Werkkamer Loof.
niet meenemen s.v.p.

A GUIDE TO
THE MEASUREMENT OF ANIMAL BONES
FROM ARCHAEOLOGICAL SITES

as developed by the Institut für Palaeoanatomie, Domestikationsforschung und Geschichte der Tiermedizin of the University of Munich

by

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INTRODUCTION TO THE SERIES

Publication has always been a valued part of the Peabody Museum's contribution to anthropological scholarship. In the Museum's first year, 1866, the annual report outlined progress on research projects, and these reports were soon augmented by occasional papers contributed by the staff. A more formal publication program was begun in 1888 with the *Peabody Museum Papers*, a series which has continued to be active for nearly ninety years.

The spectrum has been broadened through the years with the addition of the *Memoirs* and *Monograph* series, the *American School of Prehistoric Research Bulletins*, and the *Peabody Museum Press* publications. Each of the series was instituted to meet specific publishing requirements, but now a new need has become evident, and the *Peabody Museum Bulletin* is our response to it.

This inaugural volume of the *Bulletins* demonstrates the problem and the solution. Publishing costs for composition, printing, paper, and binding have reached a level that makes short runs of publications addressed to highly specialized audiences prohibitively expensive when traditional manufacturing processes are used. In order to make valuable information available to students and scholars, we are concentrating on efficiency and economy and are foregoing some of the niceties of book production that would increase prices more than anyone would like.

The *Bulletins* will add a useful flexibility to the Peabody's publication program. We are happy to add this volume and this series to our list.

Stephen Williams
Director
October 1976

FOREWORD

For the specialist in zooarchaeology, no foreword to this *Guide* is really necessary. For the nonspecialist or student, however, and particularly for those from the English-speaking world, a few words of introduction might be of value.

The purpose of publishing this *Guide* in English is to make available to as wide an audience as possible the results of more than twenty years of experience of the Munich school of osteoarchaeology in the taking of measurements. The expectation is that the compilation will serve as a standard to which future work will refer. Both the author of the *Guide*, Dr. von den Driesch, and the director of the Institute for Palaeoanatomy, Professor Boessneck, have expressed the desire that the reader clearly understand that the measurement definitions published here are those which workers in the Institute have found useful and which they hope will be useful to others. "If they are useful, use them; if they are not, change them," expresses their sentiments, qualified by the provision that if different, the method of taking each dimension should be clearly described. Thus, within clearly recognized limits, the hope is that this *Guide* will be used as a handbook by faunal analysts working particularly in the Old World and will help to standardize the taking of measurements. Such standardization is essential if comparisons are to be made between assemblages studied by different workers.

Although standardization of measurements is an important goal, it will not be completely attainable, particularly for cranial material. Measurements taken for purposes of species identification need to conform to those found useful by systematists. Such dimensions, however, may not be suited to the description of variation resulting from the interaction of human and animal populations. The measurement definitions presented in this *Guide* are particularly useful for documenting dimensions which reflect changes in the size and proportions of identified species. Additional or different measurements will need to be defined to distinguish between closely related or similar species. In doing this, nonspecialists should not only be acquainted with relevant literature, but also seek the advice and guidance of knowledgeable zoologists. A danger of compilations like this one is that they lend themselves to being used as "cookbooks" with little consideration being given to the reasons why individual dimensions are being measured.

A couple of other potential or actual shortcomings of the *Guide* should also be pointed out. In the first place, the present work deals primarily with the larger Holocene animals whose remains are commonly encountered in assemblages from European sites. The direct applicability of this compilation, therefore, is limited to Europe and the Near East, although its indirect utility, particularly as a guide to measurement of the postcranial skeleton, extends to similar and related species throughout the world. Secondly, terms such as *greatest, smallest,* and *breadth* do not conform to the more common English *maximum, minimum,* and *width.* The author feels that closer approximations to the terminology used in the original German version of this *Guide* are preferable, particularly in the construction of abbreviations for postcranial dimensions. Although this point of view might be debated, it should be noted that all terms have been used in a consistent fashion throughout the work.

Finally, it is important to note that while the primary contribution of the *Guide* lies in its sixty-two figures and accompanying measurement definitions for both mammals and birds, the narrative portion of the work contains definitions and discussion which are indispensable to the proper use of this handbook in particular and of measurement data in general. A particularly important concept expressed both in the text and in Table 1 is that not all measurements are equal. Skeletal parts are recovered from archaeological sites in differing frequencies, are of varying value for the documentation of size, and are measurable with differing degrees of precision. All these factors affect the quality of the data collected and thus place limits on the nature and extent of possible interpretation. It is earnestly to be hoped that whenever measurements are taken, using this or any other guide, they will not be casually manipulated as abstract data, but will be carefully interpreted in the context of their particular element, species, site, area, and time period with due regard for biological and archaeological realities and for the strengths and limitations of this approach to documentation.

Richard H. Meadow
Peabody Museum
October 1976

PREFACE

This guide to the measurement of animal bones was originally developed by Professor Joachim Boessneck and myself as part of the program of instruction for students working on osteoarchaeological theses in the Institute of Palaeoanatomy, Domestication Research, and History of Veterinary Medicine of the University of Munich. During conferences of osteoarchaeologists held in Budapest (1971) and in Groningen (1974), it was suggested that I complete and distribute this measuring guide in order to promote and standardize the taking of measurements of animal bones recovered from prehistoric and early historic sites. The original hope was for publication in various languages, but with the high cost of printing, only this English version is to be published. The original German text, however, is available in reduced xerographic form from the Institute in Munich.

I thank the Director of the Institute, Professor Boessneck, for his assistance in the preparation of this work. He in particular, because of his long and varied experience in osteoarchaeology, is in a position to judge a compilation of this kind. He aided me continually with critical advice in the choice and definition of measurements and in the arrangement of the diagrams. I thank him sincerely for his unremitting help.

I likewise particularly thank the scientific draftsman of the Institute, Mr. R. Zluwa, for the preparation of the illustrations and for marking in the measurements. He executed this tedious task with great patience.

I am indebted to Dr. C. Grigson of the Odontological Museum in London for translation of the introductory chapter and of the chapter on the measurement of mammalian skulls. My translation of the second part of the work was edited by Mrs. M. Fernando of Munich. Finally Mr. R. Meadow of Cambridge, Massachusetts, reedited the complete manuscript in preparation for publication. In addition, Dr. A.T. Clason of Groningen and Dr. J. Clutton-Brock of London helped me by word and by deed. My thanks to all.

Angela von den Driesch
Institut für Palaeoanatomie
September 1976

PART ONE

INTRODUCTORY STATEMENTS

INTRODUCTION

The measurement of bones that are to be scientifically studied is an essential part of their documentation. It is only when truly comparable measurements have been taken that it is possible to say anything objective about the size or form of the animal, to establish evolutionary lines, or to learn as much as possible about the history of the domesticated animals. (For further discussion, see Boessneck and von den Driesch 1976).

Among osteoarchaeologists working in Central Europe there is wide agreement that measurements must be taken on certain commonly occurring complete bones as well as on fragmentary specimens which are complete enough for certain dimensions to be taken. Furthermore, it is widely agreed that these measurements must be published in a clear and unambiguous form. One should measure not only skulls, teeth, toothrows, and complete long bones, but also the ends of long bones and the smaller bones such as those of the wrist, ankle, and foot. These last are usually very frequent in archaeological deposits and therefore can often be used to demonstrate the variation within an animal population better than the less numerous complete long bones. For most bones, more than one dimension should be taken in order to better elucidate the size and proportions of the animal.

The complete publication of single measurements is an expensive undertaking and usually has to be limited to essential information. Examples in the literature of the last ten years show how the documentation of bone finds can be done in an economical yet comprehensive fashion with the aid, for example, of diagrams and summarizing tables. It would take a whole chapter to go into all the possibilities. Here it is emphasized that for the primary publication of site material, the simplest and most objective presentation of the unprocessed metrical data is of primary importance. Only the least abstracted type of documentation can guarantee the use by others of the basic data in ways not envisioned or not pursued by the original analyst.

On the one hand, research completed early in the history of osteoarchaeology is largely out of date as far as interpretations are concerned. In so far as the early workers included measurement data, however, their publications can still form a valuable basis for modern osteoarchaeological research. On the other hand, there are numerous faunal analysts working on bone collections from parts of Europe and from the Near East who even up to the most recent times have failed to publish any measurement data, with the result that the value of their research is greatly reduced (e.g., Bataller 1952, 1953; Martín-Roldán 1959; Reed 1960; Hole and Flannery 1962; Perkins 1964). Other workers have published measurements, but too few and highly selective in nature (e.g., Ducos 1967; Hole, Flannery, and Neely 1969).

WHAT SHOULD BE MEASURED

The decision on which skeletal parts to measure and which measurements should be taken must in the end be made by each research worker for himself. The choice of measurement depends on the value of a find and on the aims of the research. No norm can be set for the specialist. However, if we hope, from the point of view of universal validity, to achieve comparable results, the use of the same measurements is of the greatest importance in original research on site refuse.

The following bones and parts of bones should be measured:

1) Complete skulls, larger skull fragments, mandibles, toothrows, and single cheek teeth (so long as they are identifiable). The following teeth should be measured individually in the case of the common domestic animals:

   Equids: P^2-M^3 and P_2-M_3*
   Ruminants: M_3
   Pigs: M^3 and M_3
   Carnivores: P^4(-M^2) and M_1(-M_3).

2) Complete long bones as well as the phalanges of digitigrades (carnivores and lagomorphs) which, however, should be measured only when their exact radial position in the hand or foot can be established. The articular ends of long bones should also be measured.
3) Patellae, larger wrist and ankle bones, and the distal sesamoid bone of equids.
4) The first two cervical vertebrae and the sacrum as well as any vertebrae between them whose exact serial position in the vertebral column can be established.
5) The penis bone of carnivores.

Bones that have been in a fire and subjected to high temperatures or calcined become smaller to an extent which depends upon the degree of influence of the heat. To obtain an idea of the extent of the size (and weight) loss, the following experiment was conducted by the author together with H. J. Gregor of the Anthropological Institute of the University of Munich: single skeletal parts of the right and left sides of the bodies of different wild and domesticated animals were measured and weighed. The bones of the right side then were heated for one hour at a temperature of 850° C., and those of the left side were heated for one hour and twenty minutes at a temperature of 1000° C. in a muffle oven. As a result of treatment, the bones of the right side turned black, and on average they had lost 5% of their size and c. 50% of their weight. The bones of the left side turned white, were on the average 15% smaller, and had also lost 50% of their weight. For example, the lateral length of both astragali of a wild pig before heating was 40.5 mm; following the experiment, the measurement of the right astragalus was 38.5 mm and of the left 34.5 mm. (See also Iregren and Jonsson 1973.)

*The teeth are numbered and designated as follows:

I^1, I^2, I^3, C, P^1, P^2, P^3, P^4, M^1, M^2, M^3	Upper Jaw
I_1, I_2, I_3, C, P_1, P_2, P_3, P_4, M_1, M_2, M_3	Lower Jaw

I = Incisor, C = Canine, P = Premolar; M = Molar.

The results of the heating experiment suggest, therefore, that carbonized and calcined bones should not be measured; if measurements are taken, they are of only limited use. In addition, bones that are pathologically or anatomically abnormal are only measurable in a limited way and have to be interpreted specially case by case.

In general, only the bones of full grown animals should be measured; in the young animal an increase in size has to be allowed for and the resulting corrected measurement is not precise enough to permit an accurate estimation of size. The measurement of bones that are known to be from young animals can only be justified in the case of exceptional size or in the study of particular age groups (see von den Driesch and Boessneck 1970; Boessneck and von den Driesch 1973, p. 19 and table 13). If bones of young animals are measured, these have to be specially designated.

In the case of slaughter refuse, with its numerous bone fragments, it is not possible in every case to estimate the exact age of the animal from which one particular bone derived. Because the epiphysal union of the proximal and distal ends of long bones can take place at different ages, when broken ends of long bones are examined one often cannot determine whether they belonged to fully grown animals or to animals that were still young at the time of slaughter. For example, in order to be sure that only tibiae from full grown animals are being measured, only tibiae with both proximal and distal epiphyses fused should be measured. Such a procedure will, of course, considerably reduce the number of measurable bones, since complete tibiae are rare in slaughter refuse. For this reason all fused distal tibiae should be measured, even though some may not have fused proximally. In the case of ungulates, proximal epiphyses fuse about one and one-half years after the distal epiphyses (Zietzschmann 1924, Silver 1963). During this period an animal can still grow considerably.

The distal epiphysis of the tibiae fuses to the diaphysis at the end of the second or during the course of the third year in most domestic animals, by which time the animal has already passed its phase of most rapid growth. At this age the inclusion of dimensions of certain bones like the distal tibia, which come from animals whose immaturity cannot be recognized, will have less impact on the statistical results than will the inclusion of measurements of other bones whose epiphyses have already fused in the first year of life, e.g., the scapula. This situation suggests that not all bones whose articular ends are measured have the same usefulness for the estimation of size because under one category of articular ends young animals could be included in greater numbers than under another.

Epiphysal sutures are still visible for rather a long time after the actual fusion takes place, the region of fusion being dotted with large pores. Articular ends of the early fusing elements which bear such telltale signs should not be measured. For skeletal parts that have no sutures, like the astragalus, one can use the degree of compactness of the bone as a criterion of age. Bones of young animals are more porous, their structure is more spongy, and they are lighter than bones from fully grown animals. None of these characters can be used with certainty, however, so that the measurement of bones from young animals cannot be avoided altogether.

In the refuse of prehistoric and early historic sites, certain skeletal parts of the commonly kept animals are especially frequent, while others are less common, and still others are seldom found. These different frequencies result from the fact that the bones of prehistoric and early historic sites were shattered in varying degrees and to the fact that certain parts of the skeleton preserve better than others. So one finds, for example, only a few of the larger limb bones of the common food animals because these bones usually were broken open by the inhabitants of the more ancient sites in order to obtain the marrow. The large long bones of equids and of the smaller ungulates, however, are often better preserved than those of cattle and red deer whose bones were much more intensively utilized. In the case of the small domestic animals, complete long bones of sheep and goat predominate over those of pigs because the use of pigs exclusively for food almost invariably led to their slaughter at a young age. The bones of young animals are less resistant to soil conditions than are the bones of fully grown animals.

Of the horned animals, the horncores of goats are more durable than those of cattle and sheep which tend to disintegrate because of their greater porosity and crumbly consistency. One therefore gets relatively more measurements from the horncores of goats than from those of cattle or sheep.

Complete toothrows of small hoofed mammals are more often measurable than those of the large ungulates because large skulls are more likely to have been broken up for marrow. For similar reasons, short bones generally are better preserved than the larger long bones. If such bones fall below a certain size, however, they are more easily overlooked in an excavation where sieving is not carried out. Because of this, measurements of the short bones of large animals are taken more often than those of small animals.

The proximal and distal ends of broken long bones are also preserved in differing frequencies. Measurable ends of those long bones whose epiphyses fuse at an early age (such as the distal humerus and the proximal radius) occur in greater numbers because the bone consolidates earlier. Ends whose epiphyses fuse later (such as the proximal humerus and the distal radius) tend to be less frequent not only because not all animals of a population are permitted to complete growing before they are slaughtered, but also because the wall of the bone is less compact and thus less resistant to destructive forces. Such bones are therefore less frequently available for measurement. Ultimately, of course, the preservation of a bone depends also on the structure of the spongy bone [illegible]

All of the above considerations must be taken into account during the evaluation of measurements of each part of the skeleton. Table 1 brings together this information for each measurable component of the skeletons of the more important hoofed mammals.

TABLE 1

SKELETAL PART	FREQUENCY *hoofed mammals* *large*	 *small*	RELATIVE VALUE *hoofed mammals* *large*	 *small*	MEASURABILITY *hoofed mammals* *large*	 *small*
complete SKULL	o	o	1	1	+/-	+/-
HORNCORE	x[1]	xx[2]	3	3	+	+
MAXILLA: complete toothrow	o-x	x-xx	1	1	+/-	+/-
MANDIBLE: complete toothrow	x	xx-xxx	1	1	+/-	+/-
single M3	xx	xxx	1	1	+/-	+/-
ATLAS, AXIS	x	x	2	2	+	+
SCAPULA, whole	o	o	3	3	+	+
distal	xx	xx	3	3	+	+
HUMERUS, whole	o	x	1	1	+/-	+/-
proximal	x	x	1	1	+/-	+/-
distal	xx	xxx	3	3	-	-
RADIUS, whole + distal	x	x-xx	1	1	+	+
proximal	xxx	xxx	3	O/C:4 S:3	+	+
ULNA, proximal	xx	O/C:x S:xxx	1/4[3]	1/4[3]	-/+	-/+
PELVIS, whole	o	x	1	1	+	+
acetabulum	xx	xx	4	4	-	-
FEMUR, whole + distal	B:o E:x	x	1	1	+ +/-	+
proximal	x	xx	1	1	+	+
PATELLA	x	x	4	4	+	+
TIBIA, whole+proximal	x	x-xx	1	1	+	+
distal	xx-xxx	xx-xxx	2	2	+	+
CALCANEUS	x	x	2	2	+	+
ASTRAGALUS	xxx	xx	4	4	E:- B:+	+
ruminant CENTROTARSALE	xx	x	4	4	+	+
whole and distal METAPODIALS	xx	xx	E:3 B:2	O/C:3 S:2	+	+
proximal METAPODIALS	xxx	xxx	4	4	+	O/C:+ S:+/-
PHALANX 1	xxx	xx	E:3 B:2	O/C:4 S:2	+/-	+/-
PHALANX 2	xxx	x-xx	3	O/C:4 S:3	+/-	+/-
PHALANX 3	xx	x	4	4	E:- B:+	+

TABLE 1: *Relative values of the measurable skeletal parts of the common hoofed mammals.*

KEY: Frequency:
- o = almost none
- x = rare
- xx = moderately frequent
- xxx = frequent

Relative value of the measurement for size estimation:

postcranial skeleton:

1 = very good, because the bone certainly came from a fully grown animal.

2 = good, because the bone came from an animal whose age can be determined from epiphysal fusion to have been 2 - 3 years old and which therefore had attained nearly full adult size.

3 = moderate, because among the measured bones there may be those from animals aged 1 - 2 years.

4 = slight, because among the measured bones there may be those of animals aged less than 1 year.

skull:

All skull measurements have the value '1' because one measures only those skulls and skull fragments which come from animals that reached the age of complete permanent dentition and so would have shown no more real growth. (Exception: detached horncores cannot be used unless the age of the animal can be established.)

Measurability:

+ = the measurements are clear and easy to take.
- = the measurements are difficult to take.

Animal species:
- E = Equid
- B = Bos
- S = Sus
- O/C = Ovis/Capra

NOTES:
1) Only Bos.
2) Only Ovis and Capra. The horncores of goat are usually more frequent than those of sheep.
3) The relative value depends upon whether the epiphysal fusion of the tuber olecrani can be ascertained.

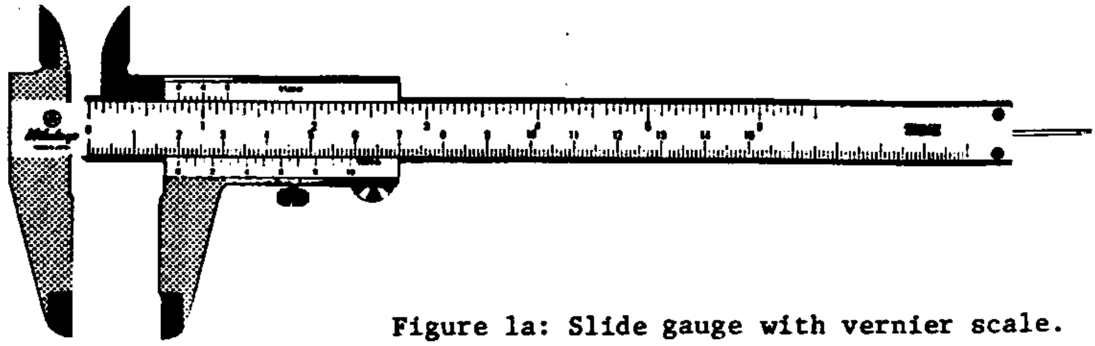


Figure 1a: Slide gauge with vernier scale.

MEASUREMENTS AND MEASURING INSTRUMENTS

Measurements are given in millimeters, and only exceptionally in centimeters. For the longer dimensions (the bones of larger animals) the measurements are given to the nearest 0.5 mm and for the shorter dimensions (bones of small mammals, birds, reptiles, and amphibians) to the nearest 0.1 mm.

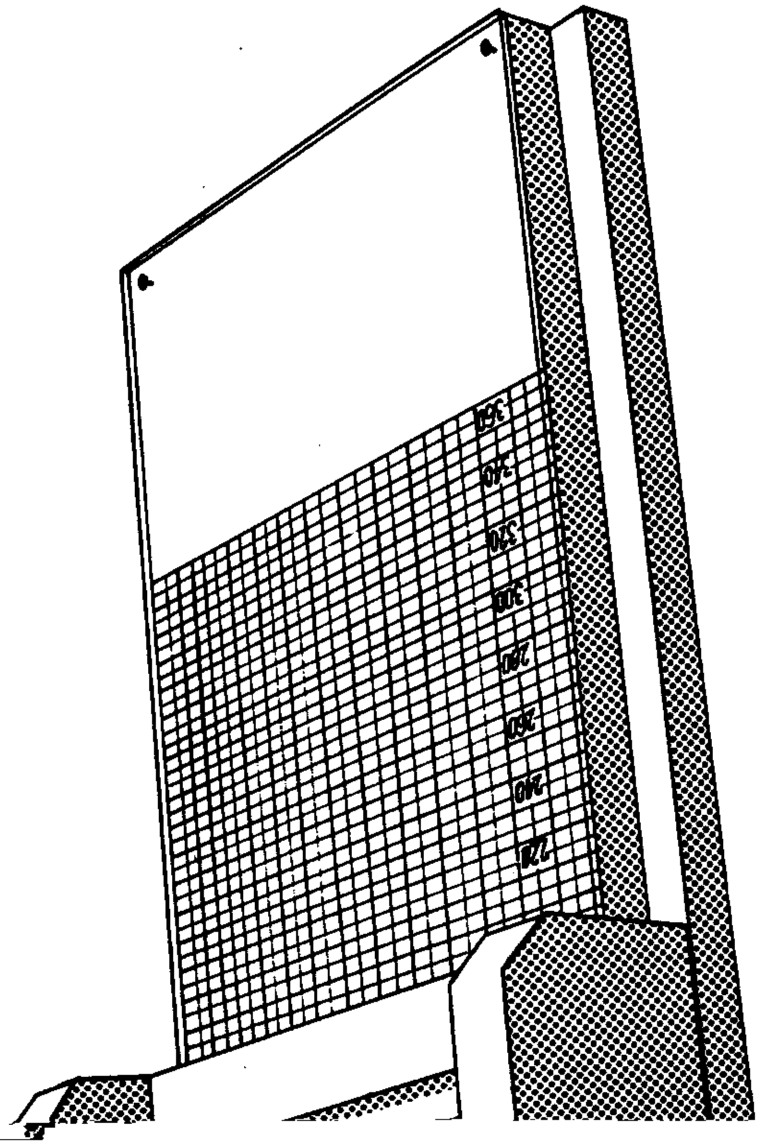
Usually the measurements are taken with a slide gauge fitted with a vernier scale (Fig. 1a). A modification of this is the dial slide gauge which is calibrated in millimeters and tenths of millimeters (Fig. 1b). This type of scale has the advantage that the eye does not tire so quickly when a large series of measurements is being taken. When projections of bone hinder the taking of measurements with a slide gauge, one has to use curved callipers equipped with a scale (Fig. 1c) to reach both measuring points.

In this regard, two automatic measuring apparati developed independently by Gejvall (1973) in Stockholm and Dolling and Reichstein (1975) in Kiel are of interest. The advantage of such apparatus is that reading and recording mistakes are eliminated; individual measurements are automatically recorded and punched onto perforated tape which then can be interpreted by computer.

For many bones the use of a measuring box is helpful (Fig. 2). Such a device is suitable for taking dimensions for which the two measuring points do not lie in the same plane and for which the dimensions must be measured in projection (e.g., the distal end of the femur in large animals, the greatest breadth of the astragalus in the horse, and the greatest length of the first phalanx in the horse). In many such cases, however, a slide gauge with long and wide arms can be successfully employed.

For the measurement of circumferences and curves (of horncores and diaphyses of long bones) one uses a tape measure or a smooth thread that is neither too thick nor too thin and which is marked and then laid on a scale. Such measurements can be made only to the nearest millimeter.

When a bone is slightly damaged the complete length or breadth can be estimated and recorded in brackets. The only purpose of recording the actual measurement is as a check on the estimated measurement.



THE TAKING OF MEASUREMENTS

In the taking of measurements there will always be discrepancies from one research worker to the next which will influence the final results. Even one and the same person may not always work in the same way. Anyone who has measured bones knows that merely to measure the bones of the right and left sides in the same way is difficult enough. Discrepancies occur, however, primarily because, regardless of the true dimensions, some bones are less precisely measurable than others (see also Table 1). Here are some examples: most measurements of the skull can be taken without difficulty because they can be taken from easily defined fixed points (see below under "Skull: Cranium"). Where necessary one can mark these points on the actual skull itself. Also for most of the long bones one can measure length and often breadth (width) with hardly any inaccuracy (e.g., greatest proximal breadth of radius and, in horses and ruminants, greatest distal breadth of metapodials, lengths of the astragalus, etc.), and such measurements are unrestrictedly comparable.

The situation is different with single teeth. One usually finds in the literature that the "length" and "breadth" (width) of the single teeth of herbivores are measured "near to the biting surface." The use of the term "near to" is very subjective: one person may measure farther up and another farther down. Furthermore, there is a difference between the measurements of loose teeth and those which are fixed in a jaw and which cannot be removed without damaging the bone. The pointers of the measuring instrument can be fixed easily on loose teeth; one finds that with teeth that are still in their sockets the measuring instruments cannot reach the same points. One manipulates them until one thinks that one has made approximately the same measurement as on loose teeth. These circumstances, however, generally mean that one uses a different standard for teeth in sockets than for loose teeth.

A number of such inconsistencies will be apparent to the user of the present work. In order to give at least some indication of such difficulties, in the following pages the sign "+" is given for dimensions which are precisely measurable and the sign "-" for dimensions which are less precisely measurable. It is not, however, the purpose of the present work to eliminate all imprecisions. It is simply not possible to arrive at an exact, infallible definition for every dimension. Our intention here is to demonstrate that one must oneself be clear about the occurrence of inexactitudes and that one must bear in mind this state of affairs in any subsequent comparisons with measurements given in the literature. In order to be quite certain, one should use only the "good" (precisely measurable) dimensions to arrive at a true picture. Given this advice, the question arises whether it would not be more appropriate to leave out the measurements that are difficult to take (e.g., the distal breadth [width] of the humerus in ruminants, the greatest breadth of the astragalus in equids or all dimensions of the proximal ulna) as many authors have in fact done. We believe that the omission of skeletal measurements that are difficult to take accurately should not be made a rule because among those bones there are some whose dimensions are very important for the estimation of size, for example the teeth and the phalanges. In conclusion, it may be said that in large samples these inaccuracies even themselves out as is shown when the size changes of cattle in Europe are worked out from measurements available in the literature (Boessneck et al. 1971, pp. 56 ff.).

In the following pages the definitions of measurements for crania, mandibles, teeth, vertebrae, and limb bones of both common mammals and birds--the result of more than twenty-five years of experience of the Munich school of osteoarchaeology--have been brought together. These definitions are explained partly by diagrams and partly by short descriptions. This arrangement has been made primarily for beginners and inexperienced research workers. It is also intended to be used as a "Field Guide" for bone measurement, particularly on excavation sites where literature may be lacking.

PART TWO

MEASUREMENT OF THE MAMMALIAN SKELETON

GENERAL

The most important introduction to the measurement of bones is Duerst's work of 1926: "Vergleichende Untersuchungsmethoden am Skelett bei Säugern." Duerst gathered together all the information on the measurement of skulls and limb bones of mammals that existed in the literature at that time, and he clearly defined the measurements and measuring points. Many of these, particularly those of the skull, are still named and selected in the same way. His selection of measurements, however, goes far beyond the needs of osteoarchaeology, and the special requirements of this discipline are not always recognized. The measurements defined by Duerst are extremely numerous, but experience has shown that only a few well-defined dimensions need be measured in order to estimate size and proportions from bones recovered from archaeological deposits. Nevertheless Duerst's work remains very important as an introduction and for specialized research of other kinds.

The assembling of measurements from the practical experience gained during the course of research by Hescheler's school (see Boessneck 1969, pp. 49 ff.), particularly in Kuhn's dissertation (1932), influenced the methodological development of comparative osteology almost more than did Duerst's great theoretical work. The precise definition, however, of these subsequently widely-used measurements, and of newly introduced additional measurements, has been lacking until now. For even if similar sets of measurements are now generally used in the osteoarchaeological research of German-speaking workers, differences still do exist with the result that comparability of results suffers. It is high time for methods to be standardized in detail.

In order to define measurements it is important to know how to denote the directions and planes of the animal body. Unfortunately such nomenclature differs in zoological, veterinary, and medical textbooks.

(Compare, for example, Romer 1971, pp. 9 ff. with Ellenberger and Baum 1943, pp. 1 ff. and Nickel, Schummer, and Seiferle 1961, p. 7. Anthropology uses other directional nomenclature as well.) I propose to use the nomenclature that is set out in Figures 3 and 4 in order to overcome the lack of standardization. The direction toward the plane of support (the ground) is termed *ventral* and the opposite direction is *dorsal* (or *frontal*). The *median plane* divides the body longitudinally into similar halves. Planes parallel to the median plane are *paramedian* or *sagittal*. A surface which is nearer than another to the median plane is *medial* to it and a surface which is farther than another from the median plane is *lateral* to it. The direction toward the head is termed *cranial* and toward the tail *caudal*, with the front and back sides of the scapula, humerus, pelvis, and femur designated accordingly. With respect to part of the head, the corresponding terms are *oral* and *nasal* directed toward the mouth and nose with the opposite being *aboral* or *nuchal*.

The definitions of *dorsal* and *volar* (or *palmar*) in the forelimb and *dorsal* and *plantar* in the hind limb, derive, like many other expressions from human anatomy, and come from dorsum manus and dorsum pedis (the back of the hand and of the foot), vola (or palma) manus and planta pedis (the palm of the hand and the sole of the foot, respectively). These terms can be used in animals for all the limb bones below the elbow and knee. *Proximal* and *distal* express relative directions in the long axis of the limbs. It also must be noted in the cases of horncores, antlers and tail bones that the direction toward the tip is designated as *distal* and toward the head or toward the body as *proximal*.

Linear measurements are designated as *length, breadth* (width), *depth, or height*. It is necessary to pay strict attention to the following definitions:

Length a) for all bones of the axial skeleton and of the pectoral and pelvic girdles is that dimension measured in a cranio-caudal direction.

b) for all bones of the remaining appendicular skeleton is the dimension measured in a proximo-distal direction.

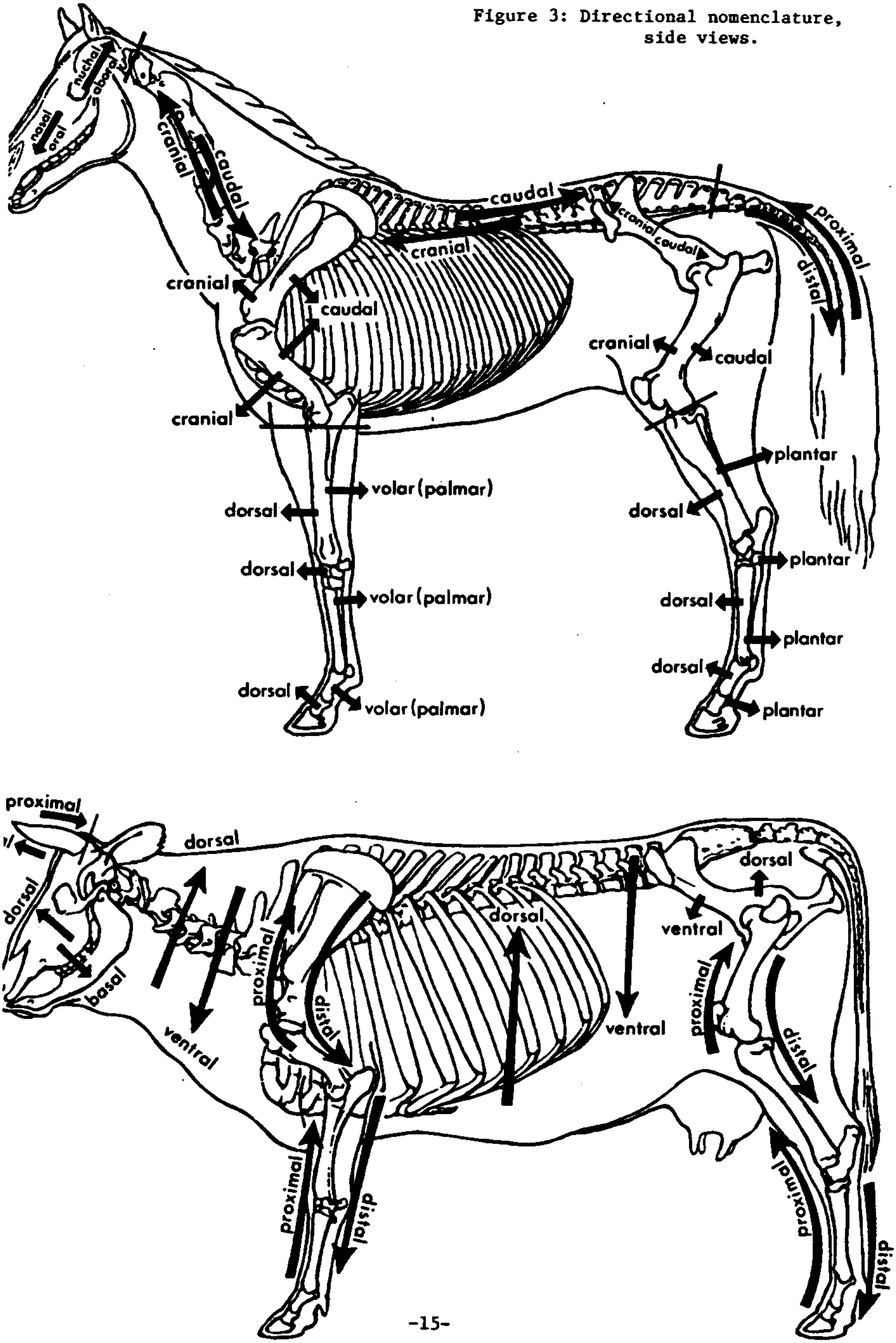
Breadth (width) on all bones is that dimension measured in a medio-lateral direction.

Height for all bones of the skull, of the axial skeleton, and of the pectoral and pelvic girdles is that dimension measured in a dorso-ventral direction.

Depth for all bones of the extremities is that dimension measured a cranio-caudal direction (i.e., dorso-volar or dorso-plantar).

Measurements that do not lie in any one of the three basis directions a designated as *diagonals* or *diameters*.

Figure 3: Directional nomenclature, side views.



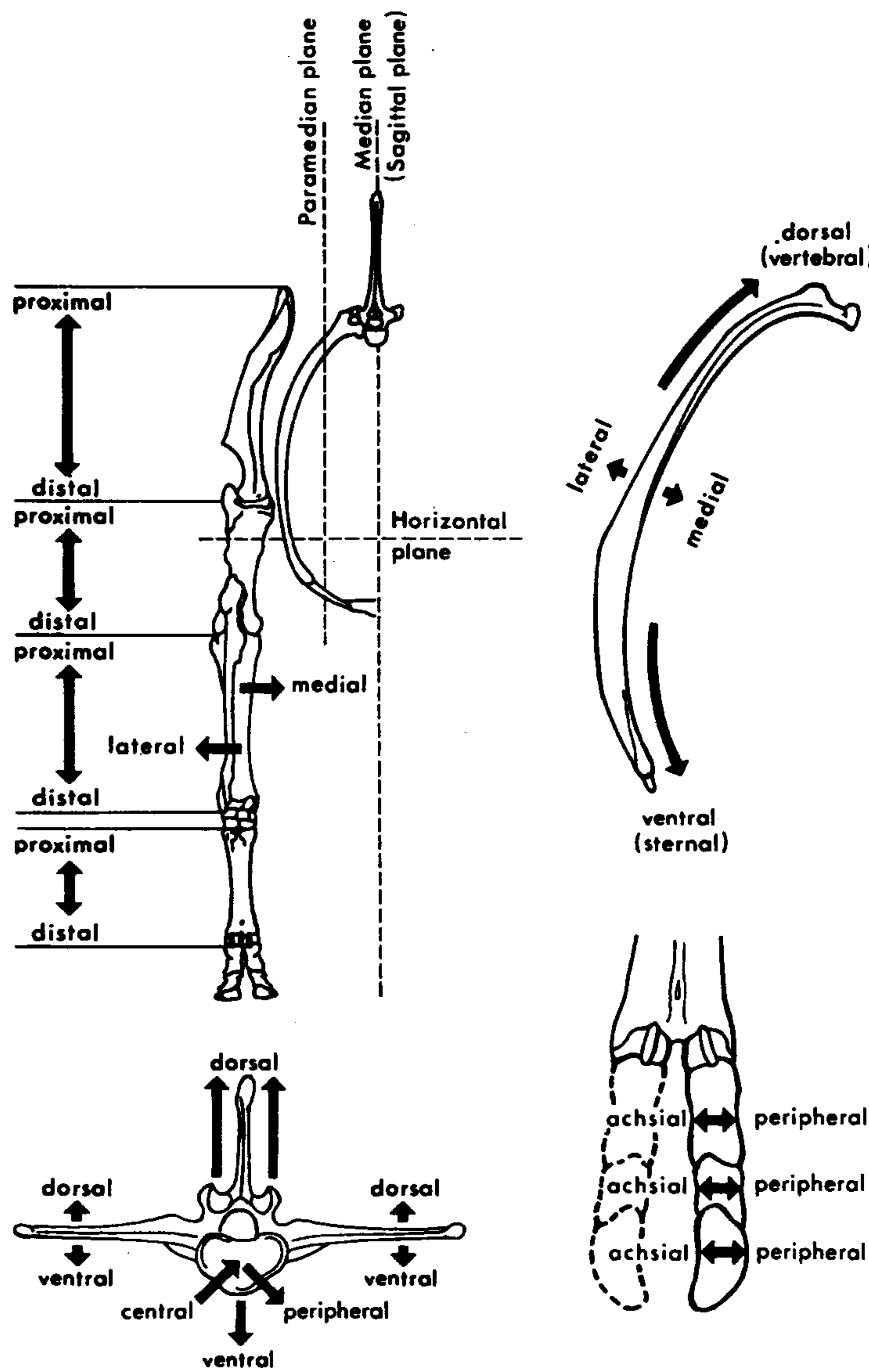


Figure 4: Directional nomenclature, fore and aft views.

SKULL

CRANIUM

All individually important measuring points that are used in the text and in the illustrations are defined following Duerst (1926, pp. 237 ff.). Some remarks, however, on the points *opisthokranion and akrokranion* are necessary. According to Duerst (ibid.), the opisthokranion is "the most aboral point on the skull vertex" and the akrokranion is "the most aboral and highest point that lies in the median plane." Length measurements taken from the opisthokranion, according to Duerst, would obviously be measured from a point that is not actually in the median plane and so would have to be measured in projection (Duerst 1926, Figs. 108 and 109). Of the animals being considered here, in camels, sheep, goats, red deer, dogs, cats, and hares the opisthokranion and the akrokranion coincide (also Duerst 1926, Fig. 107). In horses and cattle the two points are only a few millimeters apart and hence we propose that in those two species length measurements should be taken from the akrokranion, there being scarcely any difference between measurements taken from the two points. A fixed point on the skull can be comprehended more easily than one that has to be projected into the median plane and thus is situated in space. In the pig, however, the opisthokranion and the akrokranion are situated significantly farther apart from one another because the nuchal crest is drawn out more or less aborally depending on the type of pig. Thus for the pig it is very important to note that the two points are quite clearly distinct.

For anatomical terms such as *foramen magnum* which are used in the definitions of measuring points, reference is made to Nickel, Schummer, and Seiferle (1961) and to Sisson and Grossman (1950). Please also note that before measuring it is advisable to mark on the skull all those points that are defined by the intersection with the median plane of a line joining two points.

Definitions of measuring points of the cranium

- A - Akrokranion, the most aboral point on the vertex of the cranium in the median plane.
- B - Basion, the orobasal border of the foramen magnum in the median plane.
- Br - Bregma, the median point of the parieto-frontal suture.
- Ect - Ectorbitale, the most lateral point of the frontal bone on the occipital side of the orbit.
- Ent - Entorbitale, the naso-medial indentation of the orbit that corresponds with the inner angle of the eye in the living animal.
- Eu - Euryon, the most lateral point of the braincase.
- F - Frontal midpoint, the median point of the line joining the Ectorbitalia (only in carnivores).
- H - Hormion, the aboral border of the vomer in the median plane.
- If - Infraorbitale, the (dorso) aboral point of the foramen infraorbitale.
- L - Lambda, the median point of the parieto-occipital suture.
- N - Nasion, the median point of the naso-frontal suture.

Ni - Nasointermaxillare, the most aboral point of the premaxilla on the facial surface.

O - Opisthion, the nuchodorsal border of the foramen magnum in the median plane.

Op - Opisthokranion, the median point of the line joining the most aboral-dorsal points of the cranium.

Ot - Otion, the most lateral point of the mastoid region (in cattle, red deer, and dogs this is dorsal to the opening of the external auditory meatus, in horses, camels, sheep, goats, and cats it is occipital to the meatus; in pigs it is on the opening of the meat

P - Prosthion, the median point of the line joining the most oral points of the premaxillae. In all ruminants and in pigs the prosthion has to be projected into space. At best one can use one pointer of the slide gauge to fix the most oral point of the two premaxillae.

Pd - Postdentale, the median point of the line joining the aboral points of the alveoli of the hindmost cheekteeth.

Pm - Premolare, the median point of the line joining the oral points of the alveoli of the foremost cheekteeth.

Po - Palatinoorale, the median point of the palatine-maxillary suture.

Rh - Rhinion, the median point of the line joining the most oral points of the nasals.

S - Synsphenion, the midpoint of the suture between the basisphenoid and the presphenoid (= Intersphenoidsuture).

Sp - Supraorbitale, the median point of the line joining the aboral borders of the supraorbital foramina.

St - Staphylion, the most aboral point of the horizontal part of the palate in the median plane.

Zy - Zygion, the most lateral point of the zygomatic arch.

Tooth formulae of the different species (upper/lower jaws):

Equus	$\frac{3.\ 1.\ (4)\ 3.\ 3}{3.\ 1.\ 3.\ 3}$	Canis	$\frac{3.\ 1.\ 4.\ 2}{3.\ 1.\ 4.\ 3}$
Camelus	$\frac{1.\ 1.\ 3.\ 3}{3.\ 1.\ 2.\ 3}$	Felis	$\frac{3.\ 1.\ 3.\ 1}{3.\ 1.\ 2.\ 1}$
Bos, Ovis and Capra	$\frac{0.\ 0.\ 3.\ 3}{3.\ 1.\ 3.\ 3}$	Ursus	$\frac{3.\ 1.\ 4\text{-}1.\ 2}{3.\ 1.\ 4\text{-}1.\ 3}$
Cervus	$\frac{0.\ 1.\ 3.\ 3}{3.\ 1.\ 3.\ 3}$	Lepus and Oryctolagus	$\frac{2.\ 0.\ 3.\ 3}{1.\ 0.\ 2.\ 3}$
Sus	$\frac{3.\ 1.\ 4.\ 3}{3.\ 1.\ 4.\ 3}$		

Measurements of the cranium of Equus (Figs. 5a,b,c,d and 6a,b)

1) Profile length = total length: Akrokranion - Prosthion (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (+)
3a) Basilar length: Basion - the point between the two I^1 (difficult to measure when the incisors cannot be removed from the jaw)
4) Short skull length: Basion - Premolare (+)
5) Basicranial axis: Basion - Hormion (-)
6) Basifacial axis: Hormion - Prosthion (+)
*(7) Neurocranium length: Basion - Nasion. Not shown in Fig. 5. Can be taken only with curved callipers (+)
8) Viscerocranium length: Nasion - Prosthion (+)
9) Upper neurocranium length: Akrokranion - Supraorbitale (+)
10) Facial length: Supraorbitale - Prosthion (+)
11) Basion - most oral point of the facial crest on one side (+)
12) Most oral point of the facial crest on one side - Prosthion (+)
13) Short lateral facial length: Entorbitale - Prosthion (+)
14) Length of braincase: Opisthion - Ectorbitale (+)
15) Lateral facial length: Ectorbitale - Prosthion (-)
16) Greatest length of the nasals: the median point of intersection of the line joining the aboral borders of the nasals - Rhinion (+ except in old horses in which the fronto-nasal sutures are obliterated)
17) Basion - Staphylion (-)
18) Median palatal length: Staphylion - Prosthion (+)
18a) Palatal length: the median point of intersection of the line joining the deepest indentations of the choanae - Prosthion (-)
19) Dental length: Postdentale - Prosthion (+)
20) Lateral length of the premaxilla: Nasointermaxillare - Prosthion (-)
21) Length of the diastema (P^2-I^3) (+)
22) Length of the cheektooth row (measured along the alveoli) (+)
22a) Length of the cheektooth row (measured near the biting surface) (+)
23) Length of the molar row (measured along the alveoli on the buccal side (-)
23a) Length of the molar row (measured near the biting surface) (-)
24) Length of the premolar row (measured along the alveoli on the buccal side (-)
24a) Length of the premolar row (measured near the biting surface) See Fig. 6a (-)

*Measurement numbers which do not appear in the figures are enclosed in full parentheses - "( )".

25) Length and breadth of P^2
26) Length and breadth of P^3
27) Length and breadth of P^4
28) Length and breadth of M^1
29) Length and breadth of M^2
30) Length and breadth of M^3

The form of the biting surface is very variable in <u>Equus</u> and is particularly dependent on the degree of wear. For the length measurement (except for M3) the most aboral points of the aboral contact surface are the fixed points from which to measure.

In M^3 the most oral points of the oral contact surface are used. For breadth measurements one always uses the most buccal points of the cheektooth as the fixed points (Fig. 6b).

31) Greatest inner length of the orbit: Ectorbitale - Entorbitale (+)
32) Greatest inner height of the orbit. Measured in the same way as M 31 (+)
33) Greatest mastoid breadth: Otion - Otion (+)
34) Greatest breadth of the occipital condyles (+)
35) Greatest breadth at the bases of the paraoccipital processes (+)
36) Greatest breadth of the foramen magnum (+)
37) Height of the foramen magnum: Basion - Opisthion (-)
38) Greatest neurocranium breadth = greatest breadth of the braincase: Euryon - Euryon (-)
39) Least frontal breadth = least breadth of skull = least breadth of the forehead aboral of the orbits (+)
40) Least breadth between the supraorbital foramina (+)
41) Greatest breadth of skull = greatest breadth across the orbits = greatest frontal breadth* : Ectorbitale - Ectorbitale (+)
42) Least breadth between the orbits: Entorbitale - Entorbitale (+)
43) Facial breadth between the outermost points of the facial crest at the point of intersection of the maxillo-jugal suture with the facial ridge (+, except in old horses, in which the suture may be already obliterated)
44) Facial breadth between the infraorbital foramina (least distance) (-)
45) Greatest breadth of "snout": measured across the outer borders of the alveoli of I^3 (+)
46) Greatest breadth on the curvature of the premaxillae (+)
47) Least breadth in the region of the diastema (+)
48) Greatest palatal breadth: measured across the outer borders of the alveoli (-)
(49) Greatest skull height inclusive of the lower jaws: Gonion ventrale (see below under "Mandible" for point definition) - the highest point of the skull in projection (best measured on a table). Not shown in Fig. 5 (-)
50) Basion height: Basion - the highest point of the skull in projection

*In the literature one often finds this measurement defined as Zygion - Zygion, while Duerst (1926, Fig. 108) has drawn the Ectorbitale and Zygio inaccurately. The most lateral points of the horse skull are the two Ectorbitalia. The Zygion lies rather more basally and less laterally. S the greatest breadth of the skull must be measured between the ectorbital points.

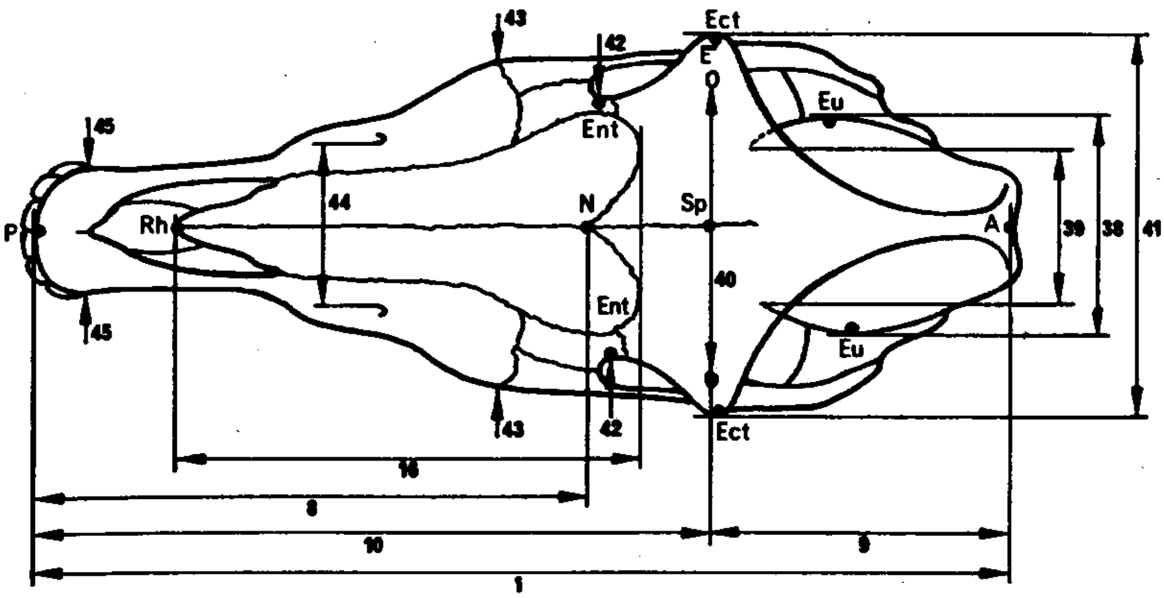


Figure 5a: Equus cranium, dorsal view.

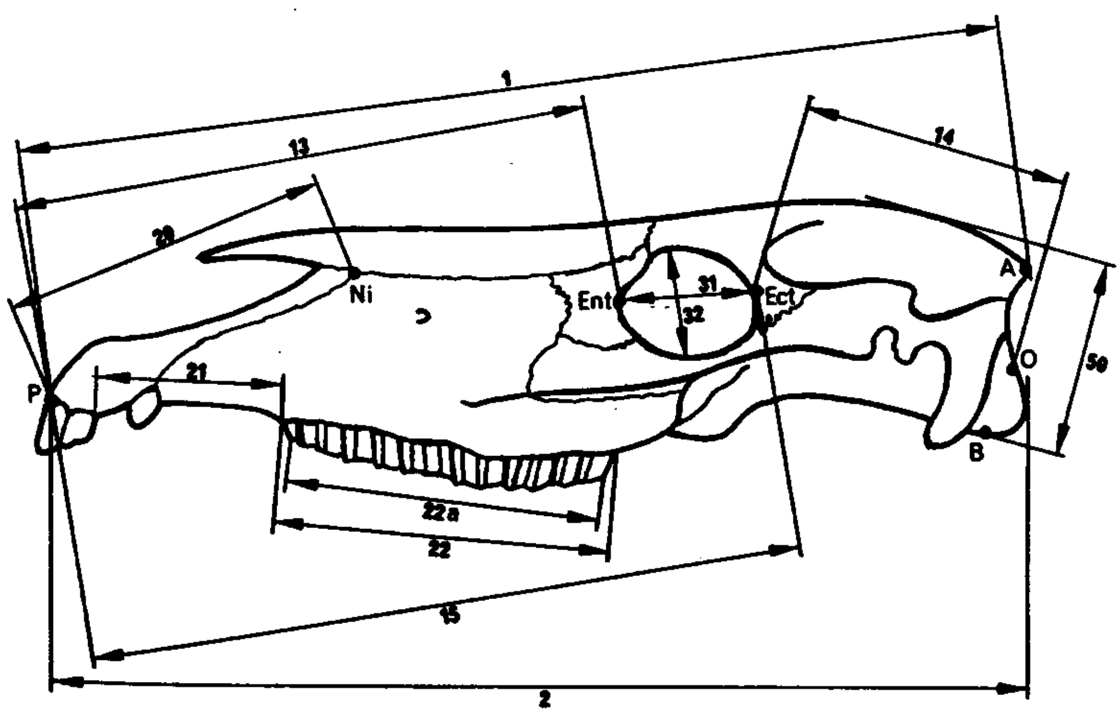


Figure 5b: Equus cranium, left side view.

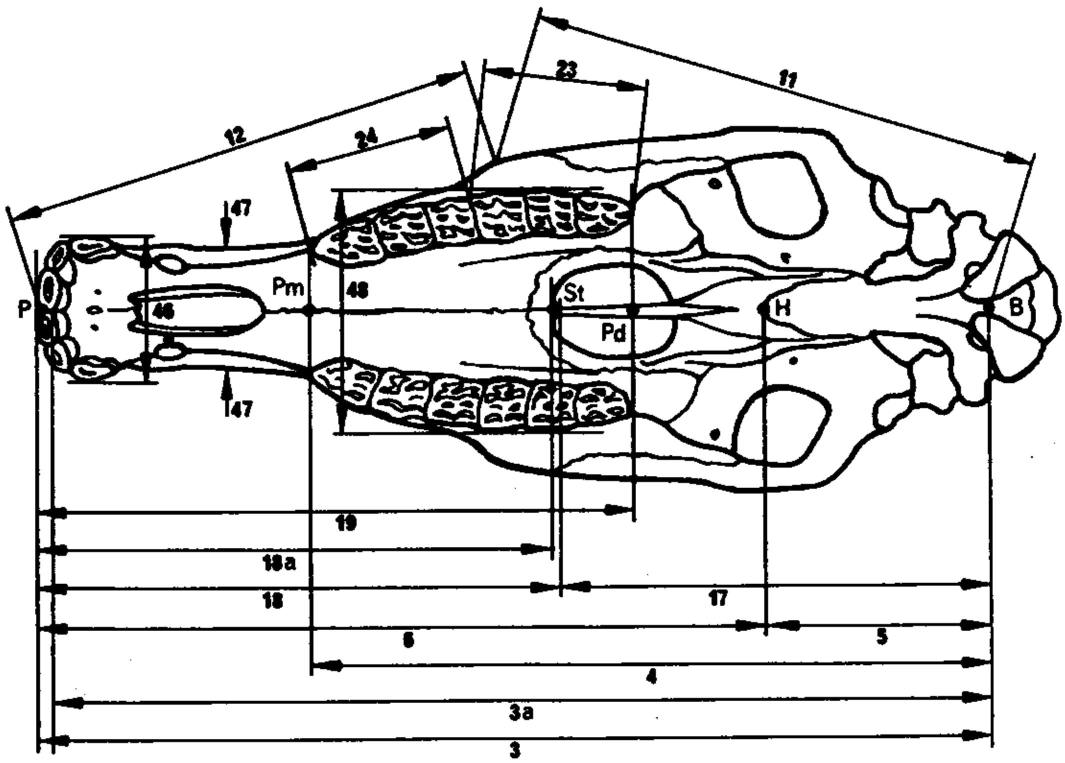


Figure 5c: Equus cranium, basal view.

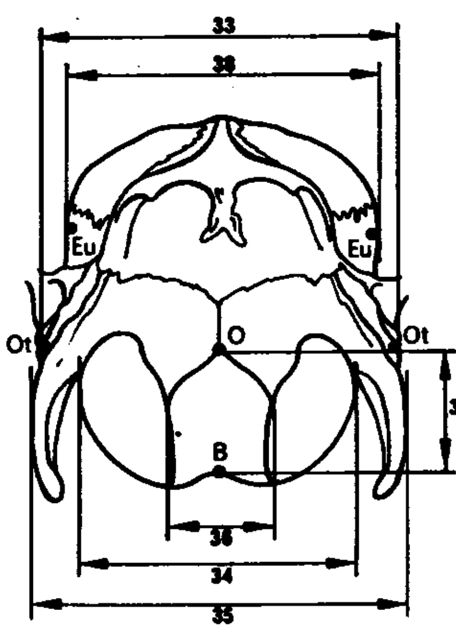


Figure 5d: Equus cranium, nuchal view.

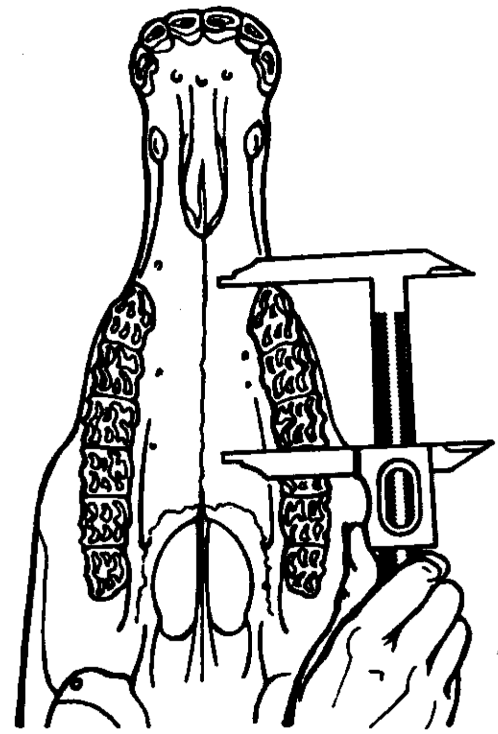


Figure 6a: *Equus* cranium, basal view, showing measurement of premolar row (M 24a).

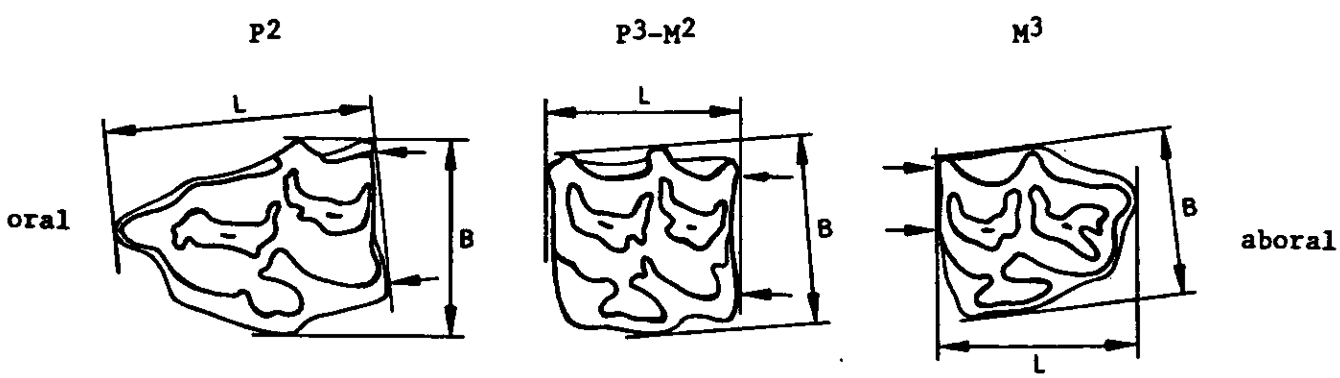


Figure 6b: Length (L) and breadth (B) at the biting surface of *Equus* maxillary teeth. (See M 25-30.)

Measurements of the cranium of Camelus (Fig. 7a,b,c)

1) Profile length - total length: Akrokranion - Prosthion (See definition of point "P" above). (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (-)
4) Short skull length: Basion - Premolare (-)
4a) Short skull length: Basion - the median point of intersection of the line joining the oral points of the alveoli of P^3 (+)
5) Lateral neurocranium length: Akrokranion - Ectorbitale on one side (+)
6) Short lateral facial length: Entorbitale - Prosthion (+)
7) Opisthion - Ectorbitale (+)
8) Akrokranion - Infraorbitale (+)
9) Basion - Staphylion (-)
10) Median palatal length: Staphylion - Prosthion (+)
10a) Palatal length: the median point of the line joining the deepest indentation of the choanae - Prosthion (-)
11) Dental length: Postdentale - Prosthion (+)
12) Lateral length of the premaxilla: Nasointermaxillare - Prosthion (+)
13) Length of the cheektooth row, M^3-P^2 (measured along the alveoli) (+)
13a) Length of the cheektooth row, M^3-P^3 (measured along the alveoli) (+)
14) Length of the molar row (measured along the alveoli on the buccal side) (-)
15) Length of the premolar row, P^2-P^4 (measured along the alveoli on the buccal side) (-)
15a) Length of the premolar row, P^3-P^4 (measured along the alveoli) (-
16) Greatest inner length of the orbit: Ectorbitale - Entorbitale (+)
17) Greatest inner height of the orbit. Measured in the same way as M 16 (+)
18) Greatest mastoid breadth: Otion - Otion (+)
19) Greatest breadth of the occipital condyles (+)
20) Greatest breadth at the bases of the paraoccipital processes (+)
21) Greatest breadth of the foramen magnum (+)
(22) Height of the foramen magnum: Basion - Opisthion. Not shown in Fig. 7 (-)
23) Greatest neurocranium breadth = greatest breadth of the braincase Euryon - Euryon (-)
24) Least frontal breadth = least breadth of the forehead aboral of the orbits (+)
25) Greatest breadth of skull = greatest breadth across the orbits = greatest frontal breadth: Ectorbitale - Ectorbitale (+)
26) Least breadth between the orbits: Entorbitale - Entorbitale (+)
27) Facial breadth between the infraorbital foramina (least distance) (-)

28) Greatest breadth of the premaxilla: measured in the region of the bony nostril (-)

29) Greatest palatal breadth: measured across the outer borders of the alveoli (-)

30) Basion height: Basion - the highest point of the skull in projection (-)

31) Height of the horizontal part of the maxilla: from the front border of the alveoli of P^3 at right angles to the most dorsal point of the maxilla on one side (-)

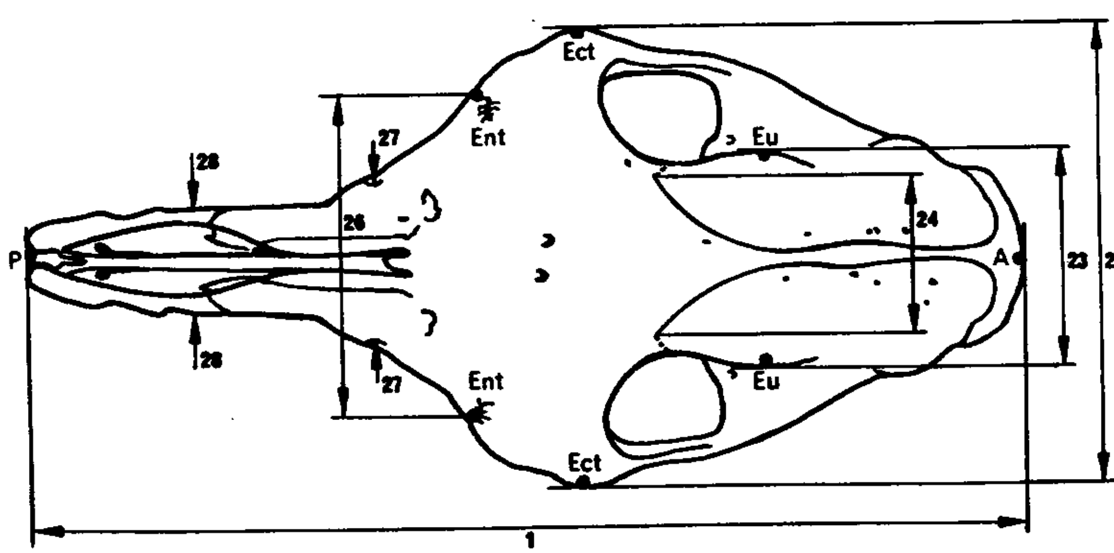


Figure 7a: Camelus cranium, dorsal view.

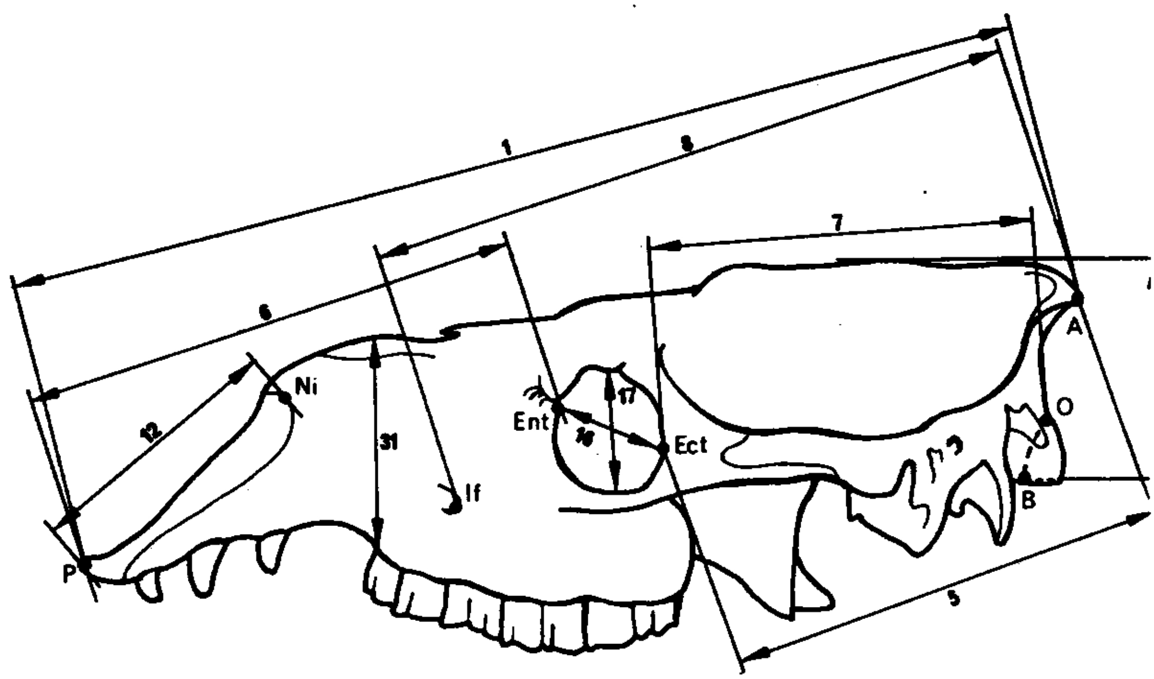


Figure 7b: Camelus cranium, left side view.

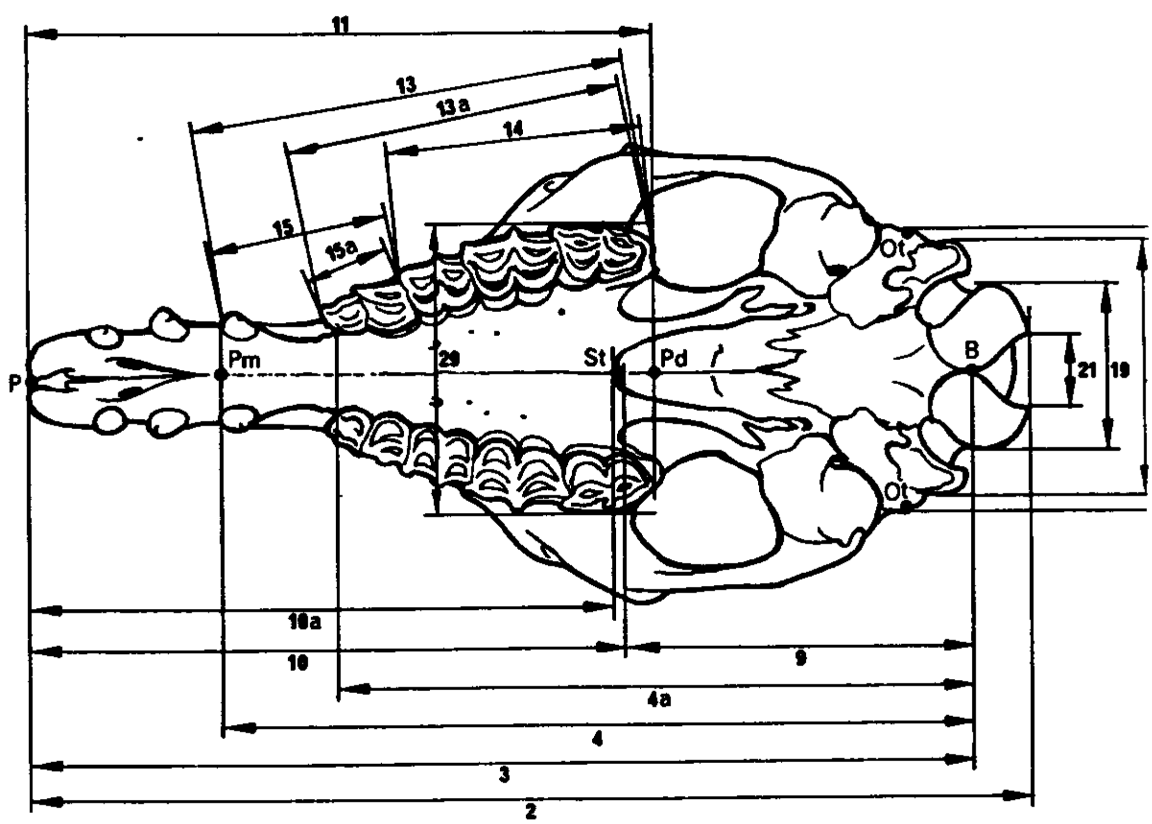


Figure 7c: Camelus cranium, basal view.

Measurements of the cranium of *__Bos__* *(Fig. 8a,b,c,d)*

1) Profile length = total length: Akrokranion - Prosthion (See definition of point "P" above) (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (+)
4) Short skull length: Basion - Premolare (+)
5) Premolare - Prosthion (+)
6) Neurocranium length: Basion - Nasion. Can be taken only with curved callipers (-)
7) Viscerocranium length: Nasion - Prosthion (+)
8) Median frontal length: Akrokranion - Nasion (+)
9) Greatest frontal length: Akrokranion - the median point of intersection of the line joining the oral points of the frontals (+)
10) Short upper cranium length: Akrokranion - Rhinion (+)
11) Akrokranion - Infraorbitale of one side (+)
12) Greatest length of the nasals: Nasion - Rhinion (+)
13) From the aboral border of one occipital condyle to the Entorbitale of the same side (+)
14) Lateral facial length: Ectorbitale - Prosthion (+)
15) From the aboral border of one occipital condyle to the Infraorbitale of the same side (+)
16) Infraorbitale - Prosthion (-)
17) Dental length: Postdentale - Prosthion (+)
18) Oral palatal length: Palatinoorale - Prosthion (-)
19) Lateral length of the premaxilla: Nasointermaxillare - Prosthion (+)
20) Length of the cheektooth row (measured along the alveoli) (+)
21) Length of the molar row (measured along the alveoli on the buccal side) (-)
22) Length of the premolar row (measured along the alveoli on the buccal side) (-)
23) Greatest inner length of the orbit: Ectorbitale - Entorbitale (+)

38) Greatest palatal breadth: measured across the outer borders of the alveoli (-)

39) Least inner height of the temporal groove, roughly from the middle of one bone edge to the other (-)

40) Greatest height of the occipital region: Basion - highest point of the intercornual ridge in the median plane (+)

41) Least height of the occipital region: Opisthion - highest point of the intercornual ridge in the median plane (+)

42) Least distance between the horncore tips (+)

42a) Distance between the horncore tips, measured round the curve with a tape measure (-)

43) Greatest tangential distance between the outer curves of the horncores (+)

Note: Measurements 44-46 are taken exactly on the ring of bony nodules.

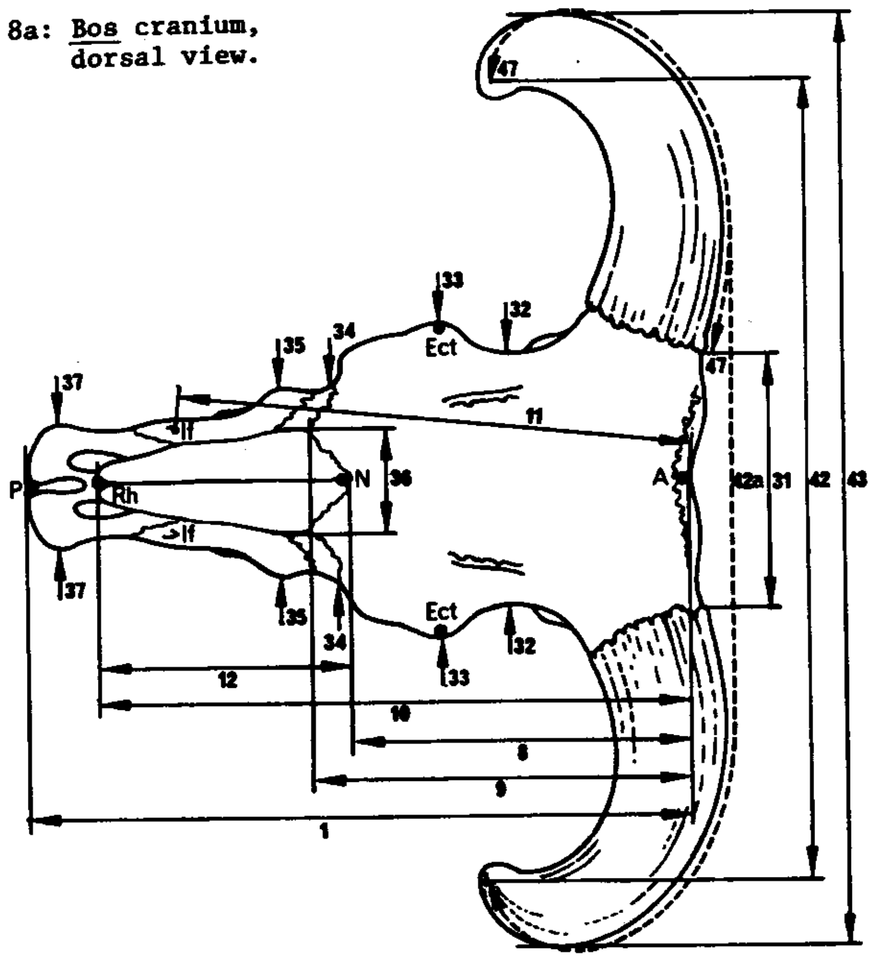
(44) Horncore basal circumference. Not shown in Fig. 8 (+)

45) Greatest (oro-aboral) diameter of the horncore base (+)

46) Least (dorso-basal) diameter of the horncore base (+)

47) Length of the outer curvature of the horncore (tape measure) (-)

Figure 8a: Bos cranium,
dorsal view.



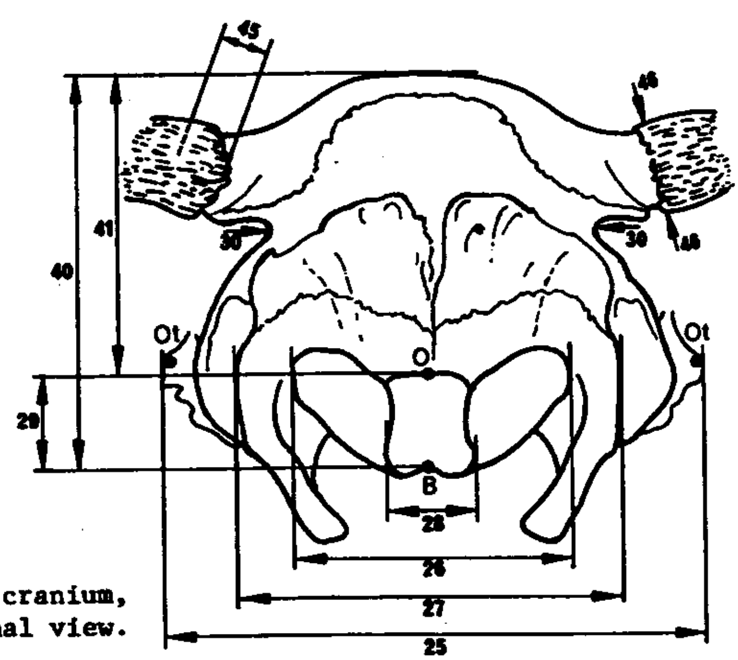
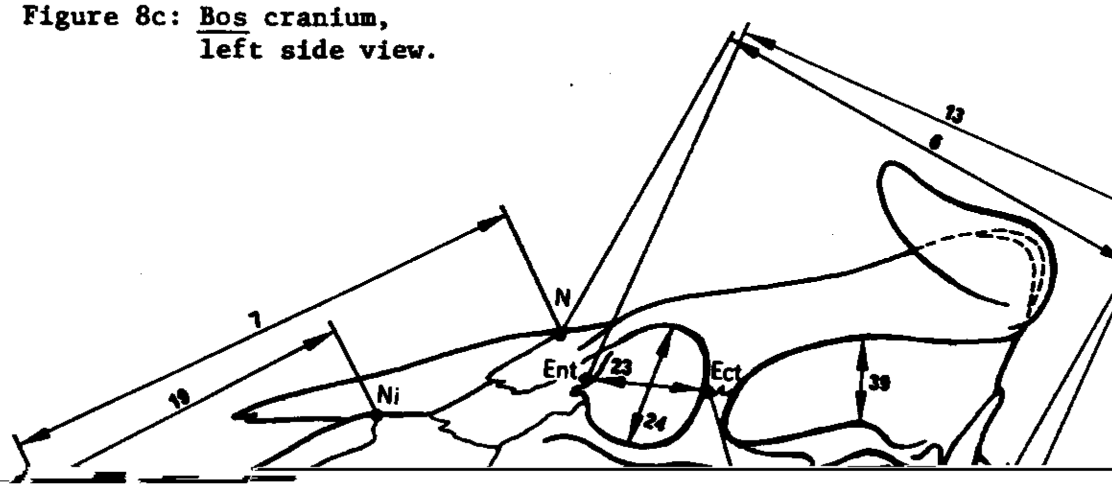


Figure 8b: Bos cranium,
nuchal view.

Figure 8c: Bos cranium, left side view.



Measurements of the cranium of Ovis and Capra (Figs. 9a,b,c,d and 10)

1) Profile length: Akrokranion - Prosthion (See definition of Point "p" above) (+)
2) Condylobasal length: aboral border of occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (+)
4) Short skull length: Basion - Premolare (+)
5) Premolare - Prosthion (+)
6) Neurocranium length: Basion - Nasion. Can be taken only with curved callipers (+)
7) Viscerocranium length: Nasion - Prosthion (+)
8) Median frontal length: Akrokranion - Nasion (+)
9) Akrokranion - Bregma (+)
10) Frontal length: Bregma - Nasion (+)
11) Upper neurocranium length: Akrokranion - Supraorbitale (+)
12) Facial length: Supraorbitale - Prosthion
13) Akrokranion - Infraorbitale of one side (+)
14) Greatest length of the lacrimal: most lateral point of the lacrimal - the most oral point of the lacrimo-maxillary suture (+)
15) Greatest length of the nasals: Nasion - Rhinion
16) Short lateral facial length: Entorbitale - Prosthion (+)
17) From the aboral border of one occipital condyle to the Infraorbitale of the same side (+)
18) Dental length: Postdentale - Prosthion (-)
19) Oral palatal length: Palatinoorale - Prosthion (-)
20) Lateral length of the premaxilla: Nasointermaxillare - Prosthion (+)
21) Length of the cheektooth row (measured along the alveoli) (+)
22) Length of the molar row (measured along the alveoli on the buccal side) (-)
23) Length of the premolar row (measured along the alveoli on the buccal side) (-)
24) Greatest inner length of the orbit: Ectorbitale - Entorbitale (+)
25) Greatest inner height of the orbit. Measured in the same way as M 24 (+)
26) Greatest mastoid breadth: Otion - Otion (+)
27) Greatest breadth of the occipital condyles (+)
28) Greatest breadth at the bases of the paraoccipital processes (+)
29) Greatest breadth of the foramen magnum (+)
30) Height of the foramen magnum: Basion - Opisthion (-)
31) Least breadth of parietal = least breadth between the temporal lines (+)
32) Greatest breadth between the lateral borders of the horncore bases (+)
33) Greatest neurocranium breadth = greatest breadth of the braincase: Euryon - Euryon (-)
34) Greatest breadth across the orbits = greatest frontal breadth = greatest breadth of skull: Ectorbitale - Ectorbitale (+)
35) Least breadth between the orbits: Entorbitale - Entorbitale (-)
36) Facial breadth: breadth across the facial tuberosities (+)
37) Greatest breadth across the nasals (+)

Figure 9a: <u>Ovis</u> cranium, dorsal view.

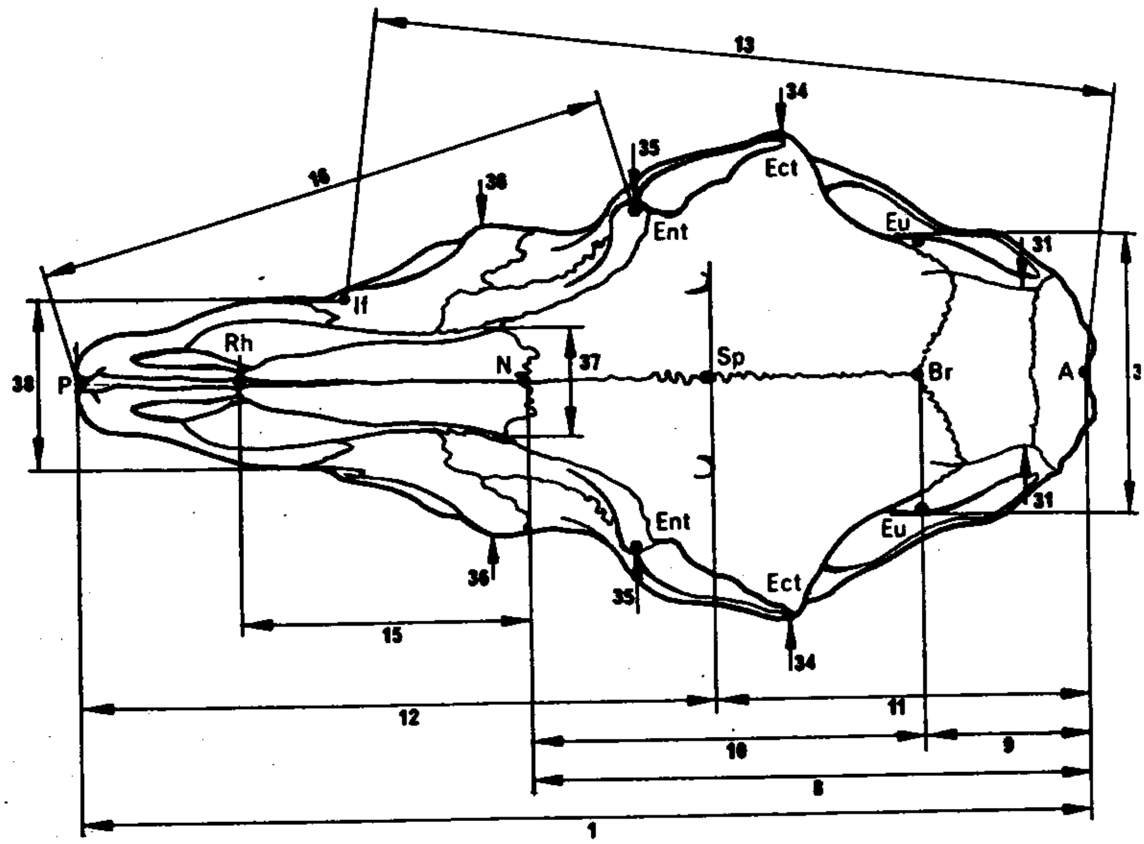
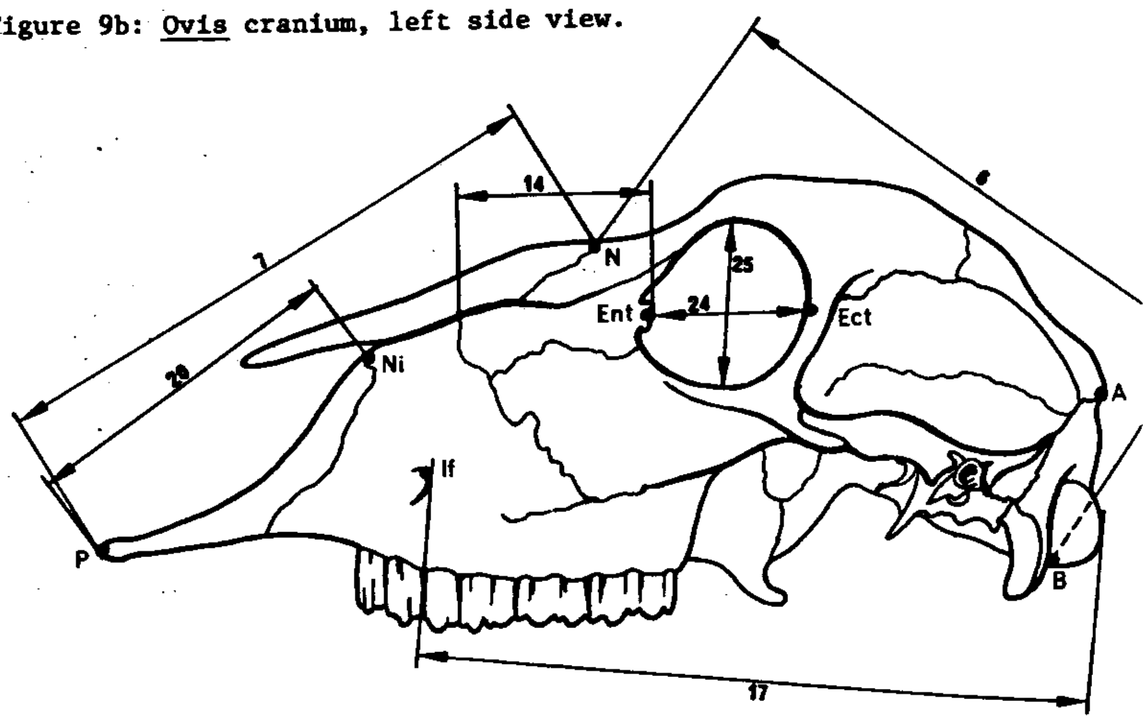
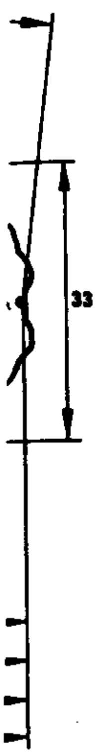


Figure 9b: <u>Ovis</u> cranium, left side view.





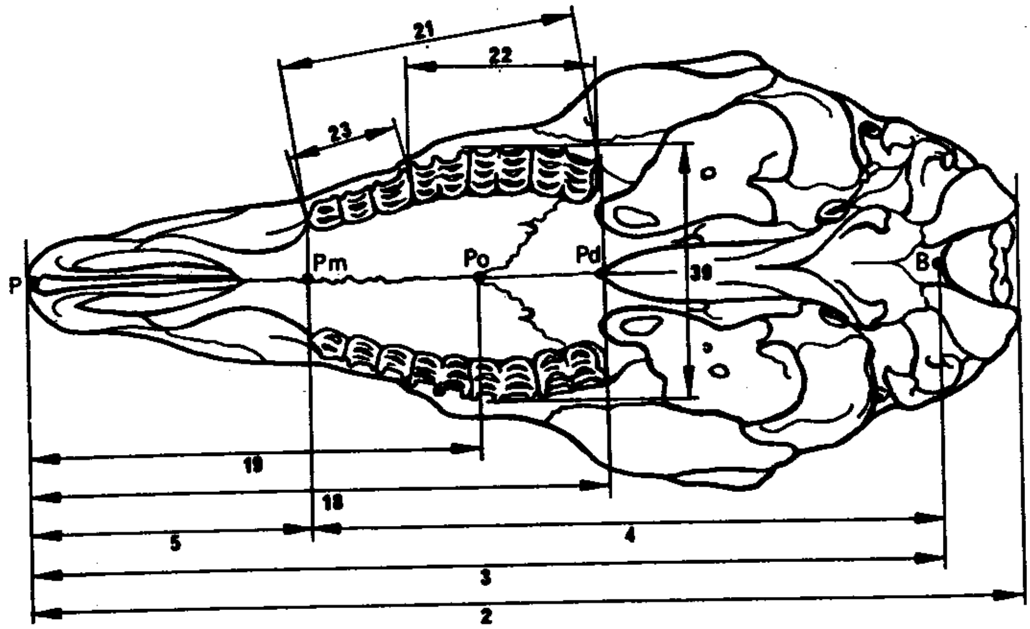


Figure 9c: Ovis cranium, basal view.

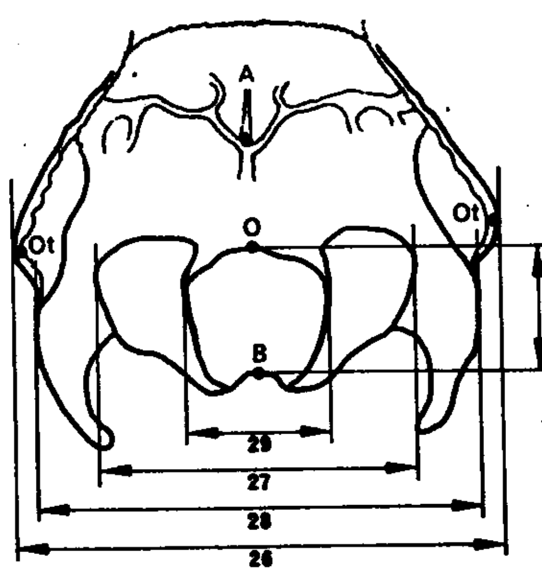


Figure 9d: Ovis cranium, nuchal view.

38) Greatest breadth across the premaxillae (+)
39) Greatest palatal breadth: measured across the outer borders of the alveoli (-)
40) Horncore basal circumference
41) Greatest (oro-aboral) diameter of the horncore base (+)
42) Least (latero-medial) diameter of the horncore base (+)
(43) Length of the horncore on the front margin (tape measure). Not shown in Fig. 10 (+)

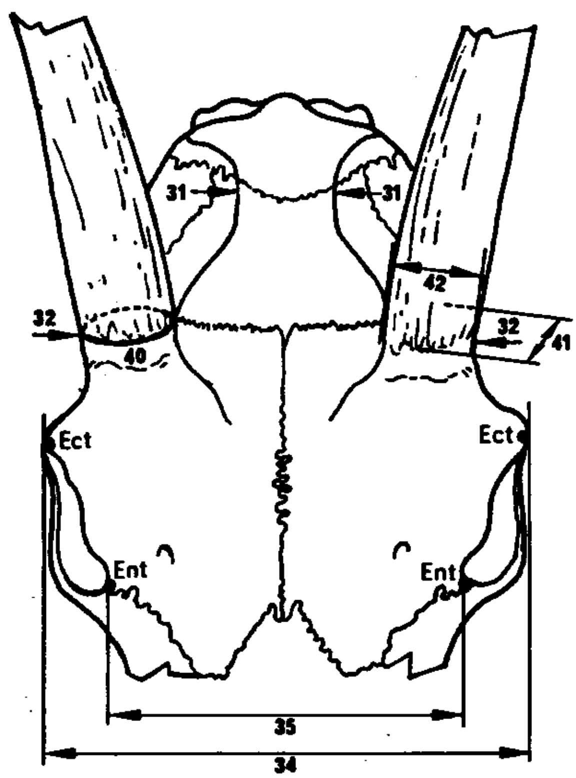


Figure 10: Capra cranium, dorsal view.

Measurements of the cranium of *<u>Cervus</u>* *(Fig. 11a,b,c)*

1) Total length = greatest length: Akrokranion - Prosthion (See definition of point "P" above) (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (+)
4) Short skull length: Basion - Premolare (+)
5) Premolare - Prosthion (+)
6) Basicranial axis: Basion - Synsphenion (-)
7) Basifacial axis: Synsphenion - Prosthion (-)
8) Neurocranium length: Basion - Nasion. Can be taken only with curved callipers (+)
9) Viscerocranium length: Nasion - Prosthion (+)
10) Median frontal length: Akrokranion - Nasion (+)
11) Lambda - Nasion (+)
12) Lambda - Rhinion (+)
13) Lambda - Prosthion (+)
14) Akrokranion - Infraorbitale of one side (+)
15) Greatest length of the nasals: Nasion - Rhinion (-)
16) Short lateral facial length (="snout" length): Entorbitale of one side - Prosthion (+)
17) Median palatal length: Staphylion - Prosthion (-)
18) Oral palatal length: Palatinoorale - Prosthion (-)
19) Lateral length of the premaxilla: Nasointermaxillare - Prosthion (+)
20) Length of the cheektooth row (measured along the alveoli) (+)
21) Length of the molar row (measured along the alveoli on the buccal side) (-)
22) Length of the premolar row (measured along the alveoli on the buccal side) (-)
23) Greatest inner length of the orbit: Ectorbitale - Entorbitale (+)
24) Greatest inner height of the orbit. Measured in the same way as M 23 (+)
25) Greatest mastoid breadth: Otion - Otion (+)
26) Greatest breadth of the occipital condyles (+)
27) Greatest breadth at the bases of the paraoccipital processes (+)
28) Greatest breadth of the foramen magnum (+)
(29) Height of the foramen magnum: Basion - Opisthion. Not shown in Fig. 11 (-)
(30) Greatest neurocranium breadth = greatest breadth of the braincase: Euryon - Euryon. Not shown in Fig. 11 (-)
31) Least frontal breadth = least breadth of the forehead aboral of the orbits (+)
32) Greatest breadth across the orbits = greatest frontal breadth = nearly greatest breadth of skull: Ectorbitale - Ectorbitale (+)
33) Least breadth between the orbits: Entorbitale - Entorbitale (+)
34) Zygomatic breadth: Zygion - Zygion (+)
35) Greatest breadth across the nasals (-)
36) Greatest breadth across the premaxillae (+)
37) Greatest palatal breadth: measured across the outer borders of the alveoli (-)

38) Basion - the highest point of the superior nuchal crest (+)
39) Circumference of the burr. The tape measure should be placed exactly on the bony nodules of the burr (-)
40) Proximal circumference of the burr = circumference of the distal end of the pedicel (+)
41) Distal circumference of the burr (+)
(42) Neurocranium capacity (cc., see M 42 of Canis)

Note: For the measurement of antlers (and horncores) refer to specializ works such as Haltenorth and Trense 1956, pp. 55 ff.

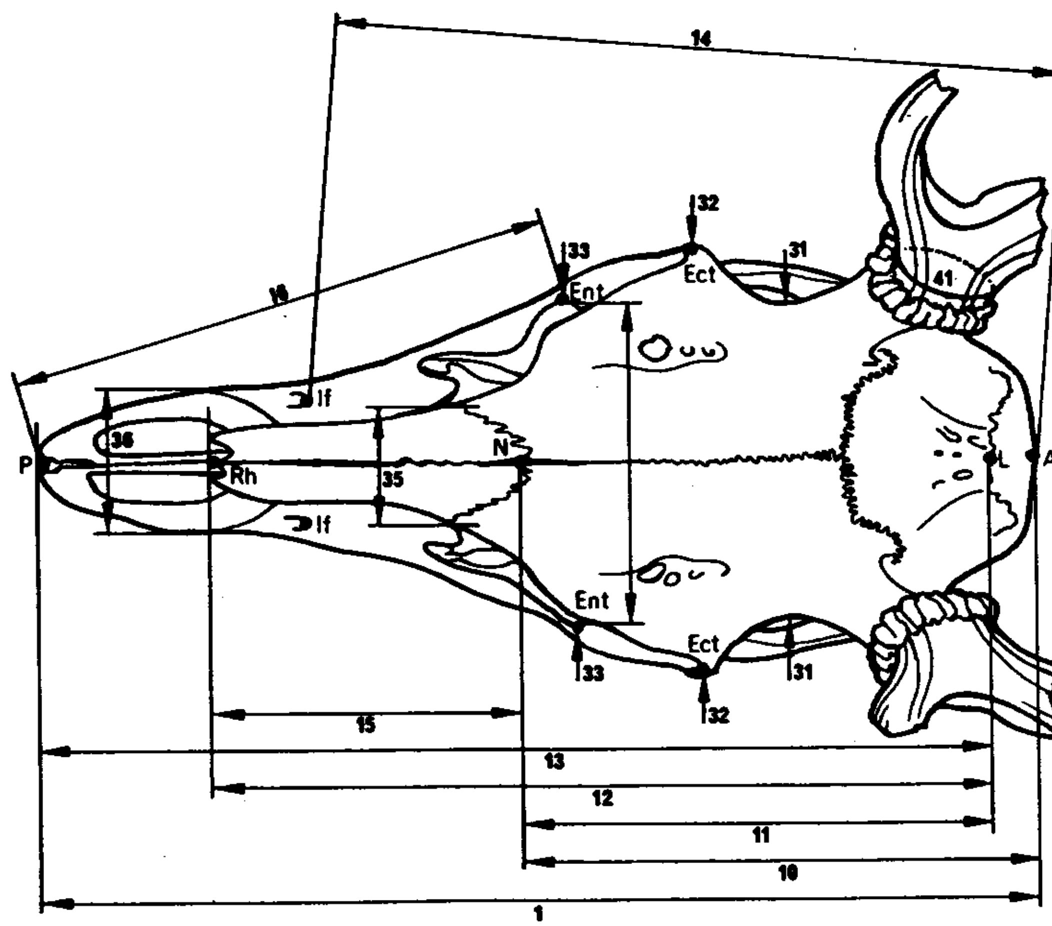


Figure 11a: Cervus cranium, dorsal view.

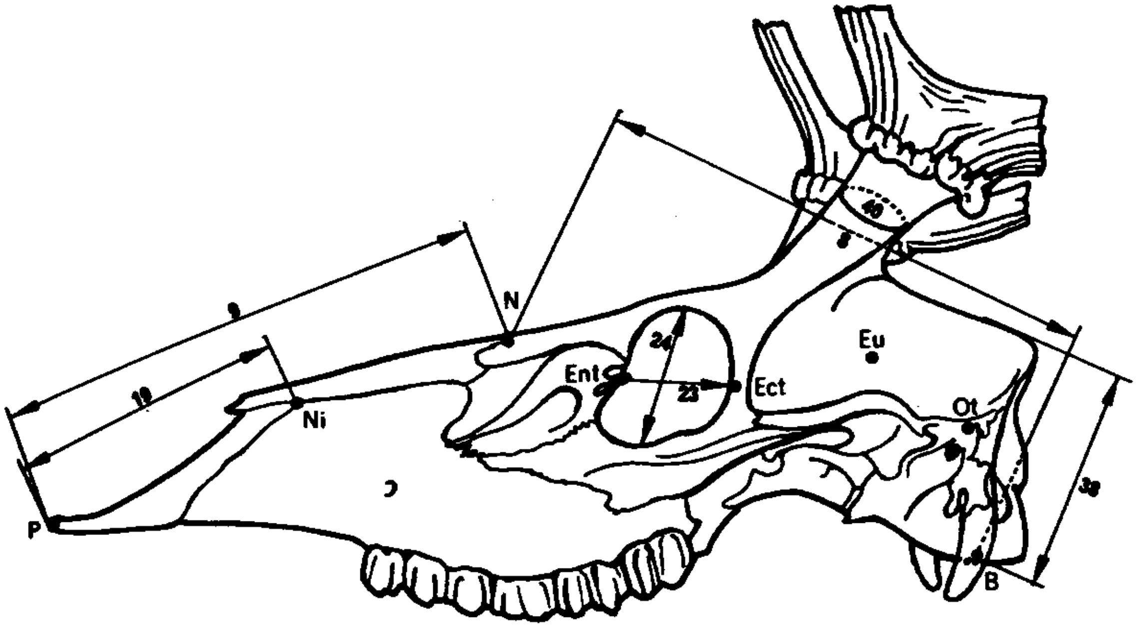


Figure 11b: Cervus cranium, left side view.

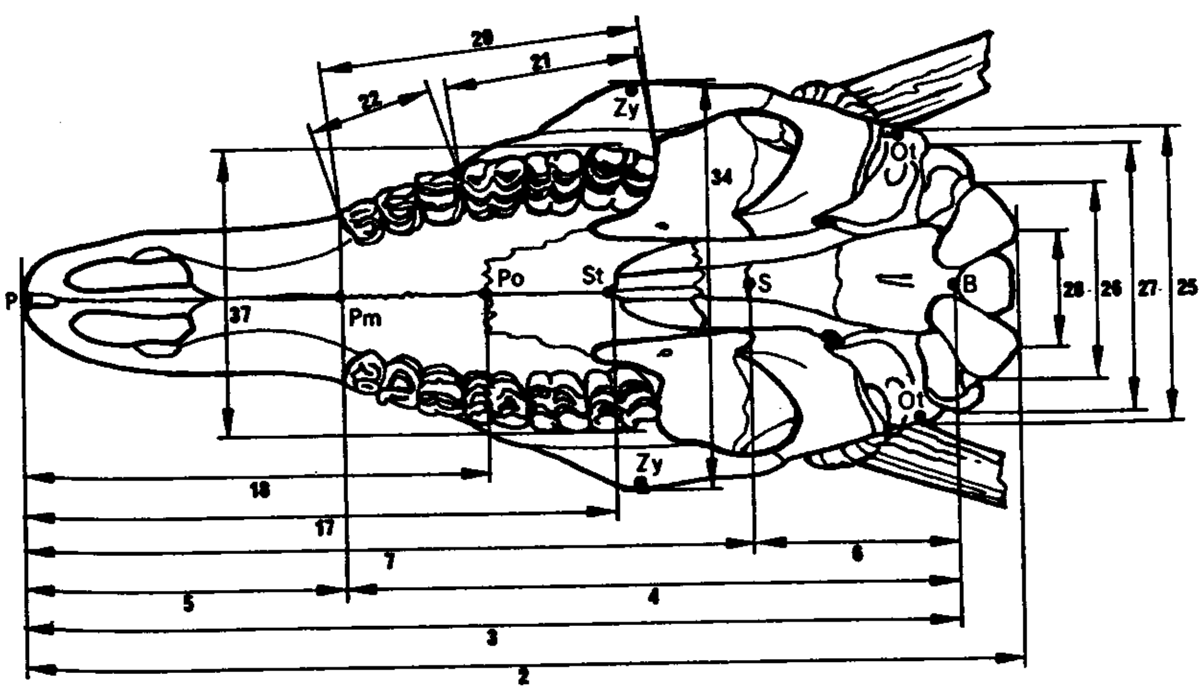


Figure 11c: Cervus cranium, basal view.

Measurements of the cranium of Sus *(Figs. 12a,b,c,d,e,f and 13)*

1) Profile length: Akrokranion - Prosthion (See definition of point "P" above) (+)
1a) Opisthokranion - Prosthion (See discussion under "Skull" above.) The opisthokranion lies in space and is best established when one point of the slide gauge touches the two most aboral points of the linea nuchalis superior (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (+)
4) Short skull length: Basion - Premolare (+)
5) Premolare - Prosthion (+)
6) Basicranial axis: Basion - Hormion (-)
7) Basifacial axis: Hormion - Prosthion (-)
8) Neurocranium length: Basion - Nasion. Can be taken only with curved callipers (+)
9) Median frontal length: Akrokranion - Nasion (+)
10) Viscerocranium length: Nasion - Prosthion (+)
11) Upper neurocranium length: Akrokranion - Supraorbitale (+)
12) Facial length: Supraorbitale - Prosthion (+)
13) Parietal length: Akrokranion - Bregma (+)
14) Frontal length: Bregma - Nasion (+)
Note: In very old pigs the parieto-frontal suture is obliterated and the Bregma is no longer visible.
15) Greatest length of the nasals: Nasion - Rhinion (+)
15a) Short nasal length: Nasion - median point of intersection of the line joining the most aboral points of the naso-maxillary sutur (-)
16) Basion - Staphylion (-)
17) Median palatal length: Staphylion - Prosthion (+)
18) Dental length: Postdentale - Prosthion (+)
19) Entorbitale - Infraorbitale (-)
20) Infraorbitale - Prosthion (-)
21) Upper length of the lacrimal: aboral-dorsal point of the lacrimal on the orbital rim - the most oral point of the fronto-lacrimal suture (see Fig. 12b) (-)
22) Height of the lacrimal. Formerly called "breadth" (see definitio of linear measurements above). Measured from the most dorsal point where the lacrimal, jugal, and maxilla meet (-)
23) Lateral length of the premaxilla: Nasointermaxillare - Prosthion
24) Greatest inner length of the orbit: Ectorbitale - Entorbitale (-)
25) Length from the aboral border of the alveolus of M^3 - aboral border of the alveolus of C (+)
26) Length from the oral border of the alveolus of P^1 - aboral border of the alveolus of I^3 (+)
27) Length of the cheektooth row (measured along the alveoli) (+)
27a) Length of the cheektooth row, M^3-P^2 (measured along the alveoli) (-)

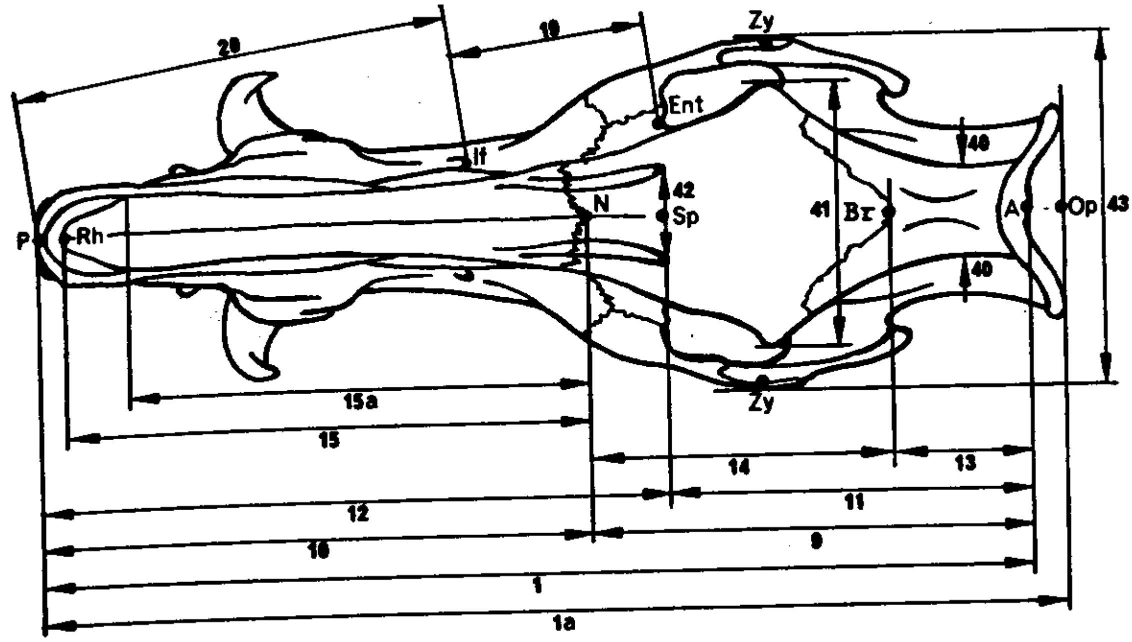


Figure 12a: Sus cranium, dorsal view.

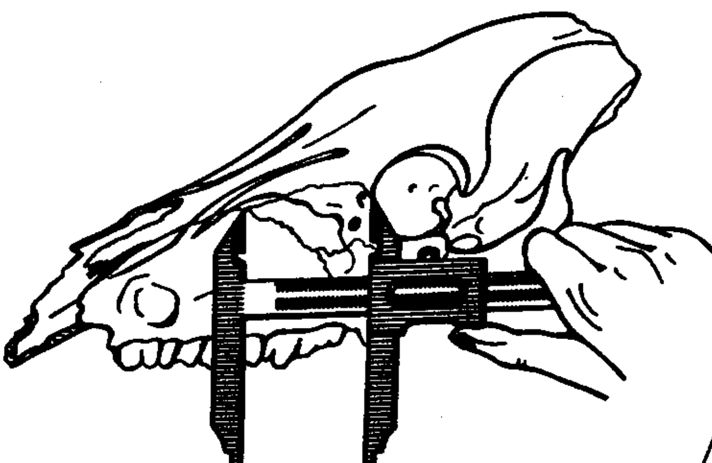


Figure 12b: Sus cranium, M 21.

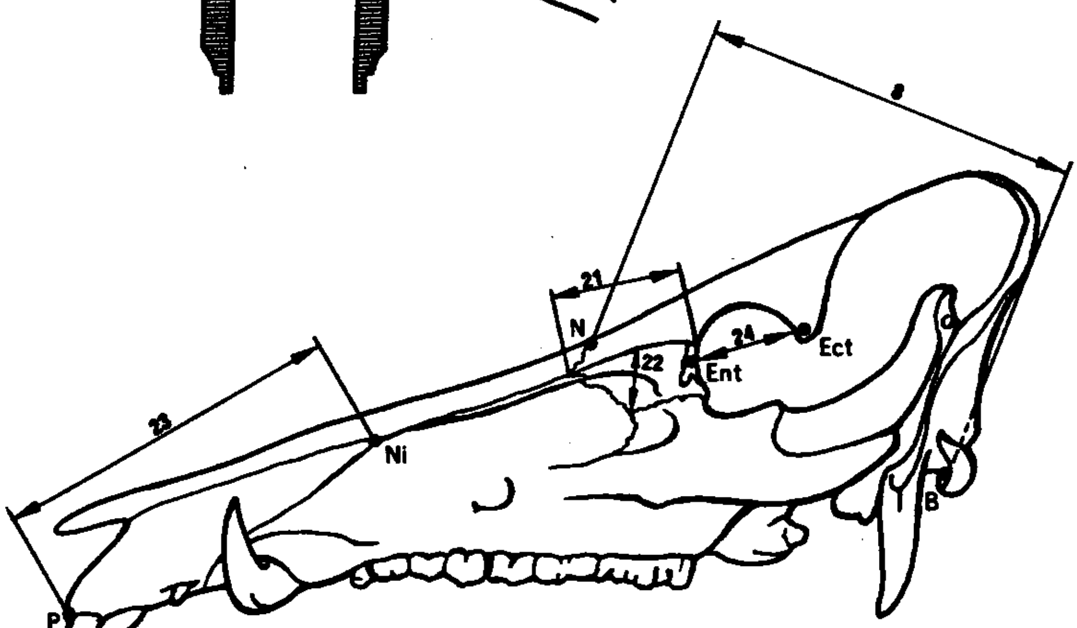


Figure 12c: Sus cranium, left side view.

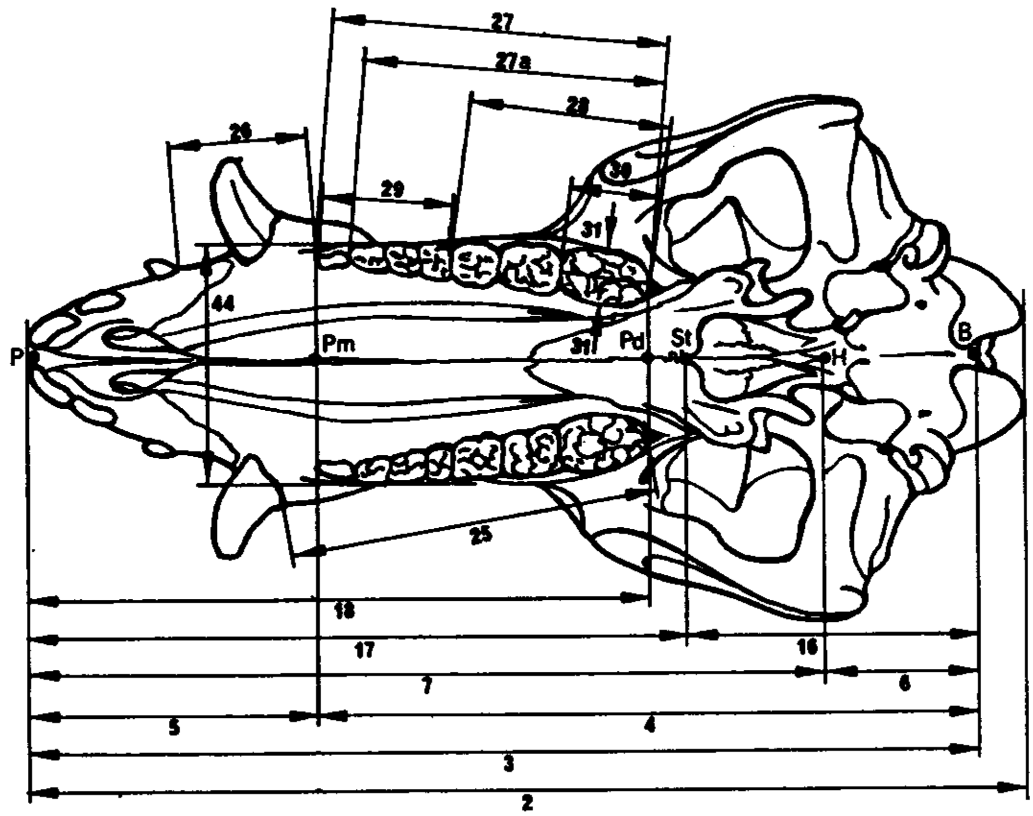


Figure 12d: Sus cranium, basal view.

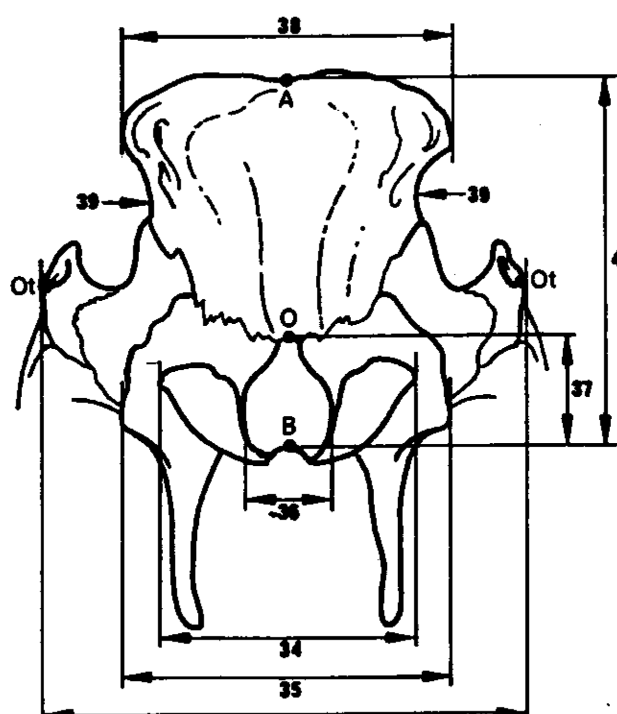


Figure 12e: Sus cranium, nuchal view.

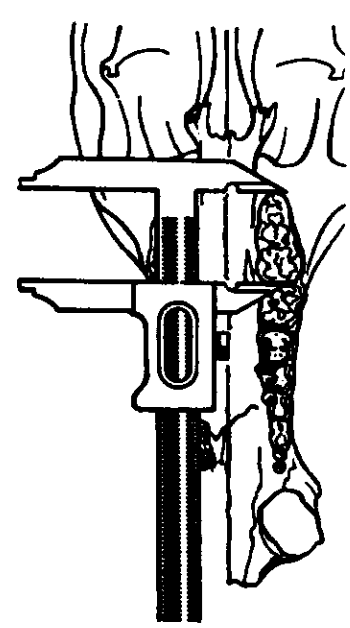


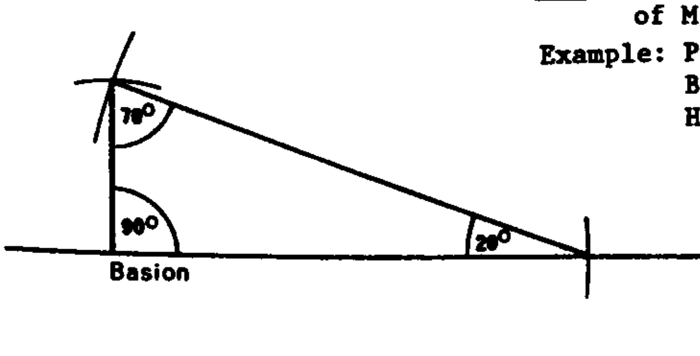
Figure 12f: Sus cranium

28) Length of the molar row (measured along the alveoli on the buccal side) (-)
29) Length of the premolar row (measured along the alveoli on the buccal side) (-)
(29a) Length of the premolar row, P^2-P^4 (measured along the alveoli on the buccal side). Not shown in Fig. 12 (-)
30) Length of M^3 measured near the base of the crown (Fig. 12f) (-)
31) Breadth of M^3 measured near the base of the crown (-)
(32) Greatest diameter of the canine alveolus. Not shown in Fig. 12 female (+), male (-)
33) Greatest mastoid breadth = breadth across the openings of the external auditory meatus: Otion - Otion (+)
34) Greatest breadth of the occipital condyles (+)
35) Greatest breadth at the bases of the paraoccipital processes (+)
36) Greatest breadth of the foramen magnum (+)
37) Height of the foramen magnum: Basion - Opisthion (-)
38) Greatest breadth of the squamous part of the occipital bone (+)
39) Least breadth of the squamous part of the occipital bone = breadth at the narrowest points of the lineae nuchales laterales (+)
40) Least breadth of the parietal = least breadth between the temporal lines (+)
41) Greatest frontal breadth = greatest breadth across the supraorbital processes: Ectorbitale - Ectorbitale (+)
42) Least breadth between the supraorbital foramina (+)
43) Zygomatic breadth = greatest breadth of skull: Zygion - Zygion (+)
44) Greatest palatal breadth: measured across the outer borders of the alveoli (-)
45) Height of the occipital region: Basion - Akrokranion (+)
46) Angle between the lines of measurements nos. 3 and 45
47) Angle between the lines of measurements nos. 3 and 1
48) Angle between the lines of measurements nos. 1 and 45

Note: These three angles can be graphically established (following Reitsma 1935, p. 15 and Figs. 40, 89, and 90). One marks off the basal length on a straight line with a pair of compasses, and then still using compasses one marks off the other two lines in the same proportions, as shown in Figure 13. The angles can then be read off by using a protractor.

Figure 13: Sus cranium, calculation of M 46, 47, 48.

Example: Profile length: 268 mm.
Basal length: 250 mm.
Height of occipital region: 89 mm.



100mm

Measurements of the cranium of Canis (Figs. 14a,b,c,d and 15a,b,c)

Harcourt equivalent

I 1) Total length: Akrokranion - Prosthion (+)

2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)

3) Basal length: Basion - Prosthion (+)

4) Basicranial axis: Basion - Synsphenion (= Intersphenoid suture) (+)

5) Basifacial axis: Synsphenion - Prosthion (+)

(6) Neurocranium length: Basion - Nasion. Not shown in Fig. 14. Can be taken only with curved callipers (+)

7) Upper neurocranium length: Akrokranion - Frontal midpoint (+)

III 8) Viscerocranium length: Nasion - Prosthion (+)

9) Facial length: Frontal midpoint - Prosthion (+)

10) Greatest length of the nasals: Nasion - Rhinion (-)

11) Length of braincase (following Wagner 1930, p. 13). This measu ment can be taken only when the cribriform plate is preserved. One inserts a thin ruler through the foramen magnum; the front end must reach the cribriform plate and the measurement is rea off against the Basion (-)

12) "Snout" length: oral border of the orbits (median) - Prosthion

IX 13) Median palatal length: Staphylion - Prosthion (+)

13a) Palatal length: the median point of intersection of the line joining the deepest indentations of the Choanae - Prosthion (-

14) Length of the horizontal part of the palatine: Staphylion - Palatinoorale (+)

14a) Length of the horizontal part of the palatine corresponding to M 13a (-)

XI 15)* Length of cheektooth row (measured along the alveoli on the buccal side) (-)

16) Length of the molar row (measured along the alveoli on the buccal side) (-)

17) Length of the premolar row (measured along the alveoli on the buccal side) (-)

18) Length of the carnassial, measured at the cingulum (Fig. 15a) (

18a) Greatest breadth of the carnassial (Fig. 15a) (-)
Until now the breadth of the carnassial has been measured with out the medial projection. Because this dimension is difficul to measure exactly I propose to leave it out and to measure or the greatest breadth.

(19) Length of the carnassial alveolus. Not shown in Fig. 14 (-)

20) Length and breadth of M^1, measured at the cingulum (see Fig. 1 (-)

21) Length and breadth of M^2, measured at the cingulum (see Fig. 1 (-)

* For wild canids another length measurement is also important:
(15a) Aboral border of the alveolus of M^3 - oral border of the alveolus of C. Not shown in Fig. 14

22) Greatest diameter of the auditory bulla (following Wagner 1930, p. 21): from the most aboral point of the bulla on the suture with the paraoccipital process up to the external carotid foramen (-)
23) Greatest mastoid breadth = greatest breadth of the occipital triangle: Otion - Otion (+)
24) Breadth dorsal to the external auditory meatus (+)
25) Greatest breadth of the occipital condyles (+)
26) Greatest breadth of the bases of the paraoccipital processes (+)
27) Greatest breadth of the foramen magnum (-)
28) Height of the foramen magnum: Basion - Opisthion (-)
29) Greatest neurocranium breadth = greatest breadth of the braincase: Euryon - Euryon (-)
IV 30) Zygomatic breadth: Zygion - Zygion (+)
31) Least breadth of skull = least breadth aboral of the supraorbital processes = breadth at the postorbital constriction* (+)
32) Frontal breadth: Ectorbitale - Ectorbitale (+)
33) Least breadth between the orbits: Entorbitale - Entorbitale (+)
X ≈ 34) Greatest palatal breadth: measured across the outer borders of the alveoli (-)
35) Least palatal breadth: measured behind the canines (-)
XII 36) Breadth at the canine alveoli (+)
37) Greatest inner height of the orbit (+)
38) Skull height (following Wagner 1930, p. 19). The two pointers of the slide gauge are placed basally on the basis of the skull (on the basioccipital) and dorsally on the highest elevation of the sagittal crest (+)
39) Skull height without the sagittal crest (following Wagner 1930, pp. 19 ff.) the slide gauge is placed in the same position as for M 38 with the difference that the upper pointer is placed beside the sagittal crest on the highest point of the braincase (-)
40) Height of the occipital triangle: Akrokranion - Basion (-)
(41) Height (length) of the canine, measured in a straight line from point to point. This measurement is only possible if the tooth can be removed from the jaw (+)
(42) Neurocranium capacity = capacity of the braincase (cc). This can only be measured when the ethmoid is preserved. The foramina of the braincase are stopped up with wadding; when it is completely free of dirt and earth the braincase is filled with millet seeds and shaken repeatedly to remove air pockets. Finally, the seeds are tipped into a measuring beaker and their volume is read off (+)

+ additional measurements by Nussbaumer, M (1976, 1978)

- PL, HB, MX and obere Reisszahnlänge

Nussbaumer, M. (1976) Das Problem der Hirnstammbasis bei den Dachshunden. Seperatdruck aus dem Jahrbuch des Naturalhistorischen Museums der Stadt Bern BD. 6, 1975-1977.

*According to Duerst 1926, p. 238 = Frontostenion - Frontostenion

Nussbaumer, M. (1978) Biometrischer Vergleich der Topogenesmuster an der Schädelbasis kleiner und mittelgroßer Hunde.
Sonderdruck aus: Zeitschrift für Tierzüchtung und Züchtungsbiologie 95 (1), 1-14.

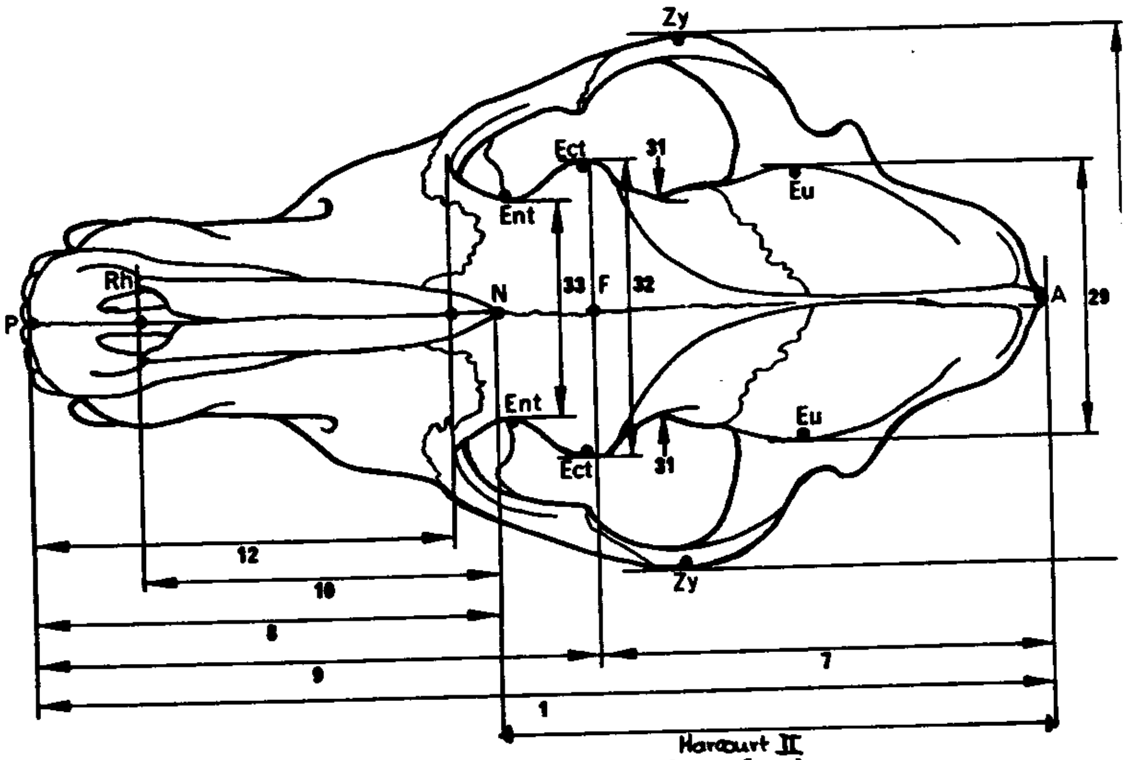


Figure 14a: Canis cranium, dorsal view.

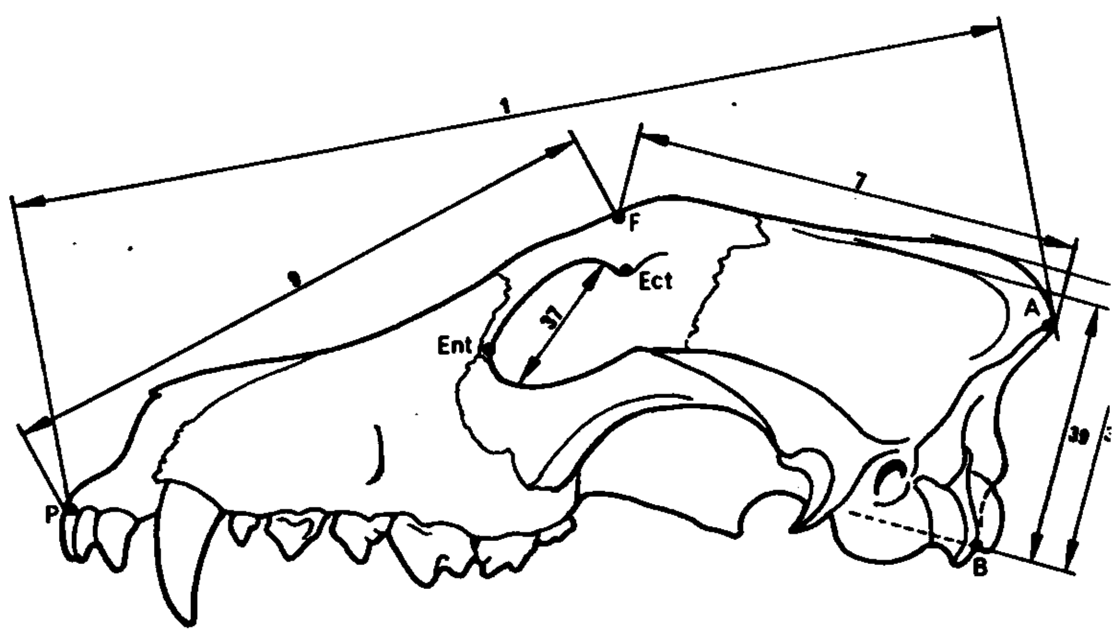
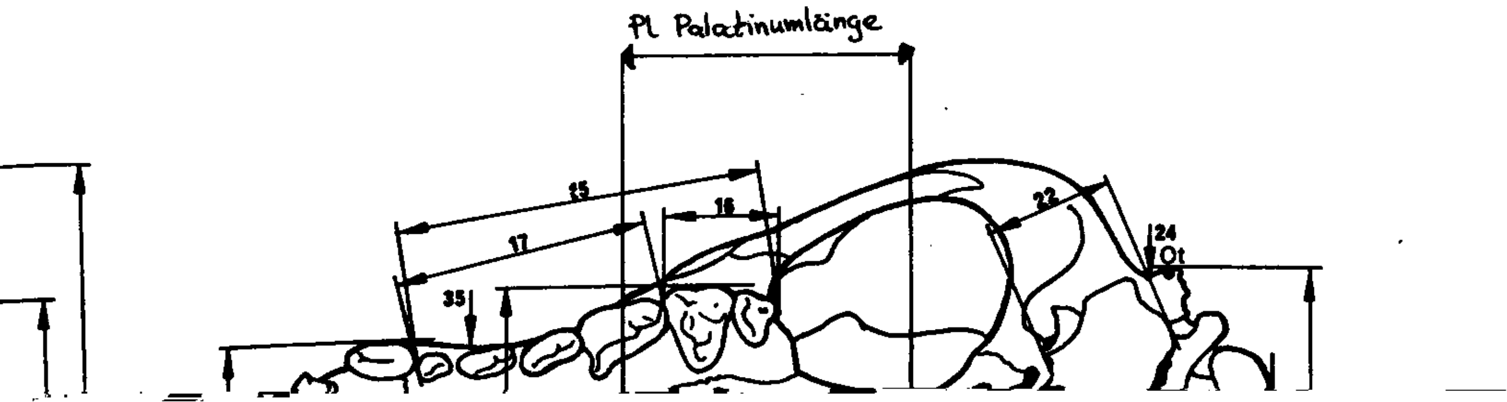


Figure 14b: Canis cranium, left side view.



Pl Palatinumlänge
15
16
17
22
24
Ot
35

Measurements of the cranium of Ursus (Fig. 16a,b,c)

Because the skull of the bear is very similar in form to that of th dog, one can use the same dimensions for its measurement. One has to leave out measurements no. 13a and 14a because the indentation of the edges of the Choanae is much weaker in bears. Also it is unusual for the neurocranium capacity of bears to be measured.

Additionally, the following toothrow measurement should be taken:

Length from P^4 - M^2 (measured along the alveoli on the buccal side) (

The taking of length and breadth measurements of single teeth (P^4-M should be done as depicted in Figure 16a-c. Single teeth can be meas properly only when they are removed from the alveoli.

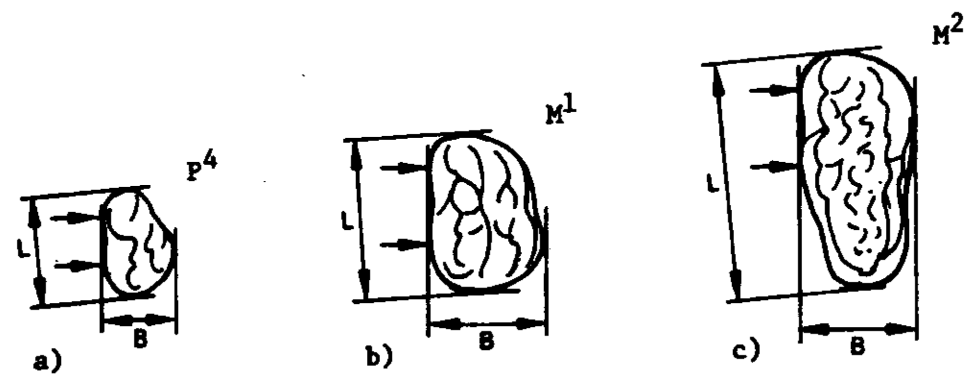


Figure 16a-c: Ursus maxillary teeth, length (L) and breadth (B)

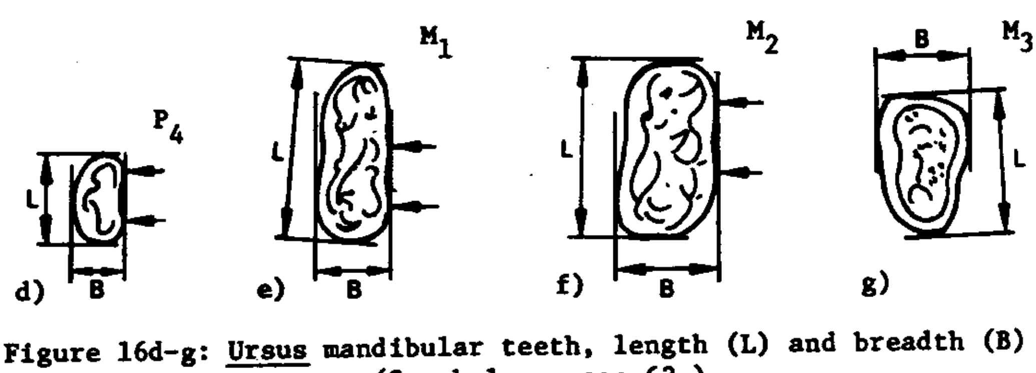


Figure 16d-g: Ursus mandibular teeth, length (L) and breadth (B)
(See below, page 62.)

Measurements of the cranium of <u>Felis</u> (Fig. 17a,b,c)

1) Total length: Akrokranion - Prosthion (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (+)
3) Basal length: Basion - Prosthion (+)
4) Basicranial axis: Basion - Synsphenion (= Interspenoid suture) (+)
5) Basifacial axis: Synsphenion - Prosthion (+)
6) Neurocranium length: Basion - Nasion. Can be taken only with curved callipers (+)
7) Upper neurocranium length: Akrokranion - Frontal midpoint (+)
8) Viscerocranium length: Nasion - Prosthion (+)
9) Facial length: Frontal midpoint - Prosthion (+)
10) Lateral length of "snout": oral border of the orbit of one side - Prosthion (+)
11) Median palatal length: Staphylion - Prosthion (+)
11a) Palatal length: the median point of intersection of the line joining the deepest indentations of the Choanae - Prosthion (-)
12) Length of the cheektooth row (measured along the alveoli on the buccal side) (-)
13) Length of the premolar row (measured along the alveoli on the buccal side) (-)
14) Length of P^4. As in the dog taken from the buccal part of the cingulum (-)
(15) Length of the carnassial alveolus. Not shown in Fig. 17 (+)
16) Greatest diameter of the auditory bulla: from the most aborolateral point to the most oromedial point (-)
17) Least diameter of the auditory bulla: from the middle of the opening of the external acoustic meatus up to the most medial protrusion of the bulla on the opposite side of the bulla (-)
18) Greatest mastoid breadth = greatest breadth of the occipital triangle: Otion - Otion (+)
19) Greatest breadth of the occipital condyles (+)
20) Greatest breadth of the foramen magnum (+)
21) Height of the foramen magnum: Basion - Opisthion (+)
22) Greatest neurocranium breadth = greatest breadth of braincase: Euryon - Euryon (-)
23) Zygomatic breadth: Zygion - Zygion (+)
24) Frontal breadth: Ectorbitale - Ectorbitale (+)
25) Least breadth between the orbits: Entorbitale - Entorbitale (+)
26) Greatest palatal breadth: measured across the outer borders of the alveoli (-)
27) Breadth at the canine alveoli (+)
28) Least breadth aboral of the supraorbital processes = breadth of the postorbital constriction (+)
29) Facial breadth between the infraorbital foramina (least distance) (+)
30) Greatest inner length of the orbit: Ectorbitale - Entorbitale (+)
31) Greatest inner height of the orbit (+)
32) Height of the occipital triangle: Akrokranion - Basion (-)
(33) Neurocranium capacity = capacity of braincase (cc). Taken in the same way as for the dog M 42 (+)

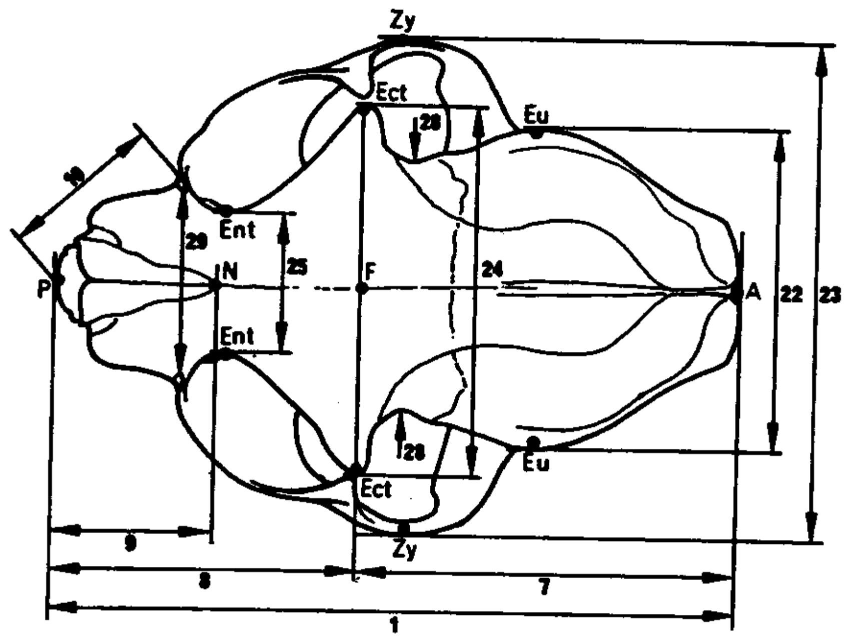


Figure 17a: Felis cranium, dorsal view.

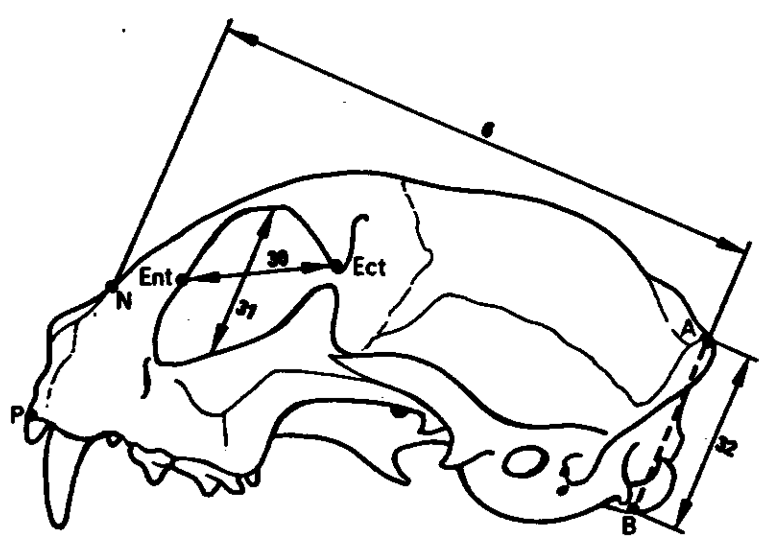


Figure 17b: Felis cranium, left side view.

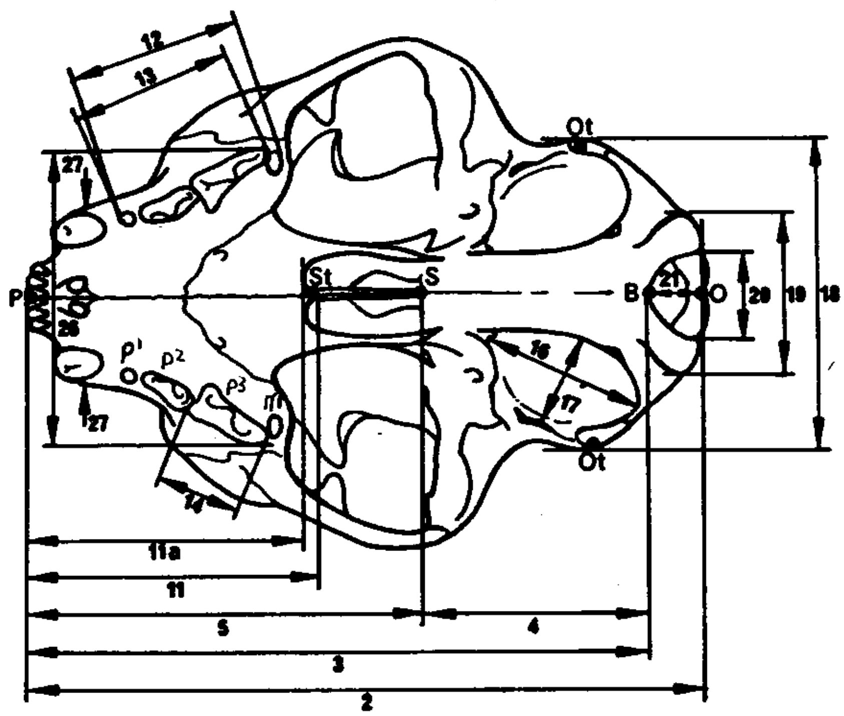


Figure 17c: Felis cranium, basal view.

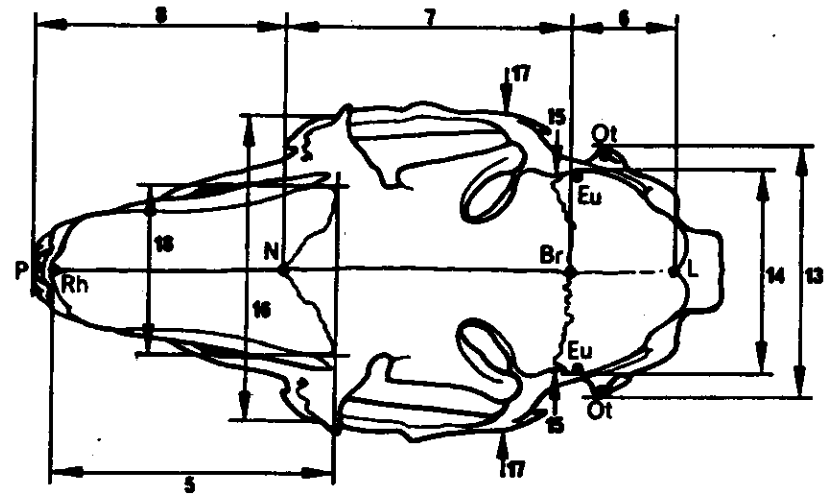


Figure 18a: Lepus cranium, dorsal view.

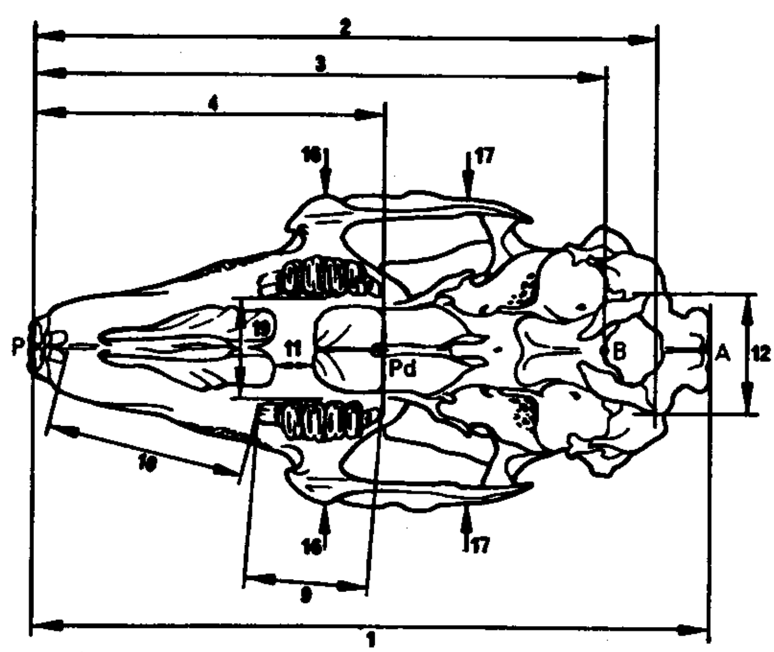
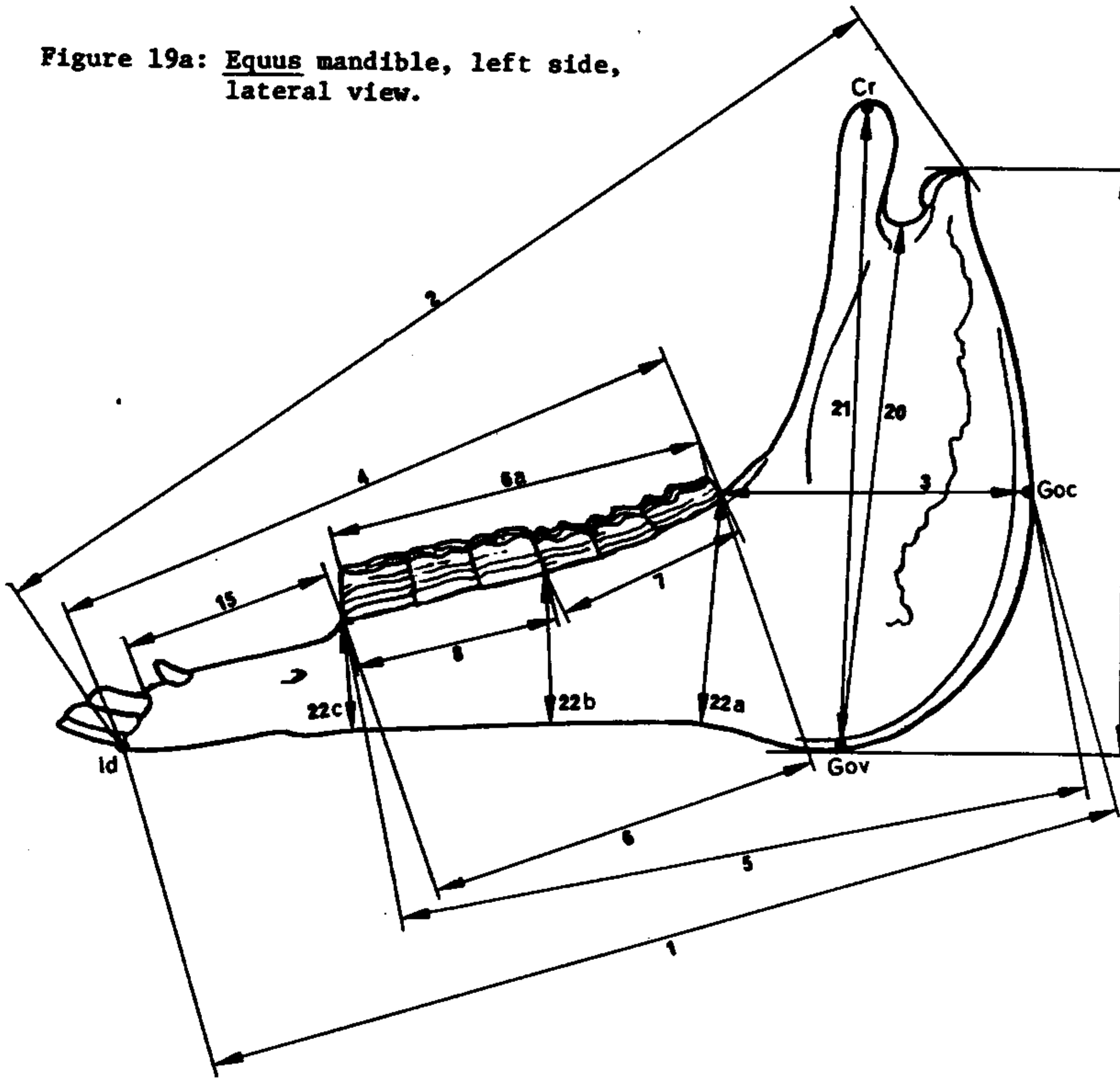


Figure 18b: Lepus cranium, basal view.

Measurements of the cranium of Lepus and Oryctolagus (Fig. 18a,b)

1) Total length: Akrokranion - Prosthion (+)
2) Condylobasal length: aboral border of the occipital condyles - Prosthion (-)
3) Basal length: Basion - Prosthion (+)
4) Dental length: Postdentale - Prosthion (-)
5) Greatest length of the nasals: the median point of intersection of the line joining the aboral borders of the nasals - Rhinion (+)
6) Parietal length: Lambda - Bregma (+)
7) Frontal length: Bregma - Nasion (+)
8) Viscerocranium length: Nasion - Prosthion (+)
9) Length of the cheektooth row (measured along the alveoli on the buccal side) (+)
10) Length of the diastema: the oral border of the alveolus of P^2 - aboral border of the alveolus of I^2 of one side (-)
11) Palatal length (following Hauser 1921, p. 54): the length of the palatal bridge of one side (+)
12) Greatest breadth of the occipital condyles (+)
13) Greatest breadth across the openings of the external acoustic meatus (+)
14) Greatest neurocranium breadth = greatest breadth of the braincase: Euryon - Euryon (-)
15) Breadth of skull (following Hauser 1921, p. 53). The points of the slide gauge are placed in the temporal fossae dorsal of the zygomatic processes of the temporal (+)
16) Oral zygomatic breadth (following Hauser 1921, p. 54): greatest breadth across the oral part of the zygomatic arch (+)
17) Aboral zygomatic breadth (following Hauser 1921, p. 54): greatest breadth across the aboral part of the zygomatic arch (+)
18) Greatest breadth of the nasals
19) Palatal breadth (following Hauser 1921, p. 54): breadth between the inner borders of the alveoli of the second cheekteeth (-)

Figure 19a: Equus mandible, left side, lateral view.



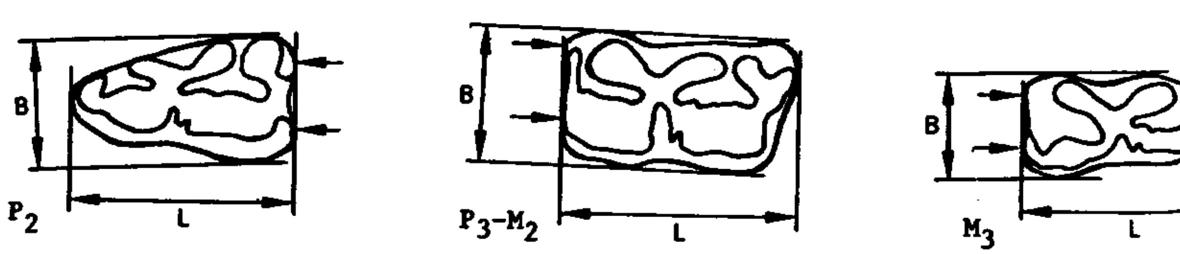


Figure 19b: Equus mandibular teeth, length (L) and breadth (B) at the biting surface (see M 9,10,11,12,13,14.)

MANDIBLE

The most important measuring points of the mandible (according to Duerst 1926, pp. 243 ff.) are the following:

Cr - Coronion - the highest point of the coronoid process
Goc - Gonion caudale - the most aboral point of the angle of mandible
Gol - Gonion laterale - the most lateral point of the angle
Gov - Gonion ventrale - the most basal point of the angle
Id - Infradentale - the most prominent median point at the oral border of the alveoli of the incisors (corresponds to the Prosthion of maxilla).

Note that all length and height measurements for the mandible refer to only one-half of the jaw.

Measurements of the mandible of ***Equus*** *(Fig. 19a,b)*

1) Length from the angle: Gonion caudale - Infradentale (+)
2) Length from the condyle: aboral border of the condyle process - Infradentale (+)
3) Length: Gonion caudale - aboral border of the alveolus of M_3 (-)
4) Length of the horizontal ramus: aboral border of the alveolus of M_3 - Infradentale (+)
5) Length: Gonion caudale - oral border of the alveolus of P_2(+)

(16) Greatest breadth across the curvature of incisors, measured at the outer borders of the alveoli of I_3. Not shown in Fig. 19a (+)

(17) Greatest breadth across the curvature of incisors, measured near the biting surface of the I_3. Not shown in Fig. 19a (+)

(18) Smallest breadth of the two halves in the region of the diastema. Not shown in Fig. 19a (+)

19) Aboral height of the vertical ramus: Gonion ventrale - highest point of the condyle process. Usually measured in projection. Best measured on the table or by placing one arm of the slide gauge along the basal border of the mandible and measuring the distance in projection (see Duerst 1926, p. 333) (-)

20) Middle height of the vertical ramus: Gonion ventrale - deepest point of the mandibular notch. Not to be measured in projection but directly from the Gonion ventrale (see Duerst 1926, p. 333) (+)

21) Oral height of the vertical ramus: Gonion ventrale - Coronion. Not to be measured in projection, but like measurement no. 20 directly from the Gonion ventrale (see Duerst 1926, p. 334) (+)

22a) Height of the mandible behind M_3 from the most aboral point of the alveolus (-)

22b) Height of the mandible in front of M_1. Measured at right angles to the basal border (-)

22c) Height of the mandible in front of P_2. Measured at right angles to the basal border (-)

Note: The height measurements can be taken on the lingual or buccal side, wherever they are easier to take. Indicate from which side the measurements have been made.

(23) Breadth of the two halves between the most lateral points of the two angles = Gonion laterale - Gonion laterale. Not shown in Fig. 19a (+)

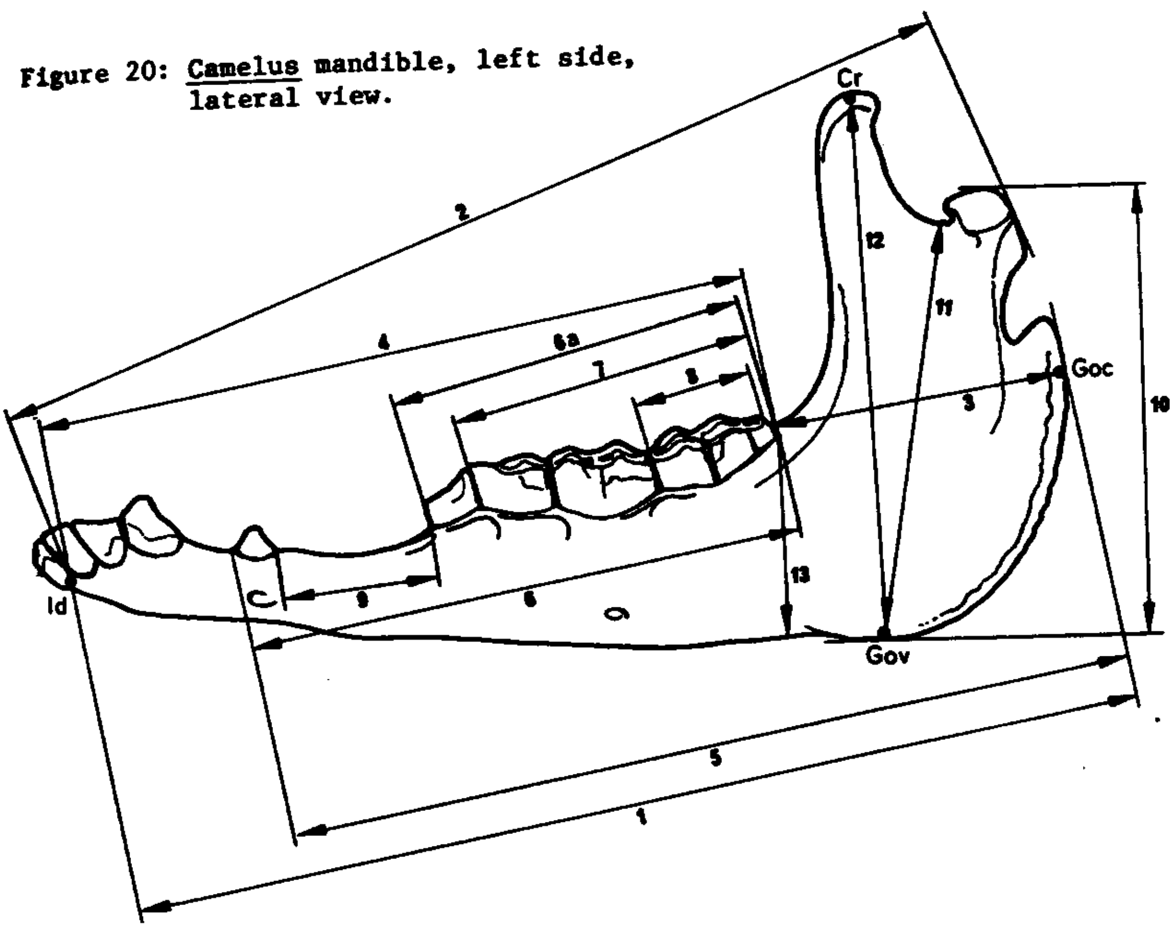
(24) Breadth of the two halves between the condyle processes: measured between the most lateral points of the two condyle processes. Not shown in Fig. 19a (+)

(25) Breadth of the two halves between the coronoid processes: measured between the most lateral points of the two coronoid processes. Not shown in Fig. 19a (-)

Measurements of the mandible of *Camelus* (Fig. 20)

1)-4) Same as Equus measurements.
5) Gonion caudale - oral border of the alveolus of P_3 (+)
6) Length of the cheektooth row, M_3-P_3, measured along the alveoli on the buccal side (+)
6a) Length of the cheektooth row, M_3-P_4, measured along the alveoli on the buccal side (+)
7) Length of the molar row, measured along the alveoli on the buccal side (-)
8) Length and breadth of M_3, measured near the biting surface (Fig. 21b) (-)
9) Length of the diastema between P_4 and P_3: oral border of the alveolus of P_4 - aboral border of the alveolus of P_3 (+)
10) Aboral height of the vertical ramus: Gonion ventrale - highest point of the condyle process (see Equus M 19) (+)
11) Middle height of the vertical ramus: Gonion ventrale - deepest point of the mandibular notch (see Equus M 20) (+)
12) Oral height of the vertical ramus: Gonion ventrale - Coronion (see Equus M 21) (+)
13) Height of the mandible behind M_3, from the most aboral point of the alveolus. Measured at right angles to the basal border (-)

Figure 20: Camelus mandible, left side, lateral view.



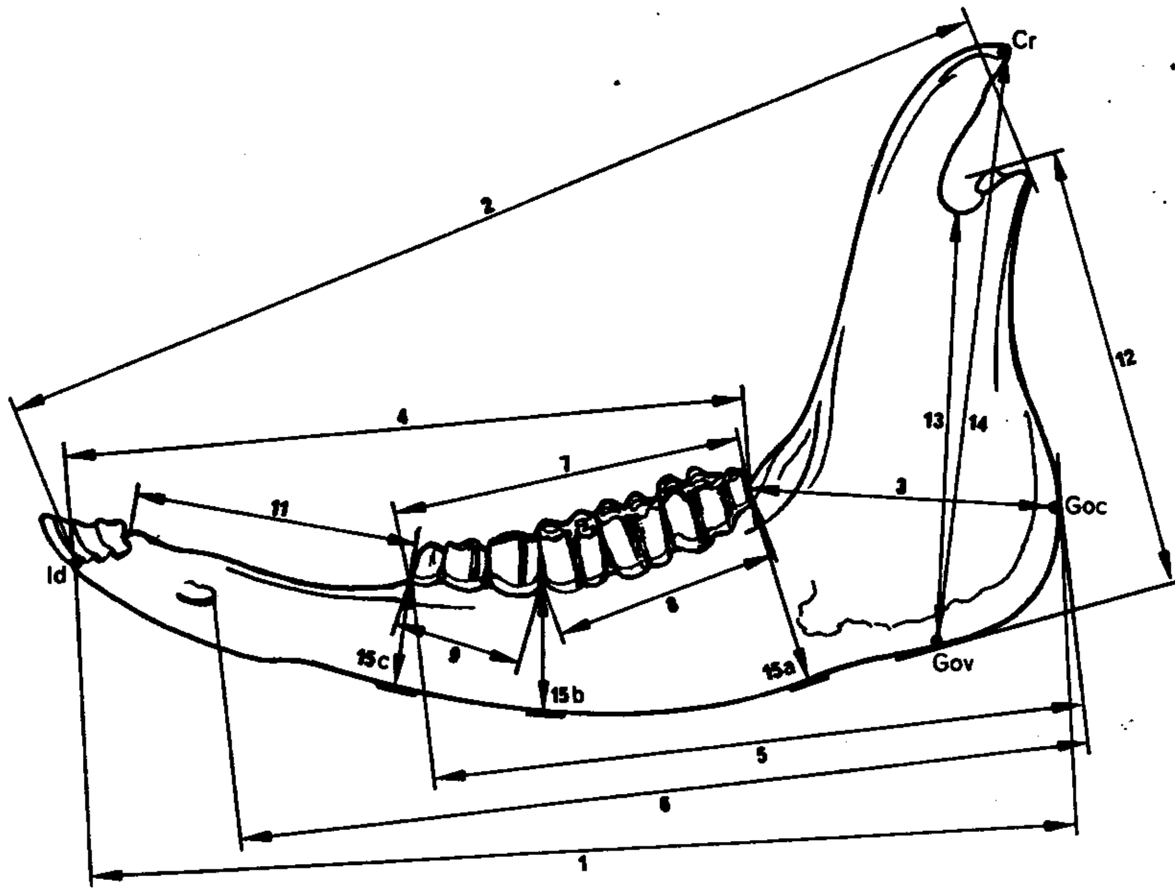
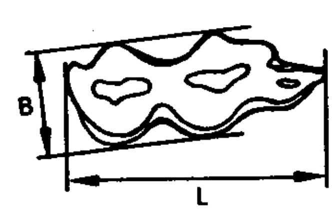


Figure 21a: Bos mandible, left side, lateral view.

Figure 21b: Bos M_3

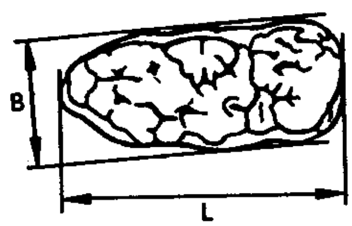


Length (L) and breadth (B)
at the biting surface.
(see M 10)

Measurements of the mandible of Ruminantia with the exception of Camelus (Fig. 21a,b)

1)-5) Same as Equus measurements
6) Length: Gonion caudale - the most aboral indentation of the mental foramen (+)
7) Length of the cheektooth row, measured along the alveoli on the buccal side (+)
8) Length of the molar row, measured along the alveoli on the buccal side (-)
9) Length of the premolar row, measured along the alveoli on the buccal side (-)
10) Length and breadth of M_3, measured near the biting surface (Fig. 21b) (-)
11) Length of the diastema: oral border of the alveolus of P_2 - aboral border of the alveolus of I_4(=C) (+)
12) Aboral height of the vertical ramus: Gonion ventrale - highest point of the condyle process (see Equus M 19) (+)
13) Middle height of the vertical ramus: Gonion ventrale - deepest point of the mandibular notch (see Equus M 20) (+)
14) Oral height of the vertical ramus: Gonion ventrale - Coronion (see Equus M 21) (+)
15a) Height of the mandible behind M_3 from the most aboral point of the alveolus on the buccal side (-)
15b) Height of the mandible in front of M_1 (see note after Equus M 22c) (-)
15c) Height of the mandible in front of P_2 (see note after Equus M 22c) (-)

Figure 22a: Sus M_3



Length (L) and breadth (B)
near the base of the crown.
(see M 10)

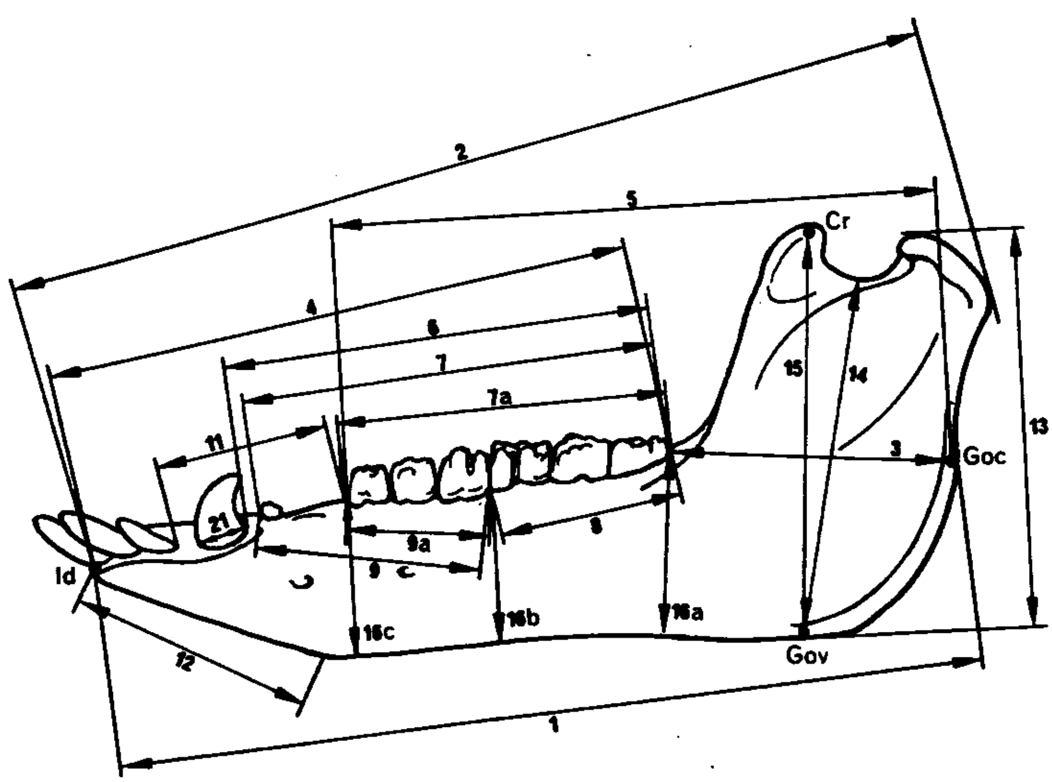


Figure 22b: Sus mandible, left side, lateral view.

Measurements of the mandible of *Sus* (Fig. 22a,b)

1)-5) Same as *Equus* measurements

6) Length: aboral border of the alveolus of M_3 - aboral border of the canine alveolus (+)

7) Length of the cheektooth row, M_3-P_1, measured along the alveoli on the buccal side (+)

7a) Length of the cheektooth row, M_3-P_2, measured along the alveoli on the buccal side (+)

8) Length of the molar row, measured along the alveoli on the buccal side (-)

9) Length of the premolar row, P_1-P_4, measured along the alveoli on the buccal side (-)

9a) Length of the premolar row, P_2-P_4, measured along the alveoli on the buccal side (-)

10) Length and breadth of M_3, measured near the base of the crown (Fig. 22a) (-)

11) Length: oral border of the alveolus of P_2 - aboral border of the alveolus of I_3 (+)

12) Length of the median section of the body of mandible: from the mental prominence - Infradentale (+)

13) Aboral height of the vertical ramus: Gonion ventrale - highest point of the condyle process (see *Equus* M 19) (+)

14) Middle height of the vertical ramus: Gonion ventrale - deepest point of the mandibular notch (see *Equus* M 20) (+)

15) Oral height of the vertical ramus: Gonion ventrale - Coronion (see *Equus* M 21) (+)

16a) Height of the mandible behind M_3, from the most aboral point of the alveolus (-)

16b) Height of the mandible in front of M_1 (see note after *Equus* M 22c) (-)

16c) Height of the mandible in front of P_2 (see note after *Equus* M 22c) (-)

(17) Breadth of the two halves across the alveoli of the canine teeth. Not shown in Fig. 22b (+)

(18) Breadth of the two halves between the most lateral points of the two angles = Gonion laterale - Gonion laterale. Not shown in Fig. 22b (+)

(19) Breadth of the two halves between the condyle processes, measured between the most lateral points of the two condyle processes. Not shown in Fig. 22b (+)

(20) Breadth of the two halves between the coronoid processes, measured between the most lateral points of the two coronoid processes. Not shown in Fig. 22b (-)

21) Greatest diameter of the canine alveolus (+)

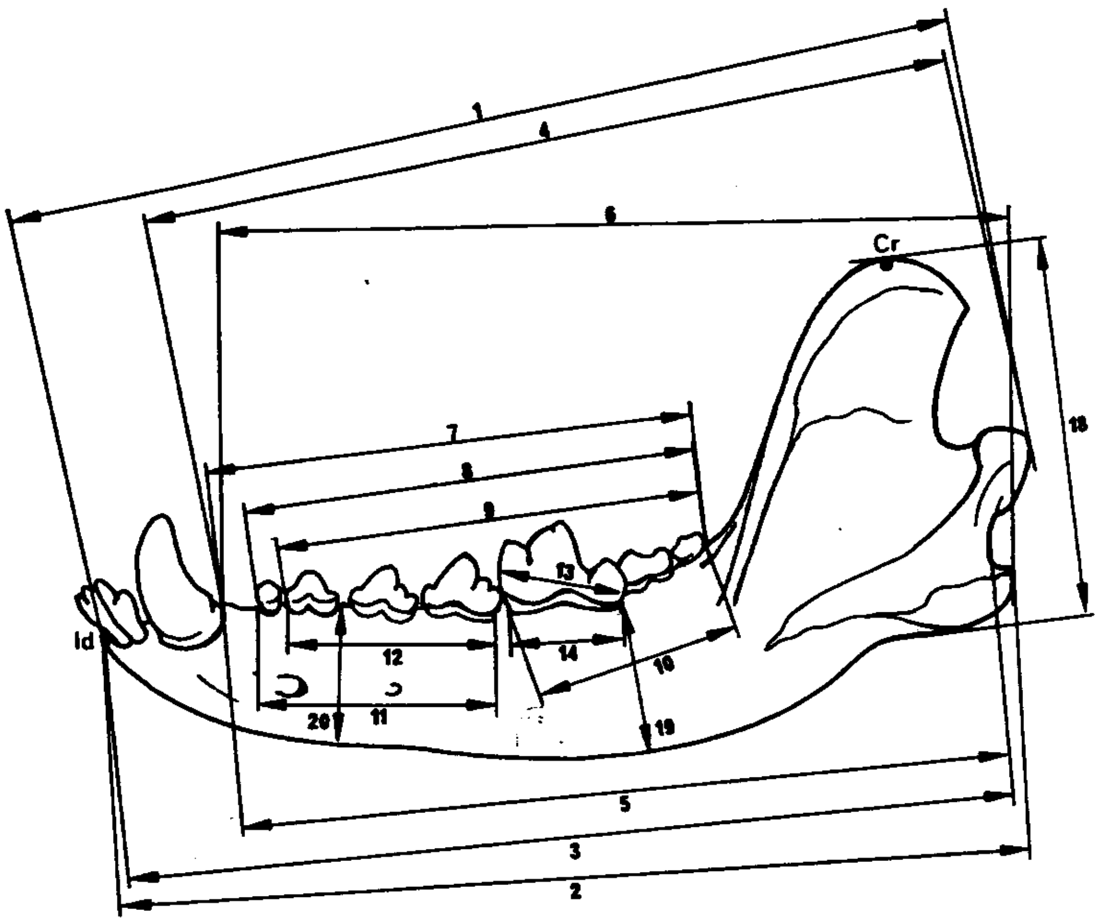


Figure 23a: Canis mandible, left side, lateral view.

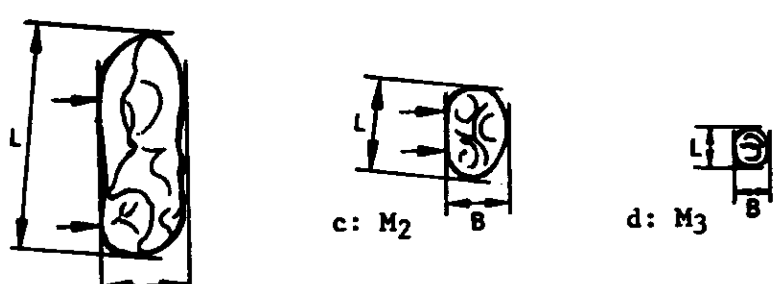


Figure 23b-d: Canis mandibular teeth, length (L) and breadth (B), M 13, 15, 16.

Measurements of the mandible of Canis (Fig. 23a,b,c,d)

1) Total length: length from condyle process - Infradentale (+)
2) Length: the angular process - Infradentale (+)
3) Length from the indentation between the condyle process and the angular process - Infradentale (+)
4) Length: the condyle process - aboral border of the canine alveolus (+)
5) Length from the indentation between the condyle process and the angular process - aboral border of the canine alveolus (+)
6) Length: the angular process - aboral border of the canine alveolus (+)
7) Length: the aboral border of the alveolus of M_3 - aboral border of the canine alveolus (+)
8) Length of the cheektooth row, M_3-P_1, measured along the alveoli (+) Harcourt XV
9) Length of the cheektooth row, M_3-P_2, measured along the alveoli (+)
10) Length of the molar row, measured along the alveoli (+)
11) Length of the premolar row, P_1-P_4, measured along the alveoli (-)
12) Length of the premolar row, P_2-P_4, measured along the alveoli (-)
13) Length and breadth of the carnassial, measured at the cingulum (Fig. 23b). If all teeth are in the alveoli, the length is best measured from dorsal (-)
14) Length of the carnassial alveolus (+)
15) Length and breadth of M_2, measured at the cingulum (Fig. 23c) (-)
16) Length and breadth of M_3, measured at the cingulum (Fig. 23d) (-)

Note: Single molars are easy to measure if they can be removed from the alveoli.

(17) Greatest thickness of the body of jaw (below M_1). Not shown in Fig. 23a (+)
18) Height of the vertical ramus: basal point of the angular process - Coronion (+)
19) Height of the mandible behind M_1, measured on the lingual side and at right angles to the basal border (-)
20) Height of the mandible between P_2 and P_3, measured on the lingual side and at right angles to the basal border (-)
(21) Height (length) of the canine, measured in a straight line from point to point. This measurement is only possible if the tooth can be removed from the jaw. Not shown in Fig. 23a (+)
(22) Calculation of the basal length (following Brinkmann 1924): measurement no. 2 multiplied by 1.21
(23) Calculation of the basal length (following Brinkmann 1924): measurement no. 4 multiplied by 1.37
(24) Calculation of the basal length (following Brinkmann 1924): measurement no. 5 multiplied by 1.46
(25) The mean of M 22, 23, and 24
(26) Calculation of the basal length (following Dahr 1937): measurement 8 multiplied by 2.9, minus 44 mm

Measurements of the mandible of Ursus (Figs. 16d,e,f,g and 23a) [see p. 46.]

1)-7) Same as Canis measurements
8) Length of the cheektooth row, P_4-M_3, measured along the alveoli (+)
9) Length of the molar row, measured along the alveoli (-)
10) Length and breadth of P_4, measured at the cingulum (Fig. 16d) (+)
11) Length and breadth of M_1, measured at the cingulum (Fig. 16e) (+)
12) Length and breadth of M_2, measured at the cingulum (Fig. 16f) (+)
13) Length and breadth of M_3, measured at the cingulum (Fig. 16g) (+)
14) Height of the vertical ramus: basal point of the angular process - Coronion (+)
15) Height of the mandible behind M_2, measured on the buccal side (-)
16) Height of the mandible between P_4 and M_1, measured on the buccal side (-)
(17) Height (length) of the canine, measured in a straight line from point to point. This measurement is only possible if the tooth can be removed from the jaw (+)

Measurements of the mandible of Felis (Fig. 24)

1) Total length: length from the condyle process - Infradentale (+)
2) Length from the indentation between the condyle process and the angular process - Infradentale (+)
3) Length: the condyle process - aboral border of the canine alveolus (+)
4) Length from the indentation between the condyle process and the angular process - aboral border of the canine alveolus (+)
5) Length of the cheektooth row, P_3-M_1, measured along the alveoli (+)
(6) Length and breadth of M_1, measured at the cingulum. Not shown in Fig. 24; measured in the same way as for dog (+)
7) Length of the carnassial alveolus (+)
8) Height of the vertical ramus: basal point of the angular process - Coronion (+)
9) Height of the mandible behind M_1, measured on the buccal side (+)
10) Height of the mandible in front of P_3, measured on the buccal side (+)

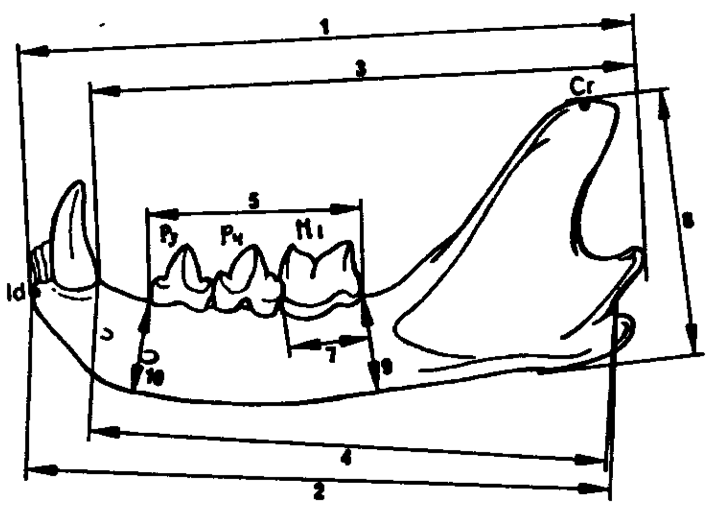


Figure 24: Felis mandible, left side, lateral view.

Measurements of the mandible of Lepus and Oryctolagus (Fig. 25)

1) Length from angle = greatest length: Gonion caudale - Infradentale (+)
2) Length of the cheektooth row, measured along the alveoli (+)
3) Length: aboral border of the alveolus of M_3 - Infradentale (+)
4) Length of the diastema: oral border of the alveolus of P_3 - Infradentale
5) Height of the vertical ramus: Gonion ventrale - highest point of the condyle process. Not to be measured in projection (see Hauser 1921, Fig. 10) (+)
5a) Height of the vertical ramus, measured in projection (see Duerst 1926, p. 333). Best done by placing one pointer of the slide gauge along the basal border of the mandible. This measurement can be taken precisely only if mandible is intact.

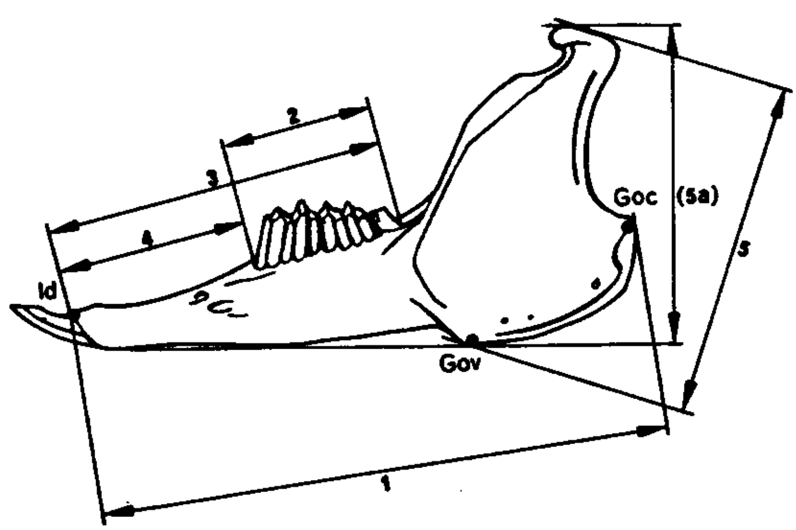


Figure 25: Lepus mandible, left side, lateral view.

POSTCRANIAL SKELETON

The *greatest length* of limb bones is measured in all cases from the most proximal prominent point to the most distal prominent point. But since in some bones these two points do not lie in the same axis (Fig. 26), one has to measure in such a way that the (imagined) longitudinal axis of the bone lies parallel to the scale of the measuring instrument. One thus measures the greatest length in projection. Such a procedure is easy with a bone whose shaft (corpus) is straight or almost straight (e.g., the radius of ruminants). More difficult to measure is the length of a bone whose shaft is curved or whose proximal and distal ends are twisted, facing in opposite directions (e.g., the radius of <u>Sus</u>).

The *breadth* measurements of proximal and distal ends of limb bones are measured from the most lateral prominent point to the most medial prominent point. In many bones this dimension is at right angles to the imagined longitudinal axis of the bone (Fig. 26a). There are, however, bones in which the most lateral and the most medial point lie in different planes, i.e., one of the two points lies more proximally or more distally than the other (e.g., the distal tibia of the bear, Fig. 26b). In such cases Duerst (1926, p. 463) suggests measurement in projection which is best accomplished by using a measuring box. But in our own experience this leads to very inexact results, especially when only the proximal or distal ends of the bones are present and one cannot establish the longitudinal axis of the bone. For that reason, we consider it surer to measure the direct distance from the most lateral to the most medial prominent point regardless of their positions. One measures therefore the diagonal rather than the breadth. The rare cases in which one should not measure the diagonal will be noted specifically (e.g., "greatest breadth" of astragalus of <u>Equus</u>).

Abbreviations instead of numbers are used for designating the measurements of bones of the mammalian postcranial skeleton and of the bird skeleton. The purpose of such abbreviations is to save time and space in the documentation of finds. Nouns are abbreviated with capital letters (e.g., L = length; C = corpus; F = facies) and adjectives with lower case letters (e.g., p = proximal; d = distal) except when they are at the beginning of an abbreviation (e.g., greatest length = GL). Unavoidably some few words which begin with the same letter will be abbreviated in the same way. Thus *diaphysis* is abbreviated with a "D" as is *depth,* but from the position of the letter in the abbreviation or from the abbreviation combination one can at once perceive which noun is meant. Generally one word is abbreviated to only one letter; in order to preserve clarity, however, this was not possible with all words (e.g., pe = *peripher* because p = *proximal,* just as cr = *cranial* and cd = *caudal).*

The abbreviations used to designate the measurements, moreover, have been designed to conform as much as possible to the usual German abbreviations. In order for this to be practicable, it was often necessary to refer to Latin terms. Complete uniformity could not be achieved with every word, however, and discrepancies occur in the following words:

English	German
D = depth	T = Tiefe
Di = diagonal	D = Durchmesser
C = circumference	U = Umfang
S = smallest	K = Kleinste

In addition, to permit this English compilation to serve as a guide to German osteoarchaeological publications, the German abbreviation immediately follows the English abbreviation where they differ.

NOTE: For the convenience of the user, illustrated parts of the post-cranial skeleton have been designated L (left) or R (right) in the upper right corner of each drawing where appropriate.

Figure 26a: Ovis radius.

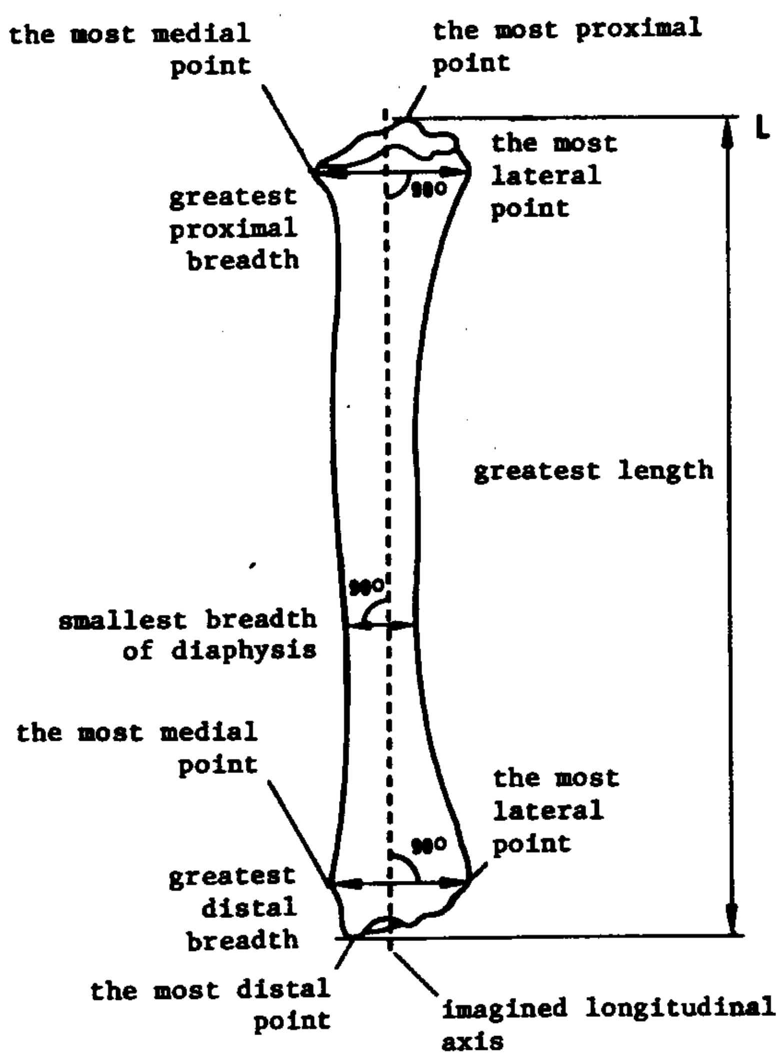
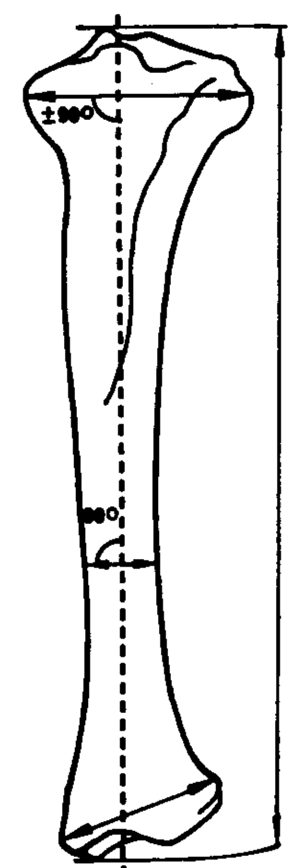


Figure 26b: Ursus tibia



ATLAS (Fig. 27a-c)

GB - Greatest breadth over the wings (+)

GL - Greatest length (+)

BFcr - (Greatest) breadth of the Facies articularis cranialis (= cranial articular surface) (+)

BFcd - (Greatest) breadth of the Facies articularis caudalis (= caudal articular surface) (+)

GLF - Greatest length from the Facies articularis cranialis to the Facies articularis caudalis (-)

LAd - Length of the Arcus dorsalis (= dorsal arch), median. Measured only in carnivores (+)

H - Height. Measured in a measuring box in such a way, that one lays the atlas with its cranial side on the bottom of the box and closes the blocks over the dorsal and ventral arches (+)

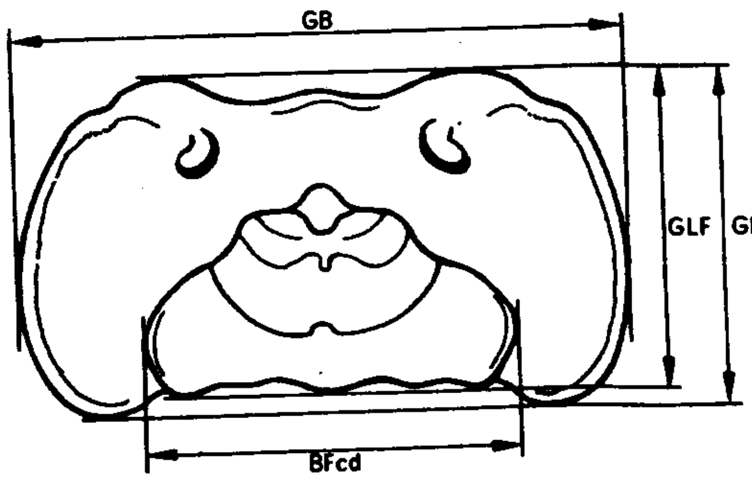


Figure 27a: Bos atlas, caudodorsal view.

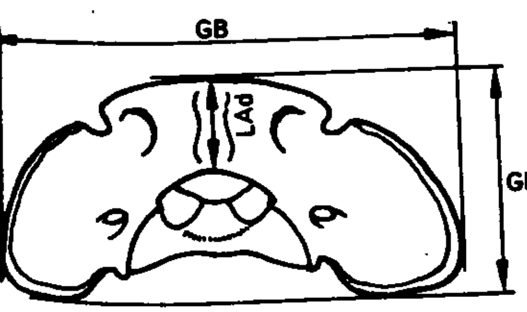


Figure 27b: Canis atlas, dorsal view.

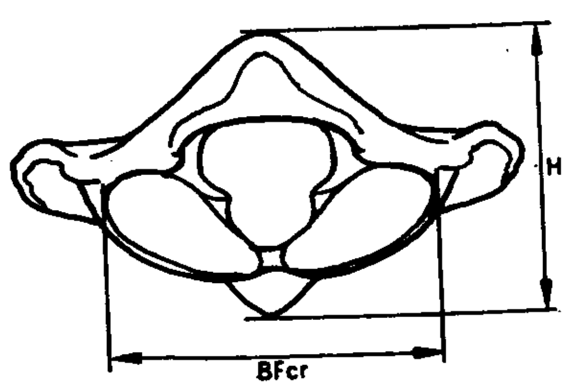


Figure 27c: Sus atlas, cranial view.

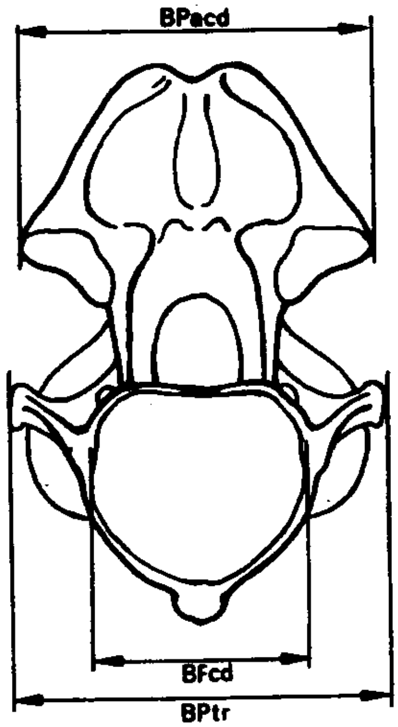


Figure 28a: Equus axis,
caudal view.

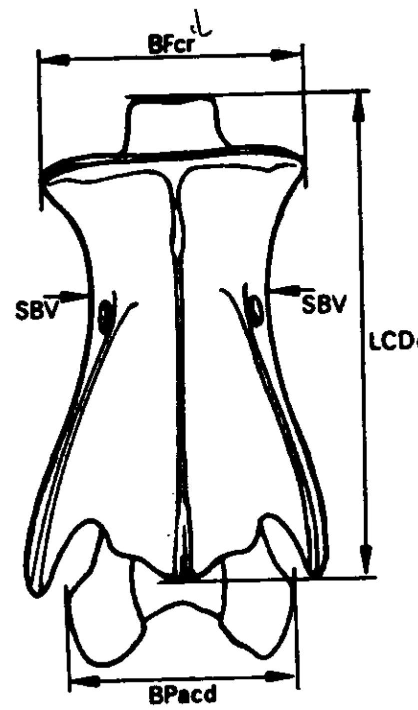


Figure 28b: Cervus axis,
ventral view.

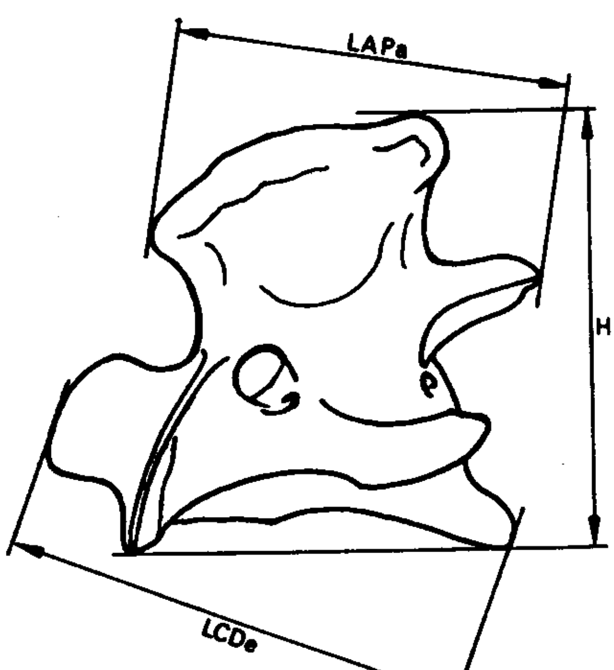


Figure 28c: Bos axis,
left side view.

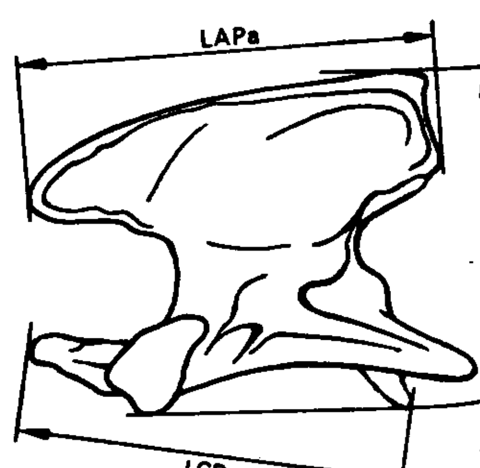


Figure 28d: Canis axis,
left side view.

[illegible] (Fig. 28a-d)

[illegible] - (Greatest) length in the region of the corpus (= body) including the dens. If the caudal epiphysal plate has not yet fused, one measures without the caudal articular surface adding a note to that effect (+)

LAPa - (Greatest) length of the arch including the Processus articulares caudales (+)

BFcr - (Greatest) breadth of the Facies articularis cranialis (= cranial articular surface) (+)

BPacd - (Greatest) breadth across the Processus articulares caudales (+)

BPtr - (Greatest) breadth across the Processus transversi (+)

SBV - KBW (German) = Smallest breadth of the vertebra (+)

BFcd - (Greatest) breadth of the Facies terminalis caudalis (= caudal articular surface)

H - (Greatest) height. Measured in a measuring box. One lays the two basal prominent points of the body of the vertebra on the fixed block of the instrument and closes the other block over the highest point of the spinous process (+)

SACRUM (Fig. 29a,b)

Since the number of segments in the sacrum can vary within a species, it is important to note the number of segments when recording measurements of length.

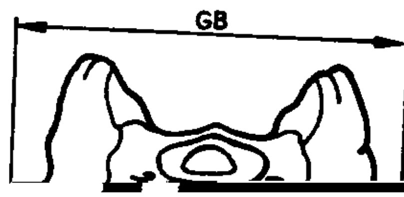
GL - Greatest length on the ventral side: from the cranial borders of the wings to the caudoventral border of the body of the last vertebra (+)

PL - Physiological length, measured between the centers of the bodies of the most cranial and the most caudal vertebrae (+)

GB - Greatest breadth (across the wings) (+)

BFcr - (Greatest) breadth of the Facies terminalis cranialis (= cranial articular surface) (-)

HFcr - (Greatest) height of the Facies terminalis cranialis (-)



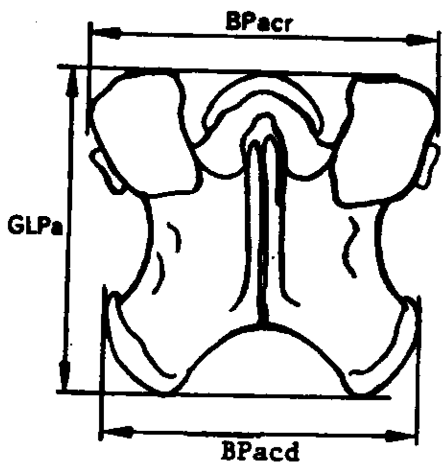


Figure 30a: Ovis cervical vertebra, dorsal view.

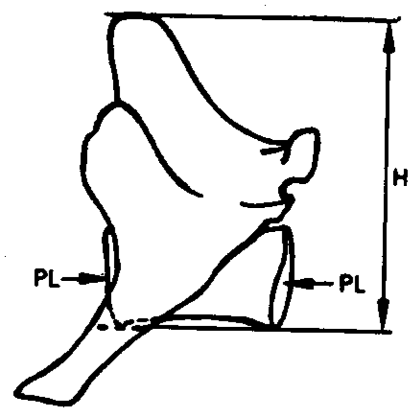


Figure 30b: Canis lumbar vertebra, left side view.

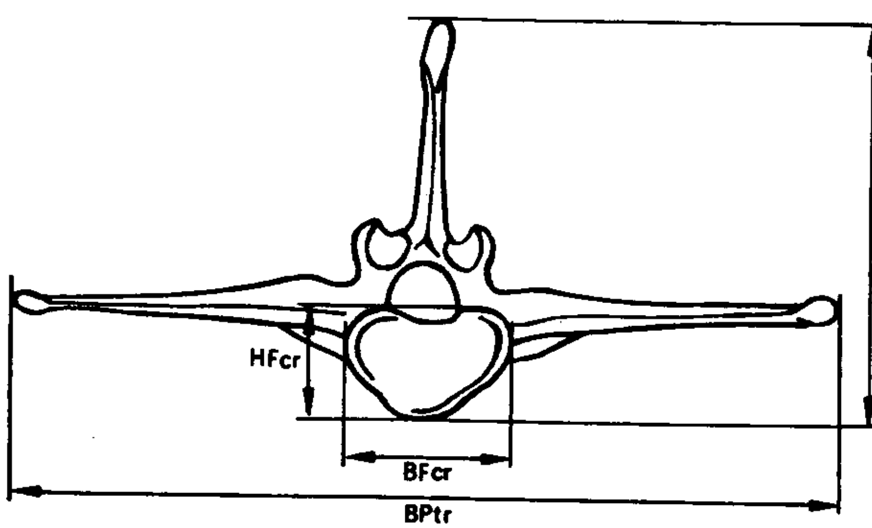


Figure 30c: Equus lumbar vertebra, cranial view.

REMAINING VERTEBRAE (Fig. 30a-d)

PL - Physiological length of the body. Measured between the centers of the Facies terminalis cranialis and the Facies terminalis caudalis (+)

GLPa - Greatest length from the Processus articulares craniales to the Processus articulares caudales (in cervical vertebrae) (+)

BPacr - (Greatest) breadth across the Processus articulares craniales (in cervical vertebrae) (+)

BPacd - (Greatest) breadth across the Processus articulares caudales (in cervical vertebrae) (+)

BPtr - (Greatest) breadth across the Processus transversi (+)

BF(cr/cd) - (Greatest) breadth of the Facies terminalis cranialis/caudalis (= cranial/caudal articular surface) (in thoracic vertebrae including the facets for the heads of the ribs) (-)

HF(cr/cd) - (Greatest) height of the Facies terminalis cranialis/caudalis (-)

H - (Greatest) height

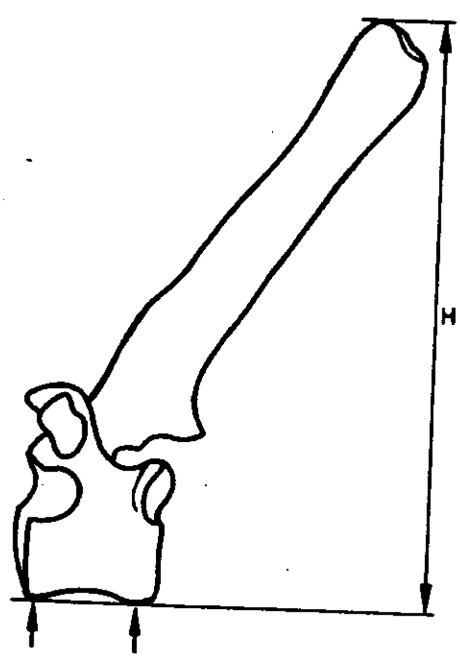


Figure 30d: Equus thoracic vertebra, left side view.

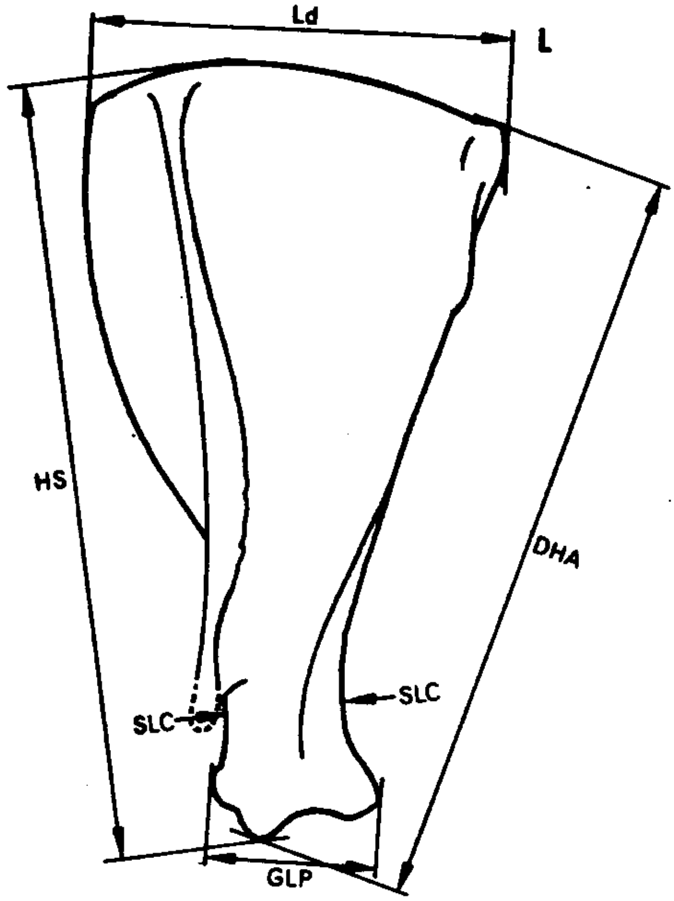


Figure 31a: Bos scapula, lateral view.

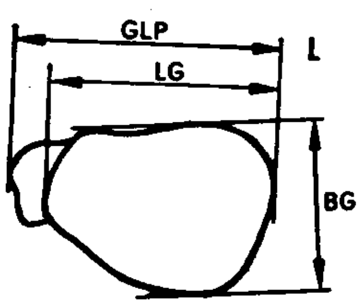


Figure 31b: Bos scapula, distal view.

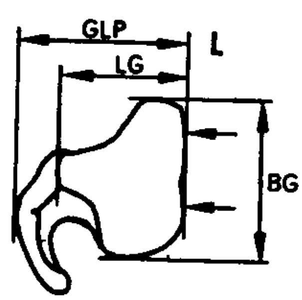


Figure 31c: Lepus scapula, distal view.

SCAPULA (Fig. 31a-e)

HS - Height (see definitions of linear measurements p. 14) along the spine (+)

DHA - Diagonal height (see definitions of linear measurements p. 14): from the most distal point of the scapula to the thoracic angle (+). In scapulae where the thoracic angle is rounded (-)

Ld - (Greatest) dorsal length. Not to be measured in scapulae where one angle or both angles are rounded (+)

SLC - KLC (German) - Smallest length of the Collum scapulae (neck of the scapula). In general (+). Not easy to measure in scapulae of those ruminants which possess a crest on the aboral border of the neck (e.g., sheep). Not possible to measure in some species of carnivores.

GLP - Greatest length of the Processus articularis (glenoid process) (+)

LG - Length of the glenoid cavity. Measured to include the cranial lip of the glenoid cavity, parallel to the GLP, since one often cannot recognize the border of the glenoid cavity. Difficult to measure in pigs.

BG - Breadth of the glenoid cavity - Greatest breadth of the glenoid angle. (+)

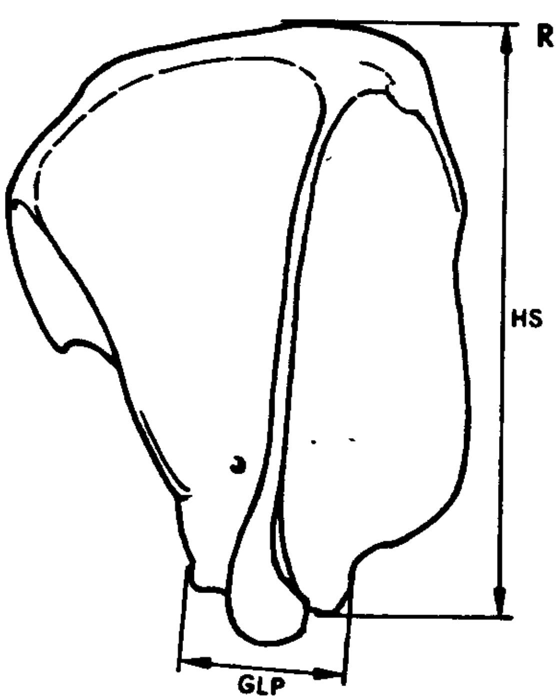


Figure 31d: Ursus scapula, lateral view.

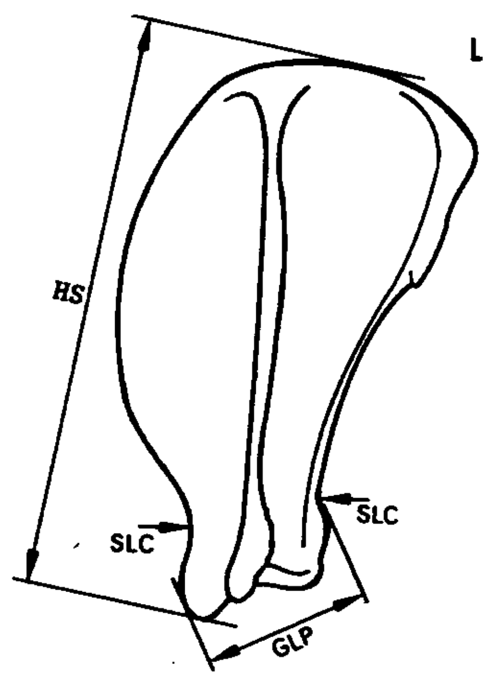


Figure 31e: Canis scapula, lateral view.

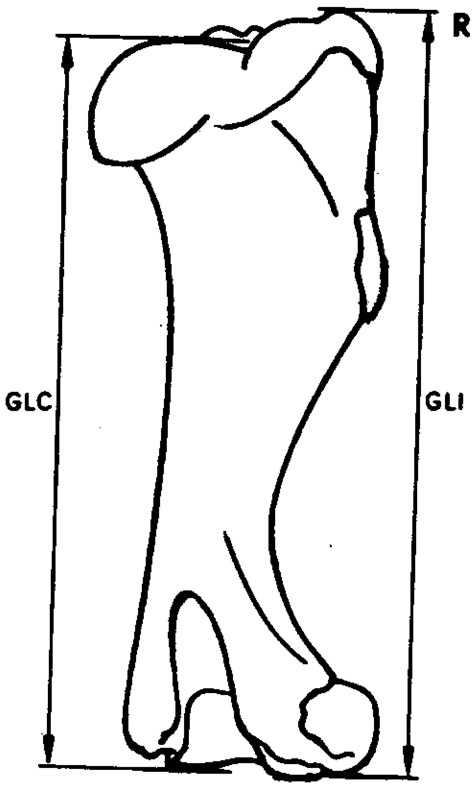


Figure 32a: Equus humerus,
caudolateral view.

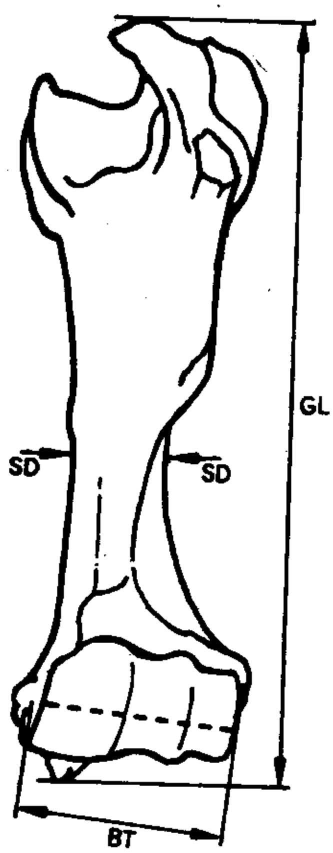


Figure 32b: Bos humerus,
cranial view.

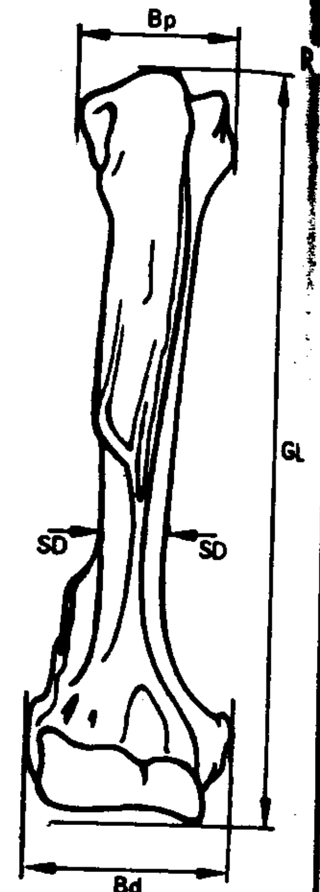


Figure 32c: Ursus humer
cranial vi

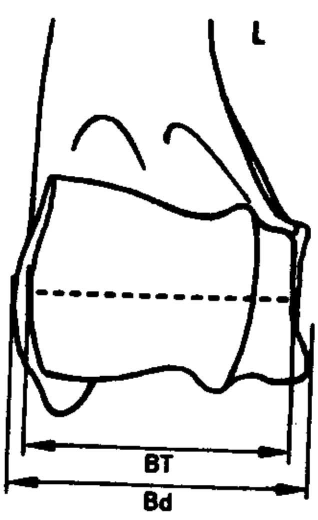


Figure 32d: Cervus humerus,
distal end,
cranial view.

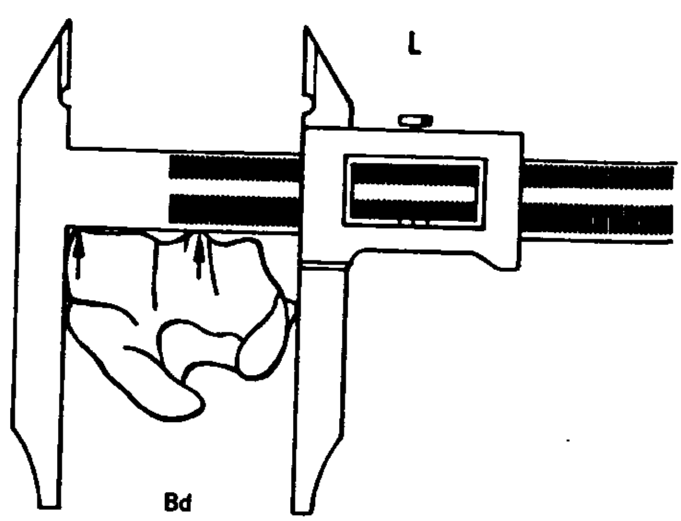


Figure 32e: Bos humerus,
distal view

HUMERUS (Fig. 32a-g)

GL - Greatest length (+)

GL1 - Greatest length of the lateral part (following Kiesewalter 1888): from the cranial part of the lateral tuberosity to the most distal point of the lateral border of the trochlea. Only in horses (+)

GLC - Greatest length from caput (head) (+)

Bp - (Greatest) breadth of the proximal end. Not in canids or lagomorphs (-)

Dp - Tp (German) - Depth of the proximal end. Only in canids and lagomorphs.

SD - KD (German) - Smallest breadth of diaphysis (+)

Bd - (Greatest) breadth of the distal end. Difficult to measure in ruminants and equids, because the most lateral and the most medial prominent points do not lie in the same plane and moreover the trochlea, especially in Bos, is oblique. If this distance is measured at right angles to the imagined longitudinal axis of the bone, the result is a disproportionately high value. This measurement is therefore to be taken in equids and ruminants as is shown in Figure 32e. A slide gauge with broad callipers must always be used (-)

BT - (Greatest) breadth of the trochlea. Only in equids and ruminants. The trochlea is measured in the middle from the cranial side including the outer borders of both the lateral and medial condyles (-)

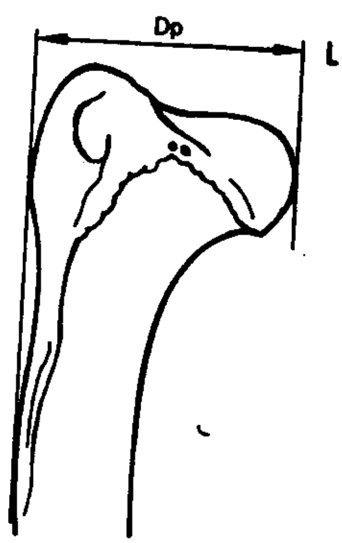


Figure 32f: Canis humerus, proximal end, lateral view.

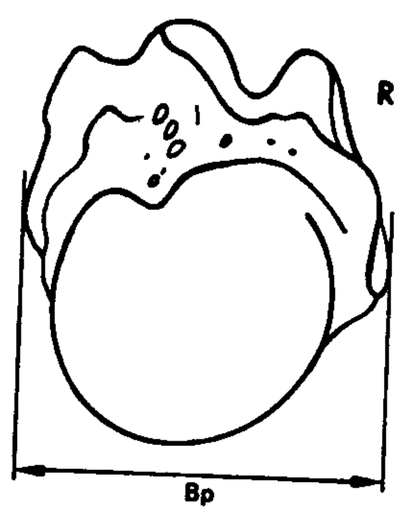


Figure 32g: Equus humerus, proximal view.

RADIUS AND ULNA (Fig. 33a-g)

Radius and Ulna:

GL - Greatest length
GL1 - Greatest length of lateral part (following Kiesewalter 1888, only in horses).

Radius:

GL - Greatest length (+)
PL - Physiological length. In general only in horses. One measures in the longitudinal axis of the bone from the proximal articular surface to the distal articular surface (+)
Ll - Length of the lateral part (following Kiesewalter 1888, only in horses) (+)
BP - (Greatest) breadth of the proximal end (+)
BFp - (Greatest) breadth of the Facies articularis proximalis (humeral articular surface). Measured in the same plane as Bp. Only in equids and ruminants (+)
SD - KD (German) - Smallest breadth of diaphysis. In radii in which the corpus is twisted (e.g., pig and bear), the alignment for the SD measurement is determined by the direction of the proximal articular surface (+)
CD - UD (German) - (Smallest) circumference of diaphysis. In general only in horses, where this measurement serves well to denote proportions (+)
Bd - (Greatest) breadth of the distal end (+)
BFd - (Greatest) breadth of the Facies articularis distalis. Measured in the same plane as Bd. Only in equids and ruminants (+)

Ulna:

GL - Greatest length (+)
LO - Length of the olecranon. Only in ruminants (-)
DPA - TPA (German) - Depth across the Processus anconaeus. One measures the shortest distance from the Processus anconaeus to the caudal border of the ulna (-)
SDO - KTO (German) - Smallest depth of the olecranon. Cannot be accurately measured in bears.
BPC - (Greatest) breadth across the coronoid process = greatest breadth of the proximal articular surface (+)

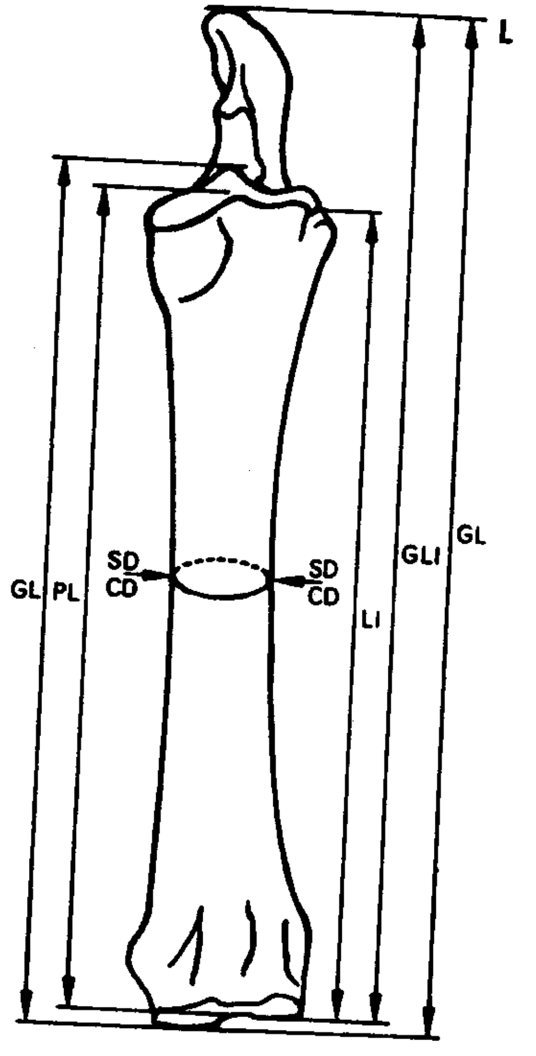


Figure 33a:
Equus radius and ulna, dorsal view.

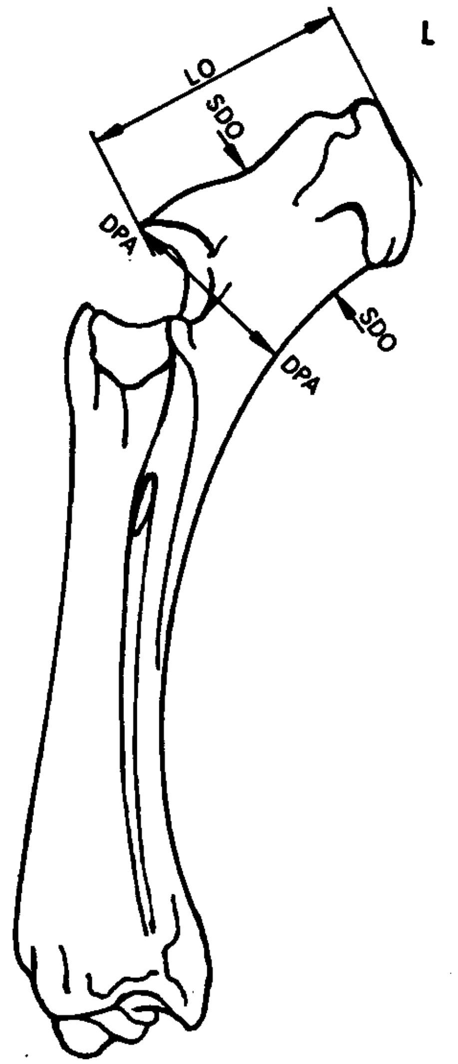


Figure 33b:
Bos radius and ulna, lateral view.

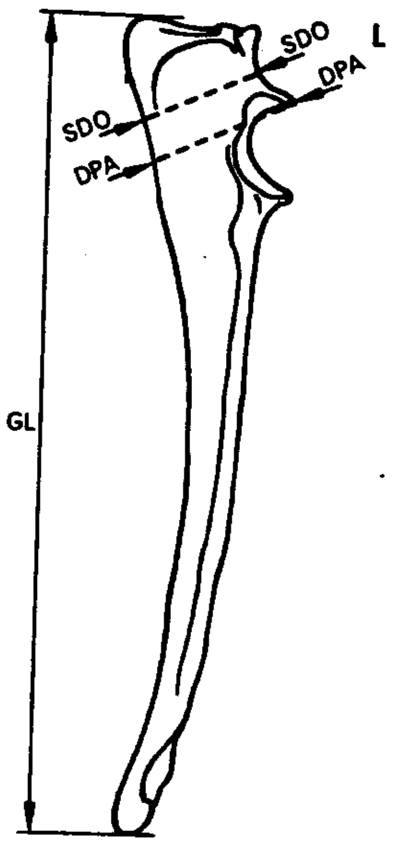


Figure 33c: Canis ulna, medial view.

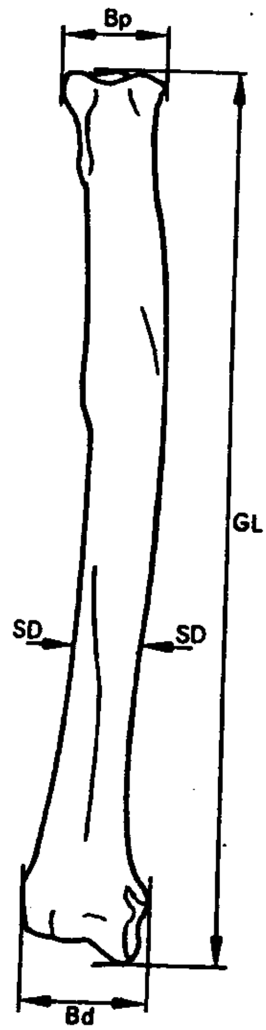
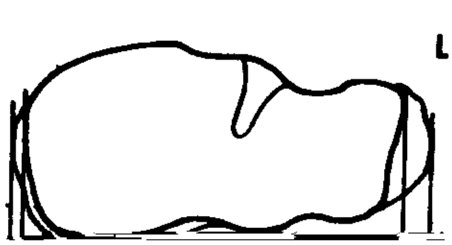
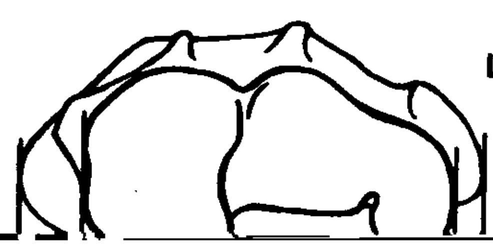


Figure 33d: Canis radius, dorsal view.

Figure 33e: Cervus ulna, proximal end, dorsal view.





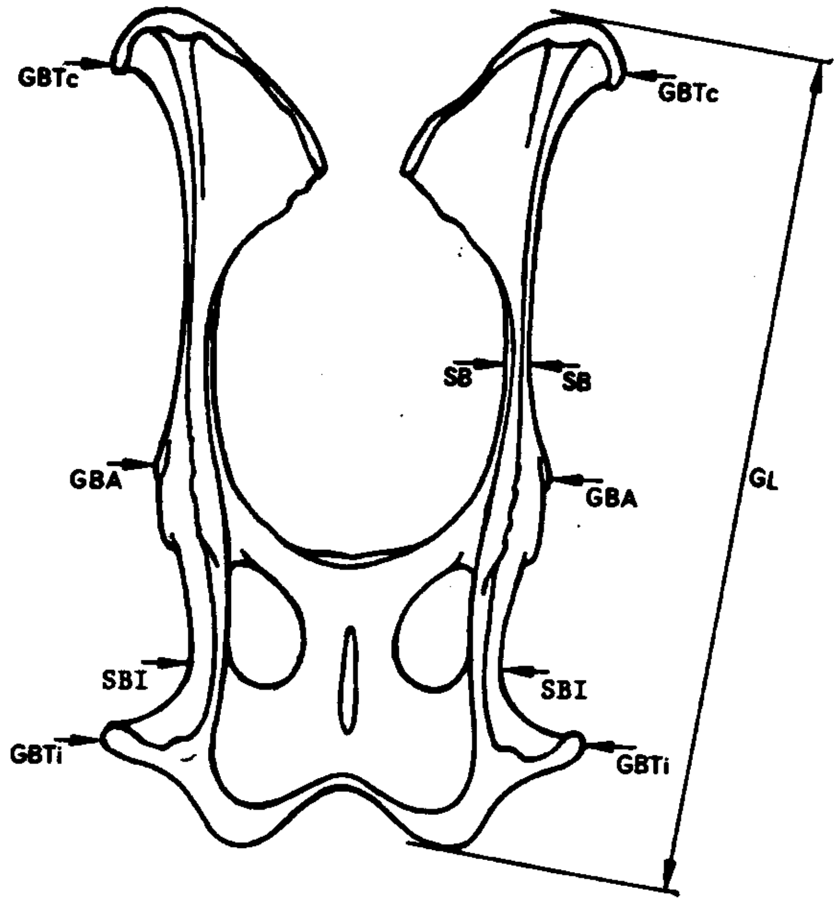


Figure 34a: <u>Ovis</u> pelvis, dorsal view.

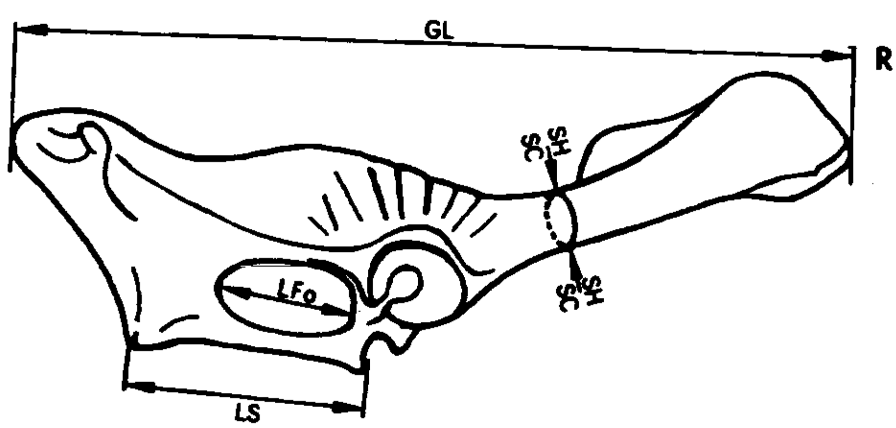


Figure 34b: <u>Sus</u> pelvis, lateral view.

PELVIS (Fig. 34a-d)

GL - Greatest length of one half. Important: epiphyseal parts of the Tuber coxae and the Tuber ischiadicum must have fused! (+)
LA - Length of the acetabulum including the lip (-). Measured only in species whose acetabulum forms a clear lip. In addition, one measures in horses and pigs, as well as in all other species which have no lip, the LAR
LAR - Length of the acetabulum on the rim (+)
LS - Length of the symphysis. Only measured when the two halves have fused.
SH - KH (German) - Smallest height of the shaft of ilium (+)
SB - KB (German) - Smallest breadth of the shaft of ilium
SC - KU (German) - Smallest circumference of the shaft of ilium
LFo - Inner length of the foramen obturatum (+)
GBTc - Greatest breadth across the Tubera coxarum - greatest breadth across the lateral angle (+)
GBA - Greatest breadth across the acetabula (+)
GBTi - Greatest breadth across the Tubera ischiadica (+)
SBI - KBI (German) - Smallest breadth across the bodies of the ischia (+)

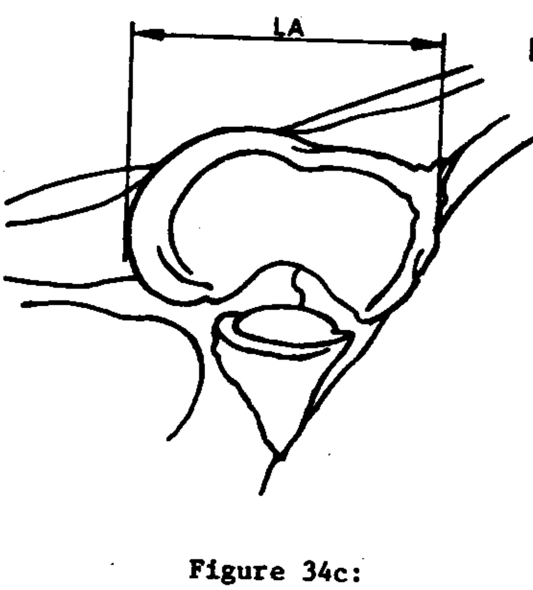


Figure 34c:
Bos pelvis,
acetabulum.

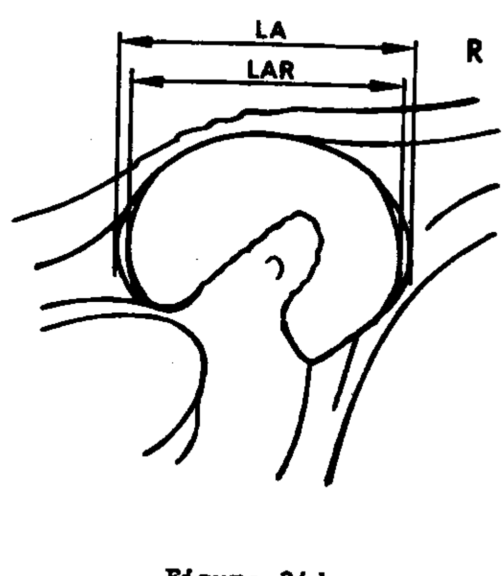


Figure 34d:
Equus pelvis,
acetabulum.

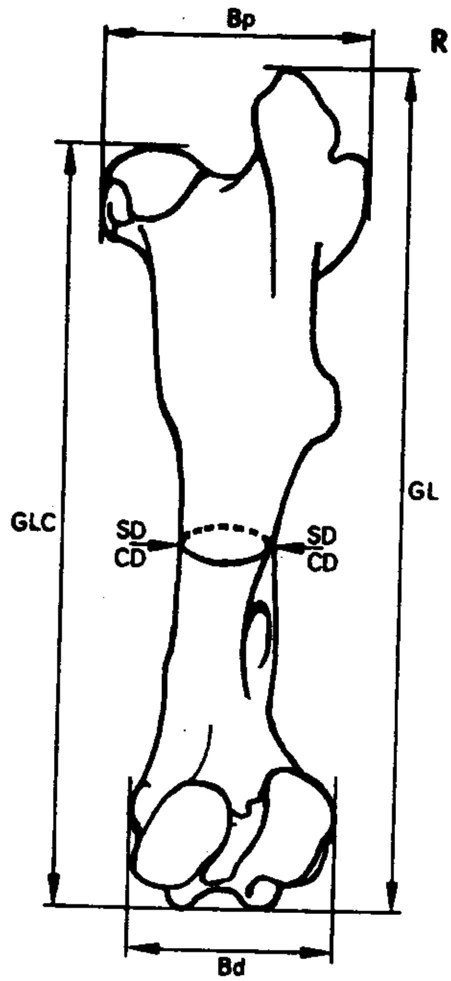


Figure 35a: *Equus* femur, caudal view.

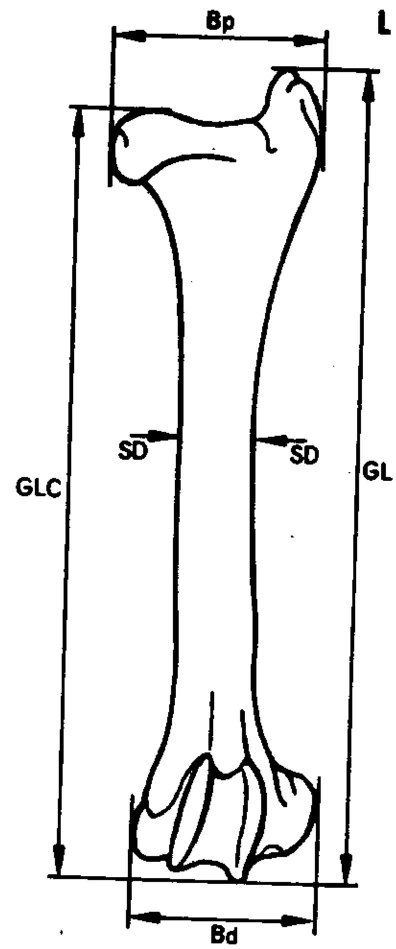


Figure 35b: *Ovis* femur, cranial view.

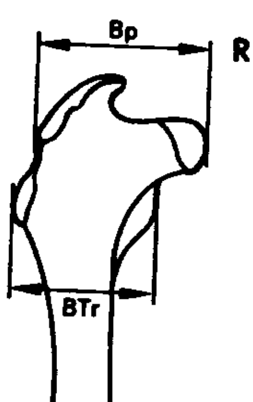


Figure 35c: *Lepus* femur, proximal end, cranial view.

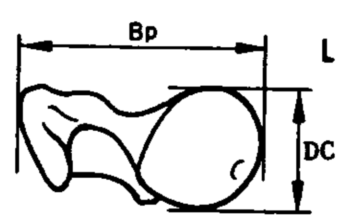


Figure 35d: *Canis* femur, proximal view.

FEMUR (Fig. 35a-d)

GL - Greatest length. In equids, ruminants, pigs, and lagomorphs = lateral length (+)
GLC - Greatest length from caput femoris (head). In some carnivore species = greatest length (+)
Bp - (Greatest) breadth of the proximal end (+)
BTr - (Greatest) breadth of the region of the Trochanter tertius. Only in lagomorphs to be measured parallel to the Bp!
DC - TC (German) - (Greatest) depth of the Caput femoris (+)
SD - KD (German) - Smallest breadth of diaphysis (+)
CD - UD (German) - (Smallest) circumference of diaphysis (see note to CD under "Radius and Ulna") (+)
Bd - (Greatest) breadth of the distal end. In hoofed animals measured in a measuring box.

PATELLA (Fig. 36)

GL - Greatest length (+)
GB - Greatest breadth (+)

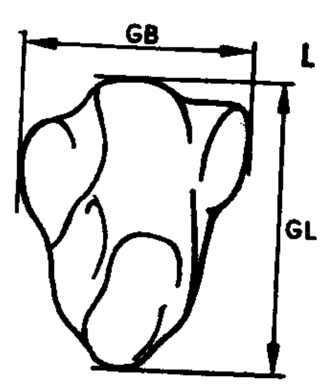


Figure 36: Bos patella, cranial view.

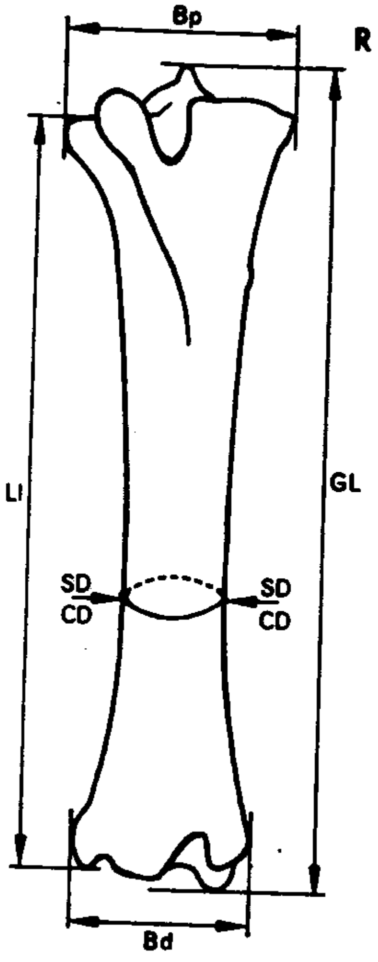


Figure 37a:
<u>Equus</u> tibia,
dorsal view.

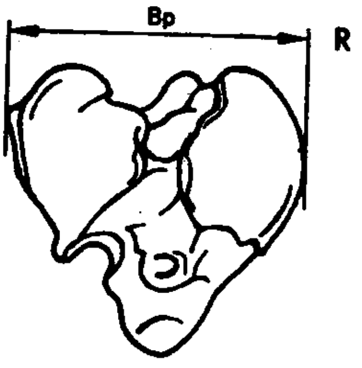


Figure 37b:
<u>Capra</u> tibia,
proximal view.

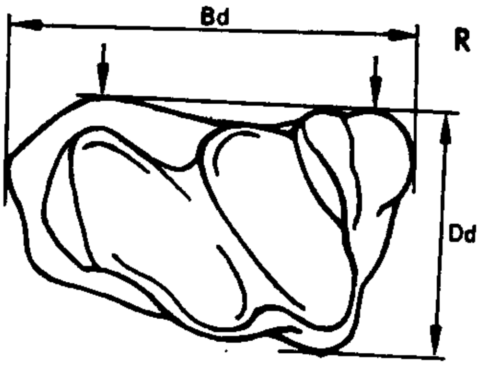


Figure 37c:
<u>Equus</u> tibia,
distal view.

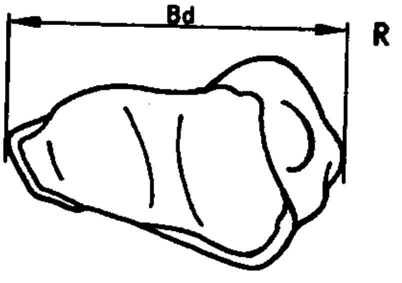


Figure 37d:
<u>Ursus</u> tibia,
distal view.

TIBIA (Fig. 37a-d)

GL - Greatest length (+)
Ll - Lateral length on the outer side (following Kiesewalter 1888, only in horses)
Bp - (Greatest) breadth of the proximal end (+)
SD - KD (German) - Smallest breadth of the diaphysis (+)
CD - UD (German) - (Smallest) circumference of the diaphysis (see note to CD under "Radius and Ulna") (+)
Bd - (Greatest) breadth of the distal end
Dd - Td (German) - (Greatest) depth of the distal end. Usually measured only in equids and lagomorphs.

FIBULA (Fig. 38)

GL - Greatest length (+)

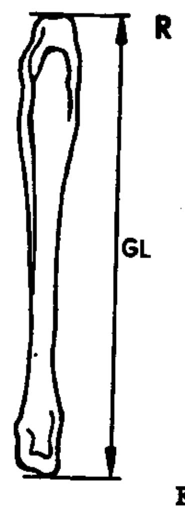


Figure 38: <u>Sus</u> Fibula, lateral view.

OS MALLEOLARE (Fig. 39)

GD - GT (German) - Greatest depth (+)

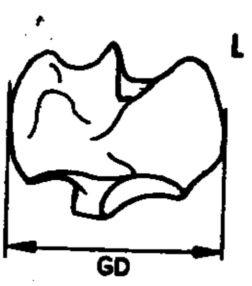


Figure 39: <u>Bos</u> Os malleolare, lateral view.

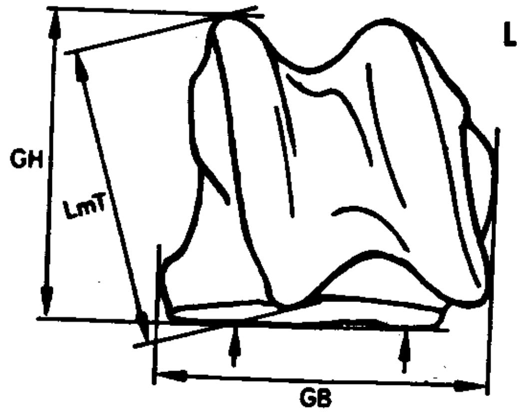


Figure 41a: Equus astragalus, dorsal view.

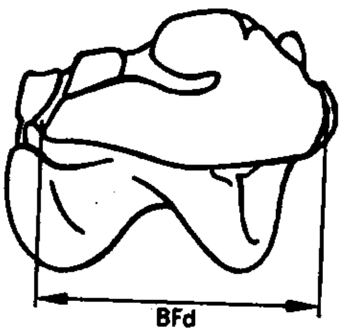


Figure 41b: Equus astragalus, distal view.

Figure 41c: Bos astragalus, medial view.

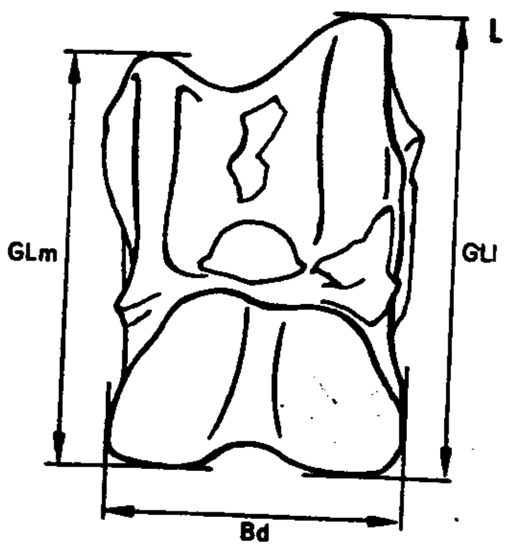


Figure 41d: Bos astragalus, dorsal view.

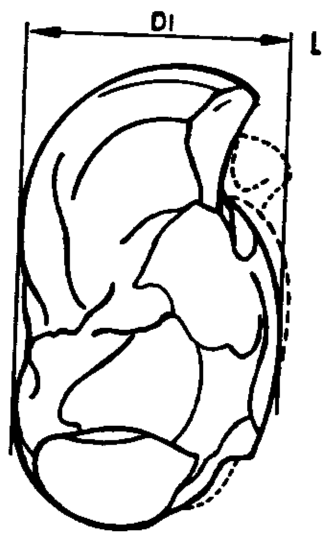


Figure 41e: Bos astragalus, lateral view.

CARPAL AND TARSAL BONES (Figs. 40-43)

Larger carpal bones (Fig. 40a-c)

GB - Greatest breadth. Measured in a measuring box or with a slide gauge with broad callipers

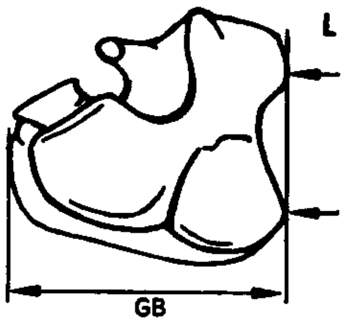


Figure 40a:
Equus
Os carpale 3

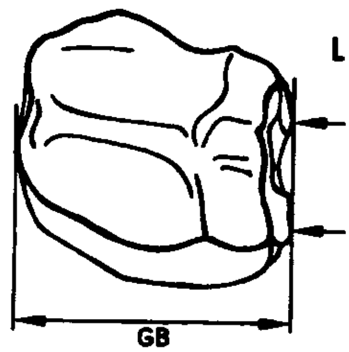


Figure 40b:
Bos
Os carpale 2+3

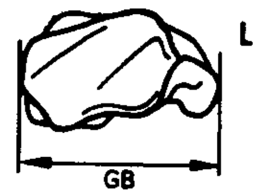


Figure 40c:
Canis
Os intermedio-radiale

Astragalus (=talus) (equids) (Fig. 41a,b)

GH - Greatest height (= length). Measured in a measuring box (-)
GB - Greatest breadth. Only in a measuring box can an equid astragalus be accurately measured. One lays the distal side of the bone on the bottom of the box. The measurement is taken in projection (-)
BFd - Breadth of the Facies articularis distalis (distal articular surface) (+)
LmT - Length of the medial part of the Trochlea tali (+)

Astragalus (=talus) (Artiodactyla) (Fig. 41c-f)

GLl - Greatest length of the lateral half (+)
GLm - Greatest length of the medial half (+)
Dl - Tl (German) - (Greatest) depth of the lateral half (+)
Dm - Tm (German) - (Greatest) depth of the medial half (-)
Bd - (Greatest) breadth of the distal end
Note: In Ovis, Capra, and Cervus there is a projection on the medial side in the middle between the proximal and the distal part of the astragalus. This makes it impossible to measure the Dm accurately. In the astragalus of the camel, also, the Dm and the Bd are impossible to measure precisely. Since the axis of the astragalus of Sus is slightly twisted, one takes only the two length measurements.

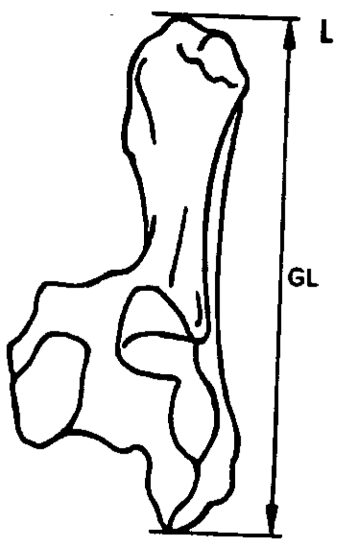


Figure 42a:
Equus calcaneus,
dorsal view.

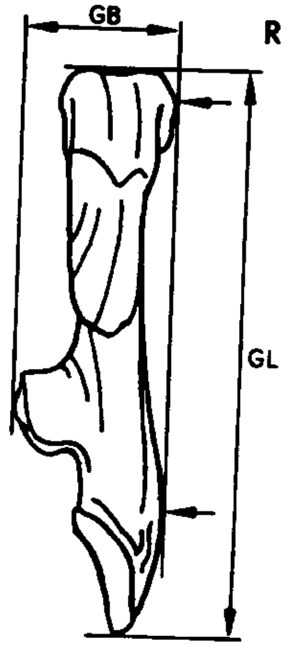


Figure 42b:
Cervus calcaneus,
plantar view.

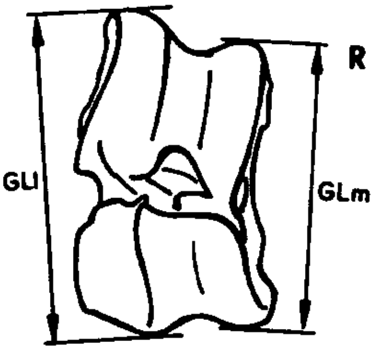


Figure 41f:
Sus astragalus,
dorsal view.

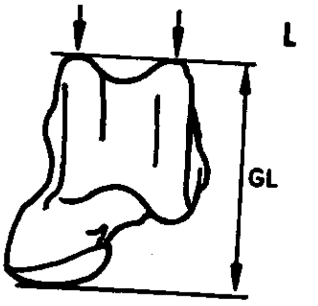


Figure 41g:
Canis astragalus,
dorsal view.

Astragalus (=talus) (carnivores and lagomorphs) (Fig. 41g)

GL - Greatest length (+)

Calcaneus (Fig. 42a,b)

GL - Greatest length (+)
GB - Greatest breadth. Measured in a measuring box or with a slide gauge with broad callipers

Other tarsal bones (Fig. 43a-c)

GB - Greatest breadth. Measured in a measuring box or with a slide gauge with broad callipers (+)

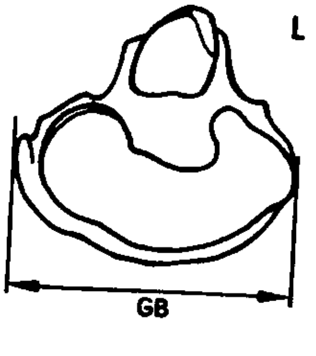


Figure 43a:
Equus
Os tarsale 3

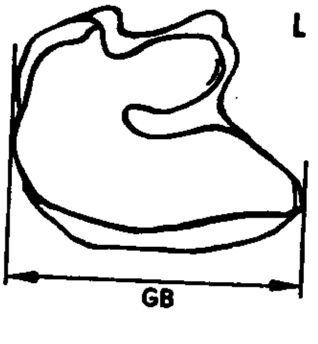


Figure 43b:
Equus
Os tarsi centrale

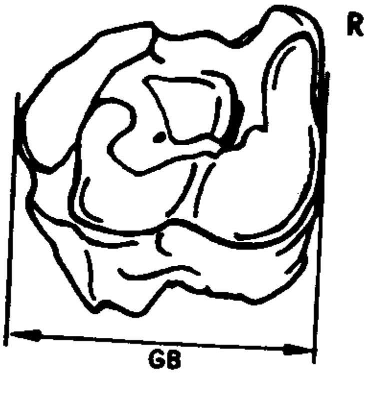


Figure 43c:
Bos
Os centrotarsale

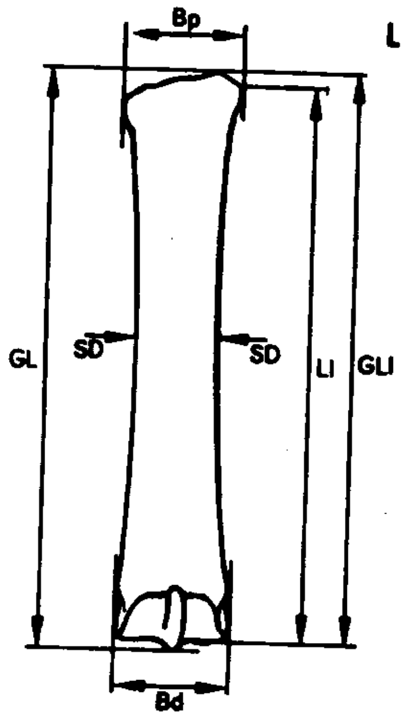


Figure 44a: Equus
Metacarpus III,
dorsal view.

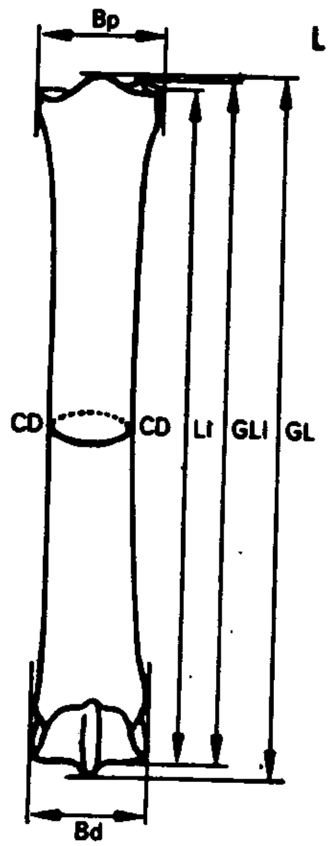


Figure 44b: Equus
Metatarsus III

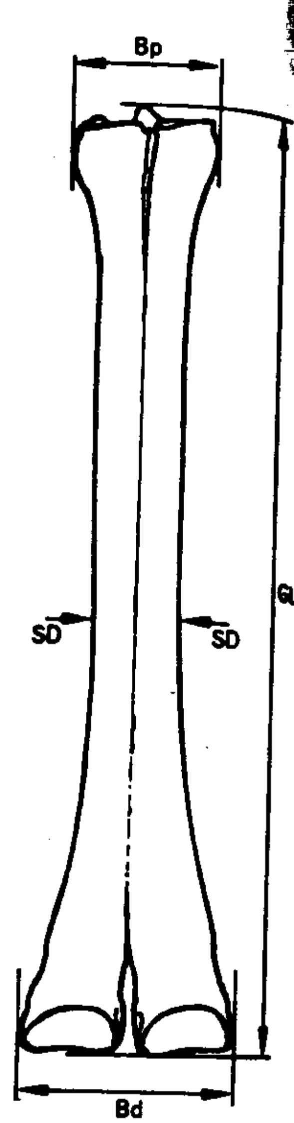


Figure 44c: Camelus
Metatarsus III+IV,
dorsal view.

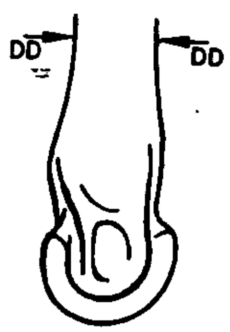


Figure 44d: Capra
Metatarsus III+IV,
side view.

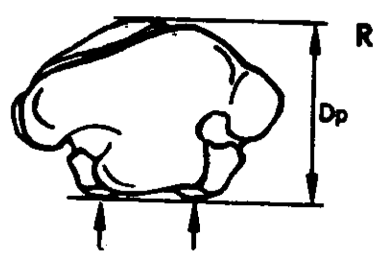


Figure 44e: Equus
Metacarpus III,
proximal view.

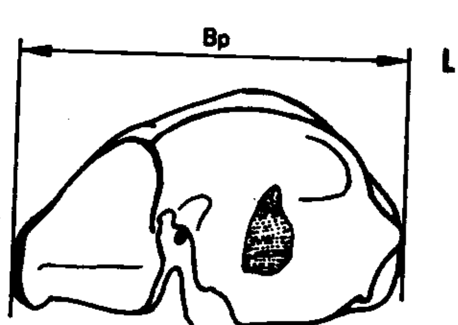


Figure 44f: Bos
Metacarpus III+IV,
proximal view.

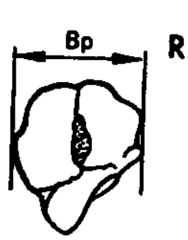


Figure 44g:
Ovis
Metatarsus
III+IV,
proximal view.

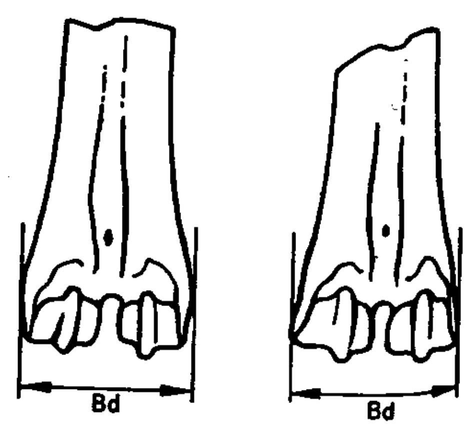


Figure 44h: Bos
Metatarsi III+IV,
dorsal view.

METAPODIALS (Fig. 44a-o)

Equids and ruminants (Fig. 44a-i)

GL - Greatest length (+)
GL1 - Greatest length of the lateral part. Only in Equus. (+)
Ll - Lateral length on the outer side (following Kiesewalter 1888, only in horses)
Bp - (Greatest) breadth of the proximal end. The metatarsus in Bos is measured in such a way that the plantar border of the proximal articular surface lies parallel to the scale of the measuring instrument (Fig. 44i, below) (+)
Dp - Tp (German) - (Greatest) depth of the proximal end. Usually only in equids where it is easy to measure only in the metacarpus.
SD - KD (German) - Smallest breadth of the diaphysis (+)
CD - UD (German) - (Smallest) circumference of the diaphysis (see note to CD under "Radius and Ulna") (+)
DD - TD (German) - (Smallest) depth of the diaphysis
Bd - (Greatest) breadth of the distal end (+)
Dd - Td (German) - (Greatest) depth of the distal end. Usually only in equids (+)

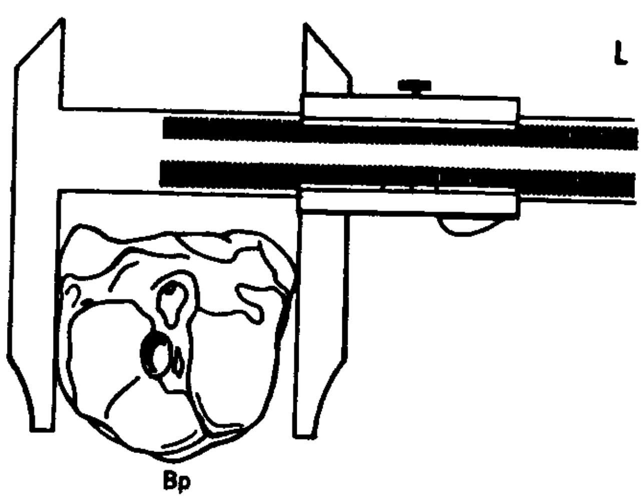


Figure 44i: Bos metatarsus III+IV, proximal view.

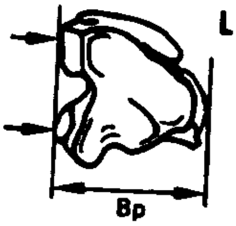


Figure 44j:
Sus
Metacarpus III,
proximal view.

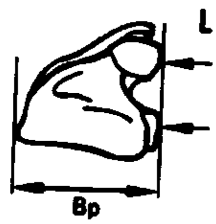


Figure 44k:
Sus
Metacarpus IV,
proximal view.

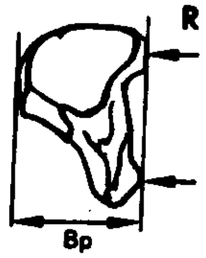


Figure 44l:
Sus
Metatarsus III,
proximal view.

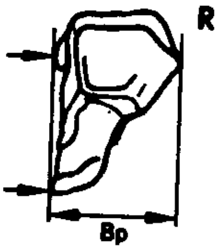


Figure 44m:
Sus
Metatarsus IV,
proximal view.

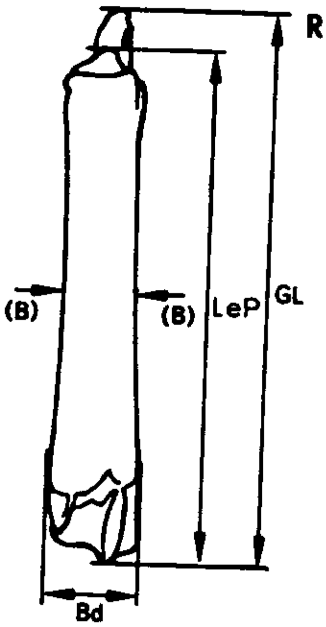


Figure 44n:
Sus
Metatarsus IV,
dorsal view.

<u>Sus</u> *(Fig. 44j-n)*

Note: For the second and fifth metapodial bones one measures only the GL
GL - Greatest length (-)
LeP - LoP (German) - Length excepting thè plantar projection (+)
Bp - (Greatest) breadth of the proximal end. The fixed points for one of the callipers are the two small articular facets on the inner or axial border of the proximal end (-)
B - Breadth in the middle of the diaphysis (-)
Note: Bp and B are unusual measurements. Many research workers do not take them.
Bd - (Greatest) breadth of the distal end (+)

Carnivores and lagomorphs (Fig. 44o)

GL - Greatest length (+)
Bd - (Greatest) breadth of the distal end (+)

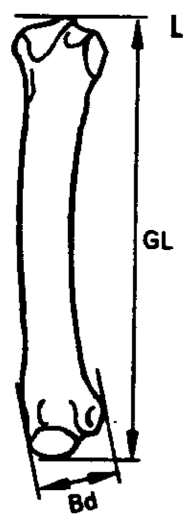


Figure 44o:
<u>Canis</u> Metacarpus V,
dorsal view.

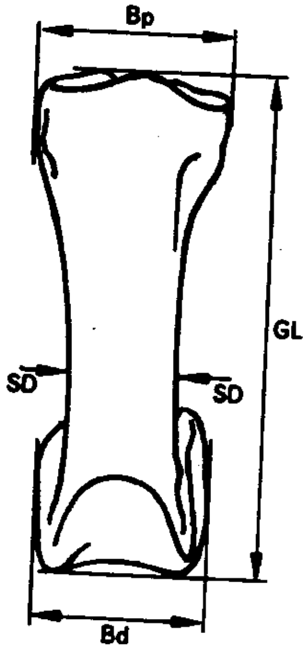


Figure 45c: *Camelus* Phalanx 1, dorsal view.

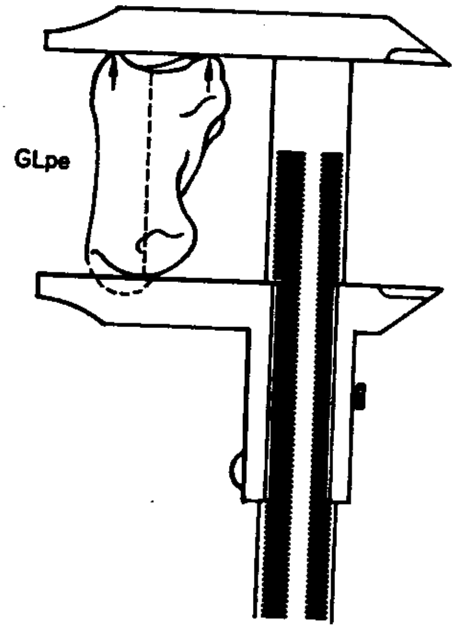


Figure 45d: *Bos* phalanx 1, anterior, peripheral view.

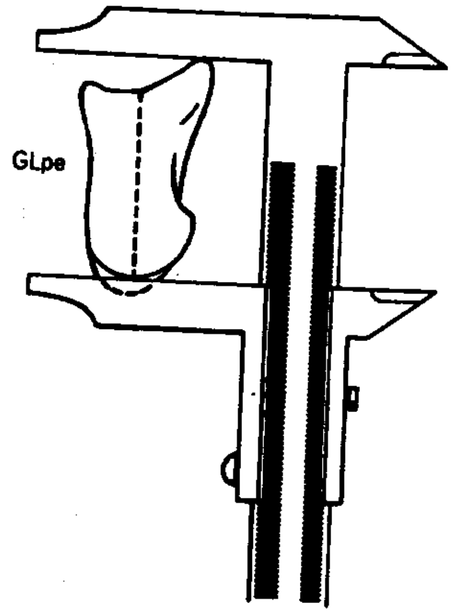


Figure 45e: *Bos* phalanx 1, posterior, peripheral view.

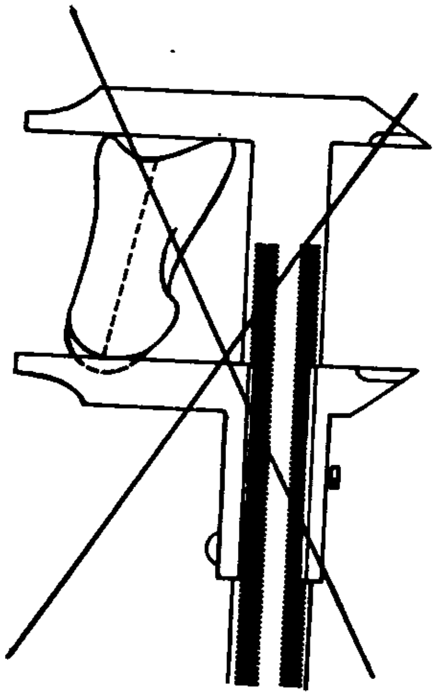


Figure 45f: *Bos* phalanx 1, posterior, peripheral view.

PHALANX I (Fig. 45a-f)

Equids (Fig. 45a,b)

GL - Greatest length (measuring box!) (+)
Bp - (Greatest) breadth of the proximal end (+)
BFp - (Greatest) breadth of the Facies articularis proximalis (proximal articular surface) (+)
Dp - Tp (German) - Depth of the proximal end (+)
SD - KD (German) - Smallest breadth of the diaphysis (+)
Bd - (Greatest) breadth of the distal end (+)
BFd - (Greatest) breadth of the Facies articularis distalis (+)

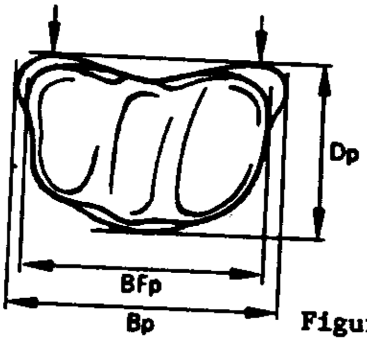


Figure 45a: Equus
Phalanx 1, proximal view.

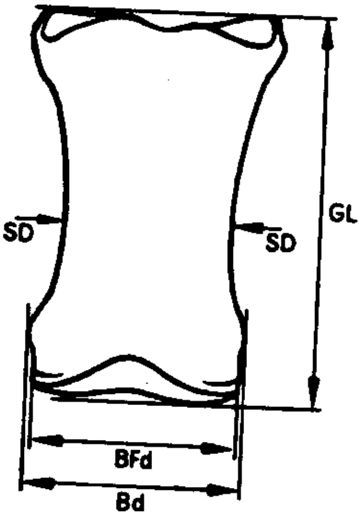


Figure 45b: Equus
Phalanx 1,
dorsal view.

Camel (Fig. 45c), carnivores, and lagomorphs

GL - Greatest length (+)
Bp - (Greatest) breadth of the proximal end (+)
SD - KD (German) - Smallest breadth of the diaphysis (+)
Bd - (Greatest) breadth of the distal end (+)

Bovids and Sus (Fig. 45d-f)

GLpe - Greatest length of the peripheral (abaxial) half. Most of the anterior first phalanges of Bos are formed in such a manner that the proximodorsal and the proximovolar prominent parts of the peripheral section of the proximal articular surface can serve as fixed points for one of the callipers. If one were to measure the posterior phalanges in the same way, many of them would be oriented obliquely in the measuring instrument. One has to hold these bones in such a way that the (imagined) longitudinal axis of the bone lies parallel to the measuring scale (Fig. 45e, not Fig. 45f) (-)
Bp - (Greatest) breadth of the proximal end (+)
SD - KD (German) - Smallest breadth of the diaphysis (-)
Bd - (Greatest) breadth of the distal end (+)

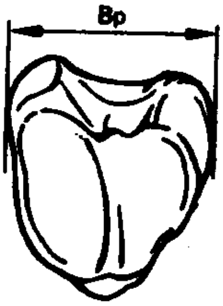


Figure 46c: Bos
Phalanx 2,
proximal view.

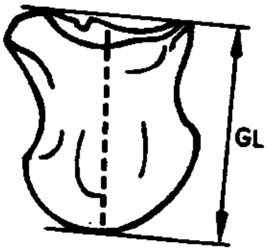


Figure 46d: Bos
Phalanx 2,
peripheral view.

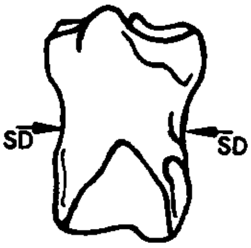


Figure 46e: Bos
Phalanx 2,
dorsal view.

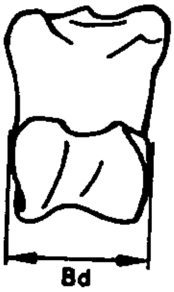


Figure 46f: Bos
Phalanx 2,
volar/plantar view.

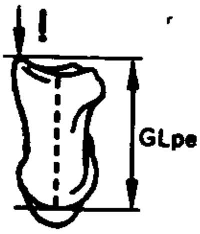


Figure 46g: Capra
Phalanx 2,
peripheral view.

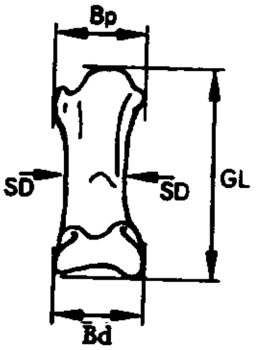


Figure 46h: Canis
Phalanx 2,
dorsal view.

PHALANX 2 (Fig. 46a-h)

Equids (Fig. 46a,b)

GL - Greatest length (measuring box!) (+)
Bp - (Greatest) breadth of the proximal end (+)
BFp - (Greatest) breadth of the Facies articularis proximalis (proximal articular surface) (+)
Dp - Tp (German) - Depth of the proximal end (+)
SD - KD (German) - Smallest breadth of the diaphysis (+)
Bd - (Greatest) breadth of the distal end (+)

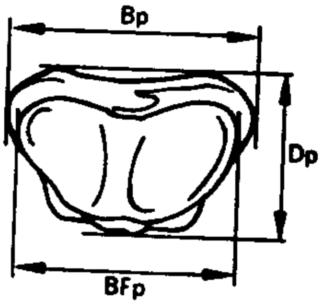


Figure 46a: Equus Phalanx 2, proximal view.

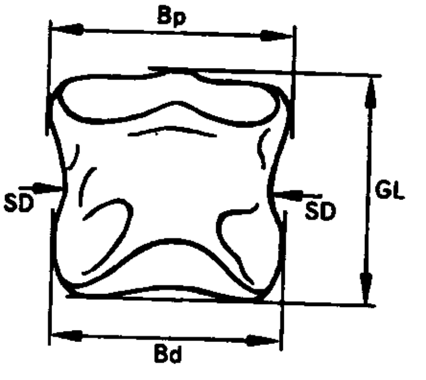


Figure 46b: Equus Phalanx 2, dorsal view.

Other species (Fig. 46c-h)

GL - Greatest length. In ruminants = greatest length of the peripheral (abaxial) half. As in Phalanx 1, the (imagined) longitudinal axis of the bone has to lie parallel to the scale of the measuring instrument
Bp - (Greatest) breadth of the proximal end (+)
SD - KD (German) - Smallest breadth of the diaphysis (-)
Bd - (Greatest) breadth of the distal end (+)

NAVICULAR (DISTAL SESAMOID BONE) OF EQUIDS (Fig. 47)

GB - Greatest breadth (+)

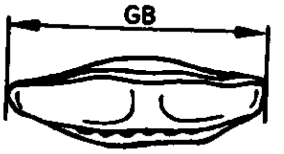


Figure 47: Equus distal sesamoid

PHALANX 3 (Fig. 48a-d)

Equids (Fig. 48a,b)

GL - Greatest length (+)
GB - Greatest breadth (+)
LF - Length of the Facies articularis (articular surface) (-)
BF - Breadth of the Facies articularis (-)
Ld - Length of the dorsal surface (+)
HP - Height in the region of the extensor process (measuring box!) (+)

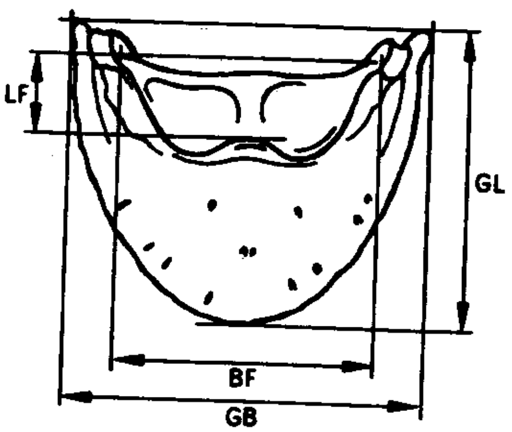


Figure 48a: Equus
Phalanx 3,
dorsoproximal view.

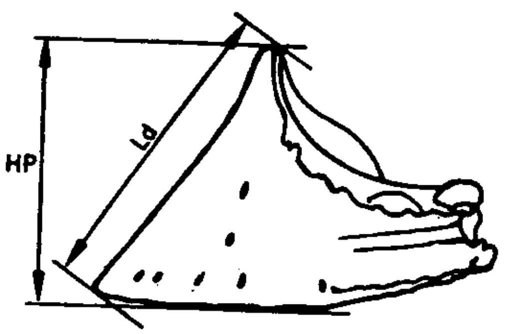


Figure 48b: Equus
Phalanx 3,
side view.

Ruminants and Sus (Fig. 48c,d)

DLS - (Greatest) diagonal length of the sole (+)
Ld - Length of the dorsal surface (+)
MBS - Middle breadth of the sole = breadth in the middle of the sole (+)

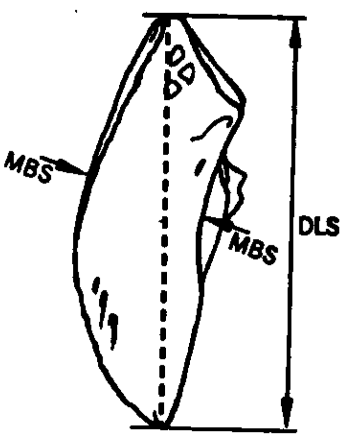


Figure 48c: Bos
Phalanx 3,
view of sole.

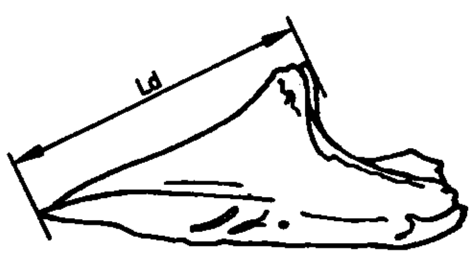


Figure 48d: Bos
Phalanx 3,
peripheral view.

PART THREE

MEASUREMENT OF THE BIRD SKELETON

GENERAL

The measurement of bird bones from site refuse is only beginning to be carried out. It is just as necessary for distinguishing the species and for the documentation of size and variation as is the measurement of mammal bones and should be dealt with in the same way.

The primary sources for the following guide to the measurement of bird bones are five comparative morphological investigations carried out on the bones of recent birds: Bacher 1967, Woelfle 1967, Erbersdobler 1968, Kraft 1972, and Fick 1974. These studies have been undertaken in the Institute of Palaeoanatomy at the University of Munich under the guidance of J. Boessneck. In the first three papers only measurements for bones of the postcranial skeleton are defined and explained with diagrams. The last two papers deal also with the skull. It is obvious that for special investigations more measurements may become necessary (e.g., Ballmann 1966, pp. 35 ff.)

Reference to these five studies will show that they do not utilize a standard nomenclature. The reason for this is the nonuniformity of the nomenclature in the previously published literature. Nevertheless each of the five authors tried to be consistent in his own work, explaining all terminology additionally by diagrams, so that each of the works, considered separately, is clear and comprehensible. Misunderstandings may arise only when one work is compared with another. This state of affairs demonstrates how very necessary it is to standardize nomenclature in the osteology of birds.

Apart from the general nonuniformity in the nomenclature, special complications arise in the designation of measurements for bird bones. The bones of the wings, whether adjacent to the body or extended, have different positions in relation to the body than do the bones of the forelimbs of mammals (Fig. 3). This situation leads, if one refers to the (whole) skeleton, to different definitions for the directions (see Kraft 1972). For the sake of standardization, however, one should use for birds the same scheme as for mammals. One should not follow the change in the definitions of *breadth* and *depth* proposed by Kraft (1972).

The following measurements represent only a selection. The selection was chosen primarily with an eye to being able to compare measurements with those from bird bones found in the literature. Only data for prehistoric and early historic bird bones from alluvial times have been taken into consideration (e.g., Schweizer 1961, Dräger 1964, Schülke 1965, Müller 1967, Sauer-Neubert 1969, Hornberger 1970, Kühnhold 1971, Küpper 1972). Furthermore, an effort was made to choose measurements which can be taken in the same way for the bones of all bird species living in Europe. Since the bones of the different bird species, and especially the skulls, differ considerably in shape, the selection of dimensions which can be measured in the same way is limited. Each research worker must decide for himself whether he wants to add other dimensions which he then must define exactly and, if need be, explain by diagrams.

The following compilation is based primarily on experience gained while dealing with the bones of the domestic hen (the most frequently encountered avian remains of pre- and early historic sites) as well as from the bones of geese and ducks. The instructions are therefore applicable mainly to the bones of these birds. Much rarer than the bones of hens, geese, and ducks are the bones of pigeons and crows. Only in exceptional cases do the bones of any other bird families occur more frequently than these five in site refuse.

SKULL

CRANIUM (Fig. 49a-e)

GL - Greatest length: Protuberantia occipitalis externa - Apex praemaxillaris (+)

CBL - Condylobasal length: aboral border of the occipital condyle - Apex praemaxillaris (+)

GB - Greatest breadth, wherever it is to be found, usually across the Processus postfrontales (+)

GBP - Greatest breadth across the Processus postfrontales (+)

SBO - KBO (German) - Smallest breadth between the orbits on the dorsal side = smallest breadth of the Pars nasalis of the Frontale (+)

GH - Greatest height in the median plane: from the Basitemporale in the median plane to the highest and median point of the braincase. One calliper lies on the nasal or ventral point of the Basitemporale (-)

In most species, the following measurements can also be taken:

LP - Length from the Protuberantia occipitalis externa to the most aboral points of the Processus frontales of the Incisivum in the median plane

LI - (Greatest) length of the Incisivum: Apex praemaxillaris - most aboral points of the Processus frontales of the Incisivum in the median plane

Parts of and points on the cranium (Fig. 49):

1 = Protuberantia occipitalis externa
2 = Apex praemaxillaris
3 = Processus postfrontalis
4 = Pars nasalis of the frontal bone
5 = Processus frontalis of the praemaxilla
6 = Basitemporale (= Basisphenoid)
7 = Linea nuchalis superior
8 = Condylus occipitalis

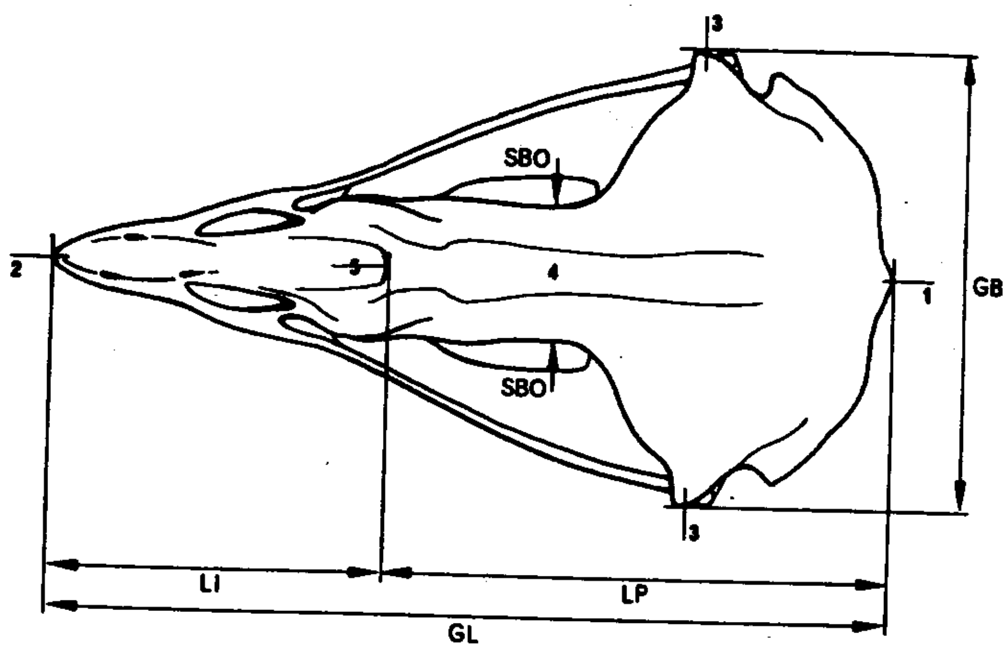


Figure 49a: Cranium of <u>Aquila</u>, dorsal view.

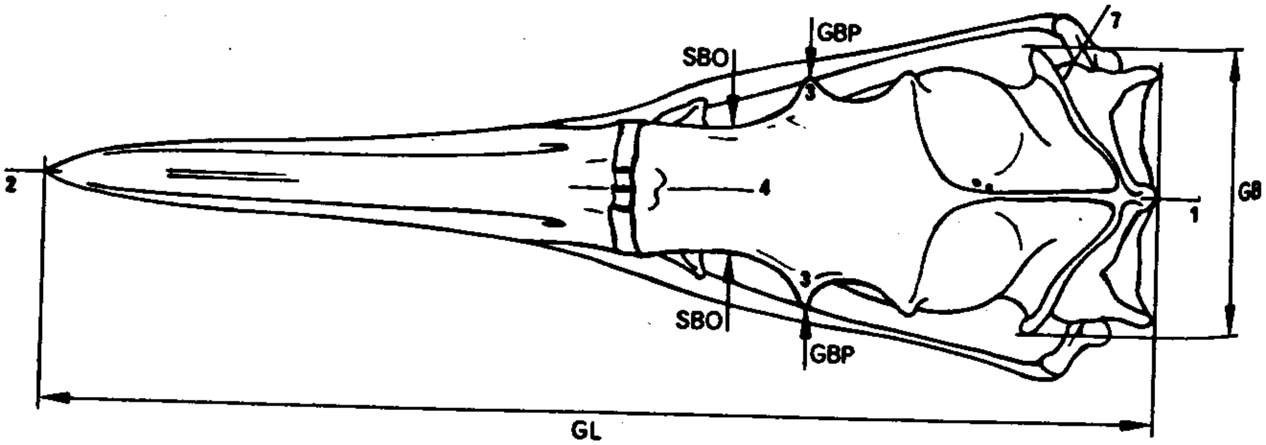


Figure 49b: Cranium of <u>Phalacrocorax</u>, dorsal view.

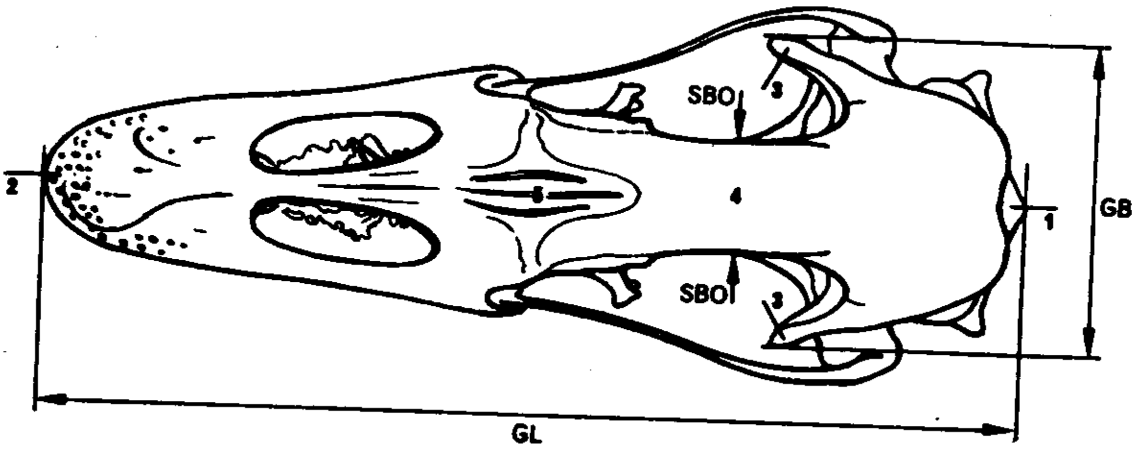


Figure 49c: Cranium of Anser, dorsal view.

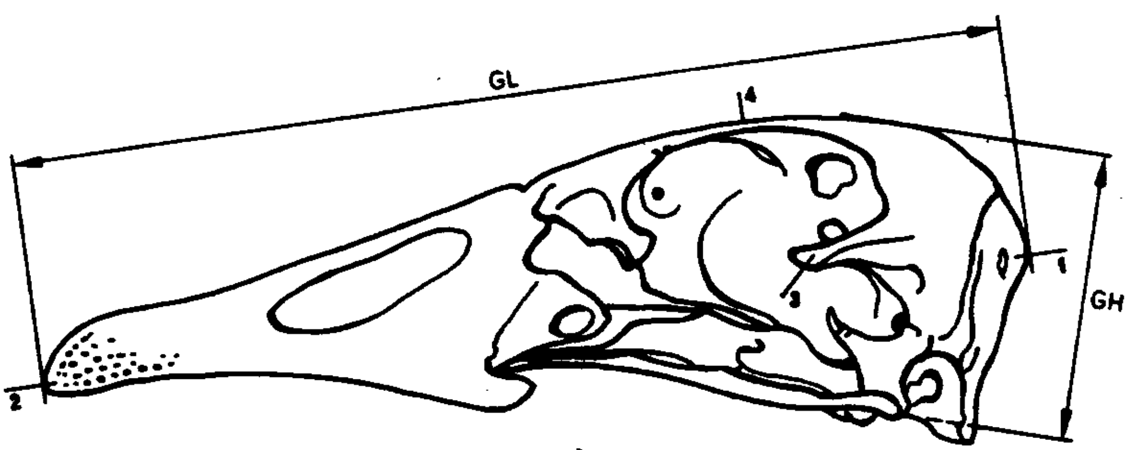


Figure 49d: Cranium of Anser, left side view.

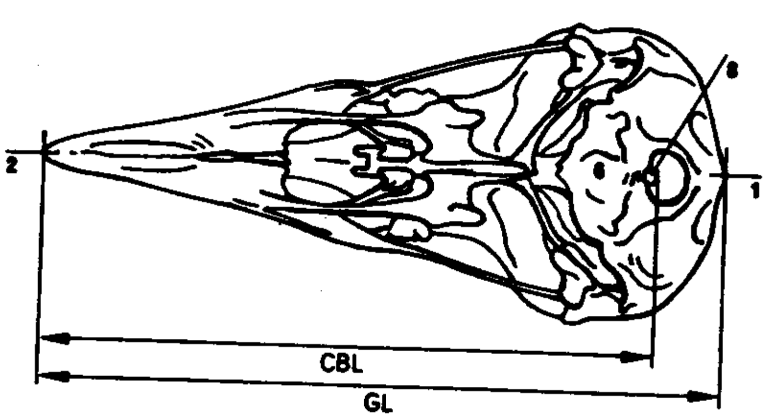


Figure 49e: Cranium of Gallus, basal view.

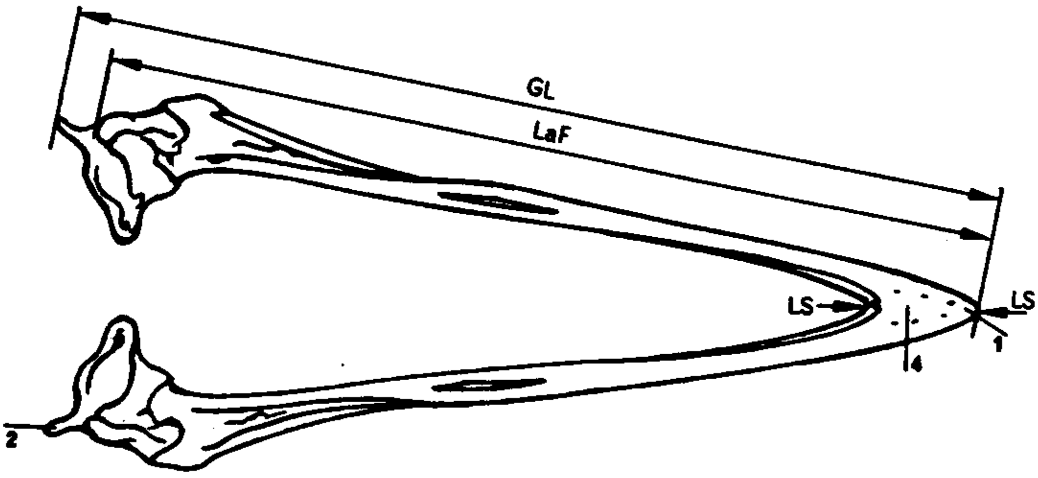


Figure 50a: Mandible of Otis, dorsal view.

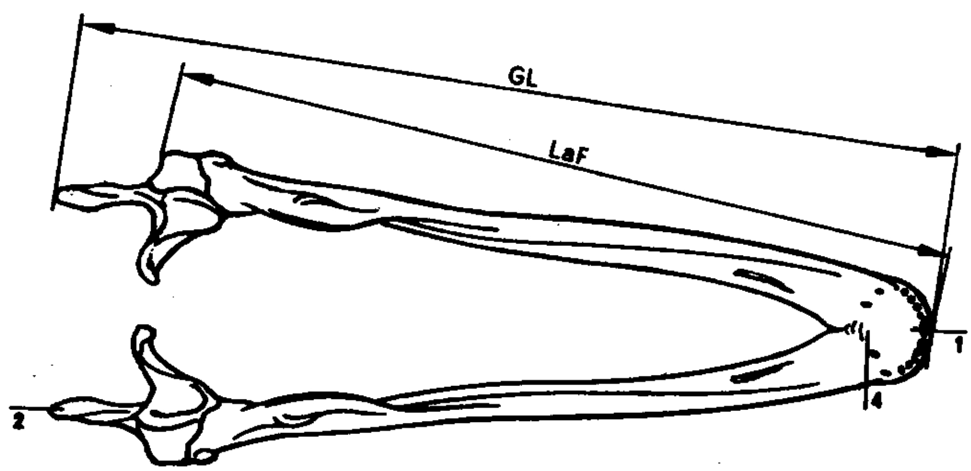


Figure 50b: Mandible of Anser, dorsal view.

MANDIBLE (Fig. 50a-c)

GL - Greatest length of one-half of the mandible: Apex to the most aboral point of the mandible (+)

LaF - Length from the most aboral point of the Facies articularis (= articular surface) on one side to the Apex

In those species in which the inner border of the Symphysis forms a wide open angle, one can measure the

LS - Length of the Symphysis

Parts of and points on the mandible (Fig. 50):

1 = Apex
2 = Processus aboralis
3 = Processus lateralis
4 = Symphysis mandibulae

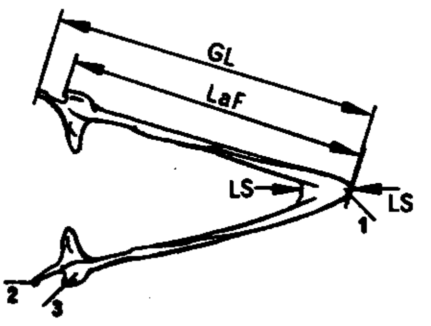


Figure 50c: Mandible of Alectoris, dorsal view.

Parts of and points on the sternum (Fig. 51):

1 = Manubrium sterni
2 = Labium ventrale s. externum
3 = Labium dorsale s. internum
4 = Crista sterni s. Carina
5 = Apex cristae sterni
6 = Metasternum
7 = Facets of the costosternal articles

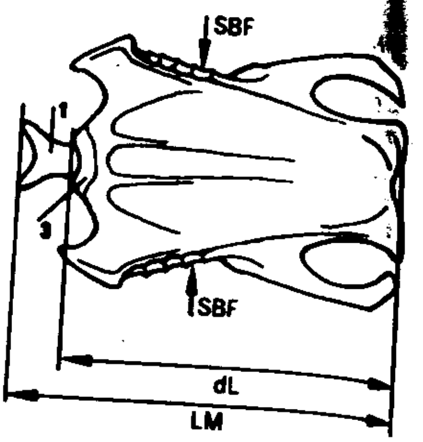


Figure 51a: Sternum of *Corvus*, dorsal view.

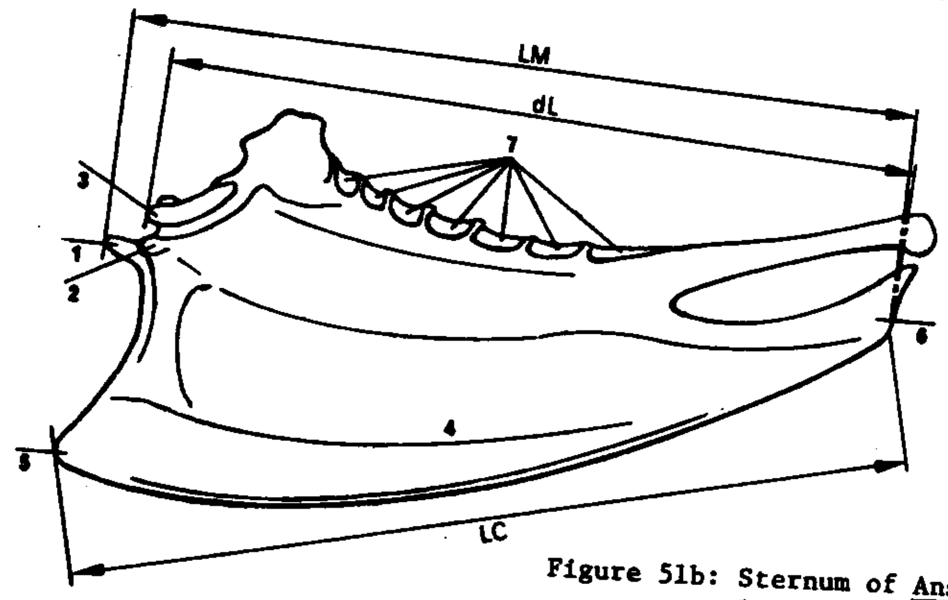


Figure 51b: Sternum of *Anser*, lateral view.

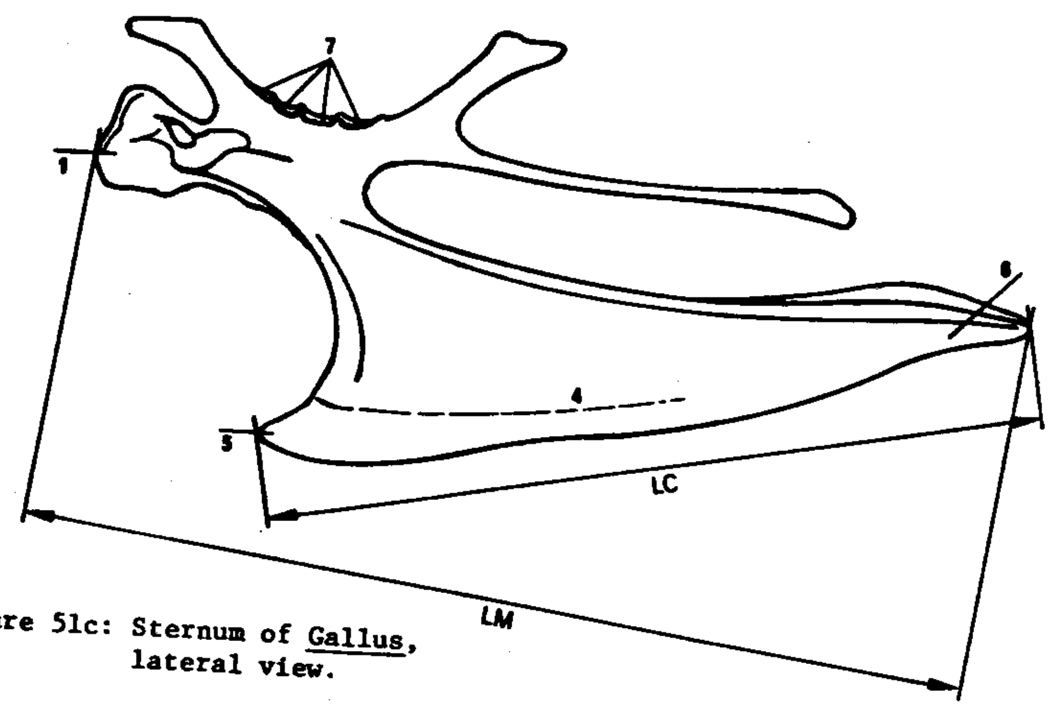


Figure 51c: Sternum of *Gallus*, lateral view.

STERNUM (Fig. 51a-d)

LM - Length from the Manubrium sterni: from the cranial point of the Manubrium sterni (or the median point of the line joining the cranial points of the Manubrium sterni) to the caudal border (or point) of the Metasternum in the median plane (+)

dL - Dorsal length: from the cranial point of the Labium dorsale or internum (or the median point of the line joining the cranial points of the labia) to the caudal border (or point) of the Metasternum in the median plane

Note: In some species (e.g., Galliformes and Anseriformes) the LM is almost the same as the dL

LC - Length of the Crista sterni: from the Apex cristae sterni to the caudal border (or point) of the Metasternum in the median plane (+). In some species the Crista sterni disappears before reaching the caudal border of the Metasternum. Nevertheless one has to measure to the Metasternum, because no fixed points exist at the caudal end of the Crista sterni.

SBF - KBF (German) - Smallest breadth between the facets for the costosternal articulations, measured at the narrowest part (+)

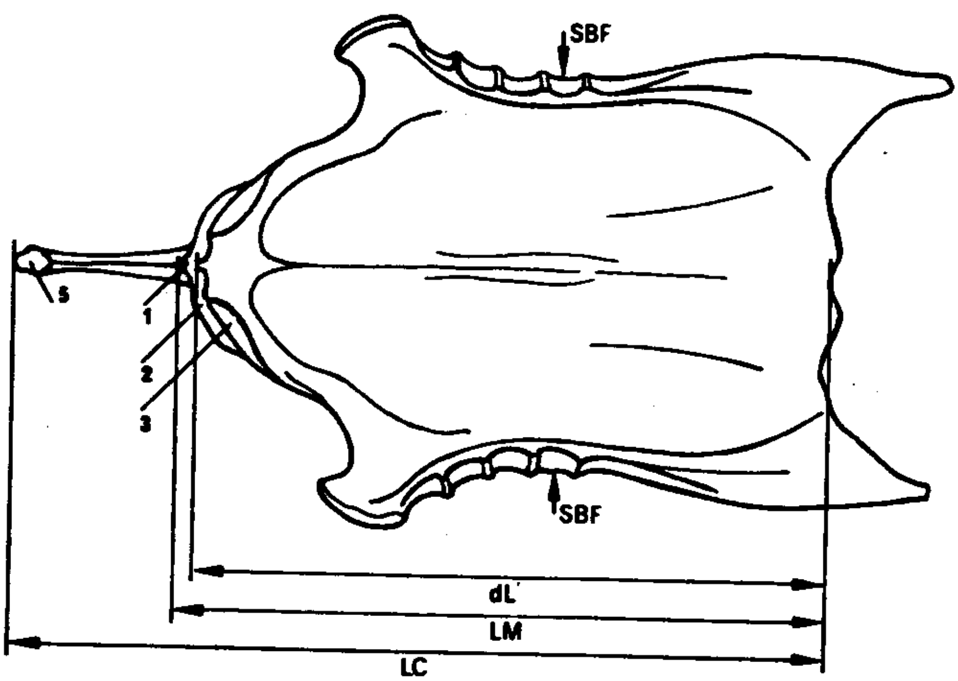


Figure 51d: Sternum of Phalacrocorax, dorsal view.

1 = Processus lateralis

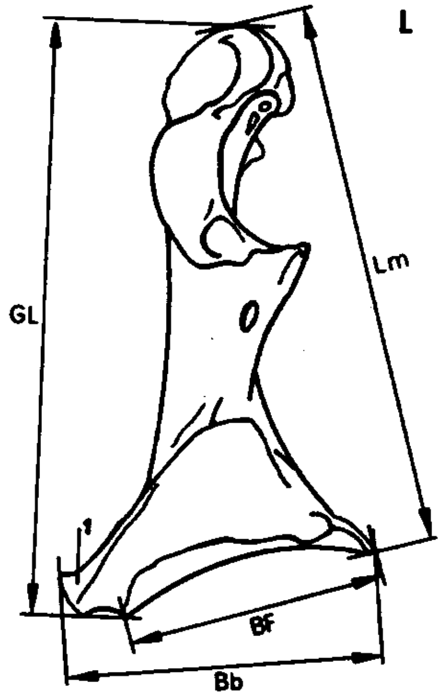


Figure 52a: Coracoid of <u>Aquila</u>, caudal view.

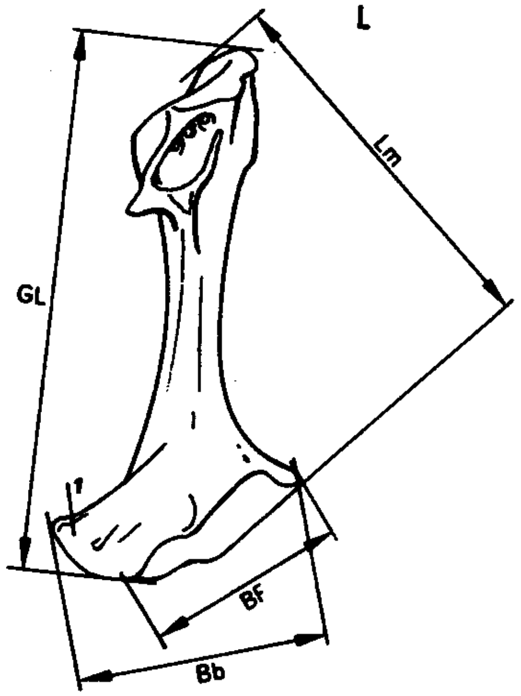


Figure 52b: Coracoid of <u>Sula</u>, caudal view.

CORACOID (Fig. 52a-d)

GL - Greatest (diagonal) length (+). Measured generally to the distal point of the basal articular surface, exceptionally to the distal point of the Processus lateralis (e.g., in eagles and ganets).
Lm - medial length (+)
Bb - (Greatest) basal breadth (+)*
BF - Breadth of the Facies articularis basalis (= basal articular surface) (+)**
Note: In the Apodidae, Bb = BF.

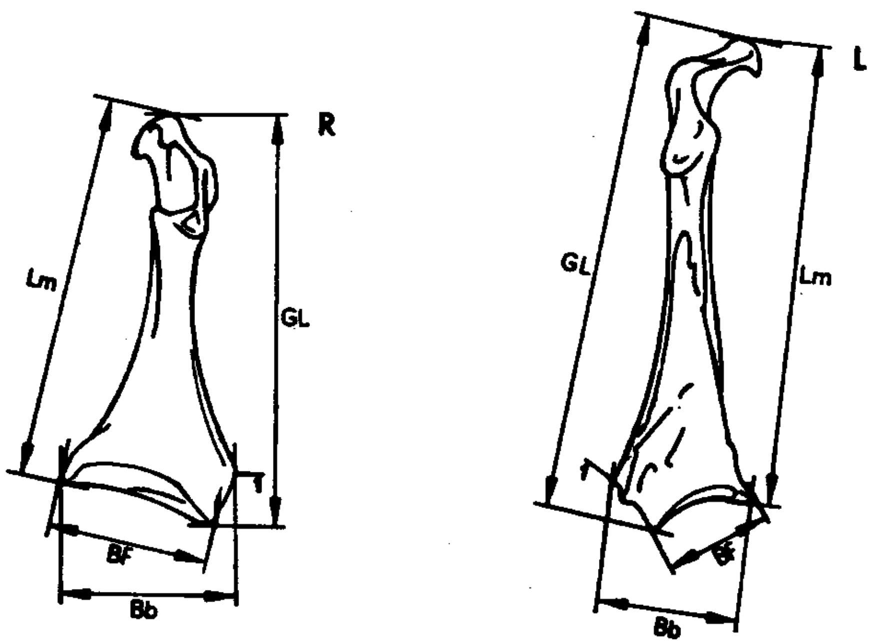


Figure 52c: Coracoid of <u>Anas</u>, caudal view.

Figure 52d: Coracoid of <u>Gallus</u>, caudal view.

*Bacher (1967, p. 11) and Erbersdobler (1968, p. 10) designate this measurement as DD - Durchmesser distal (=distal diameter).

**This measurement is designated by the same two authors as BB - basale Breite (=basal breadth). These designations have been adopted by some other authors, a fact which must be taken into account when making comparisons with the literature.

SCAPULA (Fig. 53a-c)

GL - Greatest length (+)
Dic - Dc (German) - (Greatest) cranial diagonal (-)*

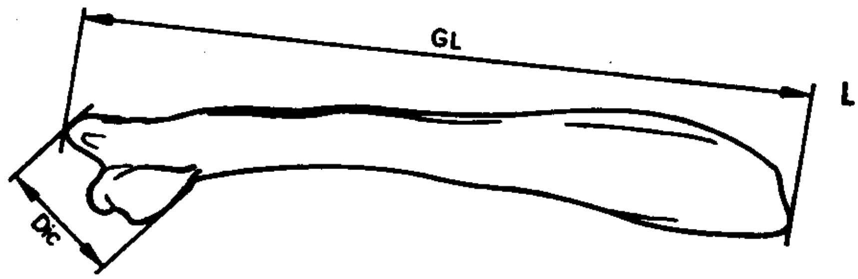


Figure 53a: Scapula of Otis, dorsolateral view.

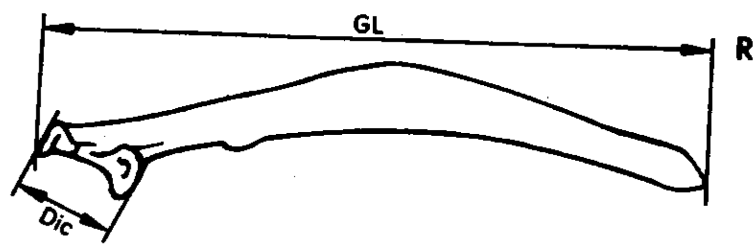


Figure 53b: Scapula of Gallus, ventromedial view.

Figure 53c: Scapula of Corvus, cranial view.

*Erbersdobler (1968, p. 11) designates this measurement as BC - Breite cranial (=cranial breadth).

Parts of and points on the humerus (Fig. 54):

1 = Tuberculum mediale s. ventrale
2 = Tuberculum laterale s. dorsale
3 = Processus supracondylicus radialis
4 = Crista lateralis

HUMERUS (Fig. 54a-d)

GL - Greatest length (+)
Bp - Breadth of the proximal end from the Tuberculum laterale or dorsale to the Tuberculum mediale or ventrale, without the Crista lateralis. One measures the greatest distance although this measurement is not at right angles to the longitudinal axis of the bone (-)

Note: At the proximal end of the humerus of the pigeon Fick (1974, p. 21) measures only the Dip - proximal diagonal. Also in small birds one can measure only the Dip - i.e., the proximal breadth including the Crista lateralis.

SC - KC (German) - Smallest breadth of the corpus (+)*
Bd - (Greatest) breadth of the distal end. Measured without the Processus supracondylicus radialis, which one can find in some species (Procellariiformes, Charadriiformes, Passeriformes) at the distal end of the corpus. This measurement is best taken from the distal aspect (+)

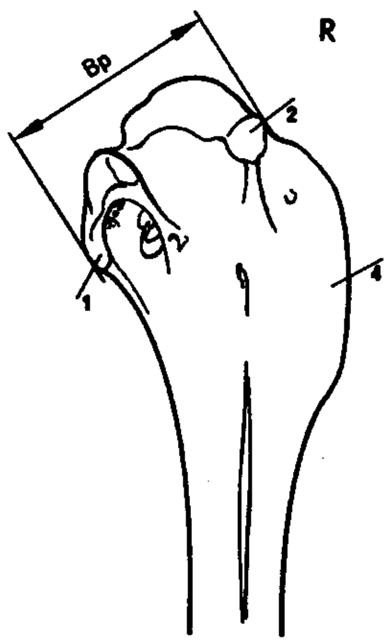


Figure 54d: Humerus of Otis, proximal end, medial or ventral view.

*Many authors designate this measurement as KS - Kleinste Breite des Schaftes (=Smallest breadth of the shaft).

Parts of and points on the ulna (Fig. 56):

1 = Olecranon
2 = Facies articularis medialis s. ventralis
3 = Facies articularis lateralis s. dorsalis

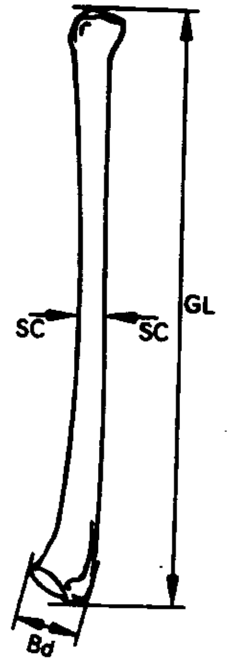


Figure 55: Radius of Gallus.

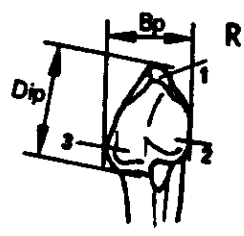


Figure 56a: Ulna of Gallus, proximal end.

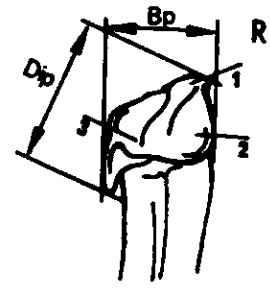


Figure 56b: Ulna of Phalacrocorax, proximal end.

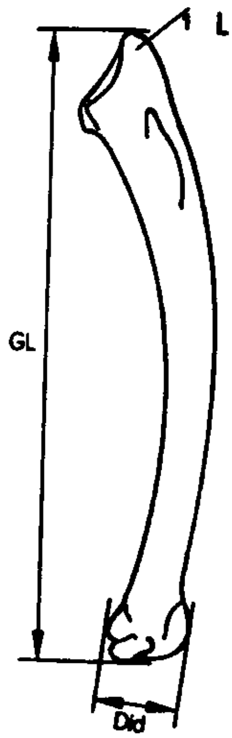


Figure 56c: Ulna of Gallus.

Figure 56d: Ulna of Gallus.

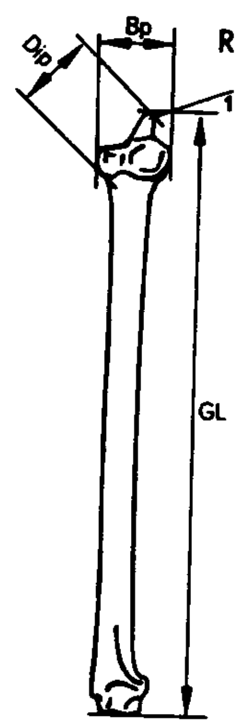


Figure 56e: Ulna of Corvus.

RADIUS (Fig. 55)

GL - Greatest length (+)
SC - KC (German) - Smallest breadth of the corpus (-)*
Bd - (Greatest) breadth of the distal end (+)

ULNA (Fig. 56a-e)

GL - Greatest length (+)
Dip - Dp (German) - (Greatest) diagonal of the proximal end from the caudal border of the Olecranon to the cranial border of the Facies articularis lateralis or dorsalis (-)**
Bp - (Greatest) breadth of the proximal end from the Facies articularis medialis or ventralis to the Facies articularis lateralis or dorsalis (-)**
SC - KC (German) - Smallest breadth of the corpus. This measurement is easy to take in ulnae of Galliformes because the corpus is compressed from both sides. One measures the narrowest part of the compression. This measurement cannot be taken exactly in birds where the corpus of the ulna is round. It therefore has to be either omitted or redefined as the case may be.***
Did - Dd (German) - (Greatest) diagonal of the distal end (+)

* See note to SC of the Humerus
** Important: Bacher (1967, Fig. 5) measures the Bp in the same way as is explained here, but measures the Dip in a completely different way.

Parts of and points on the carpometacarpus (Fig. 57):

1 = Os metacarpale I
2 = Os metacarpale II
3 = Os metacarpale III
4 = Processus distalis

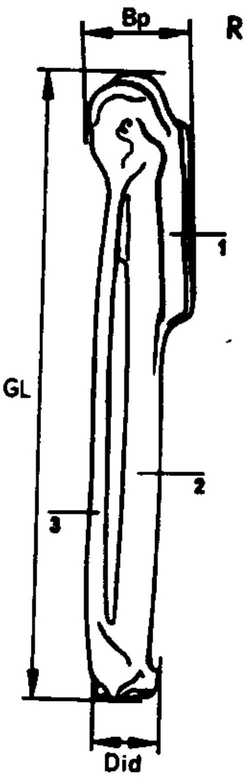


Figure 57a: Carpometacarpus of <u>Gavia</u>.

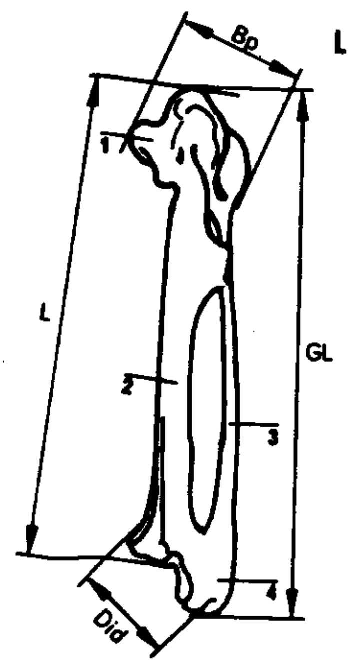


Figure 57b: Carpometacarpus of <u>Corvus</u>.

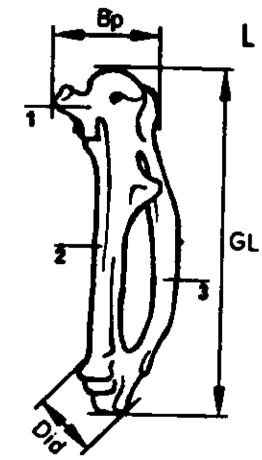


Figure 57c: Carpometacarpus of <u>Gallus</u>.

CARPOMETACARPUS (Fig. 57a-c)

GL - Greatest length (+)
L - Length of the metacarpus II, from articular surface to articular surface without the Processus distalis. Only measured in birds where a distinctly developed Processus distalis is to be found, e.g., in Passeriformes
Bp - (Greatest) breadth of the proximal extremity. One measures the greatest distance although this measurement is in some species more diagonal than at right angles to the longitudinal axis of the bone (+)
Did - Dd (German) - Diagonal of the distal end. One measures only the distal articular surface. This measurement lies at right angles to the longitudinal axis of the bone in birds which do not possess a Processus distalis. In birds which possess a Processus distalis this measurement is not taken at right angles to the longitudinal axis.

PHALANX 1 ANTERIOR OF THE 2ND DIGIT (Fig. 58)

GL - Greatest length (-)
L - Length from articular surface to articular surface (+)

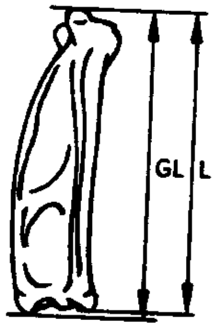


Figure 58:
Phalanx 1 anterior of Anser, digit II.

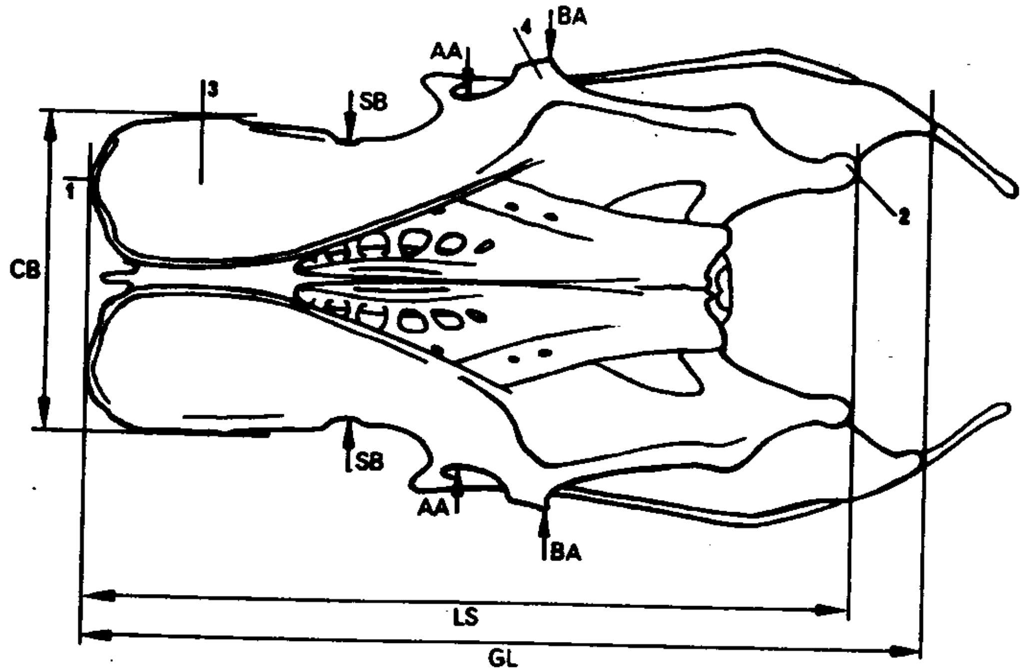


Figure 59a: Pelvis of Gallus, dorsal view.

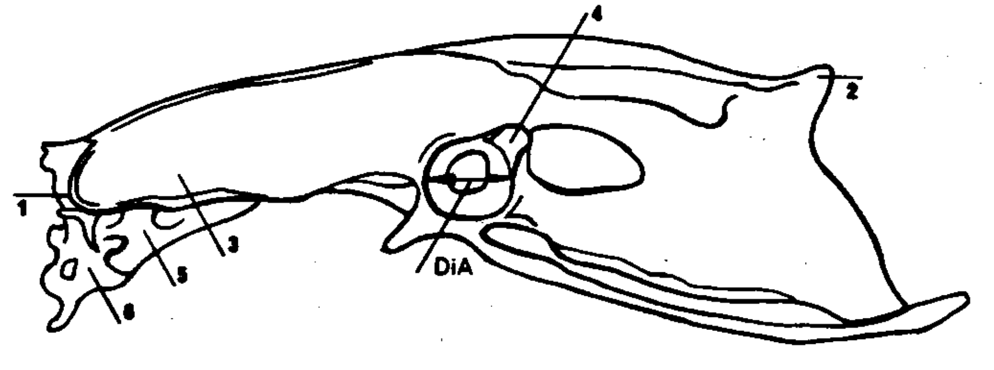


Figure 59b: Pelvis of Gallus, lateral view.

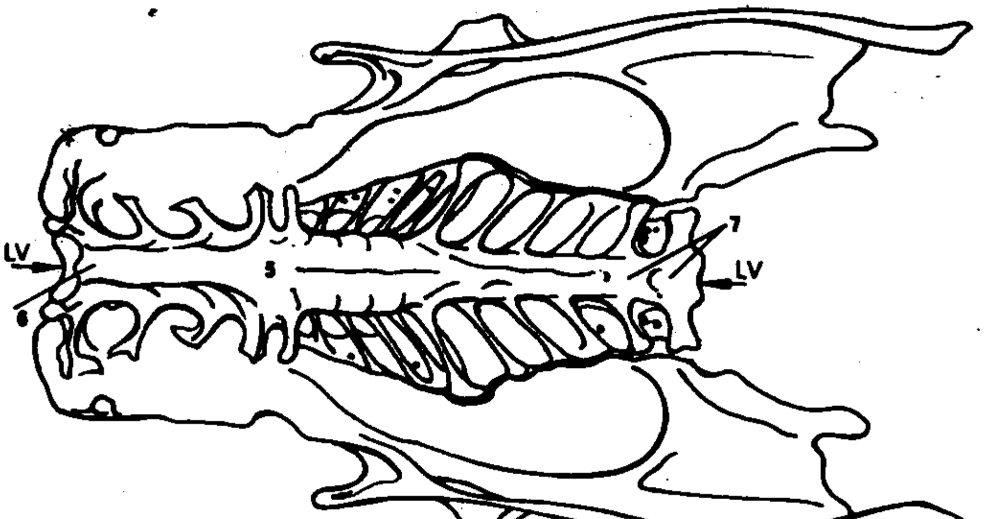


Figure 59c: Pelvis of Gallus, ventral view.

PELVIS (Fig. 59a-f)

GL - Greatest length (without pubis): cranial border of the ilia (= Margo iliocranialis) - most caudal points of the ischia
LS - Length from the cranial border of the ilia to the Spinae iliocaudales. Measured only in species which have distinctly developed Spinae iliocaudales.
Note: In some species, the LS = GL
LV - Length along the vertebrae, centrally = length of the Os lumbosacrale, from the most cranial (thoracic) vertebra fused with the Os lumbosacrale to the most caudal (coccygeal) vertebra fused with the Os lumbosacrale
CB - Cranial breadth = greatest breadth across the Partes glutaeae of the ilia (+)
SB - KB (German) - Smallest breadth of the Partes glutaeae (+)
AA - Breadth between the borders of the acetabula, measured at the narrowest part (+)
DiA - DA (German) - Diameter of one acetabulum: greatest distance including the Labium acetabuli (-)
BA - Breadth in the middle: breadth across the two antitrochanter (+)

Points on and parts of the pelvis (Fig. 59):

1 = Margo iliocranialis
2 = Spina iliocaudalis
3 = Pars glutaea
4 = Antitrochanter
5 = Os lumbosacrale
6 = Vertebra thoracosynsacralis
7 = Vertebrae caudales

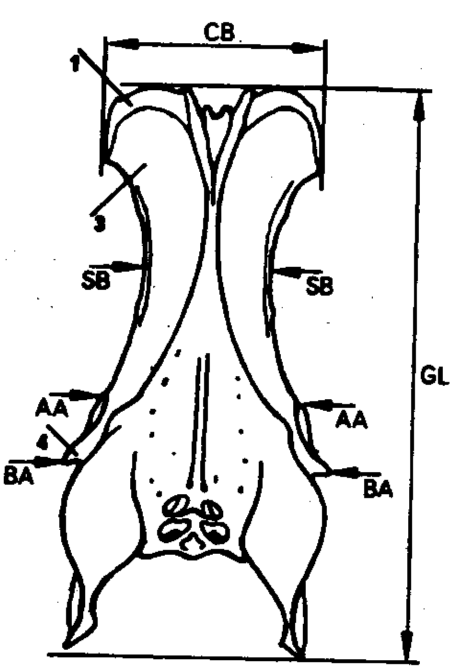


Figure 59d: Pelvis of Buteo, dorsal view.

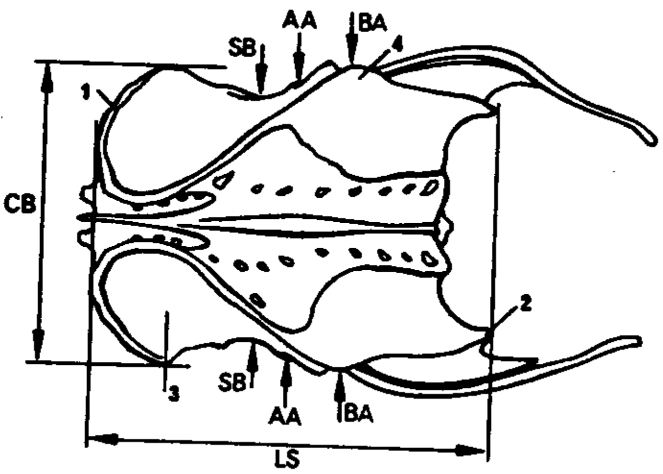
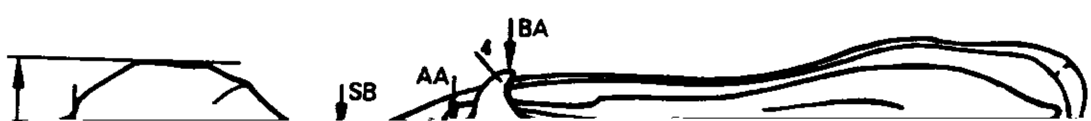


Figure 59e: Pelvis of Columba, dorsal view.



FEMUR (Fig. 60a-c)

GL - Greatest length (+)
Lm - medial length (+)
Bp - (Greatest) breadth of the proximal end: Caput femoris - most lateral point of the Trochanter major (-)*
Dp - Tp (German) - (Greatest) depth of the proximal end. The fixed points for one calliper of the measuring instrument are the cranial points on the Caput femoris and on the Trochanter major.*
SC - KC (German) - Smallest breadth of the corpus. Measured in the same plane as Bd (-)**
Bd - (Greatest) breadth of the distal end (+)
Dd - Td (German) - (Greatest) depth of the distal end. The fixed points for one calliper of the measuring instrument are the caudal points of the Condyli lateralis and medialis.

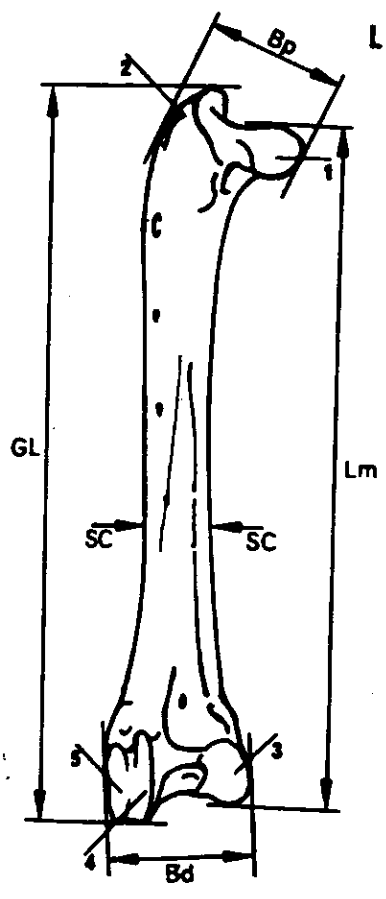


Figure 60a: Femur of Gallus, caudal view.

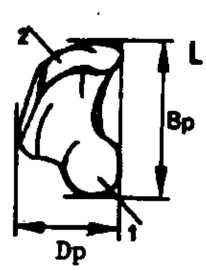


Figure 60b: Femur of Gallus, proximal view.

Points on and parts of the femur (Fig. 60):

1 = Caput femoris
2 = Trochanter major
3 = Condylus medialis
4 = Condylus lateralis
5 = Condylus fibularis

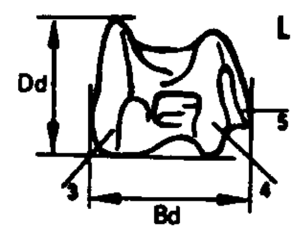


Figure 60c: Femur of Gallus, distal view.

*Erbersdobler (1968, Fig. 9) designates the Bp as Dp - Durchmesser proximal (=proximal diameter) and the Dp as Bp - Breite proximal (=proximal breadth). This point should be noted when comparing literature which is based on Erbersdobler's data.

**See note to SC of the Humerus.

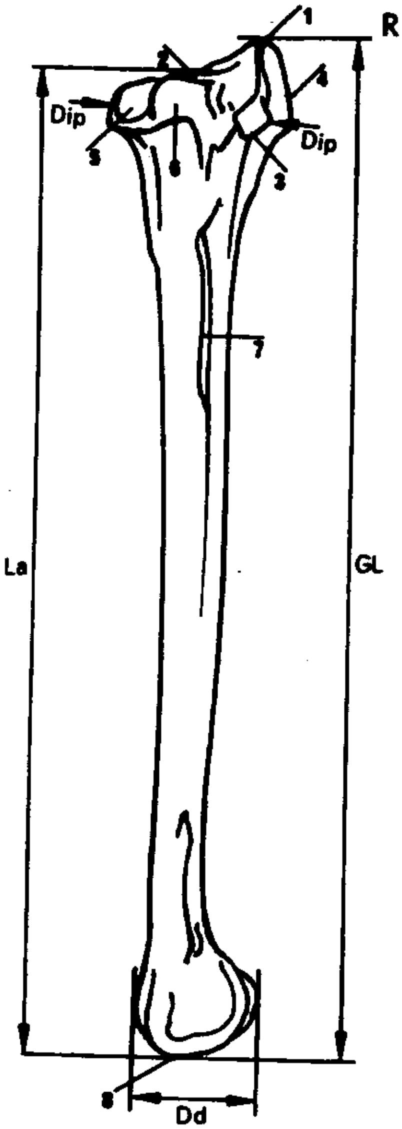


Figure 61a: Tibiotarsus of Gallus, lateral view.

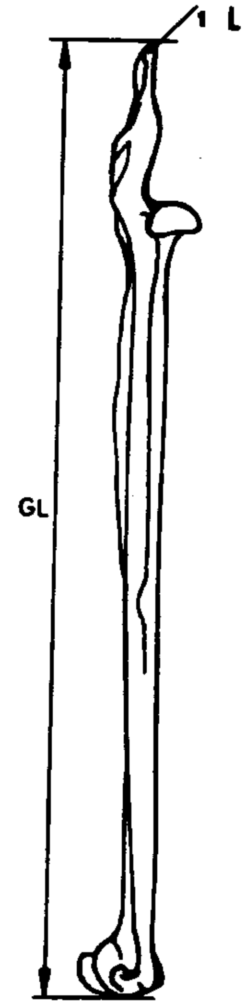


Figure 61b: Tibiotarsus of Podiceps, lateral view.

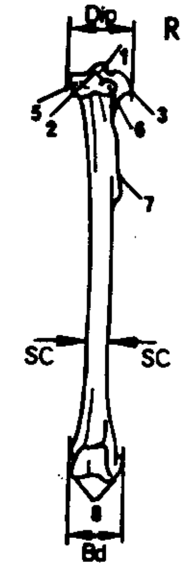


Figure 61c: Tibiotarsus of Columba, plantar view.

TIBIOTARSUS (Fig. 61a-e)

GL - Greatest length. In the divers (Gaviidea and Podicipedidae) this measurement has to be measured in a fashion analogous to the other species (i.e., including the extremely long Processus cnemialis) (+)

La - Axial length: from the Tuberculum centrale to the distal border of the Trochlea tibiotarsi

Dip - Dp (German) - (Greatest) diagonal of the proximal end: from the Condylus medialis femoralis to the Crista lateralis, even though in some species the distance from the Condylus medialis femoralis to the Crista tibiae is greater (+)

SC - KC (German) - Smallest breadth of the corpus. Measured in the same plane as Bd (-)*

Bd - (Greatest) breadth of the distal end (+)

Dd - Td (German) - Depth of the distal end. The fixed points for one calliper of the measuring instrument are the caudal points of the condyles (+)

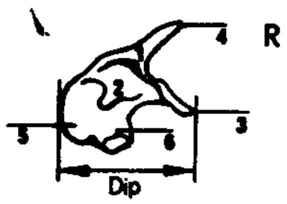


Figure 61d: Tibiotarsus of Anser, proximal view.

Points on and parts of the tibiotarsus (Fig. 61):

1 = Processus cnemialis
2 = Tuberculum centrale
3 = Crista lateralis
4 = Crista tibiae
5 = Condylus medialis femoralis
6 = Condylus lateralis femoralis
7 = Crista fibularis
8 = Trochlea tibiotarsi

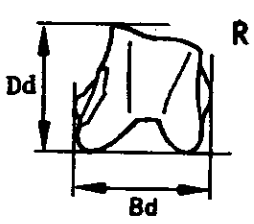


Figure 61e: Tibiotarsus of Anser, distal view.

*See note to SC of the Humerus.

TARSOMETATARSUS (Fig. 62a-c)

GL - Greatest length (+)
Bp - (Greatest) breadth of the proximal end (+)
SC - KC (German) - Smallest breadth of the corpus (+)*
Bd - (Greatest) breadth of the distal end. Measured in projection at right angles to the longitudinal axis of the bone.

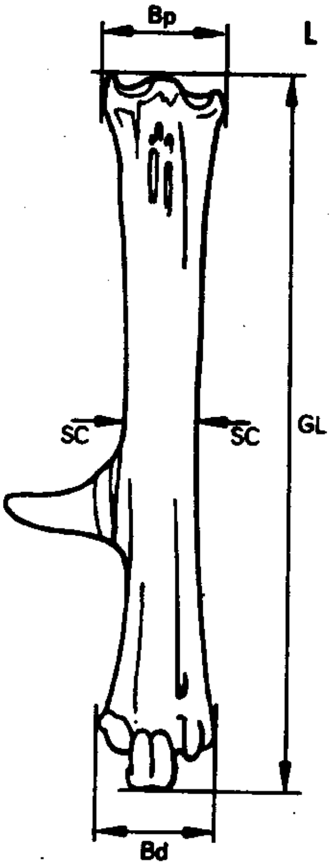


Figure 62a: Tarsometatarsus of <u>Gallus</u>, dorsal view.

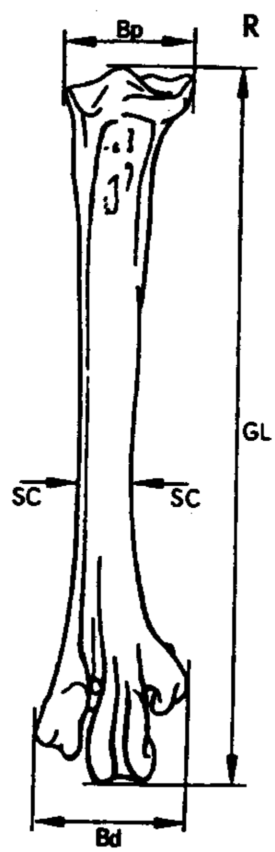


Figure 62b: Tarsometatarsus of <u>Anser</u>, dorsal view.

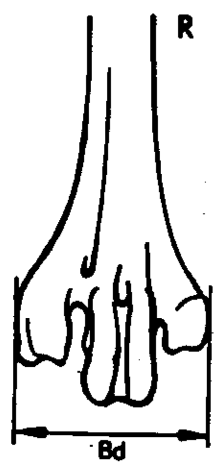


Figure 62c: Tarsometatarsus of <u>Otis</u>, dorsal view.

*See note to SC of the Humerus.

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