Categories of pathological manifestation

Element	Site of lesion	Age-related	Inflammatory	Traumatic	Congenital
Vert T	Caudal	*			
Vert T6	Caudal				*
Vert T7	Cranial				*
Mandible	P2			*	
Mandible	P2		*	*	
Mandible	P2				*
Cranium	Left canine		*	*	
	Right P2		*		
	Palatine		*	*	
Cranium	Parietal/temporal			*	

Non-suppurative arthropathy

A thoracic vertebra exhibited periarticular exostosis and lateral articular extension of the caudal costal facets.

Inflammatory lesions

Cranial material from the smaller dog showed bony proliferation in the medial alveolus of the left canine - possibly infection of the root following tooth breakage. The cranial alveolus of the right P2 also had an inflammatory lesion.

Trauma

The larger animal had a healed depressed fracture of the right parietal/temporal bones over the ventral portion of the parietal-temporal suture.

The smaller dog had a traumatic depression of the right palatine-maxillary suture at the cranial palatine foramen. There was partial healing, but pitting of the bone surface indicates that there was some post-traumatic inflammation.

Dental

The smaller animal had a mandibular P2 broken in the jaw, and P2 broken above the jawline with an inflammatory lesion in the alveolus.

The larger animal had a rotated mandibular P2.

Table 5.27
Dogs: Baldock contexts: Tooth Loss
Mandibular

Feature	Layer	R/L	C	P1	P2	P3	P4	M1	M2	M3
Well 18	10	R			*					
		R)			*					
		L)			*					
	12	R			*					
		L		*	*					
Well 484	11	L								*
		L				*				
		R			*					
		R		*					*	
Well 557	5	R)					*			
		L)					*			
		R		*						
		R				*				
		L								*
		L		*			*			

Maxillary

Feature	Layer	R/L	C	P1	P2	P3	P4	M1	M2
Well 18	12	L				*			

SUMMARY AND DISCUSSION

Congenital abnormalities in the Baldock dogs seem to be both minor and infrequent. There is at least one bow-legged individual in each well, and one of these is a very small dog under 30 cm. There is a case of absence of the third molar, and another where a vertebral dorsal facet is absent. These anomalies have been noted in other small dogs, both comparative and archaeological. There are certainly no features which occur with the regularity that might be ascribed to familial relationship.

The age-related conditions are predominantly represented by changes in the joints, and soft tissue ossifications at the site of ligament attachment. There are 61 lesions that fall into this group, and they occur in each well, but this includes nine vertebrae likely to derive from one small individual with the condition of spondylosis deformans. This is an arthropathy of the spine in which bony outgrowths develop around the vertebral bodies which can eventually fuse (see Chapter 4). This animal had reached the middle stage of the disease. Another well produced a vertebra from a larger dog in the latter

stages of the condition. Apart from these two individuals, the evidence is that animals of all sizes were developing bony changes due to maturity, but there were no instances of clinical osteoarthritis which would suggest the presence of elderly dogs.

Inflammatory lesions are less evenly distributed across the three wells. In one, there are severe lesions of lumbar vertebrae which may derive from the larger dog suffering from spondylosis deformans. The maturity of the spondylosis suggests that the infection is a later event, and the state of the spinous processes also suggests that the inflammation was a result of a post-traumatic infection. The only other infections observed in this well were a lesion on the sacrum of a small dog, mild lesions on the metapodia of at least two small dogs, and an infection on the scapula of a dog probably standing over 40 cm.

The second well produced mild lesions on the distal humerus and a scapula from dogs in the middle range, and another lumbar vertebra with a likely post-traumatic infection. And two infections of the metapodials, one of which is an osteomyelitis of the front paw.

The pattern of bone infection in the third well is different. Here at least five dogs present lesions of established osteomyelitis, and they come from all size ranges. The smallest was very small - between 22 and 25 cm. A large dog also had an advanced septic arthritis in a hind paw.

As for trauma, there were healed head injuries recovered from four dogs. One of these was remarkable in that a blow across the front of the head had resulted in the whole of the facial region of the animal being depressed, effectively turning it's head into a brachycephalic head. The animal had recovered from this without any evidence of infection. The other cranial trauma all involved the frontal and muzzle areas. Other healed fractures involved the vertebral spinous processes and the bones of the foot.

Two of the wells produced unhealed traumatic lesions. In one, a large and a small dog had suffered comminuted, unreduced and infected fractures of a foreleg. The proliferative callus formation shows that the injuries were sustained a matter of weeks before death. A medium sized animal had an injury to the shoulder which fractured the glenoid, and again the callus formation indicates survival for a short period.

The other well contained articulating vertebrae with lesions indicating that the animal suffered a broken back in the lower thoracic and higher lumbar region. This is the same small animal that suffered from spondylosis. The facies of the vertebrae are fractured transversely with the lower portion depressed, and these lower halves are eburnated which shows that the animal survived in some state long enough for the bones to move against each other. Because of the spondylosis the intervertebral discs may have been incompetent so this may not have taken very long. The nature of the lesions suggests that this is a compression fracture where the vertebrae are forced into each other and the spine buckles. In quadrupeds this is more likely to be caused by a collision than a blow.

What the pathology suggests is that the condition of the dogs may vary between the wells. Although each well appears to contain a similar number of adult, but not elderly dogs, of a similar range of sizes, one well in particular is notable for the number of dogs with an advanced, inflammatory and very painful condition. This is also the well with the preponderance of neonatal and perinatal pups (S. Hamilton-Dyer, pers. comm.). It is also one of the two wells containing animals which had suffered injuries with terminal consequences. The third well has less in the way of advanced bone infection but does have one dog with a condition that would have rendered it very slow and stiff, and two others which had already survived substantial head injuries.

In short, there is a case for saying that health and condition of these animals is poorer than might be expected considering the lack

of age-related anomalies. Certainly there are indications of some serious problems in the group. If this is so, then perhaps these deposits are a result of simple survival of the fittest. If the dogs died or were destroyed because of a catastrophic disease event, such as rabies, then one would not expect to see the recent trauma, unless of course those dogs survived a fall into a dry well and subsequently died from their injuries. That implies that the dogs were thrown in alive. This could explain the compression fracture and subsequent, highly anomalous, eburnation in the vertebrae, but there is little justification for such an interpretation. On the whole it seems more likely that dogs in poor condition, or with injuries, succumb to disease, starvation or exposure and their bodies are disposed of. This explanation could well account for the neonatal deaths. The apparent shortage of elderly dogs may simply be that few animals survived to old age in this population.

Finally, if these animals did die through such natural causes then we could have some confidence that the size range is reasonably representative for this site at this time. If these are rubbish dogs then they will be a concentration of the dog background mentioned at the beginning of this chapter - the disarticulated one per cent that are rarely measured. And this is perhaps where understanding of the species should lie, among the abused rather than the ritualised.

Fig. 5.1

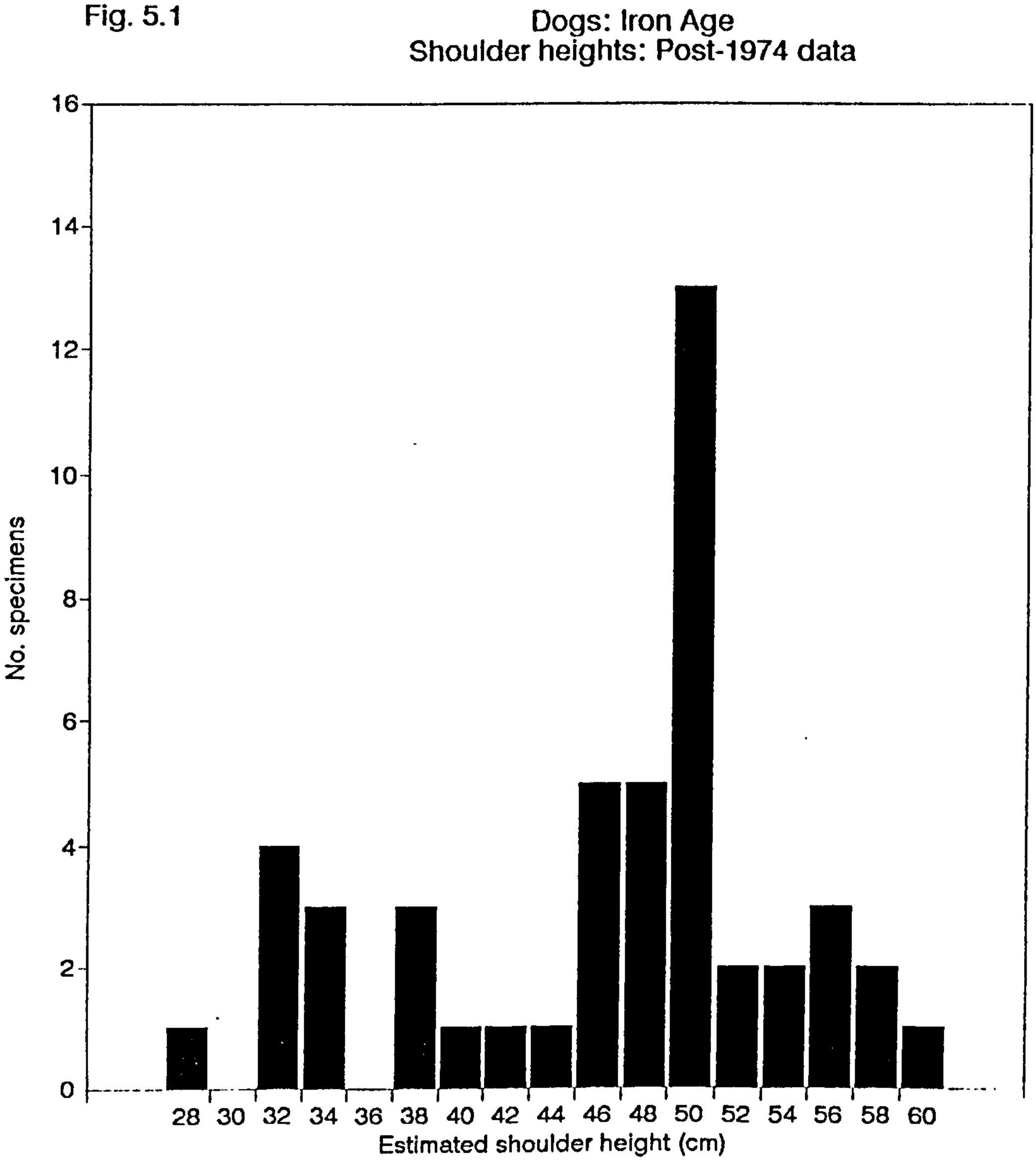

Dogs: Iron Age
Shoulder heights: Post-1974 data
No. specimens
0
2
4
6
8
10
12
14
16
28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60
Estimated shoulder height (cm)

Fig. 5.2

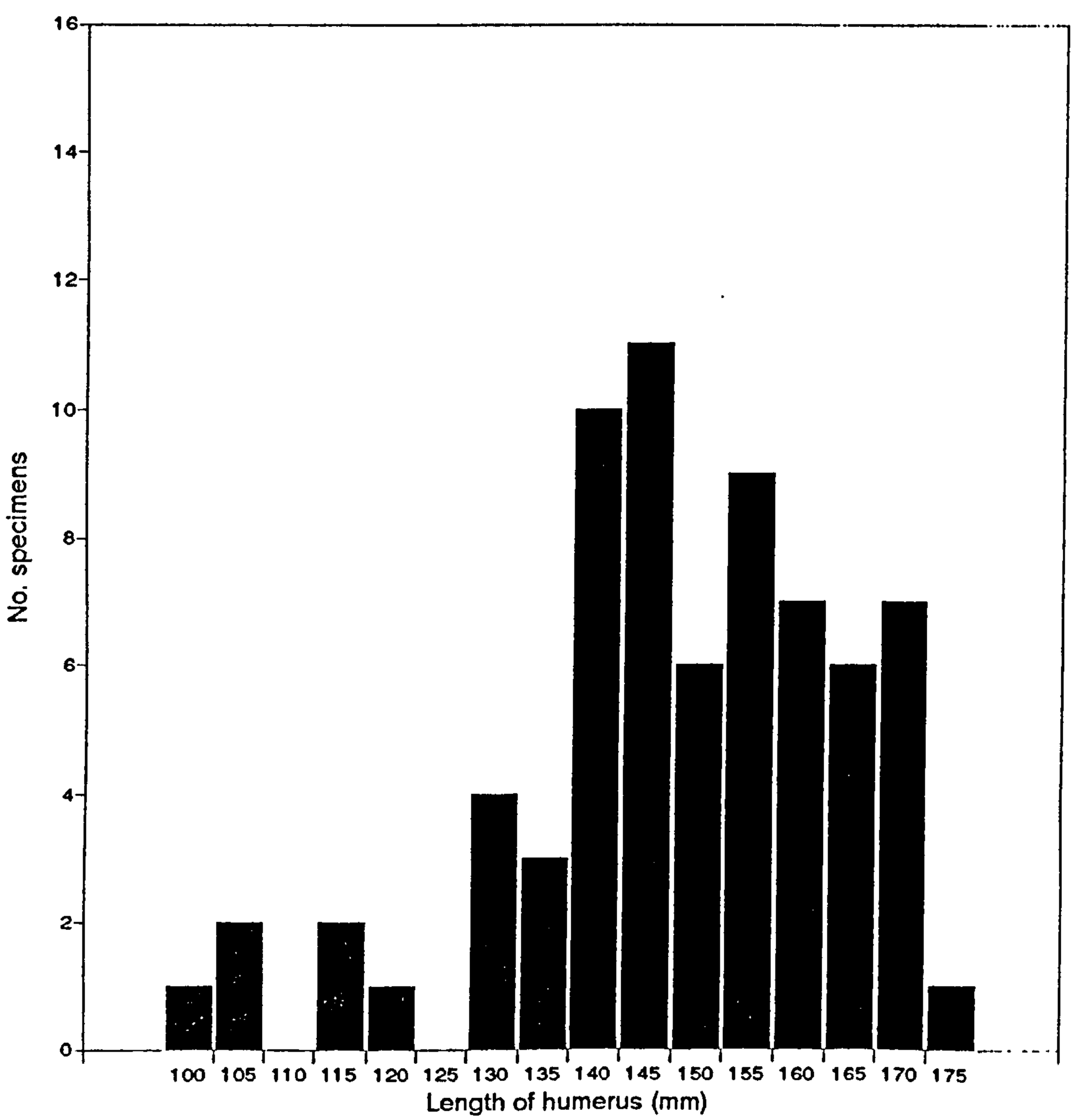

Dogs: Iron Age
Harcourt data
No. specimens
0
2
4
6
8
10
12
14
16
100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175
Length of humerus (mm)

Fig. 5.3

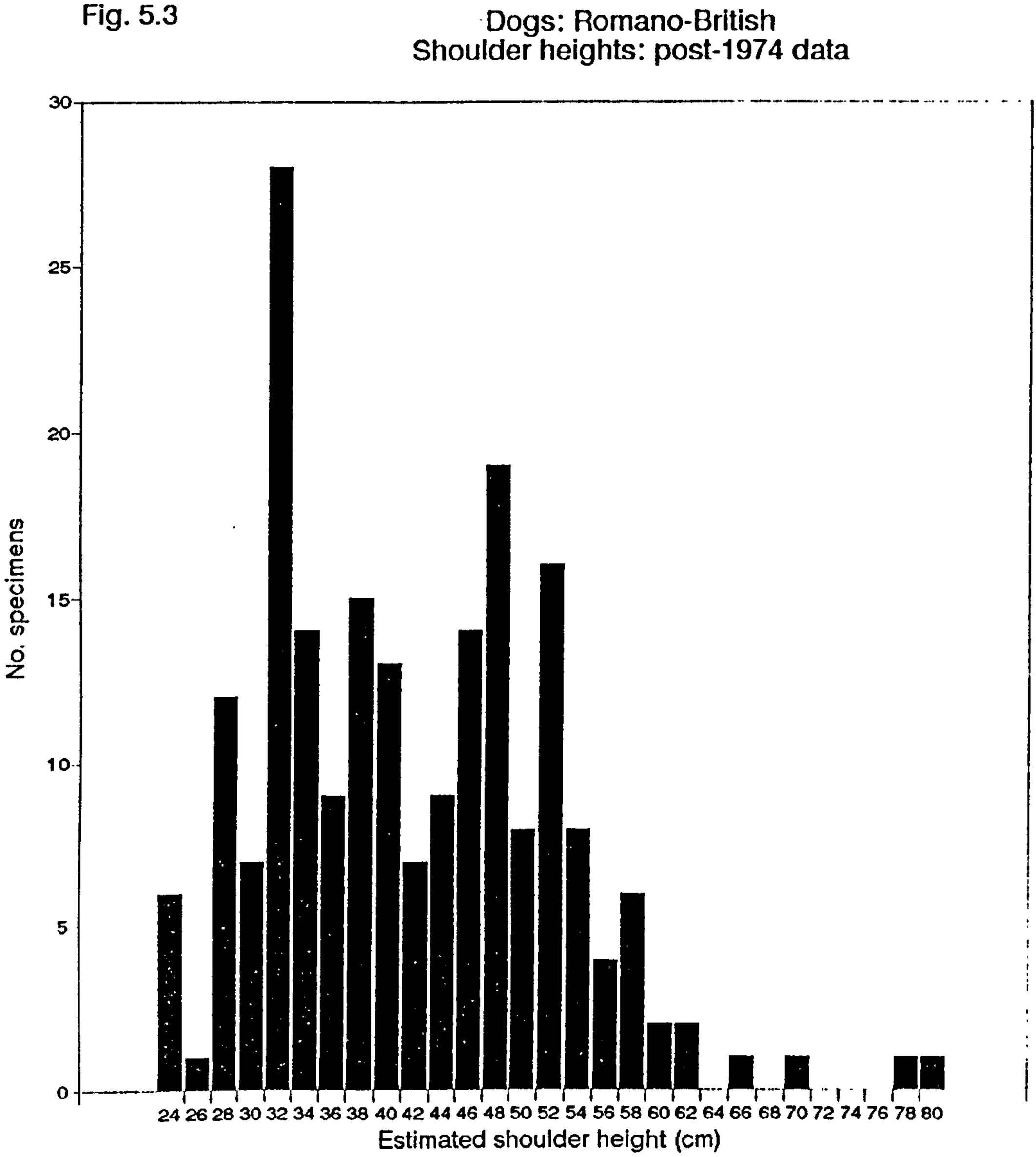

Dogs: Romano-British
Shoulder heights: post-1974 data
No. specimens
0
5
10
15
20
25
30
24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80
Estimated shoulder height (cm)

Fig. 5.4

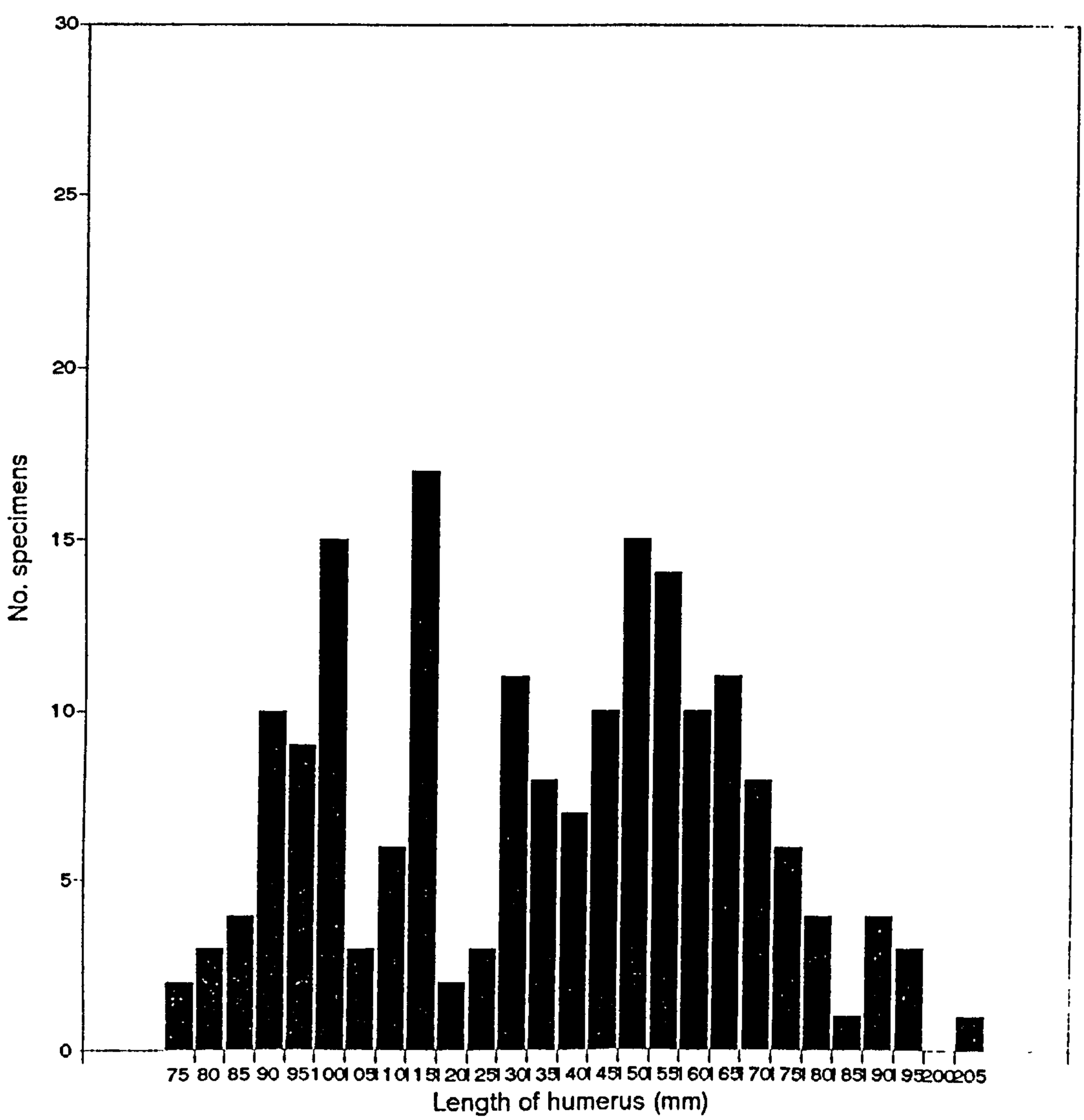

Dogs: Romano-British
Harcourt data
No. specimens
0
5
10
15
20
25
30
75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205
Length of humerus (mm)

Fig. 5.5

Dogs: Shoulder height categories
IA & R-B: post-1974 data

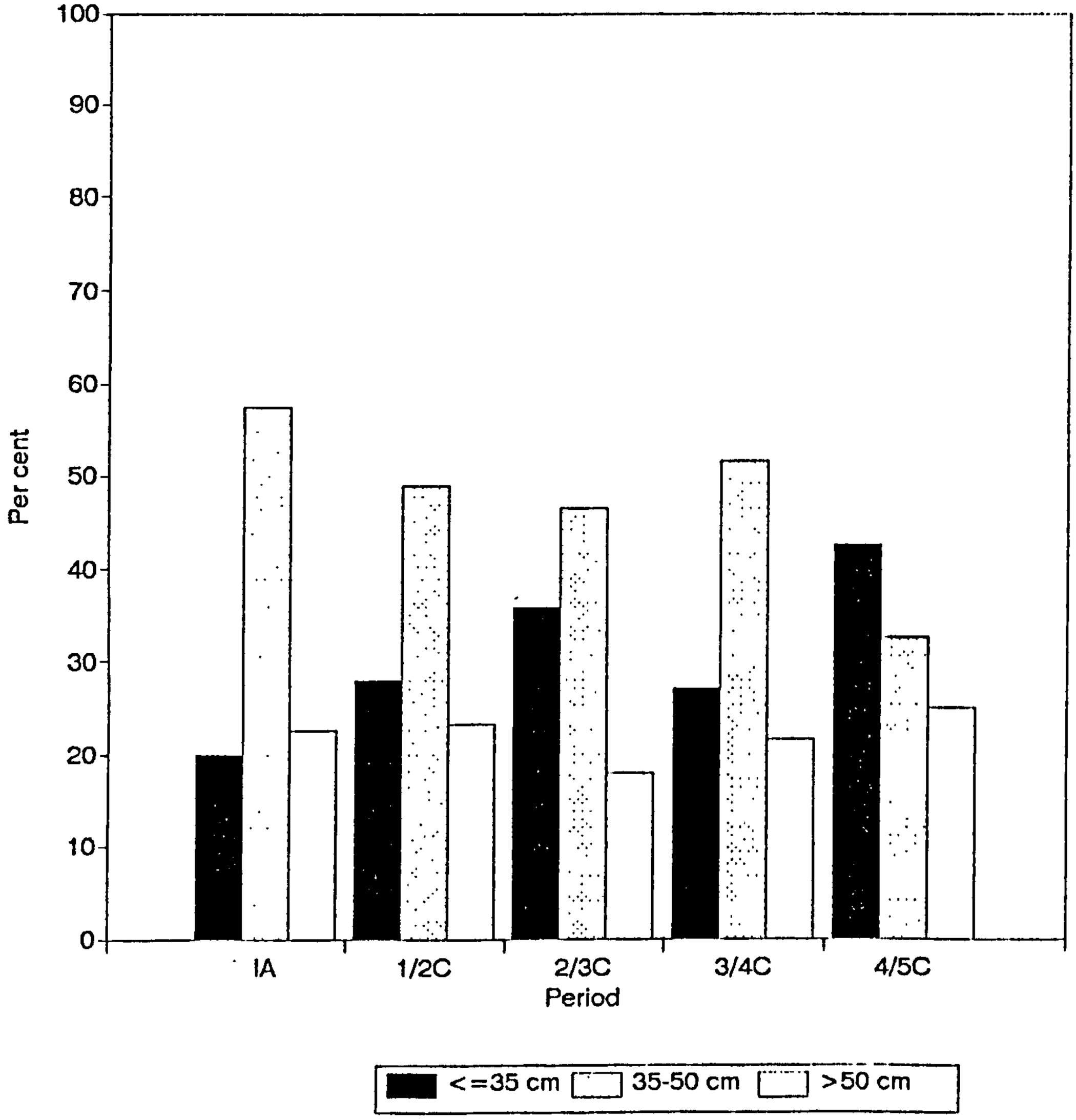


Fig. 5.6

Dogs: Shoulder height categories
Iron Age: post-1974 data

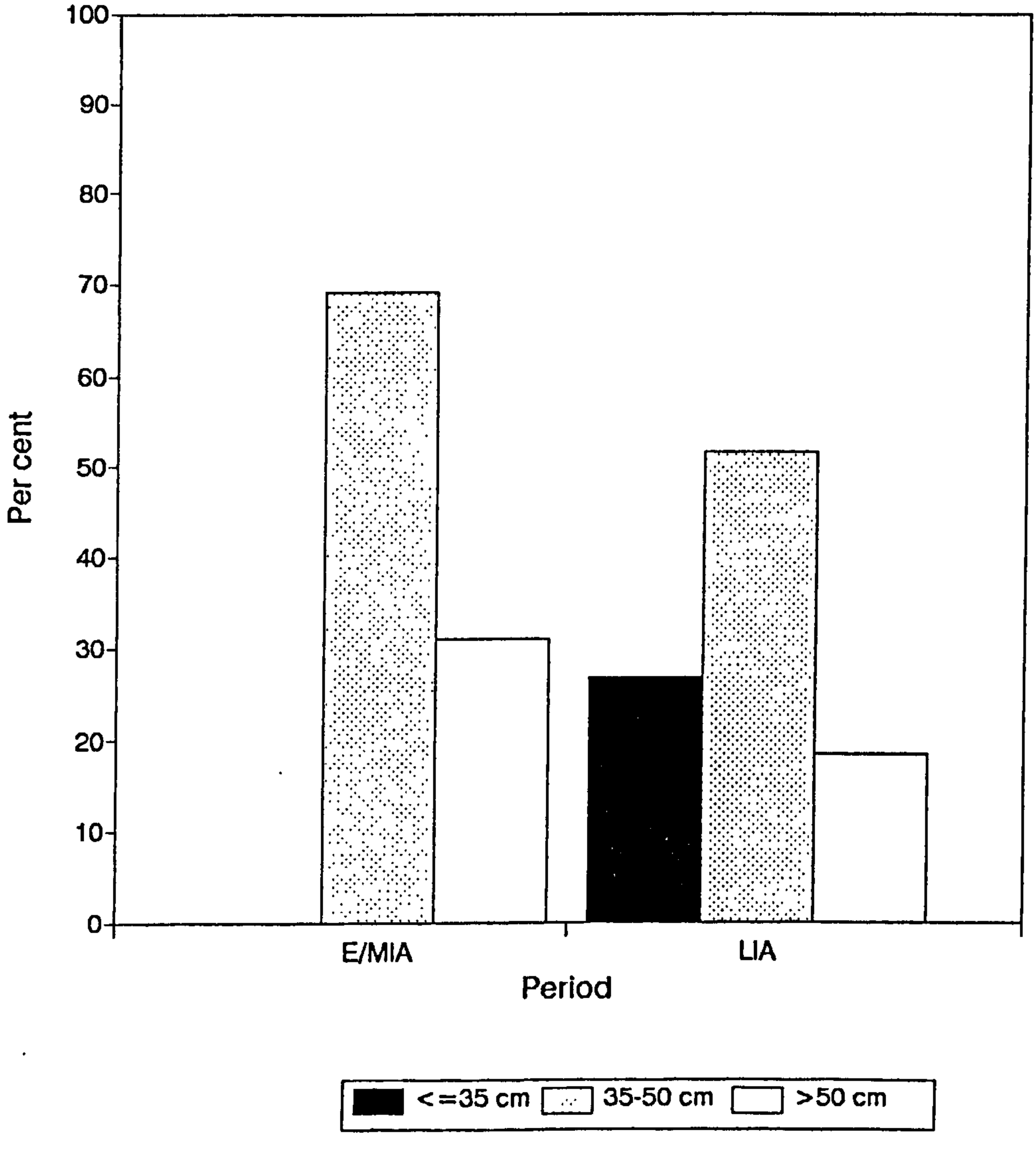


Fig. 5.7

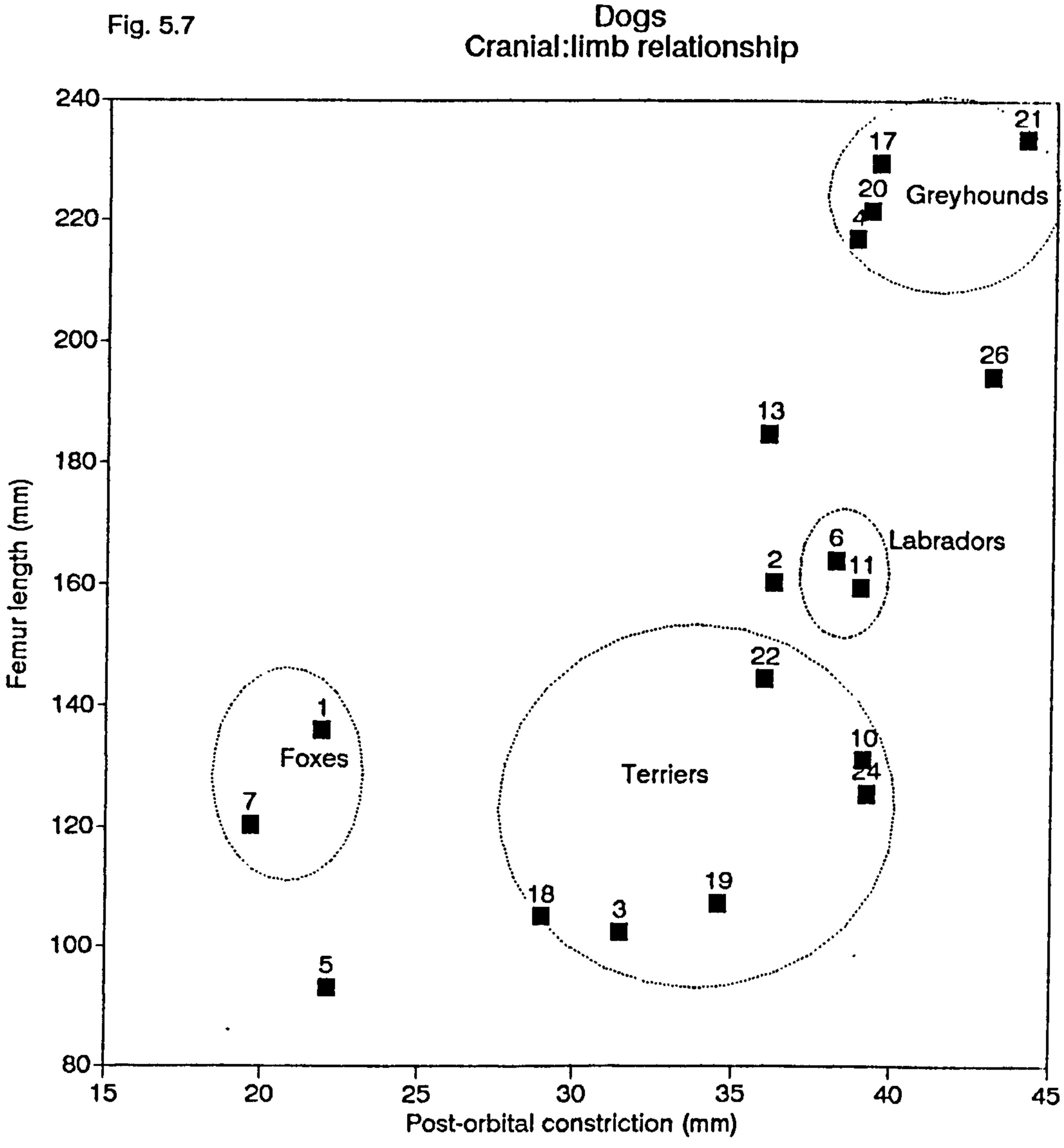

Dogs
Cranial:limb relationship
Femur length (mm)
Post-orbital constriction (mm)
240
220
200
180
160
140
120
100
80
15
20
25
30
35
40
45
Greyhounds
17
21
20
4
26
13
Labradors
6
11
2
22
Foxes
1
7
5
Terriers
10
24
18
3
19

Fig. 5.8

Dogs
Cranial dimensions: Ento- & ectorbitale

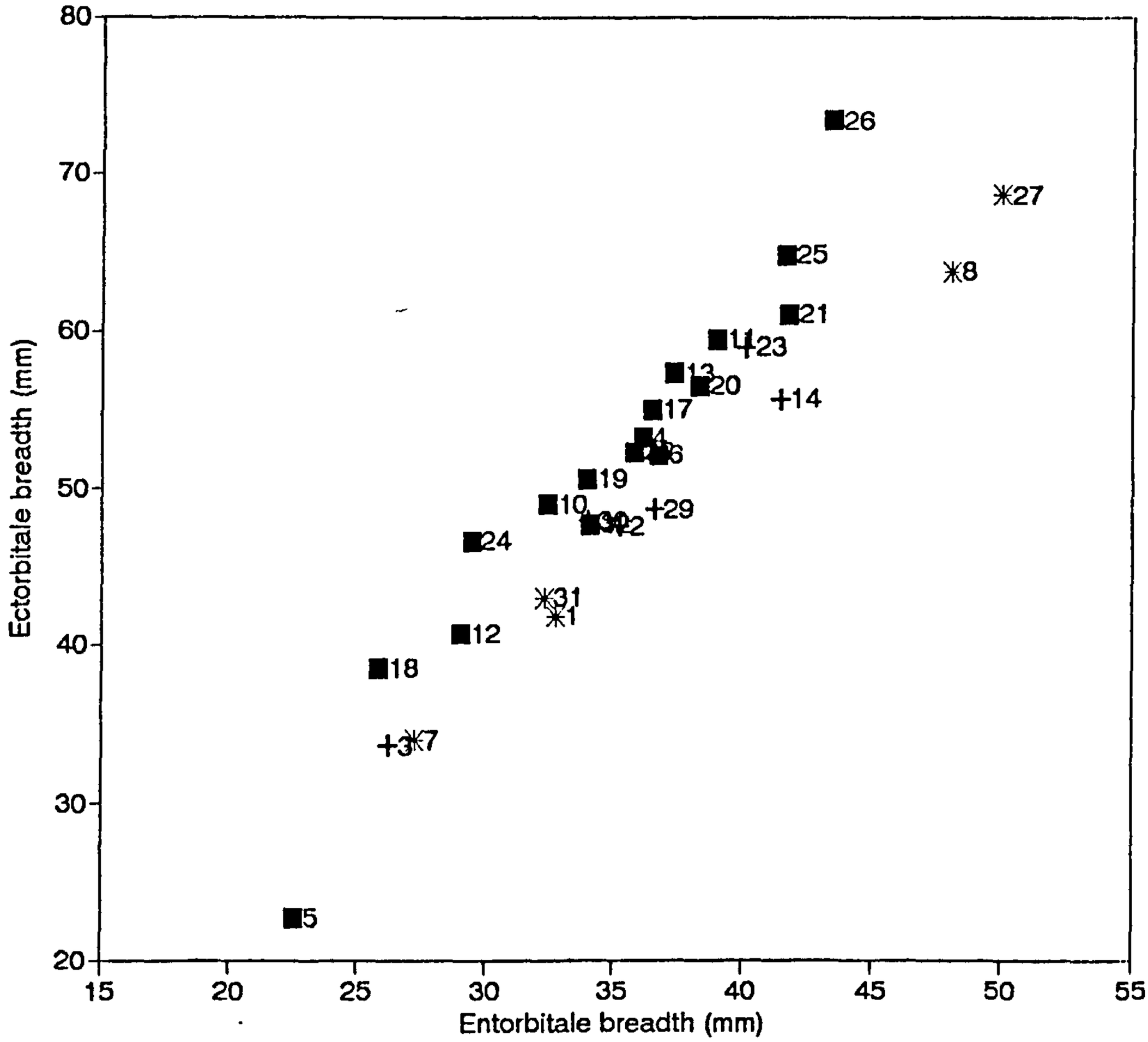


Fig. 5.9

Dogs: Cranial dimensions
Post-orbital & entorbitale breadth

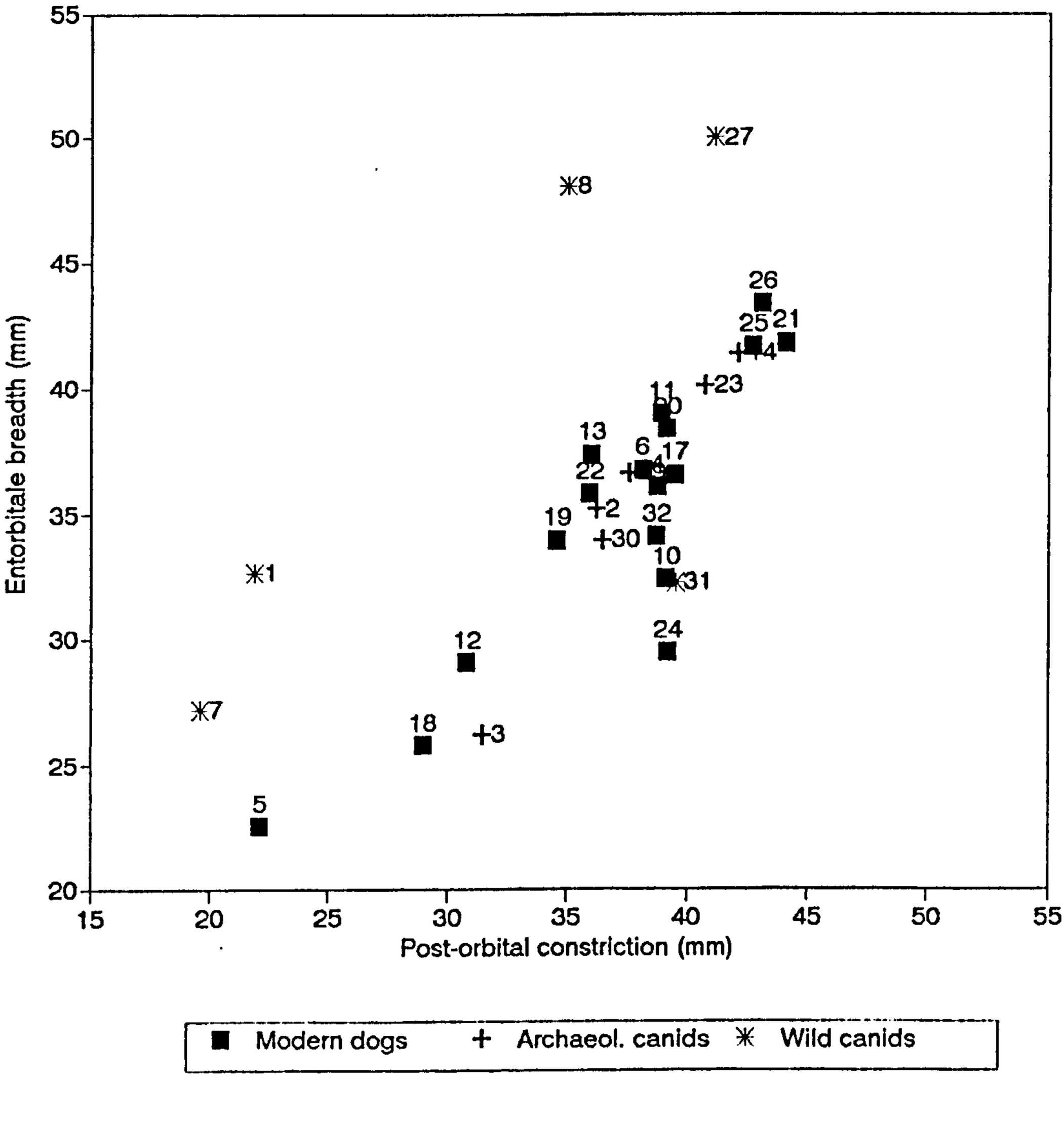
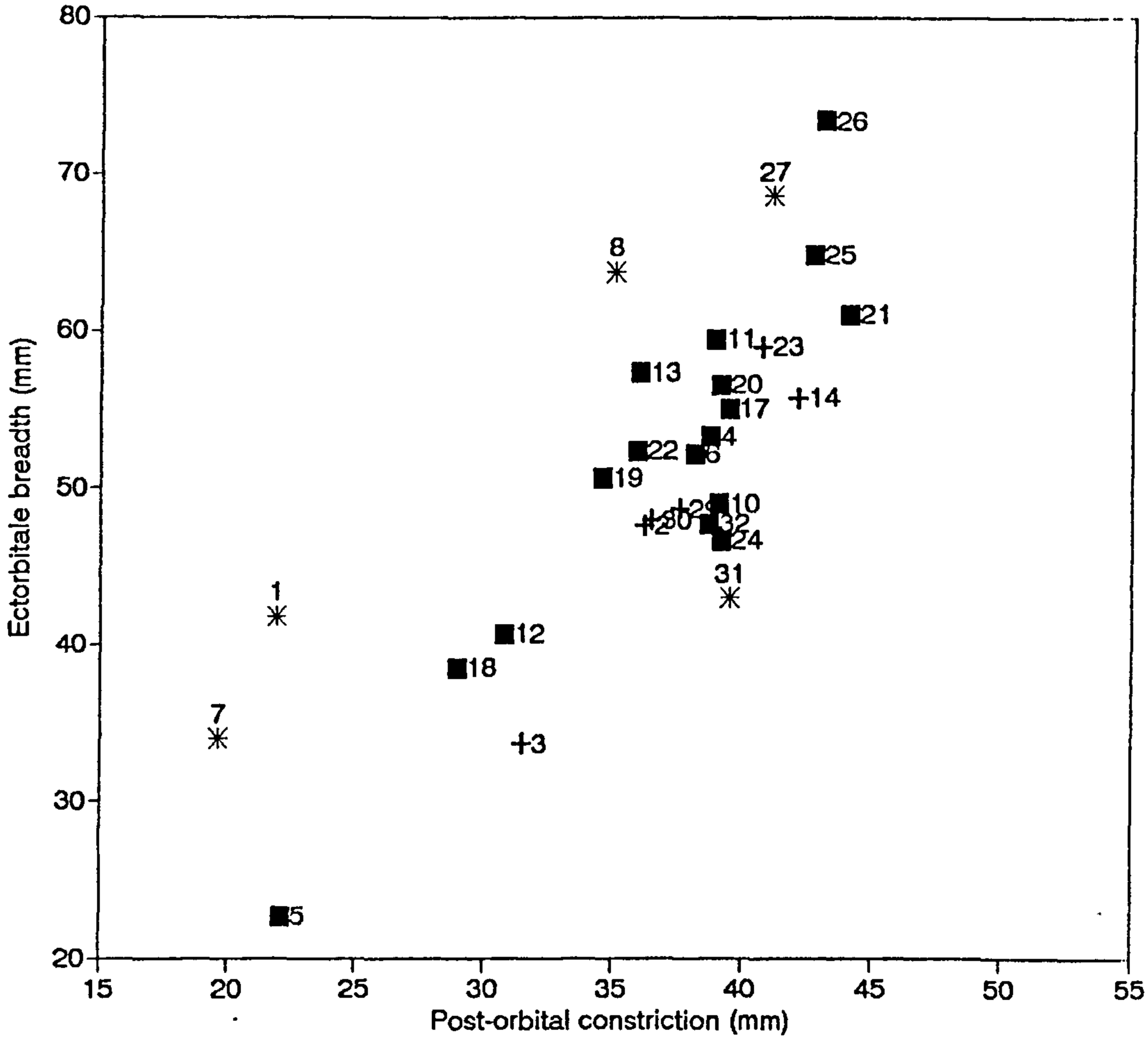


Fig. 5.10

Dogs: Cranial dimensions
Post-orbital and ectorbitale breadth



■ Modern dogs + Archaeol. canids ✳ Wild canids

Fig. 5.11
Stalnes Road Farm

Plan of skull and associated fragments: Context G14
(reproduced from site photographs SRFS 89 371/372 G14)

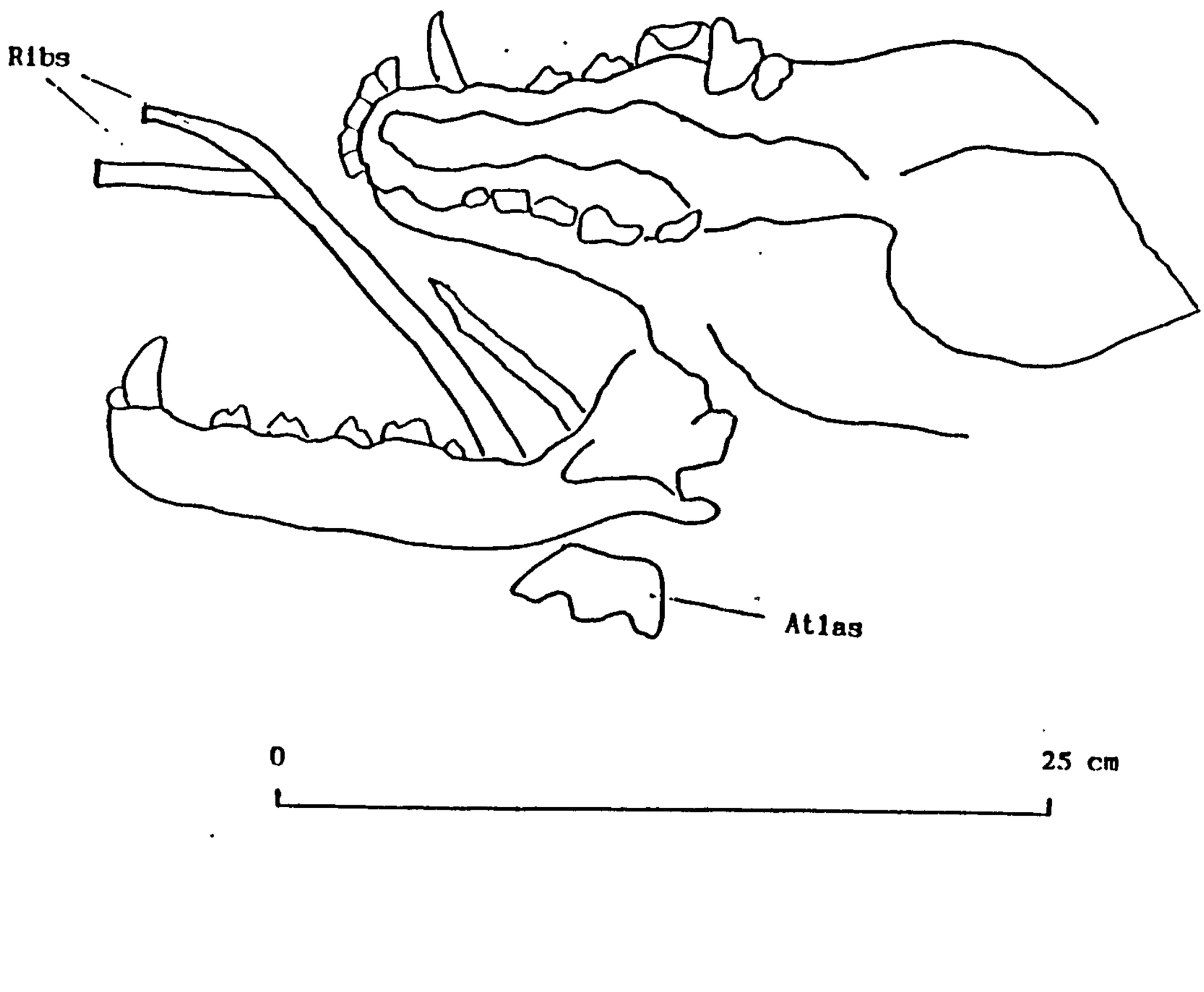


Fig. 5.12
Staines Road Farm

Cranium: Context G14
Dorsal view

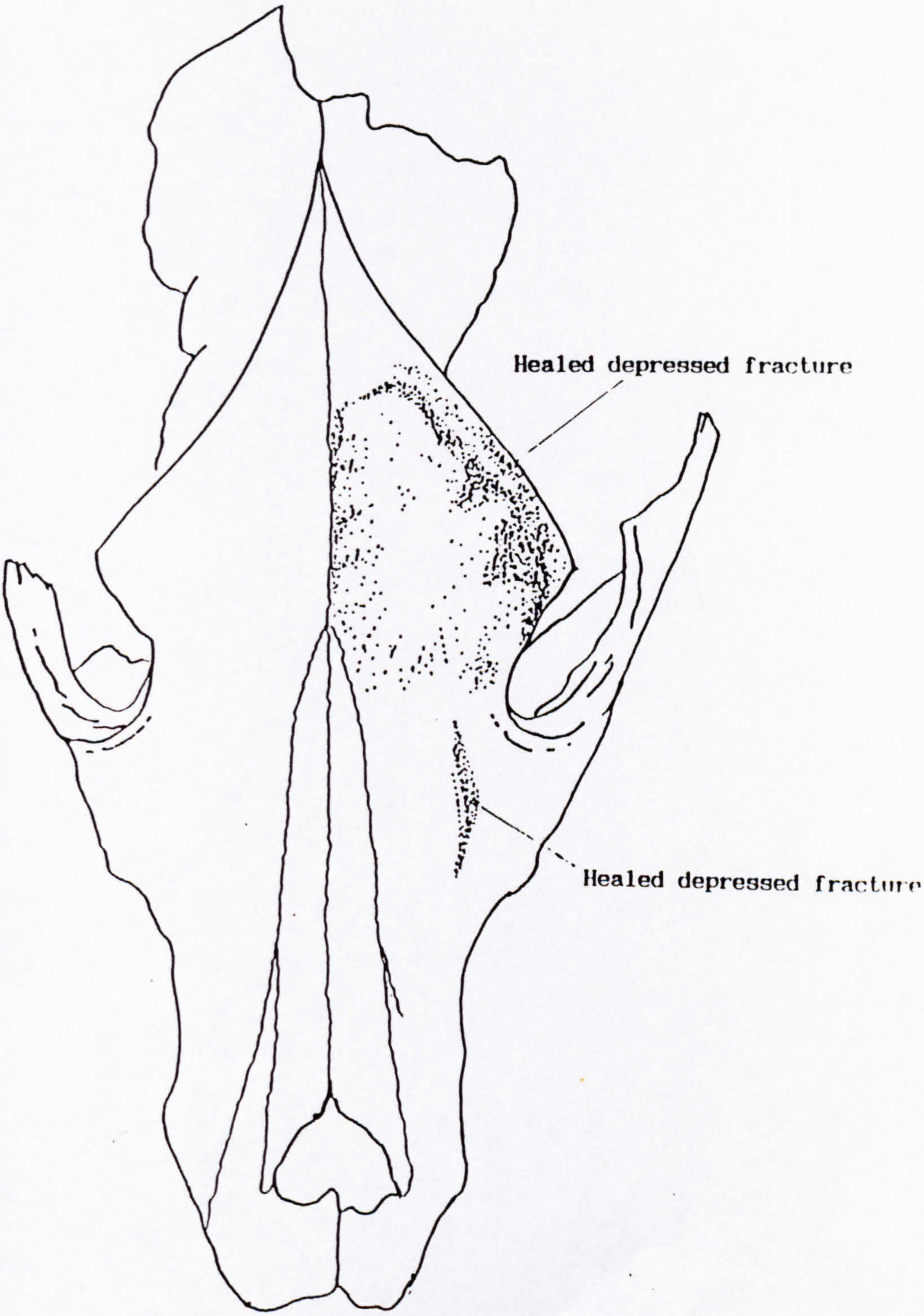


Fig. 5.13
Staines Road Farm

Cranium: Context G14
Ventral view

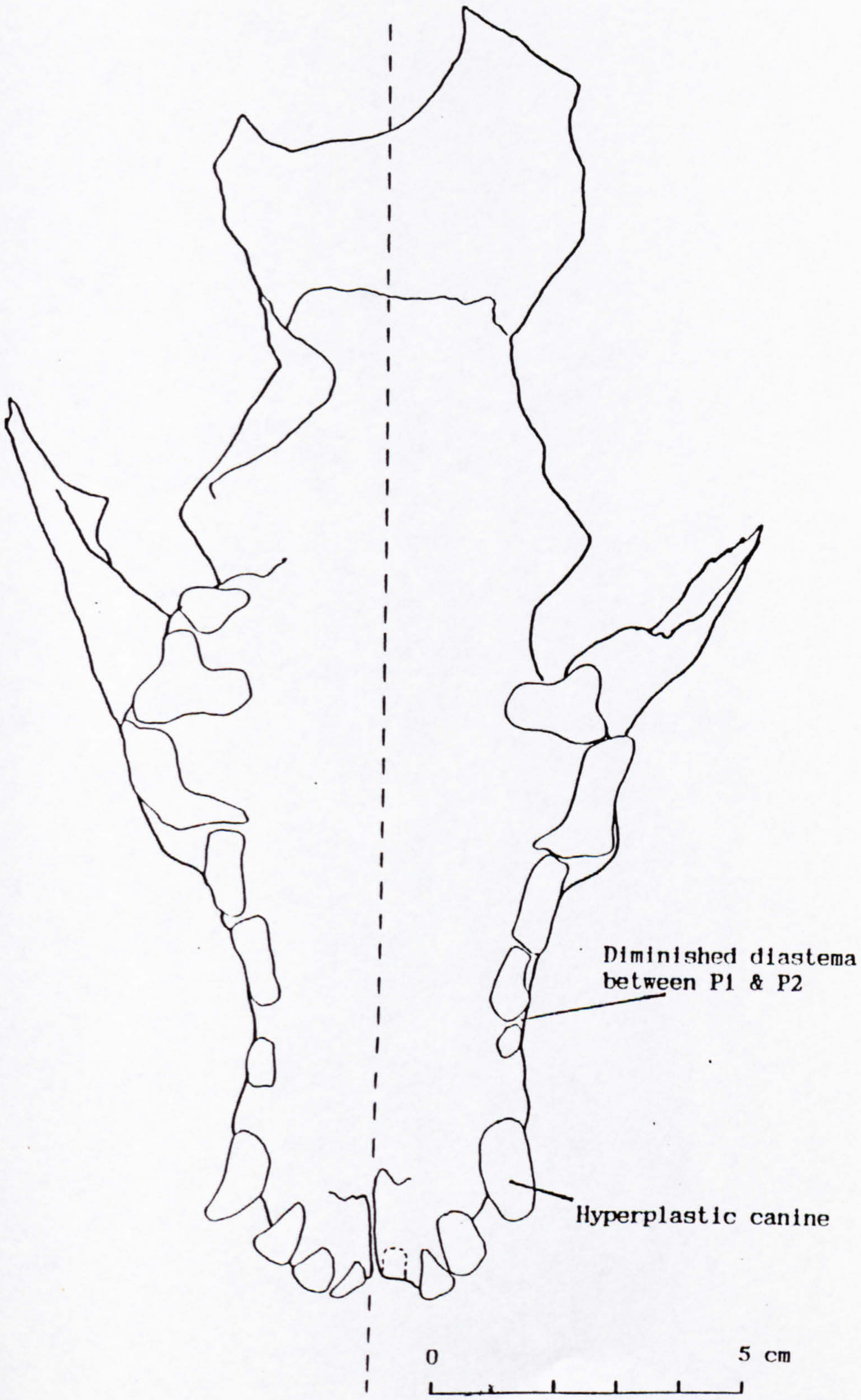


Fig. 5.14
Baldock: Iron Age dog buried in ditch

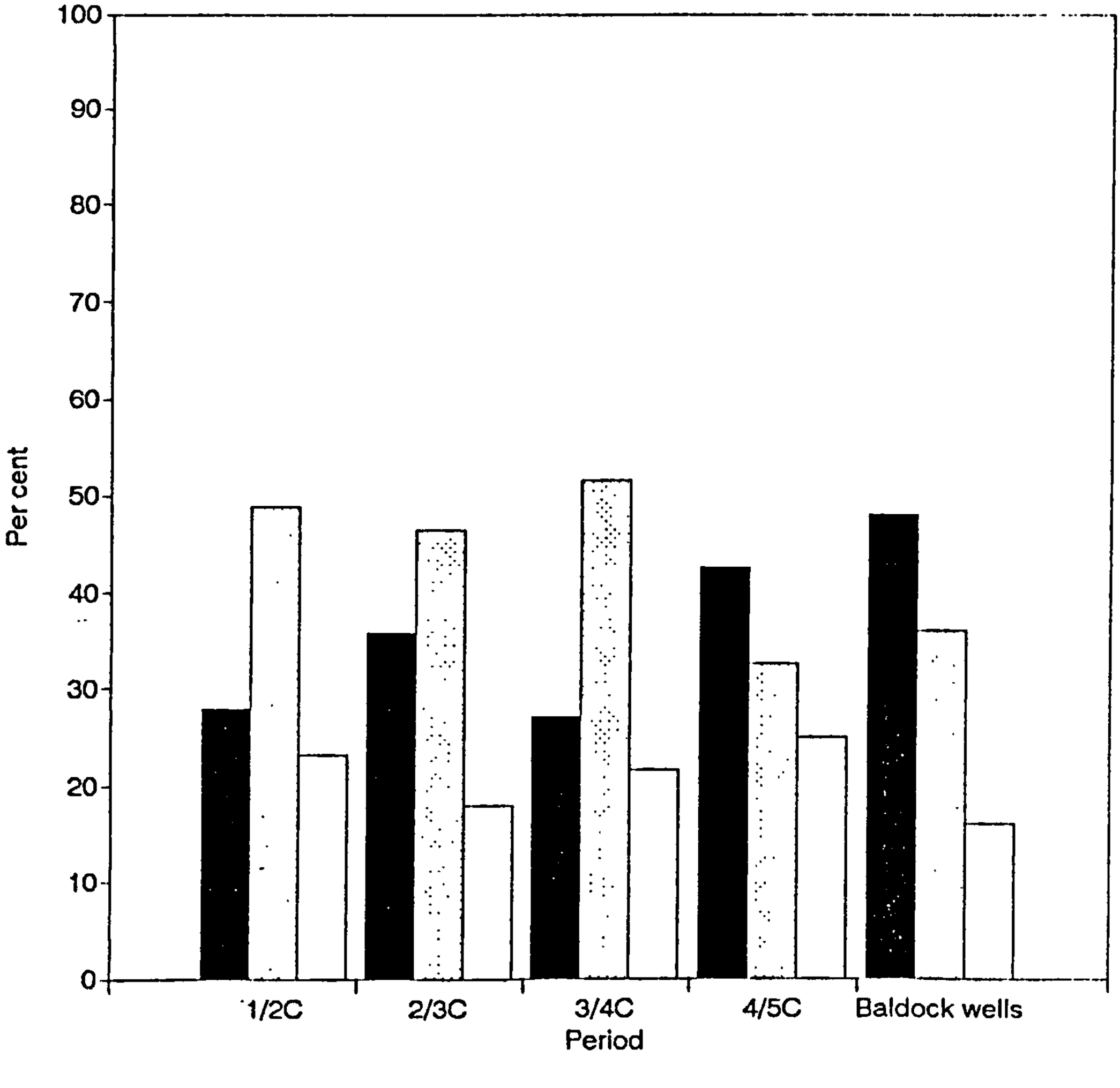
Cranium



Scale 1:1

Fig. 5.15

Dogs: Shoulder height categories
R-B post-1974 data & Baldock wells



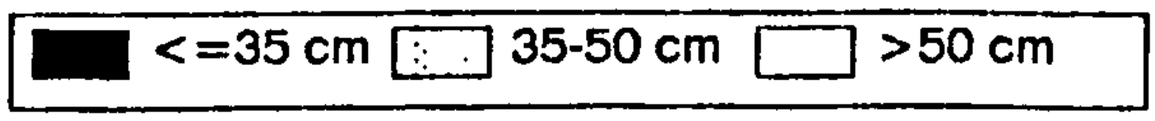


Fig. 5.16

Dogs: Cranial dimensions: Baldock
Ento- and ectorbitale breadth

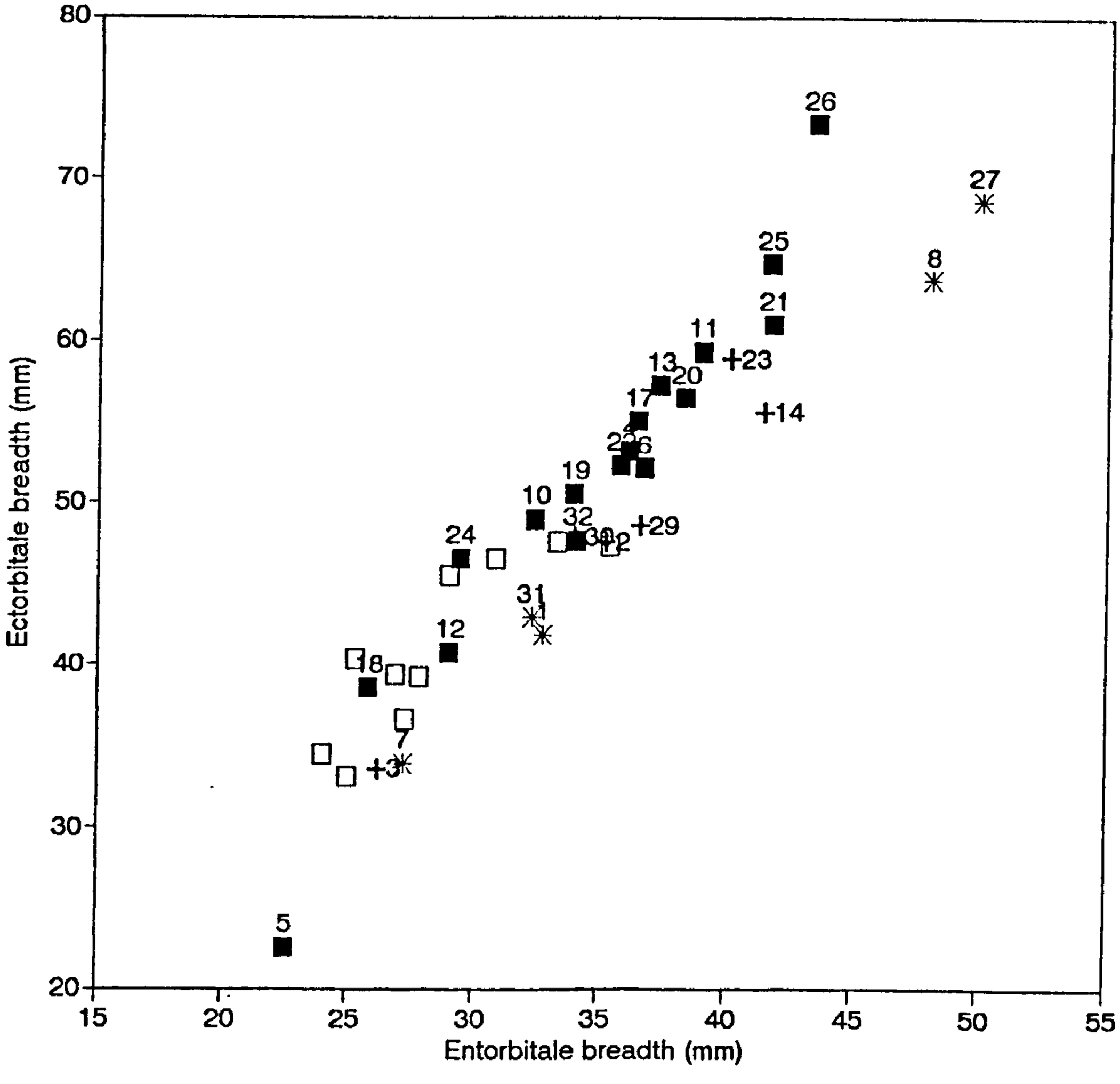


Fig. 5.17

Dogs: Cranial dimensions: Baldock
Post-orbital and entorbitale breadth

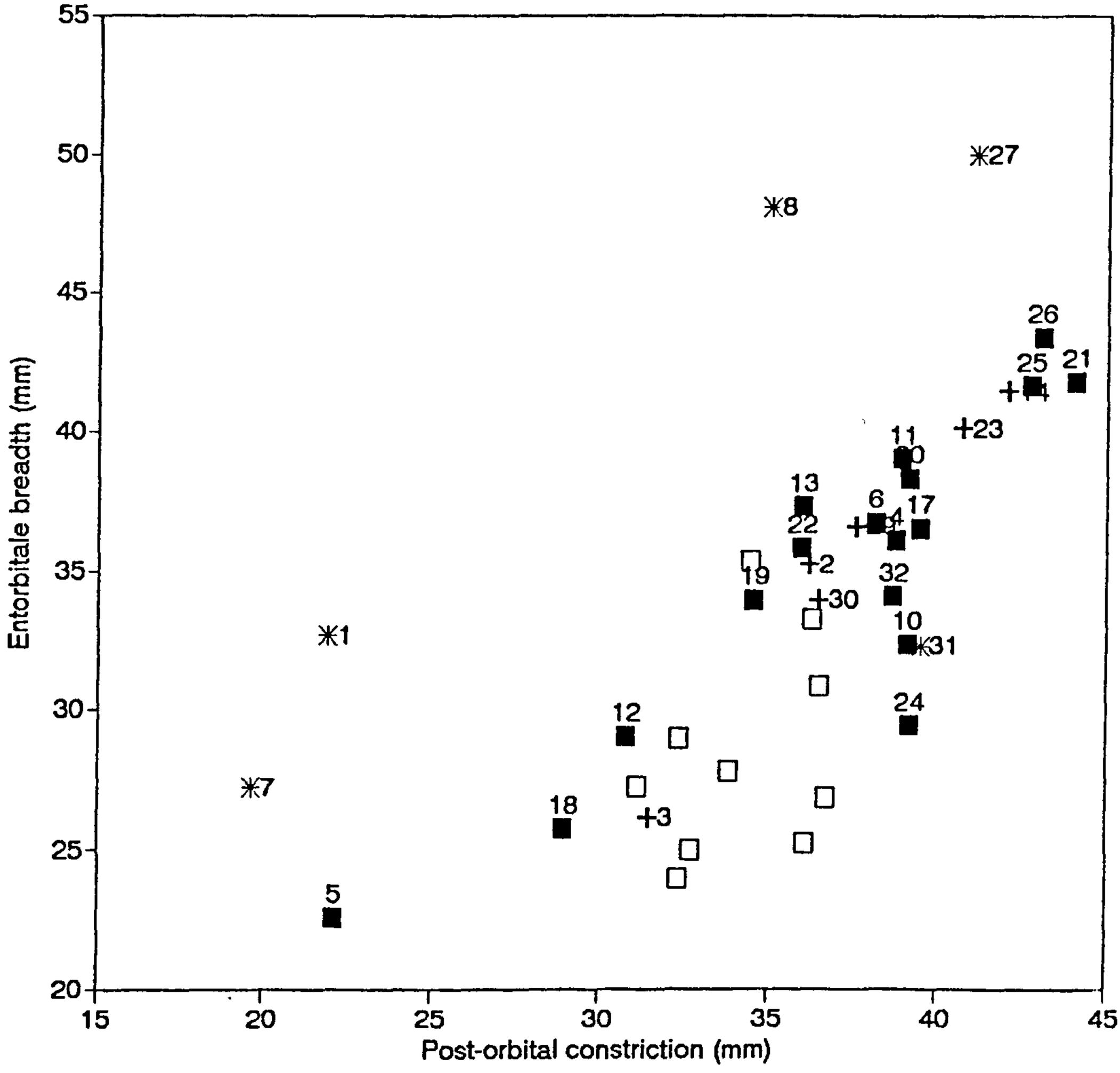
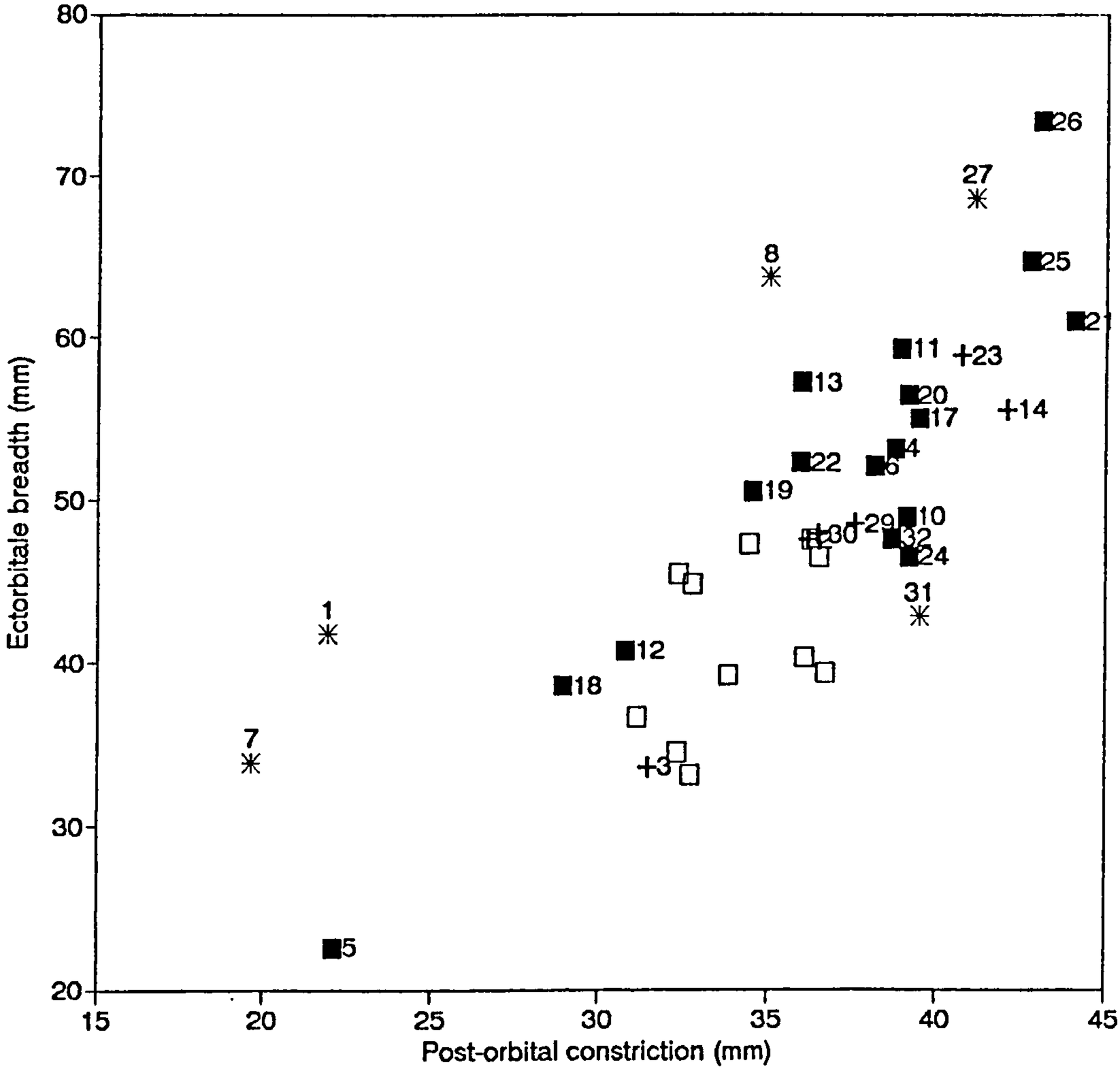


Fig. 5.18

Dogs: Cranial dimensions: Baldock
Post-orbital and ectorbitale breadth



■ Modern dogs + Archaeol. canids ✳ Wild canids □ Baldock wells

CHAPTER 6

NORTH RONALDSAY SHEEP - A CASE STUDY OF COMPARATIVE MATERIAL DRAWN FROM A POPULATION OF *OVIS ARIES* OCCUPYING TWO CONTRASTING ENVIRONMENTS

The major aim of this thesis is to suggest, demonstrate, hypothesise and test the validity of natural osteological reaction as a practical archaeological tool. As argued in previous chapters, presenting pathology as a visible and quantifiable variable is an essential prerequisite to the development and testing of hypotheses suggested by osteological abnormality. While the hypotheses may have a useful archaeological relevance, the main aim is to demonstrate the dynamic of pathology within groups. Assessing variation in terms of natural pathological load should lead to discussion of where human or environmental influences can be identified.

The collection of comparative material from North Ronaldsay was designed as an ethnographic exercise to define certain environmental and human factors in a sample of modern faunal material where the individual was invisible in the remains but the flock was observable in life. Again, the limbs were the subject of the analysis, and it is the relationship between joint morphology and variations in the environment which is the core of the study.

There are three primary factors operating in this study; joint conformation, management strategies, and the physical environment. If it is accepted that that two of the three factors considered here are constant - human intervention and joint morphology - can the contrast in the environmental parameter be invoked as an initiating stimulus to the pathological condition?

As a source of such material, the value of the native Orkney sheep as it now exists on North Ronaldsay lies in its genetic isolation and geographic definition. Primary requirements for this exercise are that skeletal material is deposited in the area of development of the live animal, and that the "background noise" of osteological variation reflects homogeneity of genetic influence.

The Orkney native sheep is a relic breed of an unimproved type and the indigenous group on North Ronaldsay is now the only surviving flock. This primitive, short-tailed (13 vertebrae, not the usual 20) sheep is related to the northern short-tailed group of breeds of Scandinavia, and is of the ancestral stock from which derived the modern Shetland breed. Its date of arrival in Orkney is not known, but the islands were under Norse rule from 875 to 1468, and Ryder (1983) considers that the breed shows Norse influence.

The oral tradition of the island

North Ronaldsay is acknowledged to have one of the weaker oral traditions of the Orkney group, and the lore relating to the sheep is somewhat vague. This may of course be intentional and such reticence will be familiar to those who have lived within isolated and diminishing communities. In this case, the reasons may be quite simple. The islanders have been subjected to a number of aggressive anthropological studies, and while archaeologists are welcomed, the people take delight in saying that they can sense an anthropologist's arrival in Kirkwall and thereafter exhibit an entertaining array of outlandish characteristics. Whilst every assistance possible was given me with collecting and understanding current evidence - be it stock, skeletons, buildings, crops, fishing, kelp, or method of local government - little was forthcoming in the way of anecdotal material about husbandry and land management. However, it is their general belief that the sheep dyke is contemporaneous with the Burrian broch and associated settlement, whose occupation has been ascertained to extend until about 800AD. The islanders consider themselves of Norse descent, but hold the opinion that the sheep were already on the island at the time of the Norse occupation. This of course would not preclude a Norse influence being visible today.

The particulars of the population

Whilst the breed is of great interest in its antiquity and its demonstration of primitive characteristics, it would be spurious to claim too much integrity for it as suitable comparanda for archaeological types. While there are no reservations that the flock

is a primitive (unmodified) relic (Ryder 1970, 1981; O'Connor 1982), there must be serious doubts as to whether it can be considered a primitive representative. The specialities of its diet and environment, and the consequent physiological adaptations that have been identified, render it highly location-specific. But for the task in hand - the study of joint variation with environmental contrasts - the peculiar and long-term constraints imposed on this sheep's lifestyle render its remains as eminently suitable source material and its antiquity is, in fact, irrelevant.

Documentary material relating to agricultural practices

North Ronaldsay is the most northerly island in the Orkney group (Fig. 6.1). It lies at latitude 59°22'N, longitude 2°24'W and is an irregularly shaped island of approximately 4.8km north to south and a maximum of 1.6km east to west. It is low lying, with a maximum elevation of 23m above sea level, and extends to approximately 984 hectares. One of its most significant features is the peripheral dry stone wall, some 2 metres high and of unknown origin, defining the boundary between shore and inland. It is the fact that the sheep are confined to the seaward side of this wall that forms the basis for the environmental definitions in this study. It is therefore necessary to put forward evidence concerning the length of time the sheep have been excluded in this way, and the degree of management they have been subjected to over that time.

The conditions pertaining at the end of the 18th century are apparent in the report of the Rev. W. Clouston in the Statistical Account for 1793.

> "The air is rather moist and raw which, by obstructing the perspiration, often occasions colds. The most prevailing distempers are colds, colics, cutaneous eruptions, scorbatic complaints, and rheumatisms, which last the people generally call the gout. All which probably proceed from cold and wet clothes. There are some instances of scrophula, or Kings Evil, and two or three persons afflicted with the white swelling. Fevers sometimes prevail; and when they seize one person in a house, they often affect the whole family. Relapses are frequent, as they are not at pains to wash the bedclothes when they have recovered."

And the differences between North Ronaldsay and Sanday, its nearest neighbour, are also commented upon:

> "The number of farmers in the Isle of North Ronaldsay is 44, and on Sanday 47. It must strike the attention of the reader that, in such a small isle as North Ronaldsay, there should be nearly an equal number of farms as in Sanday, although neither its extent or population is above a fourth part of the isle of Sanday. The largest farms in this county are in Sanday; and all North Ronaldsay is parcelled out in small farms."

The population records for 1791, those gathered by Clouston, put the inhabitants of North Ronaldsay at 420, a rise of 36 since the previous count in 1787. Sixty-four dwellings housed the community, which was equally divided between male and female. The livestock return records 249 horses, 256 horned cattle, 1900 sheep and 2 swine. The rather startling figure for horses is explained as follows:

> "It will appear there are a great number of horses, which must be kept for the purpose of carrying the sea ware, which they do by two wooden creels, which are square and ribbed, and one placed to each side of the horse, the bottom of which opens so as to let the ware upon the ground it is intended to manure. Oxen are used only for carts and few or none for ploughing."

("Sea ware" is the upcast seaweed, predominantly *Laminaria* spp.)

An indication is given that the quality of the livestock may be somewhat below that on which customary inventory value would have been determined:

> "The stock list has been collected from the several tenants, and the most intelligent farmers, with as much precision and accuracy as possible. But it may be necessary to observe that if any calculation should be made of the value of them, that to estimate the horses at £3 each, horned cattle great and small at £1 or £1.5s., and sheep at 2s 6d each is a high computation.
>
> Unlike Sanday, where the stocking belongs to the proprietor of the Island, on North Ronaldsay the stocking belongs entirely to the tenants."

The tillage supported by the cultivated land is described only

in very general terms. For both islands within the parish Clouston states that:

> "Sanday and North Ronaldsay produce bear, or big (barley) and small black oats, potatoes, cabbages, turnips, but no wheat or rye; of garden stuffs, onions, carrots, parsnip, and salad stuffs. There are no trees of any kind. Berry bushes may grow but do not succeed well."

For North Ronaldsay itself two-thirds of the arable land was sown with bear barley and one-third with oats. Each house had a small garden in which up to 1500 or 2000 cabbages would be grown, but no cabbage was grown in the fields. The economics were summed up fairly briefly:

> "They usually raise more grain than is sufficient for the inhabitants and also supply themselves with beef, pork, mutton and poultry. After paying 4½ or 5 chalders (a Scottish dry measure of about 6 imperial bushels) bear to Sir Thomas Dundas as Superior, and also to the proprietor some 13 chalders or more as rent, the farmers sell some bear and meal in small quantities, which cannot be ascertained, but is not considerable."

Clouston calculates the arable acreage of the island in 1791 as 344 acres from the number of ploughs recorded and a supposed acreage per plough of 8 or 9, which suggests the total number of ploughs at slightly less than 40 - so approaching one plough per farm. The North Ronaldsay plough is described as small and single-handed. If oxen are not used for ploughing then the requirement here for horses is reinforced. There is also the clear indication that cultivation, unlike the stock management consequent upon the sheep which is discussed later, is an individual and not a communal activity, although Clouston's observation that there are no wagons and only one cart may suggest that haulage was a community-based responsibility. And again, with oxen undertaking the draught work, the disparity between cattle and horse numbers is emphasised.

Sheep husbandry practices

There is no mention in the 1793 Statistical Account of the perimeter wall, nor indeed of any details of sheep husbandry. Research into

the 19th century literature has so far produced an earliest comment on the wall by Pringle in 1874:

> "The arable part of North Ronaldsay, or about three-quarters of its area, is enclosed by a high dyke, leaving a strip of waste ground all around, next the sea. To this strip the sheep of the island, which are of the small original breed, are confined, their food consisting chiefly of the seaweed which is drifted ashore in great quantities. These sheep are kept chiefly for their wool, which is very fine, but small in quantity."

Ryder (1983) comments that although the date of the wall is unknown, it was associated with strip cultivation and corresponded to the boundary wall of common hill grazing, to which the shore on North Ronaldsay is equivalent. It does certainly appear that the late 18th century livestock census figures are only compatible with the arable activities, or indeed with the potential of the island as a whole, if the foreshore is "livestock bearing". Assuming the adult bovid as one livestock unit, and the adult equid to be the same, it is reasonable to consider the native sheep to be 0.3 units, although this may be over-optimistic given that these sheep are the smallest in Britain. Thus, a very general calculation on the 1793 figures will indicate the required stocking level for the island. The cattle population is taken to be half adult, and the remainder as youngstock of varying age. For the horses, three-quarters are taken to be adult. As regards the sheep, the number of rams is taken to be the same as the number of farms at that date (44) and single lambing is assumed.

Cattle:	128 adult @ 1 unit	128
	64 yearlings @ 0.7 units	45
	64 youngstock @ 0.5 units	32
Horse	187 adult @ 1 unit	187
	31 yearlings @ 0.7 unit	22
	31 youngstock @ 0.5 units	16
Sheep	44 rams @ 0.3 unit	13
	928 ewes/wethers @ 0.3 unit	278
	750 lambs (say) @ 0.15 units	112

The total area of the island is 2431 acres of which 336 acres of rough pasture lie outside the sheep dyke. The enclosed area is thus 2095 acres, of which 334 were arable in 1791 leaving 1761 acres. If all the livestock were contained within the enclosed interior the stocking rate would approach 0.5 units per acre, a very doubtful situation in the absence of supplementary concentrates. If the sheep are confined to the outside of the dyke, the interior supports a more realistic stocking rate under unimproved conditions of 0.25 units per acre.

It is of course possible that some intermediate management strategy operated whereby the 336 acres of pasture outside the wall were available to stock other than just the sheep. Of the literature examined so far, the earliest reference to the exclusion of the sheep of 1874 coincides with the first observation that the native Orkney sheep occurs only in North Ronaldsay. Baikie's comments of 1824 relate to the husbandry of the breed throughout Orkney and express concern over the variability in condition according to the degree of attention flocks receive:

> "In some of the hilly islands of Orkney, they are permitted to roam about, a prey to dogs and eagles, and subject to the various distempers peculiar to sheep, deprived of the chance of any remedy being attempted; and in this wild and neglected state, the weight of the entire carcase seldom exceeds from 25–30 lbs. Their flesh is, besides, coarse and dry, and from their proneness to feed largely on seaweed, of a disagreeable flavour, which some people have, very inaptly, supposed to resemble that of venison.
>
> . . . The Orkney sheep meets with the best treatment in the smaller and flat islands, where they are constantly under the eye of their owners, who either keep them tethered, that is, fastened, on those parts of the island where the pasture is most suitable, or put them in adjacent uninhabited islands, called Holms, where when their number is properly limited, so as not to overstock the pasture, they seem to thrive better than in any other method at present in practice in Orkney."

It is interesting to compare these notes with those of Pringle, written half a century later:

> "The original breed of sheep in Orkney was the short-tailed breed common to Shetland and Norway. They were of various colours - white, black, brown, grey and spotted. They fed to 6lbs or 8lbs per quarter, the mutton being very delicate, although it had a blackish colour, and a somewhat peculiar flavour - relished by those who were accustomed to it - when the sheep were fed much upon seaweed, of which they were very fond. They wandered at large over the commons, no attempt at herding being made, except that each owner put his mark on his flock, the different marks being registered in the baron-bailie's book of the parish where the owner resided. These sheep were very wild, and it was only when it was necessary to shear them, or rather to have the wool pulled off, that the different lots pastured on a common were gathered together. There are now few of the original breed remaining except in the remote island of North Ronaldsay . . ."

where more general improvement measures had been attempted, albeit in the face of some opposition:

> "In 1832 Mr. Robert Scarth, factor to the proprietor, introduced a new system of land management into the island. These improvements were not effected without having to encounter much prejudice, and also have to overcome a great deal of awkwardness on the part of the people at the first start. Nor has the improvement been confined to the land, for it has extended also to the people, infusing an amount of energy into them which they did not possess under the old system, and leading them to materially improve their social position. The inhabitants are very primitive in their habits, and strongly attached to their native island, notwithstanding its remoteness and the little intercourse they have with other places."

The problems of imposing a greater degree of management on a somewhat uncooperative breed may have had some influence in its subsequent geographical contraction, as Baikie reports:

> "As winter herding is now beginning to be introduced into Orkney the practice of permitting the sheep to wander about during the winter months must soon necessarily have an end; and this hitherto much neglected, but useful animal, will probably be better fed and attended to than heretofore. The people, however, are generally averse to what they deem a hardship, and rather than submit to winter herding, they speak of entirely getting rid of the native breed of sheep, and substituting the Cheviot breed, which is found more tractable, and which some of the farmers already have accustomed to pasture with the cattle and to accompany them on their return to be housed

at night."

Pringle (1874) relates another, less successful, attempt at improvement at the beginning of that century:

> "Malcolm Laing, the historian of Scotland, attempted to improve the breed of sheep in Orkney by the introduction of Merinos to his property in Eday and Sanday. He began in 1808, and said that the wool of the Merino-Orkney cross was 300% more favourable than that of the original Orkney. The experiment however did not affect any permanent alteration in the character of the Orkney breed, and was finally abandoned. The Merinos were liable to foot rot although Mr. Laing's flock does not appear to have been so liable to that disease as Merinos in other parts of the kingdom. Nor did he find it necessary to have their feet encased in stout leather boots as Sir John Sinclair did when he introduced the breed into Caithness . . ."

By 1874 the virtual isolation of the breed on North Ronaldsay is reported by Farrall:

> "Until the beginning of this century there was only one breed of sheep on the islands . . . Some of the original type still exist in North Ronaldshay, like the stragglers of a vanishing race . . ."

The current sheep population

Although popularly referred to as feral, the sheep are owned by the crofters and used to keep to their own area of beach known as a clowgang. From 1790 onwards, until the second half of this century, the sheep population was controlled at around two thousand through the Sheep Court, a body of twelve elected sheep men acting on regulations laid down by the landlord. When the regulations were revised in 1902 they showed that each tenant - and by then there were 71 - was allowed to keep between 10 and 60 sheep on the shore, and that the sheep men were allowed to keep ten extra sheep for their trouble. The wall was the responsibility of the tenants - each had to repair a specified length and maintain it "to above leaping height". (Ryder 1983)

Although it is maintained by some local people that the clowgang system still exists and that in the main sheep remain in the areas of shore allocated to the croft of ownership, serious doubt has been cast on this assumption by Britt and Baker in their report on the health of the flock in 1986 (Britt & Baker 1990). However, and this is a key point in the ensuing analyses, the sheep are territorial in that they seem to respect strong, but to us invisible boundaries. How these boundaries relate to the original clowgangs (areas of foreshore traditionally associated with individual crofts) could not be tested in this exercise, nor has it been defined by other workers. The problem on the island now is that there are only seven crofters left, insufficient to carry out what have always been communal activities of wall maintenance, clipping and gathering for lambing, The sheep no longer have any economic value, and the major effort of the Sheep Court has to go into the preservation of the wall to keep the animals on the beach and away from the fields. Labour (Orkney County Council) and funding (EEC grants) have to be obtained for this.

This human/wall/sheep relationship is a fragile one, balanced entirely on the wall remaining constant regardless of the deficiencies on the human side of the equation.

Britt and Baker's report strongly urged a reduction in the flock number due to the very heavy parasite load and incidence of malnutrition. In 1989 and 1990 the flock was culled, primarily of aged sheep. It is now locally reckoned that the flock numbers about 3000, which represents a reduction of over 1000. However the steep decline in the human population in the last two generations means that the people to sheep ratio is seriously unbalanced, and flock management has, to all intents and purposes, been minimal for at least the last twenty-five years, although total abandonment has only occurred on the north-east peninsular.

The fieldwork

My fieldwork took place in May 1991 and 1992 when lambing was well in progress. It used to be customary for pregnant ewes to be brought in off the beach and tethered by one foreleg on grass to

lamb, being turned back on the shore after a few days. No ewe is supposed to raise twins. However the very large number of new born and twin lambs observed on the beach suggests that many ewes are not now being brought in to lamb. Lamb mortality seemed mainly due to exposure and gull attack. The number of lamb carcasses was not calculated, but the impression is that lamb mortality is high. The carcasses appeared to be mainly of lambs of a few days old, which lends support to the impression that much lambing now takes place on the beach.

A relevant qualitative observation is that in six circuits of the island only two lame sheep were seen. This is in accordance with Baker's notes that the flock has exceptionally healthy feet.

> "Hair on the knees of many of the sheep was worn away so that the skin on the anterior aspect of the carpal joints was bald. This appears to be due to abrasion caused by kneeling to feed. It was of no clinical significance except in one case where the skin was also severely abraded and an infection of the underlying tissue had developed. Some grassland sheep adopt a habit of kneeling to graze because of pain from diseased or traumatised feet, but the North Ronaldsay flock have exceptionally healthy feet, only one case of overgrown walls and one of excessive wear was seen." (Britt & Baker 1990)

Spatial definition of sample collection

The bone sample was collected on a geographical and topographical basis and the collection areas are shown on Fig. 6.2. Area boundaries may in some cases correspond to the traditional clowgangs but the collection sectors were not designed to conform to these alone. The main aim was rather to get the best delineation between rock and sand foreshore while at the same time avoiding spatial population contamination. There are two major sources of possible contamination. Firstly, an area boundary which can be defined geographically, such as a bay, may have little relevance to the perambulatory activities of the sheep.

Secondly, an unknown but probably considerable number of carcases are carried offshore and fetch up some time later at a point

determined by the strength and direction of the tide. Local advice was taken on both these points, and the collection areas selected are believed to represent sites of occupation, death and deposition of the resident portion of the flock.

The north-west coast of the island, that is areas 5, 2, 1 and 7 on Fig. 6.2, is predominantly exposed rock with extensive deposits of *laminaria* spp. This is the seaweed that constitutes the largest part of the sheep diet. *Laminaria digitata* is the most common, and the sheep eat both the fronds and the stape (stem) cortex, although the stape medullary tissue is not eaten.

Some grassed areas are accessible to the sheep in area 5 and at the north of area 7, but the grass, such as it is, is cropped to soil level and areas away from the natural drainage depressions are virtually devoid of vegetation. At the time of my visit grazing predominantly took place on the rocks; on the grass the sheep were either ruminating or "spaced out" - the only way to describe the vacant preoccupation they exhibited here. On the beach their behaviour and disposition were noticeably more purposeful.

The eastern and southern coast presents a very different environment. This is covered by areas 3, 4, 8, 9 and 11 and is mainly sand beach with low rocky promontories at Haskie Taing, South Taing and the Point of Burrian. This side of the island is more sheltered, particularly in the wide bay of areas 3, 4 and 8. Around the Point of Burrian in areas 9 and 11 the sea comes very close to the wall and the grazing ground is very restricted. In area 4 is another area of very poor quality grass.

Area 10 on the north-east has been treated as a separate environment. This is an extensive rock beach with large deposits of *laminaria*, and with access to a large area of poor vegetation around the lighthouse. There is also a range of old stone pens and the ruins of the old lighthouse buildings, and these provide good shelter. The sheep in Area 10 have been totally unmanaged for about 10 years since the abandonment of the croft. This factor is reflected in the

appearance of the flock. No culling has taken place during this period, so the number of obviously aged animals was greater.

Area 6 in the south-west is traditionally the grazing of the laird's farm and is physically separated by a wall north of Doo Geo and a gate at the pier in South Bay. Although the sheep have access to the beach, they are mainly confined to the landward side of the wall, and beach mortality among them is minimal. This area has therefore been excluded from the analysis.

Collection strategy

Concentrations of disarticulated bone were found in three main locations. In corners formed by changes of direction or indents in the wall which formed catchments for storm debris. In pens and crus (circular walled enclosures) which provided winter shelter and are sites of winter mortality. And on grass areas where carcasses are scattered by gulls. Bones found below high water mark were in the main abraded and less suitable for analysis, and so were not collected.

Bones were collected preferentially for completeness and epiphyseal fusion, but bones with one fused epiphysis were also included. Some broken mature bones were also collected.

Elements collected were humerus, radius, ulna, metacarpal, femur, tibia and metatarsal. Pelves and scapulae were examined for instances of gross pathology but were not collected except where they are part of a recovered skeleton. The condition of the bone varied from fresh material to highly weathered bone, some of which was very porous and covered with lichen growth.

Analysis

For the purposes of analysis some amalgamation of collection areas is necessary.

<u>Areas 1 and 2</u> are combined. These were the first areas to be cleared and were deliberately restricted in order to assess the time

involved in the proposed collection strategy; they are effectively one-half of a collection area.

Areas 8, 9 and 11 are also combined. They are each low in specimens due to the restricted foreshore and the tendency for sand dunes to form which bury the bone material. The amalgamated area thus extends from the physical barrier at the pier to Haskie Taing, which is a traditional clowgang boundary.

The analysis is primarily concerned with the effects of the contrasting terrains of the east and west coasts. Thus, "east" is defined as Areas 3, 4, 8, 9 and 11, "west" as Areas 1, 2, 5 and 7. Area 10 is treated individually because the flock here is unmanaged, although its rock shore is directly comparable to the west. Isolation of Area 10 also precludes contamination between east and west.

The total long bone collection was 1,426. Another 359 bones of other elements were also retrieved as either being of particular pathological interest or as part of complete articulations recovered from carcases or incomplete skeletons. Four skeletons were excavated from the dunes above high water mark; in addition two fresh specimens, one immature ram and one aged ewe, were eviscerated, defleshed and disarticulated - these animals do not contribute to the sample under analysis here.

In Southampton the bones were boiled, cleaned, and those with soft tissue adhesions were treated in sodium perborate solution. Bones were numbered in sequences of 1000, the first digit indicating status:

1	Adult
2	Juvenile
3	Incomplete
4	Non limb elements

All limb bones were measured, and each component of the limb joints from the proximal humerus and femur to the distal metapodia was then examined for any osteological deviations.

The humero-radial joint

The samples of humerus and radius have been measured according to the convention of von den Driesch (von den Driesch 1976), except measurement H7, and are recorded thus:

Humerus	Radius	
H1	R1	Gross length
H2	R2	Proximal width
H3	R3	Proximal depth
H4	R4	Distal width (Bd)
H5	R5	Distal depth
H6	R6	Minimum shaft width
H7		Height of coronoid

No significant differences were found between areas on absolute measurements or the derived ratios.

The investigative work has been on the distal humerus and proximal radius where the initial examination suggested there were significant incidences of specific lesions. In the humerus the lesion takes the form of a lateral bony excrescence extending distally (Plate 6.1), sometimes accompanied by a medial exostosis. In the radius, there is again a lateral exostosis at the articular margin (Plate 6.2). Both lesions were rarely accompanied by other visible expressions of osteoarthrosis.

The most advanced lesions (Plate 6.3) concur with those described by Baker and Brothwell:

> "A common finding, both in modern and ancient sheep, is exostoses on the lateral aspect of the elbow joint. These can be so large as to reduce movement and in extreme cases result in ankylosis of the joint. These lesions are thought to be traumatic in origin and thus any severe blow to this site can initiate the changes. However, in modern flocks the condition has been associated with pens or races for holding and separating the sheep brought in from fields and hill grazing, and the term Penning Elbow has been coined for this condition. Ancient assemblages of sheep bones with a high incidence of this disease can be attributed to the same cause."
> (Baker & Brothwell 1980)

> "Traumatic injuries are the commonest sheep disease to be seen in the Brook Street (Winchester) levels; "penning elbow", which occurs from the Roman period to the 14th century, accounts for nearly all these cases. In this condition there are exostoses on the lateral aspect of the elbow affecting the radius and humerus. The lesions vary in size from minor swellings to large masses of new bone which can result in ankylosis of the joint. Shepherds who recognise this form of arthritis associated the lesion with trauma to this relatively exposed site during the use of pens or races used for holding and sorting the sheep for various aspects of management. The occurrence of lesions of this nature would suggest that similar practices were carried out in the vicinity of Winchester over a long period of time. Baker and Brothwell (1980) found only five cases during their survey and therefore the very large number of cases at Winchester is of particular interest." (J. Baker pers. comm.)

The condition has been noted in the skeletal collection of feral Soay sheep held at the Natural History Museum where an incidence of 23% is reported (Clutton-Brock et al 1990).

In the North Ronaldsay material there appears to be a good series of the condition extending from the initial appearance of a small lateral osteophyte to the large protrusive exostoses, although no cases of fusion were found. The lesions are highly consistent in their apparent developmental character and have proved susceptible to measurement. The site and extension of the lesions are shown in Fig. 6.3.

In a total of 190 complete adult humeri, 73 exhibited lesions (38.4%), and of the 156 radii 53 were affected (34.0%).

The following bone measurements and ratios were found to have significant relationship to the lesions (A = 1% level; B = 5% level):

Humerus

	H1	H2	H3	H4	H5	H6	H7
H1		B		A		A	B
H2				A		B	
H3				A		A	B
H4					A		A
H5							
H6							
H7							

Radius

	R1	R2	R3	R4	R5	R6
R1						
R2			B			
R3					B	
R4						
R5						
R6						

To deal with the humerus first, in terms of overall morphology of the element, lesions tended to occur in specimens of greater "stoutness" or "robusticity" as defined by the relationship between gross length and minimum shaft width. This is illustrated in Figs. 6.4 and 6.5. Fig. 6.4 shows the frequency of normal and anomalous specimens across the ratio range. Fig. 6.5 shows the cumulative distribution of the gross length:minimum shaft width ratio for normal humeri and those exhibiting lesions. The affected humeri show a significant tendency to "stoutness" - where shaft width is relatively large with respect to the bone height.

The two significant ratios which present a different case involve the distal end only, and these are distal width:distal depth and distal width:height of coronoid. The distal width, as an absolute measurement, when conditional upon the presence or absence of lesions has a Kolmogorov-Smirnov statistic of 0.3689 (n=190), ρ=0.0000, and the frequency of normal and anomalous specimens across its range is shown in Fig. 6.6.

Fig. 6.7 illustrates the frequency of this dimension by region, and there is no significance in the geographical distribution.

However, where it is possible absolute measurements are avoided for analysis because of their susceptibility to intra-group variability. **"Shape" rather than "size" will indicate morphological variation.** So although the distal width has the highest significance, the analysis concerns the three-dimensional expression.

If the distal humerus is viewed as essentially a cylinder, then the ratios of distal width:distal depth and distal width:height of coronoid both identify the relationship between cylinder length and diameter. The distal width:height of coronoid however is derived from two planes of measurement and this may enhance the independence of each dimension; therefore this ratio is the one illustrated here.

Fig. 6.8 shows the cumulative distributions of normal and anomalous humeri across this index. The lesions are tending to occur where distal width is relatively large with respect to the height of the coronoid - in longer, thinner cylinders. Fig. 6.9 demonstrates the increasing frequency of lesions at the higher ratios by expressing their occurrence as a percentage of each ratio group.

Fig. 6.10 gives the cumulative distributions of this ratio for the west and east regions - these are not significantly different (K-S = 0.1988, ρ = 0.1358, N(west) = 95, N(east) = 53), but it is worth noting the tendency for the elongated distal end to occur in the east. This is reflected again in Fig. 6.11 which also includes area 10.

These results would suggest, therefore, that lesions should occur relatively more frequently in the east, but not to a significant degree. Omitting area 10, the chi-square value (n=147 for west and east) is 4.283, 1 df, ρ=0.0385, and so at the 5% level the null hypothesis (there is no difference is occurrence between east and west) must be rejected. Fig. 6.12 however shows the distribution of normal and anomalous specimens by region, where each group within

the ratio step is expressed as a percentage of the regional total, and the predominance of the anomaly on the west is clear.

For the radius, all the absolute measurements with the exception of the distal depth were significant at the 5% level when conditional on the presence or absence of the lateral exostosis. Proximal depth was significant at <1%, and the frequency of lesions across the range of this dimension is shown in Figs. 6.13 and 6.14. The two significant ratios derived using proximal depth as a component are proximal width:proximal depth and proximal depth:distal depth.

For archaeological purposes a bivariate expression is most useful (meaning "most frequently useable") when it is derived from a single metaphysis which is more likely to survive as a unit than a complete bone. The first illustration is therefore of the proximal width:proximal depth, and Fig. 6.15 shows the cumulative percentages, with the lesion tending to occur where the proximal depth is large relative to the width. However, the distribution of lesions when translated to percentages of the ratio groups is not very helpful (Fig. 6.16).

Fig. 6.17 shows the ratio range by region, and whilst the West and East are broadly comparable, the distribution for Area 10 is positively skewed. When showing the frequency of lesions within the ratio, therefore, West and East are combined in Fig. 6.18 and Area 10 shown in Fig. 6.19.

Again, these are not particularly helpful. Although there is a difference in the distribution of normal and anomalous specimens across the ratio range, there is little that can be said about the relationship between these two groups.

The relationship between the proximal depth and the distal depth is more interesting, although useability may be diminished as already noted, and there may be a problem of differential development, which is discussed later. Fig. 6.20 indicates that the distribution of the ratio is similar between the three regions, but the cumulative

percentages and significance presented in Fig. 6.21 show that the anomalous group occurs mainly where the proximal depth is large relative to the distal depth. Fig. 6.22 shows this more clearly by presenting the normal and anomalous groups as percentages of the number of specimens in each ratio step. Figs. 6.23 and 6.24 show the frequency of normal and affected bones across the range for the West and East combined, and Area 10 separately; the rising incidence of lesions as the ratio increases is very clear in both cases.

As for the humerus in Fig. 6.12, Fig. 6.25 shows normal and anomalous specimens by west and east, expressed as percentages of the regional totals.

Although the radius sample supports that of the humerus in that there is a significant difference in the distribution of lesions across an expression of morphological variation, the null hypothesis that there is no significant difference between the occurrence of lesions between west and east is accepted (χ^2 = 0.700, 1 df, ρ = 0.4027, n = 117), in the case of the radius. However, there are other factors that should be considered here.

Using measurements from two opposing epiphyses assumes equal development in time in all planes of both extremities. For the radius this assumption may not be valid - the proximal radius achieves ossification of the epiphyseal cartilage within the first year, whereas the distal epiphysis will retain an active centre of osteogenesis until epiphyseal fusion in the third or even fourth year of life. So, a gradient can be introduced into the data which reflects only the range of ages at which fusion of the distal radius occurs. For the Orkney population, this may possibly be compounded by a degree of delayed fusion - inconsistencies were noted in the recovered male carcase between the ageing indicators of dentition, horn growth and epiphyseal fusion (S. Hamilton-Dyer pers. comm.). Inhibited eruption of permanent incisors in the breed has already been noted by Baker:

> "North Ronaldsay sheep do not seem to conform to the rules relating ageing to the eruption of permanent incisor teeth which are useful for estimating the age of more conventional

> breeds of sheep. Generally eruption is delayed so that the animals are older than dentition suggests. Another ancestral breed, the Soay of St. Kilda, shows similar slow tooth development, achieving full mouth condition in five or six years" (Britt and Baker 1990)

The derived ratio for the humerus, however, involves one epiphyses only which fuses within the first year. The ratio is thus contained within the structure determined by a single centre of osteogenesis, and any differential in age at fusion should be reflected only in scale and not morphology, as defined metrically. The distal humerus is thus likely to have greater integrity as an indicator of genetically defined conformation.

The lesions themselves proved quite susceptible to measurement in the humerus in the following planes:

Lateral protrusion (distal width including lesion - distal width)
Height of lesion
Basal width of lesion
Basal width of osteophyte

The osteophyte erupts from a bony flange which develops on the proximo-posterior circumference of the capitulum (see Fig. 6.3). The base of the flange is visible as a vascular line from which it is possible to measure the height of the osteophyte. The basal width of the lesion is the distance between the two extremities of the flange, and the basal width of the lesion is the width of the osteophyte at the point of eruption from the flange.

Regression confirms that the lesions are markedly consistent in their developmental progression (Fig. 6.26). And, unlike incidence, there is no regional variation in the degree of development. Neither is there any variation in this "severity" related to either the absolute dimensions of the bone itself, or to the ratios derived therefrom.

The precision of measurement on the radius was far less satisfactory. Two planes were attempted:

Lateral protrusion
Cranio-caudal depth

The lateral protrusion can be ascertained by subtracting the proximal width from the width including the lateral osteophyte, but this produces a derived dimension with a much increased level of experimental and standard error. The cranio-caudal depth is the distance between the horizontal extremities of the exostosis, but these points are far less clear in the radius than in the humerus.

A height dimension is also possible by subtracting the gross length of the bone from the lateral height measured to the top of the lesion - this gives a vertical extension but does not quantify the lesion directly. Again, the level of precision in such a derived measurement is too low.

The point of extrusion of the exostosis is rarely defined and thus direct measurement becomes subjective. However, it is possible to make a qualitative judgement as to the severity and advancement of the lesion. As with the humerus, the lesions appear consistent in development and unrelated in their maturity either to whole bone dimensions or geographical location.

The proximal and distal articular facies of the metapodia

119 metacarpals and 112 metatarsals, all complete and fused, constitute the sample of metapodia. Where sample size permitted, metrical analyses produced no significant differences in bone size or morphology between region, nor between groups of normal bones and those exhibiting any degree of pathology. Osteological anomalies, however, are well represented in these elements as shown in the following tables.

Table 6.1
North Ronaldsay sheep: Metacarpal: Regional representation of normal and anomalous specimens

Region	Total	Normal	Arthropathic	Soft tissue ossification	Other
		%	%	%	%
1	46	56.5	19.6	19.6	4.3
2	50	62.0	20.0	16.0	2.0
3	23	47.8	30.4	21.8	0

Table 6.2
North Ronaldsay sheep: Metatarsal: Regional representation of normal and anomalous specimens

Region	Total	Normal	Arthropathic	Soft tissue ossification	Other
		%	%	%	%
1	60	58.3	41.7	0	0
2	36	52.8	44.4	0	3.8
3	16	31.3	68.7	0	0

Arthropathic manifestations and bony excrescences at the sites of tendon insertion constitute the majority of the anomalies observed. Those noted under the heading of "other" are a small number of traumatic or infective lesions which are not considered further here.

The soft tissue ossifications are, without exception, the development of bone at the sites of normal physiological stress, where sub-periosteal obsteoblastic action is stimulated by normal, but repeated demands, to reinforce the lines of strain imposed by typical muscle action acting on the tendon insertions into the bone. The mechanics of this reaction have been summarised in Chapter 2. These anomalies, particularly when observed in the absence of other pathologies, can be a useful indicator of maturity, and it is therefore not surprising that they are best represented in this sample in the metacarpals of Region 3, the area of modern flock abandonment. An interesting point is, of course, the absence in this sample of such ossification in the metatarsals of any region. It raises the question of whether, in sheep, the metacarpals are subjected to greater stresses because of the evolved design of the element, or whether the activity of this particular flock makes extraordinary demands

upon the limbs of the forequarter. Further investigations of other flocks, outside the confines of this research, may produce archaeologically useful information to support or interrogate the current ageing techniques.

The arthropathic manifestations have been collated according to the incidence of particular and discrete anomalies, or of multiple exhibition. Here, of course, for archaeological practicality it is necessary to fragment the bone hypothetically in order to present proximal or distal epiphyses as circumscribed units bearing independent articular and periarticular surfaces. Nevertheless, taking advantage of the completeness inherent in comparative material, no statistical relationship was observed between anomalies exhibiting on opposing epiphyses within the same elements. The following tables therefore specify and enumerate the irregularities observed on each affected epiphysis, and detail them by reference to the position on each face or facet of the normal articular plan of that epiphysis.

Table 6.3
North Ronaldsay sheep: Proximal metacarpal: Expressions of articular anomaly

Facet		Site					Arthropathic expression		
Lat	Med	Lat	Med	Ant	Post	Cent	Fiss	Depress	Other
*						*		*	
*				*				*	
*		*		*		*		*	A E P
*		*						*	
*			*					*	
*						*		*	
*						*		*	E
	*		*		*		*		
	*		*				*		
*		*							
*	*	*	*						P
*		*							E

Key: A = articular extension
E = eburnation
G = grooving
P = periarticular exostosis
R = remodelling
D = destruction
F = fusion

Table 6.4
North Ronaldsay sheep: Distal metacarpal: Expressions of articular anomaly

Facet		Site					Arthropathic expression		
Lat	Med	Lat	Med	Ant	Post	Cent	Fiss	Depress	Other
*		*					*	*	
*		*						*	
*		*							E P
*	*	*	*						A E G P R
*	*	*	*						A E G P R
*		*		*		*			A E G P
*		*		*		*			A E G P
*		*		*					E
*	*	*	*	*	*				P
*		*							E
*	*	*	*	*					E P
*	*	*	*						P
*	*	*	*	*	*				A E G P D
*	*	*	*	*	*				P

Table 6.5
North Ronaldsay sheep: Proximal metatarsal: Expressions of articular anomaly

Facet				Site					Arthropathic expression		
Lat	Med	LP	MP	Lat	Med	Ant	Post	Cent	Fiss	Depress	Other
*				*					*		
*				*					*		
*				*			*		*		
* 4				*			*		*		
* 6				*			*		*	*	
*				*	*				*	*	
	* 1				*				*		
	*				*				*		
	*				*		*		*		
	*		*		*		*		*		
* 7				*						*	
*				*	*					*	
*				*	*					*	
*				*	*	*				*	
*						*				*	
*						*				*	
* 1						*		*		*	
* 2							*			*	
* 3								*		*	
* 5								*		*	
	* 3				*						
	*				*						
	*				*	*					
	*				*	*					E
	*					*					
	* 7					*	*				
	* 6					*					
	*					*	*				
	* 2										
		* 4					*				
		*									
		* 5						*			
			*					*			
			*					*			
			*					*			
			*					*			
			*					*			
			*					*			
	*			*		*		*			E
	*				*	*					A P
	*			*	*	*	*				P F

LP = lateroplantar MP = medioplantar
The paired numbers identify specimens exhibiting on two faces

Table 6.6
North Ronaldsay sheep: Distal metatarsal: Expressions of articular anomaly

Facet		Site					Arthropathic expression		
Lat	Med	Lat	Med	Ant	Post	Cent	Fiss	Depress	Other
*		*	*					*	
*			*					*	
*			*					*	
*			*	*				*	
*			*	*				*	
*			*	*				*	
*						*		*	
*						*		*	
	*		*		*			*	
	*		*	*					P

Two points are immediately obvious from these tables. The first is the predominance of fissures and depressions as expressions of articular anomaly. Not only do they occur most frequently, they also occur most frequently alone. They do not, in themselves, identify any clinical condition; neither have they proved susceptible to any tests of significance which were deemed applicable to this population. Yet such manifestations have been noted and reported in archaeological herbivore material of various sources, but which remain unpublished (S. Stallibrass pers. comm; D. Brothwell pers. comm.). This thesis provides an opportunity to consider this manifestation as it exhibits in modern, medieval and prehistoric animals, and the discussion is presented in Part B of Chapter 7.

The second point is the apparent susceptibility in this population to the accumulative expressions of potential clinical osteoarthritis in the distal metacarpal. Such a result in the retrieved skeletal material would suggest that lameness or stiffness in the forequarter would be apparent in the living flock, but this is not the case observed by Britt & Baker (Britt & Baker 1990) or by the writer.

Femur and Tibia

In both elements the number of observed anomalies was low and the number of arthropathic categories high. The data is thus unsuitable for quantitative analysis beyond the basic account of incidence.

Nevertheless, the relatively high percentage of femoral arthropathy in Region 3 is compatible with the results obtained for the metapodia. The tibia appears to have a very low susceptibility to pathological lesions in general in this population.

Table 6.7
North Ronaldsay sheep: Femur: Regional representation of normal and anomalous specimens

Region	Total	Normal	Arthropathic	Soft tissue ossification	Other
		%	%	%	%
1	99	79.8	16.2	2.0	2.0
2	136	91.2	8.1		0.7
3	47	61.8	34.0	2.1	2.1

Table 6.8
North Ronaldsay sheep: Femur: Arthropathic manifestations

Arthropathic Expression	Reg 1		Reg 2		Reg 3	
	Prox	Dist	Prox	Dist	Prox	Dist
Extension						3
Extension, exostosis				1		
Extension, eburnation				1		
Extension, eburnation, lipping	1					
Eburnation	1	1				
Eburnation, exostosis				1		
Exostosis	2	1				4
Depression		2		1		3
Lipping	8		6	1	5	1

Table 6.9
North Ronaldsay sheep: Tibia: Regional representation of normal and anomalous specimens

Region	Total	Normal	Arthropathic	Soft tissue ossification	Other
		%	%	%	%
1	100	94.0	3.0	3.0	
2	50	94.0	4.0		2.0
3	44	93.2	4.5	2.3	

Table 6.10
North Ronaldsay sheep: Tibia: Arthropathic manifestations

Arthropathic Expression	Reg 1		Reg 2		Reg 3	
	Prox	Dist	Prox	Dist	Prox	Dist
Fissure			1		1	
Exostosis		1	1			
Depression	1					
Extension, exostosis		1				
Extension, grooving, exostosis, destruction, fusion					1	

Implications

First, to summarise the observations and results; there is no difference in the management strategies, such as they are, between the west and east coasts of the North Ronaldsay. The decline in the level of management has been accelerating over the last 40 years, but it is likely that the sheep have been confined to the shore for the last 200 years. The traditional thrice-yearly pound of the whole flock no longer occurs, but the remaining crofters do still pen sheep for shearing and lug-marking (ear marking). The pens are stone built, and the sheep will use them of their own accord for shelter, as the Soays do on Hirta (Jewell et al 1974).

It is of course impossible to assess the date of death when the collection strategy relies on the retrieval of disarticulated, dry bone which has accumulated over at least two centuries. Some bones included in this analysis may therefore be derived from animals which were kept under shepherding regimes of the old crofting system. However, this system was consistent throughout the island, as was its disintegration, except for one area which has been keep separate throughout the analysis.

The west coast of the island is predominantly rock, both as boulders and in extensive inclined strata disrupted by steps and fissures. The more sheltered eastern coast comprises mainly sandy bays delineated by rocky headlands.

Observations on the joint surfaces of the long bones of the sheep suggest that there may be a relationship between the frequency of a

particular humero-radial arthropathy and terrain. Humeral lesions show a relationship with those distal epiphyses which are wider relative to their depth. The profile of joint variation in this or any other morphological expression is not significantly different between east and west. However, the frequency of the humeral lesions is greater in the west.

Arthropathies visible in the metapodia cannot be related to geographical factors, but may reflect the age structure of particular sections of the flock, and this is supported by distribution of lesions in the femur.

The humero-radial lesions are identical to those traditionally described as "penning elbow". The outcome of the analyses described in this chapter raises the question of whether the identified incidence and progressive behaviour of the condition are concomitant with the results of occasional blows sustained during gathering or penning. And if there is a reasonable doubt, what other initiating circumstances may be suggested?

The site of both the humeral and radial exostoses corresponds to the outer insertion of the lateral collateral ligament of the elbow joint. This short, strong ligament attaches proximally to the lateral epicondyle of the humerus and distally to the lateral tuberosity of the radius, just distal to the margin of the articular surface. The elbow joint has only one degree of freedom around an axis which passes through the proximal attachments of the collateral ligaments (Getty 1975, 355). Complete extension is prevented chiefly by the tension of the collateral ligaments and the biceps brachii.

Lesion development appears to be favoured by a relatively shallow distal articulation, where the height of the capitulum is reduced relative to the distal width. This will have the effect of reducing the distance between the lateral epicondyle and the lateral tuberosity of the radius, thus shortening the lateral collateral ligament.

A short ligament may be more susceptible to stress at its attachments than a longer one - Chapter 2 discusses ossification at attachments where the periosteum is repeatedly raised. A tensile force, P, acting on a ligament of length L will increase this length by Δ L. (This applies to all materials.) Δ L can be expressed as follows:

$$\Delta L = \frac{PL}{AE}$$

where P = force
L = original length
A = cross sectional area
E = Young's modulus (modulus of elasticity).

So it can be seen that, in very broad terms indeed, under the same force the potential for increased length of ligament is always less for ligaments that were shorter to begin with. Because the amount of strain that can be stored in these shorter ligaments is therefore less than in long ones, tensile stresses acting on their attachments will be greater at lower initial forces. For the hinge joint of the elbow, with its single degree of freedom, the force acting on the lateral collateral ligament is probably latero-medial, the result of the weight of the animal being taken on the forequarters as it jumps from a higher to a lower point. The susceptibility to pathological strain in animals with shorter ligaments is therefore enhanced where progress requires repeated absorption of shock by the limbs, as in clambering over rock and boulder rather than walking over sand.

The tendency for the traumatic humero-radial lesions to be differentiated between rocky and sandy environments, but for the progressive and degenerative arthropathies of the other long bones to be undifferentiated geographically, supports this hypothesis.

The relevance of this to archaeological material is essentially twofold.

1. It is not intended to challenge the *possibility* of elbow lesions in archaeological sheep being induced by collisions in pens or races. It is intended, however, to demonstrate that the development of the

condition may be initiated by other stress factors, and that these factors, if known or postulated, may have a direct bearing on the interpretation of the animal remains.

2. The significance, and therefore the relevance, of any lesion (in this case the humero-radial exostosis) can only be appreciated through its relationship to the sample in which it occurs. This means the relationship of the individual specimen to the element group, and of the specific manifestation to the incidence of all other pathological exhibitions (in this case the humero-radial exostosis to the entire arthropathic incidence encountered in the long bones).

Fig. 6.1
Orkney Islands

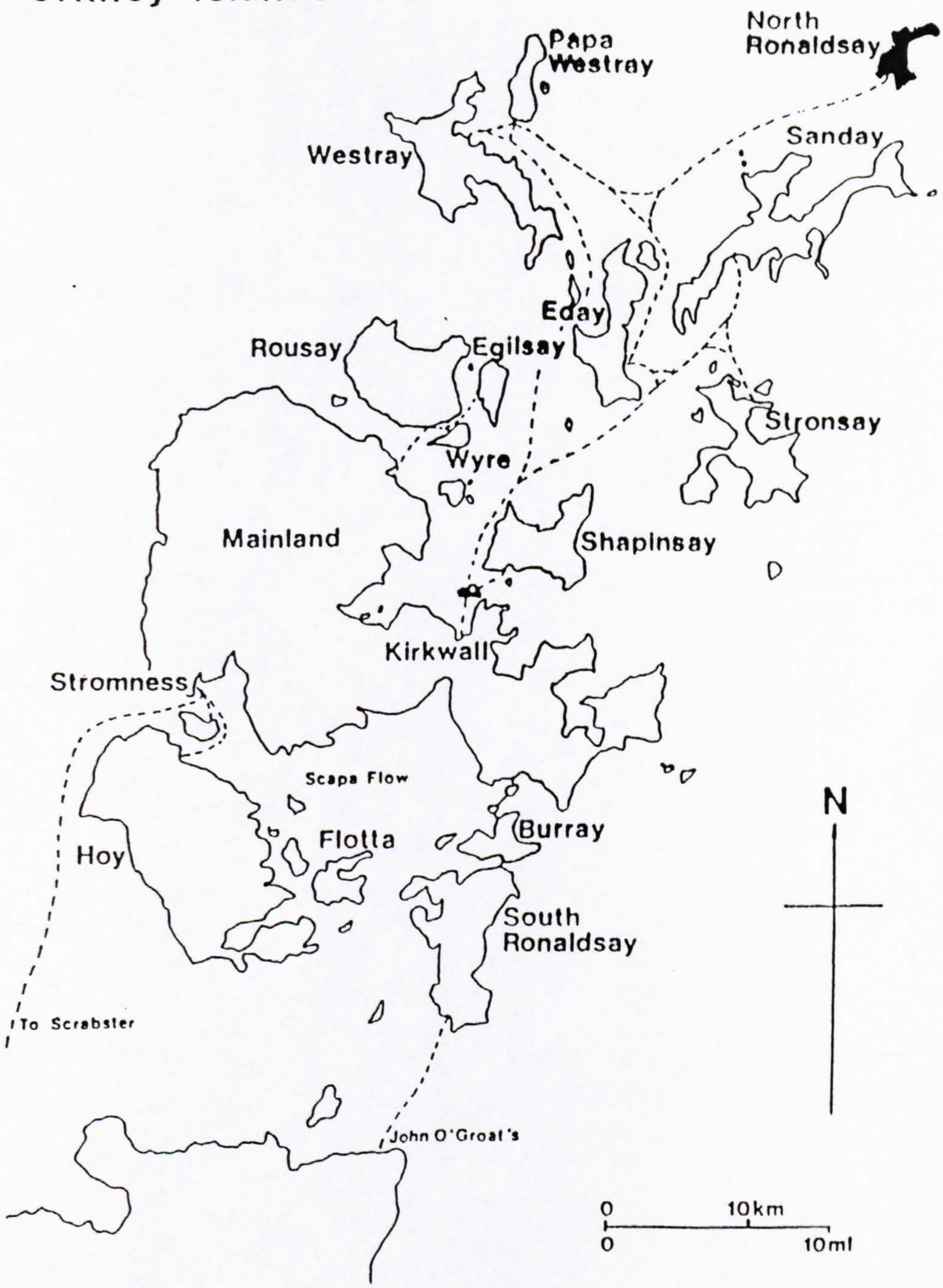


Fig. 6.2
North Ronaldsay: collection areas and boundaries

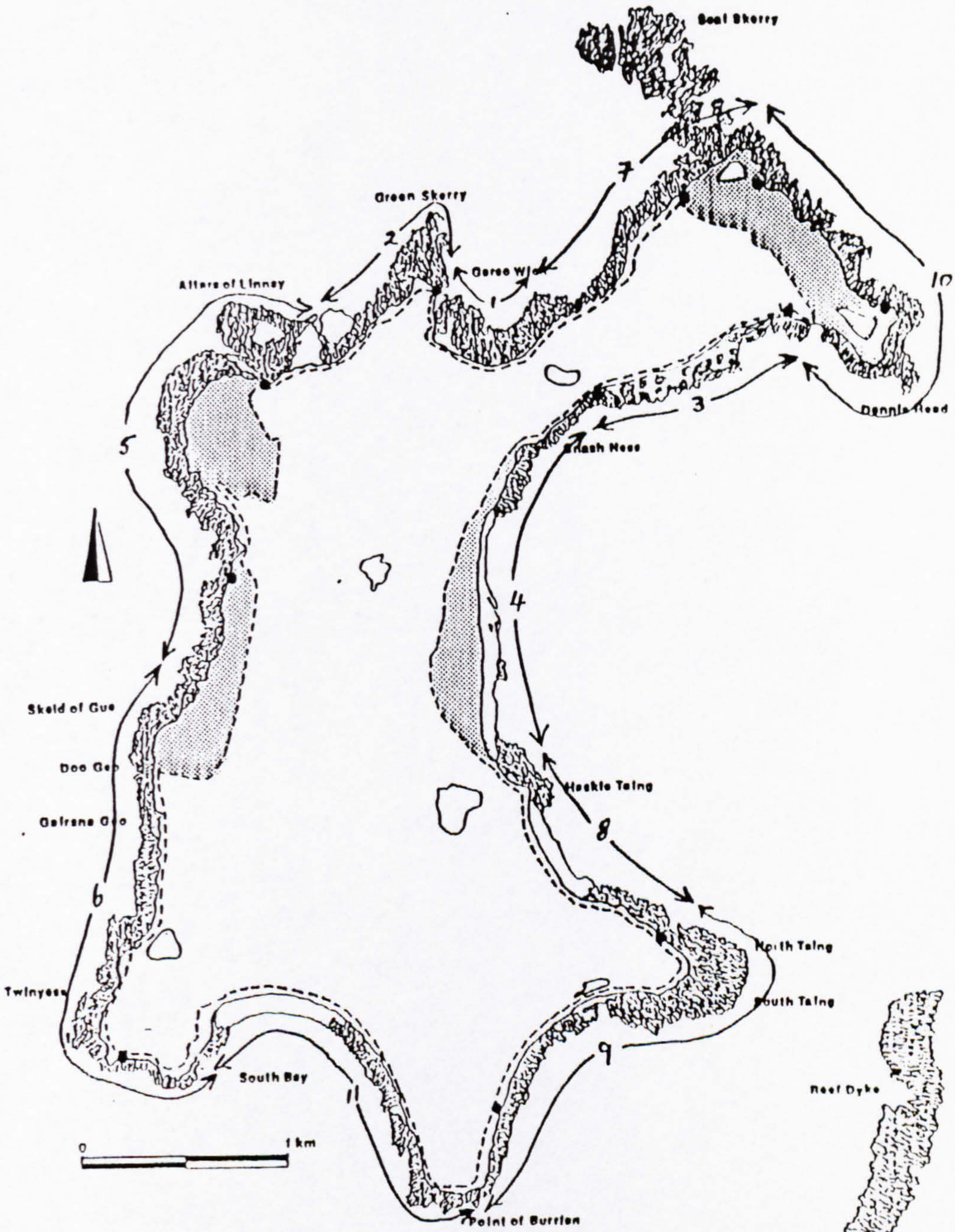


Fig. 6.3
North Ronaldsay sheep:

Lateral exostoses at the humero-radial articulation

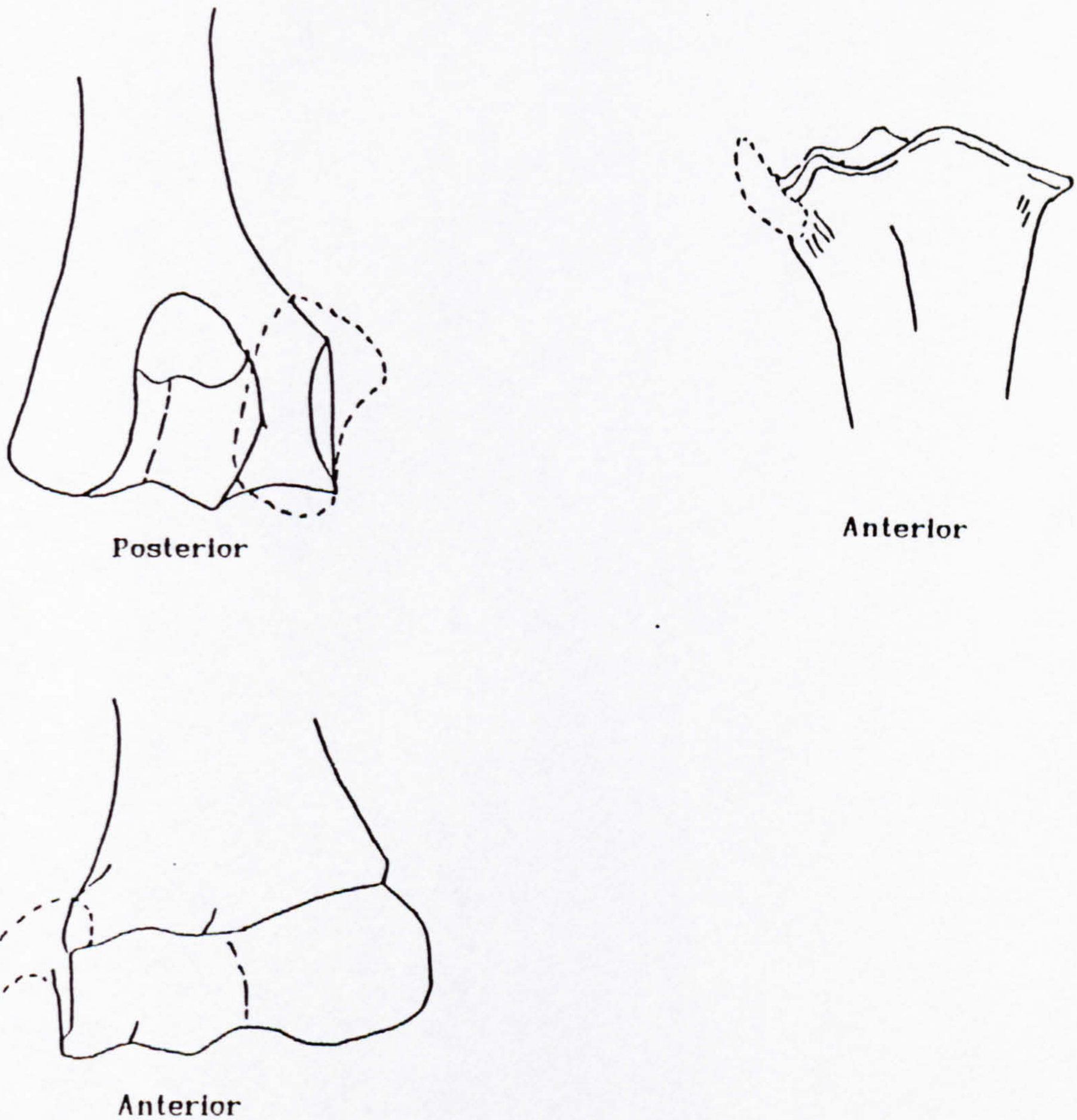


Fig. 6.4

North Ronaldsay sheep
Metrical distribution of humeral lesion

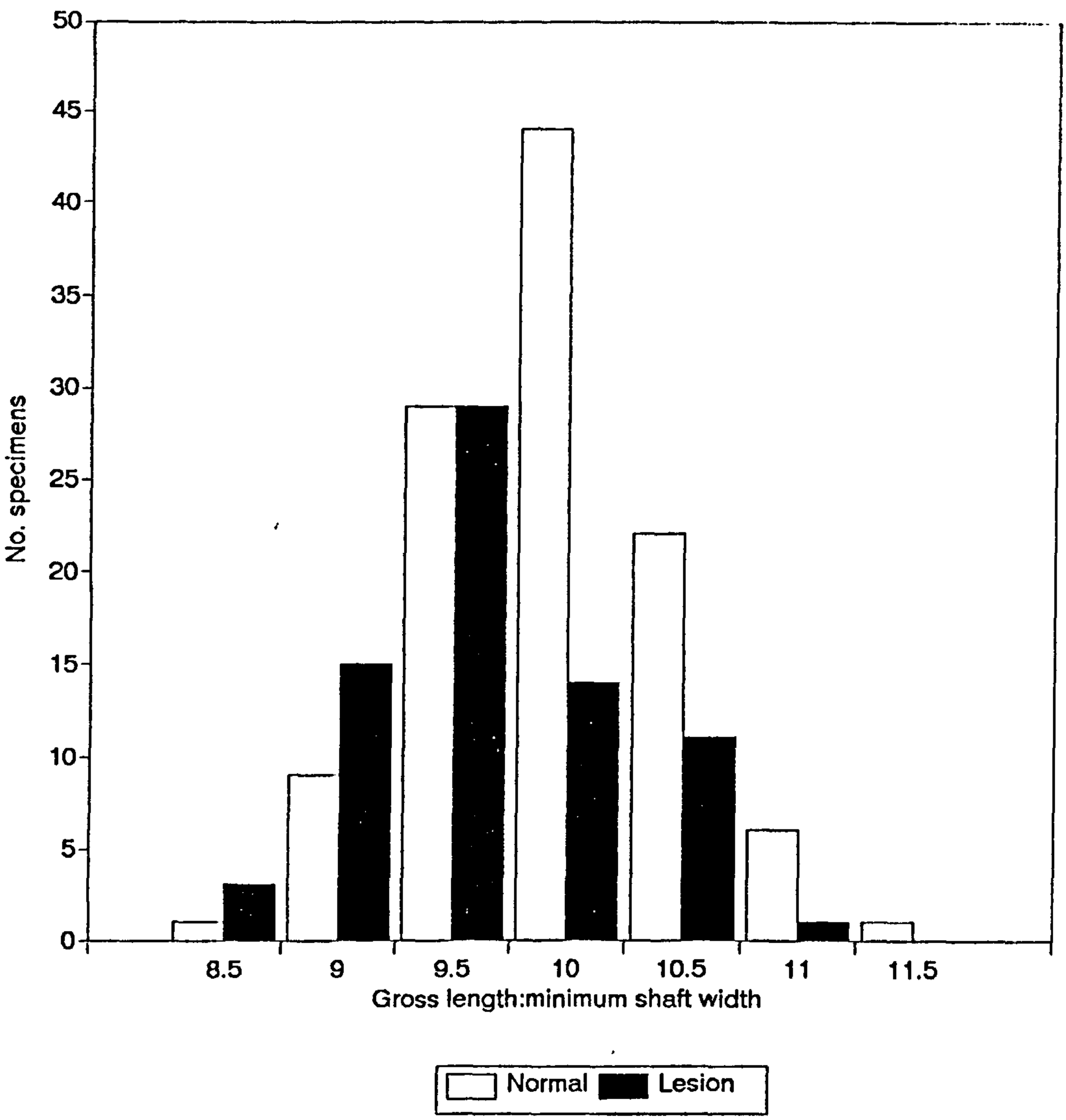


Fig. 6.5

North Ronaldsay humeri

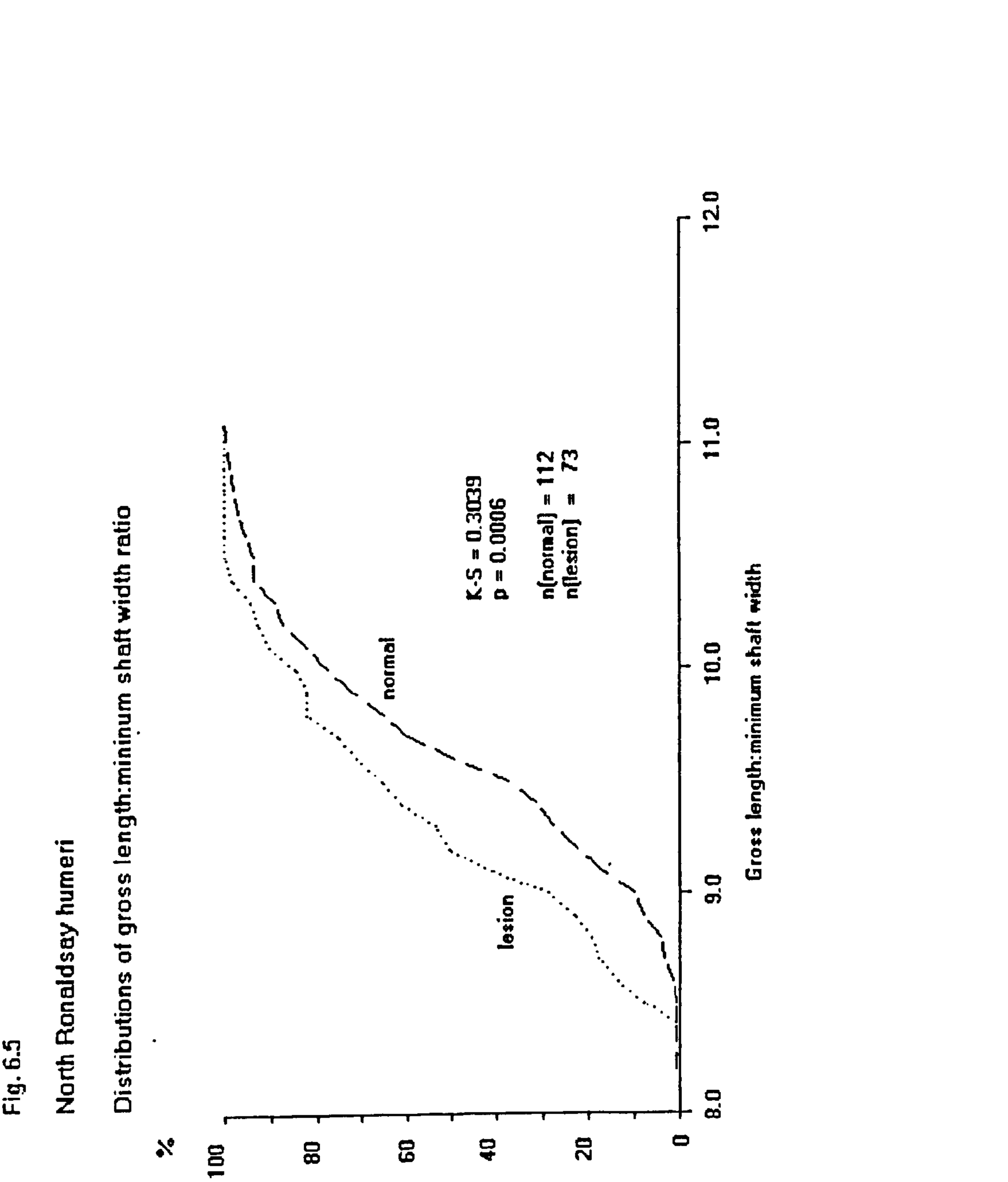


Fig. 6.6

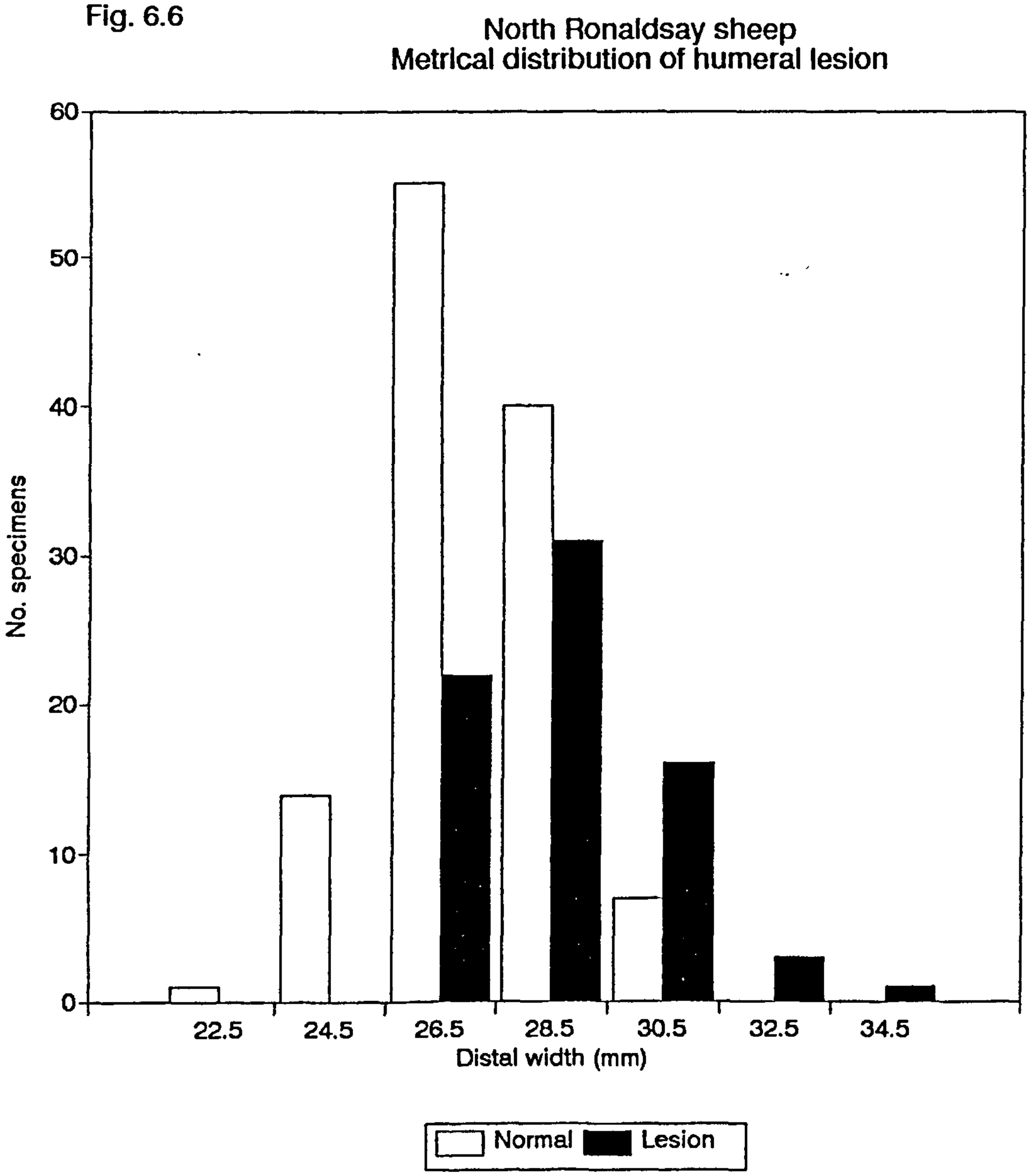

North Ronaldsay sheep
Metrical distribution of humeral lesion
No. specimens
60
50
40
30
20
10
0
22.5
24.5
26.5
28.5
30.5
32.5
34.5
Distal width (mm)
Normal
Lesion

Fig. 6.7

North Ronaldsay sheep: Humerus
Geographical distribution of dist width

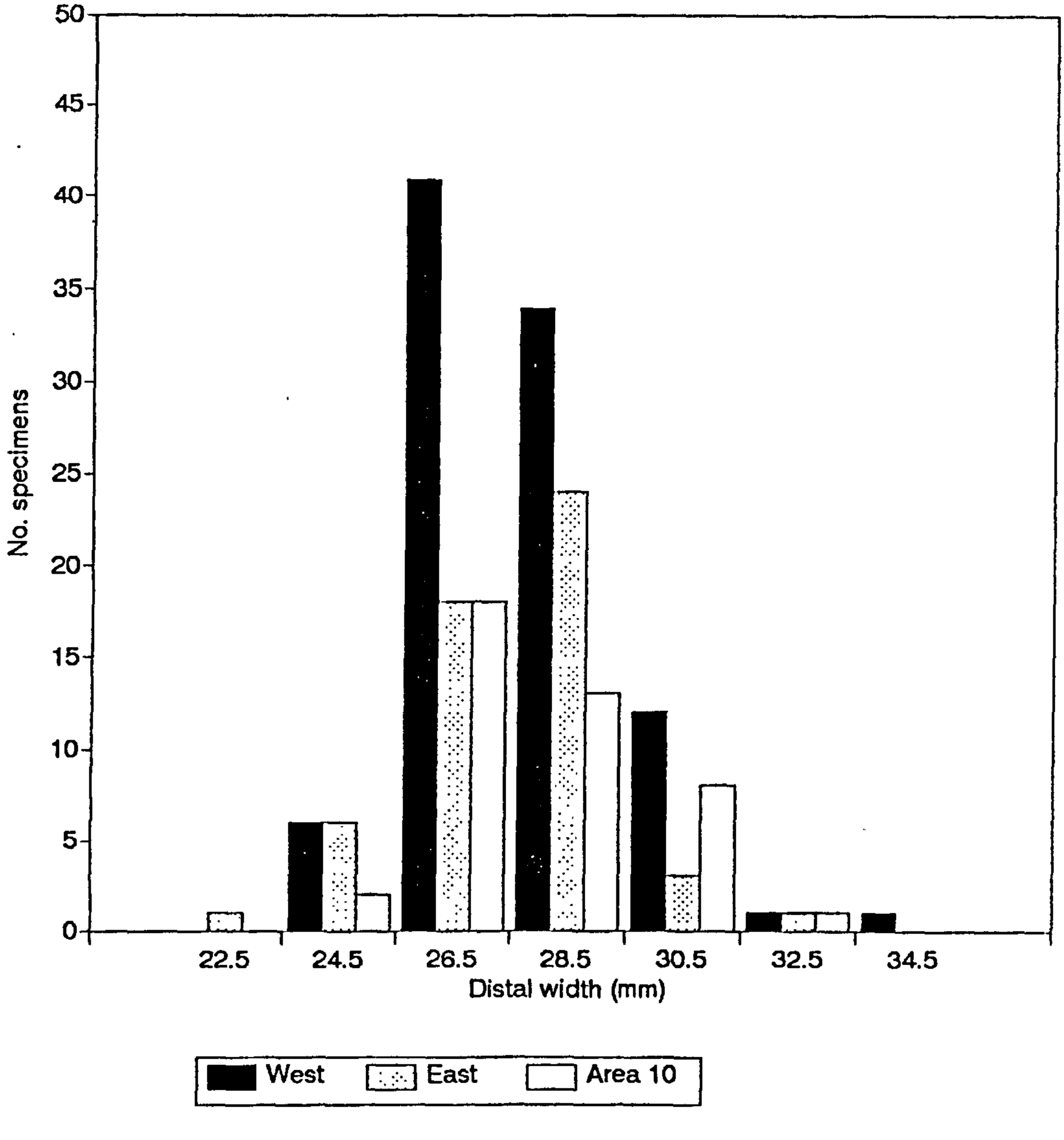


Fig. 6.8

North Ronaldsay humeri

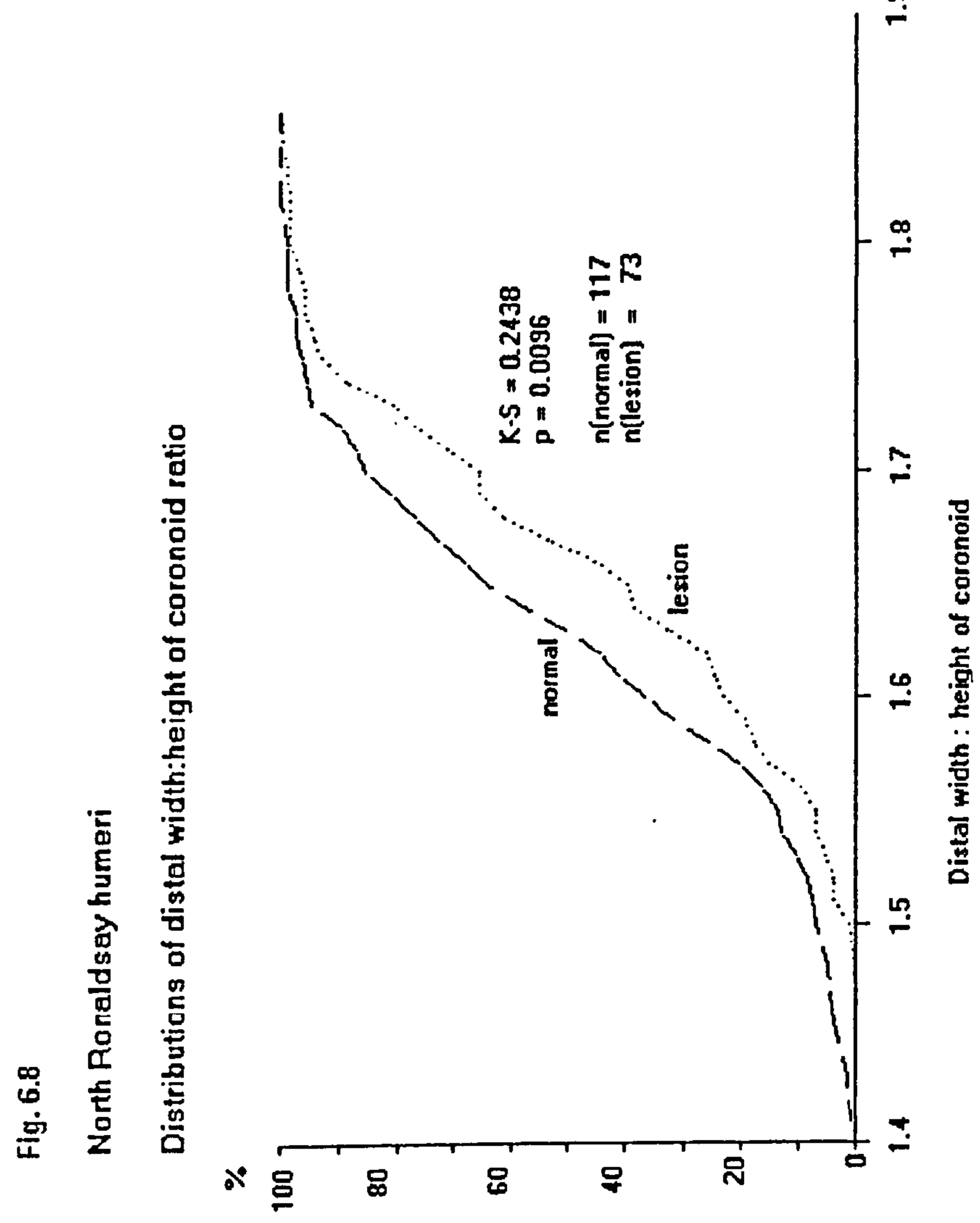


Fig. 6.9

North Ronaldsay sheep: Humerus
Incidence of exostosis in distal ratio

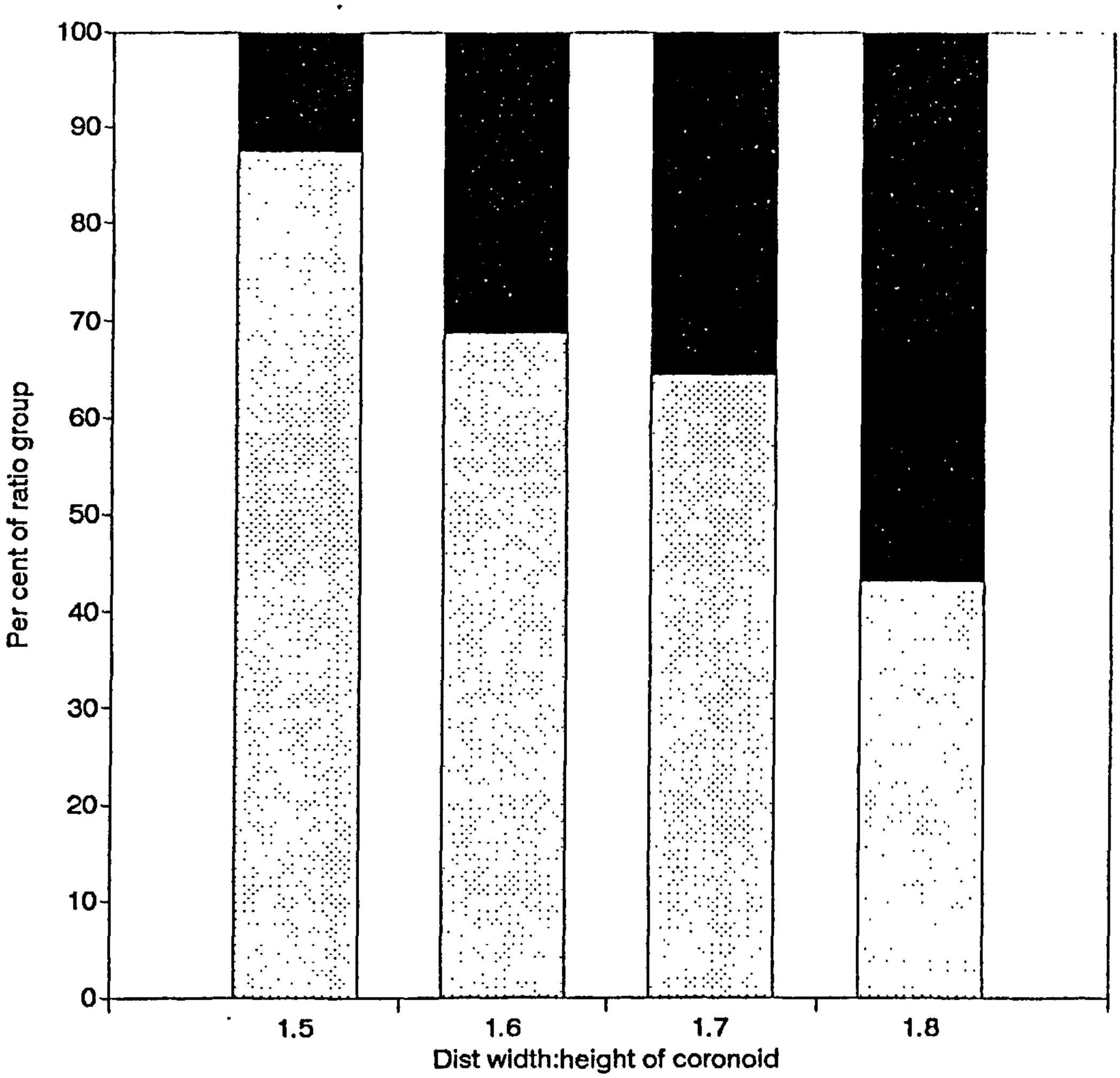


Fig. 6.10

North Ronaldsay humeri

Distributions of distal width:height of coronoid by region

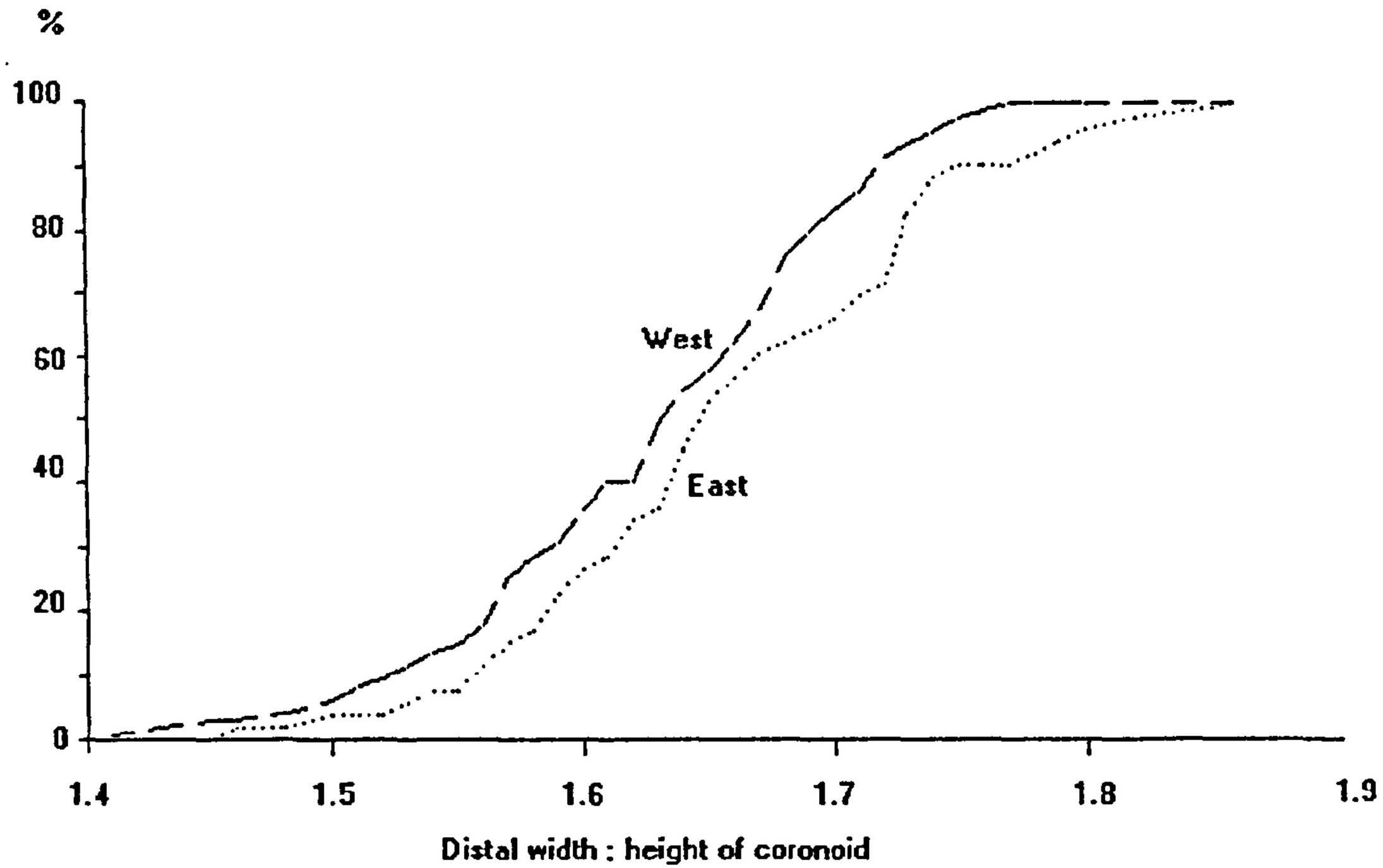
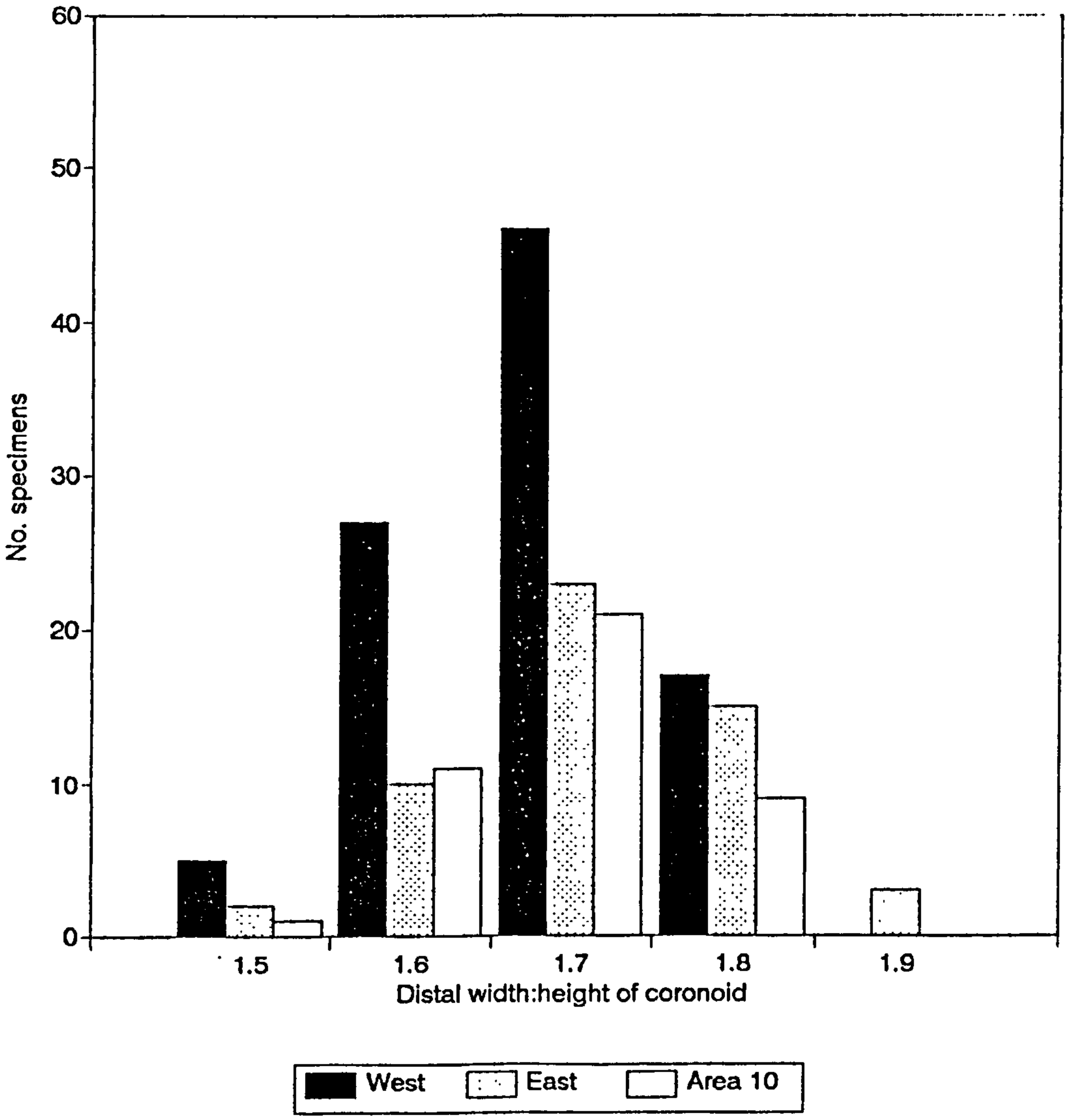


Fig. 6.11

North Ronaldsay sheep: Humerus
Geographical distribution of dist ratio



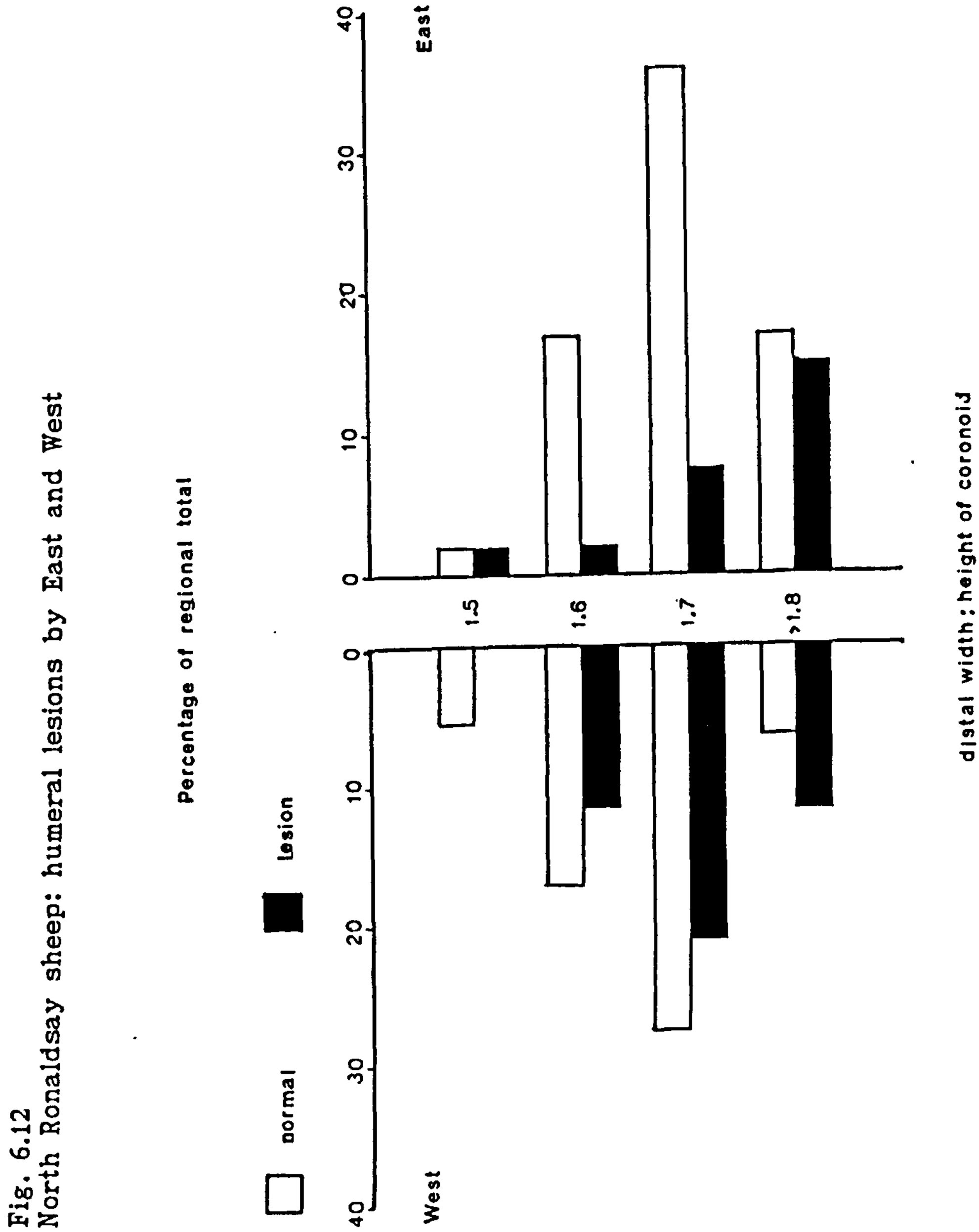


Fig. 6.12
North Ronaldsay sheep: humeral lesions by East and West

Fig. 6.13

North Ronaldsay sheep: Radii
Metrical distribution of radial lesion

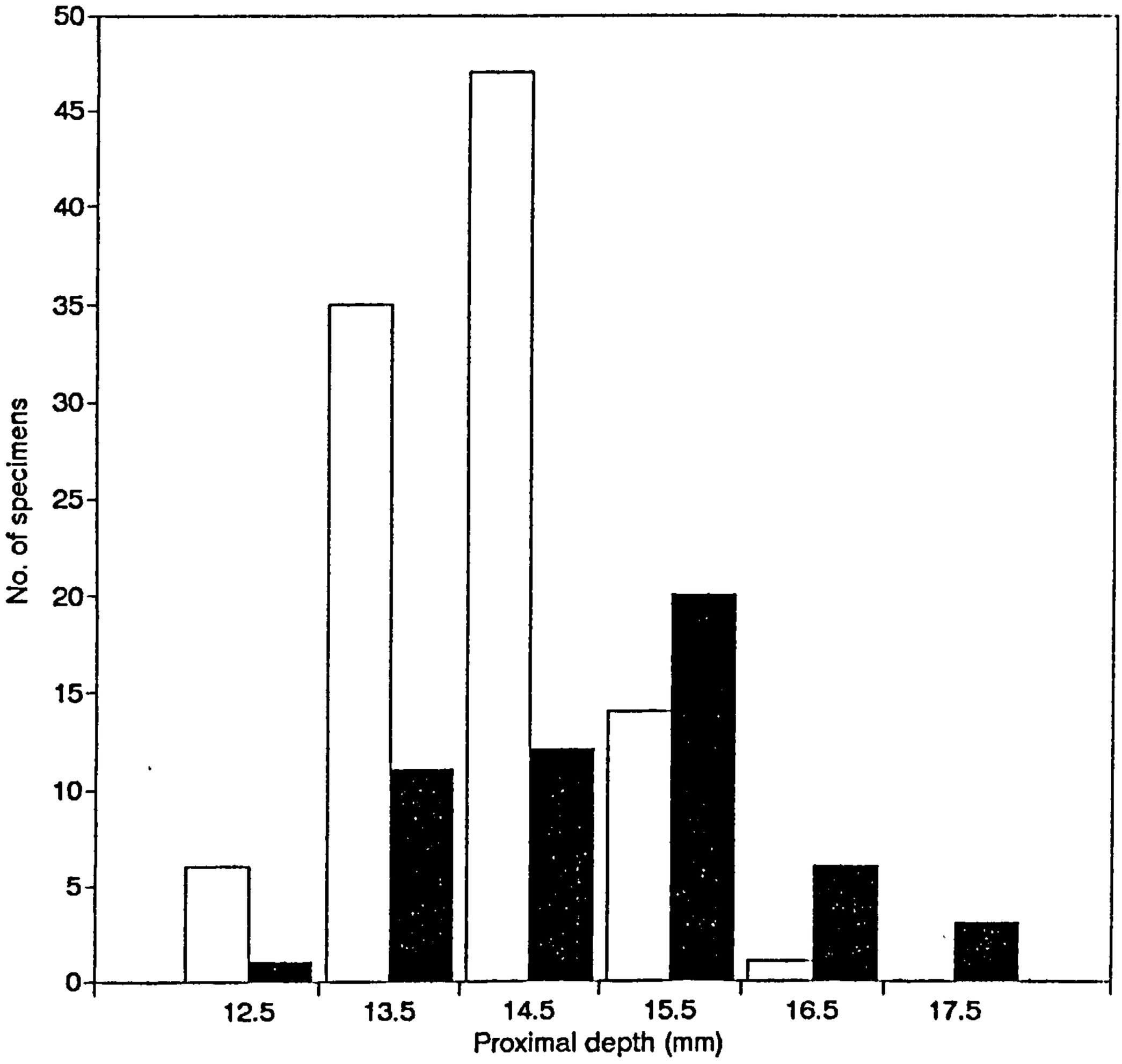


Fig. 6.14

North Ronaldsay: Radius
Geographical distribution of prox depth

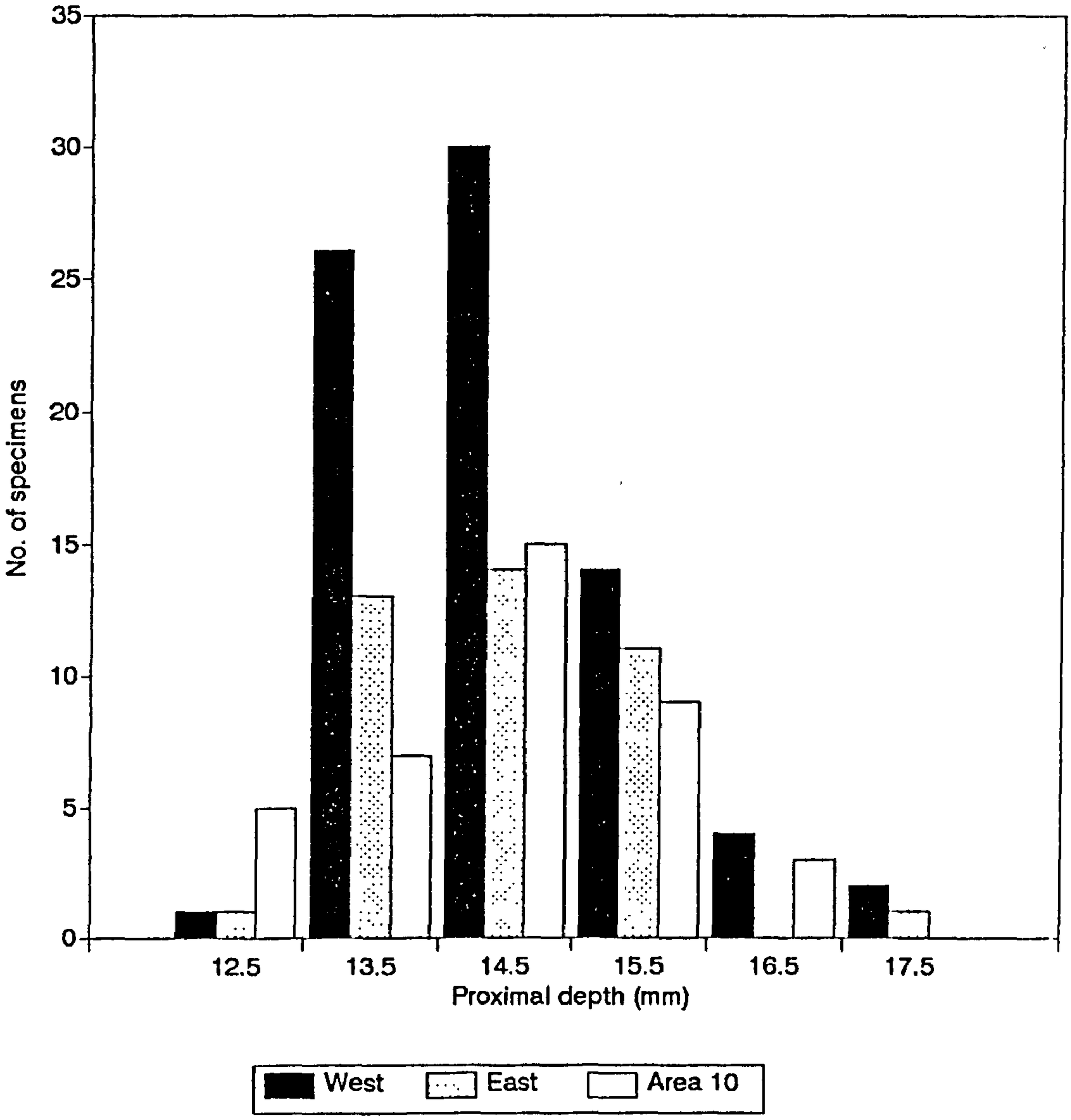


Fig. 6.15

North Ronaldsay radii

Distributions of proximal width:proximal breadth ratio

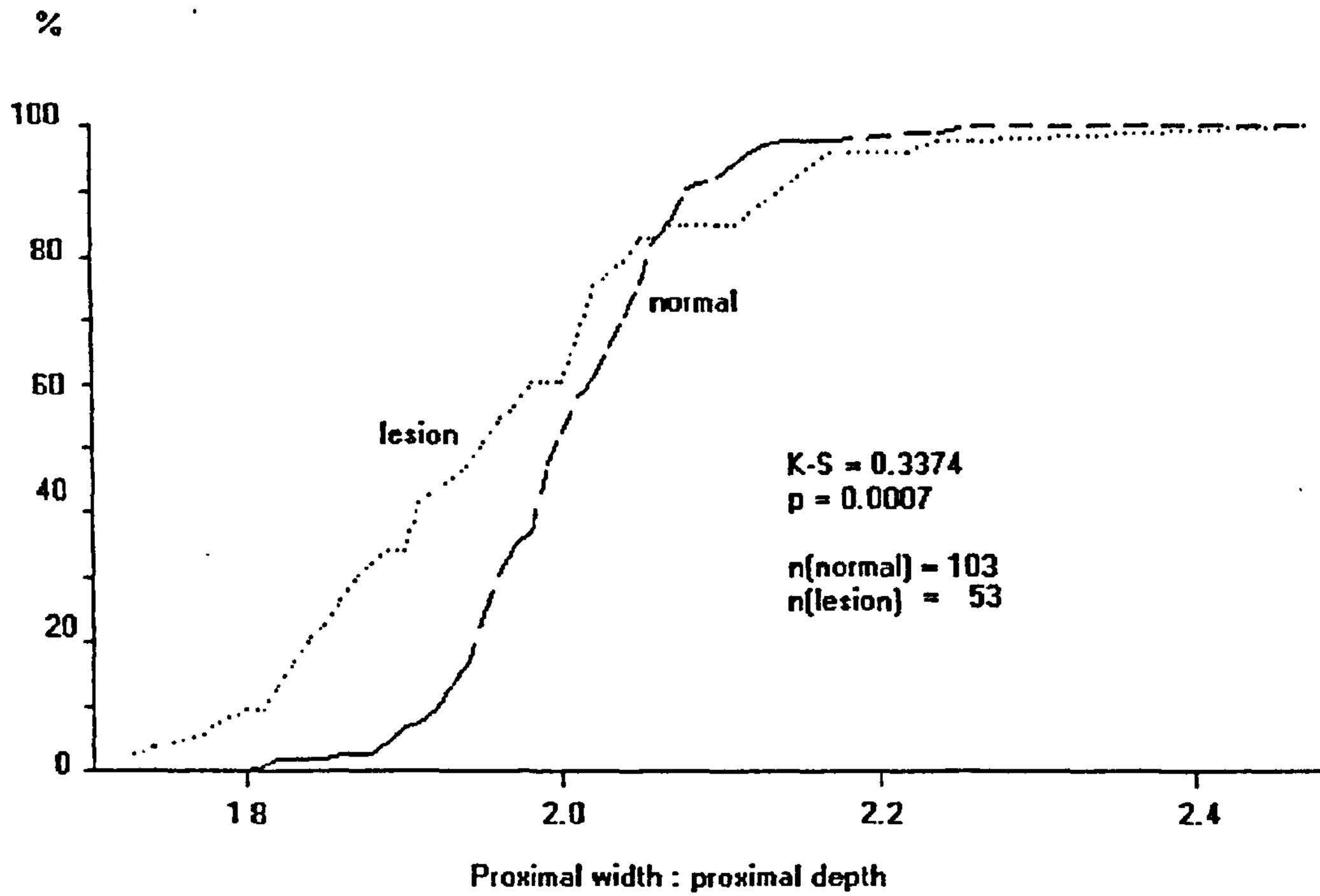


Fig. 6.16

North Ronaldsay: Radius
Incidence of exostosis in prox ratio

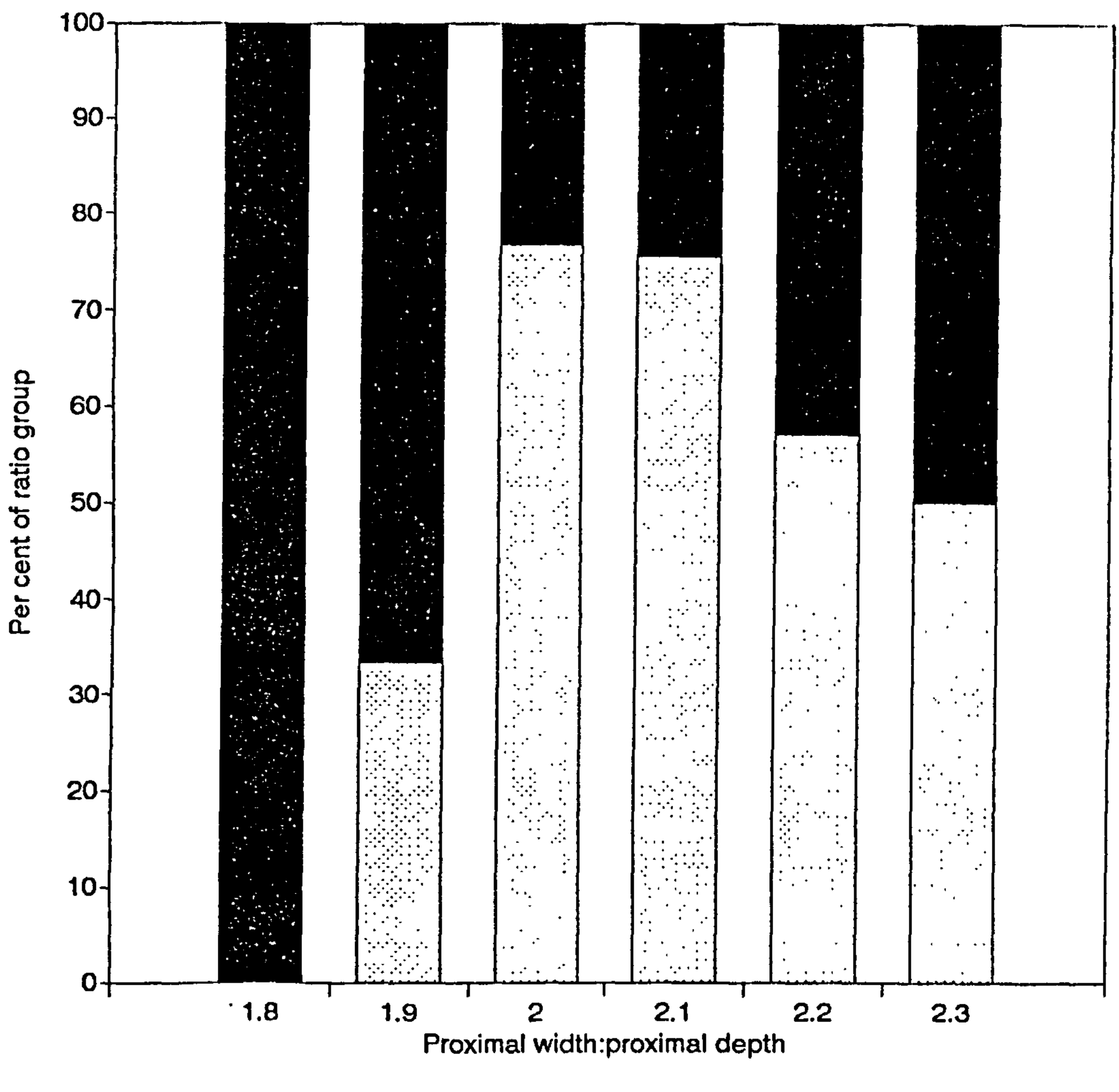


Fig. 6.17

North Ronaldsay sheep: Radius
Geographical distribution of prox ratio

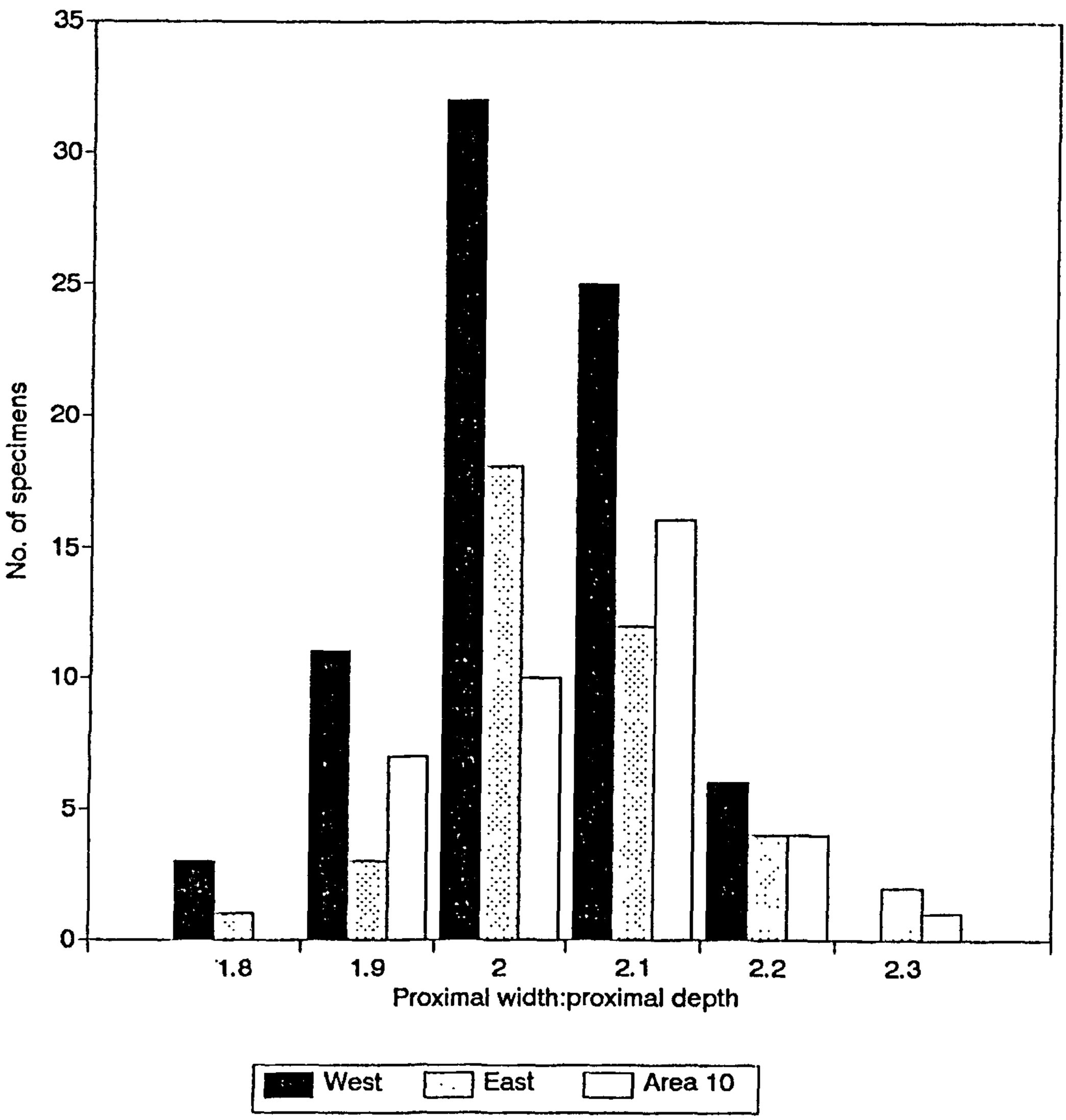


Fig. 6.18

North Ronaldsay sheep: Radius
West and East regions combined

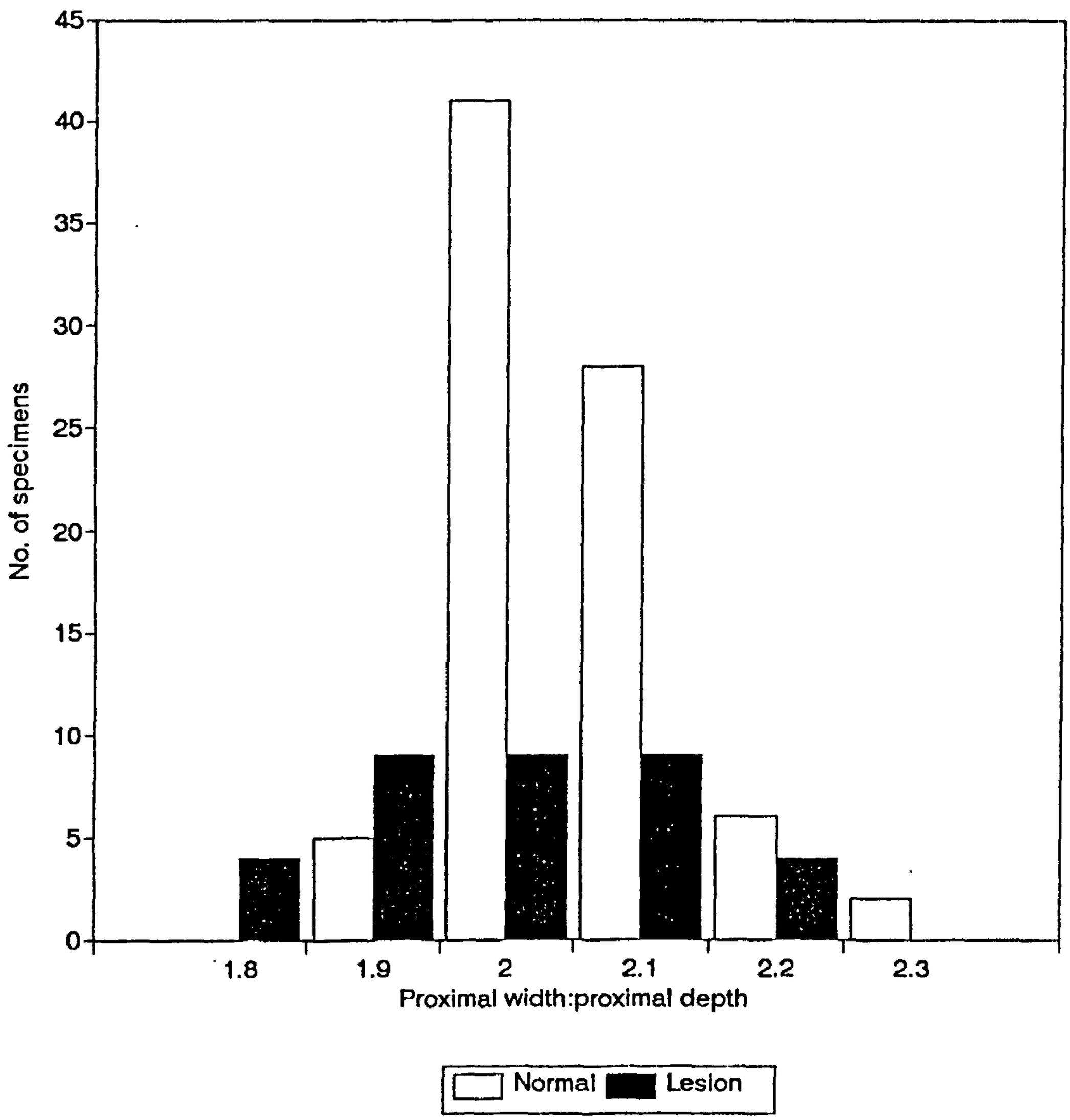


Fig. 6.19

North Ronaldsay sheep: Radius
Area 10

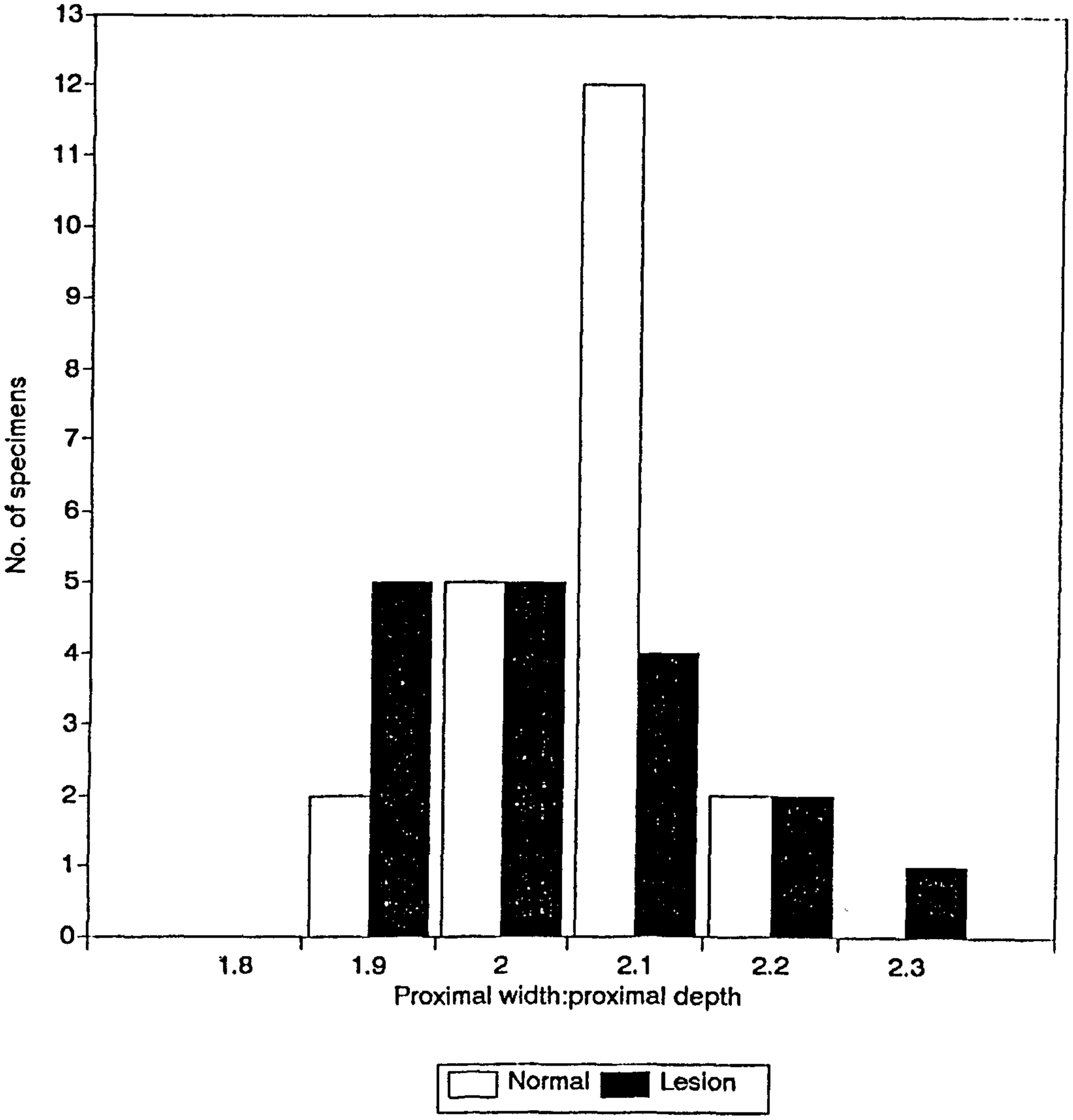


Fig. 6.20

North Ronaldsay sheep: Radius
Geographical distribution of prox ratio

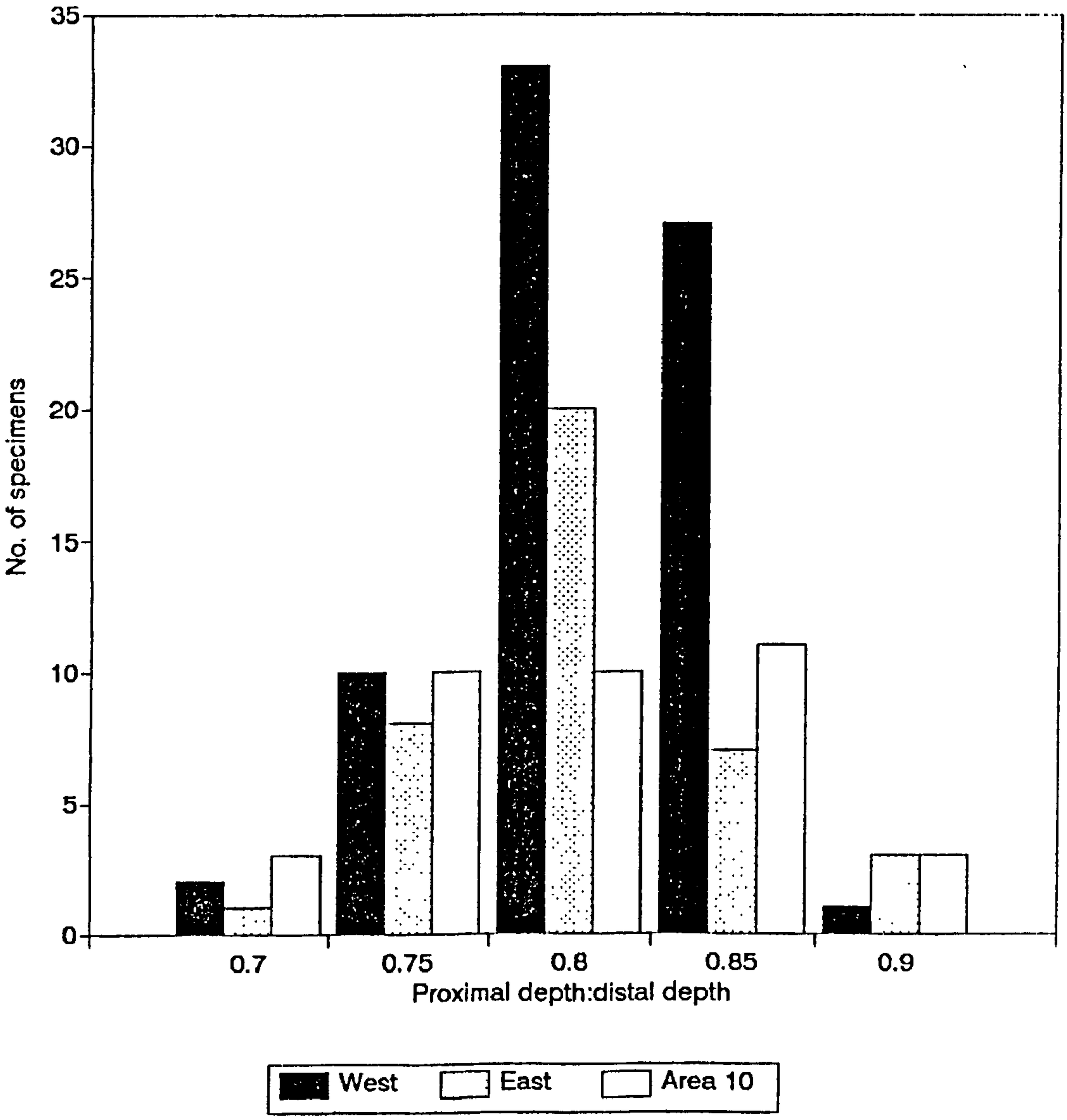


Fig. 6.21

North Ronaldsay radii

Distributions of proximal depth:distal depth ratio

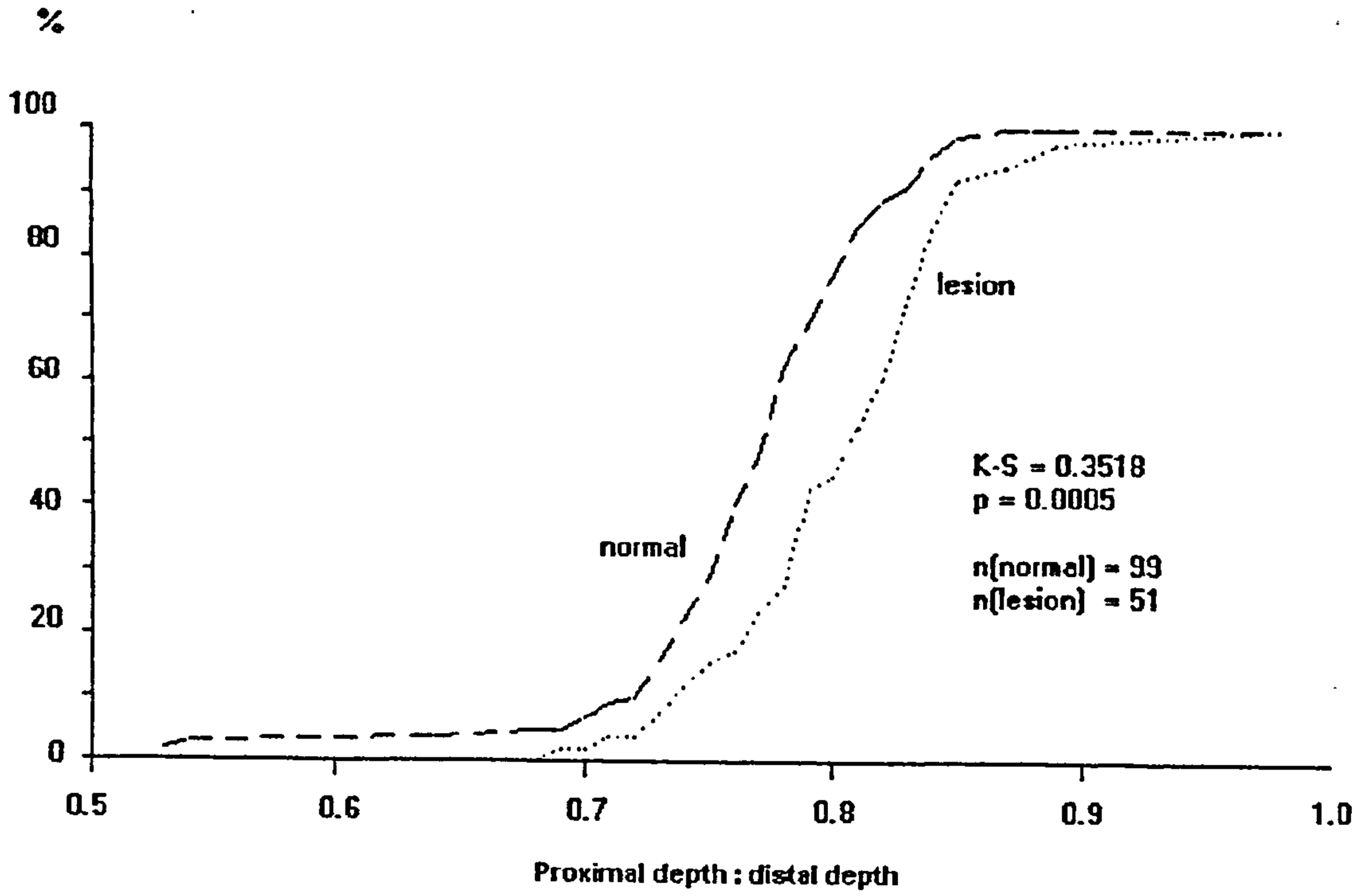


Fig. 6.22

North Ronaldsay sheep: Radius
Incidence of exostosis: prox:dist ratio

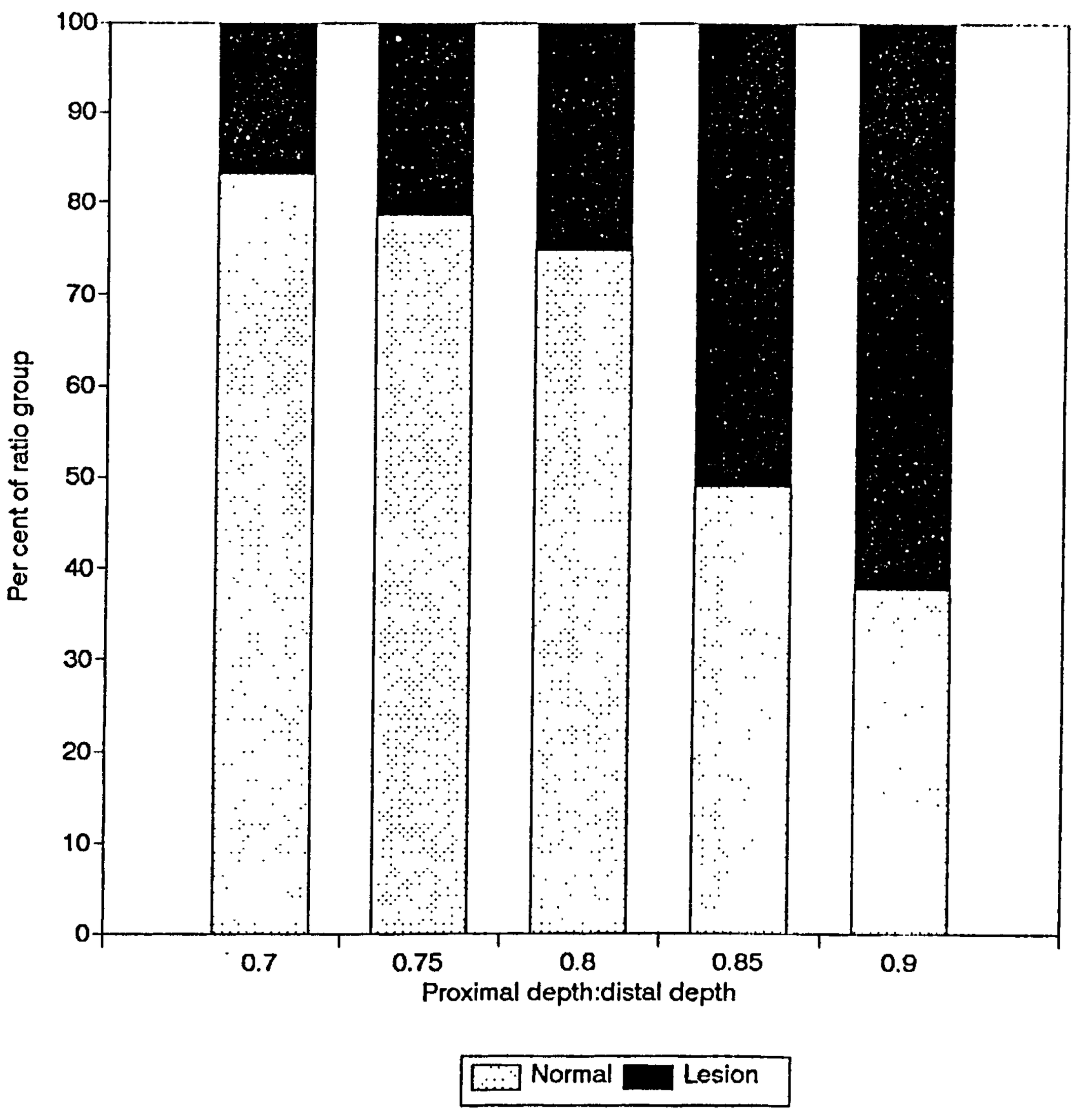


Fig. 6.23

North Ronaldsay: Radius
West and East combined

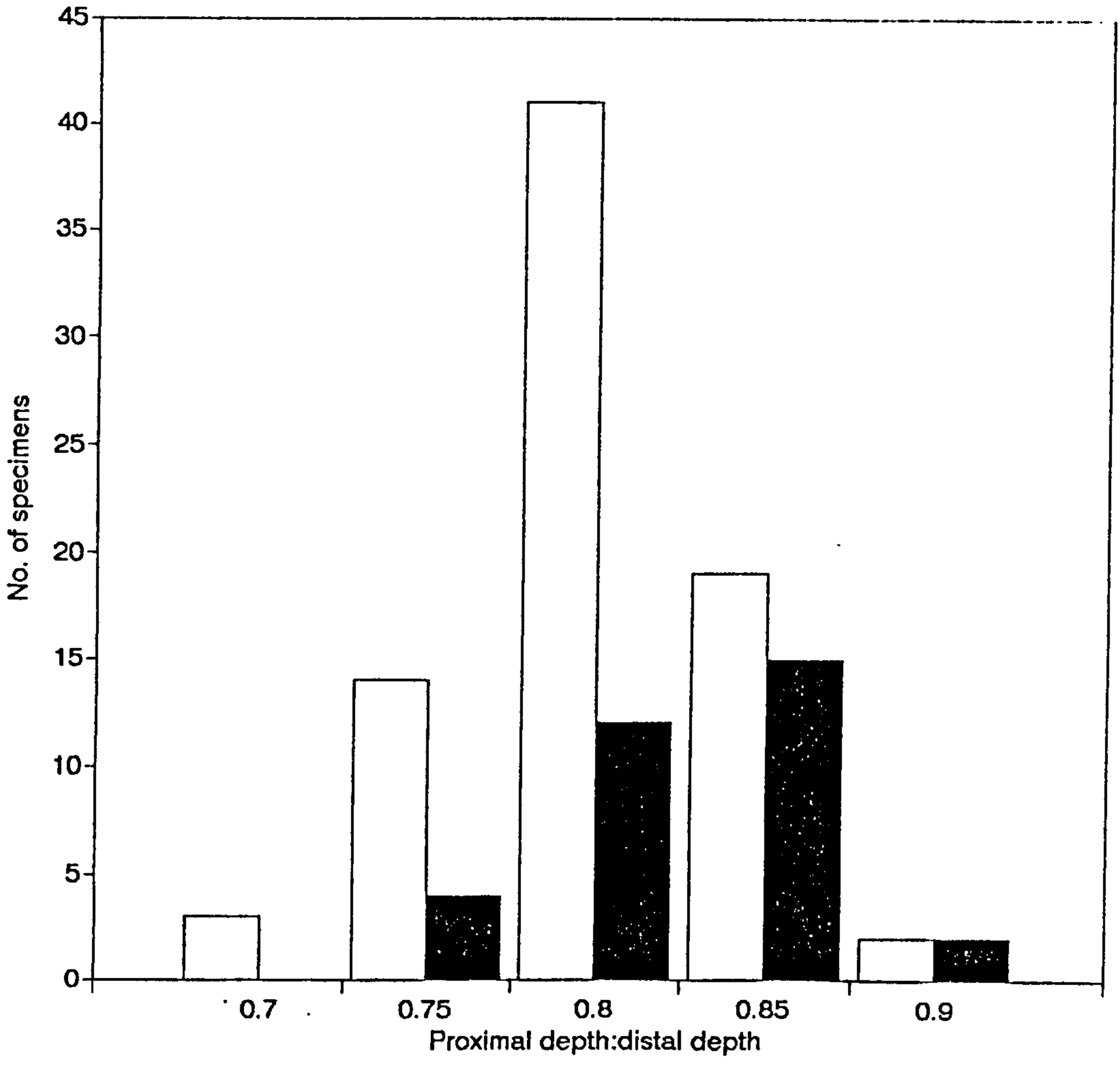


Fig. 6.24

North Ronaldsay: Radius
Area 10

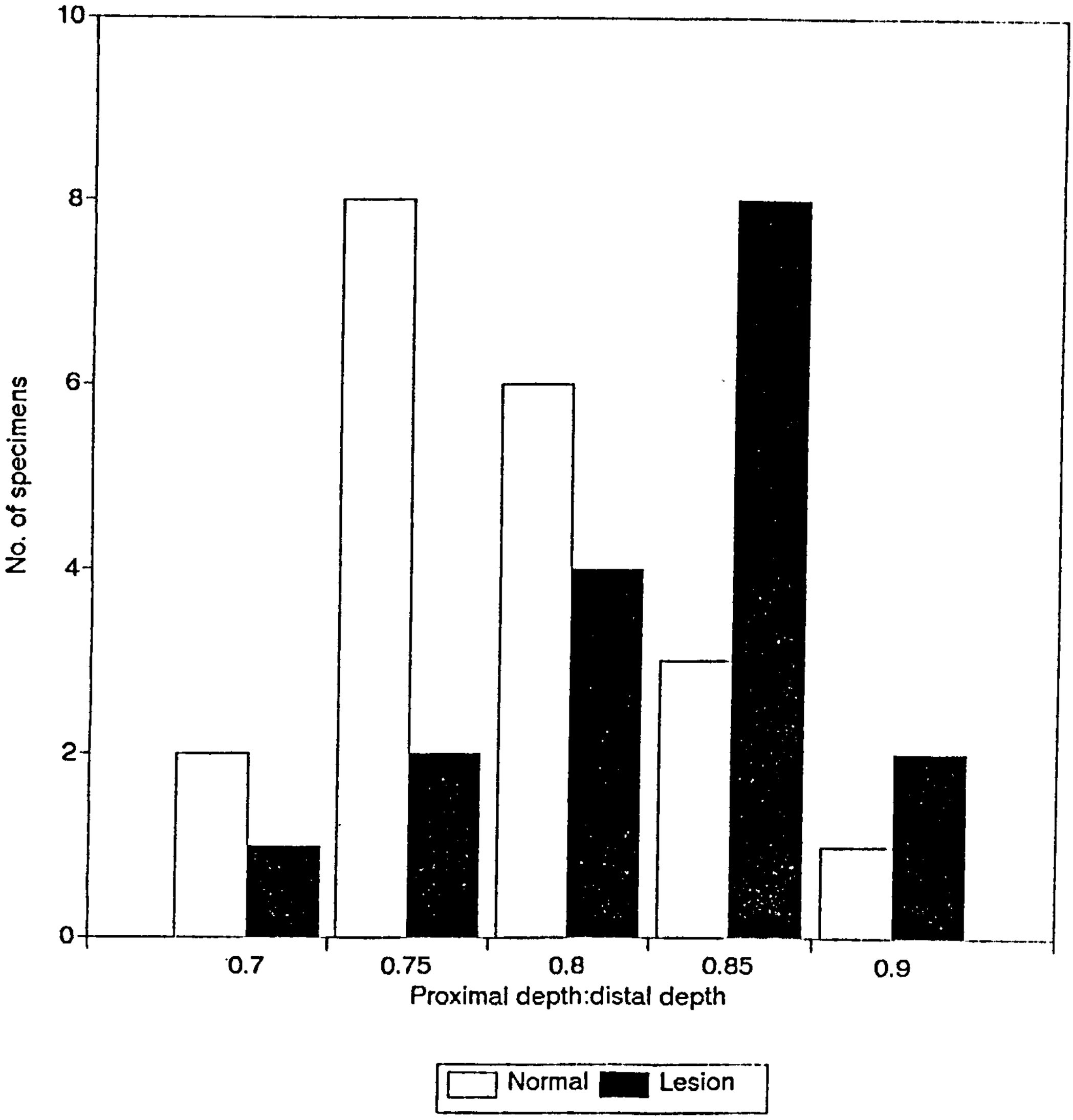


Fig. 6.25
North Ronaldsay sheep: radial lesions by East and West

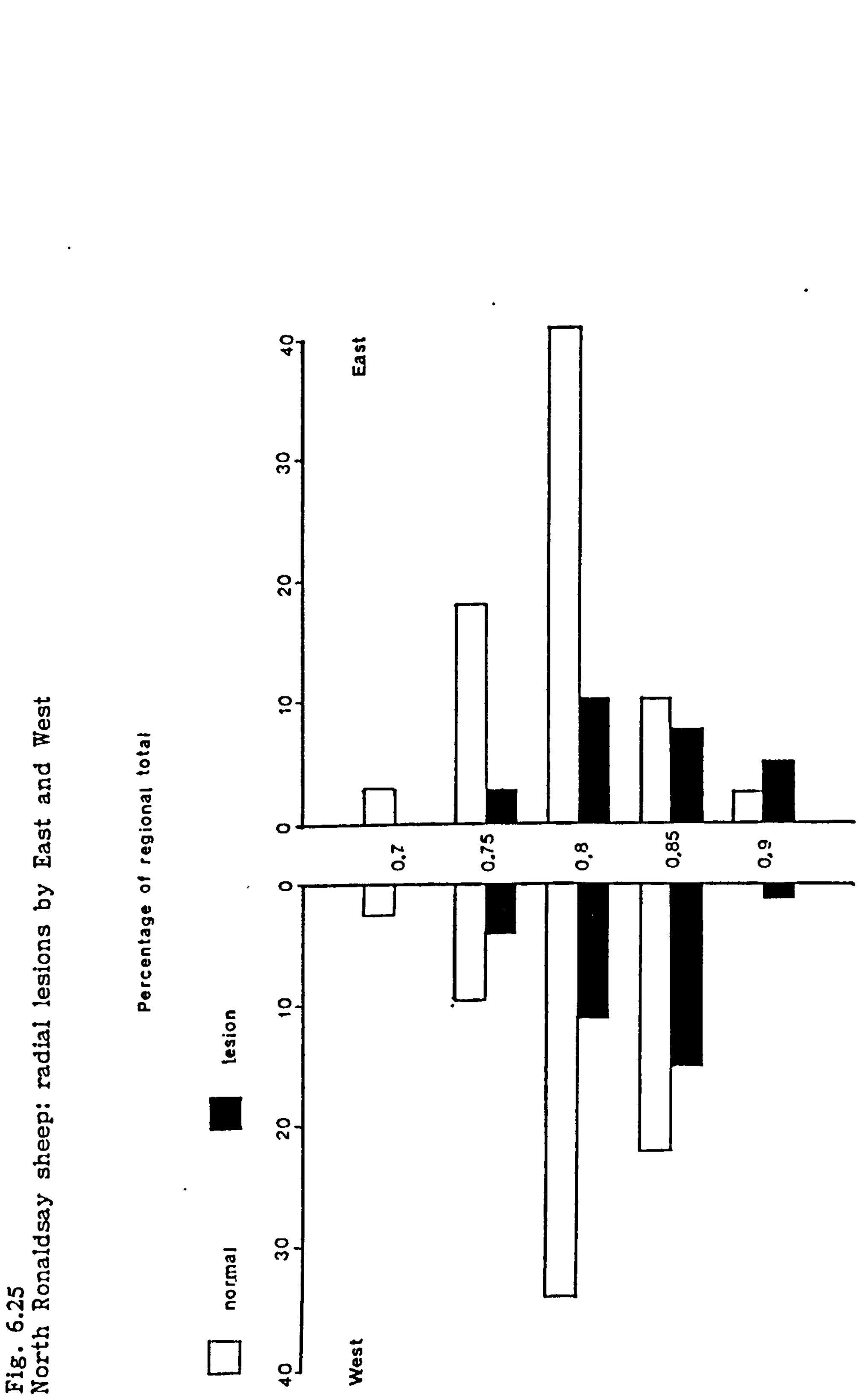
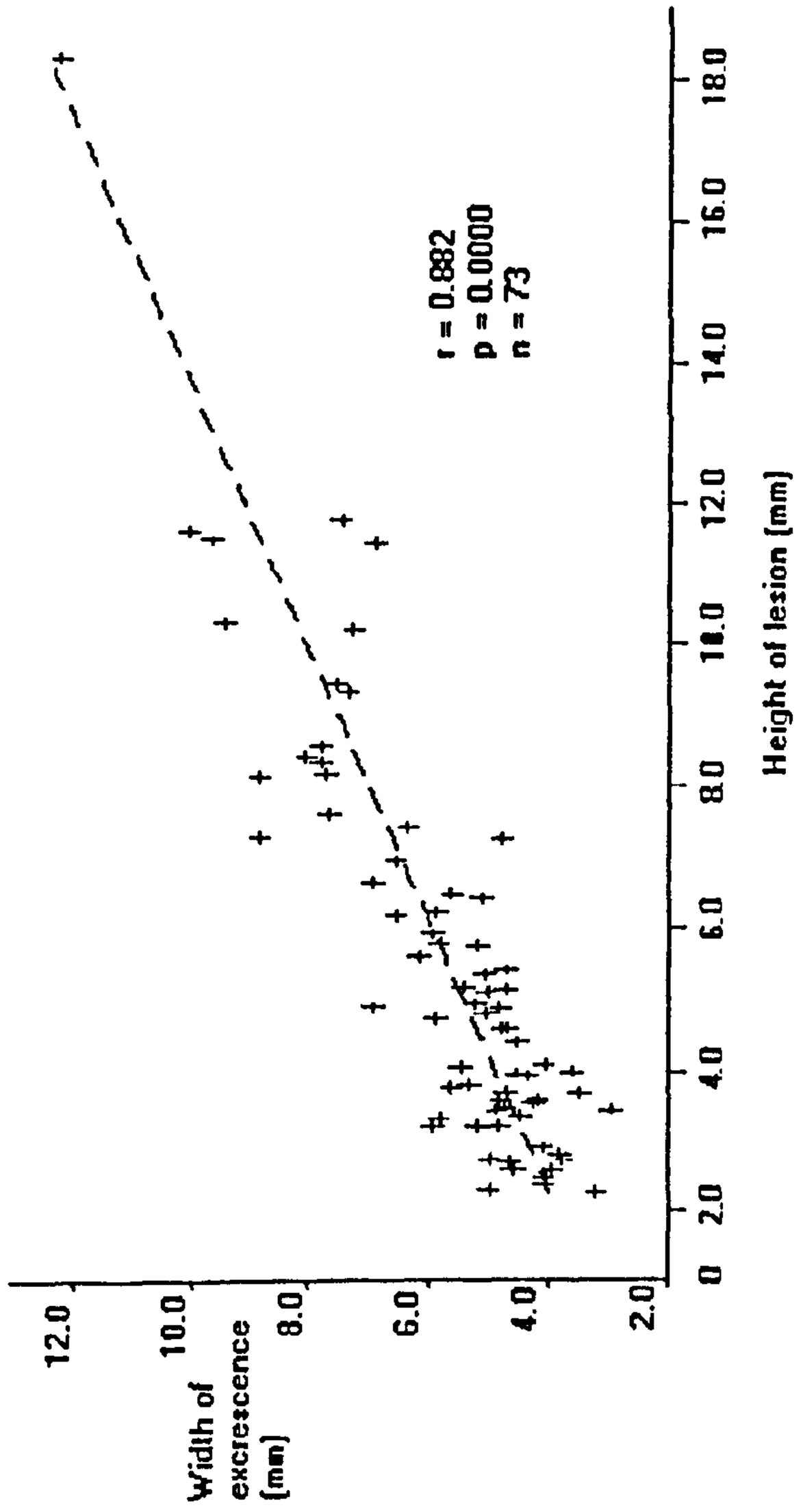


Fig. 6.26

North Ronaldsay humeri

Dimensions of lateral osteophytes



CHAPTER 7

STUDIES OF THE PATHOLOGY OBSERVED IN SHEEP IN TWO ARCHAEOLOGICAL ANIMAL BONE ASSEMBLAGES

This chapter is concerned with the identification and analyses of pathological manifestations in archaeological sheep from two very different faunal assemblages. As with the chapters on canid pathology, no claims are made for the straightforward extrapolation of inference from comparative to archaeological material. It is the ethos of the methodology, the validity of the quantification of observations, and the variety of interpretation that is suggested as meaningful.

The material from the Late Bronze Age site at Fiave-Carera, where the entire collection of sheep remains were made available for the study, is in an excellent state of preservation having been recovered from the waterlogged deposits of lake dwellings, and the degree of fragmentation is very low. In contrast, the group, of medieval sheep from Winchester, derives from a series of urban excavations with a much higher degree of fragmentation and lower preservation quality. In this case all the sheep limb elements were submitted for this study.

It was also noted that the Winchester sheep assemblage contained a number of horncores exhibiting depressions in the basal region. The consistency of presentation of this anomaly offers an opportunity to apply the kind of quantitative methodology developed in this thesis, and so these are also described in this chapter.

In addition to the sheep remains from Winchester, all abnormalities observed by the various contracted workers in any species were presented for further examination. The material from Winchester thus gave an excellent opportunity to demonstrate the difference between the results obtained through the methods propounded in this thesis, and those which might be available by more traditional methods. The section on the Winchester assemblage therefore expands its realm of interest to encompass all referred specimens in addition to the particular species under study (*Ovis*). The aim is to illustrate the

proposal that abnormalities have far less interpretative potential when reported in isolation than they do when viewed as occurrences within the whole species representation.

A) MEDIEVAL SHEEP - A SURVEY AND ANALYSIS OF THE PATHOLOGICAL LESIONS EXHIBITED IN AN ARCHAEOLOGICAL ASSEMBLAGE FROM WINCHESTER

Animal remains recovered in medieval deposits from Victoria Road, Henly's Garage, St. Johns Street and Chester Road, Winchester (Serjeantson, in prep.), were made available for this study by two routes. All the sheep limb bones and horn cores were passed in entirety to the writer; all other elements and species were presented only where already identified as pathological by the contracted analysts. This section can therefore demonstrate two methods of reporting, the holistic and more quantitative approach which is the underlying argument to this thesis, whereby the pathologies are presented within the structure of a full metrical analysis, and the traditional, purely descriptive catalogue of those remains which are visually anomalous without the aid of a microscope.

i) Arthropathic lesions in the limbs of the sheep

As described in Chapter 6, sheep appear to be uniquely susceptible to a particular condition of the humero-radial joint wherein an osteophyte of consistent morphology develops on the lateral distal humerus and proximal radius. In its mature form this exostosis is easily recognisable in archaeological material, even where the osteophyte has become broken or abraded post-mortem. It has been reported in material from Northampton, North Elmham Park, Barnsley Park, and Aikerness (Baker & Brothwell 1980), and commented on as being present in all levels at Winchester (Baker, unpub.). It has been noted by the writer in material from a 17th century pit at Tunsgate, Arundel. In modern animals it is recorded in the island populations of St. Kilda (Clutton-Brock et al 1990) and North Ronaldsay (see Chapter 6), and has been observed in bones from Welsh mountain sheep (Hamilton-Dyer pers. comm.). Its appearance in this Winchester assemblage (Plates 7.1 and 7.2) is discussed here within the general arthropathic background of the sheep limbs.

Traditionally the explanation for the anomaly is that it is a consequence of a trauma sustained when animals are put through races or pens - hence the common term "penning elbow". Recent work suggests that it may also be related to the environment and that repeated minor shocks, such as might be experienced through moving repeatedly over rocky ground, may produce the same lesion. The condition has not been recorded in either modern or archaeological goat, and yet it is not uncommon in sheep. The osteological morphology of the elbow joint is distinctive between sheep and goat - in goat the medial epicondylar area of the humerus is more developed, and the trochlea as a whole has a slightly more posterior presentation. In the proximal radius, the lateral tuberosity is more pronounced in sheep. Although these features have not as yet proved susceptible to metrical differentiation, they may possibly have a bearing on why sheep develop an exostosis under stress in the lateral elbow joint and goats do not.

In the humerus the lesion presents as a broadly based osteophyte on the dorsal part of the periphery of the capitulum, which develops in the ventral direction. In the centre of the basic exostosis a secondary, narrower excrescence erupts. In the radius, the osteophyte appears on the lateral tuberosity and develops dorsally. The morphology of the lesions is consistent in all specimens and at all stages, and is measurable. The points of departure of the exostosis from the normal bone are visible as changes in angle accompanied by a line of vascularisation.

The areas of origin of the osteophytes in both the distal humerus and the proximal radius are the sites of attachment of the lateral collateral ligaments of the elbow joint. Ligaments have very limited elasticity, and osteoblastic activity can be generated by stresses at their attachments where their structure penetrates the periosteum and enters the underlying bone. This stimulation of the sub-periosteal obsteoblasts causes the development of bony nodules, which will build up as long as the stresses are maintained.

The aetiology of the lesion therefore presents a problem; it may be a single or occasional trauma such as collision which initiates the bony development, or it may be a long period of minor action on that joint for which the animal has not adapted.

This was illustrated and discussed in Chapter 6, and it produces a dilemma for the consideration of archaeological material. Challenging the neat and reiterated explanation of agricultural practice as the exclusive cause of an identifiable abnormality, and suggesting that it may also be the result of enviromental factors, rather undermines the value of the lesion as a husbandry indicator. As, to date, the only interesting property of the abnormal elbows has been their perceived association with pens, Chapter 6 might be seen as having a rather negative impact on the interpretative value of pathology.

Here, once again, it is necessary to reiterate the underlying principle of the research design. Looking at lesions in isolation and pegging them directly to modern veterinary diagnoses will inevitably invoke a modern translation. In many cases these interpretations may be right, but in an unknown number of instances they may be partial, or wrong. Identifying the human factor in animal pathology is straightforward in our current society where the degree of human management is high and the other parameters are visible and understood. Pathology will represent a response to stress, but the permutations of stress impingeing on the archaeological animal may be very different. Animal palaeopathology is not a highly developed discipline, but in many ways has already fallen into the equifiniality trap. It tends to use abnormalities to identify circumstances, when in fact the lesions can only be interpreted fully if the circumstances are known. Chapter 6, by suggesting that factors other than direct human influence may be responsible for osteophytic elbows in sheep, tries to cut the circular argument. It emphasises that the proportion of stressed sheep in a group might be more interesting, comparatively, than the possibly erroneous identification of a particular practice on the basis of one lesion.

In this light, the thesis argues for the premise that any condition observable in bone should be analysed within the background of the normal elements in the specific assemblage, and should also acknowledge all other recognised osteological anomalies in that species within the periods under review. Indeed, for rural assemblages there is an argument for considering the anomalies of all species together, in that conditions may combine to produce comparable inter-special pathological patterns.

The sheep from the Winchester Suburbs

In the case of the sheep from the Winchester Suburbs all pathological circumstances were recorded from selected joint surfaces of limb bones - distal humerus, proximal radius, distal metacarpus and distal metatarsus. Within the dated sub-samples, 10th to 17th centuries, the 16th century predominates, but no group is of appropriate size for any statistical analysis or even percentage expressions. The observations are all therefore presented as unprocessed data, i.e. either as absolute numbers of specimens or derived minimum numbers of individuals.

Table 7.1 shows the minimum number of individuals per phase as estimated from elements, and the minimum number of animals which exhibit an arthropathic anomaly other than the humero-radial lateral exostoses. Only complete, fused articular ends were studied, so the total MNI figure is not necessarily the same as that from the assemblage as a whole. This can therefore be considered an "arthropathic background" against which the more particular lesion can be viewed.

Table 7.1
Winchester sheep: MNI represented by limb elements: Arthropathies other than humero-radial lateral exostoses

Date	Phase	Humerus		Radius		Metacarpal		Metatarsal	
		Total	Arthro	Total	Arthro	Total	Arthro	Total	Arthro
10C	VR529	5		3		1	1	1	
	VR530	1		2	1			1	1
	VR532			1		3		3	2
	HG29	4	1	10	4	4	1	2	1
13C	SJS16	1				1	1		
13-14C	VR616	1							
	VR635	1		4		3		2	1
	VR637	1	1			1		1	1
	HG20	2		1					
	CHR53	4	2	4	1	3	2	1	1
14C	SJS30	2		3		1		2	
	VR700	2		1		2	1	2	
14-15C	VR792	1	1						
	VR685			1					
16C	VR763	12	3	17	4	9	2	10	4
	SJS49	9	1	13	1	6	2	5	1
17C	CHR56	15	1	5	2	6	2	3	2

In the metapodia, these other lesions are predominantly what appear to be incompetences of the subchondral bone. They appear as splits or fissures in the articular surface, or as more rounded depressions. They are almost certainly due to some stress on or in the joint (Brothwell pers. comm.) but they rarely occur in association with other manifestations and are probably sub-clinical. The linear lesions are always aligned in the plane of joint movement and occur most commonly at the articular margins, although some do appear close to the saggital ridge.

Tables 7.2, 7.3, 7.4 and 7.5 set out the positions of these lesions in relation to the facies and facets of the metapodial articular surfaces. Some preferential locations are apparent, particularly the lateral aspects of the metatarsal joint surfaces, and the medial distal metacarpal.

Table 7.2
Winchester sheep: Proximal metacarpal: Expressions of subchondral incompetence

Date	Facet		Site					Arthropathic expression
	Lat	Med	Lat	Med	Ant	Post	Cent	
10C		*	*			*		Fissure
13-14C	*			*				Fissure
		*		*	*			Depression
16C	*			*				Fissure

Table 7.3
Winchester sheep: Distal metacarpal: Expressions of subchondral incompetence

Date	Facet		Site					Arthropathic expression
	Lat	Med	Lat	Med	Ant	Post	Cent	
10C		*	*			*		Fissure
		*	*					Fissure
13C		*		*		*		Fissure
13-14C	*		*			*		Fissure
14C		*					*	Fissure
16C		*					*	Fissure
		*	*			*		Fissure
		*					*	Fissure
	*					*	*	Fissure
17C	*	*				*	*	Fissure
		*		*			*	Fissure
		*					*	Fissure

Table 7.4
Winchester sheep: Proximal metatarsal: Expression of subchondral incompetence

Date	Facet				Site					Arthropathic expression
	Lat	Med	LP	MP	Lat	Med	Ant	Post	Cent	
10C	*				*			*		Fissure
	*				*			*		Fissure
	*		*					*		Fissure
	*					*				Fissure
	*								*	Depression
16C		*				*				Depression
	*	*	*		*	*				Fissure/depress
	*				*			*		Fissure/depress

Table 7.5
Winchester sheep: Distal metatarsal: Expression of subchondral incompetence

Date	Facet				Site					Arthropathic expression
	Lat	Med	LP	MP	Lat	Med	Ant	Post	Cent	
10C		*			*					Fissure
	*				*			*		Fissure
	*							*		Depression
	*					*				Fissure
13-14C	*					*	*			Fissure
		*			*			*		Depression
	*					*		*		Fissure
16C	*	*			*	*				Depression
	*				*		*			Fissure
	*					*	*			Fissure
	*					*		*		Fissure
	*					*		*		Fissure
	*					*				Fissure
		*							*	Fissure
	*					*				Fissure
17C		*				*				Fissure
		*				*		*		Fissure

LP = Lateroplantar MP = Medioplantar

In the humerus, lesions other than lateral exostoses again appear mainly as splits in the subchondral bone, usually on the medial facet. In the radius however the splits are absent although depressions in the articular surface do occur. In this element the most common lesion, apart from the lateral osteophyte, is extension of the proximal articular surface, predominantly at the medial margin of the medial facet.

Table 7.6 presents the occurrence of the lateral humero-radial lesions within the minimum numbers represented by each of these two elements.

Table 7.6
Winchester sheep: MNI represented by limb elements: humero-radial lateral exostoses

Date	Phase	Humerus		Radius	
		Total	Exostosis	Total	Exostosis
10C	VR529	5		3	
	VR530	1		2	
	VR532			1	
	HG29	4		10	1
13C	SJS16	1			
13-14C	VR616	1			
	VR635	1		4	
	VR637	1			
	HG20	2		1	
	CHR53	4	1	4	1
14C	SJS30	2		3	1
	VR700	2		1	1
14-15C	VR792	1			
	VR685			1	
16C	VR763	12	3	17	2
	SJS49	9	3	13	4
17C	CHR56	15	1	5	

Two clear inconsistencies in the data warn against making substantive comments. Firstly, the discrepancy between MNIs derived for the same phase from different elements, arising mainly, although not entirely, from the under-representation of the metapodia. This will affect the arthropathic profile negatively in that the distal limbs appear more susceptible to sub-clinical arthropathies as demonstrated in Chapter 6. The real "background" arthropathy is therefore likely to be substantially higher than indicated in Table 7.1. Secondly, the imbalance of the phase group numbers precludes justifiable comparisons.

Taking the dated groups more broadly, however, the sample sizes become more compatible as shown in Tables 7.7 and 7.8. At this coarse level - very small sample sizes and large sample periods - it is possible to make some very general observations. The relationship of the number of arthropathic individuals to the group totals is reasonably consistent, with the metapodia suggesting a higher incidence, which is as expected. The 16th and 17th century humeri and radii are relatively low in arthropathic lesions, but not in lateral exostoses.

Table 7.7
Winchester sheep: Summary MNI: Distal humerus & proximal radius

Date	MNI		
	Total	Arthropathic	Lateral exostoses
10th century	16	5	1
13th "	1)	1)	)
13-14th "	9) 15	3) 5	1) 4
14th "	4)	)	2)
14-15th "	1)	1)	)
16th "	30	5	7
17th "	15	2	1

Table 7.8
Winchester sheep: Summary MNI: Metapodia

Date	MNI	
	Total	Arthropathic
10th century	9	5
13th "	1)	)
13-14th "	7) 11	4) 5
14th "	4)	1)
14-15th "	)	)
16th "	16	6
17th "	6	2

Metrical analysis

Turning now to the dimensional analysis of the articulations under review, once again the imbalance in sample size mitigates against statements made on observation of variation. However, the form of the distal humerus, as shown in simple bivariate terms in Fig. 7.1, suggests that perhaps the 16th century group is less homogenous morphologically.

Figs. 7.2 and 7.3 show the absolute and cumulative distributions of the distal humeral articular width, Bt (von den Driesch 1976), suggesting a trend over time towards a more slender elbow. There is no statistical significance between groups on any absolute measurements or derived ratios for the humerus or radius. This suggests that any trend in the articular width indicates a slight difference in type and not a significant morphological variant.

Figs. 7.4 and 7.5 illustrate the cumulative distributions of certain metrical determinants for which it is possible to present statistical results, albeit at the bottom end of justifiable sample size. The distal

metapodia were susceptible to parametric analysis on at least one component at a significance level of 5%, although a 1% level would be more satisfactory on these sample sizes. For the metacarpal there is a significant difference between the pre-16th century group and the later material in the relationship of the medial trochlea to the intertrochlear incisor. The relative width of the incisor is greater in the later group. There is, however, no significance in the absolute width of the incisor for the metacarpal. For the metatarsal, on the other hand, it is the absolute width of the incisor which is significant - the width is greater in the 16th and 17th century material.

Again, this suggests that there is a slight shift in type, but that shift would not be apparent as a physiological anomaly, and certainly would not be visible in terms of gross size.

To summarise, it appears that there is a minor but significant difference in the joint morphologies of the later sheep. However, it is likely that the heterogeneity of the 16th and 17th century flock, compared with the earlier animals, is possibly the greater factor, based on the very limited data available here.

The arthropathic evidence does not contravene this view. There is no group of specimens, either by phase or by period, which suggests any extreme of age or husbandry. On the basis of comparative studies described in this thesis the arthropathic load of a normal population of this species, as represented by fused epiphyses, might be expected to be around 30-40%, and this is the proportion displayed by this Winchester assemblage. Certainly (if the lateral exostoses of the humero-radial articulation are excluded) there are no manifestations at any period of clinical age-related arthropathy. The exhibited lesions, apart from these particular anomalies, are those of deficiencies in the subchondral bone which were likely to have been apparent as fibrillations in the articular cartilage but which did not produce any incapacity in the animal under the conditions in which it was maintained.

As far as these exostoses of the elbow joint are concerned, the observations of Baker and Brothwell (Baker & Brothwell 1980) are confirmed - that the lesions do occur at all levels at Winchester. What this study establishes, however, is their frequency. The results suggest that in the groups from the 10th to 15th century the arthropathic background is fairly stable, as is the occurrence of the humero-radial exostosis. In the 16th and 17th centuries the background diminishes, but not the incidence of the humero-radial lesions; this coincides with a greater morphological heterogeneity. Although these samples are too restricted for any conclusions to be drawn, there is no reason why they should not form the basis for a hypothesis which could be tested if the same procedures were carried out on other comparable sites, and the results pooled. A simple, and very tentative, hypothesis therefore might be that the 16th and 17th century flock comprises a greater variety of type, is slaughtered at an earlier age, but is maintained in circumstances which produce the same pathological response. This could mean that the animals of all periods originate in a similar environment, are subjected to the same management stresses, or at any point in the timespan one causal factor is replaced by another. This is the pivotal point; it is not the appearance of the individual gross lesion which is indicative, but the variation in frequency of the condition. Therefore, although this sample is too small to investigate the hypothesis further, the benefit in recording all instances of the arthropathies is clear. Any significant variation in the frequency of this type of mechanically derived condition will probably indicate an change in the extrinsic stresses imposed on the animal because multiple causal factors should produce a higher incidence of the condition.

A further relevant observation is that, on the limited evidence available here, advanced lesions occur in all periods. Table 7.9 presents the measurements of the osteophytes. In this assemblage there can be no argument that where the condition has occurred, it has been able to progress to maturity.

Table 7.9
Winchester sheep: Dimensions of humeral osteophytes

Date	Distal width	Distal width inc. lesion	Height of lesion	Width of lesion	Width of excresence
13-14 C	28.6	29.1	1.9	7.6	1.4
16 C	26.5	27.6	1.9	8.9	2.4
	28.1	28.6	2.7	7.7	3.4
	27.7	28.8	2.2	8.3	
	28.5	29.7	1.7	6.1	3.2
	29.1	30.6	3.3	9.8	4.0
	29.1	31.6	5.3	7.0	4.1
	29.1	31.9	4.6	10.7	7.1
	31.5	32.6	3.3	8.6	3.9
	30.9	37.8	5.5	12.1	9.5
17 C	28.6	29.5	3.9	10.0	2.9
	29.9	32.6	5.0	10.2	7.6

Metrical comparison

Analyses of the metrical data have produced no justifiable relationships between the dimensions of the distal humerus or proximal radius and the occurrence of lateral exostoses. In this assemblage there are no grounds for saying that there is a susceptibility to this condition in the conformation of either the distal humerus or the distal radius. There is no observable concurrence between period and incidence, or between period and severity. Although the animals of the 16th century appear to have a minor variation in the limb joint morphology, this is not reflected in the arthropathy. Overall, this assemblage from the Winchester Suburbs has not produced evidence to contradict the view traditionally expressed by archaeozoologists on the basis of Baker and Brothwells' opinion (Baker & Brothwell 1980), that the lateral osteophytes of the elbow joint in sheep are due to an osteological reaction to trauma. But whether such injuries are sustained by collision with pens or races is still an open question as we have, as yet, no independent knowledge of the extent of use of pens at any period.

The results of work on the larger body of comparative material reported in Chapter 6 indicates that the incidence of these humero-radial lesions may be as much a result of environment, joint morphology, and possibly age, as it assumed to be of human management. As far as possible, the parameters of morphology and age have been addressed for Winchester insofar as they can be

defined by metrical analysis and the application of fusion sequence data. As with many assemblages covering this timespan, the question of environment cannot be addressed directly because the size and range of environments in the catchment area in which the sheep were raised is not known with certainty.

However, although no substantiated conclusions on the arthropathic condition in general, or the pathology of the elbow in particular, can be drawn from such a small sample covering so many centuries, it is possible to be explicit about two of the observations.

a) Compared with the large feral population described in Chapter 6, the overall arthropathic load carried by the Winchester sheep is similar, although it does decrease in the 16th and 17th centuries. This decrease may be a result of earlier slaughter, or it may be associated with the apparent variety of joint morphology in these later periods. Such variety might indicate an expansion of the gene pool with a consequent improvement in the skeletal conformation.

b) Humero-radial osteophytes developing from the ossification of the lateral colateral ligament, popularly known as "penning elbow", occur regularly over the seven centuries. On this timescale, and particularly in the light of the results reported in Chapter 6, there is no basis for identifying this lesion as a traumatic injury originating in human activity alone. However, the consistency of its appearance suggests that, in a sufficiently large sample, a significant positive variation in its frequency would be apparent where such an extrinsic stress was applied.

To summarise therefore, the so-called "penning elbow", as an accepted manifestation of animal management, does not fulfill our traditional expectations as an indicator of particular husbandry techniques when subjected to quantitative analysis, either in comparative or in archaeological material. As previously emphasised, this is not to say that close shepherding will not instigate the condition. What needs to be recognised is that human influence may only be recognised in the fluctuations of the appearance of this

anomaly, and not in the singular observation of one or two highly developed osteophytes per assemblage.

ii) Anomalous depressions in the basal region of the sheep horn cores

This section discusses and analyses a particular pathological anomaly of the horncores of sheep, and whilst no comparative study on horncores has been presented in this thesis, this is an opportunity to apply a quantitative approach to a commonly encountered condition.

Anomalous "thumbprint" sized depressions have been reported in sheep horncores since 1959 (Polloth 1959). These depressions are clearly visible to the naked eye, but do not appear to disrupt the natural development and orientation of the matrix.

Polloth attributed the condition as seen in the Manching material to castration, but subsequent observations in modern ewes have revised the aetiology to malnutrition. Indeed, amongst Hirta and mainland Soays, the anomaly is only found in ewes (Clutton-Brock et al 1990 and U. Albarella pers. comm.).

Both Hatting (Hatting 1975) and Clutton-Brock (Clutton-Brock 1990) have demonstrated that the core walls of females are thinner than those of males, and the cavities are more extensive, which may make them more vulnerable to deformation. This is, however, also true of wethers, particularly where castration takes place early. Clutton-Brock considers that the horncores of female sheep can respond to malnutrition or depletion of essential nutrients during breeding or lactation with a regression in growth, or loss of bone from the horncores, producing the "thumb print". The implication may be, therefore, that the underlying factor in the development of the anomaly is hormonal acting upon a secondary sex characteristic. Alternatively or additionally, a deficiency of Vitamin D - as might occur where only poor quality winter fodder is available - will inhibit uptake of calcium; this may have an effect on ewes which lamb in years where a late spring follows a cold winter, and the spring flush

is delayed. The appearance of the anomaly may therefore be stress related, and may have a useful bearing on the circumstances surrounding the maintenance of ewes.

Horncores of sheep from the Winchester Suburbs were examined for the presence of these anomalous indentations. Similar anomalies have been noted and discussed in both archaeological and modern material by Hatting (Hatting 1975) and Clutton-Brock (Clutton-Brock et al 1990), and in archaeological material only by Polloth (Polloth 1959) and Clason (Clason 1977).

The condition presents as shallow lacunae usually in the basal half of the core and situated on the flatter medial face (Plate 7.3). The perimeters of the depressions are poorly defined and usually integrate smoothly into the normal plane of the core. They are therefore difficult to measure, but are the area of a small thumb print.

Table 7.10
Winchester sheep: Occurrence of lacunae in horncores

Site	Date	Phase	Breadth	Depth	Ratio	Lacunae
HG	10 C	29	55.7	40.5	1.38	0
HG		29	36.7	25.3	1.45	0
HG		29	31	23.4	1.32	0
HG		29	37.7	25.9	1.46	0
VR		529	31.4	20	1.57	0
VR		529	24.6	24.2	1.02	0
VR		530	34.7	24.2	1.43	0
VR		530	29.3	17.5	1.67	0
VR		530	42.5	28.5	1.49	0
VR		530	30.4	21	1.45	1
VR		530	35.1	22.1	1.59	2
VR		530	38.7	25.8	1.50	3
VR		532	29.6	20.5	1.44	0
SJS	13 C	16	44.3	36	1.23	0
SJS		16	37	22.1	1.67	0
SJS		16	33.6	23	1.46	2
HG	13-14 C	20	26.5	19.7	1.35	0
VR		635	20	11.9	1.68	0
VR		637	29.5	20.4	1.45	0
VR		637	49.1	39.4	1.25	0
VR		637	26.3	19.3	1.36	0
VR		637	31.6	19.9	1.59	1
VR	16 C	763	27.2	19.3	1.41	1
VR		763	28.8	22.8	1.26	1
VR		763	22.5	16.6	1.36	2
SJS		49	33.3	23.2	1.4	2
SJS		49	33.9	21.3	1.6	2
SJS		49	38.3	23.5	1.6	1
CHR	17 C	56	35.6	22.6	1.58	1

The Winchester Suburbs have produced 29 measurable sheep horncores from 10th century to 17th century contexts. The measurements for these are the latero-medial breadth and the oro-aboral depth (von den Driesch 1976), and these are summarised in Table 7.10 together with the occurrences of lacunae. The specimen from VR530 with three depressions actually presented two on the medial face and the third on the lateral.

The breadth:depth ratio is calculated to express the range of cross-sectional morphology of the cores between round and D-shaped. Distribution across this range is shown in Fig. 7.6 for the 10th century group, 13th and 13-14th century, and 16th and 17th century. It is interesting to see that all the cores of the 16th and 17th century exhibit these anomalies, but they are only visible in 5 of the 22 specimens prior to the 16th century.

Fig. 7.7 shows the pattern of anomalous horncores within the ranges of the two dimensions. There is clearly no morphological difference between normal and abnormal cores, but the abnormality has not occurred in the few cores which are significantly larger. This would conform to the observations in present-day Soay sheep of Albarella (Albarella in prep.) and Clutton-Brock (Clutton-Brock et al 1990); thumbprints in horncores only occur in ewes. In Section B of this chapter this argument is developed further with the horncores from Late Bronze Age Fiave-Careras in Northern Italy.

iii) Specimens referred by contracted analysts for further examination

This section demonstrates the results, and their serious limitations, that can be achieved by the traditional method of referral "for further study". Notwithstanding the care taken in identifying anomalies in the assemblage, or the detail of subsequent examination, the value of the pathological description is highly compromised by the lack of the supporting data.

This catalogue is presented by period, location and phase, but does of course only discuss material already assessed by three independent analysts as being of pathological interest. In order to produce a coherent summary for each period, the anomalies have been assigned as arthropathic, infective, traumatic or congenital, and each period is prefaced with this tabulated summary.

a) 10th Century AD

Table 7.11
Winchester: 10th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
10 C						
530	Cattle	Rib		*		
		Mcar p		*		
		Pelvis	*			
	Sheep	Mand		*		
	Dog	Tibia	*			*
29	Cattle	Phal 1		*		
		Phal 1			*	
		Pelvis		*	*	
		Mtar p	*			

VICTORIA ROAD

PHASE 530

Cattle:

There are two instances of infective or aggravated conditions. A rib (Context 3136) had a proliferative lesion of the head and tubercle which extended onto the neck. The lateral articular surfaces of the tubercles were destroyed, and the articular surface of the head was lifted.

In Context 3170 the proximal end of a left cattle metacarpal showed either a septic arthritis, or an osteomyelitis exuding through the subchondral bone. Four sinuses on the posterior aspect of the articular surface were accompanied by periarticular exostoses anteriorly, medially and laterally. There was mild eburnation of the lateral edge of the lateral facet.

The acetabulum of a cow (Context 3441) was eburnated at the perimeter of the articular surface adjacent to the pubis. This is probably associated either with age or poor conformation.

A single dental anomaly was presented from Context 3174 with the loss of a left mandibular P2, the alveolus being filled normally.

Sheep:

A left mandible in Context 3039 had lost M3. The alveolus was filled, but the jawbone recession indicates that an infection had been overcome.

Dog:

Context 3174 produced a bowed left tibia from a dog with an estimated shoulder height of about 29.5 cm (Harcourt 1974). The bowing is almost certainly congenital rather than the result of an osteodystrophic condition such as rickets. The proximal articulation had periarticular exostoses, most developed antero-medially, and eburnation of the intercondylar eminance. Pitting of the medial surface of the medial condyle suggests an early inflammatory arthritis. The soft tissue ossifiation on the medial malleolus indicates that this was a mature dog.

HENLY'S GARAGE
PHASE 29

Cattle:

A 1st phalanx from Context 827 had proliferative reactive bone extending from the lateral palmar/plantar tuberosity into the distal epiphysis, with extension of the articular surface of the anterior distal trochlea. The same context produced another 1st phalanx with an aggravated, probably stress-related, lesion in the form of a deep linear depression in the central distal lateral trochlea, 6 mm in length.

A right cattle acetabulum in Context 831 had sustained a fracture of the dorsal portion of the subchondral bone. This had healed, but with a subsequent inflammation which produced a lesion cranial of the ischiatic tuber with a draining sinus.

Also in Context 831 a proximal right metatarsal had periarticular exostoses anteriorly, probably an age-related manifestation.

Sheep:

Four sheep ribs from Context 877 were presented with pitted indentations below the neck. Further examination suggests that these are juvenile, and the indentations are the site of the insertion of *M. Levatores costarum*, a muscle that is part of the breathing mechanism, which become small tubercles in the adult animal.

b) 13th Century AD

Table 7.12
Winchester: 13th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
13 C 13	Cattle	Phal 1	*	*		

ST. JOHN'S STREET

PHASE 13

Cattle:

The single anomaly referred from this period is a cattle lst phalanx from Context 194, with pitting and bony proliferation of the proximal epiphysis, anteriorly and medially. This is accompanied by extension of the articular surface of the anterior distal trochlea. This may be an early arthropathy of the distal articulation induced by an infection or aggravated soft tissue injury of the fetlock joint.

c) 13-14th Century AD

Table 7.13
Winchester: 13-14th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
13-14 C 616	Cattle	Ulna p		*		
635	Cattle	Carpal		*		
783	Dog	Maxilla				*
29	Cattle	Phal 1 Phal 1	 *		* *	
53	Cattle	Pelvis Phal 1 Mtar d Rib	 *	* * * *		
	Sheep	Tibia Radius		* *		

VICTORIA ROAD

PHASE 616

Cattle:

The proximal portion of a left calf ulna (Context 499) had been extensively gnawed post-mortem. However, immediately above the proximal interosseous space it was possible to identify a portion of a proliferative inflammatory lesion. The flaring of the bone on the medial edge of the trochlear notch suggests the lesion extended at least mid-way into the notch, and on the lateral side, just proximal of the coronoid process, is a draining sinus. The animal was probably sustaining an active osteomyelitis close to or within the elbow joint at the time of death.

VICTORIA ROAD

PHASE 635

Cattle:

A left ulnar carpal bone from Context 3886 had an infective lesion in its lateral surface with small draining sinuses.

VICTORIA ROAD
PHASE 783
Dog:
In Context 1218 was a canid skull with teeth fully in wear but with the cranial sutures visible suggesting that the animal was mature but not elderly. The left P1 was missing, with the alveolus filling. The animal had the probable congenital anomaly of a supernummary caudal right molar tooth.

ST. JOHN'S STREET
PHASE 29
Cattle:
Context 290 produced two cattle lst phalanges which probably derive from at least one aged individual.

The first had well developed palmar/plantar tuberosities, but the development was assymetrical in that the medial was more pronounced. The distal articular surface was extended on the antero-medial trochlea, and there was bony development on the medial and lateral distal epiphysis at the sites of attachment of the collateral ligament and axial bands.

The second exhibited some soft tissue ossification on the lateral palmar/plantar tuberosity. Distal to this there was pitted and reactive bone on the lateral and anterior epiphysis which extended onto the anterior articular surface. The sites of the attachment of the collateral ligament with highly developed, with soft tissue ossification, and the central articular surface of the distal lateral trochlea was eburnated.

CHESTER ROAD

PHASE 53

Cattle:

The lesions referred from this phase are predominantly infective. The first, a right acetabulum from Context 145, has an area of pitted bone on the ventral pubis which probably indicates a periosteal infection.

A cattle 1st phalanx in Context 108 has a proliferative reactive lesion on the proximal epiphysis which is most severe anteriorly and medially. The pitting and proliferation are also visible on the lateral aspect of the diaphysis, extending into the distal epiphysis which has small draining sinuses anteriorly. This bone also has arthropathic lesions which may not be related to the infective. The distal medial trochlea has a raised islet in the subchondral bone with the start of detachment anteriorly; and the distal lateral trochlea has a circular depression about 1 mm in diameter. It is possible that these are manifestations of the condition of *Osteochondritis dissecans* in the interphalangeal joint. This is generally acknowledged to be a stress-related condition consequent upon repeated joint shock.

Also in Context 108 was a distal left metatarsal where the lateral condyle was deeply grooved in the plane of movement, the grooves extending laterally from the intertrochlear notch to the sagittal ridge. There is highly developed soft tissue ossification at the site of attachment of the lateral collateral ligament of the fetlock joint, and distal to this the bone is pitted and disorganised and is probably infected; unfortunately abrasion of the bone makes it impossible to be more precise. The perimeter of the anterior articular surface exhibit clefts, but these may well be congenital defects.

The remaining bovine lesion comes from Context 65 and is probably a healed periosteal infection of the medial side of a rib. The lateral side - that which is more susceptible to extrinsic forces such as bruises - is normal.

Sheep:

Two contexts produced sheep elements with inflammatory conditions. Context 59 had the right tibia of a juvenile sheep with an inflammatory lesion on the medial diaphysis. This extended 16 mm distally from mid-shaft. A right radius from Context 145 had a healed periosteal lesion, also on the medial diaphysis, and extending 10 mm distally from mid-shaft.

d) 14th Century AD

Table 7.14
Winchester: 14th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
14 C						
700	Cattle	Phal 2	*			
	Sheep	Mand		*		

VICTORIA ROAD

PHASE 700

Cattle:

A second phalanx in Context 284 with articular extension proximo-laterally indicates the presence of a mature animal.

Sheep:

A left mandible has a healed minor infection below M1 lingually.

e) 14-15th Century AD

Table 7.15
Winchester: 14-15th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
14-15 C						
792	Pig	Mtar IV		*		
	Sheep	Mand				*
		Mand				*
		Mand		*		
		Mand		*		*

Referred material for this period included no cattle remains.

VICTORIA ROAD

PHASE 792

Pig:

A left 4th metatarsal from a juvenile animal (Context 858) has a swollen diaphysis in the anterior-posterior plane, with pitting of the bone and a small draining sinus posteriorly. This is likely to indicate an osteomyelitis.

Sheep:

The anomalies for this species are all dental and contained within Context 860.

A left mandible exhibited over-wear of M1, and another left mandible showed under-wear of P3 and P4. A right mandible had over-wear of caudal P4 and M1, with the M1 broken longitudially and with a cavity in the caudal portion and jawbone recession lingually. Another right mandible also had M1 broken with a cavity buccally; this animal also had a congenital absence of P2.

f) 15th Century AD

Table 7.16
Winchester: 15th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
15 C 756	Sheep	Tibia d	*			

VICTORIA ROAD

PHASE 756

Sheep:

The only referral from this period is a right sheep tibia from Context 952 with fusion of the distal tibia with distal fibula - this is probably an indication only of age and not disease.

g) 15-16th Century AD

Table 7.17
Winchester: 15-16th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
15-16 C						
763	Cattle	Mtar p	*	*		
		Mtar p	*			

VICTORIA ROAD

PHASE 763

Cattle:

The proximal end of a left metatarsal in Context 3025 had a circumferential linear incompetence of the anterior margins of the medial and lateral facets. These were more noticeable in the lateral facets where the anomaly extended further into the articular surface and was accompanied by eburnation. The antero-lateral aspect of the bone of the epiphysis was pitted and disorganised, and suggested the presence of inflammation.

A proximal right metatarsal from Context 3001 had periarticular bony development anteriorly and medially, with a highly developed medial tuberosity. These manifestations are almost certainly age-related.

h) 16th Century AD

Table 7.18
Winchester: 16th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
16 C						
49	Cattle	Mcar d	*			
		Mtar p	*			
		Mtar p	*			
		Phal 1	*			
		Phal 1	*			
		Phal 1	*			
		Phal 1	*			
		Phal 1	*			
		Phal 1	*			
		Phal 1	*			
		Phal 1	*	*		
		Phal 2	*			
	Pig	Mtar III	*			

ST. JOHN'S STREET

PHASE 49

Cattle:

In Context 319 were three elements with mild but notable anomalies. A right metatarsal had slight bony development at the medial edge of the proximal articular surface, and also a narrow linear fissure and adjacent depression at the medial periphery of the medial articular facet. A 1st phalanx exhibited articular extension and remodelling of the distal anterior trochlea, and a 2nd phalanx had an islet in the subchondral bone of the postero-medial aspect of the distal medial trochlea.

Context 330 also produced a proximal right metatarsal with bony periarticular development medially and laterally, and again exhibited parallel fissures at the margin of the articular surface medially. A 1st phalanx had extension of the proximal articular surface antero-laterally, with a cleft, probably congenital, in the proximal articular surface at right angles to the margin. Another 1st phalanx had mild periarticular exostoses anteriorly.

In the same context the distal portion of a right metacarpal had fissure, islets and detachment of the articular surface on the medial aspect of the medial condyle - a manifestation of stress involving the articular surface and subchondral bone alone, and possibly another instance of *Osteochondritis dissecans*.

Context 336 produced a 1st phalanx with a broad fissure in the proximal articular surface, situated at the margin of the lateral facet in the antero-posterior plane, but this time without islets or evidence of detachment.

In Context 337, however, a 1st phalanx again showed a fissure with islets and destruction of the subchondral bone in the antero-posterior plane of the proximal lateral facet. This was accompanied by extension of the proximal articular surface antero-laterally; and distally a broad fissure with islets, detachment and destruction of the centre of the lateral trochlea.

Another 1st phalanx was recovered from Context 337 with the extension of the proximal articular surface antero-laterally.

A 1st phalanx from Context 340 also had extension of the proximal articular surface antero-laterally. This specimen also had a fissure with an islet in the cranio-caudal plane in the centre of the lateral articular surface. Distally, there was extension of the articular surface anteriorly and posteriorly. Also, there was soft tissue ossification and remodelling at the site of the lateral collateral ligament, and some pitting of the bone which may suggest infection or aggravation. The bone was also noticeable in that of the two palmar/plantar tuberosities only the lateral was well developed, and that to a high degree indicating an asymmetry in gait.

Pig:

A right metatarsal III in Context 337 had periarticular exostosis of the proximal articular surface anteriorly. The hole in the articular surface of this specimen is post-mortem damage.

17th Century AD

Table 7.19
Winchester: 17th century AD: Summary of pathological categories

Date & Phase	Species	Element	Arthro	Infection	Trauma	Congenital
17 C						
56	Cattle	Rib			*	
	Sheep	Scapula	*			
		Vert L	*			
	Dog	Vert T	*			
		Ulna d			*	

CHESTER ROAD

PHASE 56

Cattle:

A rib from Context 19 has a bony eminence on the cranial edge, which is probably the result of soft tissue injury, e.g. a strained muscle attachment.

Sheep:
A right scapula, also from Context 19, has minor articular extension of the latero-posterior glenoid, and eburnation of the lateral portion of the glenoid cavity. This are likely to be age-related manifestations.

A lumbar vertebra from the same context exhibits a probable age-related osteoarthritis. The caudal face has mild eburnation, circumferential grooving, and periarticular exostosis.

Dog:
Context 19 produced a canid thoracic vertebra with manifestations of osteoarthritis. The cranial and caudal facies had mild eburnation, and both exhibited periarticular exostoses.

The same context produced what may well be a highly distorted distal ulna, where a traumatic torsion has occurred in the juvenile prior to fusion with the stylus process.

iv) Deficiencies in the "referral" method
The problem in presenting pathology in this way - by describing the discrete gross lesions - is twofold. First, there is likely to be an under-representation of pathology because the identifications are initially made with the naked eye; this may well reduce observations of sub-clinical conditions to a negligible level. Secondly, by referring only the lesions and not the sample containing the lesions, it is impossible to relate the pathological specimen to the group.

Table 7.20 shows the number of referrals of cattle limb bones in conjunction with the data on MNI and NISP for those phases containing pathological cattle limbs. The anomalous specimens represent **9.6%** of the accumulated NISP for limb bones in phases where anomalies were present. Taking the NISP value for all cattle long bones, however, the pathological percentage falls to **2.1%**. Table 7.21 summarises the observations of arthropathy alone in sheep limb bones; here these lesions are present in **29.3%** of the identified specimens examined (fused epiphyses). However, the summed NISP value for all sheep humeri, radii and metapodials is 940, and as a

percentage of this figure the pathological representation falls to 9.7%.

There are, of course, factors other than the method of observation and recording which are likely to contribute to the differential. Small fragments of cattle bones are easier to identify to species than those of sheep, and thus the NISP values will not be directly comparable. The humero/radial joint is more often left complete in sheep, but complete metapodials and phalanges can be as common amongst cattle bones as sheep. In cattle, therefore, the pathological distribution will be biased in favour of the lower limb. Additionally, at Winchester the sheep may be more mature than the cattle, particularly in the later phases, giving a higher proportion of fused ends of long bones and a greater susceptibility to arthropathies.

Table 7.20
Winchester: Cattle limb bones: Referred pathology

Date	Phase	MNI	Element	NISP	Referred pathology
10C	53	12	Mcar	20	1
	29	14	Ph1	7	2
			Mtar	41	1
13C	13	1	Ph1	1	1
13-14C	616	2	Ulna	3	1
	53	11	Ph1	31	1
			Mtar	19	1
15-16C	763	9	Mtar	14	2
16C	49	7	Mcar	13	1
			Mtar	15	2
			Ph1	32	7
			Ph2	22	1

Table 7.21
Winchester: Sheep limb bones: Observed arthropathy

Element	No. examined	Arthropathies observed
Humerus	100	22
Radius	98	30
Metacarpal	59	18
Metatarsal	54	21

B) FIAVE-CARERA

A LATE BRONZE AGE SHEEP ASSEMBLAGE FROM NORTHERN ITALY

The animal remains from Fiave were recovered from the waterlogged deposits associated with the Late Bronze Age lake dwellings. The size of the assemblage and the contextual information supplied suggests that the remains can be treated as an entity. The number of goat horncores observed, together with the number of distal humeri clearly derived from goat on the basis of the postero-medial structure, demand that this group be treated as a sheep/goat assemblage, in that the pathological analysis is concerned with fragmented metapodia with limited sheep/goat differentiation.

i) Pathology observed in the limbs

The limb bones of the sheep/goat assemblage which were made available for this study are extremely well preserved. The surface of the bone, although showing the effects of post-excavation handling, is in good condition, and the epiphyses and articular surfaces are remarkably intact.

Observed pathology relates overwhelmingly to one condition, the linear or sub-circular incompetence of the subchondral bone of the epiphyses of the long bones. Apart from this condition, the only noted lesion in the limb bones was a compound infected fracture of a metatarsal bone.

Table 7.22 shows the incidence of the anomalies within the element groups. The predisposition of the metapodia, and the metatarsal in particular, conforms to the findings of the studies on North Ronaldsay and the Winchester Northern Suburbs.

Table 7.22
Fiave sheep: Incidence of arthropathic lesions in the limbs

Element	Total examined	Arthropathic elements	Arthropathic elements as percentage of total
Humerus	34	-	-
Radius	29	3	10.3
Metacarpal	47	9	20.9
Femur	9	-	-
Tibia	20	-	-
Metatarsal	51	15	29.4

This condition has already been described in the material from North Ronaldsay and Winchester. In Fiave, the lesion presents in the most definitive form. Here, in the absence of weathering or post-depositional organic alteration, it is possible to see these fissues extending through to the epiphyseal trabeculae, with the subchondral margins of the lesions expressed as a smooth, bevelled edge.

As discussed earlier in this thesis, there is no aetiology suggested in veterinary or zoological sources for such manifestations. In archaeological material, however, they have been observed almost as a matter of course where the subchondral layer has not been fully breached (personal comments by J. Bourdillon, A. Bullock, D. Brothwell, J. Egerton, K. Manchester, M. Iles, T. O'Connor, K. Rielly, C. Roberts, D. Serjeantson, P. Smith, S. Stallibrass).

Repeated occurrences within assemblages have been noted (S. Stallibrass pers. comm.), and the probability of joint stress as an initiating cause has been suggested (personal comments by D. Brothwell and M. Ryder).

It may well be that once the epiphyseal trabecular bone has been exposed by the transgression of a subchondral fissure, post-depositional bacterial or inorganic leaching action renders the vulnerable rim of the cleft indistinguishable from post-mortem damage. Evidence of stress or incompetence of the hyaline cartilage which extends into its underlying dense subchondral bone might therefore only be visible where such post-mortem activity is minimalised. It may be, therefore, that assemblages recovered from such anaerobic conditions as pertained at Fiave will produce mature, unadulterated lesions of this nature.

This last case study, therefore, is an illustration of the closed circle within which animal palaeopathology has currently to operate. What we have here is an anomaly with a very high frequency of archaeological observation generally, exemplified in a small assemblage derived from particular deposits; but the lesion is without modern parallel in veterinary pathology. Because of the lack of a modern

aetiology, should we continue to assign the lesion to normal deviation in our archaeological material? And thus we encounter the underlying ethos of the original research design; to what extent should we adopt an osteological variation as normal, and therefore unremarkable in reports? Splits and fissures in the subchondral bone are, and have always been, ignored by archaeozoologists largely because of their inconsequence in modern veterinary practice because they are sub-clinical, assymptomatic, and probabable not congenital.

Using the same convention as for the North Ronaldsay and Winchester samples, the following tables show the sites of these anomalies in the Fiave group. The terms "fissure" and "depression" are used describe predominantly linear or predominantly area lesions respectively.

Table 7.23
Fiave sheep: Proximal metacarpal: Expressions of subchondral incompetence

Phase	Facet		Site					Arthropathic expression
	Lat	Med	Lat	Med	Ant	Post	Cent	
C		*					*	Depression
E		*		*		*		Depression
		*			*			Depression
U		*		*	*			Depression

Table 7.24
Fiave sheep: Distal metacarpal: Expressions of subchondral incompetence

Phase	Facet		Site					Arthropathic expression
	Lat	Med	Lat	Med	Ant	Post	Cent	
D		*		*		*		Fissure
E	*		*	*	*	*		Fissure
		*	*	*	*	*		Fissure
	*			*				Fissure
		*	*	*				Fissure

Table 7.25
Fiave sheep: Proximal metatarsal: Expression of subchondral incompetence

Phase	Facet				Site					Arthropathic expression
	Lat	Med	LP	MP	Lat	Med	Ant	Post	Cent	
C		*				*				Fissure
		*				*		*		Fissure
	*				*			*		Fissure
				*					*	Depression
D		*				*				Fissure
		*				*		*		Fissure
		*				*				Fissure
	*				*					Fissure
		*				*				Fissure
		*				*				Depression
E	*				*		*			Fissure
		*				*				Fissure
			*		*	*	*	*		Fissure

LP = Lateroplantar MP = Medioplantar

Table 7.26
Fiave sheep: Distal metatarsal: Expression of subchondral incompetence

Phase	Facet				Site					Arthropathic expression
	Lat	Med	LP	MP	Lat	Med	Ant	Post	Cent	
C	*						*			Fissure
E	*					*				Fissure

Table 7.27 compares the percentage representation of arthropathic elements of the three studies, and Table 7.28 details the sites of the subchondral abnormalities. In each study, where there is sufficient data, the tendency in the proximal metapodia for lateral lesions to occur on the lateral facet and medial lesions on the medial facet is clear. Indeed, there are no lesions occurring at all in the lateral quadrant of the medial facets.

Table 7.27
Sheep: Comparison of all metapodial arthropathies between three groups

Sample	Arthropathic percentage							
	Metacarpal				Metatarsal			
	n	Prox	n	Dist	n	Prox	n	Dist
North Ronaldsay	103	11.7%	103	12.6%	98	41.8%	98	10.2%
Winchester	28	14.3%	59	20.3%	21	38.1%	53	32.1%
Fiave	41	9.8%	20	25.0	44	25.0%	28	7.1%

n = element total

Table 7.28
Sheep: Sites of subchondral fissures or depressions

	Lateral facet			Medial facet		
	Lateral (inc. combinations)	Medial only	Other combinations	Medial (inc. combinations)	Lateral only	Other combination
PROXIMAL METATARSAL						
North Ronaldsay	10	-	6	7	-	6
Winchester	4	1	2	2	-	-
Fiave	3	-	-	8	-	-
PROXIMAL METACARPAL						
North Ronaldsay	5	1	4	3	-	-
Winchester	-	2	-	1	-	1
Fiave	-	-	-	2	-	2
DISTAL METATARSAL						
North Ronaldsay	1	2	5	1	-	-
Winchester	3	3	6	3	1	2
Fiave	-	1	-	-	-	-
DISTAL METACARPAL						
North Ronaldsay	2	-	-	-	-	-
Winchester	1	-	2	2	1	7
Fiave	1	1	-	3	-	-

This pattern suggests that, for the proximal metapodia, the initial stresses are peripheral, and the predominance of linear fissures occurring circumferentially at the margins of the facets supports this. However, it is not readily apparent whether these stresses are structural, mechanical or developmental.

Comparing the anomalous incidence in the Fiave group with North Ronaldsay and Winchester, overall the lesions appear to be relatively under-represented in the Fiave material. Within the arthropathic groups, however, it is possible to look at the relative severity of the anomalies. Severity, in this condition, is probably best expressed by the extent to which the lesion has occupied the articular surface rather than any more subjective assessment of the depth of fissures. As already indicated it seems very likely, on the basis of the appearance of the Fiave material, that although lesions will be visible wherever the subchondral layer is preserved, the quality of preservation will substantially affect the apparent degree of severity.

In Fig. 7.8 the percentage occurrence of single and multiple sites within the arthropathic groups is illustrated. This shows that the progress of the condition in the Fiave animals is not obviously less than in those from North Ronaldsay or Winchester, even though the number of lesions within the sample is.

Another point of interest in Fig. 7.8 is the low representation of multiple sites in the North Ronaldsay group. In a sample of this size it might be expected that proportionally more extended lesions might be visible in this relatively fresh comparative material. Additionally, as Tables 6.1 and 6.2 show, there is a higher incidence of the anomalies in North Ronaldsay Region 3, which is known to carry a greater proportion of very aged animals than Regions 1 and 2. This suggests there may be an age-related factor here; if this is the case, however, it is necessary to concede that the Fiave and Winchester groups may have an older age profile.

What is almost certainly happening is that the low sample numbers for the archaeological groups, especially Winchester, are forcing the significance of a low number of aged animals.

ii) Depressions in the basal horncores

Fifty-three sheep horncores were examined from the Fiave assemblage. In seven cases "thumbprint" anomalies, conforming in every respect to those described in Section A of this chapter, were observed.

Fig. 7.9 plots these depressions relative to the breadth and depth measurements of the base of the horncore (von den Driesch 1976). This picture confirms, and indeed enhances, the results for Winchester. The anomalies occur in a fairly confined group in the middle range. Again, no lesions are visible in the larger cores and, in the case of Fiave where we have a better size range than at Winchester, neither are they occurring in the smaller specimens.

This gives further support to the hypothesis that the lesions only occur in ewes, and additionally adds some weight to the argument

that it is associated with breeding animals. While larger horncores may possibly all be from males, it is unlikely that the small cores are totally derived from males. The middle-range cores may be of both sexes, but will include the majority of females of breeding age. If sheep horncores have a relative development similar to that described for cattle by Armitage (Armitage 1982), the horncore could still be putting on growth when the ewe is into her second, or possibly even third, lactation.

Fig. 7.1

Winchester sheep: Humerus
Distal morphology by period

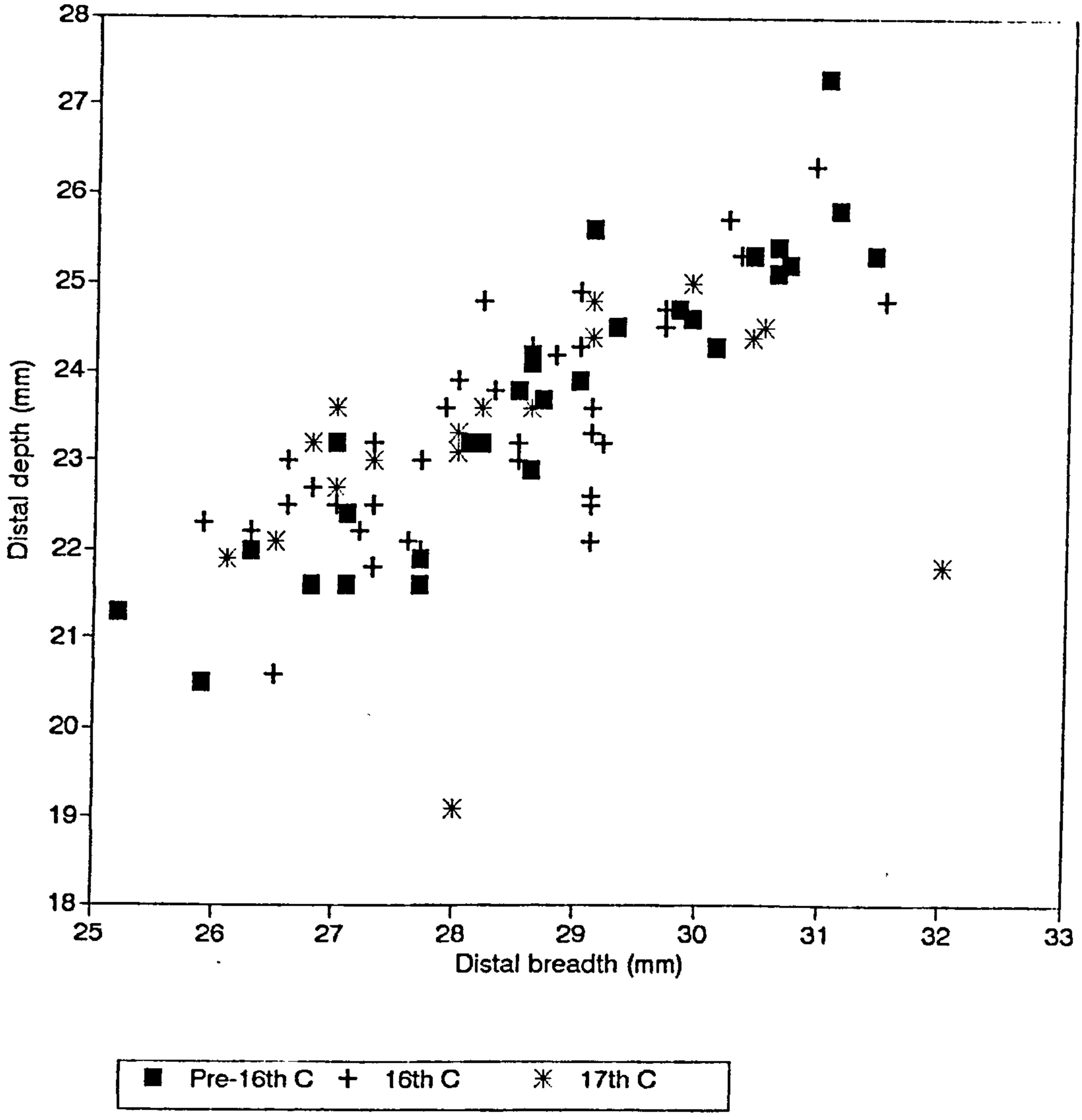


Fig. 7.2

Winchester sheep: Humerus
Distal articular width (Bt) by century

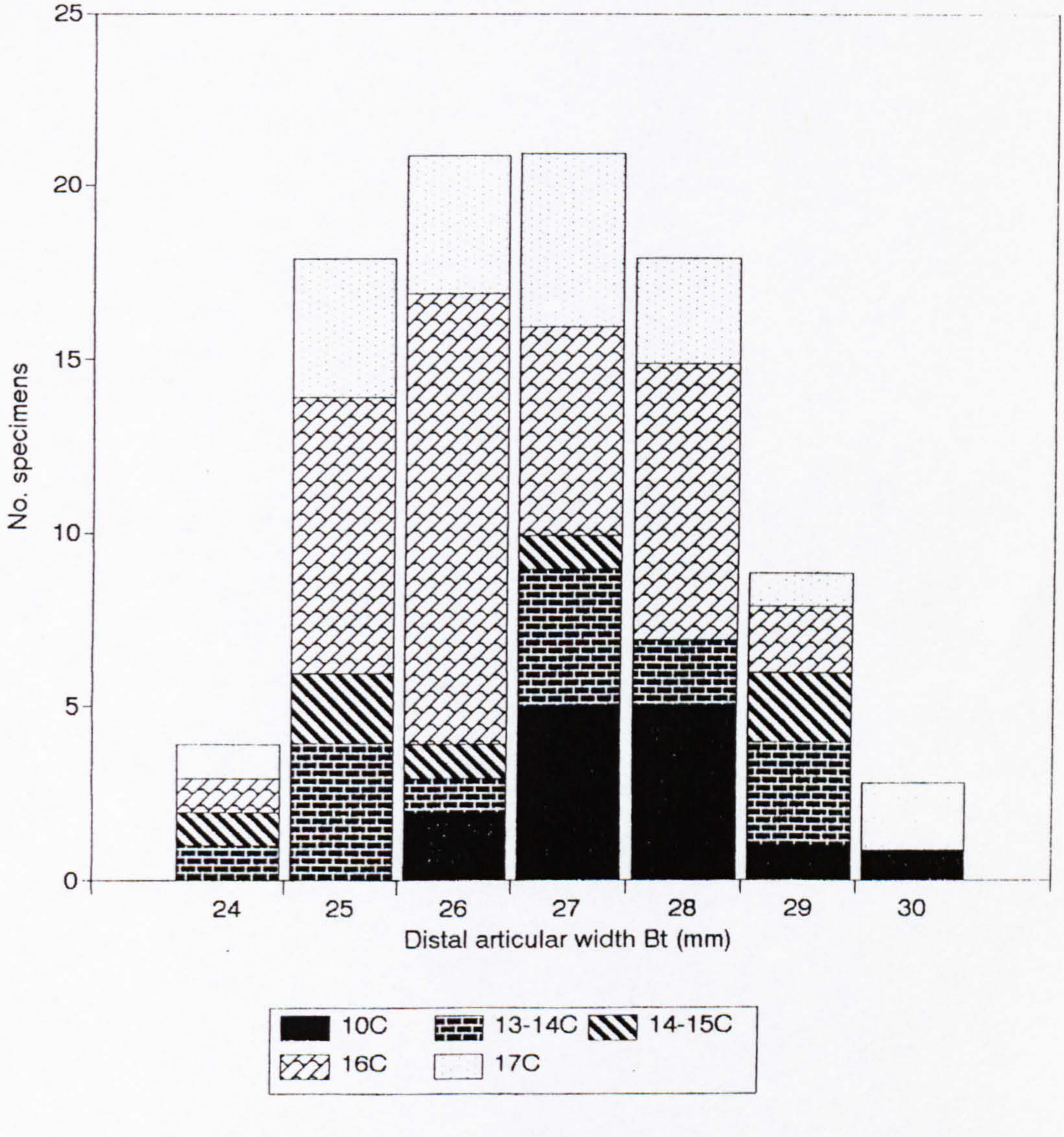


Fig. 7.3

Winchester sheep: Humerus

Cumulative distributions of width articular surface (Bt)

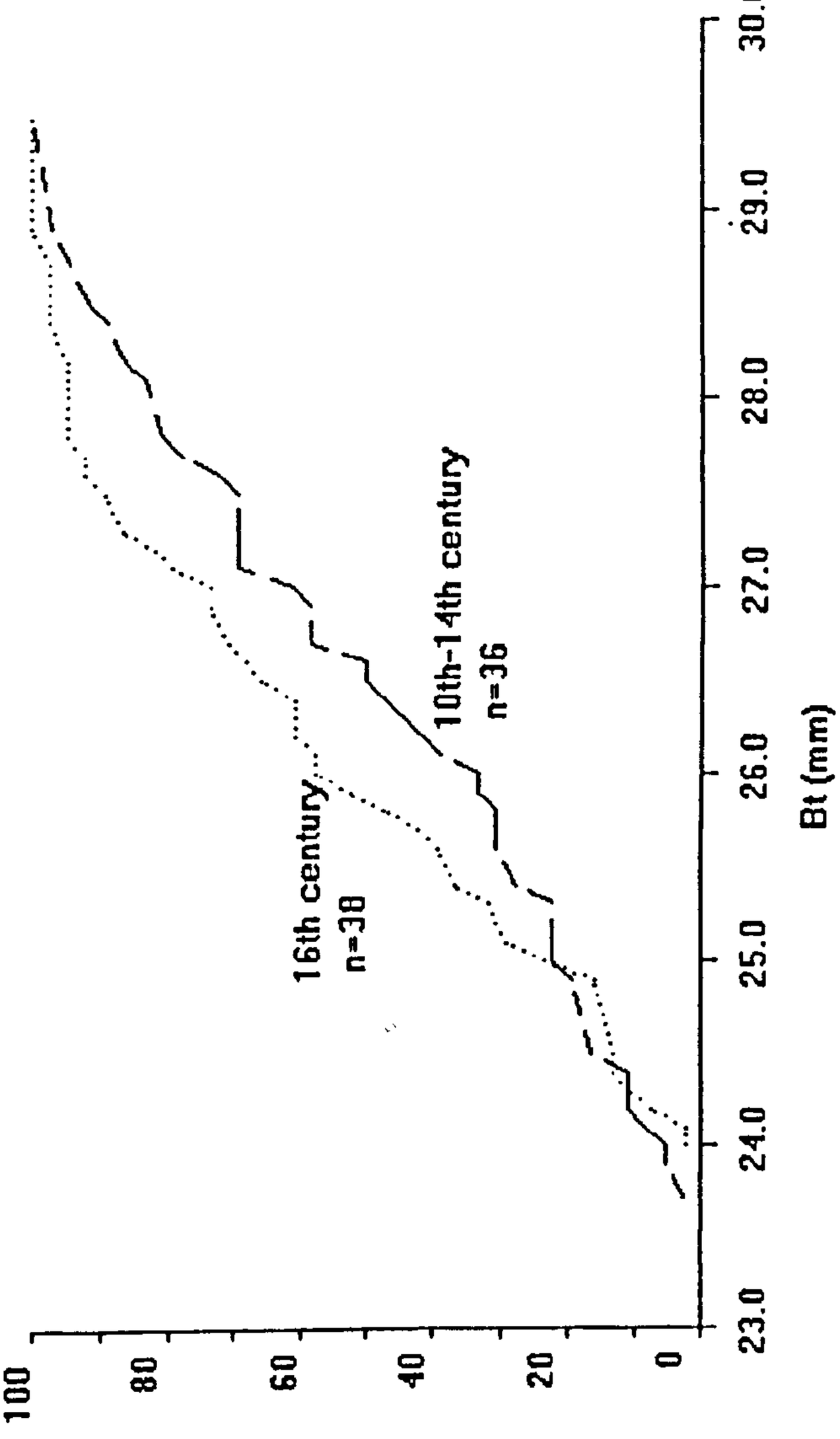


Fig. 7.4

Winchester sheep: Metacarpal

Cumulative distributions of ratio
width medial trochlea : width intertrochlear incisor

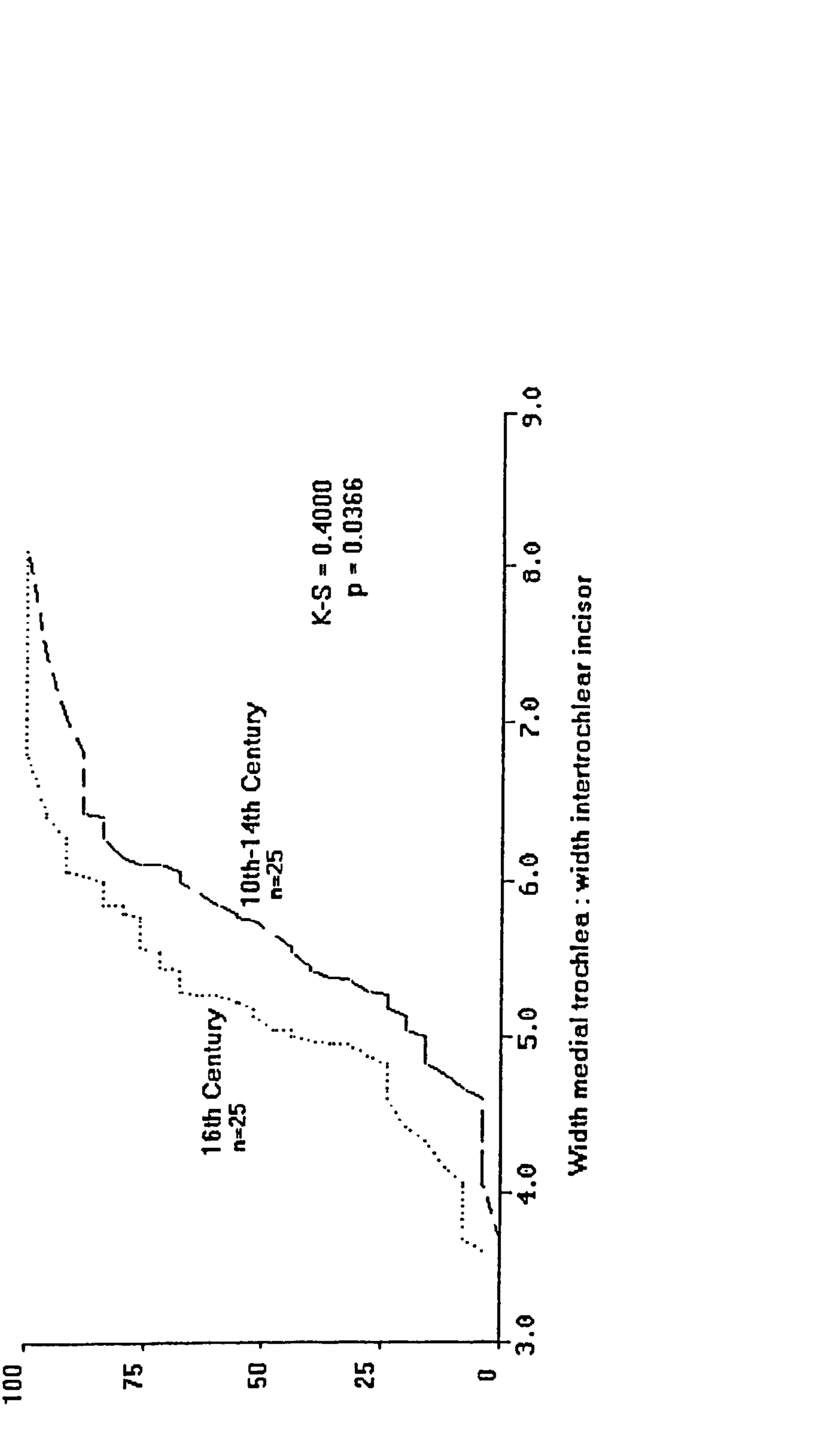


Fig. 7.5

Winchester sheep: Metatarsal

Cumulative distributions of width intertrochlear incisor

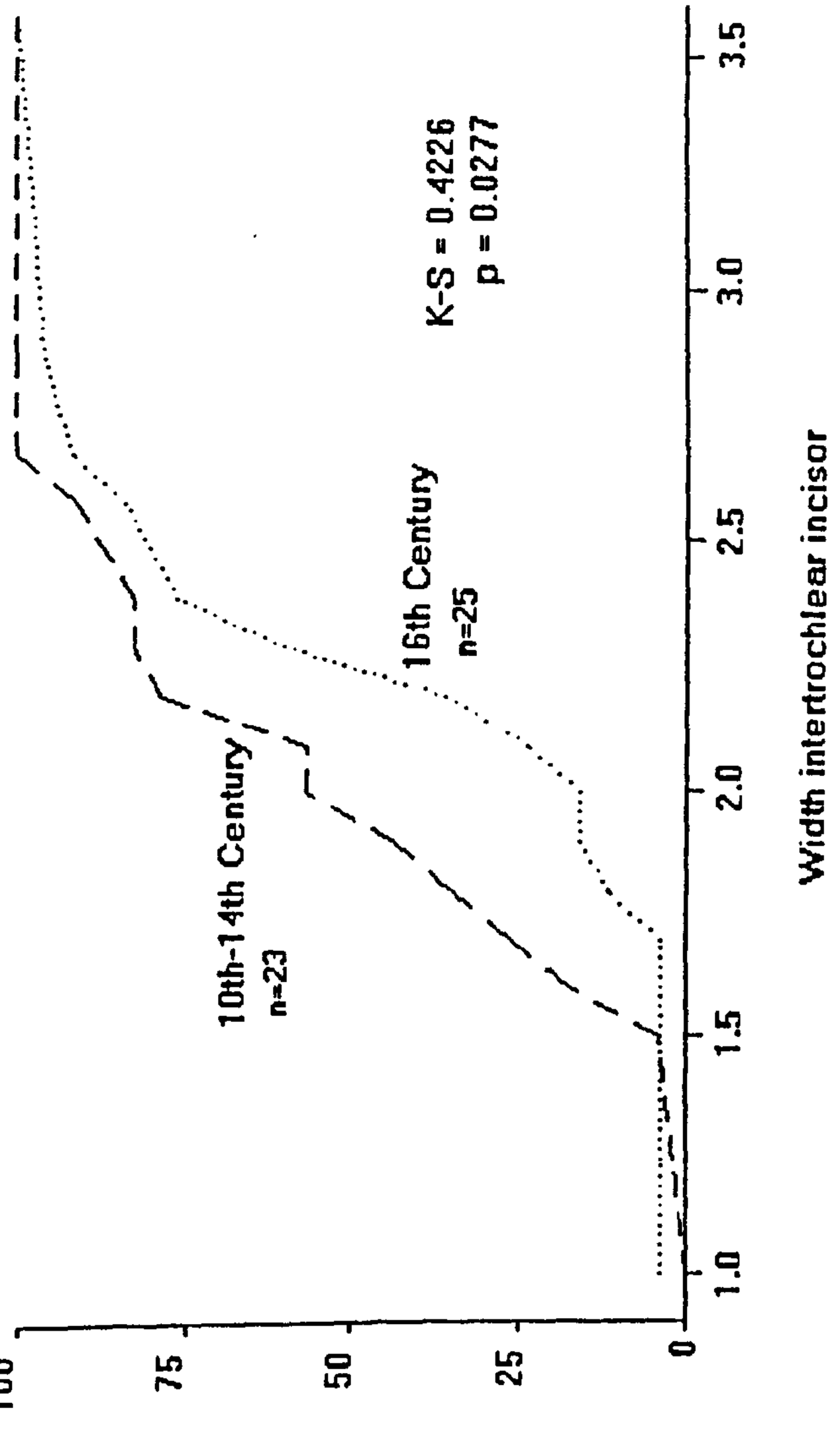


Fig. 7.6

Winchester sheep: Horncores
Cross-sectional morphology

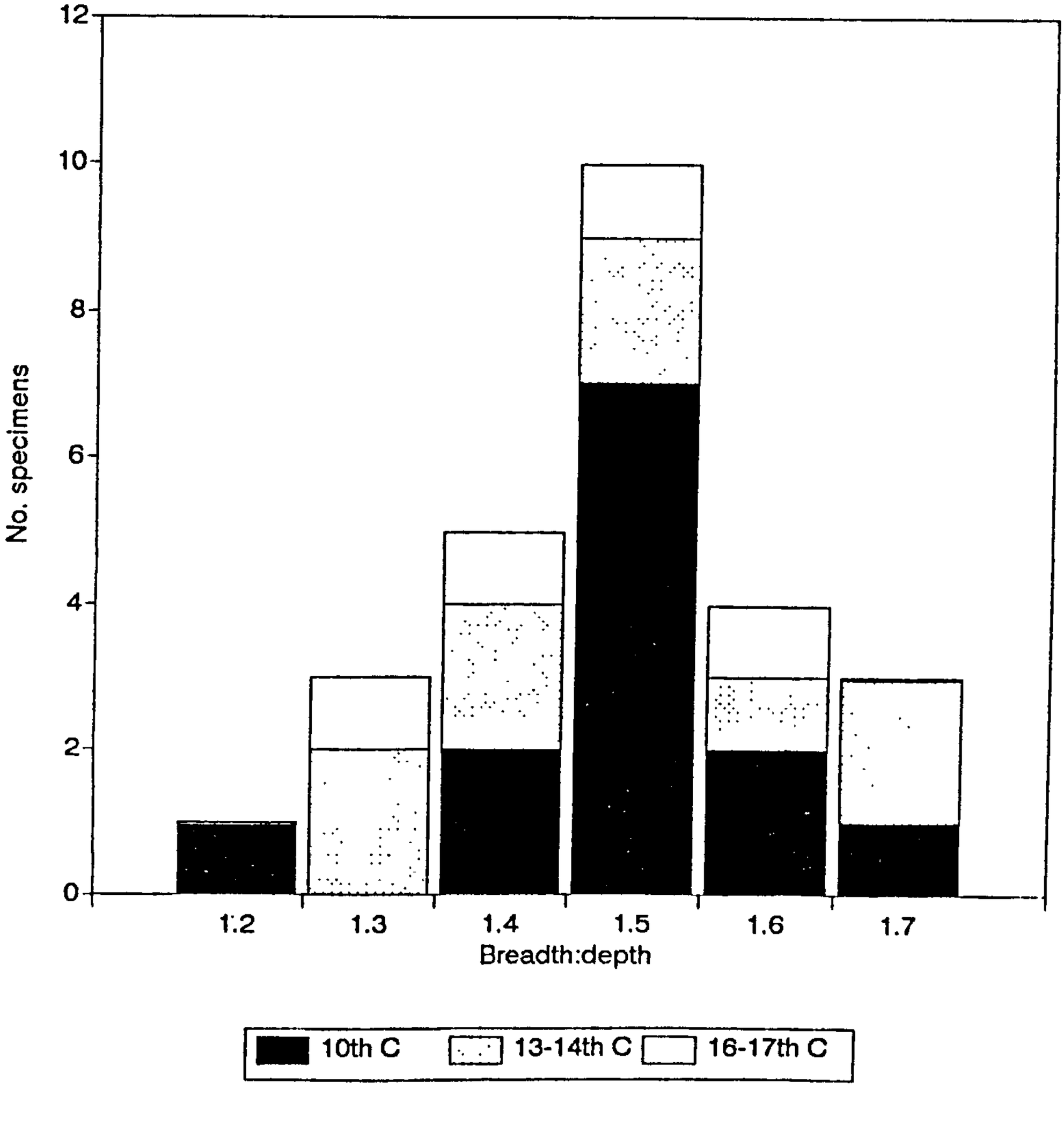


Fig. 7.7

Winchester sheep: Horncores
Incidence of anomalies

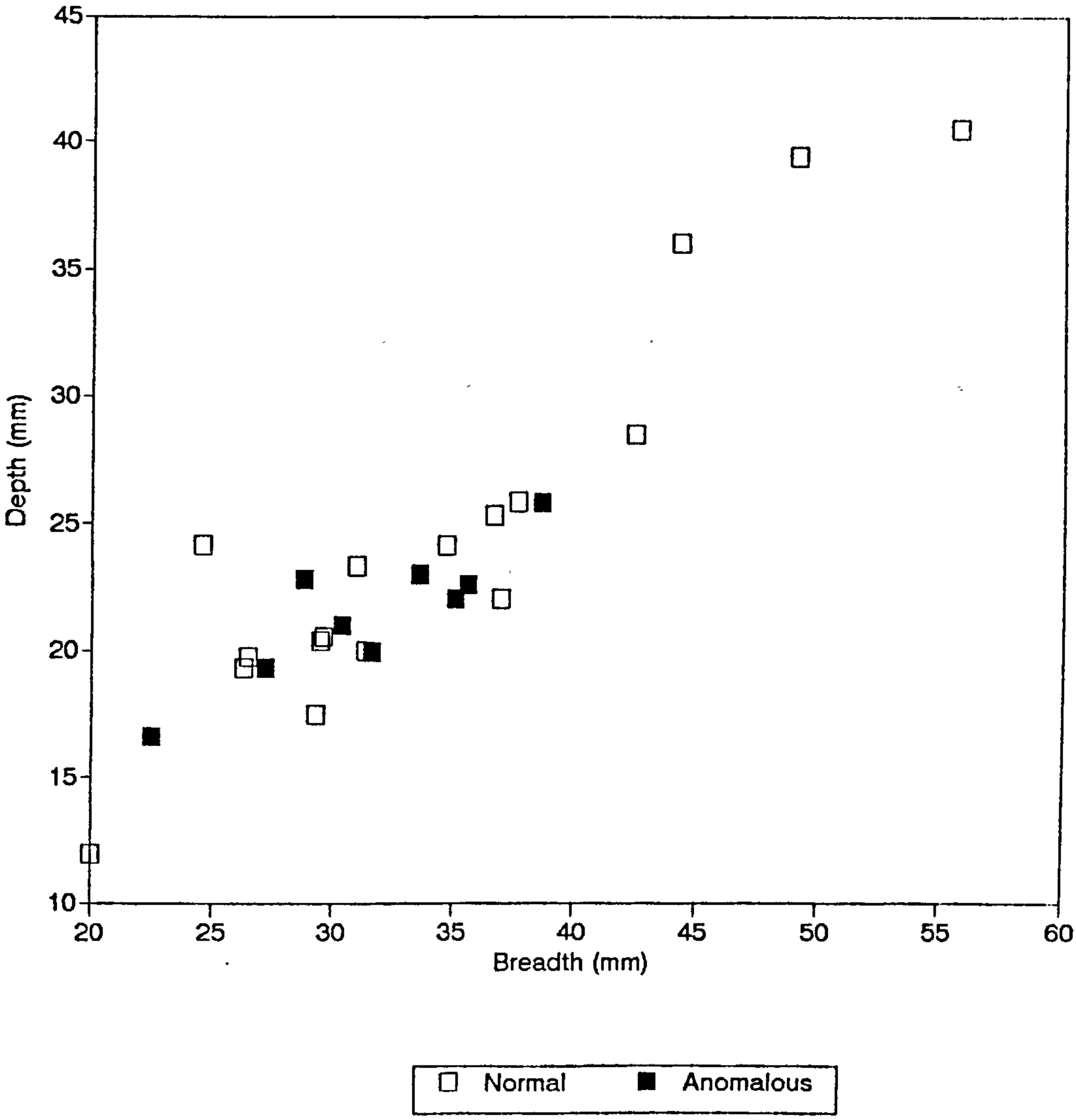


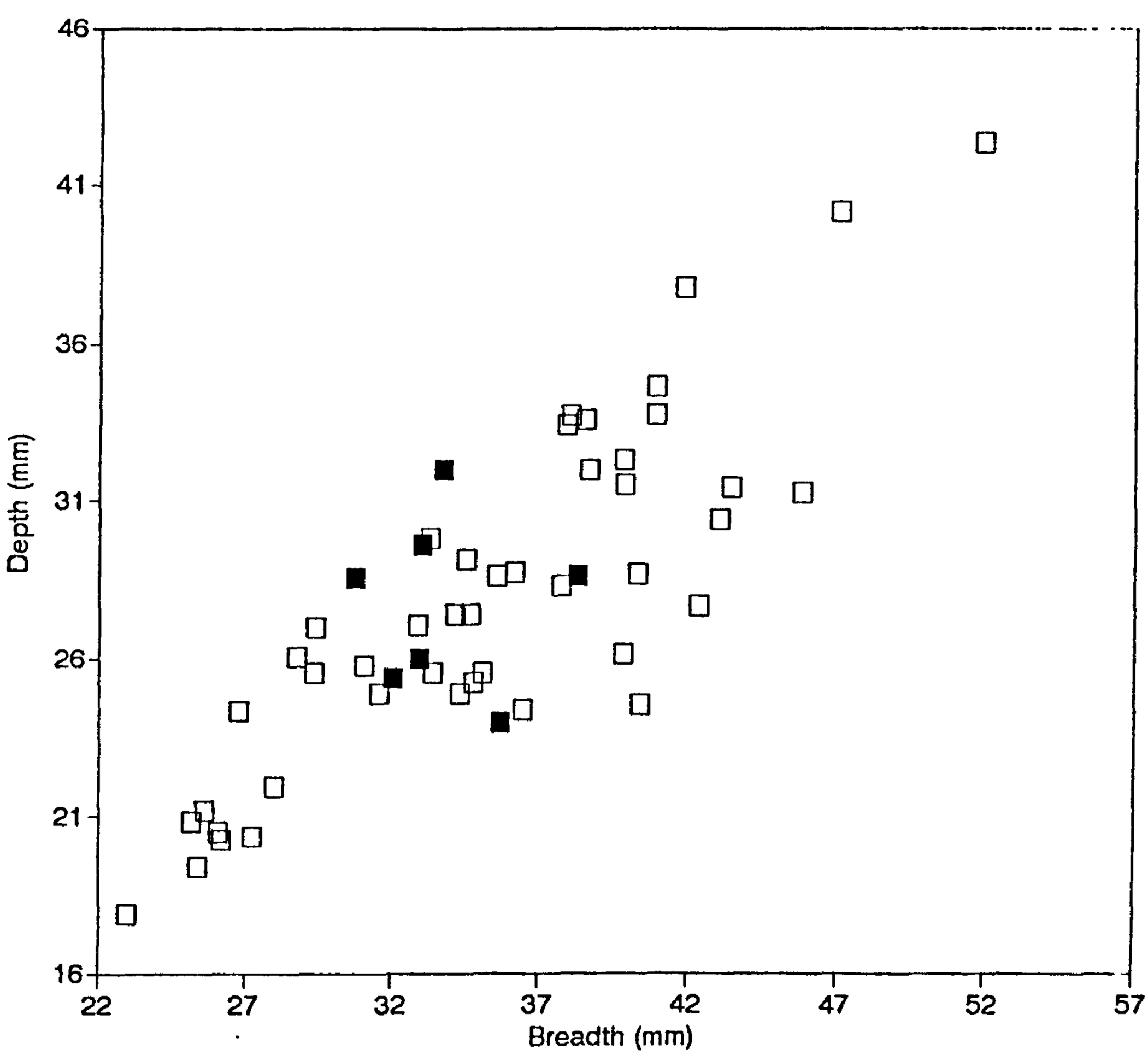
Fig. 7.8
Fiave sheep: Frequency of multiple sites in the arthropathic groups

	Metacarpal		Metatarsal	
	Prox	Dist	Prox	Dist
1 SITE				
N. Ron'sy				
Winchester				
Fiave				
2 SITES				
N. Ron'sy				
Winchester				
Fiave				
3+ SITES				
N. Ron'sy				
Winchester				
Fiave				

= 100%

Fig. 7.9

Fiave sheep: Horncores
Incidence of anomalies



□ Normal ■ Anomalous

CHAPTER 8
SUMMARY AND DISCUSSION

The initial research design for this study developed from a series of persistently unanswered questions on a particular aspect of past human/animal relationships. Animal bone reports are primarily designed to quantify the presence of species, identify the post-mortem but ante-burial disarticulation and fragmentation processes, and assess the taphonomic influences on the assemblage. These three categories of interest, objectively evaluated, provide a basis of comparison within and between sites, regions and period, and thus endow each assemblage with an array of characteristics defined through this comparison.

For the domesticates the basis of comparison is the observed selection of species for some form of post-mortem consumption, and the syntheses developed from these observations place the emphasis on the stimuli responsible for such selection. Under this strategy what is sought, and frequently identified, is the motivation behind the observed consumption. The value of this as an indicator of human behaviour consequent upon preference, contingency or cultural attitude is undeniable.

The questions underlying this thesis do not directly confront the current analyses of the realisation of assets of past societies. What does seem to be deficient is a recognition of the degree of human input represented in the animal remains, the degree to which the health and condition of animals may impinge upon the human societies with which they are associated, and the reflection of symbiotic or antipathetic attitudes between human and animal. Very rarely, and then only speculatively, are these issues addressed in the consideration of animal remains, and indeed they are rightly excluded from the process of faunal reporting because they have not produced direct, incontrovertible and reproducible osteological evidence.

The exploration of some of these aspects of the man/animal relationship which are seen to be so subjective, and yet which hold

so much potential in understanding the ethos of societies dependent upon animal husbandry, is the investigative aim upon which this research is based. Consuming, or assigning, animals can represent the successful outcome of a long term investment, the contingent realisation of a depreciating asset, the disposal of an unwanted drain on resource, or an emotional or religious deposition. Contextual information, along with the faunal analysis, can give broad indications. Consideration of the health condition of the deposited animals may elucidate further. Recognising variation in condition across archaeological assemblages will activate comparison. Assessing variation in terms of natural pathological load should lead to discussion of where human or environmental influences can be identified.

In short, what this thesis propounds is that osteological variation - whether caused by disease, congenital factors, trauma, or developmental restraints imposed by human intervention or environmental stress, must be taken into account. To make this kind of variation compatible within current faunal reporting it is necessary to put forward argument and methodologies which are acceptable within current procedures.

When the ideas for the original research were deliberated, three rudimentary approaches became clear:

1. To identify a particular pathological lesion which had been reported archaeologically, and investigate it through archaeological material, literature, veterinary, and agricultural sources.

2. To investigate osteological pathology in one species which could be identified and traced in archaeological deposits, and subject it to veterinary opinion and ethnographic analysis.

3. To apply directly the methodologies and reporting procedures developed in human palaeopathology to appropriate animal deposits.

Each approach was evaluated, and each was considered to have a useful research potential. From the archaeological point of view the problem-orientated investigation of lesions within species has current merit, but equally the potential for investigating the pathology of animals recovered completely in 'special deposits' has a broader interest. Pathological abnormalities that might occur across a range of species are, perhaps, of less direct concern unless they can be tied to other broader cultural shifts.

During these considerations it became clear that all of these potential research strategies were based on two untested assumptions. The first is that all pathological lesions in archaeological animals conform to modern veterinary identification and explanation. The second is that pathology relates only to the individual in whose skeleton it occurs.

From the recognition of these possible deficiencies in the traditional thinking a major structural component of this thesis was developed - the use of extensive corpora of comparative material on which to test the presence, visibility, and variation of all osteological anomalies, whether or not they conformed to modern veterinary interpretation. By applying pathology, including the asymptomatic and sub-clinical, to populations, the necessity to identify and explain lesions only in terms of the individual was obviated.

On this basis, the third approach - adapting human palaeopathological procedures for application to appropriate animal skeletons - was rejected as a core strategy because of the severe limitations that would be imposed on the selection of suitable archaeological remains, and the consequent restriction of the study to relatively intact skeletons. While such studies have much value in explaining the circumstances surrounding the individual in a particular context, they have limited application to faunal assemblages drawn from refuse accumulation. It is, however, a useful and obvious strategy to employ in circumstances where this more forensic approach is likely to yield the most relevant information. In this thesis it has been applied to the Late Neolithic wolf skull at Staines Road Farm, where

the pathology may have a direct bearing on the history of a ritually deposited animal. It has also been used on two of the animals from Baldock, the Iron Age dog buried in a ditch and the early Roman-British animal interred in a double human burial. In both cases the visible sequence of pathology can be usefully allied to the other properties of the animals, both physical and contextual. For this study, however, the main value of such discrete remains is the quality of their input into the dataset of animal pathology in general, and the pathology of their species in particular.

The final structure of this thesis therefore comprises two comparative case studies on two orders, each study parameterised by different collection strategies and precognition but both concentrating on the limbs. The fundamental purpose of these is to present pathology as a visible and quantifiable variable in the development and testing of certain hypotheses. It is the search for the variable which has been the concern of this research; while the hypotheses may have a useful archaeological relevance, the main aim has been to demonstrate the dynamic of pathology within groups.

The comparative work is accompanied by archaeological studies which encompass a range of material; partial skeletons, complete discrete depositions, groups of single elements, referred specimens of all species, and large fragmentary accumulations of a single species. The methods of reporting and quantification of pathology are derived directly from the techniques evolved during the comparative studies, but for the canids in particular further methodology has been developed to express the modifications evident in *Canis familiaris* during the periods in which the remains originate. If, as is justifiably supposed, such modifications are the result of selective breeding to accommodate human preference or requirement, they are congenital manifestations and thus relevant to the body of this thesis.

DISCUSSION

The evaluation of any results in this work depends entirely on whether the pathological analyses are seen as archaeologically useful;

in other words whether they contribute to the understanding and interpretation of the assemblages to which they are applied. This is not problem-orientated research in the normally accepted meaning of the term. Major questions about animal pathology were not being asked at the time the research proposal was put foward, and faunal workers did not feel hindered by a lack of reference works or methodologies to apply to the lesions they encountered. The point of this work is to suggest, demonstrate, hypothesise and test the validity of natural osteological reaction as a practical archaeological tool. Nevertheless, although this is a vast field which can only be partially addressed in a work of this nature, the results consequent upon the choice and use of the skeletal material dictate the value of the theory.

These results are probably best discussed by taking each basic component of their derivation in turn.

The comparative material

a) The foxes

The suburban foxes loaned by Professor Harris gave an unparalleled opportunity to look at a collection of skeletons, in excellent condition, of a single population. Given the background information available - age, sex, weight, cause of death - a variety of analyses were possible. What was required, however, was a system of recording pathology in foxes which would be applicable to commonly identifiable elements in other species, and particularly canids. A survey and analysis of the limb bones would satisfy these requirements.

The method of skeleton preparation used by Professor Harris - evisceration followed by natural decomposition of soft tissue and drying of bone in the open, with a few instances of treatment in very dilute sodium perborate, meant that the preservation of lesions was very high. The most superficial traces of periostitis were visible at 6x magnitude. In the strictest sense of the term, therefore, this is not archaeologically comparable material. In no circumstances of prolonged burial would this quality of bone be recovered. What this degree of preservation does offer, however, is the opportunity to

record a very high level of incidence of conditions which affect bone. Most importantly, it was possible to trace the development of arthropathic conditions from the initial minor readjustment of the articular margins through to the multiple manifestations of degenerative osteoarthritis. With the visibility of the sub-clinical exhibitions came the potential for exploring the relationships between the joint changes and the lesions of more acute origin - the infective and the traumatic - and the other hyperostotic manifestations.

Early arthropathic and hyperostotic anomalies are less fragile than the many minor infective lesions which may only extend slightly to the sub-periosteal layer. They will therefore be more commonly visible in archaeological material. Because they are relatively common, and because they are not obviously abnormal, they are rarely recorded. In the light of the results from the fox sample, however, they may have a great deal to contribute regarding the age structure of the assemblage, and particularly in assessing the relative ages of the mature individuals, and there is no reason why this promulgation should be restricted to canid remains.

The North Ronaldsay sheep

This comparative collection was accumulated under a totally different regime to the foxes, and was designed as an ethnographic exercise to define certain environmental and human factors in a sample of modern faunal material where the individual was invisible in the remains but the flock was observable in life. Again, the limbs were the subject of the analysis.

Over the two seasons of collection, when the beaches were effectively cleared of all limb bones, it was clear that the pathology commonly known in archaeology as 'penning elbow' was a consistent occurrence in the flock. The subsequent analysis, benefiting from the observations in the suburban foxes, showed that the development of degenerative arthropathy may be related to age, but that the particular manifestations of humero-radial osteophytes were significantly associated with the terrain on which the sheep spent their lives. By assessing the degree of human intervention, it was

possible to suggest that penning, or other potentially traumatic management strategies, were less likely to be the cause of the lesions than the day to day stresses imposed by the environment.

As with the foxes, this is perhaps a case of attacking (or possibly raising) a problem which was not on the agenda. 'Penning elbow' was not a commonly encountered condition in archaeology, and indeed was not recognised archaeologically before its description by Baker and Brothwell (Baker & Brothwell 1980). Baker (unpublished manuscript) had observed the anomaly in sheep from Brook Street, Winchester, and commented that shepherds traditionally associated it with collisions with pens or races. Archaeologically, therefore, it becomes diagnostic of a particular activity in animal husbandry.

However it is less neat, but possibly more useful, to consider the possibility that this lesion may be a consequence of minor, but sustained, environmental stress. The point about the North Ronaldsay sheep is that they are not particularly agile or athletic, and do not appear to have modified skeletally to life on slippery rocks, although their digestive system has certainly adapted to their diet of *laminaria* seaweed. In this flock, the indications are that there is a skeletal reaction, probably bilateral and asymptomatic except in old age, to repeated and minor traumata.

This may be a minor point in current archaeozoological thinking. However it is important if pathological lesions are going to continue to be invoked as representing particular aspects of animal husbandry. It is changes in the management and exploitation of animals which give so many indications of changes in society, and pathology may well have a valuable contribution to the recognition of these changes. But the archaeological evidence of pathology has to be stringently researched in order to ascertain its real meaning.

The archaeological material

a) The canids

The domestic dog almost certainly represents the earliest human domination and exploitation of another species. Furthermore, the dog

is the only archaeological species actually created by man. This thesis has, obviously, taken the view that *Canis lupus* and *Canis familiaris* are accepted as individual species even though they are able to interbreed and the ancestral *lupus* is still co-existent with the derived *familiaris*. The existence and success of domestic dog, in all its multitudinous forms, is not only an affront to Linnean classification but represents a singular phenomenon in the history of man/animal relationships. The human/dog relationship continues unchanged into our own modern, urban, non-agricultural, society, while retaining its earlier roles in areas of hunting, animal husbandry and security. The human affiliation with dog may well be the result of an easy symbiosis between two species of similar social habit which has persisted throughout all the cultural vascillations of the human side of the partnership.

The archaeological evidence has never contradicted the view that dog exists with humans in a sympathetic way, as opposed to the exploited role accorded to the other major domesticates. However exploitation - consumption - is more readily visible in the faunal record because it tends to leave concentrations of debris. In such debris dog has a low representation; but it has attracted more interest where it appears as a special deposit. Its archaeological appearance in more or less complete burials may well reflect the position of the species in the human perception of the time, but for our understanding of the prevailing conditions of deposition we need to know as much about the background condition of the species as we do about those particular bodies.

The case studies in this thesis have sought to illustrate some of these problems. Three canids deposited as discrete burials, in very different circumstances, have been described, and a series of multiple dog discards have been analysed to try to elicit the composition of those depositions in terms of the individuals.

b) The sheep

In contrast to dog, archaeological sheep will always prove deficient in the age-related conditions, not only in terms of articular degeneration

but also in the degree of post-traumatic and post-infective reparation. As with all domesticates which we identify through their consumption debris, we are looking at the remains of animals likely to have been despatched before full maturity, and often in the sub or early adult phase of their potential lifespan. Any skeletal modification or reparation that we observe is therefore likely to be biased towards those conditions which manifest early in the skeleton.

It is also true to say that the natural morphological variation in sheep, even over long periods of time, is a great deal less than in dog. This does not necessarily mean that a sheep is less likely to develop a skeletally-involved condition than a dog, but the number of conditions and range of initiating circumstances may well be more restricted. Variation in the relational aspects of skeletal structure, as opposed to the purely dimensional, will undoubtedly increase the variety of osteological manifestations. In sheep, therefore, we might expect to recognise consistent patterns of bone lesions over the whole span of archaeozoological investigation up to the improvements and specialisms of the 17th century, and possibly later. The limited amount of work accomplished under this research programme has supported that expectation, and this has not been contradicted in observations made on assemblages which have not been considered in this thesis, such as Yarnton (Smith in prep.), Runnymede (Serjeantson in prep.) and Gloucester (Clark in prep.).

If one then considers the difference in social habit, opportunistic tendency, and autonomy of action endowed by 'intelligence', it becomes even more obvious that pathology, as a reflection of life events, will appear more diverse in dogs and more predictable in sheep.

If this is the case, and particularly if the assertion proves to be applicable to cattle as the other major herbivore, then it is extremely advantageous to the argument that pathology is a valid variable in the analysis of these species in antiquity. If we can express the pathological load in terms of presence and degree in species where we can be reasonably confident that the potential for anomalous

manifestations is consistent, we are moving towards the ability to express the relative condition of animal groups differentiated by time and space. This opens up the possibilities of examining other evidence – environmental, structural, artefactual or cultural – as potential co–factors, on the same basis as is currently employed in the analysis of other, traditionally recognised, assemblage characteristics.

The archaeological animal is a multi–purpose, adaptive, but environmentally determined resource. Its final consumption, the conscious selection of its characteristics for that consumption, and the mechanics of its deposition as consumer waste, parameterise its input into the analyses of ancient economy. If the same material can produce evidence of biological, environmental or exploitation dynamics, then the case to answer is whether or not this would be material evidence. On the assumption that ecological information is not only material but essential to the consideration of settlement and economy, then the work involved in assessing that data potential seems justified. The argument for the archaeological relevance of such work takes as a first principle the importance of the human interaction with the animal in life. This is a poorly addressed area in traditional faunal analysis, and the rigorous use of pathological data may be a substantial step towards rectifying that deficiency.

Plate 5.1

Staines Road Farm. Canid cranium dorsal view.


cm

Plate 5.2

Staines Road Farm. Canid left mandible.


Cm

Plate 6.1

North Ronaldsay sheep. Humeri, showing developmental stages of distal lateral osteophyte.


Cm

Plate 6.2

North Ronaldsay sheep. Radii and ulnae showing developmental stages of proximal lateral osteophyte.


cm

Plate 6.3

North Ronaldsay sheep. Humero-radial joint showing showing advanced ossification of lateral colateral ligament.


Cm

Plate 7.1

Winchester sheep. Distal humeri showing developmental stages of lateral osteophyte.


Cm

Plate 7.2

Winchester sheep. Radii, showing developmental stages of proximal lateral osteophyte.

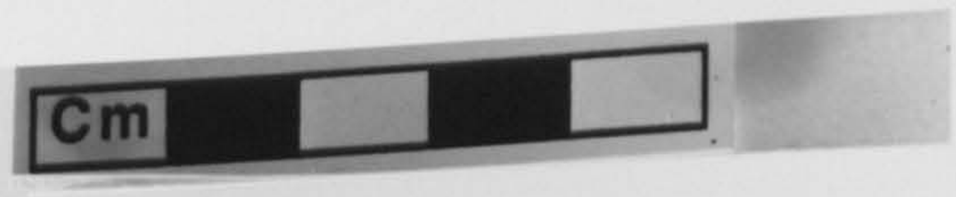

17c

319


Cm

Plate 7.3

Winchester sheep. Horncores exhibiting "thumbprint" depressions.


Cm

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