26 *The Ageing of Domestic Animals*

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THE METHODS for determining the age at death of domestic animals by examination of their hard parts differ little from those used in ageing any other animals. However, owing to the close association of domestic animals with man much more detailed information is available in relation to age changes in the skeleton and dentition than in the case for any animals other than man himself. The science of ageing an animal by the appearance of its teeth in life (or death) is probably as old as animal husbandry.

Really accurate estimates of the age of an animal can be made only when the following conditions are fulfilled—(a) that it belongs to a species or breed of which the age characteristics are well documented, (b) that its plane of nutrition is known, (c) that most of the teeth and a representative selection of bones are available and (d) that it is not yet fully adult. Archaeological material cannot satisfy all these criteria, since, first, age characteristics are well known only for modern domestic animals, most of which are considerably selected and inbred. Tooth eruption dates and epiphysial fusion dates differ very significantly between individual breeds within a single species. It is a reasonable assumption that bony remains from sites dated before intensive selective breeding began will show age characteristics similar to the more primitive of modern domestic animals rather than to those more highly specialized, provided that the archaeological material is definitely the same species as its modern counterpart. Second, the plane of nutrition of the animal can only be guessed at, usually from the bones whose age is to be determined, which leads to a danger of circular argument. Third, it is only under rather favourable circumstances that several bones can be identified positively as belonging to one animal. Fourth, it is fortunate that where food animals are concerned many are slaughtered before reaching adulthood and this slightly simplifies the task of ageing many bones.

METHODS—BONES

Assessment of age. This relies on a number of factors which are linked with the embryological, foetal and post-natal method of bone development and growth. With the exception of the clavicle and some parts of the skull, bones are first preformed in cartilage which then ossifies and becomes rearranged structurally. The process of ossification is constant for each bone. Long bones usually show a primary centre of ossification in the middle of the shaft and at least one epiphysial centre at each end (Fig. 38a). Complex bones such as vertebrae have more centres (Table A). Cartilaginous zones, the epiphysial plates, persist between the primary and secondary centres, allowing growth, until a relatively constant age for each particular epiphysis when the cartilage becomes ossified and the primary and secondary centres fuse. There are, however, some regions of cartilage which do not ossify, even in old age, although calcium salts may be deposited within cartilage, giving it a superficial appearance of bone. The costal cartilages and the proximal parts of the suprascapular cartilages of large animals may be affected in this way.

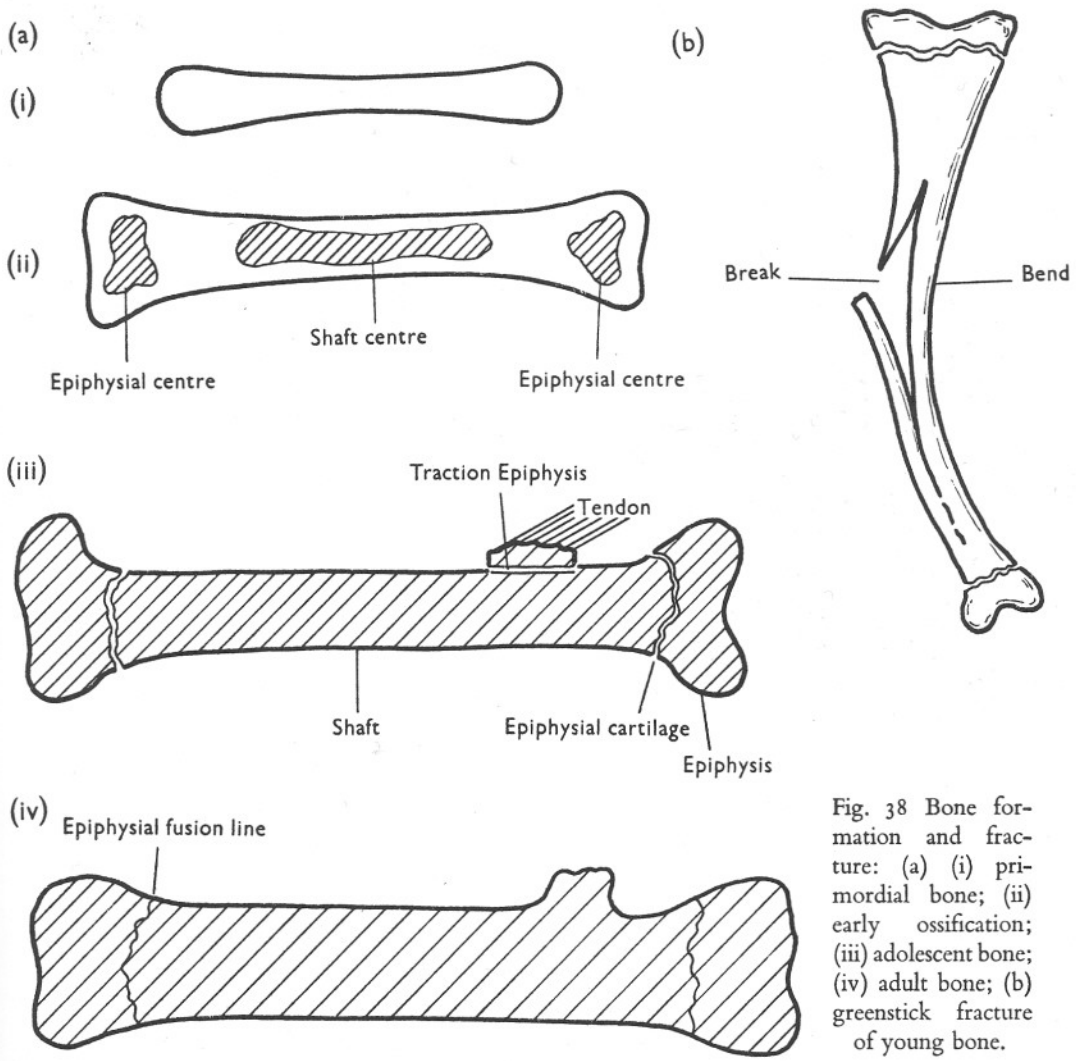

Fig. 38 Bone formation and fracture: (a) (i) primordial bone; (ii) early ossification; (iii) adolescent bone; (iv) adult bone; (b) greenstick fracture of young bone.

Once a skeleton has started to ossify, the age of an animal may be determined fairly accurately by noting the regions where epiphysial fusion has occurred. From the point of view of the skeleton, full adulthood is reached when all epiphyses are fused and from this time onwards the indications of advancing age are very much less precise. The following changes in bones take place during the adult period, and serve as a rough guide (if evidence of tooth wear is lacking) as to whether the animal is a young, middle-aged or elderly adult. At first the shafts of the limb bones are relatively long and slender and the extremities are large. There are few surface marks on the bone and prominences for tendon and muscle attachments are small. In the mid-adult phase the bones become more rugged in appearance and the extremities are relatively narrower.

TABLE A

Ossification centres and ages of fusion in post-cranial skeleton of domestic animals.

Bone	*Ossification Centres*	*Fusion*
Vertebrae	Body 1 Arch 2 + Spine 1 Epiphyses 2	Horse, ox—body and arch fuse at or just after birth; bodies fuse with epiphyses at 5 years. Pig, sheep, dog—body and arch fuse at 3–6 months.
Atlas	4	Horse and ox—wings not fused till 6 months.
Axis*	7	Epiphysis between body and odontoid in horse open till 3–4 years.
Sacrum†		Body epiphyses may never fuse. Unite with each other before uniting with body.
Costal cartilages‡		
Sternum	Manubrium 1 Sternebrae, 2 each	Sternebral centres fuse early except in last sternebra of ruminants which remain in 2 parts till old age.

* Anterior notch of axis becomes a foramen in old horses.
† Bases of spines fuse in old horses. Spines fuse in young adult cattle and sheep.
‡ Ossify or calcify commonly in old age.

Bone	*Ossification Centres*	*Fusion*				
		Horse Ass	*Ox*	*Sheep*	*Pig*	*Dog*
Scapula	Bicipital tuberosity	1 yr 8 mo.	7–10 mo.	6–8 mo.	1 yr.	6–7 mo.
	Tuber spinae	3 yrs				
Humerus	Proximal epiphysis	3–3½ yrs.	3½–4 yrs	3–3½ yrs.	3½ yrs	15 mo.
	Distal epiphysis	15–18 mo.	12–18 mo.	10 mo.	1 yr.	8–9 mo.
Radius	Proximal epiphysis	15–18 mo.	12–18 mo.	10 mo.	1 yr.	11–12 mo.
	Distal epiphysis	3½ yrs	3½–4 yrs	3 yrs	3½ yrs	11–12 mo.
Ulna	Olecranon*†	3½ yrs	All at 3½–4 yrs	3 yrs	3–3½ yrs	9–10 mo.
	Distal end	Before 2 birth mo.				11–12 mo.
Metacarpus	Proximal epiphysis‡§	Before birth	Before birth	Before birth	Before birth	Before birth
	Distal epiphysis	15–18 mo.	2–2½ yrs	18–24 mo.	2 yrs	8 mo.
1st Phalanx	Proximal epiphysis	13–15 mo.	Before birth	Before birth	2 yrs	7 mo.
	Distal epiphysis	Before birth	1½ yrs	13–16 mo.	Before birth	Before birth

TABLE A continued:

Bone	*Ossification Centres*	*Fusion*				
		Horse Ass	*Ox*	*Sheep*	*Pig*	*Dog*
2nd Phalanx	Proximal epiphysis	9–12 mo.	Before birth	Before birth	1 yr	7 mo.
	Distal epiphysis	Before birth	1½ yrs	13–16 mo.	Before birth	Before birth
3rd Phalanx	No true epiphysis¶	Partly ossified at birth				
Pelvis (os innominata = os coxae)	Fusion of main bones	1½–2 yrs	7–10 mo.	6–10 mo.	1 yr.	6 mo.
	Ilium—Tubercoxae					
	Ischium—sciatic tuberosity	All fused at 4½–5 yrs	All fused by 4½ yrs	All fused by 3½ yrs	All fused by 6–7 yrs	Sciatic tuberosity at 2 yrs
	Pubis–Acetabular bone					
Femur	Proximal end (2 epiphyses)‖	3–3½ yrs	3½ yrs	2½–3 yrs	3½ yrs	1½ yrs
	Distal end (1 epiphysis)	3–3½ yrs	3½–4 yrs	3–3½ yrs	3½ yrs	1½ yrs
Tibia	Proximal epiphysis	3–3½ yrs	3½–4 yrs	3–3½ yrs	3½ yrs	1½ yrs
	Distal epiphysis**	20–24 mo.	2–2½ yrs	1½–2 yrs	2 yrs	13–16 mo.
Fibula	Proximal epiphysis	Doubtful 2–3 yrs	Fused with tibia 2–3 yrs		3½ yrs	15–18 mo.
	Distal epiphysis	Fuses with tibia 1–3 mo.	Separate bone	Separate bone	2½ yrs	15 mo.
Fibular Tarsal (Calcaneum)	Tuber calcis	3 yrs	3–3½ yrs	2½–3 yrs	2–2½ yrs	13–16 mo.
Metatarsal	Proximal epiphysis	Before birth	Before birth	Before birth	Before birth	Before birth
	Distal epiphysis	16–20 mo.	2¼–3 yrs	20–28 mo.	2¼ yrs.	10 mo.

* Interosseus radio-olecranon ligament ossifies in horse at 3–4 yrs.
† Radio-ulnar ligament ossifies in dog at 2 yrs.
‡ Metacarpals 3 and 4 of ruminants are joined by cartilage at birth.
§ Ossification occurs at 3–8 mo. (old figures give 12–15 mo.).
¶ In old horses the lateral cartilages may ossify to form 'side bones'.
‖ A traction epiphysis at 3rd Trochanter in horse ossifies variously from 2 to 4 yrs.
** Lateral malleolus separate at birth to 3 mo. in foal.

Marks caused by blood vessels become obvious and tendon attachments may ossify to give 'traction epiphyses'. Smaller prominences associated with muscle attachment appear, and depressions at muscle origins are deep. The cortex of the bone is thick and the bone is heavy. In senility, calcium resorbtion takes place resulting in a bone with a thin cortex and large medullary cavity. Rarefaction is common. Similar changes may occur in pregnancy.

Certain pathological features may be present which can also be a guide to the probable age. For instance, so-called 'greenstick' fractures occur only in young bones (Fig. 35b); malignant bone tumours usually appear in the adolescent or young adult but arthritic changes and signs of healed inflammatory changes, especially on the legs of large animals, are commonest in middle to late life. Changes in the alveoli of the jaws where teeth have been lost in life may be useful as guides to age. The alveolar cavity is slowly filled with bone after loss of a tooth, and if no cavity at all is present, particularly at the site of a deep-rooted tooth, it is an indication that the jaw is probably not from a young adult. The size of the maxillary sinuses in horse, ox, sheep and goat gives a fairly close correlation with age even when teeth or other parts of skull are missing. The lower the floor of this sinus, the older the animal. In extreme old age, high-crowned teeth may grow right out of the jaw leaving the floor of the maxillary sinus below the level of the palate. In the foal, the maxillary sinus is almost full of developing teeth, at $5\frac{1}{2}$ years it is full of embedded parts of permanent teeth and in old age it is largely filled with air.

In the horned domestic animals the cavity of the frontal sinus extends into the bony horn-core. A horn-core from a young animal normally has a rather narrow cortex and a large sinus cavity. With advancing age the cavity is reduced and the cortex thickens. Horn-cores showing signs of repaired damage are more likely to come from mature animals. If the horn itself survives it will be found to show annual growth rings, the first of which appears at two years of age in cattle.

Detailed assessment of age. The tables above indicate the ages at which the epiphyses of the major bones fuse with the shaft in the common domestic mammals. There is unfortunately no complete agreement on exact fusion ages and the figures given in the tables are means and as far as possible these data refer to 'scrub' crossbred animals. High planes of nutrition and sheltered conditions tend to accelerate epiphysial fusion.

Certain features may be amplified as these are not obvious in tables. The proportions of the skull change strikingly with age. In young mammals the brain case is large relative to the face, but during the growing period the face usually increases in size faster than the cranium. Taking the horse as an example (Table B), in a young foal the bones of the forehead are convex, but as growth occurs the frontals and nasals flatten and may become concave in old age. The maxillary region of the face is also primarily convex but it becomes concave as the cheek teeth grow out of the skull. The relationship of the rostral end of the facial crest to the cheek tooth immediately below it, is as follows: in the new-born, the posterior part of the third premolar, in the three-year-old the posterior part of the fourth premolar, and in the mature adult the first molar. The premaxilla in young horses has a downward curve which is gradually lost with age. The caudal border of the vertical ramus of the mandible becomes narrow and sharp in very old horses. The long axis of the bony orbit in the young adult is on a line passing through the necks of the incisor teeth and the external auditory opening but in old age it is lower and on a line joining the occipital tubercle and the rostral end of the zygomatic crest.

The cranium behind the post-orbital bars is wider in a young than in an adult animal: the various prominences, especially the lachrymal tubercle and nuchal and sagittal

crests, increase with age, and the infra-orbital foramen, which in early life is present as a slit, becomes large and almost round in old age.

METHODS—TEETH

General. The teeth are the most durable and in many ways the most informative hard

TABLE B

The skull of the horse—centres of ossification and fusion ages.

Bone	*Centres of ossification*	*Fusion ages*	*Notes*
Occipital	Supraoccipital 2 × exoccipital Basioccipital	Supra with exocc. at 18 mo. Basi with exocc. at 3–4 mo.	4 bones at birth but only 1 bone in adult
Sphenoid	One in each of 4 wings One in body = 5	With occip. at 5 yrs	
Ethmoid	2 in each lateral mass 1 in perpendicular plate = 5		At birth perpendicular and cribriform plates are cartilaginous
Interparietal	2 main centres	With parietals at 3–4 yrs With supraoccipital at about 5 yrs	Often paired in young animals Fusion v. variable
Parietal	Each has one centre	Parietals fuse across mid-line about 4 yrs Parieto-occipital fusion 5 yrs Parieto-squamous fusion 12–15 yrs	Central part more convex in foal than adult No external parietal crest in foal
Frontal	Each has one centre	With each other or parietals only in old age	
Squamosal (Squamous temporal)	Each has a single centre	With parietal at 12–15 yrs	
Periotic (Petrosal or Petrous temporal)	At least 2	At or soon after birth	Rarely fuses with adjoining bones
Pterygoid Maxilla Lachrymal Palatine Zygomatic	1 each (Some may have small secondary centres)		Normally remain separate. May unite with adjoining bones in old age
Premaxilla	1	The two bones fuse across mid line at about 4 yrs	
Nasal	1	Mid line suture is unfused even in old age	
Mandible	2 in each branch	The 2 centres fuse before birth. The 2 halves fuse at 2–4 mo.	

structures of the body. It may be possible to infer, from a single tooth, not only the species or feeding habits of an animal, but also its age and approximate size. However, for accurate determination of age from teeth it is necessary to have at least a selection of them from an animal, preferably still embedded in the jaw. The teeth which give the best indication of age in the adult are those of the 'high-crowned' or hypsodont type which grow out of the jaw at an approximately constant rate as they are worn away, and whose character changes not only in regard to length but also in respect of the crown pattern of the interfolded layers of cement, enamel and primary and secondary dentine. It is unfortunate that maximum accuracy in ageing of teeth can be accomplished only in the infantile and adolescent animal, the same periods in which bones give their most reliable indication of age. There are, however, as in the case of bone, certain signs to be found in the teeth of adults which will indicate whether they are from young, middle-aged or senile animals. Although changes in horse teeth are dealt with in detail in the tables it is worth noting that the first molar is rather commonly attacked by caries in the young to middle-aged adult, whereas caries in other cheek teeth is much less common and is usually an indication of advanced age. In cattle, the incisor teeth are always movable in the jaw in life, so that there is a relatively large amount of soft tissue in the incisor alveoli. Thus it is common to find in normal cattle that the roots of the incisors are much smaller than the alveolar cavity. On the other hand, especially in carnivores, if the teeth show roots which are markedly smaller than the alveoli, and the alveolar walls are rough, then it is probable that the specimen suffered from paradontal disease and was old. A common sequel to this condition is readily detectable in archaeological material due to the resorbtion and destruction of bone at the original abscess site. The tooth most often affected by abscesses of the root is the carnassial tooth of the upper jaw (premolar 4) in old dogs. Frequently the maxillary bone over the roots of this tooth is eroded so that a sinus develops between alveolus and the surface.

Very heavily worn teeth, or jaws showing alveoli from which teeth have been lost in life, naturally indicate an old animal, but considerable caution must be exercised in coming to such a conclusion unless there is confirmatory evidence from other (skeletal) sources. Young dogs which eat large quantities of bones or play with and chew hard materials such as wood or stones, may present a pattern of tooth wear suggestive of extreme senility, whereas old animals which have eaten mainly meat and have not had to scavenge may have almost unworn teeth. In this latter case, however, there is nearly always some wear on the canines and carnassials and the tips of the incisors. Among herbivores the type of soil and herbage plays a major part in tooth wear. Animals on sandy soil and short grass show the highest rate of wear, whereas animals feeding largely on foliage or on lush grass from soft soils with a low silica content show only slow tooth abrasion. Certain areas are well known at the present time to produce rapid tooth wear. For instance, ponies living on Dartmoor often seem, on the evidence of their teeth, to be as much as two years older than they are in fact.

Details of ageing by teeth in individual species. (1) *Horse.* Table C gives tooth eruption dates in live horses, that is the age at which the tooth cuts the gum and not the age at which it first appears out of the bone. In archaeological material teeth which are

unworn and project only slightly above the jaw line are best regarded as being at a stage represented by the earliest dates given here. If a tooth shows the slightest evidence of wear then it must have been erupted, and in all probability will have been erupted for at least 2–3 months. Teeth usually take about six months from eruption to come into full wear.

TABLE C

Tooth eruption ages in the horse.

Tooth	*Deciduous teeth*	*Permanent teeth*
Incisors*		
Central 1/1	Present at birth	2½–3 yrs
Lateral 1/1	3–4 wks	3½–4 yrs
Corner 1/1	5–9 mo.	4½–5 yrs
Canine 1/1	Rarely emerges from jaw	4–5 yrs
Premolars		
1 1/1 Wolf tooth	Inconstant, 6 mo.	Inconstant, 2½ yrs
2 1/1	Present at birth	2½ yrs
3 1/1		2½ yrs
4 1/1		3½ yrs
Molars		
1 1/1	Absent	Wide variation. 7–14 mo. Usually present by 1 yr
2 1/1		2–2½ yrs
3 1/1		3½–4½ yrs

* It is usual for the upper milk incisor teeth to be replaced by permanent teeth slightly earlier than those of the lower jaw.

It is of great importance to distinguish permanent from deciduous incisor teeth and the following characteristics may be used. The milk teeth have a definite 'neck'; they are grooved on the lingual and smooth on the labial surfaces; they are small and the enamel is white; they often show signs of resorbtion of the root due to the presence of following teeth; when present in the jaw they are arranged in a semi-circle. The permanent incisors appear as follows (Fig. 39a): they are long and curved and diminish gradually from crown to root without a neck, the curve being restricted to the crown region, the root being straight; they are grooved on the labial aspect; the enamel is a dirty white and the infundibulum is much deeper than in milk teeth; there is a

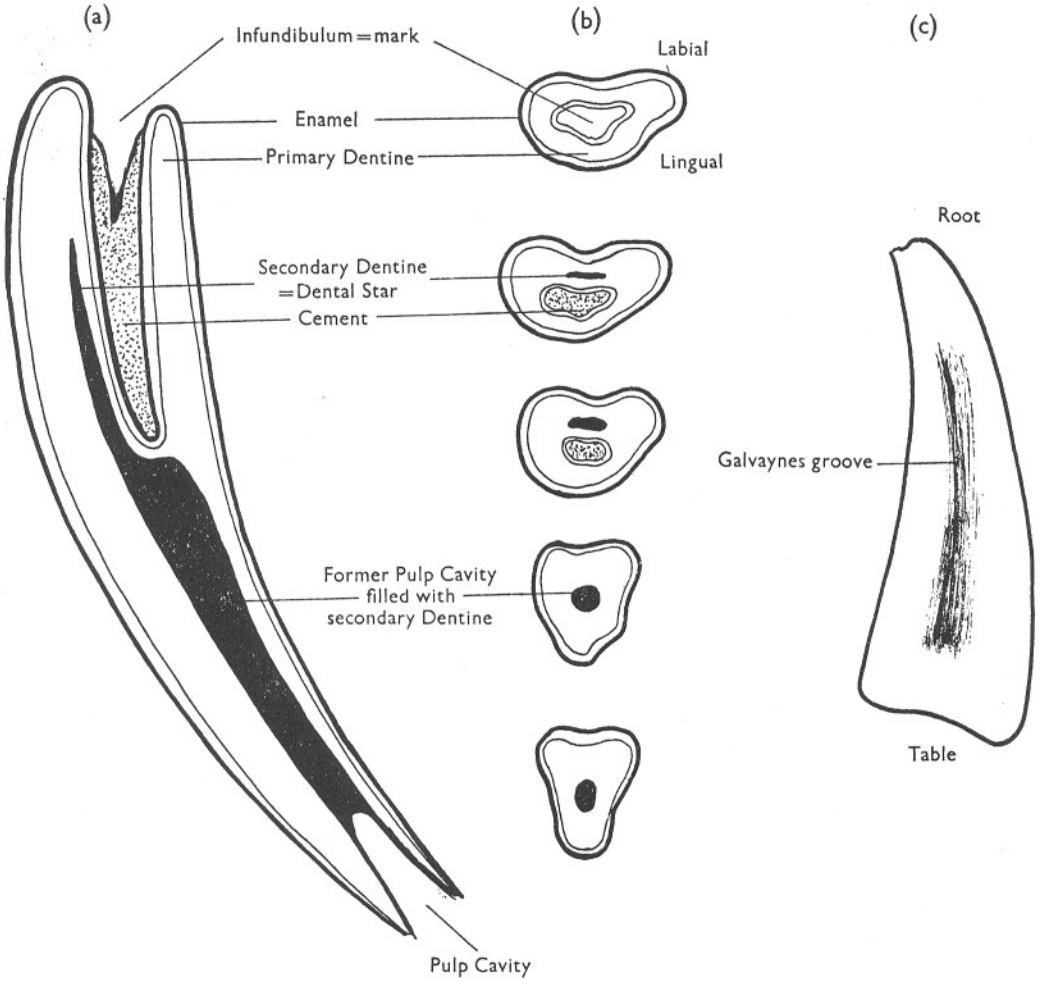

Fig. 39 Incisors of horse: (a, b) lower middle incisor: longitudinal section and cross-sections viewed from above (note the outer layer of cement has been omitted to avoid confusion); (c) upper lateral incisor, showing Galvayne's groove.

considerable change in cross-section from the crown to root, the crown being twice as wide laterally as it is antero-posteriorly whereas in the root region the antero-posterior diameter is twice the lateral (Fig. 39b).

When all the teeth have erupted and are in wear, it is necessary to resort to other characters for determining age. The incisor teeth of horses show valuable clues to age provided that tooth wear has remained within normal limits. The first is the infundibulum or mark, and the second is the star, which is formed by the filling of the pulp cavity with secondary dentine of a colour different from that of the primary dentine. (Fig. 39a, b). The third is that the shape of the table (the biting surface) varies with age in a constant manner. Lastly, the labial groove (of Galvayne) of the upper corner incisor is confined to the middle third of the tooth so that it remains within the jaw

until approximately the tenth year (Fig. 39c), it is half-way down the erupted front of the tooth at 15, the full length at 21 and only the distal half shows a groove at 30 years. The following list shows the expected appearance of teeth at differing ages.

Birth	Milk central incisors and premolars
1–5 months	Milk central plus lateral incisors and premolars
6–12 months	Milk central plus lateral plus corner incisors and premolars plus first molar
1 year	Infundibulum worn out of central incisors. Corner incisors in wear but thin walled. Incisor teeth close together
18 months	Infundibulum lost from lateral incisors. First molar in wear
2 years	Incisor teeth wide apart. Infundibulum lost from corner incisor. Second molar appears
$2\frac{1}{2}$ years	Permanent central incisor and first and second permanent premolar cut. Second molar in wear
3 years	Permanent central incisor and first and second permanent premolar in wear
$3\frac{1}{2}$ years	Permanent lateral incisor and third permanent premolar cut plus lower canines
4 years	Permanent lateral incisor in wear. Upper canine may appear (males). Third molar appears
$4\frac{1}{2}$ years	Permanent corner incisor appears. Upper canine usually present as a sharp knife edge—but only in males. Third molar in wear
5 years	Permanent corner incisor in wear, but inner wall still level with jaw and the upper tooth is much longer laterally than antero-posteriorly. Canine in wear. Star on central incisor
6 years	Upper corner incisors, diameters almost equal laterally and a.p. and inner walls in wear. Infundibulum very shallow on central. Star on lateral incisor
7 years	Upper corner square, often with a posterior 'hook'. Lower corner in wear on inner as well as outer walls, all of which are thick. Infundibulum lost from central incisor. Canines blunt
8 years	Infundibulum lost from lateral incisors and very shallow on lower corners
9 years	All infundibular marks absent on incisors. No labial groove on upper corner beyond alveolar cavity. Central incisor table is triangular
10 years	Appearance of Galvayne's groove on labial aspect of upper corner incisor. Lateral incisor table triangular
11 years	Corner incisor table becoming triangular
12 years	All incisor table markedly triangular
13 years	Often a posterior hook on corner incisor
15 years	Galvayne's groove $\frac{1}{2}$ down erupted part of upper corner incisor
18 years	Central incisor table width = thickness a.p.

21 years	Galvayne's groove reaches full length of erupted part of tooth. Narrowing of lower jaw and separation of roots of incisors marked
26 years	Width of central incisors = $\frac{1}{2}$ a.p. diameter
30 years	Galvayne's groove half-way off upper corner incisor

The rate of wear of horse teeth is not constant, e.g. between 5 years and 7 years the incisors are worn away at about $\frac{1}{4}$ inch per year while later in life the rate is much reduced so that over 20 years of age the incisors are ground off at about $\frac{1}{4}$ inch per 5 years. The lower cheek teeth tend to wear faster than the upper as they have a smaller surface area; also the central cheek teeth wear faster than those at each end of the row. In old horses this often leads to an undulation of the surface of cheek teeth. Very smooth molars and premolars are also characteristic of old age.

Lastly, the arrangement of the incisor teeth in the jaw is referable to the age of the animal. In youth the upper and lower teeth meet to form a vertical line with their labial surfaces (Fig. 40). As the animal ages the angle at which the teeth meet becomes progressively less than 180° until in old age, the incisors, especially of the lower jaw, protrude almost horizontally from the jaws (Fig. 40).

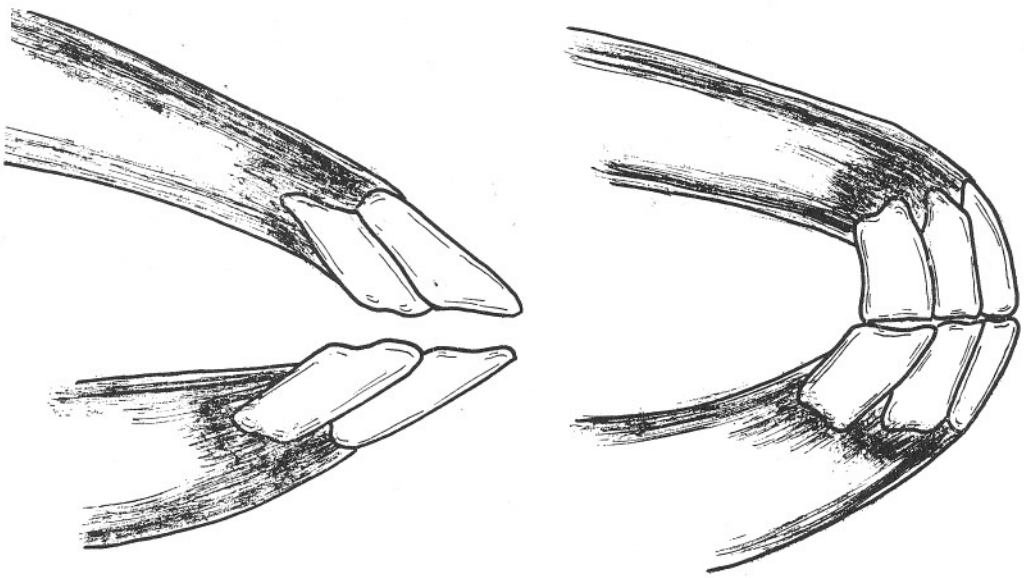

Fig. 40 Change of the angle of profile of teeth; this is due to the curvature of the crown and straight roots.

No doubt horse dealing is almost as old as domestication of horses and dealers are distinguished by the ingenuity they show in attempting to improve on the natural appearance of horses' teeth, to the confusion of their clients. The common forms of deception consist of the production of an 'artificial infundibulum' in old incisor teeth by burning a hole and the filing away of the front of the incisors to reduce the acuteness of the angle at which they meet. Both of these practices help to produce a 'young' old horse. Both are easily detected if the normal arrangement of dentine and enamel is

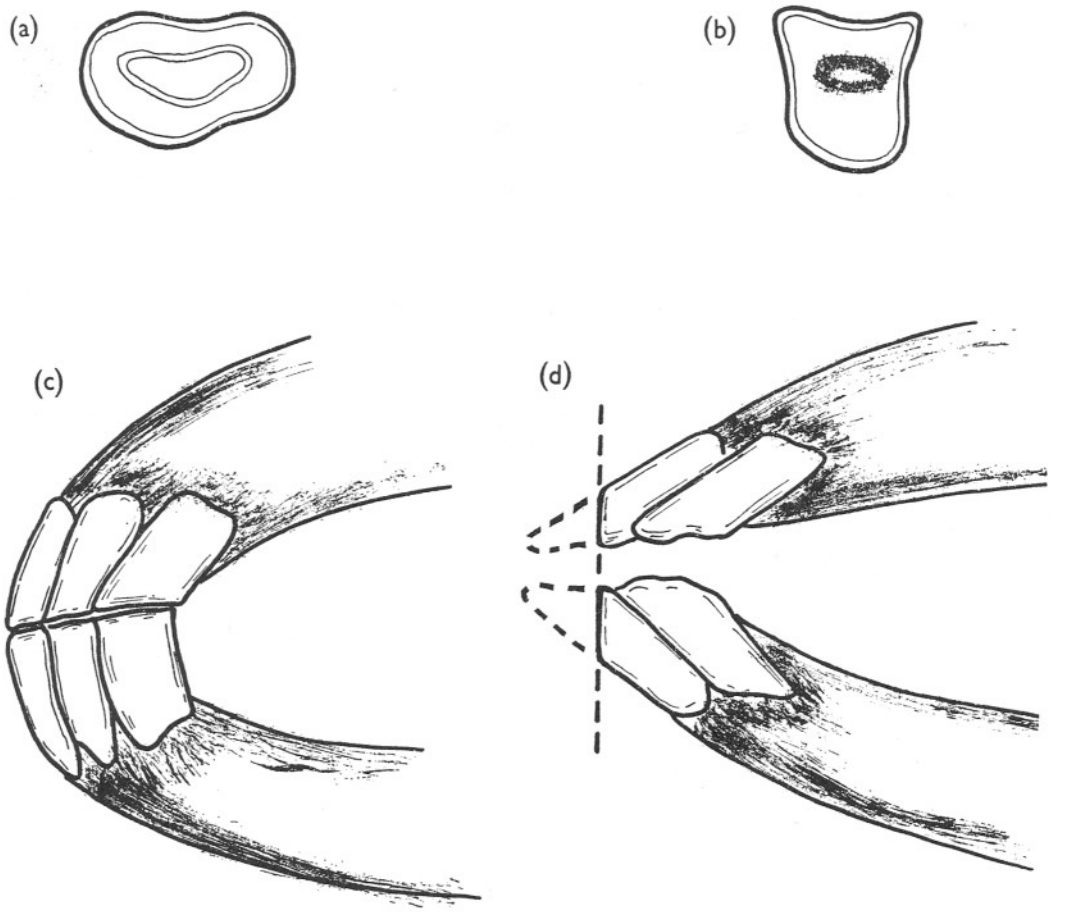

Fig. 41 'Bishoping'; (a) natural mark; enamel surround is present; tooth is wider than long; (b) false mark; no enamel surround; tooth is longer than wide; (c) young teeth, meeting at 180°; (d) old teeth, filed to give 180° front surface.

understood (Fig. 41). In the first case no enamel surrounds the false 'mark' and in the second the enamel will be missing from the front of the filed incisors (Fig. 41). This type of 'faking' used to be very common and is known as 'Bishoping', which suggests a rather disreputable connection with the church. Another trick which has a long history is that of removing the milk incisors in order to 'force' the permanents and give a very young horse a more mature appearance. This is easily detected by reference to the molars and premolars.

(2) *Ox.* The teeth of cattle show great variation in eruption dates depending on breed, management and nutrition. The better the housing and feeding and the more highly bred, the earlier the eruption of teeth. It is noticeable in the early works on domestic animals that the ages given for tooth eruption may be as much as twice that given by modern authors for improved breeds—see Table D. It seems reasonable to take the older figures as more applicable to archaeological material unless there is independent

TABLE D

Tooth eruption ages in the ox. (Bue)

Tooth	*Deciduous teeth*	*Permanent teeth*	*Chauveau 19th century*	*Commercial Crossbred stock 1950. MR**	*Ranch cattle MR**
Incisors					
1 central 0/1	Present at birth	14–25 mo.	18 mo.	20–24 mo.	22–24 mo.
2 middle 0/1	Present at birth	17–36 mo.	30 mo.	30 mo.	30–36 mo.
3 lateral 0/1	Present at birth or in first 2 wks	22–40 mo.	42 mo.	36 mo.	42 mo.
Canine 0/1 (=incisiform corner)	At birth or in first 2 wks	32–48 mo.	54 mo.	42–48 mo.	54–60 mo.
Premolars					
1	Occasional	Occasional, always lost before 3 yrs			
2 1/1	Birth to 3 wks	24–30 mo.	18 mo.	30 mo.	
3 1/1	Birth to 3 wks	18–30 mo.	30 mo.	30 mo.	
4 1/1	Birth to 3 wks	28–36 mo.	42 mo.	36 mo.	
Molars					
1 1/1		5–6 mo.	6–9 mo.	6 mo.	
2 1/1	Absent	15–18 mo.	30 mo.	15–18 mo.	
3 1/1		24–30 mo.	4–5 yr	24 mo.	

* MR: Miller and Robertson.[18]

evidence that the system under which the animals were kept afforded good protection against weather and periodic starvation. Some features not obvious from the table are given below:

Birth to 3 months	Incisor crowns overlap
6 months	Incisors are side by side
1 year	Spaces between incisors, heavily worn
2 years	Central permanent incisors show some wear
$2\frac{1}{2}$–3 years	2 pairs permanent incisors in wear
3–4 years	3 pairs permanent incisors in wear
4–5 years	4 pairs permanent incisors in wear with some overlapping of teeth

5–10 years	Progressive wearing of incisors and reduction of overlap with eventual almost complete loss of crown leaving root stumps with 'tips' of enamel only
12–14 years	Widely separated stumps of incisors
14–16 years	Gradual closing up of stumps of incisors

Separate incisor teeth can be placed as young if the labial surfaces bear longitudinal wavy lines, or aged if these are absent. The incisors are at first convex in outline and are levelled by wear. This wear removes the enamel to expose a line of yellow dentine. Within this a darker streak appears later (the secondary dentition) which changes in shape with age; from being long (transversely) it shortens, then widens into a square and finally becomes round in the root.

It is worth noting that the last milk premolar of the lower jaw is very large in ruminants and has 3 cusps. It may be easily mistaken for a permanent tooth.

TABLE E

Tooth eruption ages in the sheep. (pecora)

Tooth	*Deciduous teeth*	*Permanent teeth*	
		Modern figures (improved breeds)	*Semi-wild, hill sheep, old figures (1790)*
Incisors			
Central 0/1	Birth to 1 wk	12–18 mo.	18 mo.
Middle 0/1	Birth to 1 wk	18–24 mo.	30 mo.
Lateral 0/1	Birth to 2 wks	27–36 mo.	42 mo.
Canine 0/1 (corner incisor)	Birth to 3 wks	33–48 mo.	50 mo.
Premolars			
1	Usually absent	Usually absent	
2 1/1	Birth to 6 wks	21–24 mo.	30 mo.
3 1/1	Birth to 6 wks	21–24 mo.	30 mo.
4 1/1	Birth to 6 wks	21–24 mo.	40 mo.
Molars			
1 1/1	Absent	5 mo. (upper) 3 mo. (lower)	6 mo.
2 1/1		9–12 mo.	18 mo.
3 1/1		18–24 mo.	3–4 yrs

(3) *Sheep.* Sheep vary widely in the age at which they reach maturity, the so-called improved breeds maturing much earlier than hill breeds. Figures published by authors in the late eighteenth and early nineteenth centuries suggest that at that time sheep were regarded as having similar tooth eruption dates to cattle, but modern authorities, referring to modern breeds of sheep, give eruption dates which are considerably younger. The incisors of sheep are long and narrow so do not show the same changes as those of the ox. They are normally held rigidly in the jaw. Sheep teeth come into wear 3–5 months after they are erupted.

(4) *Goat* (Table F: improved breeds early dates, rough goats late dates).

(5) *Pig.* Like sheep, pigs have been selected into a great many breeds whose maturation varies considerably. Only very general reliance can be placed on eruption dates as indication of age. The pig is peculiar in that the first premolar is not deciduous and is

TABLE F

Tooth eruption ages in the goat.

Tooth		*Deciduous teeth*	*Permanent teeth**
Incisors†			
Central	o/1	Birth	15 mo.
Middle	o/1	Birth	21 mo.—27 mo.
Lateral	o/1	Birth	27 mo.—36 mo.
Canine (corner incisor)	o/1	1–3 weeks	36 mo.—40 mo.
Premolars			
1		Usually absent	Usually absent
2	1/1	3 mo.	17–20 mo.—30 mo.
3	1/1	3 mo.	17–20 mo.—30 mo.
4	1/1	3 mo.	17–20 mo.—30 mo.
Molars			
1	1/1		5–6 mo.
2	1/1	Absent	8–10 mo.—12 mo.
3	1/1		18–24 mo.—30 mo.

* Early dates: improved breeds; later dates: rough goats.
† Incisors are frequently broken in old goats due to eating twigs.

TABLE G

Tooth eruption ages in the pig.

Tooth		*Deciduous teeth*
Incisors		
Central	1/1	1–3 wks 4–14 days
Lateral	1/1	10–14 wks 6–12 wks
Corner	1/1	Birth
Canine		Birth
Premolars		
1	1/1	
2	1/1	7–10 wks
3	1/1	1–3 wks 1–5 wks
4	1/1	1–4 wks 2–7 wks
Molars		
1	1/1	
2	1/1	
3	1/1	

* As usual, data from late 18th-century

variable in appearance, also alone of the domestic animals it possesses a tooth, the canine, which grows throughout life. Very long lower canines (more than 8 inches) indicate an old animal.

The lower incisors become heavily worn from digging and in old pigs the molar and premolar crowns may be worn flat or even concave.

(6) *Dog and Cat.* The domestic carnivores are relatively long-lived yet their teeth provide little evidence of age after the first eight months of life.

At one year all dog incisors are in wear but still have the *fleur-de-lys* shape which is completely lost by two years. Cats frequently lose the incisor teeth in middle age.

(7) *Camel.* Although the ageing of camels by their teeth has been practised in Arabia since before the tenth century, information on the subject is still rather vague.

TABLE H

Tooth eruption ages in the dog. (cane)

Permanent teeth	*Old Data* Permanent*	*Tooth*	*Deciduous teeth*	*Permanent teeth*
		Incisors		
12–17 mo.	2½–3 yrs	Central 1/1		
		Lateral 1/1	4–6 wks	3–5 mo.
17–20 mo.	2½–3 yrs	Corner 1/1		
8–12 mo.	6–12 mo.	Canine 1/1	3–5 wks	5–7 mo.
8–12 mo.	12 mo.	Premolars		
		1 1/1	Absent	4–5 mo.
3½–6½ mo.				
Inconstant		2 1/1		
12–16 mo.	2 yrs			
		3 1/1	5–8 wks	5–6 mo.
12–16 mo.	2 yrs			
		4 1/1		
12–16 mo.	2 yrs			
		Molars		
		1 1/1		4–5 mo.
4–6 mo.	1 yr			
		2 1/1		5–6 mo.
7–13 mo.	1½–2 yrs			
		3 1/1		6–7 mo.
17–22 mo.	3 yrs			

authors give late eruption dates.

Similar ages are given by 18th-century authors.

TABLE I
Tooth eruption ages in the cat.

Tooth		Deciduous teeth	Permanent teeth
Incisors			
Central	1/1	3–4 wks	$3\frac{1}{2}$–$5\frac{1}{2}$ mo.
Lateral	1/1		
Corner	1/1		
Canine	1/1	3–4 wks	$5\frac{1}{2}$–$6\frac{1}{2}$ mo.
Premolars			
1		Absent	Absent
2	1/0	5–6 wks	4–5 mo.
3	1/1		
4	1/1		
Molars			
1	1/1	Absent	5–6 mo.

Domestic Fowl. Owing to the very short period during which growth takes place it is not practicable to age skeletal remains except into 'young' and 'old'. Long bones in birds do not have epiphysial centres of ossification, the whole epiphysis being cartilaginous in youth. The epiphyses of long bones all ossify early (under six months). The 'keel' of the sternum is largely cartilaginous in young birds, and gradually ossifies. This process is completed between 5 and 8 months according to breed. Spurs develop on the metatarsals of males and their length is some indication of age. Old females may also develop spurs.

CONCLUSIONS

The ageing of animals from skeletal remains of any antiquity cannot be an exact science, and calls for the exercise of considerable judgement. Despite selective breeding the horse and dog seem to have retained a more constant skeletal development with age than have other domestic species. In particular, sheep and pigs are very difficult to age on the evidence of teeth alone owing to their responsiveness to feeding and management changes. It is unfortunate that the translations from Arabic of works of the thirteenth century are not always clear in respect of nomenclature of teeth and that earlier writers such as Aristotle and Varron are far from objective in their methods of ageing. Nevertheless medieval authors from Asia and Europe provide useful information on unimproved

TABLE J
Tooth eruption ages in the camel.

Tooth		*Deciduous teeth*	*Permanent teeth*
Incisors			
Central	0 or 1/1	4–6 wks	0/1 4 yrs
Middle	1/1	3–4 mo.	0/1 5 yrs
Lateral	1/1	8–9 mo.	1/1 6 yrs
Corner (Canine)	1/1	10–12 mo.	1/1 6½ yrs
Premolars			
1	0/0 (canine type)		1/1
2	1/0	4–6 mo.	0/0 4–5 yrs
3	1/1		1/(1) Lower P.M.3 if erupted is usually shed by 6–7 yrs
4	1/1		1/1
Molars			
1	1/1		1 year
2	1/1		3 yrs
3	1/1		5 yrs

For further details *see* Cornevin and Lesbre,[7] Monod,[19] and Lesbre.[16]

animals in many instances. Where it can be established that one breed of animal only is present in an excavation site, and if a reasonably complete set of bones and teeth for one or two individuals can be assembled, then relationship of tooth wear to epiphysial fusion dates may be determined and applied to the rest of the more fragmentary material from the same site.

There is little difficulty in classifying animals as young, aged or senile, but to decide ages to the nearest six months or year clearly requires very close study and considerable luck in obtaining appropriate bones or teeth.

REFERENCES

1 ARISTOTLE. *Natural History of Animals*, bks 2 and 4; first detailed record of observations but with many errors

2 ABU-BEKR. *c.* 1400. *Le Naceri*, bk 2, p. 54; transl. PERRON, M., Paris, 1859; difficult translation but earliest good details on horse, camel, sheep and goat; also, first details of tooth forgery in Arabia

3 BROWN, G. T. 1860. *Dentition as indicative of the age of the animals of the farm*, London

4 CHAUVEAU, A. 1888. *Traité d'anatomie comparée des animaux domestiques*, Paris, 4th ed.
5 —— 1891. *Comparative anatomy of the domesticated animals*, transl. FLEMING, G., London; useful for summary of nineteenth-century views on ageing by bones and teeth
6 COLUMELLE. *De Re Rustica*, bk 4; early observations on horse teeth
7 CORNEVIN, C. and LESBRE, X. 1894. *Traité de l'âge des animaux domestiques*; the most comprehensive book available on ageing of sheep, goats, camels, horses, dogs, cats, rabbits and guinea-pigs by examination of teeth; well illustrated
8 CRESCENZI, P. DE. *c.* 1260. *Opus ruralium commodorum*, bk 12; ageing in medieval Europe
9 DAUBENTON. *Instruction pour les Bergers*, Pamphlet *c.* 1800; ageing sheep up to 5 years
10 DUPONT, M. M. 1893. *L'âge du cheval et des principaux animaux domestiques*, Paris
11 FRANCINI, HORACE DE. 1607. *Hippiatrique*, bk 1, ch. 7
12 GIRARD FILS. 1824. Receuil de médecine veterinaire, *Mémoire sur les moyens de reconnaître l'âge du cheval*; good practical account of horse teeth
13 GIRARD, J. 1834. *Traité de l'âge du cheval augmenté de l'âge du bœuf, du mouton, du chien et du cochon*
14 HAYES, M. H. 1915. *Veterinary notes for horse owners*, London, 8th ed.; excellent photographs of horse teeth at various ages
15 HUIDEKOPER, R. S. 1891. *Age of the domestic animals*, Philadelphia
16 LESBRE, F. X. 1893. *Bulletin de la société centrale vétérinaire*, p. 147 ; dentition des camélides
17 MAYHEW, E. 1849. *The horse's mouth, showing the age by the teeth*, London; illustrations
18 MILLER, W. C. and ROBERTSON, E. D. S. 1947. *Practical animal husbandry*, Edinburgh, 5th ed.; good diagrams on horse and cow. Useful for modern horse, cattle, sheep, pig and dog
19 MONOD, O. O. 1892. Receuil de mémoires et observations sur l'hygiène et la médecine vétérinaire militaire, *De l'âge du Chameau*, Paris
20 NEHRING, 1888. *Landwirtschaftliche Jahrbücher*; comparison of teeth in wild and domestic pigs
21 NICKEL, R., SCHUMMER, A. and SEIFERLE, E. 1960. *Lehrbuch der Anatomie der Haustiere*, Berlin; the most recent information on bones and teeth
22 PESSINA. 1830. *Sul modo di conoscere dai denti l'età dei cavalli*; extremely detailed ageing of horse teeth
23 PLINY. *Natural History*, bk VIII; repetition of Aristotle
24 RUINI, CARLO. 1626. *Anatomia de Cavallo, infermità e suoi remedii*, Venice, bk 1, ch. 41; the most detailed information on horse up to that time
25 SAUNIER, GASPARD DE. 1734. *La parfaite connaissance des chevaux*, La Haye
26 SIMONDS, J. B. 1854. The age of ox, sheep and pig, *Roy. Agricultural Soc.*, London; good detail; distinguishes well-bred and common stock
27 SISSON, S. 1953. *Anatomy of the domestic animals*, ed. CROSSMAN, J. S., Philadelphia, 4th ed.; the best information in English on epiphysial fusion dates except for sheep and goat
28 SOLLEYSEL, DE. 1664. *Le parfait maréschal*, Paris; details of horse teeth up to 8 years and of faking practices in Europe
29 TAQUET, J. 1607. *Phillipica ou haras de chevaux*, Paris, Anvers ed.
30 VARRON. *De Re Rustica*, bk 2
31 VEGETIUS, PUBLIUS. *c.* 450. *Artis veterinariae sive mulo medicinae*, bk 4
32 VIBORG. 1823. *Mémoires sur l'éducation, les maladies, l'engrais et l'emploi du porc*, Paris; the first useful information on pig teeth
33 XENOPHON. *On Equitation*, bk 1, ch. III; first reference to ageing by teeth

SCIENCE IN ARCHAEOLOGY

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