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AGE DETERMINATION OF BOVINE FOETUSES

By

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With sale, consignment and insurance of cattle, the animal usually has to satisfy certain guaranteed or implied claims concerning identity, health and productive capacity. There is also the question of pregnancy: the animal shall/shall not be pregnant. Eventually, a certain day of conception, a stated bull, and always "pregnant with live foetus" at the time of delivery or commencement of the insurance, are assumed.

With irregular pregnancies, which may result in litigation and, thus, end before a court, it is important to have methods for age determination of the foetus. The foetus may be dead, mummified, macerated, aborted or not born at the assumed time. This often leads to the slaughtering of the cow.

Norwegian Trade Law (dated 24th May, 1906, no. 2) says (§ 17): "The risk of goods is transferred from the seller to the buyer at the point of delivery". The "goods" includes the foetus. Further, if the foetus was alive at the time of slaughter, determination of the time of conception may also be of importance, because erroneous or misleading details concerning the day of conception may also have legal consequences in trade and insurance.

The present investigations have this scope:

1. to survey the ossification sequence of the bones,
2. to register easily measurable foetal data which correlate significantly with age, and which are independant of mummification and maceration,

3. to investigate tooth development in foetuses with special consideration of relation to age,
4. to work out a schedule of hair eruption and hair growth for age determination

for use in age determination purposes in forensic cases.

PREVIOUS INVESTIGATIONS

The length of the foetus as a basis for age determination has been investigated by several authors (*Gurlt* 1860, *Franck* 1876, *de Bruin* 1910, *Schmaltz* 1921).

Bergmann (1922) stated that by examining hair eruption, weighing the foetus and uterus, measuring the amount of foetal fluids, and including a description of certain parts of the maternal genital tract, and the length of the foetus, it was possible to determine the age within ± 1 month.

The length of the foetus seemed to give a better correlation to age than did the weight (*Paimans* 1927, *Krediet & van der Kaay* 1936).

Investigations, carried out by *Winters et al.* (1942), included a study of the development of the various organs, and measurement of the length and breadth of the head and extremities. They used x-rays to determine the presence of ossified bone and developing teeth. Ossification was first seen at 59 days, and tooth development at 110 days, respectively. Measurements of the bones gave a better correlation to age than foetal length.

Sweet et al. (1948) also included other foetal proportions in their investigations. They concluded that none gave a sure basis for age determination.

Postma (1947) found the best correlation between foetal age and length up to an age of 32 ± 4 weeks. Hair eruption and development were also studied, and when considered together with several other parameters, the error could be reduced to 1—2 weeks.

Maneely (1952) in a general survey, stressed the need for a standard technique and in agreement with *Asdell* (1946) was sceptic about breed differences in relation to age in young foetuses.

Individual variations in the amount of foetal fluids were too great to give any useful information (*Jakobsen* 1958). The same author (1959) demonstrated a significant correlation between age and the circumference and diameter of the foetal head. These measurements cannot, however, be carried out on mummified foetuses, and in these cases the author proposed measurement of the extremities "with ossified foundation" and registration of hair eruption as supplementary parameters (*Jakobsen* 1962).

Most studies concerning age determination have been carried out on bovine material. *Götze* (1960) summed up studies in the horse and stated an error of ± 2—4 weeks.

In human medicine, age determination of foetuses is also of interest, but for other reasons. *Waaler* (1933) recommended measurement of the total length of the foetus, and of the circumference and diameter of the head. In putrefied foetuses, the ossification centres of the bones could give valuable information.

PRESENT OBSERVATIONS

The investigations include foetuses and foetus heads, collected in abattoirs with the help of veterinary inspectors. Foetuses of pregnant cows were taken at slaughter and immediately frozen. The owners were asked about the date of service and the names and the breeds of the cow and the bull. The date of slaughter was noted. Based upon this information the foetus age was fixed. If any doubt about the owner's records, the material was excluded. Otherwise only obviously erroneous material was excluded. For practical reasons — i.e. sending and preserving — only whole foetuses < 135 days were examined. The material > 135 days of age consists of heads only.

X-ray investigations

A. *Foetuses*

No special investigations concerning the development of the bovine skeleton are available at the present time. *Patten* (1948) describes the ossification procedure in general and bases his statements on investigations on swine foetuses. In a later work, *Patten* (1964) transfers these observations to human foetuses, but deals only to a small extent with the ossification sequence. Each of the more than 200 bones in the human skeleton has its own history, but no details are given. The foetuses were cleared in potassium hydroxide and glycerine (up to a length of 49 mm). Older foetuses were x-rayed.

Table 1. X-rayed foetuses.

Age, days	Number of foetuses	Sex			Breed						
		male	fe-male	?	A	B	C	D	E	F	G
55— 60	1	1				1					
61— 65	3	1		2	1	1				1	
66— 70	2		2			1	1				
71— 75	1		1			1					
76— 80	2	1	1		2						
81— 85	2		2				1	1			
86— 90	3	1	2			1	1			1	
91— 95	3	1	2			1				2	
96—100	6	2	1	3	1		2			3	
101—105	5	1	4		2	2	1				
106—110	4	2		2	1	1		1		1	
111—115	6	1	4	1	3	1				2	
116—120	9	6	1	2		3	3		1	2	
121—125	4	2	2		1		2				1
126—130	5	2	3			1	4				
131—135	6	2	1	3	1	2	1			1	1
136—140	1		1				1				
141—145	1		1		1						
Total	64	23	28	13	13	16	17	2	1	13	2

Breeds:
A: Norwegian Red and White Cattle
B: Nordland Cattle
C: Maalselv Cattle
D: Norwegian Red Poll
E: Trönder Cattle
F: Cross-bred
G: Unknown

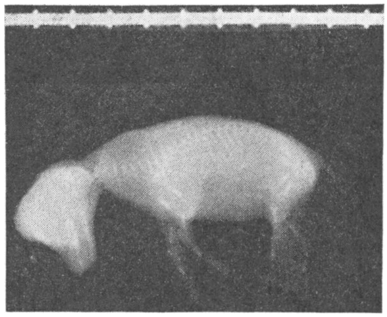
Zietschmann & Krölling (1955) summed up studies on the ossification sequence in swine foetuses corresponding to certain foetus lengths. Concerning the bovine skeleton they gave but a short survey.

The present investigations include 64 foetuses. The distribution with respect to sex and breed is given in Table 1.

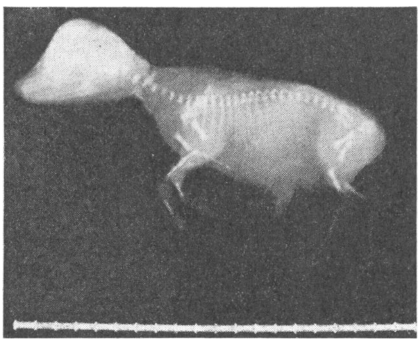
The foetuses were thawed and x-rayed with the extremities and the head parallel with the film (Figs. 1—3).

Table 2 describes the observations on ossification and indicates a certain sequence in the ossification procedure.

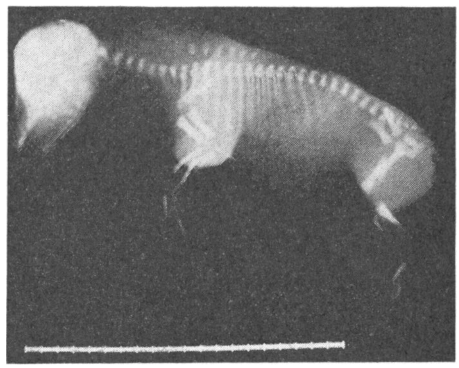
Table 2 extends to 48 parameters, but these only permit suggestions of foetus age. The interpretation of the degree of ossification based upon x-ray observation will, to a certain



F i g u r e 1. Bovine foetus, 66 days. x-ray photograph.



F i g u r e 2. Bovine foetus, 109 days. x-ray photograph.



F i g u r e 3. Bovine foetus, 120 days. x-ray photograph.

extent, be subjectively influenced because the borders of the ossification zones cannot always be pinpointed distinctly.

With more accurate and detailed analysis of the observations, some distinctly marked boundaries of the ossified bones could be measured precisely. The metacarpal and the metatarsal bones, apparently, seemed to grow straight in the lengthwise direction during ageing. This also seemed to be the case with respect to the length of the head.

B. *Special skeletal formations*

a) The cranium. The heads of 175 foetuses, 56—276 days old, were sagittally sectioned with a band-saw while still frozen, thawed and x-rayed with the medial side against the film. Both

Table 2. Ossification sequence of the bovine skeleton based upon x-rayed foetuses. Length measurements in mm.

Age, days	55-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130	131-135	136-140	141-145
Cranium	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Occip. bas.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
„ exo.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
„ supra.			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pariet. & front.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sphenoid			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ethmoid							+	+	+	+	+	+	+	+	+	+	+	+
Conchae										+	+	+	+	+	+	+	+	+
Hyoid.									+	+	+	+	+	+	+	+	+	+
Maxill. & pal.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nasal.					+	+	+	+	+	+	+	+	+	+	+	+	+	+
Incis. pr. nas.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
„ „ pal.									+	+	+	+	+	+	+	+	+	+
Mandib.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Proc. paramast.						+	+	+	+	+	+	+	+	+	+	+	+	+
Sinus front.									+	+	+	+	+	+	+	+	+	+
Teeth									alv.	gobl.	+	+	+	+	crown	+	+	+
Vertebrae																		
Cerv. & thor.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pr. spin. thor.										5	7	7	8	8	8	8	8	8
Lumb. & sacr.		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Coccygeal.					5	10	+	+	+	+	+	+	+	+	+	+	+	+
Costae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Stern. Ossif. points						5	5	5—6	5—6	6—7	6—7	7	7	7	7	7	7	7
Hum. Diaph. length		4	5	5	7	9	10	11	13	15	17	19	21	23	24	27	30	34
„ Dist. epiph.										+	+	+	+	+	+	+	+	+
Rad. Diaph. length		4	5	6	7	9	11	12	13	16	18	20	22	23	26	29	32	35
„ Prox. epiph.											+	+	+	+	+	+	+	+
Femur. Diaph. length		4	5	5	7	9	10	12	14	17	19	22	24	26	29	32	36	40
„ Dist. epiph.																+	+	+
Tibia. Diaph. length		4	5	6	8	10	12	13	15	18	21	23	26	29	31	33	38	
„ Prox. epiph.																		
Scapula		diff.	+	+	+	+	+	dense	+	3-edged	+	+	+	+	+	+	+	+
Ilium length			+	6	7	7	7	9	11	13	14	17	19	20	21	25		
Ischium length			+	+	3	4	5	7	9	10	11	13	14	15	16	18		
Carp. & tars.							?	?	diff.	diff.	+	+	+	+	+	+	+	+
Mc. Diaph. length		2	3.5	3.5	5	7	8	9	10	13	15	17	18	20	21	23	24	27
Mt. „ „		2	3	3.5	5.5	8	9	10	11	15	16	20	21	23	24	26	30	
Calcaneus									round	+	+	+	ellipt.	+	+	+	+	+
Phal. I-II-III						+	+	+	+	+	+	+	+	+	+	+	+	+

Table 3. X-rayed foetus heads. Distribution in breeds and sexes.

Nordland Cattle	37
Tröuder Cattle	32
Norwegian Red and White Cattle	29
Maalselv Cattle	42
Norwegian Red Poll	7
Döla Cattle	13
Cross-bred	15
Males	77
Females	77
Unknown sex	21

halves were photographed. The material includes breeds and sexes as given in Table 3.

The boundaries of the ossified cranium were distinct. The distance from the occipital crest to the labial tip of the incisive bone was measured on the x-ray photograph (Figs. 7—11). The results are given in Fig. 4 as a function of the age, and appear as an approximate straight curve with minor scattering.

36 of the measured heads proportionally fell far outside the curve. The owners of the animals were asked about the accurate

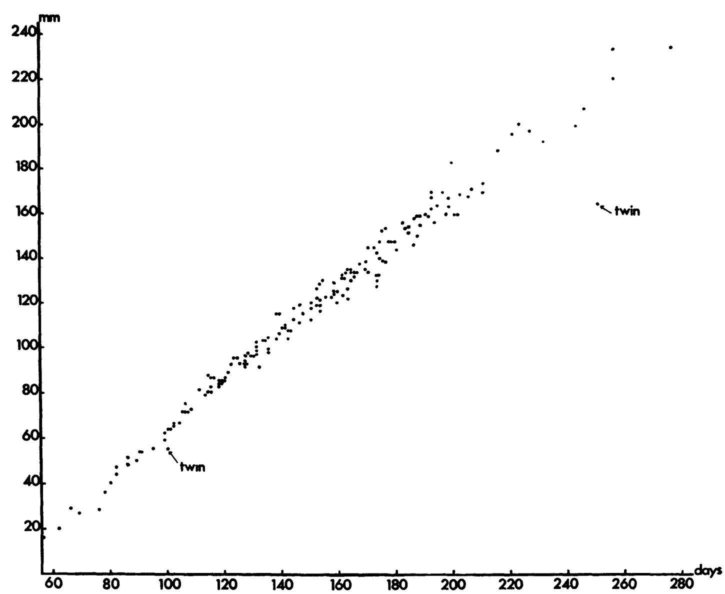


Figure 4. The length of the cranium as a function of the age.

Table 4. X-rayed metacarpal and metatarsal bones. Distribution in breeds and sexes.

Nordland Cattle	16
Norwegian Red and White Cattle	12
Maalselv Cattle	13
Norwegian Red Poll	3
Cross-bred	7
Males	22
Females	19
Unknown sex	10

date of service, and the necessity for correct information was pointed out. Only 1 of the 36 owners persisted in his previous statement. According to the owner the foetus in question should be 120 days old, and according to the curve it should be 110 days. This was the only considerable deviation. The remainder of the foetuses in question (24 owners deducted from the previously given date — 11 did not answer) were excluded from the material because of doubtful information.

b) The metacarpus and the metatarsus. The metacarpal and the metatarsal diaphyses show distinct boundaries on x-ray photographs at a foetus age of 60 days (Figs. 1—3). The material includes measurements of 51 foetuses in the age group 66—146 days. The distribution in breeds and sexes is given in Table 4.

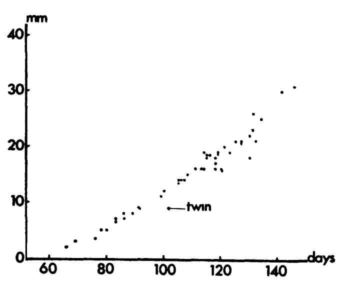


Figure 5. The metacarpal length as a function of the age.

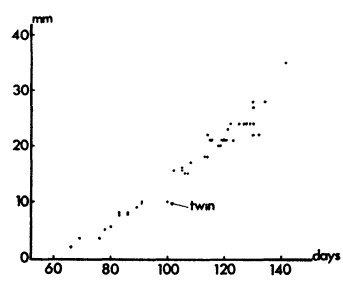


Figure 6. The metatarsal length as a function of the age.

The observations are given in Figs. 5 and 6 as functions of the age on an approximate straight curve with some scattering. In accordance with the head measurements, 2 twins were located far outside the curve.

A B. *Statistical analyses*

a) The length of the cranium in relation to age.

Breed. No significant difference was found between breeds concerning the regression of cranium length on age. The coefficients of regression varied between $b = 1.052 \pm 0.018$ for Maalselv Cattle and $b = 0.941 \pm 0.044$ for Döla Cattle. Breeds were, therefore, ignored.

Sex. No significant difference was found between sexes concerning the regression of cranium length on age. The highest coefficient was found for male ($b = 1.040 \pm 0.040$) and the lowest for unknown ($b = 1.074 \pm 0.023$).

Age group. Owing to a great variation in foetus age, the data were divided into the following groups:

< 110 days
111—155 days
156—200 days
> 200 days.

No significant difference was found between the coefficients of regression, which were $b = 1.001 \pm 0.085$ for the oldest group and $b = 1.148 \pm 0.036$ for the youngest group.

The regression of the cranium length on age was, therefore, estimated on the total material, which gave $b = 1.035 \pm 0.009$, i.e.:

$$y_{cranium} = 118 + 1.035\,(x_{age} - 151) = -38.5 + 1.035x \quad (I).$$

The coefficient of correlation between the cranium length and the age was estimated to $r = 0.9934$, i.e. $(r)^2$ — 98.7 % of the variation of the cranium length can be ascribed to the age of the foetus.

In order to investigate whether the function of the cranium length on the foetus age was a straight or curved line, a multiple analysis of regression, including age squared, was carried out:

$$y_{cranium} = -52.88 - 1.237x_{age} - 0.000652x^2_{age} \quad (II).$$

Owing to the great variation in age, even small deviations from linearity will give significant effect. The equations (I) and (II) do, however, explain about the same percentage of the total variation. The linear regression is, therefore, preferred. In Table 5 the confidence limits for equation (I) are given.

Table 5. Confidence limits of function (I) at different ages expressed in mm referring to a concrete age.

Days (age)	50	100	151.4	200	220
$t_{.05}s_y$	± 11.15	± 9.94	± 9.56	± 9.22	± 10.31

The scope of the investigations and the use of the results are, however, the measuring of x_{mm} and estimation of an unknown y_{age}. This will lead to:

$$y_{days} = 38.5 + 0.9537\, x_{mm} \quad \text{(III)}.$$

The confidence limits of equation (III) are given in Table 6.

Table 6. Confidence limits of function (III) at different cranium lengths expressed in days referring to a concrete cranium length.

Cranium lenght$_{mm}$	50	100	118	150	200
$t_{.05}s_y$	± 9.80	± 9.25	± 9.17	± 9.33	± 10.07

b) *The length of the metacarpus and metatarsus in relation to age.*

The measurements include 51 foetuses. The error in the estimates will, therefore, be relatively large. The coefficients of correlation were estimated to $r_{mc} = 0.98$ and $r_{mt} = 0.978$, i.e. 96 % and 95.6 % of the variation of the diaphysis length can be ascribed to the age of the foetus.

Measurements of the cranium length, were, therefore, preferred.

c) *The teeth.*

Enamel formation begins at the tip of the crown which is well formed when formation of the root has just made its start. At an age of 11 weeks the enamel organ in human foetuses can be compared to an inverted goblet (*Patten* 1964).

Later, calcification occurs, according to *Kraus* (1959) at an age of 3 months, according to *Patten* (1964) at 19 weeks, — and in swine foetuses at 130 mm length (*Patten* l. c.). The formation of the dentine is in connection with the formation of the enamel. The root increases in length during tooth eruption and does not acquire its full length until the crown has entirely emerged (*Patten* l. c.).

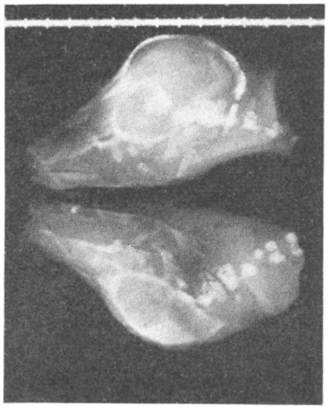


Figure 7. 127 days.

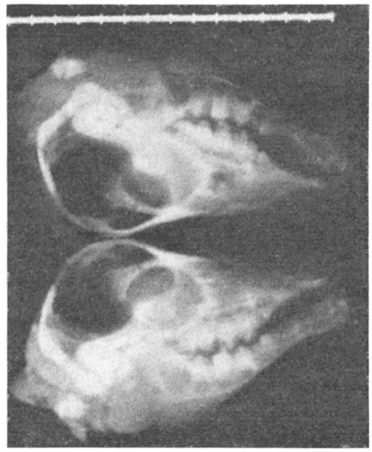


Figure 8. 173 days.

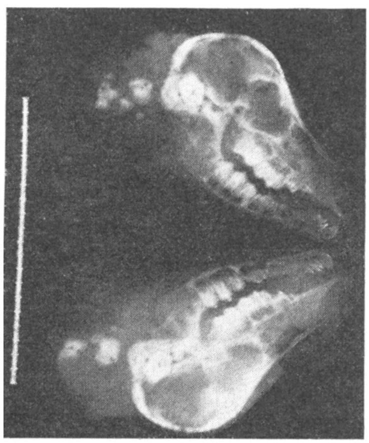


Figure 9. 192 days.

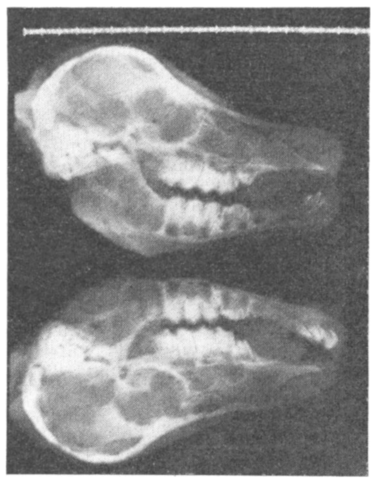
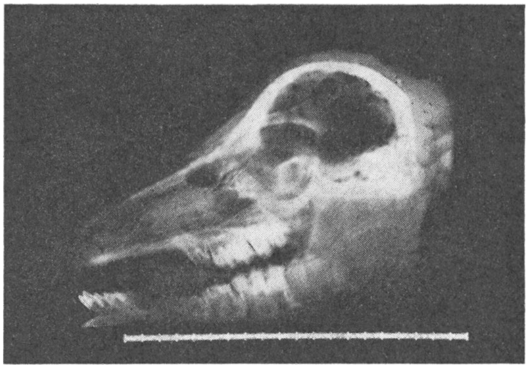


Figure 10. 210 days.

Stack (1960/61) states correlation between ashed human teeth and the foetus age.

In the present investigations small tooth formations could be identified by x-ray on sagittally sectioned heads of foetuses 96 days of age. These formations were, however, obscure shadows and difficult to describe. After the 120th day some of the teeth were distinct. Owing to technical reasons (the x-raying of sagittally sectioned heads) the investigations include the development



F i g u r e 11. 242 days.

of the cheek teeth only. These teeth show, however, a distinct sequence in appearance and in the formation of the crown, the indentations, the roots, the pulp cavity etc. Figs. 7—11 illustrate the development of the cheek teeth in foetuses of different ages.

The successive development of the single tooth and the observations during the growth process do not permit any use of objective parameters. The earliest tooth formation is described as a small or high goblet, — narrow or broad, which later is termed crown formation with small or deep indentations. Some of the crown formations begin as 2 or 3 isolated goblets or components which later join together to build a crown profile. Small extra points or tops sometimes occur on the goblet in a labial or nuchal location, and the profile of the crown is then termed 2-, 3-, or 4-waved. The root formations are first described to be diffuse, later they become distinct or definite, as does the alveolar cavity, which undergoes division by septa. These processes lead to fully developed crowns, roots and teeth.

The appraisal must thus be subjective. Age determination based on tooth development, therefore, requires a wide selection of x-ray photographs of foetuses of known age, and observations must be compared to this known material. At this department a sufficient number of x-ray photographs for this purpose is available. This method for age determination has been tested by masking x-ray photographs of known age and interpreting them in relation to a series of photographs. The maximal error of this test was ± 4 days. This postulate is empirically founded.

A description of the sequence of tooth development is given in Fig. 12.

The hair growth

Bergmann (1922) observed hair growth on the muzzle and in the eye region of bovine foetuses at the end of the 4th month of foetus age, and in the middle of the 6th month also on the eyelids, in the horn region and on the edge of the ear.

Postma (1947) has given a general survey on hair eruption in bovine foetuses. Eruption of hairs was first observed at an age of 15 weeks — on the upper and lower lips and on the eye brows. The first eye lid cilia (dorsal) were visible intraepithelially at 23 weeks and were in eruption during the 24th week. On the tip of the tail and along the edge of the ear, hairs were in the process of eruption during the 26th week. At the same time hair eruption started at the hoof border and below the ventral commissure of the vulva. Small intraepithelial zones of hairs in the face, and dense hair growth on the inner face of the ear occurred at an age of 27 weeks. During the 28th week hair eruption could be observed over the extremities and in the umbilical region. Short, diffuse hair cover was present all over the body at an age of 30—33 weeks, and dense and full growth at 35 weeks.

Götze (1960) summed up the sequence of hair growth stated by other investigators, and said generally that age determination based on hair eruption is safer than measurements and weights in "unusual cases".

Jakobsen (1962) describes the length of individual hairs on the upper lip in foetuses of 122—229 days of age, on the eye lids of the age group 194—229 days, and on the tail, the metacarpus and on the metatarsus in foetuses > 163 and > 173 days of age, respectively. He describes the further hair growth in this way: Hairs occur in the horn region at 5—5½ months of age, around the ear entrance at 5½ months, around the eyes at 6—6½ months, and total hair cover at 7½ months. As a conclusion of these investigations on hair growth and his measurements of the extremities and the head referred to earlier in this work he states that these registrations give a reliable basis for age determination, because these matters are not influenced by the mummification process. — With maceration, however, the hairs are loosened and lost (*Schmaltz* 1921).

The material in the present investigations includes heads of foetuses > 130 days of age. In all, hair eruption in 235 foetuses is examined. The results are shown in Fig. 13.

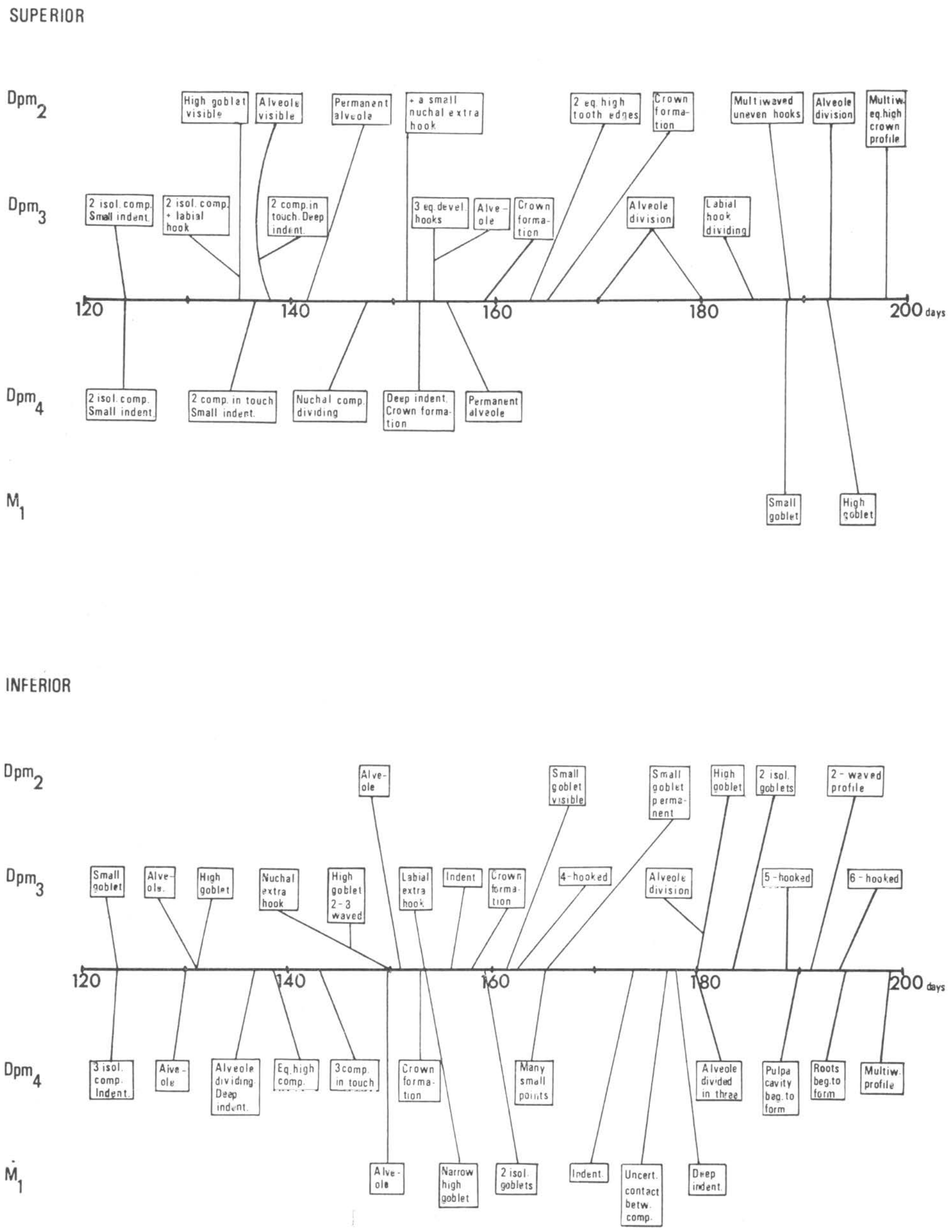
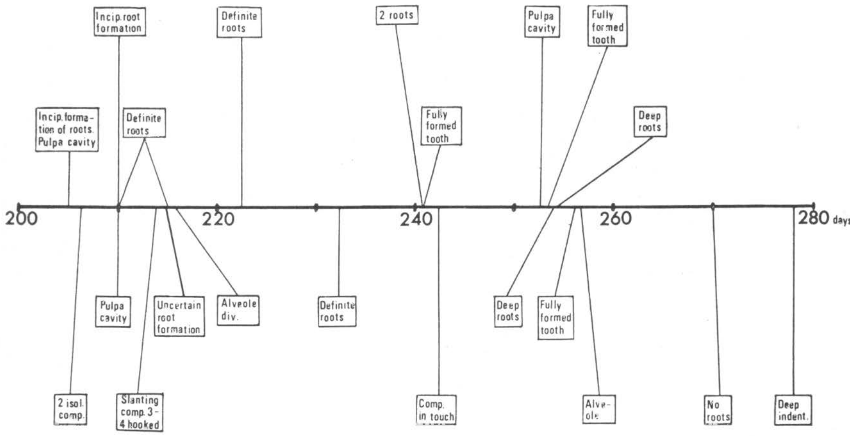
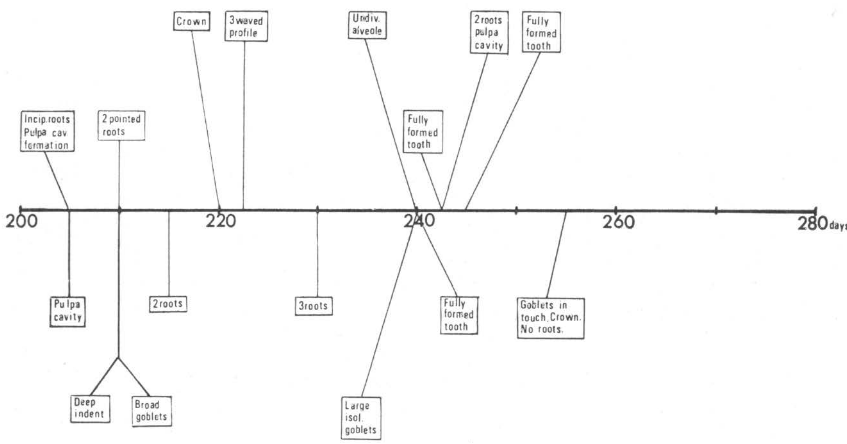


Figure 12. The sequence of tooth formation.


Incip. root formation
Definite roots
2 roots
Pulpa cavity
Fully formed tooth
Incip. formation of roots. Pulpa cavity
Definite roots
Fully formed tooth
Deep roots
200
220
240
260
280 days
Pulpa cavity
Uncertain root formation
Alveole div.
Definite roots
Deep roots
Fully formed tooth
2 isol. comp.
Slanting comp. 3-4 hooked
Comp. in touch
Alve-ole
No roots
Deep indent.


Crown
3 waved profile
Undiv. alveole
2 roots pulpa cavity
Fully formed tooth
Incip. roots Pulpa cav formation
2 pointed roots
Fully formed tooth
200
220
240
260
280 days
Pulpa cavity
2 roots
3 roots
Fully formed tooth
Goblets in touch. Crown. No roots.
Deep indent
Broad goblets
Large isol. goblets

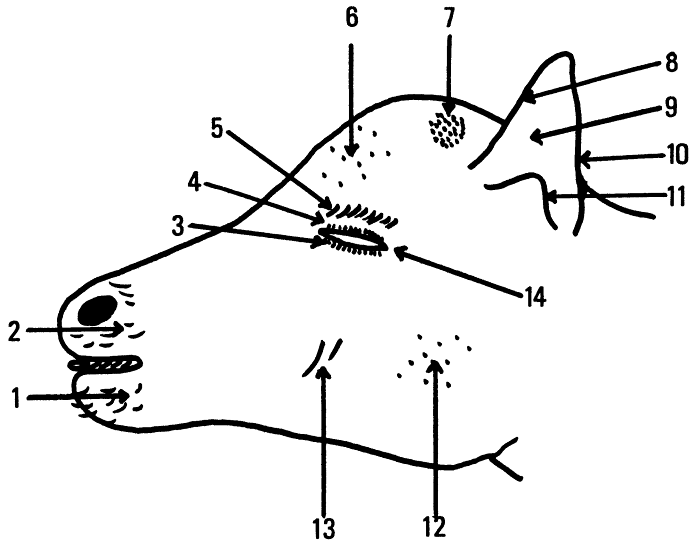


Figure 13. The hair eruption and the growth of the hairs.

1.	Visible intraep.	100—115 d
	Eruption	116—123 d
	3— 5 mm	125—140 d
	6— 7 mm	146—150 d
	8—10 mm	152—158 d
	10—12 mm	161—174 d
	12—20 mm	175 d
2.	Visible intraep.	100—113 d
	Eruption	115—123 d
	3— 5 mm	127—140 d
	6— 7 mm	142—150 d
	8—10 mm	152—158 d
	10—12 mm	160—174 d
	12—20 mm	178 d
3.	Visible intraep.	113—145 d
	Eruption	152—168 d
	1—3 mm	173—180 d
	4—5 mm	187—192 d
4.	Visible intraep.	100—142 d
	Eruption	145—152 d
	1—3 mm	158—170 d
	4—7 mm	173—192 d
5.	Visible intraep.	100 d
	Eruption	113 d
	2— 3 mm	123—129 d
	3— 5 mm	130—144 d
	5— 8 mm	145—156 d
	7—10 mm	160—169 d
	10—12 mm	170—175 d
	12—15 mm	176—180 d
	16—20 mm	180—187 d
	20 mm	190 d
6.	Visible intraep.	187 d
	Eruption	205 d
7.	Eruption over horn region	185 d
8.	Eruption	175—180 d
	2—3 mm	180—185 d
	3—5 mm	185—190 d
9.	Visible intraep.	163 d
	Eruption	170—178 d
	Dense hairs	180 d
10.	Eruption	160 d
	2—3 mm	165—174 d
	3—5 mm	175—185 d
11.	Eruption	158 d
	2—3 mm	160—165 d
	3—5 mm	170—180 d
	6 mm	190 d
12.	Visible intraep.	200 d
13.	1—2 single hairs	
	Eruption (inconstant)	130 d
	2— 3 mm	130—140 d
	3— 5 mm	130—140 d
	6— 8 mm	140— d
	8—12 mm	—170 d
14.	Eyecleft opening	161 d

Zones small intraep. devel. hairs	187—200 d
Zones hair eruption	195—210 d
Dense and short hairs	210—231 d

DISCUSSION

Previous investigations on age determination have all been founded upon the correlation between certain measurable parameters and the age of the foetus. Most of the authors have based their results upon material collected in abattoirs, and thus, relied on details of the foetus age supplied by others, and which, to a certain extent, may be erroneous. From a scientific point of view, this information may be doubtful. On the other hand, the collection of foetus material in quantity in this way is the only method possible. This method of collection, therefore, has also been used during the present investigations.

Most of the information supplied by the farmers concerning conception, breed etc. will probably, due to modern husbandry principles, be sufficiently reliable. One has, however, to exclude from the material specimens about which the information given is evidently erroneous. There will nevertheless exist a certain degree of uncertainty regarding the reliability of details concerning the age. Wrong information may alone eventually turn the scale in the statistical deviation analysis.

The measurements of body length have been the main method for age determination since Gurlt's days. With minor exceptions, it is generally agreed that the method is the best one. Undoubtedly, however, the extreme extension of the body of the dead foetus to a straight back line may give false measurements. Firstly, 1 foetus may differ from another as to which degree an extension of the back, the head and the limbs is possible. Next, the technical question of measuring a distance between the 2 exact end points of a line which are covered by muscles and skin may cause difficulties. The foetuses cannot all be stretched to the same extent owing to diversities with regard to contractures, varying texture due to putrefaction etc. *Schjött-Rivers* (1965) warns against the reliability of the length measurements in human foetuses, and states that from a technical point of view, weighing necessarily will assure greater accuracy. On the other hand, he generally warns against weighings as well, because weighings do not permit sufficiently safe conclusions either.

Concerning mummified foetuses, *Jakobsen* (1962) states that certain measurements of the extremities correlate significiantly with foetus age, thus being sufficiently reliable parameters for age determination on foetuses > 3 months of age. These statements can scarcely be applied to macerated foetuses. The resorption of soft tissue, i.e. the uncalcified parts of the skeleton formations, may cause considerable mistakes. In mummified foetuses, shrinkage must be taken into consideration. The contractures, which are commonly marked during the mummification procedure, will also make an equal degree of extension doubtful. Mummified and macerated foetuses require special interest because the problem of age determination is often connected with or caused by irregular pregnancies.

By using measurements of ossified bone formations on the x-ray photographs, the mentioned possibilities for error will be avoided. This is evident with respect to the metacarpal and the metatarsal bones. In the case of the cranium, an extreme degree of maceration may cause displacements of the individual bones due to the complexity of the cranium, and thus lead to misinterpretations. Any displacement will, however, possibly be diagnosed on the x-ray photograph, and mistakes, therefore, be rare. Owing to the very high correlation between head length and foetus age, measurements of the cranium is to be preferred, even though the metacarpal and the metatarsal diaphyses may be useful bases.

Whatever bone formations are chosen for age determination purposes, both the head and the extremities below the carpal and tarsal joints are minor parts of the body, which can be easily forwarded in a parcel to a laboratory or clinic with an x-ray apparatus available.

Totally macerated foetuses have not been investigated, owing to the difficulty connected with the exact dating of the time of foetus death. One may, however, postulate the possibility of founding age determination on length measurements of the metacarpal and the metatarsal bones in the uterine cavity.

In very young foetuses, i.e. < 120 days of age, the general development of the skeleton can be used as an approximate method for age determination. The interpretations must, however, be relative referring to known material, and a broad spectrum of x-ray photographs is thus required. The sequence of the ossification procedure, so far, is evident, but the results depend to a large extent on subjective appraisement.

This is the case, too, concerning tooth growth. Even though one can easily recognize a typical sequence with regard to the formation of goblets, indentations, crowns and roots etc., any detailed description of tooth development must be subjective.

A wide collection of x-ray photographs for comparison is therefore necessary.

Concerning hairiness, registration of the eruption and the growth of the hairs have been recommended in age determination by several investigators. This was the first method examined by the present author. The method, however, seemed unsafe, perhaps because of lack of experience and of material for comparison. Hair eruption and the sequence of hair appearance in the different regions of the body as stated by *Postma* (1947) can easily be observed on fresh material. Measurement of the length of the individual hairs and differentiation between intraepithelial hair formations and hairs in the process of eruption, may cause technical difficulties, and thus be submitted to subjective appraisal, even with fresh material. The method is at all events not suitable for investigations on macerated material where the hairs fall out and cannot be recognized with regard to the region from which they have been discharged.

As a rough and quick method, applicable to general veterinary practice, a modification of the x-ray measuring method shall be mentioned: Following sagittal sectioning of the head, the distance is measured between the occipital crest, which can be easily recognized due to a high degree of ossification and distinct borders, and the tip of the incisive bone. This tip may, however, be difficult to recognize precisely as it has a diffuse border. The measured distance in mm can then be used in formula III (see page 206).

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SUMMARY

The need for methods for age determination of foetuses is defined.

X-ray examination of the foetal head is recommended as the surest basis for age determination. Calculations are made concerning the correlation between cranial length and foetal age, and the methods used for measurements are described in detail. Measurements of the metacarpus and metatarsus may also be used, but they give a poorer correlation. A formula is worked out for age determination based on cranial measurements.

On x-ray photographs, tooth development is seen to occur in an obvious sequence. This is described. However, the interpretation of these observations is subjective and requires control material for comparison.

The same is true for the sequence of ossification of the skeleton, which in foetuses < 120 days gives the surest basis for evaluation. Here, too, a wide range of control material for comparison is necessary.

The sequence in the appearance of body hair — development and eruption — is noted, as far as the head is concerned. This alone gives an insecure basis for evaluation.

By using the 4 systems of parameters mentioned, the age of a foetus can be determined within an error of $\pm$ 4—5 days.

ZUSAMMENFASSUNG

Altersbestimmung am Rinderfetus.

Der Bedarf an Methoden zur Altersbestimmung von Feten wird angegeben.

Der Verfasser empfielt röntgenologische Untersuchungen am Kopf der Früchte als die zuverlässigste Grundlage zur Altersbestimmung. Es wurden Korrelationsberechnungen über die Länge des Schädels und das Alter der Frucht vorgenommen. Die Messungsmethoden werden in Einzelheiten beschrieben. Messungen von Metacarpus und Metatarsus sind auch anwendbar, geben jedoch eine geringere Korrelation. Eine Formel zur Altersbestimmung basiert auf Messungen am Schädel ist ausgearbeitet worden.

Die Entwicklung der Zähne tritt auf den Röntgenogrammen mit deutlicher Sequenz hervor. Sie ist beschrieben worden, jedoch sind die Auslegungen und die Beobachtungen subjektiv und verlangen ein Vergleichungsmaterial.

Dasselbe gilt der Verknöcherungssequenz im Skelett, die bei Feten unter 120 Tagen die zuverlässigste Beurteilungsgrundlage aufweist. Hier ist ebenfalls eine grosse Vergleichungsgrundlage notwendig.

Die Behaarungssequenz — Haarentwicklung und Auftreten — ist was den Kopf betrifft registriert worden. Die Behaarung allein gibt eine unsichere Beurteilungsgrundlage.

Bei einer gesamten Beurteilung der vier erwähnten Parametersysteme kann eine Altersbestimmung der Früchte mit einem Fehler von $\pm$ 4—5 Tagen vorgenommen werden.

SAMMENDRAG

Aldersbestemmelse av storfefostre.

Behovet for metoder til aldersbestemmelser av fostre er presisert. Forf. anbefaler røntgenologiske undersøkelser av fosterhodet som det sikreste grunnlag for aldersbestemmelse. Korrelasjonsberegninger over kranielengden og fosteralder er utført, og målingsmetodene beskrevet i detalj. Målinger av metacarpus og metatarsus er også anvendelige, men gir lavere korrelasjon. En formel for aldersberegning basert på kraniemålinger er utarbeidet.

Tannutviklingen fremtrer med tydelig sekvens på røntgenogrammene. Den er beskrevet, men tolkninger av observasjonene er subjektive og krever sammenligningsmateriale.

Det samme gjelder forbeningssekvensen i skjelettet, som hos fostre < 120 dager gir det sikreste vurderingsgrunnlag. Også her er et bredt sammenligningsmateriale nødvendig.

Behåringssekvensen — hårutvikling og frembrudd — er registrert forsåvidt gjelder hodet. Behåringen alene gir usikkert vurderingsgrunnlag.

Ved en fellesvurdering av de 4 nevnte parametersystemer kan aldersbedømmelse foretas med en feil på ± 4—5 dager.

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