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An evaluation of some criteria for age determination of the Pronghorn (Antilocapra americana Ord)

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AN EVALUATION OF SOME CRITERIA FOR AGE DETERMINATION OF THE PRONGHORN (*Antilocapra americana* ORD)

by

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Chairman of Examining Committee

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Dean of the Graduate School

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[1] Fish and Wildlife Service, Montana Fish and Game Department, Montana State University, and Wildlife Management Institute, cooperating.

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INTRODUCTION

This study is an attempt to add to knowledge of the life history of the Pronghorn (Antilocapra americana Ord) through a study of age criteria.

Several factors made it possible to study known-age specimens. State Fish and Game Department officials agreed to supply an experimental herd of pronghorn antelope and the superintendent of the National Bison Range cooperated by allowing the experimental herd to be confined there. With these physical facilities available the study was begun.

A review of the literature indicated that the methods currently being used to determine the age of Pronghorn were based on external appearance and horn characteristics which had not been substantiated by known-age specimens. McKean (1943) organized checking station data into "approximate" age groups without explaining the basis for determining age. Einarsen (1948) illustrated his book with excellent photographs of known-age fawns and yearlings but unfortunately these specimens were neither collected nor described in detail. McLean (1944) described the horn growth and subsequent shedding in fawns, yearlings and those $2\frac{1}{2}$ years of age, but did not mention how their ages were determined. In 1944 Rush wrote that the horns emerged on a pet fawn in Montana at the age of four months.

The need for an accurate method of age determination was clearly indicated by Buechner's treatment of biotic potential and life span in his publication "Life History, Ecology, and Range Use of the Pronghorn Antelope in Trans-Pecos, Texas" (1950). In analyzing the biotic potential of the Pronghorn, Buechner used the numbers of fawns recorded from annual

trapping operations as an indication of reproduction and the slight increase in the total herd as a method of indicating that the mortality rate was slightly exceeded by the annual increment. If an adequate hunter kill sample could have been obtained and a reliable method of age determination applied to these data, Buechner could have established a survival curve for the herd and could have determined the mortality rate for each age group within the total population. Furthermore in calculating the biotic potential of the species, it is extremely important to know what proportion of fawns eventually reach breeding age and how long the individuals in each succeeding age class remain in the population as potential breeders.

In contrast to this lack of information for use in the management of the Pronghorn is the abundance of pertinent facts in the life history of the White-tailed Deer that are available for its effective management. In 1948 Severinghaus published criteria for age determination of White-tailed Deer based on the patterns of tooth succession and subsequent wear. This has enabled game managers to determine herd composition, life span, and the slope of the survival curve of this species. This age determination technique, when applied to a suitable sample from the hunter harvest, has also indicated the variations in mortality in each age class from year to year, and the relative survival of each age class from one year to the next (Severinghaus, 1951). It was evident that if a reliable means of age determination of the Pronghorn could be found, then it would be possible to effect better management of the species through a better evaluation of mortality and survival rates. Accordingly this study was undertaken with two general objectives in mind; first to acquire a series of known-age antelope specimens, and secondly, to study each specimen

in order to develop a method of age determination suitable for use in the management of the species. This study covers some of the developmental changes in structure occurring between birth and $2\frac{1}{2}$ years. Data on tooth development and wear were used to correlate additional criteria that might be used for identification of the older age classes.

Field observations were conducted on the experimental herd at the National Bison Range and in areas of eastern Montana that support large numbers of Pronghorn.

METHODS AND MATERIALS

Experimental Animals

The experimental herd was provided by the Wildlife Restoration Division of the Montana Fish and Game Department. These animals were selected from those that were live-trapped on a "problem area" near Gardiner, Montana, on February 12, 1951. The technicians who were supervising the trapping operation had previously indicated that they could distinguish fawns and yearlings from the older age groups. Consequently a request was made for the animals to be used in this study to consist of the following classes and numbers:

Does, 1½ years or older	7
Yearling bucks (fawns of 1949)	3
Fawns (born in 1950)	5
Total	15

The animals were delivered to the Bison Range on February 14th and were released in good condition the same day.

The first 2 specimens were collected in June. These were assumed to represent specimens of approximately 12 and 24 months of age, but upon examination both specimens proved to be almost identical in stage of tooth eruption and the amount of wear. Externally these animals appeared quite different in size, horn development and behavior. Subsequent collections of the "yearling" males showed that all of them were fawns at the time of trapping. The actual composition of the herd provided for use in the study was consequently as follows:

Does, 1½ years or older	7
Male fawns (born in 1950)	4
Female fawns (born in 1950)	4
Total -	15

Tagging and Marking

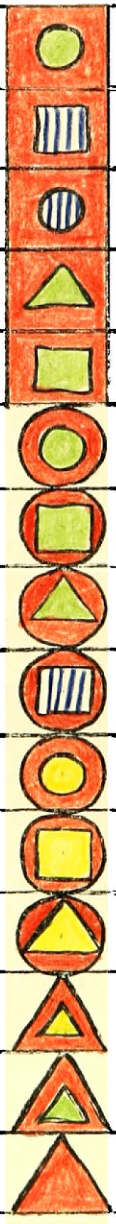
The original 15 animals were tagged by Montana State Fish and Game Department personnel. As each animal was removed from the trap a 1½ x 1½ inch plastic color marker was fastened to the left ear by piercing both the marker and the ear with a numbered metal stock tag. By using variations of color and shape it is possible to mark many animals differently in this way (Johnson, 1951).

Each marker consisted of 2 pieces of plastic cemented together with acetone. The background color was red and the shape was different for each sex and approximate age group. Individuals within each class were designated by cementing contrasting colors of different shaped plastic to the basic marker (Table 1).

The Bison Range comprises approximately 18,000 acres of rolling grazing land at elevations between 3,000-4,500 feet (Figure 1 and Plate 1). The north facing slopes support stands of ponderosa pine (Pinus ponderosa Doug.) and douglas fir (Pseudotsuga taxifolia Poir). The shrub types constitute a very small portion of the total vegetation. The remainder of the range is predominantly a grass type with bunch wheat grass (Agropyron spicatum Pursh), Idaho fescue (Festuca idahoensis Elm) and giant wild rye (Elymus condensatus Pasl.) representing the principal native species. There are many other species present but in general the composition closely approximates the description of Palouse Prairie given by Weaver and Clements (1938, 528).

TABLE 1. IDENTIFICATION MARKERS

Sex and Approx. Age	Number	Color Marker
Female fawn	1376	
Female fawn	1384	
Female fawn	1377	
Female fawn	1381	
Male fawn	1387	
Adult doe	1380	
Adult doe	1382	
Adult doe	1379	
Adult doe	1386	
Adult doe	1383	
Adult doe	1385	
Adult doe	1388	
Yearling buck *	1389	
Yearling buck *	1378	
Yearling buck *	1390	



* Later determined to have been fawns at the time of capture.

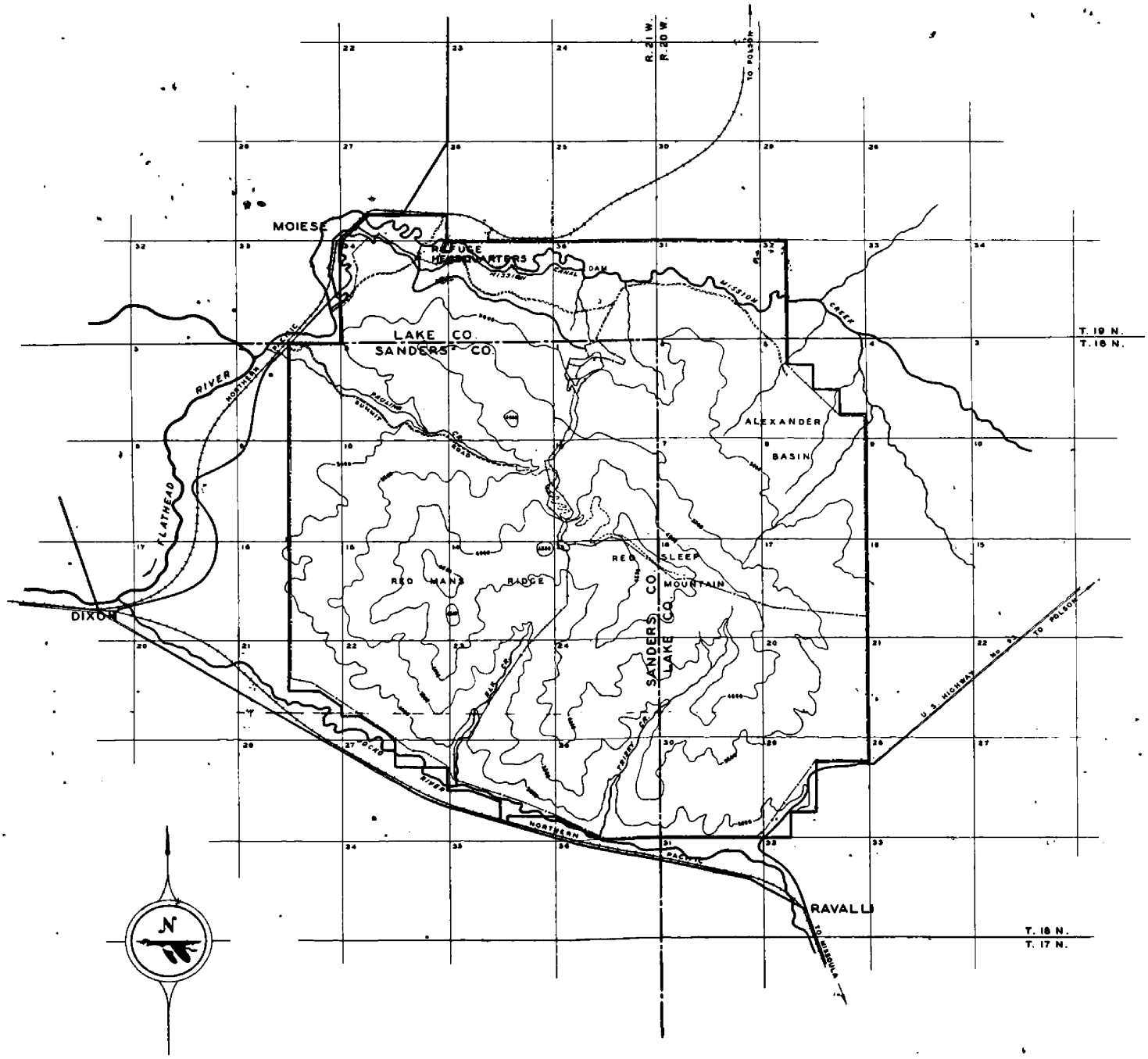
The climatic conditions at the Bison Range are influenced by the Pacific Ocean and are in general milder than those of the eastern part of the state. The annual precipitation averages about 15 inches and the summer period (between killing frosts) averages about 125 days. Temperatures may go below zero in winter and in summer may reach 100° F. (Maughan, 1941).

The entire range is surrounded by a woven wire fence eight feet high and most of the area may be reached by motor vehicle except during periods of wet weather or drifting snow.

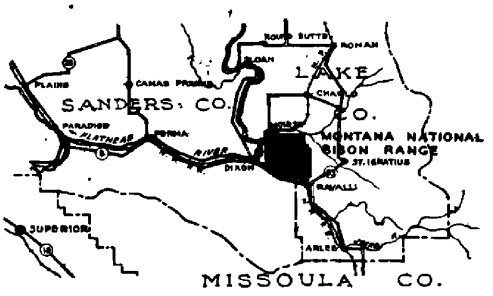
Observation of Does and Marking the Fawns

It was realized that the key to this problem depended on obtaining known-age animals; therefore, considerable effort was expended toward marking the fawns born at the Bison Range.

Records of the dates at which fawns were first seen in Eastern Montana were obtained from the Fish and Game Department and these indicated that most fawns were dropped between May 20 and June 20. Weekly observations were made of the herd released on the Bison Range from February until the end of March. Beginning in April the observation trips were made twice each week and during the latter part of May and all of June and July the author and one or more student assistants camped on the range and observed the experimental herd daily. The herd was usually located with the aid of a 20-power Bausch and Lomb spotting scope and notes were taken regarding individual behavior and location with respect to the herd. Once the animals were located an attempt was made to stalk them. Longer distances were traveled on horseback and close stalking was done on foot or by crawling. During the last week of May the adult does



CONTOUR INTERVAL 500 FEET
DATUM IS MEAN SEA LEVEL



LOCATION MAP
SCALE

LEGEND

- REFUGE BOUNDARY
- FENCE LINES
- PRIMARY ROADS
- SECONDARY ROADS
- TRAILS
- CANALS & DITCHES

PROGRESS STATUS

PROJECTS PROPOSED
" UNDER CONSTRUCTION
" COMPLETED

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF BIOLOGICAL SURVEY

GENERAL MAP

MONTANA NATIONAL BISON RANGE

SANDERS & LAKE COUNTIES

MONTANA

SCALE

WASHINGTON, D.C., APRIL 1939

55 BIS 12

Figure 1

began to leave the herd for short periods of time. When this occurred, the isolated does were observed and no attempt was made to keep the remainder of the herd in sight.

Early each day an attempt was made to locate the entire herd, either by actual count or by recording the individuals seen and checking a roster to determine which individuals were absent. Since does which later proved to be pregnant appeared heavier than either bucks or fawns of the previous year, it was possible to keep a continuous record of their behavior even when the individual marker was not seen. When the morning tally indicated that "heavy" does were absent from the herd, a search was begun until the does were found. It was soon discovered that the isolated does remained in local areas usually in different sections of the Bison Range. By marking their location on a map, it was possible to recognize individuals by their location. It was assumed that the does that had left the herd at the earliest date would give birth first and whenever possible these does were observed intensively. Usually this could be done from a high vantage point without disturbing the animals. Frequently two or more does were away from the herd and it was not always possible to watch both from one lookout. When this occurred the doe thought to be nearest to parturition was watched. Once labor was begun the doe was observed until the fawns were born.

Two does were under observation when parturition occurred and the fawns were tagged approximately one hour after birth.

Fawns were captured in the following manner: at birth or soon after, one observer trained the spotting scope on the place where the fawns were last seen and the author attempted to walk to the fawn or fawns. In the case of two of the fawns, this distance was approximately

one mile and since there were few landmarks the fawns were not found on the first attempt. In this event the hidden observer continued his watch until the doe returned and after the fawns had suckled the procedure was repeated.

Once the fawns were located, they were approached carefully and, when within reach, they were held down with one hand and a dark handkerchief was tied over their eyes. The handkerchief was useful in that the blindfolded fawns did not struggle while they were being weighed and measured. Blindfolding the fawns was described by Nichol (1942).

The following data were recorded: total length, hind foot length, tail length, shoulder height and head length. The fawns were weighed with a Chatillon spring scale which had a capacity of 30 pounds. Notes were taken regarding tooth development and external appearance.

In marking the fawns born in 1951 at the National Bison Range, a slightly different technique was used because during the early part of the study it became evident that the original herd was marked inadequately. With optimum conditions the original markers could not be distinguished at distances greater than 350 yards with a 20-power spotting scope and during periods of fog or other conditions of poor visibility, positive identification could be accomplished at no range greater than 100 yards. In an attempt to increase the distance at which the markers could be distinguished, larger markers were used for marking the fawns. These were plastic squares $2\frac{1}{2}$ x $2\frac{1}{2}$ inches and solid colors only were used. Two squares were used for each fawn, one on the front and one on the back of the same ear, which were held in place by one metal tag that pierced both squares. By using the same color for twins and placing the tags on opposite ears, it would have been possible to mark 8 fawns by using only 4 colors.

Six fawns were captured and marked by this method (Table 2). Some of these animals were subsequently sacrificed to provide the known-age specimens described in a following section.

Two sets of twin fawns were not located at birth and were 3 or 4 days old when first seen. Several attempts were made to capture these without injuring them, but the attempts were unsuccessful.

Table 2. Fawns Marked in 1951

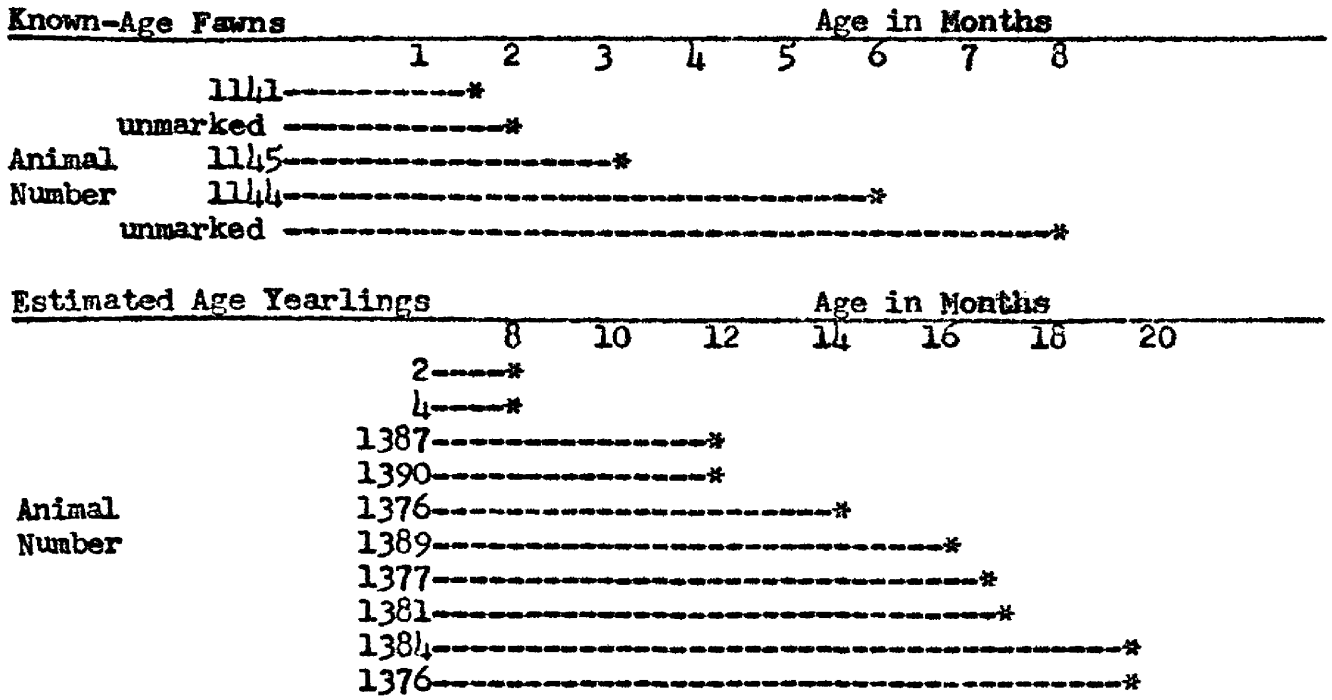
Date of Parturition	Date Marked	Color Marker	Number	Sex
May 30*	May 30	Yellow square, left ear	1141	Male
Twin to 1141 was born dead				
May 31 Twins	May 31	Green square, right ear	1143	Female
May 31	May 31	Green square left ear	1143	Male
June 6* Twins	June 6	White square, right ear	1144	Male
June 6*	June 6	White square, left ear	1145	Female
June 7	June 7	Red square, left ear	1146	Male
Twin to 1146 was not captured				

*Parturition observed

Periodic Sampling of Herd

In an attempt to utilize the experimental animals in the best possible way, a collection schedule was made which assigned an approximate collection date for each animal in the experimental herd (Table 3). The majority of the specimens was collected within 4 or 5 days of the original schedule.

Table 3. Collection Schedule by Age



*-Collected

The above arrangement was used in order that a continuous series of specimens from birth to approximately 2 years of age would be available for study.

From each animal collected the following information was recorded:

Animal number	Total length	Tooth formula
Color tag	Hind foot length	Horn measurements
Whole weight	Tail length	Chest girth
Hog dressed weight	Head length	General condition
Viscera weight	Shoulder height	Parasites

The following material was preserved from each specimen: left front cannon bone, skull, reproductive tract and the hide.

Several types of data were assembled and analyzed in the laboratory with emphasis being placed on dentition changes because this had been found to be the most reliable means for determining the age of some other big game species, Severinghaus (1948) and Murie (1951).

Collection of Hunter Killed Sample

Prior to the 1951 antelope season circulars were mailed to approximately one-third (3,000) of the hunters receiving antelope permits. The circulars explained the purpose of the collection and outlined the procedure to be followed if the hunter wished to cooperate. The jaw containers were $6\frac{1}{2}$ x $9\frac{1}{2}$ inch manila business reply envelopes printed with return address to the Wildlife Research Unit, Montana State University. Approximately 1,500 jaws were received between September and December. These jaws were placed into approximate age groups and used as a supplement to numerical analyses to determine the age composition of the hunter harvest and to attempt to develop a technique for determining the age of animals past the age of 20 months.

All known and established age jawbones were photographed and X-rayed. These techniques were also used to illustrate tooth classes in the specimens which were older than 20 months.

Specific methods will be described later in the section pertaining to each type of material.

FINDINGS

Weights and Measurements

All specimens were weighed soon after death before being eviscerated and the weight recorded as total weight in pounds (Table 4). Hog dressed weight was the total weight less the visceral weight. As used here the viscera included the heart, lungs, trachea, diaphragm, liver, stomach, intestines, kidneys and the reproductive tract. The estimated blood loss was considered with the viscera. The visceral weight was determined by subtracting hog dressed weight from the total weight. Standard measuring technique was used to obtain external body size.

The average total weight of 6 live fawns weighed from one hour to approximately 24 hours after birth was 8.3 pounds, the extremes being 5.8 and 10.0 pounds.

The total weights of the 15 animals weighed at 44 days to approximately 20 months of age showed a rather rapid increase up to the age of 12 months. From 12 to 20 months the weights varied as much as 37 pounds between individuals of the same age. Animal number 1387 was clubfooted and grazed only in the kneeling position. This may account for its small size and weight. The oldest male and the youngest male differed by 44 pounds.

The females averaged lighter in weight than the males in all age classes.

Hog dressed weight averaged approximately 75 per cent of total weight for all ages. By subtraction the visceral weight was 25 per cent of the total.

Total lengths of the 6 live fawns averaged approximately 66 cm., the extremes varying by 11 cm. The total length of all specimens increased

up to the age of 12 months and then remained relatively stable through the age of 20 months. The average length for the specimens between the ages of 12 and 20 months was approximately 142 cm. (Table 4).

Taken as a whole, the weights and measurements approximate a normal growth curve similar to those calculated by Donaldson (1915) for the rat.

Information to be presented in a later section on the growth of the cannon bone also suggests that the skeleton attains its maximum growth at the age of 12 months.

Pelage

The general characteristics of the pelage of the Pronghorn have been adequately described by Skinner (1922), McLean (1943), and Einarsen (1948). In this study, skins were collected from known-age or approximate-age animals at intervals throughout the first 20 months of life; therefore some of the specific changes that occur in color and color distribution may be illustrated by these specimens. The data presented here are in agreement with previous literature in that two molts are recognized in the Pronghorn, one in the spring and the other in the fall.

"The amounts of black, brown, and white differ in the animal according to season, sex and age", Skinner (1922). The above mentioned changes are quite evident in the specimens described in the table below.

Table 4. Weights and Measurements of Experimental Animals

Animal Number	Whole Weight Lbs.	Hog Dressed Lbs.	Viscera Weight Lbs.	Total Length cm.	Hind Foot cm.	Shoulder Height cm.	Chest Girth cm.	Ear	Tail	Age	Sex
E 1141*	10.0			67	28	53	**	**	5	At birth	M.
E 1146*	9.5			70	28	42	42	**	7	At birth	M.
E 1145*	5.8			59	24	49	34	**	5	At birth	F.
E 1144*	6.0			63	24	**	33	**	5	At birth	M.
E 1142*	9.5			70	27	45	42	**	6	At birth	M.
E 1143*	9.0			70	26	45	39	**	6	At birth	F.
E 1141	37	29	8	131	36	72	61	13	9	44 days	M.
Do 7	44	31	13	114	37	72	71	13	11	60 days	M.
E 1145	56	44	12	110	37	71	81	14	9	110 days	F.
E 1144	73	52	21	122	39	76	**	14	8	6 months	M.
Do 2	66	**	**	115	38	80	**	**	9	8 months	M.
Do 20	58	42	16	108	39	75	74	12	8	8 months	F.
El 387	68	53	15	147	42	89	**	14	10	12 months	M.
E 1390	105	82	23	146	44	91	90	15	10	12 months	M.
E 1376	105	84	21	140	42	87	95	14	11	14 months	F.
E 1389	110	82	28	140	44	**	93	14	11	16 months	M.
E 1377	106	74	32	145	43	86	94	15	11	16.5 months	F.
E 1381	96	72	34	140	41	79	**	15	9	17.5 months	F.
Do 1	87	**	**	152	39	85	**	**	10	20 months	F.
E 1384	94	68	26	129	41	80	95	14	10	20 months	F.
E 1378	112	81	31	142	44	95	100	15	9	20 months	M.

* Fawns weighed and measured alive and released.

** Data not available, in most cases because of tissue destruction by shooting.

Table 5. Appearance of Pelage

Number	Age	When Collected	Hair	Cheek Patch	Extent of Dark Facial Markings
			-In Males-		
1141	44 days	July	Fine, lighter in color than adults.	Gray	Brown, extending one-fourth distance from nose-eyes.
Do-7	60 days	August	Coarse, color same as adults	Gray	Approximately as above.
1144	180 days	December	Coarse, color same as adults	Light brown	Approximately as above.
1187	12 months	June	Shedding winter pelage.	Dark brown	Brown extended one-half distance from nose-eyes.
1190	12 months	June	Shedding winter pelage	Dark brown	Approximately as above.
1389	16 months	September	Growing winter pelage	Black	Black extending from nose to eyes and between horns.
1378	20 months	February	Thick winter pelage	Gray	Brown extending one-fourth distance from nose to eyes.
			In Females-		
1145	110 days	September	Growing winter pelage	White	All females had dark brown hair one-third of way from nose to eyes.
1376	14 months	August	Shedding winter pelage	White	
1377	16.5 months	September	Growing winter pelage	White	
1381	17.5 months	November	Growing winter pelage.	White	
1384	20 months	February	Thick winter pelage.	White	

See Plates 2 and 3 for location of cheek patch and facial markings.

The cheek patch of the males was most prominent during the breeding season and became less conspicuous as the winter coat was grown. In male fawns the cheek patch became larger and darker as the animal grew

older but in late winter the cheek patch was almost obscured by the long winter coat.

Although the number of specimens available for this study was small there is an indication that further study would be necessary before pelage change can be properly evaluated as an indicator of age.

Horn Measurements

Both males and females were examined and notes were taken describing horn formation and general condition. If present, the horns were measured in millimeters for total length, circumference at base, spread and length of prong. As used here, total length was the distance from the top of the cranium to the horn tip measured along the outside surface of the horn. The prong was measured from the tip to the anterior surface of the horn along a line perpendicular to the horn proper. The greatest distance between the outside surfaces was recorded as spread.

Table 6. Horn Measurements

Age	Spread	Circumference		Length		Prong Length	
		L	R	L	R	L	R
			----------Males----------				
44 days	60	29	30	9	9	None	
60 days	85	48	50	10	11	None	
6 months	125	85	75	60	65	6	6
8 months	104	80	82	17	18	None	
12 months	103	95	95	130	120	8	10
12 months	127	125	130	163	154	15	16
16 months	215	120	127	188	186	20	20
20 months	200	130	130	215	225	48	52
			----------Females----------				
110 days	No horns. Small whorls of hair						
14 months	No horns. Tufts of black hair, 15 mm. long.						
16.5 months	Horns 25 mm. long, extending 7 mm. above hair line.						
17.5 months	Horns 24 mm. long, extending 8 mm. above hair line.						
20 months	Horns 23 mm. long, extending 6 mm. above hair line.						

Data shown in Table 6 and Figure 1a suggest that the horns of fawns and adults are shed between October and February and are rapidly replaced by the new growth. In Table 6 under the column headed 'length' it may be seen that the first set of horns reached maximum growth by the sixth month and the second set were largest at 16 months. The horns of the 20 month animal were the third set for that particular animal and were still growing at the time of collection.

The first female to have horns of a measurable length was approximately 16.5 months of age and the same animal had the longest horns of the five females that were measured.

More data are needed before horn development can be fully evaluated.

Cannon Bone Measurements

Bone development has been used for many years in sex and age determination of Primates, Wilder and Wentworth (1918). Recently bone growth has been used to determine the age of some game species, Thomsen and Mortensen (1946), Hale (1949). In this study the cannon bone (fused third and fourth metacarpals) was examined for characters to be used in correlating physiological age with chronological age.

As each specimen was collected at the Bison Range, the left front cannon bone was taken and preserved by air drying. The extent of closure of the epiphyseal groove was recorded and each specimen was measured three ways: total length, lateral diameter and the dorso-ventral diameter. Measurements were taken at the narrowest point of the diaphysis. These measurements are summarized in Table 7 and changes in the epipnyseal groove are shown in Plates 4 and 5.

Epiphyseal cartilage was evident in all specimens less than 14 months of age. Ossification of the epiphyseal groove was complete in all specimens from 14 to 20 months.

Figure 1a. Horn Development
(not to scale)

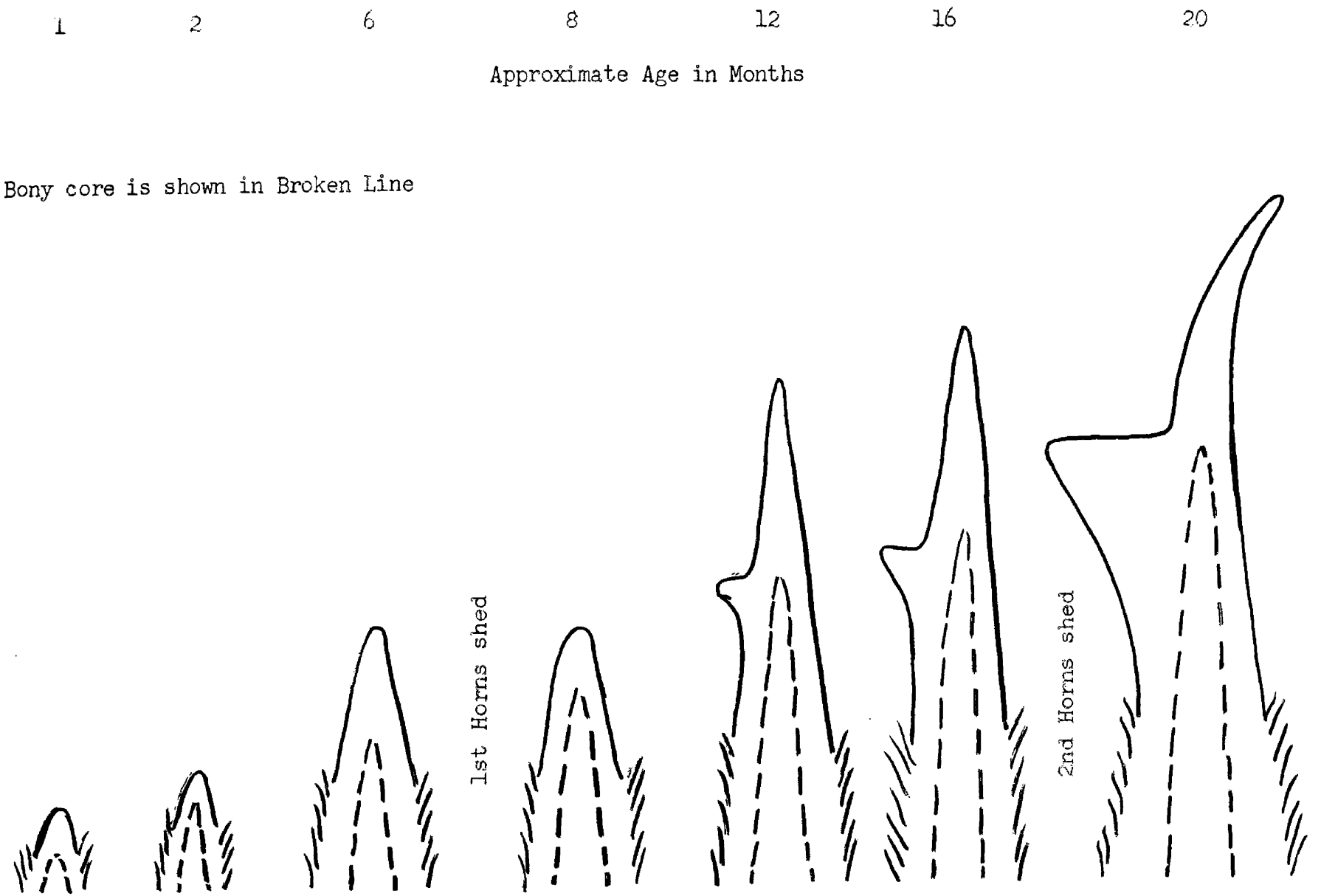


Table 7. Cannon Bone Measurements

Animal Number	Age		Length mm.	Width mm.	Depth mm.	Sex	Epiphyseal Cartilage
E 1141	44 days	(K)	182	11.7	10.0	Male	Present
Fawn of Y doe Do-7	60 days	(E)	185	13.2	10.8	Male	Present
E 1145	110 days	(K)	182	13.4	10.1	Female	Present
E 1144	208 days	(K)	191	9.5	10.9	Male	Present
Unmarked	8 mo.	(K)	193	14.1	10.7	Female	Present
E 1387	12 mo.	(E)	206	14.9	10.4	Male	Present
E 1390	12 mo.	(E)	212	15.5	12.3	Male	Present
E 1376	14 mo.	(E)	209	15.5	12.0	Female	Absent
E 1389	16 mo.	(E)	213	16.9	13.0	Male	Absent
E 1377	16.5 mo.	(E)	212	15.7	12.4	Female	Absent
E 1381	17.5 mo.	(E)	200	14.8	11.1	Female	Absent
E 1378	20 mo.	(E)	212	16.4	12.6	Male	Absent
E 1384	20 mo.	(E)	205	15.0	11.4	Female	Absent

K - Known age
E - Established age

Growth of the Mandible

It was obvious that the mandible of the adult Pronghorn was much larger than that seen in fawns. In an attempt to determine whether or not this growth rate was continuous and what portions of the bone were resorbed and subsequently reorganized, a growth chart was made up by using two control points and drawing a line around the jawbone.

That portion of the dentary bone immediately below the premolars and the first molar apparently grows very little after birth. The most growth occurs in the lengthening of the posterior portion of the bone. This growth causes the angle to move in a posterior direction as the age increases. The interdentary space or diastema lengthens with age. This space was measured and compared to age (Figure 2). From this illustration it is evident that the diastema grows about 30 mm. or an average of 1.5 mm. per month during the first 20 months.

The angle of the coronoid process also changes during the time from birth to 20 months of age. As the animal grows older the process approaches the vertical position. It would be of interest to be able to follow this occurrence through to old age since in humans this angle reverts toward the horizontal after attaining its most vertical position during middle age (Wilder and Wentworth (1918, 88).

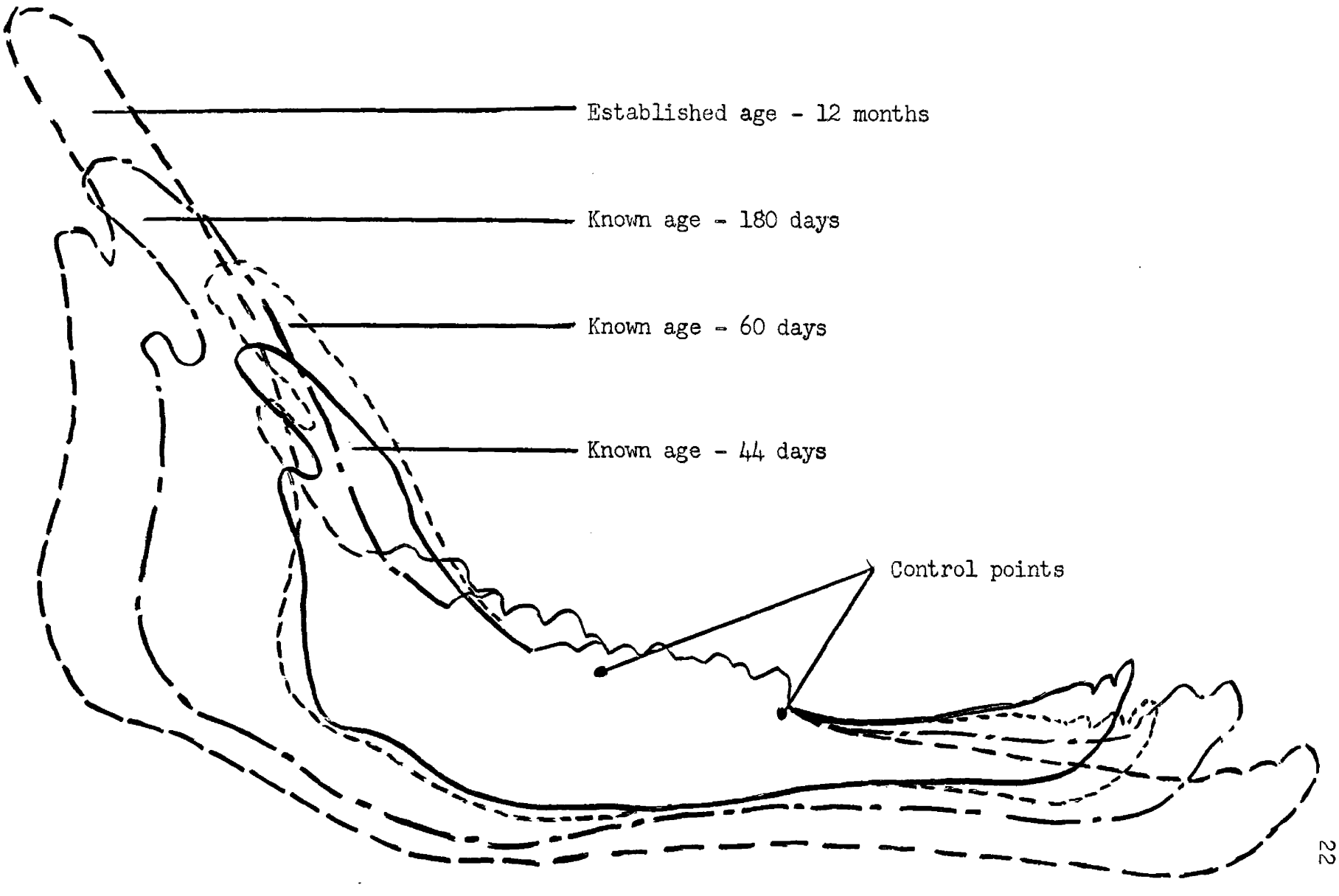
Figure 2 shows that progressive growth occurs in the diastema or interdentary space. In order to evaluate this growth, the interdentary space was measured from the anterior surface of the neck of the second premolar to the posterior edge of the canine in the lower jaw.

The diastema grew in length from approximately 40 mm. in the specimen 44 days of age to approximately 63 mm. in the 3 specimens approximately 20 months of age. Variation among specimens in the same class is quite evident. Two of the 20 months specimens varied by 9.7 mm. and the two males that were approximately 12 months old differed by 8.2 mm. (Table 8).

Table 8. Diastema Lengths

Animal Number	Length mm.	Age	Sex
E 1141	39.8	Known-age 44 days	Male
Fawn of Y Doe	39.7	Known-age 60 days	Male
E 1145	48.8	Known-age 110 days	Female
E 1144	52.9 mm.	Known-age 6 months	Male
Unmarked	55.0	Known-age 8 months	Female
#2	56.6	Established 8 months	Male
#4	51.9	Established 8 months	Male
E 1387	60.0	Established 12 months	Male
E 1390	68.2	Established 12 months	Male
E 1376	67.0	Established 14 months	Female
E 1389	70.1	Established 16 months	Female
E 1377	61.6	Established 16.5 months	Female
E 1381	64.0	Established 17.5 months	Female
#1	63.2	Established 20 months	Female
E 1387	58.5	Established 20 months	Female
E 1378	68.8	Established 20 months	Male

Figure 2 Growth of the Mandible



Actual size

Tooth Development

In order that the reader may firmly grasp the descriptive material that is to follow, a synopsis of mammalian tooth formation seems appropriate.

In the formation of a typical tooth the period of growth has been separated into 4 stages (Maximow and Bloom, 1948, 378-383), Hageboom (1938). The first stage is recognized as the bud stage and is characterized by a proliferation of the oral epithelium which invaginates the base of the epithelian tooth germ. This invagination becomes cap-like in appearance in the second stage, the third stage is bell-shaped. These stages are termed the cap and the bell stage. Calcification of the jawbone occurs during and after the bell stage and calcification of enamel and dentine occurs just following the bell stage, these are combined as the fourth stage. Following this period of growth the eruption of the tooth begins. Intra-osseous eruption is the movement of the tooth through the tissue of the jawbone. After this is complete, the tooth continues to erupt into the oral cavity and attrition occurs throughout the remainder of the life of the tooth.

Tooth Nomenclature. In view of the variations among writers concerning the designation of ruminant dentition (Riney 1951), this discussion will adhere to the following terms taken from Weber (1928) and Sisson and Grossman (1940). The method of numbering the teeth follows the method adopted by The Wildlife Society (1952). The following discussion will include only the teeth of the lower jaw.

Certain of the teeth have been lost through evolutionary processes and those present today are assigned numbers based on the original

complement of the most primitive ruminants. In most modern ruminants the first premolar is absent in the lower jaw. The canine present in the lower jaw is much modified and functions as an incisor.

The incisors are numbered 1, 2, and 3 beginning at the symphysis and progressing to the canine. They are designated I 1, I 2 and I 3. The "corner", or "incisiform canine" is termed simply canine and is designated (C). The cheek teeth are numbered in 2 groups: The premolars are numbered from front to back as numbers 2, 3 and 4 and designated P 2, P 3 and P 4. The molars are designated (M) and numbered from front to rear 1, 2, and 3 (Plate 6).

The prefix (D) preceding any tooth designation signifies that it is a temporary or deciduous one. That part of a cheek tooth that contacts its opposing tooth in the maxilla is termed the masticatory or occlusal surface. The contact surface is that part of the crown that touches the adjacent tooth in the same row.

The infundibulum is the funnel shaped cavity extending from the masticatory surface downward through the body of hyposodont and selenodont teeth and is surrounded by a layer of enamel that is known as the central enamel. The enamel surrounding the outside of the tooth is designated as peripheral enamel.

Reserve enamel is a term applied to the enamel that lies below the gum line in hyposodont teeth. This part of the crown will progress upward during subsequent eruption. The neck of a tooth is that portion between the root and the crown (Figure 3).

Dentition of the Pronghorn. The adult Pronghorn has 32 teeth.

Dental Formula

$$\text{Incisors } \frac{0}{3} \text{ canines } \frac{0}{1} \text{ premolars } \frac{3}{3} \text{ molars } \frac{3}{3} \times 2 = 32.$$

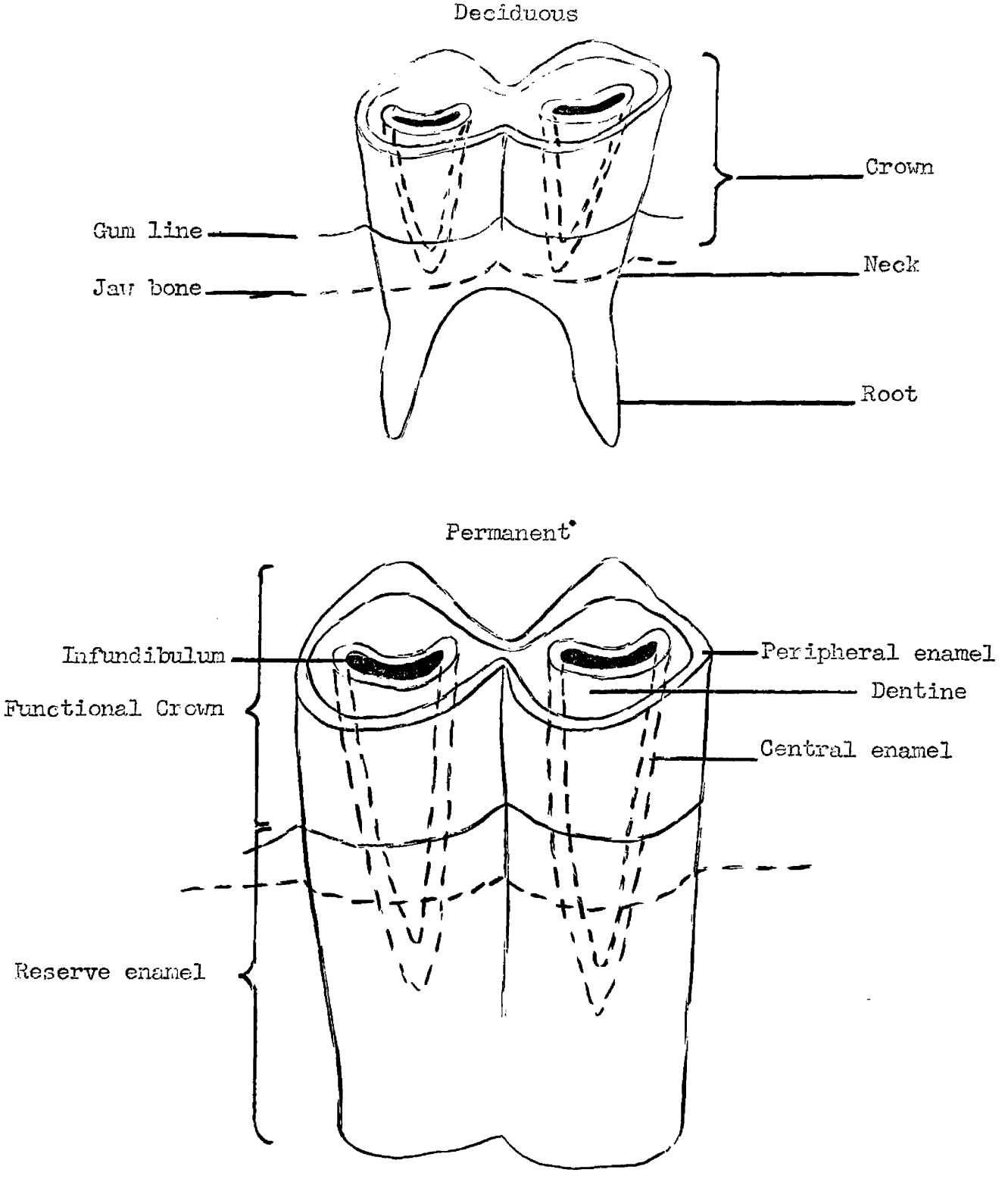


Figure 3 . Typical Hypsodont Teeth

As indicated by the formula there are 3 incisors and a canine present in the anterior end of the mandibular arch. Posteriorly there is a space, the inter-dentary space or diastema. There are 6 cheek teeth, 3 premolars and 3 molars.

The incisors are simple, spade-like teeth without multiple cusps or infundibula. They are arranged in a fan-like manner and imbedded in a way that allows a slight amount of movement. The 3 incisors are alike in appearance except for position and size. The size decreases from number 1 to number 3.

The incisors and the canines project from the jawbone in a plane of approximately 45° from the horizontal. The labial surface of the crown is slightly convex and in the unworn state, the lingual surface is spoon-shaped or concave.

Before the broad crowns are worn away each tooth is overlapped by the edge of the tooth in front, i.e., the first, I 1, slightly overlaps I 2. This is continued and I 3 overlaps the canine.

The molars become larger from the first to the third. The first 2 are similar in having 4 cusps and 2 infundibula. The third molar occupies almost twice the space required by any other cheek tooth and contains 3 infundibula and 6 prominent cusps.

All of the permanent teeth of the Pronghorn are hyposodont (high-crowned) and continue to erupt throughout the life of the animal.

As in many herbivors the enamel of the cheek teeth of the Pronghorn is formed into crescent-shaped folds (Selenodont). For purpose of this study, these folds are numbered 1, 2, and 3 from front to back and are termed cusps.

The deciduous incisors differ from the permanent ones in that

they are smaller and are tapered more abruptly thus forming a definite neck. The permanent incisors and the canines are larger and more gradually tapered to the round, pointed root.

There is no first premolar and those present are progressively more complex from the second to the fourth. The second premolar has 1 prominent cusp and one infundibulum. The third premolar has 6 small cusps and 3 infundibula. The fourth premolar is the most complex and is very similar to the molars in that there are 6 well-developed cusps and between each pair an infundibulum is present (Plate 7).

In a few animals of the collection the permanent second premolar does not erupt but the presence or absence of this tooth apparently does not affect the development of the others. Also a small number of specimens have supernumary incisors; their scarcity warrants detailed discussion unnecessary.

Description of Tooth Classes.

Age Class I (Birth)* (6 animals)

Dental Formula (Mandible): $\frac{DI}{1}$ $\frac{DC}{0}$ $\frac{DP}{1}$ $\frac{M}{0}$ = 2.

The first deciduous incisors were through the gum in the 6 animals examined. The crown extended from 1 to 3 mm. above the gum line and was covered by a thin translucent vascularized membrane. In one instance this membrane was broken during examination and in another instance a fawn tagged with the membrane intact and recaptured the next day showed the membrane broken and retracted.

The fourth deciduous premolar had erupted through the gum and extended about 1 mm. above the gum line in all 6 fawns examined. There was no membrane covering the shapply pointed cusps. This is the only class not illustrated.

live fawns.

Age Class II (44 days) (1 animal)

Dental Formula (Mandible) $\frac{DI}{3}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{1} = 8.$

The deciduous incisors and canines had reached full height above the gum but did not show evidence of wear. The lingual surfaces were cupped and a slightly raised ridge extended entirely around the margin. (Plate 16, Figure 49).

All deciduous premolars had erupted through the gum and the buccal cusps showed a slight amount of wear exposing the dentine. The lingual cusps of the fourth premolar showed wear of the enamel but only the posterior cusp was worn enough to expose the dentine.

The premolars were differentially stained. The second premolar was unstained, the third was slightly stained and the fourth showed heavy deposits of tartar. The fourth premolar had 3 infundibula. (Figure 18, Plate 7).

The radiogram, Figure 29, showed that all molars were present in the jaw in different stages of development. The morphological difference between deciduous and permanent teeth is clearly shown. The temporary teeth have well-developed roots while the permanent molars are rootless.

The second molar had not completed intra-osseous eruption and the anterior cusps would have been just below the jawbone surface in the live animal. The anterior contact surface of the second molar was below the surface of the jawbone. The third molar had not reached the bell stage as evidenced by the lack of calcification of enamel and dentine.

Age Class III (60 days) (1 animal)

Dental Formula (Mandible) $\frac{DI}{3}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{2} = 9$

The first and second deciduous incisors showed wear at this stage

to the extent that there was no longer a raised margin on the lingual surface of the teeth (Plate 16, Figure 50).

The second deciduous premolar was slightly stained but showed no evidence of wear. The third deciduous premolar was showing wear on the posterior half of the masticatory surface. A slight amount of dentine was evident. The medial infundibulum was not clearly outlined as a circle, although it may become so in later stages.

All six cusps of the fourth deciduous premolar showed wear and dentine was exposed in a strip less than the thickness of the enamel.

The first molar showed no evidence of wear and the second buccal cusp had not erupted through the gum (Plate 7, Figure 19).

The radiogram (Plate 10, Figure 30) shows additional eruption of the deciduous premolars. The second molar had progressed upward but the cusps were still below the surface of the jawbone. In the angle of the jaw the third molar was beginning to show as an opaque area.

Age Class IV (110 days) (1 animal)

Dental Formula (Mandible): $\frac{DI}{3}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{2} = 9$

The first 2 incisors showed slight wear at the tip of the lingual surface. The raised margin was still present on the third incisor and the canine (Plate 16, Figure 51).

The deciduous premolars all showed wear. The wear on the second had not exposed the dentine. The exposed dentine on the third and fourth premolars was wider than the enamel and every cusp demonstrated this amount of wear. The first molar was worn only on the first lingual and buccal cusps and the dentine of these cusps was about equal to the enamel in width. The posterior cusps of the first molar were both through the gum but showed no wear (Plate 7, Figure 20).

The radiogram (Plate 10, Figure 31) shows additional eruption of the deciduous premolars. The second molar had progressed upward until both anterior and posterior cusps were above the surface of the jawbone. In the angle of the jaw the third molar was showing definite shape. The first cusp of the tooth is clearly outlined.

Age Class V (6 months) (1 animal)

Dental Formula (Mandible): $\frac{DI}{3}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{2} = 9.$

The 3 deciduous incisors and the deciduous canine showed slight wear that did not expose the dentine (Plate 16, Figure 52).

The posterior cusp of the second deciduous premolar was worn but the dentine was not exposed. The amount of wear on the third deciduous premolar approximated that described in Class IV except that the median infundibulum was almost circular (Plate 7, Figure 21).

The width of the dentine was about twice as wide as the enamel in the fourth deciduous premolar and the anterior infundibulum had disappeared. The anterior and posterior contact surfaces of the fourth deciduous premolar were worn into the enamel. The first lingual cusp of the first molar was worn until the dentine was just slightly less wide than the enamel and the dentine of the first buccal cusp was about twice the enamel width. All 4 cusps of the second molar were through the jawbone but not through the gum. That portion of the jawbone between the posterior cusps was not completely resorbed.

The radiogram showed the second molar through the jawbone but not through the gum. The third molar showed 2 well-defined cusps and the second molar was not in apposition with the maxillary teeth. The second and third premolars had erupted to a stage in which the entire crowns were exposed above the gum line (Plate 10, Figure 32).

Age Class VI (8 months) (3 animals)

Dental Formula (Mandible): $\frac{DI}{3}$ $\frac{DC}{1}$ $\frac{DP}{3}$ $\frac{M}{2}$ = 9.

All 3 deciduous incisors showed moderate wear on the side nearest the midline or symphysis. The deciduous canine was unworn (Plate 16, Figure 53).

At this stage all cheek teeth present showed some degree of wear. The second deciduous premolar had a clearly outlined circular infundibulum while both the infundibula of the third deciduous premolar were completely worn away. The dentine of the fourth deciduous premolar was about 3 times as wide as the enamel and the median and posterior infundibula were reduced to small shallow pits. The anterior contact surface of the third premolar was worn through the enamel and at the posterior contact surface the enamel of the fourth deciduous premolar and the first molar was reduced by half. The dentine of the fourth premolar was about 4 times as wide as the peripheral enamel and the dentine of the first molar was approximately 3 times as wide as the enamel. At the posterior contact surface the peripheral enamel of the first molar was reduced to half the original thickness.

The first buccal cusp of the second molar showed twice as much dentine as enamel and the 3 remaining cusps showed an equal width of dentine and enamel.

Behind the second molar the jawbone had eroded away in the form of a slit but the third molar had not erupted through the bone (Plate 8, Figure 22).

The second molar had reached the stage of apposition and in this radiogram the extent of the infundibula may be clearly seen in this tooth. The third molar was just below the surface of the jawbone.

The deciduous premolars appear to have stopped upward movement.

The first 2 molars had grown in length such that the enamel organs were against the jawbone, however the latter shows no erosion (Plate 10, Figure 33).

Age Class VII (12 months established) (2 animals)

This class and all classes following have the full number of mandibular teeth.

Dental Formula (Mandibular): $\frac{DI}{3}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{3} = 10.$

The deciduous incisors and canines were worn to the extent that the dentine was visible. At the midline the contact surfaces of both first incisors was showing dentine and the broadest portion of the crown was worn so that the amount of overlap of the first to the second was reduced. The neck of the first incisor was above the gum line indicating that this tooth was erupting or that the permanent incisor was forcing its eruption from below (Plate 16, Figure 54).

All deciduous premolars were still present and had lost the infundibula. There was a trace of central enamel between the second cusps of the fourth premolar. The posterior contact surface of the third premolar was worn into the dentine. The lingual cusps of the second molar showed dentine equal to or slightly wider than the enamel. The third molar was entirely through the jawbone but only the anterior cusps were through the gum. These showed no evidence of wear (Plate 8, Figure 23).

The radiogram showed very little change in the deciduous premolars of these specimens as compared to those of the 8 months specimen. The third molar had almost doubled in size and had erupted through the jawbone. The basal portion of the first and second molars had moved into the jawbone. This was accomplished by erosion. The enamel organs of the 3 molars were still functioning (Plate 11, Figure 34).

Age Class VIII (14 months established) (1 animal)

Dental Formula (Mandible): $\frac{I}{1}$ $\frac{DI}{2}$ $\frac{DC}{1}$ $\frac{DP}{3}$ $\frac{M}{3}$ = 10.

The first permanent incisor, I 1 was erupting through the gum and the deciduous tooth, DI 1 had been shed. Approximately 5 mm. of the crown of I 1 was above the gum line. The exposed crown of the permanent tooth was about twice as broad as the largest of the remaining deciduous teeth, and the slight ridge around the margin was present indicating that the tooth was unworn. The neck of the second temporary incisor was slightly above the gum line (Plate 16, Figure 55).

The third deciduous incisor and canine were worn to the mid-point of the spoon-like concavity.

All deciduous premolars were still present and lacked infundibula except for a small portion of the central enamel which remained between the posterior cusps of the fourth. The anterior contact surface of the fourth premolar slightly overlapped the edge of the crown of the third premolar.

The first molar showed 3 times as much dentine as enamel on the buccal cusps and some cusps of the second molar showed dentine about twice the enamel width. The first lingual and buccal cusps of the third molar were slightly worn and the former had erupted through the gum line. The jawbone was eroded away exposing the third cusps but these were slightly below the dorsal surface of the jawbone and could be seen only after the gum was removed (Plate 8, Figure 24).

The deciduous premolars are shown in Plate 11, Figure 35 as being attached to the jaw by the roots only. The crown were entirely above the jawbone.

The third molar is longer and the contact surface is above the gumline. This figure also illustrates the rotation of the molars which

ultimately places the teeth more nearly perpendicular to the mandible.

Age Class IX (16 months established) (1 animal)

Dental Formula (Mandible): $\frac{I}{1}$ $\frac{DI}{2}$ $\frac{DC}{1}$ $\frac{DP}{3}$ $\frac{M}{3}$ = 10.

The eruption of the first permanent incisor had progressed rapidly. The tip of the crown was 12 mm. above the gum line and the marginal ridge was reduced but still present. There was no clearly defined neck in this permanent tooth (Plate 16, Figure 56).

The deciduous premolars were worn through the dentine and the cement of the roots was evident in all 3 teeth. The necks of the second and third premolars were above the gum line thus exposing the roots.

The masticatory surface of the first molar overlapped the posterior edge of the fourth premolar 1 mm. The buccal cusps of the first molar showed dentine about 4 times the enamel width. The second molar showed dentine 3 times the enamel width and on the third molar the wear of the buccal cusps was showing equal enamel and dentine. The third buccal cusp was through the gum and the third lingual cusp could be seen as a prominance under the gum (Plate 8, Figure 25).

The third permanent premolar is seen as a light colored area directly underlying the third deciduous premolar. The roots of the deciduous premolars were still intact showing that no root decalcification had occurred.

The first 2 molars had reached full length and the enamel organs appear to have been functioning. The lowest portion of the third molar extended to the jawbone and the bone showed some decalcification at this stage (Plate 11, Figure 36).

Age Class X (16.5 months established) (1 animal)

Dental Formula (Mandible): $\frac{I}{1}$ $\frac{DI}{2}$ $\frac{DC}{1}$ $\frac{DP}{3}$ $\frac{M}{3}$ = 10.

The first permanent incisor extended 4 mm. through the gum and the first temporary incisor was still present loosely held by the gum. There was no evidence of wear on the permanent tooth. The second and third incisors and the canine showed a moderate amount of wear. The necks of these 3 deciduous teeth were above the gum line. The cement of the roots was visible only on the second and third cusp of the fourth deciduous premolar. The dentine was slightly more than 3 times as wide as the peripheral enamel on the first molar. In the second molar the dentine was about 3 times as wide as the enamel. There was an equal amount of dentine and enamel visible on the first cusps of the third molar. The second cusps of the third molar were both through the gum and the third cusps were through the jawbone but not through the gum (Plate 9, Figure 26).

All 3 permanent premolars are evident in the radiogram just below the deciduous ones. The roots of the deciduous teeth were decalcified and somewhat shorter than those of the previous classes. The molars were apparently still growing since the enamel organ of the second one can be located by the presence of diffuse salts evident at the bottom of the tooth (Plate 12, Figure 37).

Age Class XI (17.5 months established) (1 animal)

Dental Formula (Mandible): $\frac{I}{1}\ \frac{DI}{2}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{3} = 10.$

The permanent incisor, I 1 had reached a level in height equal to that of the remaining teeth. Due to the curve of the crown of the permanent tooth, its position was behind the second deciduous incisor; thus the second incisor was overlapped by the teeth on either side. The 3 temporary teeth were worn about half way through the crowns (Plate 16, Figure 57).

The gum line was at the neck of the first 2 deciduous premolars,

i.e., DP 2 and DP 3. The dentine was worn through allowing the white cement of the root to be visible on all 3 teeth. The dentine of the buccal cusps of all 3 molars was at least as wide as the enamel. This ratio of dentine to enamel was 3 plus to 1, 3 to 1, and 2 to 1 in the 3 molars, from first to third. The second cusps of the third molar showed no wear and the last cusps were both through the gum but showing no wear (Plate 9, Figure 27).

The roots of the deciduous premolars are seen to be about half eroded away. The second permanent premolar was still in the early stages of development and the third permanent premolar was the most advanced of the 3.

The reserve enamel at the bases of the first 2 molars was tapered and enamel formation in the first appears to have stopped. The third molar was still in the developmental stage as evidenced by the decalcified condition of the jawbone (Plate 12, Figure 38).

Age Class XII (20 months established) (3 animals)

Dental Formula (Mandible): $\frac{I}{1}\ \frac{DI}{2}\ \frac{DC}{1}\ \frac{DP}{3}\ \frac{M}{3} = 10.$

The first permanent incisor was 13 mm. above the gum line and approximately 3 times as broad as the deciduous incisor next to it. The contact surface between the first permanent and the second deciduous tooth was worn well into the dentine of the temporary tooth. The 3 deciduous teeth were worn down to the last third of the crown (Plate 16, Figure 58). The gum line was at the necks of the deciduous premolars and the height above the gum line was quite conspicuous in the cleaned specimen. The roots of all premolars were in evidence, the necks averaging about 4 mm. above the jawbone. The wear on the masticatory surface was into the cement of the roots at several places (Plate 9, Figure 28).

The cusps of all molars except the posterior ones of the third molar were showing progressively less wear from front to rear. The pro-

portion of dentine to enamel evident on the buccal cusps of the first, second and third molars was 3 to 1, 3 to 1, and 2 to 1 respectively. The third cusps of the last molar were through the gum but not showing wear.

The radiogram (Plate 12, Figure 39) shows the permanent premolars well developed and in the last stage of intra-osseous eruption. The roots of the deciduous premolars were almost completely decalcified and absorbed. The first molar had definitely stopped growth while the second and third showed active enamel organs.

Age Class XIII (Approximately 27 months)

Dental Formula (Mandible): $\frac{I}{2}\ \frac{DI}{1}\ \frac{DC}{1}\ \frac{P}{3}\ \frac{M}{3} = 10.$

The tooth row shown in Plate 13, Figure 40, and in Plate 17, Figure 59, appears to represent a stage of development more advanced than the specimens 20 months of age and less advanced than specimens which were established in Class XIV as being approximately $3\frac{1}{2}$ years of age.

There were 2 permanent incisors in about 90 per cent of the 179 animals examined and placed in this class. The third incisors and canines were well worn. The premolars were unstained and unworn. Many of the jaws examined show these permanent premolar erupting at an angle and not advanced enough to contact the maxillary teeth. The unstained and unworn permanent premolars adequately separate this class from all others.

Age Class XIV (Approximately 40 months)

Dental Formula (Mandible): $\frac{I}{2 \text{ or } 3}\ \frac{DC}{1}\ \frac{P}{3}\ \frac{M}{3} = 10.$

This class was based on one specimen previously established as being at least 3 years of age.

There were 3 permanent incisors in about 50 per cent of the 144 specimens examined. The remaining jaws had only 2 permanent incisors.

The second premolar showed no wear but all other cheek teeth showed varying amounts of wear. The presence of all permanent cheek teeth showing wear but exhibiting 12 infundibula effectively separates this class from all others developed in this study (Plate 13, Figure 41, and Plate 17, Figure 60).

Sequence of Tooth Eruption. The following discussion is summarized in Tables 9 and 10. Six fawns were examined soon after birth and in every case the first deciduous incisors were present and the other incisors and canine could be felt just below the surface of the gum.

There were either four or five cusps of the fourth premolar through the gum about one millimeter. The other cheek teeth were neither felt nor seen in the gum.

The specimen, forty-four days of age, had three deciduous incisors and the deciduous canines fully erupted. During the elapsed time since this fawn was examined at birth, two additional premolars and the first two cusps of the first molar had erupted.

The 60 day old specimen differed from the preceding only in that the second cusps of the first molar had erupted.

The 110 day old specimen did not differ from the 60 day specimen in the pattern of eruption.

At six months, specimen #1144 showed two additional cusps that marked beginning emergence of the second molar.

At eight months all three specimens demonstrated emergence of the second and final cusps of the second molar, thus bringing the total number of cheek teeth in one ramus to five.

The two twelve month specimens both showed five cheek teeth in the tooth row and the first two cusps of the third molar were through

Table 9. Tooth Eruption Chart

Age	Animal Number	Incisor 1	2	3	Canine 1	Premolar 2	3	4	Molar[1] 1	2	3
At birth	*	D						D			
44 days	1141	D	D	D	D	D	D	D	P		
60 days	7	D	D	D	D	D	D	D	PP		
110 days	1145	D	D	D	D	D	D	D	PP		
6 months	1144	D	D	D	D	D	D	D	PP	P	
8 months	2**	D	D	D	D	D	D	D	PP	PP	
12 months	1390	D	D	D	D	D	D	D	PP	PP	P
12 months	13	D	D	D	D	D	D	D	PP	PP	PP
14 months	1376	P	D	D	D	D	D	D	PP	PP	PP
16 months	1389	P	D	D	D	D	D	D	PP	PP	PP
16.5 months	1377	DP[2]	D	D	D	D	D	D	PP	PP	PP
17.5 montns	1381	P	D	D	D	D	D	D	PP	PP	PPP
20 months	1374**	P	D	D	D	D	D	D	PP	PP	PPP

* 5 additional marked fawns
** 2 additional marked animals

Note: [1] Under Molar the number of letters denotes the cusps and their first appearance through the gum.

[2] In this specimen both teeth were present.

Table 10. Eruption of Mandibular Teeth

Teeth	Eruption
A. Deciduous	
1st incisor (DI 1)	Present at birth
2nd incisor (DI 2)	Birth to 44 days
3rd incisor (DI 3)	Birth to 44 days
Canine (DC 1)	Birth to 44 days
1st Premolar (DP 1)	Birth to 44 days
2nd Premolar (DP 2)	Birth to 44 days
3rd Premolar (DP 3)	Present at birth
B. Permanent	
1st incisor (PI 1)	14 to 17 months
2nd incisor (PI 2)	27 to 29 months
3rd incisor (PI 2)	after 29 months
Canine (PC 1)	after 29 months
1st premolar (PP 1)	20 to 29 months
2nd premolar (PP 2)	20 to 29 months
3rd premolar (PP 2)	20 to 29 months
1st molar (M 1)	Birth to 44 days
2nd molar (M 2)	60 to 110 days
3rd Molar (M 2)	12 to 16 months

the gum.

At fourteen months the first permanent incisor had erupted through the gum and in addition to the five cheek teeth previously noted the second cusps of the third molar were visible above the gum.

Specimen #1389 showed no new eruptions; thus its pattern is the same as that recorded of an animal 14 months old.

At approximately seventeen and a half months of age the jaw contained a complete set of teeth including all three cusps of the third molar. The tooth row had now reached its maximum length and in the subsequent replacement only the incisors, canines and premolars will be replaced. There was only one set of molar teeth and the first molar may be seen in any jaw from about two months until old age.

Of the experimental herd the twenty months animals were the oldest that were established and of the three specimens collected none showed any change in the eruption pattern found in the seventeen and a half month specimen.

Application of Aging Technique to the 1951 Hunter Harvest

As previously discussed, 1,322 jaws were received from the 1951 hunter kill. These jaws were catalogued and classified into tooth groups and tabulated. The jaws were placed into ten tooth groups, the first 3 groups were established by the known-age specimens and the last 7 classes were formed according to the number of infundibula present in the tooth row.

Total jaw containers issued	3,000
Total jaw containers returned	1,322 or 44.4%
Jaws received with complete data.	1,224 or 92.6% of those received.

The data below are compiled from those areas in which only either sex hunting was allowed.

Incomplete data:

Jaws not enclosed	9
Location not given	13
Sex not given	62
Hunter stated he was unsuccessful	8
Hunter stated he did not hunt	2
Hunter stated tnat head was used as trophy	4
	98 or 7.3%

Reproduction data:

It is understood tnat there may be an error in sex determination by the hunters.

Doe-fawn ratio (yearling does included	100 to 53.5
Doe-fawn ratio (Yearling does not included)	100 to 72.6
Adult-fawn ratio (yearlings included)	100 to 30.4
Buck fawn-doe fawn ratio	100 to 80.9
Adult Buck-adult doe ratio	100 to 64.6

Herd Harvest composition:

Age Class	Number	Percentage
Fawn	199	17.0
Yearling	371	31.6
2.5	165	14.0
Over 2.5	440	37.4
Total -	1,175	100.0

Refer to Table 11.

Table 11. Antelope Jaw Collection 1951

Area	Permits	Fawns M	Fawns F	Yearlings M	Yearlings F	2 and 1/2 M	2 and 1/2 F	Over 2 1/2 M	Over 2 1/2 F	Total
	----Areas in which both Sexes were Taken----									
1	50 MF	3	3	1	0	0	0	2	2	11
2	200 MF	5	5	5	1	3	4	14	7	44
3	500 MF	12	7	9	12	6	6	10	21	84
4	500 MF	10	10	11	7	4	4	9	12	67
5	900 MF	17	10	15	11	8	6	15	20	102
6	300 MF	2	2	4	2	1	2	2	7	22
7	600 MF	11	6	11	4	1	4	10	21	68
9	1500 MF	17	13	42	19	17	10	28	38	194
10	1100 MF	13	9	41	14	13	8	28	31	157
11	200 MF	1	3	15	5	11	0	12	7	54
12	300 MF	4	1	12	1	7	0	12	2	39
13	200 MF	1	7	22	5	6	0	25	9	75
19	50 MF	0	1	7	2	3	0	2	1	16
20	200 MF	1	1	13	0	5	0	5	2	27
21	200 MF	4	3	17	2	7	1	6	7	47
22	550 MF	5	6	37	7	7	9	27	12	110
23	50 MF	0	0	1	0	0	2	0	1	4
24	100 MF	0	0	5	1	0	1	5	0	12
25	35 MF	2	0	1	1	0	0	1	1	6
26) 27(38) 30	275 MF	1	2	3	3	4	4	5	10	32
31 32 33	400 MF	1	0	1	0	0	1	0	1	4
	8210	110	89	273	98	103	62	228	212	1175
	----Areas in which Bucks only or either Sex were Taken----									
14	50 M	0	0	8	0	5	0	2	0	15
15	50MF 25 M	1	1	5	2	3	1	2	2	17
16	25 M	0	0	0	0	1	0	0	0	1
17) 18(	100MF100M	0	0	6	1	3	1	4	1	16
		1	1	19	3	12	2	8	3	49

Those with insufficient data 98

Total - 1322

Tooth Measurements

In an effort to determine the variability of tooth eruption and subsequent wear, accurate measurements were taken of a sample selected from the hunter killed specimens. The distance from the gum line to the highest point of the crown was measured with a vernier caliper (Plate 6).

Severinghaus (1949) found that as white-tailed deer become older their cheek teeth become worn closer to the gum line.

In this study the mean height of the cheek teeth of 15 $3\frac{1}{2}$ year old jawbones was 6.55 mm. This height is almost identical with the mean of 6.50 mm. that was calculated for the specimens in group 6, Table 12, which were assumed to represent animals that had reached old age.

Tooth Height

This information seems to be of little value in estimating age in the Pronghorn and accordingly other methods were saught.

Wear Patterns of Teeth

Because of the fact that the permanent teeth of the Pronghorn continue to erupt throughout the life of the animal and as the tooth erupts it is worn away at the masticatory surface, the pattern of wear presented by the occlusal surface presents a series of cross-sectional views of the tooth. Since the cheek teeth contain infundibula that extend to varying depths in different teeth and also varying depths in different cusps of any one tooth, it is obvious that the cross-sectional pattern of the worn surface of the tooth row will go through a series of changes. This change of pattern has been used for many years in the determination of age in the horse (Ensminger, 1951, 976). The incisors of the horse have infundibula and the wear pattern may be easily seen in a series of live animals.

In the eruption of cheek teeth in the Pronghorn the individual

teeth erupt at different times, consequently the teeth that reach full height first will be subject to wear longer than those that erupt at a latter date. This differential in time at which the tooth begins to wear and also the varying depths of the infundibula results in difference in appearance of the masticatory surface of the teeth from year to year.

An analysis of the cheek teeth of the established and known-age specimens representing 8 months and 20 months showed that the amount of tooth worn away in 1 year was a considerable amount but since the teeth continue to progress upward as they are worn away the height above the gum line remains practically unchanged.

In contrast to this observation it was noted that the patterns of the enamel folds and the appearance of the infundibula were quite different in animals with an age difference of only 1 year (Plates 13 and 14).

Infundibula Numbers from Animals $3\frac{1}{2}$ Years and Older. It was noted that all of the infundibula had disappeared in animals with well-worn teeth whereas those with slightly-worn teeth ($3\frac{1}{2}$ years or less) still possessed all 12 of the original infundibula. It was thought then that by counting the total number of infundibula a means of classifying the older age specimens into approximate age classes might be effected. The results are shown in Table 12.

Table 12. Infundibula Numbers

Group	Number of Infundibula Present	Number Classified
1	11 or 12	144
2	9 or 10	139
3	7 or 8	47
4	5 or 6	35
5	3 or 4	30
6	1 or 2	25
7	0	22
	Total -	442

In the analysis of 442 jawbones from animals judged to be 3½ years of age or older the specimens could be placed into 7 categories. The number of specimens in each category decreased from the 1st group through the 7th. One specimen in group 1 was obtained from a hunter. This animal had been tagged in 1948. Thus this specimen was a minimum of 3½ years old when collected. It had 12 infundibula and compared favorably with the others in that group in the other aspects of wear and dental development.

Figures 25 through 33 are radiograms of the series shown in the occlusal views in Plates 13 and 14. This method of grouping is offered as a series to be either proved or disproved by comparison with known-age animals as they become available in the future.

Several characteristics are apparent in those specimens that could not be placed in an approximate age group by comparison with known-age or established age specimens.

In every case these specimens have the complete set of permanent cheek teeth but it is clearly evident that the teeth are in different stages of eruption and attrition. In the photographs, Plates 13 and 14, the specimens are arranged according to the number of infundibula present. Figures 24 and 34 have been established previously in this study as representing the approximate age of 2 years and 3 months; also Figures 25 and 35 were established by comparison with one specimen tagged by the State Fish and Game Department in 1948 and collected in 1951. This specimen was at least 3 years old, snows 12 infundibula, and is assumed to have been 3 years, 3 months.

The successive figures in this series illustrate the formation of roots and the different patterns of wear that occur as the teeth become

worn away.

By comparing the wear pattern with the sectional diagram in Figure 2 it becomes evident that the wear patterns show a series of cross-sectioned views of the tooth row.

For the convenience of technicians who may wish to use the foregoing descriptions of age classes, they have been summarized as follows (only one lower jaw being necessary):

Age	Criteria to be Used: Incisors and Canine	Criteria to be Used: Cheek Teeth
1. 3 to 5 months	All temporary	3 temporary premolars, 1st molar present
2. 15 to 17 months	One permanent incisor	3 temporary premolars, 3 molars present
3. 27 to 29 months	Usually 2 permanent incisors	Permanent premolars unworn. All molars present and showing wear
4. 39 to 41 months	Replacement not consistent	11 or 12 infundibula
5. $4\frac{1}{2}$ years*	Replacement not consistent	9 or 10 infundibula
6. $5\frac{1}{2}$ years*	Replacement not consistent	7 or 8 infundibula
7. $6\frac{1}{2}$ years*	All permanent	5 or 6 infundibula
8. $7\frac{1}{2}$ years*	All permanent	3 or 4 infundibula
9. $8\frac{1}{2}$ years*	All permanent	1 or 2 infundibula
10. $9\frac{1}{2}$ years*	All permanent	0

* Classes not yet established by known-age specimens.

It was realized that this method of age determination based on a small number of known-age jaws gave no indication of the variability among individuals. An opportunity to test variability was presented in the hunter killed sample of 250 fawns which were killed in two hunting seasons (September 7th-16th and October 26th-November 4th).

Assuming that the majority of fawns were born within a period of about two weeks in early June, those killed during the early season would have been about six weeks younger than those killed in the late

season. All fawns were determined as less than 6 months and more than 110 days by comparison with the known-age jaws and, without referring to the recorded kill data, about 90 per cent of these were correctly determined as to the season in which they were killed. This classification was possible because the jaws of the late killed fawns showed 3 or 4 cusps of the second molar while those killed in September showed only one cusp of this tooth.

SUMMARY AND CONCLUSIONS

This study was based on 15 pronghorn antelope collected from an experimental herd confined on the National Bison Range at Moiese, Montana, and an additional 1322 specimens which were collected from the annual hunter harvest in Montana in 1951.

The tagging method used on the experimental herd in the beginning of this study was later modified and although the modification made individual recognition possible at greater distances, there was a disadvantage that may be overcome. The plastic tags became brittle and some were lost after being in use for only one year. The substitution of colored aluminum markers is suggested for use in studies of long duration.

Some methods of age determination were evaluated using known and established age specimens as a basis.

Weights and measurements may have limited use in age determination but after the fawns reach the age of 12 months, it would be difficult to separate them from the older animals by these criteria alone.

There is a seasonal difference in the facial markings of bucks. The cheek patch and the dark nose are most prominent during the breeding season and are most obscure during late January and February.

The pelage changes would be difficult to see in the field and there was no indication that they do not occur in the Pronghorn at all ages.

The development of horns in male Pronghorn antelope seems to offer a practical means of age class segregation (fawns and yearlings) up to the age of 20 months but examples were found in animals of the same age which indicate that much variation may occur.

The ossification of the epiphyseal groove of the front cannon bone was complete at the approximate age of 12 months, thus its usefulness as an age criterion would be limited to separating adults from young of the year.

Tooth development and subsequent wear of the mandibular cheek teeth was found to be the most reliable means of age determination.

The method of age determination based on dental characters appears to be quite adequate for classifying animals into age classes through $3\frac{1}{2}$ years. To use this method only the mandible is necessary, and in most cases the tooth formula alone will designate the age class.

The method proposed here for determining the age of Pronghorn older than $3\frac{1}{2}$ years was developed on the basis of dental changes illustrated by radiograms. The cheek teeth continue to erupt throughout the life of the animal and simultaneously the occlusal surface is worn away. Therefore, the height above the gum of mandibular cheek teeth remains almost constant from $3\frac{1}{2}$ years to old age. The cheek teeth have infundibula that occur at various depths in different teeth and also at various depths in different cusps of the same tooth; therefore the number of infundibula present at any stage of life appears to be related to the age of the animal. The cheek teeth of animals $3\frac{1}{2}$ years of age or older may be grouped into classes according to the number of infundibula. This method lacks verification and is presented only as an approximate means of age determination pending further study.

This method has limitations in that in old age the infundibula are no longer present; also individual variation in occlusion may cause certain teeth to wear at varying rates which would alter the expected number of infundibula. The method has an advantage in that it could be

used by game technicians easily and rapidly.

In this study it has been shown that pronghorn antelope acquire the permanent set of mandibular cheek teeth at the approximate age of $2\frac{1}{2}$ years and that the eruption and replacement of incisors and canines is variable but may be used to distinguish fawn and yearlings from adults in the living animal.

A method of determining the age composition of the hunter harvest was developed, and although the results are biased by the selective shooting of adults by the hunters, the method should prove useful in the management of the species.

In the sample obtained from the hunter harvest 37.4 per cent consisted of animals $3\frac{1}{2}$ years and older. It thus appears that there is an abundance of antelope escaping into the older age classes to maintain a percentage of animals of breeding age, thus assuring high herd productivity.

The age composition of the antelope in Montana suggests that the life span may be considerably longer than has been supposed (Einarsen, 1948) and the proposed method of age determination based on infundibula number strongly indicates that a small percentage of antelope may live to be 10 years old or older.

The herd composition of hunting area 9* was very similar to that of the total sample. Thus it appears that this area could be used to obtain a minimum adequate sample in future management in Montana.

Approximately 1500 antelope mandibles were examined during the course of this study and not one instance of dental caries was found. In

* as designated by the Montana Fish and Game Department Hunter Map 1951

a few instances (less than 25) malocclusion or breakage of the enamel at a contact point had caused a gap between teeth that collected debris and the resulting impaction caused malformation of the jaw bone. Many specimens had cactus spines imbedded between the gum and the teeth but there was no indication that the presence of this material caused more than minor irritation.

The occurrence of triplets has occasionally been reported in studies of the Pronghorn (McLeen, 1944). During this study an interesting occurrence was recorded in regard to doe-fawn relationship. On August 14, 1951, a marked doe with fawns was accidentally killed. At this time her fawns were 75 days of age. Approximately 1 week later a doe was seen with 4 fawns and 3 of these were seen suckkling simultaneously. Since parturition of two of these fawns had been observed and all animals involved were clearly marked, there was no question as to the adoption. Both adopted fawns were seen alive in the spring of 1952. It seems reasonable to assume that similar situations may occur elsewhere.

Three yearling females were collected after the breeding season and in each instance the uterus contained 2 embryos. Since only a yearling buck and buck fawns were present on the Bison Range during the breeding season, it is assumed the yearling buck bred these does. This evidence seems to confirm the common assumption that male and female Pronghorn reach fertility at approximately 16 months of age.

Two known-age fawns marked at birth remained in the experimental herd at the National Bison Range, Moiese, at the time this was written. In the spring of 1952 10 fawns were trapped from wild herds, marked, and released with this experimental herd. These animals will be collected in subsequent years to constitute known-age specimens for age classes $3\frac{1}{2}$ years

LITERATURE CITED

Anthony, H. E. 1928 Fieldbook of North American Mammals. (G. P. Putnam's Sons, New York) XXVII + 647 pp.

Buechner, H. K. 1950 Life history, ecology and range use of the pronghorn antelope in Trans-Pecos, Texas. The American Midland Naturalist, 43 (2):257-354.

Donaldson, H. H. 1915 The rat, reference tables and data for the albino rat (Mus norvegicus albinus) and the Norway rat (Mus norvegicus) V + 278 pp. Wistar Institute of Anatomy and Biology, Philadelphia.

Einarsen, A. S. 1948 The pronghorn antelope and its management. (Wildlife Management Institute, Washington, D. C.) 238 pp.

Ensminger, M. E. 1951 Animal science. (The Interstate Press, Danville, Illinois), 1096 pp.

Hale, J. B. 1949 Aging cottontail rabbits by bone growth. Journal of Wildlife Management, 13 (2):216-225.

Hogeboom, F. E. 1938 Practical pedodontia or juvenile operative dentistry. (C. V. Mosby Company, St. Louis) 371 pp.

Johnson, D. E. 1951 Biology of the calf elk (Cervus canadensis nelsoni). Journal of Wildlife Management, 15 (4):396-410.

Maughan, W. E. 1941 Supplementary climatic notes for Montana, edited by Gove Hambidge, Yearbook of agriculture (United States Department of Agriculture) 955-966.

Maximow, A. A. and W. Bloom 1948 A textbook of histology. (W. B. Saunders Company, Philadelphia) XI 700.pp.

McKean, W. T. 1943 Project 12R statewide game survey. Pitman Robertson Quarterly Report, 3(2):85.

McLean, D. C. 1944 The pronghorn antelope in California. California Fish and Game Department, 30 (4):221-240.

Murie, O. J. 1951 The elk of North America. (Wildlife Management Institute, Washington, D. C.) 376 pp.

Nichol, A. A. 1942 Gathering, transplanting and caring for young antelope. Journal of Wildlife Management, 6(4):281-285.

Rush, W. M. 1944 American pronghorn. Natural History, September, 321-323.

Riney, Thane 1951 Standard Terminology for deer teeth. Journal of Wildlife Management, 15 (1):99.

Severinghaus, C. W. 1948 Tooth development and wear as criteria of age in white-tailed deer. Journal of Wildlife Management 13(2):195-215.

1951 Age composition of deer population in New York based on data obtained during 1950 hunting season. Pitman-Robertson Quarterly Report, New York Project 28R:2 April.

Sisson, S. and J. D. Grossman 1940 The anatomy of the domestic animals (W. B. Saunders Company, Philadelphia) 972 pp.

Skinner, M. P. 1922 The pronghorn. Journal of Mammalogy 3(2):82-105.

Weaver, J. E. and F. E. Clements 1938 Plant ecology (McGraw-Hill Book Company, New York) XXIII + 601 pp.

Weber, M. 1928 Die saugetiere. (Gustav Fischer, Jena) Vol. I XXIV + 898 pp.

Wilder, H. H. and B. Wentworth 1918 Personal identification. (The Gorham Press) 374 pp.

PLATE 1. Rolling grassland typical of the National Bison Range, antelope in foreground.

PLATE 2

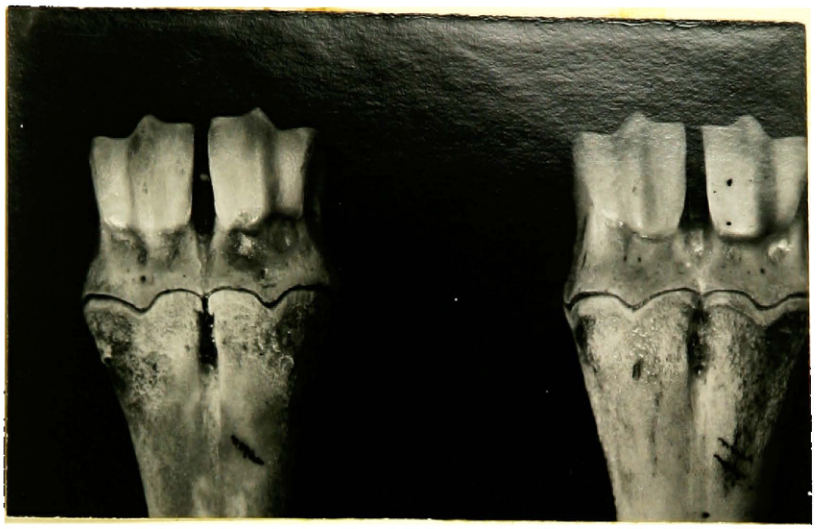
Figure 4. A 12 month male (number E 1390) showing brown hair between nose and eye and small cheek patch. This animal was collected in June 1951

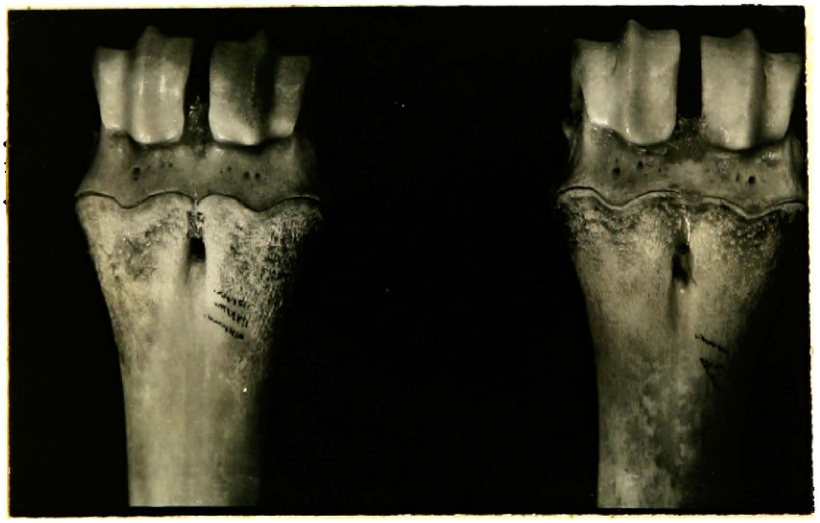
Figure 5. Front view of animal number 1390. Notice that the hair between the horns and on top of the nose is light colored.

PLATE 3

Figure 6. Buck older than $3\frac{1}{2}$ years which was killed during the breeding season. The cheek patch and the nose are black. This animal was collected in September.

Figure 7. Front view of animal described above showing the dark hair between horns and extending down the nose.





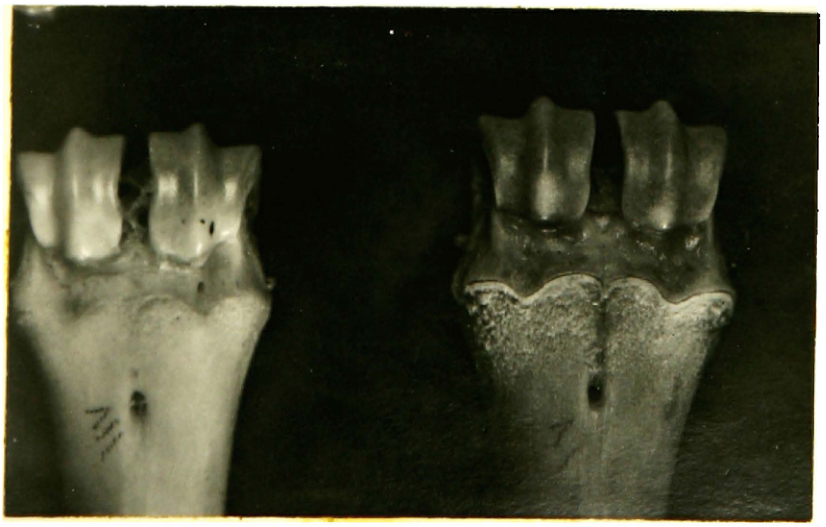


PLATE 4

Distal Ends of Cannon Bones
Approximately Actual Size

Figure 8. 44 day specimen
Animal #E-1141

Figure 9. 60 day specimen
Animal #7

Figure 10. 110 day specimen
Animal #E-1145

Figure 11. 6 months specimen
Animal #E-1144

Figure 12. 12 months specimen
The epiphyseal groove is completely ossified.
Animal #E-1390

Figure 13. 8 months specimen
Animal #2

PLATE 5

Actual Size

Figure 14. 14 months specimen
Animal #E-1376

Figure 15. 16 months specimen
Animal #E-1389

Figure 16. 17.5 months specimen
Animal #E-1381

Figure 17. 20 months specimen
Animal #E-1378

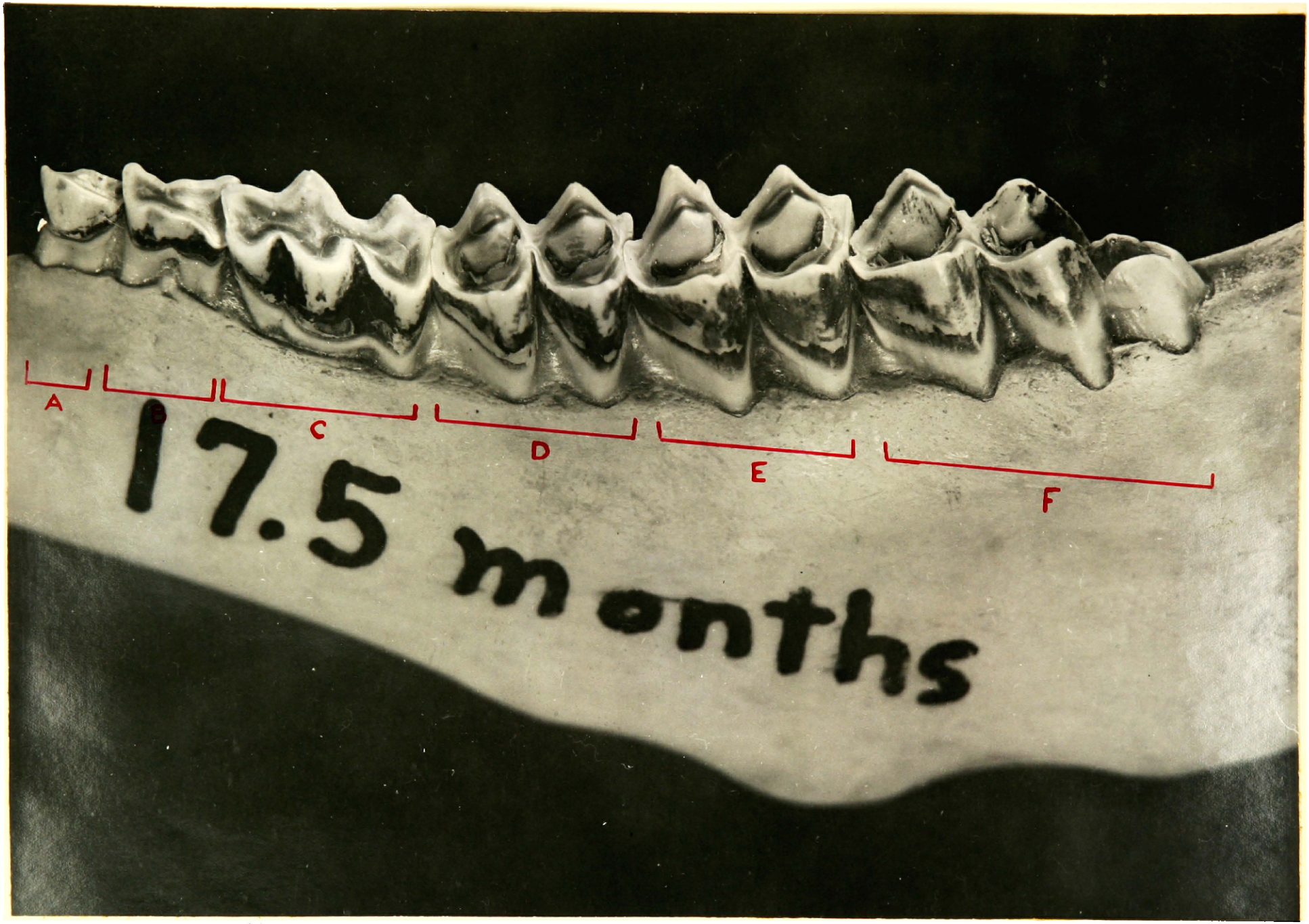

A
B
C
D
E
F
17.5 months

PLATE 6

2 x Actual Size

A. Second deciduous premolar
B. Third deciduous premolar
C. Fourth deciduous premolar
D. First molar
E. Second molar
F. Third molar

Showing the dentition of a 17.5 months animal with deciduous premolar and the permanent molars.


44 days


60 days


110 days


6 months

Actual Size

Figure 18. A 44 day specimen (Animal #E-1141). Three deciduous premolars and 1st molar present.

Figure 19. A 60 day specimen (Animal #7) illustrating the opening in the jaw bone behind the 1st molar.

Figure 20. A 110 day specimen (Animal #E-1145) showing anterior cusp of 2nd molar through the jawbone.

Figure 21. A 6 months specimen (Animal #E-1144) illustrating further development of the 2nd molar.


8 months


12 months


14 months


16 months

PLATE 8 -

Facing 60

Actual Size

Figure 22. One of three 8 months specimens (Animal #2) to illustrate the worn deciduous premolars and the opening in the jaw bone behind the 2nd molar. Note that the infundibula of the 4th premolar are present.

Figure 23. One of two specimens at 12 months showing the appearance of the first two cusps of the 3rd molar and the disappearance of the infundibula of the premolars (Animal #E-1390).

Figure 24. A specimen at 14 months (Animal #E-1376) showing the 3rd cusp of the 3rd molar erupting through the jaw bone.

Figure 25. A 16 months specimen (Animal #E-1389) showing character of wear in the molars. Notice the slight impaction between the 3rd and 4th premolars.


16.5 months


17.5 months


20 months

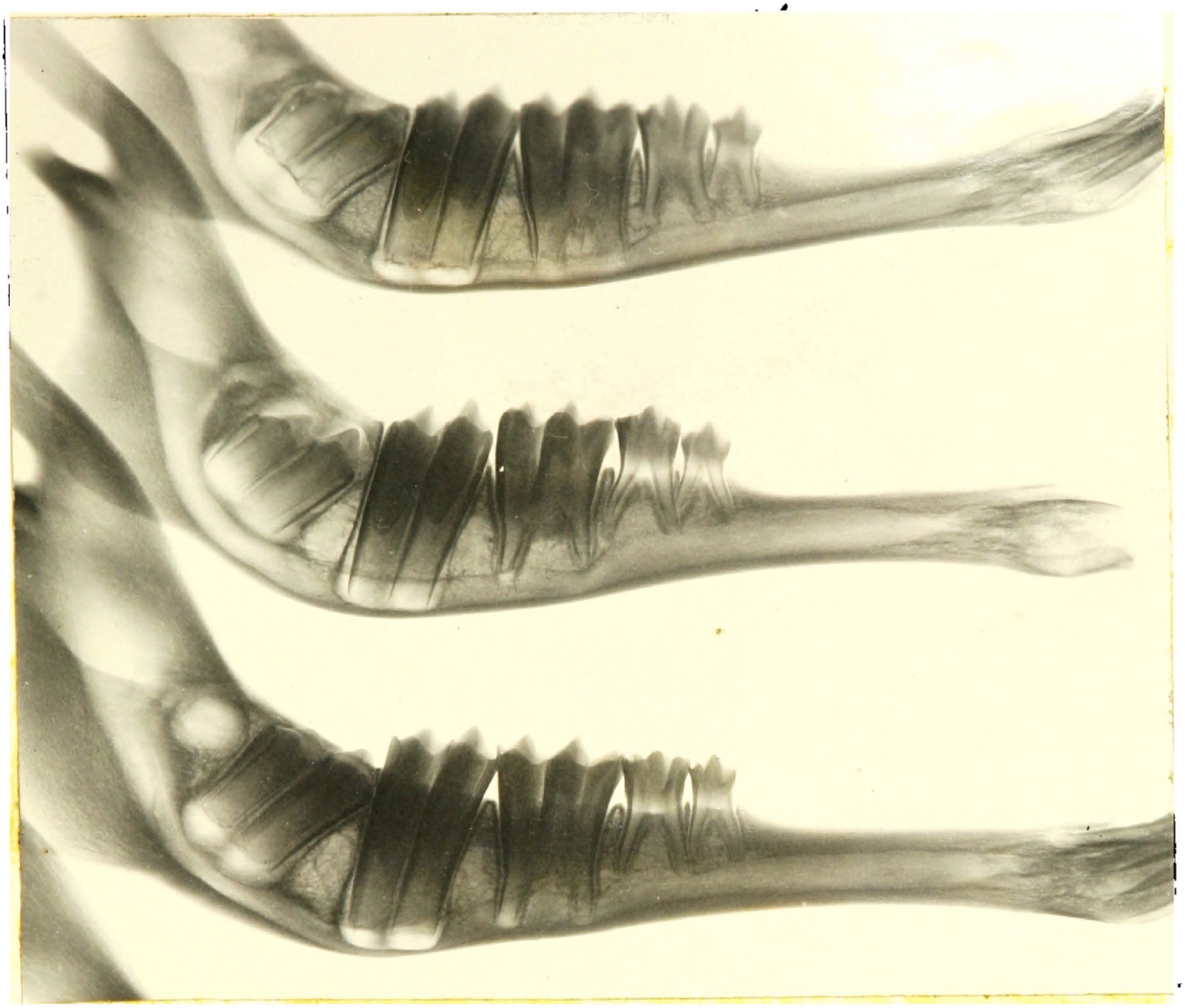
PLATE 9

Actual Size

Figure 26. A 16.5 months specimen (Animal #E-1377) that shows very little change in wear from that of the 16 months specimen.

Figure 27. A 17.5 months specimen (Animal #E-1381) showing amounts of dentine and enamel exposed on the cusps of the molars.

Figure 28. One of three 20 months specimens (Animal #E-1378) which showed the extreme wear of the premolars and the proportion of enamel to dentine exposed on the occlusal surface of the molars.



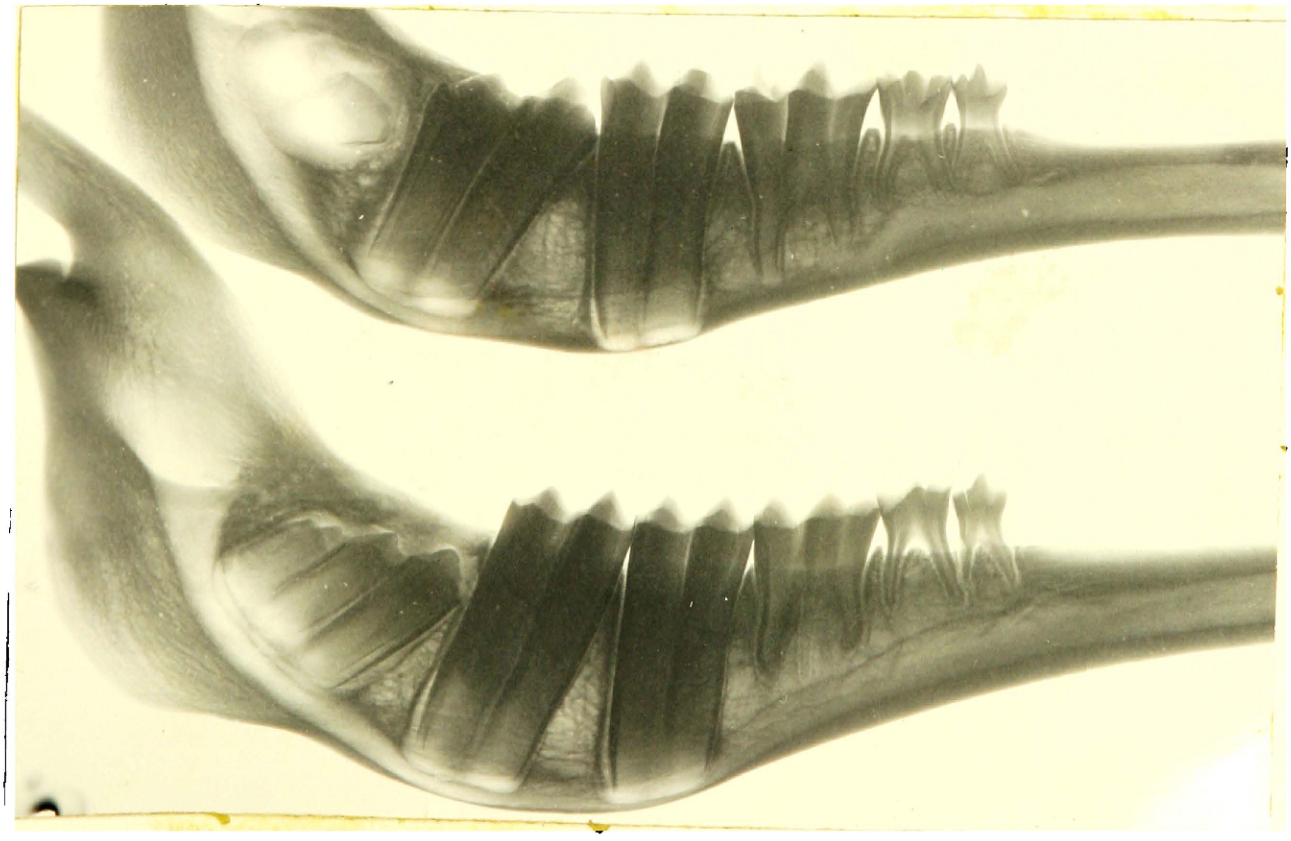


PLATE 10

Actual Size

Facing 62

Figure 29. Radiogram of 44 day specimen (Animal #E-1141) illustrating the depth of the infundibula and the condition of the 2nd molar. The deciduous teeth are rooted while the permanent molars are rootless.

Figure 30. Radiogram of 60 day specimen (Animal #7). Note position and size of 2nd molar.

Figure 31. Radiogram of 110 day specimen (Animal #E-1145). Note the appearance of the 3rd molar.

Figure 32. Radiogram of 6 months specimen (Animal #E-1144) showing the growth of the 2nd molar and the definite shape of the first cusp of the 3rd molar.

Figure 33. Radiogram of 8 months specimen (Animal #2). The 2nd molar is in apposition and the 3rd molar shows definite shape.

From Figures 29 through 33 the eruption of the premolar is shown.

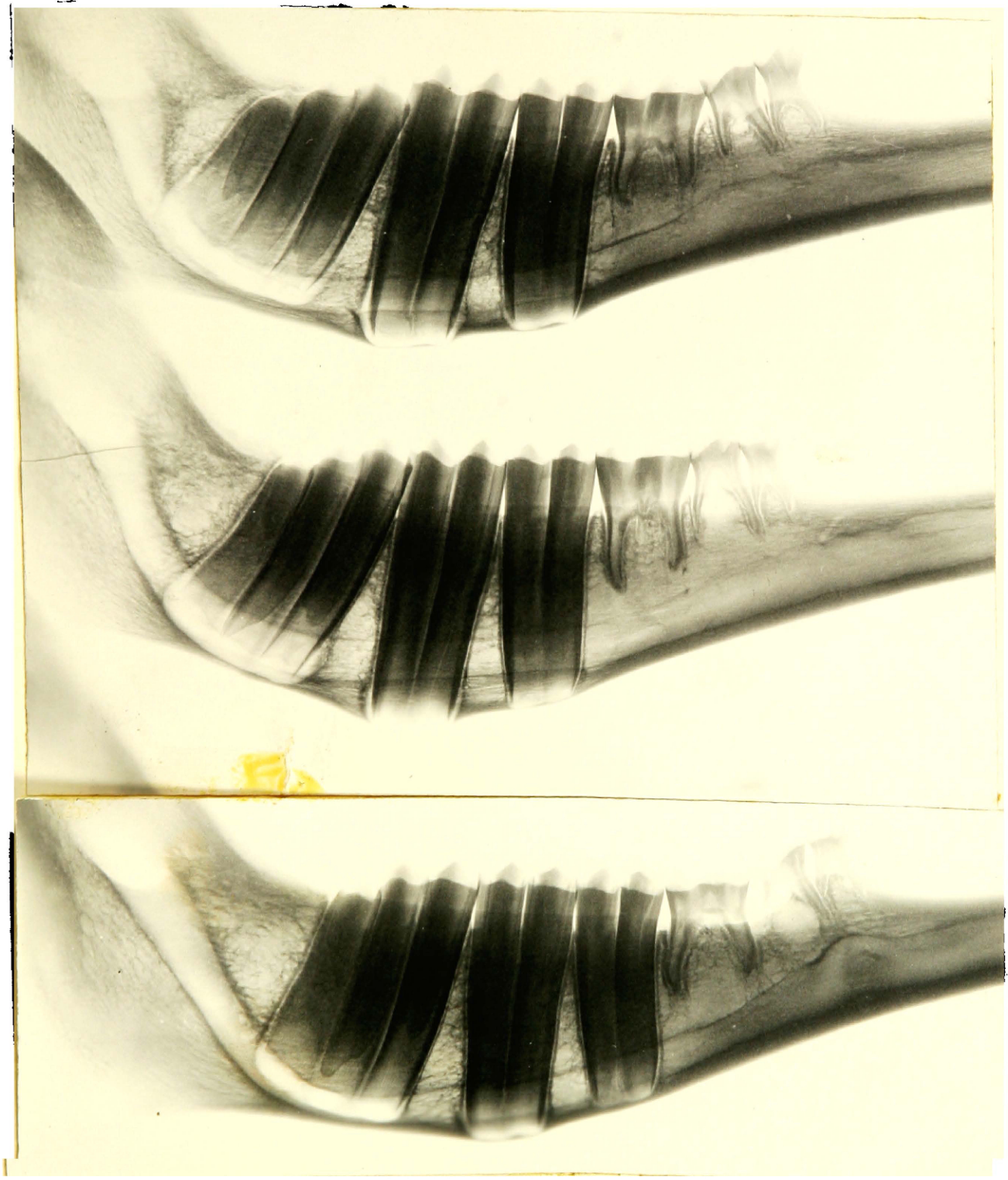


PLATE 11

Actual Size

Figure 34. Radiogram of a 12 months specimen (Animal #E-1390). The 2nd permanent premolar is the light colored area under the deciduous tooth. The first two molars had eroded the jaw bone at their roots.

Figure 35. Radiogram of 14 months specimen (Animal #E-1376). The 3rd molar was beginning to erode the jaw bone at the base of the first two cusps.

Figure 36. Radiogram of a 16 months specimen (Animal #E-1389). The 3rd permanent premolar may be seen immediately below the 3rd deciduous premolar. All three cusps of the 3rd molar are through the jaw bone.

PLATE 12

Actual Size

Figure 37. Radiogram of 16.5 months specimen (Animal #E-1377). The 3rd and 4th permanent premolars were showing definite shape. Notice the degree of root decalcification in the deciduous premolars.

Figure 38. Radiogram of 17.5 months specimen (Animal #E-1381). The infundibular depths are clearly shown and the permanent premolars show progressive development.

Figure 39. Radiogram of a 20 months specimen (Animal #E-1378). The height of the deciduous teeth above the gum line is comparable to the height of the molars even though they are ready to be shed. All three permanent premolars were completing intraosseous eruption. Notice that the 4th deciduous premolar is 3 cusped and that the permanent tooth below it has only two cusps.

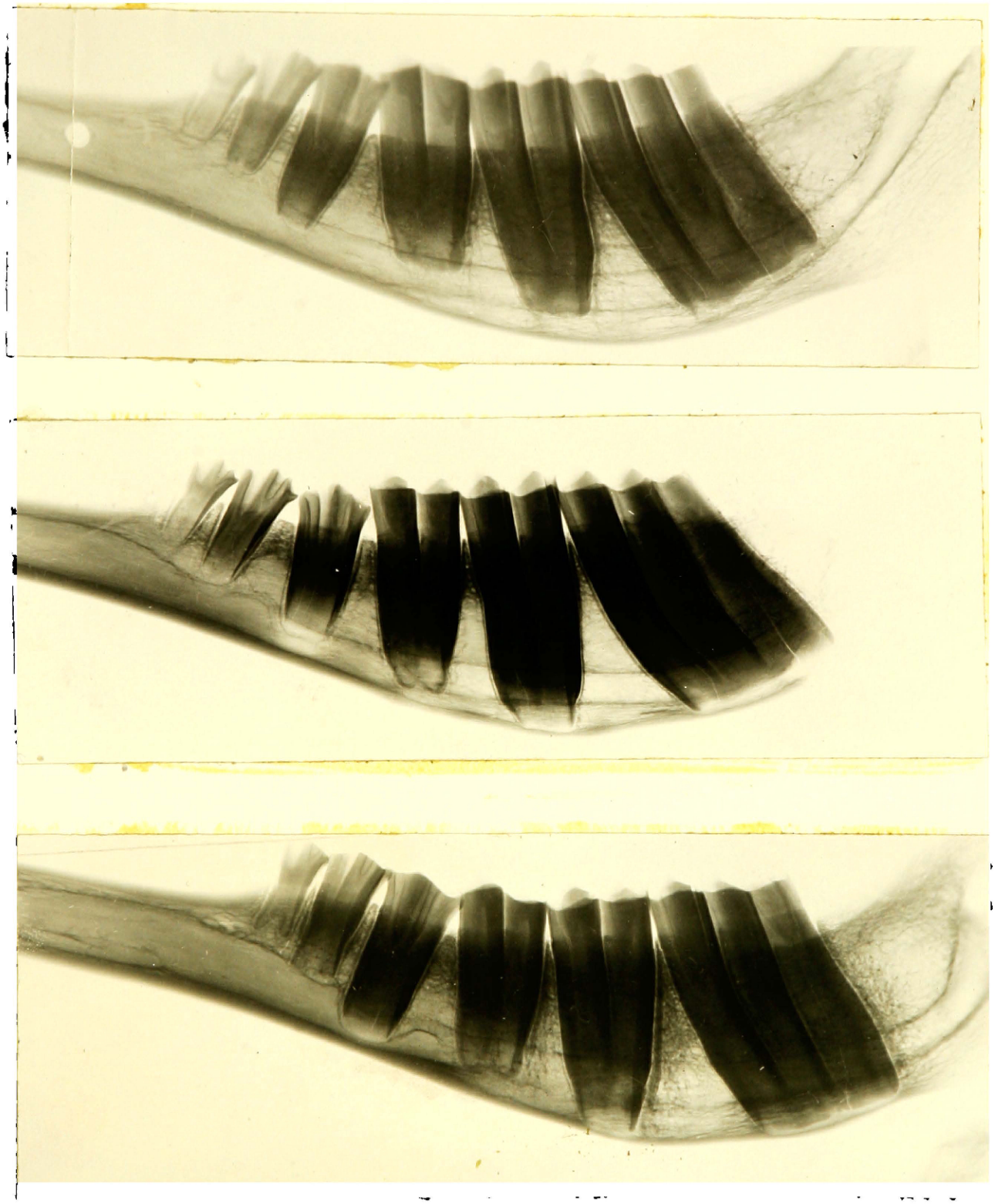


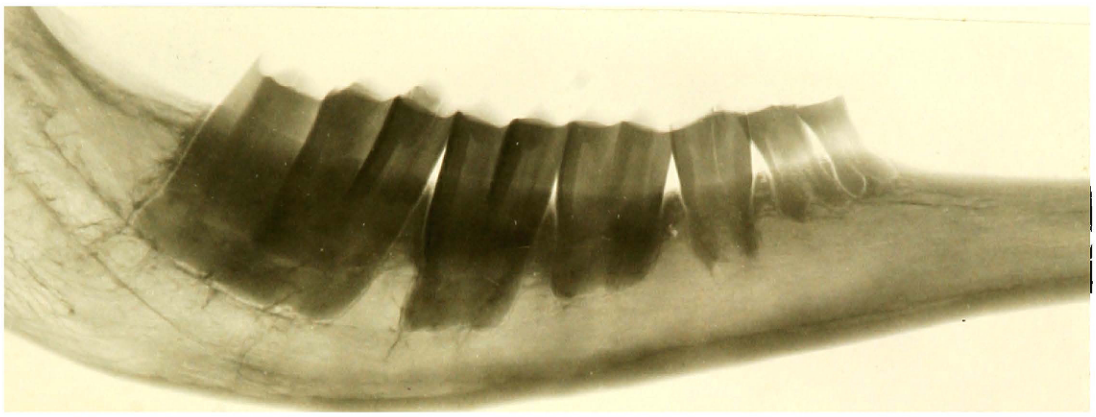
PLATE 13

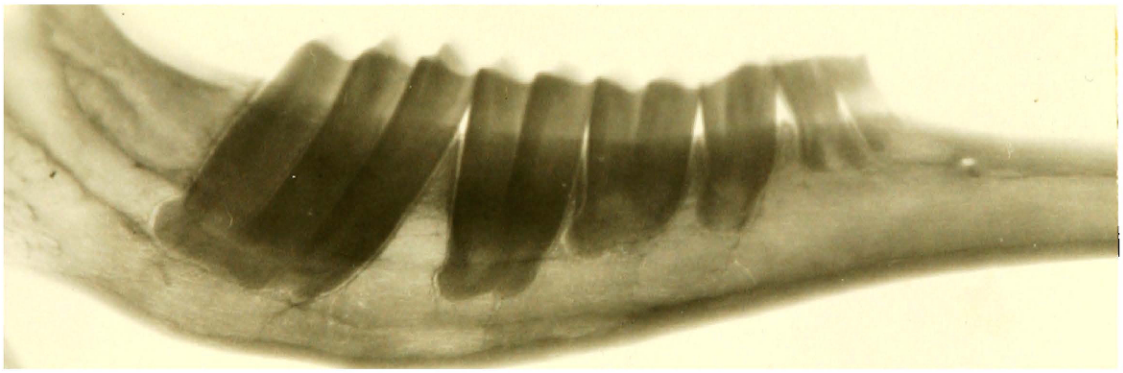
Actual Size

Figure 40. Radiogram of a 27 to 29 months specimen. The jaw shows that all permanent cheek teeth are rootless at this stage. The first molar illustrates eruption even though enamel organ is no longer functioning.

Figure 41. Radiogram of 39-41 months specimen. The molars are tapered at the base and beginning to move away from the jaw bone.

Figure 42. Radiogram of jaw thought to represent a specimen of 4½ years old. The enamel organs of the 4th premolar and all molars had stopped functioning.





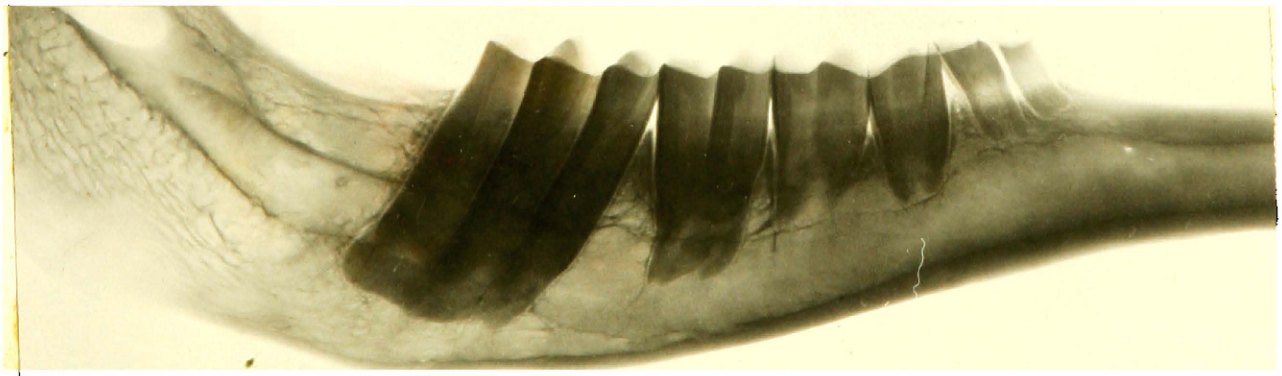


PLATE 14

Actual Size

Figure 43. Radiogram of specimen thought to represent 5½ years of age. Notice the position of the teeth in relation to the base of the jaw bone.

Figure 44. Radiogram of specimen thought to represent 6½ years of age. Illustrates root-like formations on all teeth.

Figure 45. Radiogram of specimen thought to represent 7½ years of age.

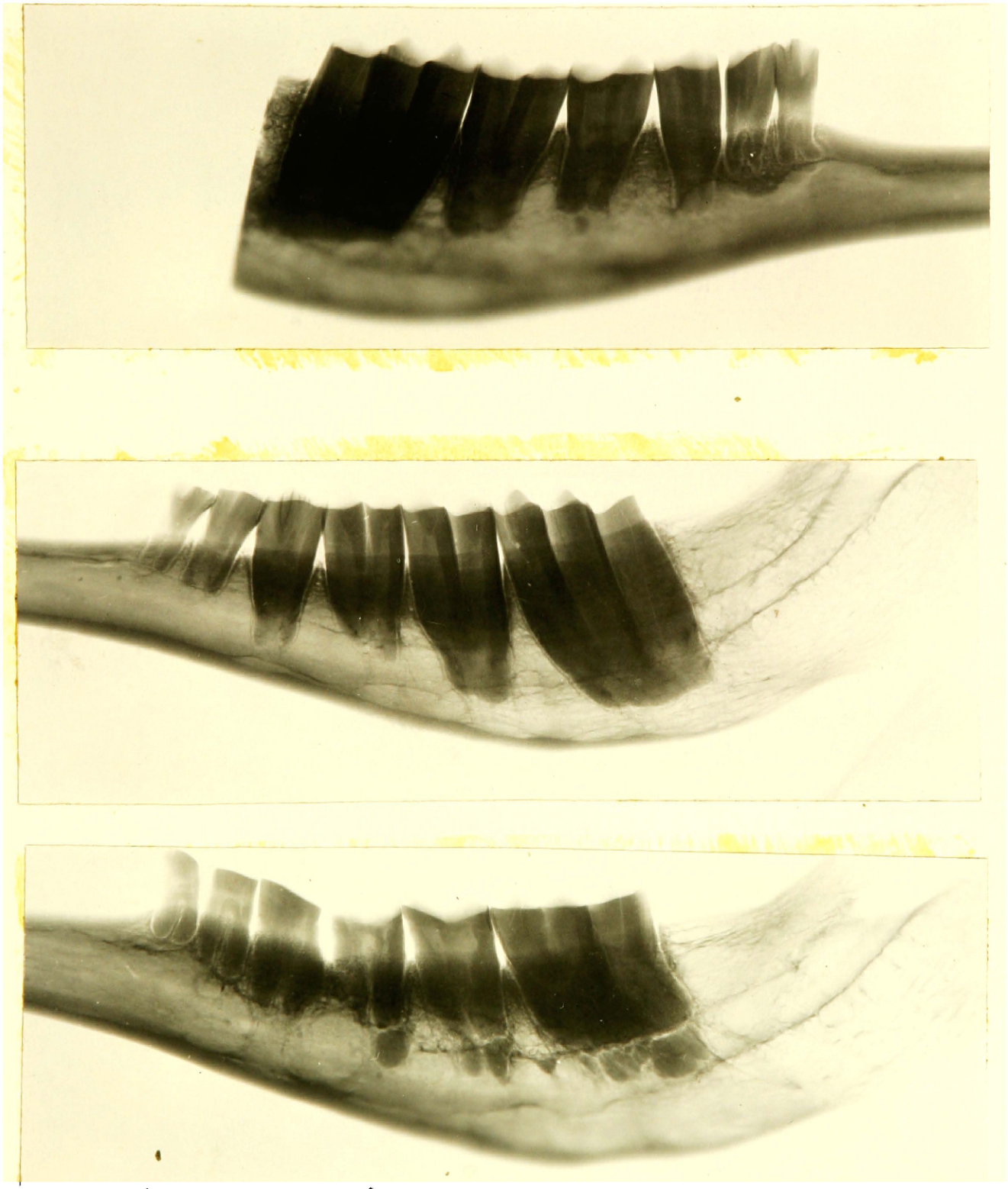


PLATE 15

Actual Size

Figure 46. Radiogram of specimen thought to represent 8½ years of age. This specimen had two infundibula remaining.

Figure 47. Radiogram of specimen thought to represent 8½ years of age. This specimen had only one infundibulum remaining.

Figure 48. Radiogram of specimen thought to represent 9½ years and older. This specimen had lost all 12 infundibula. Notice separation of contact points.










PLATE 16

Actual Size

Figure 49.
Incisors of Animal #E-1141 collected at 44 days of age.

Figure 50.
Incisors of Animal #7 collected at 60 days of age.

Figure 51.
Incisors of Animal #E-1145 collected at 110 days of age.

Figure 52.
Incisors of Animal #E-1144 collected at 180 days of age.

Figure 53.
Incisors of Animal #2 collected at 8 months of age.

Figure 54.
Incisors of Animal #E-1390 collected at 12 months of age.

Figure 55.
Incisors of Animal #E-1376 collected at 14 months of age.

Figure 56.
Incisors of Animal #E-1889 collected at 16 months of age.

Figure 57.
Incisors of Animal #E-1381 collected at 17.5 months of age.

Figure 58.
Incisors of Animal #E-1384 collected at 20 months of age.

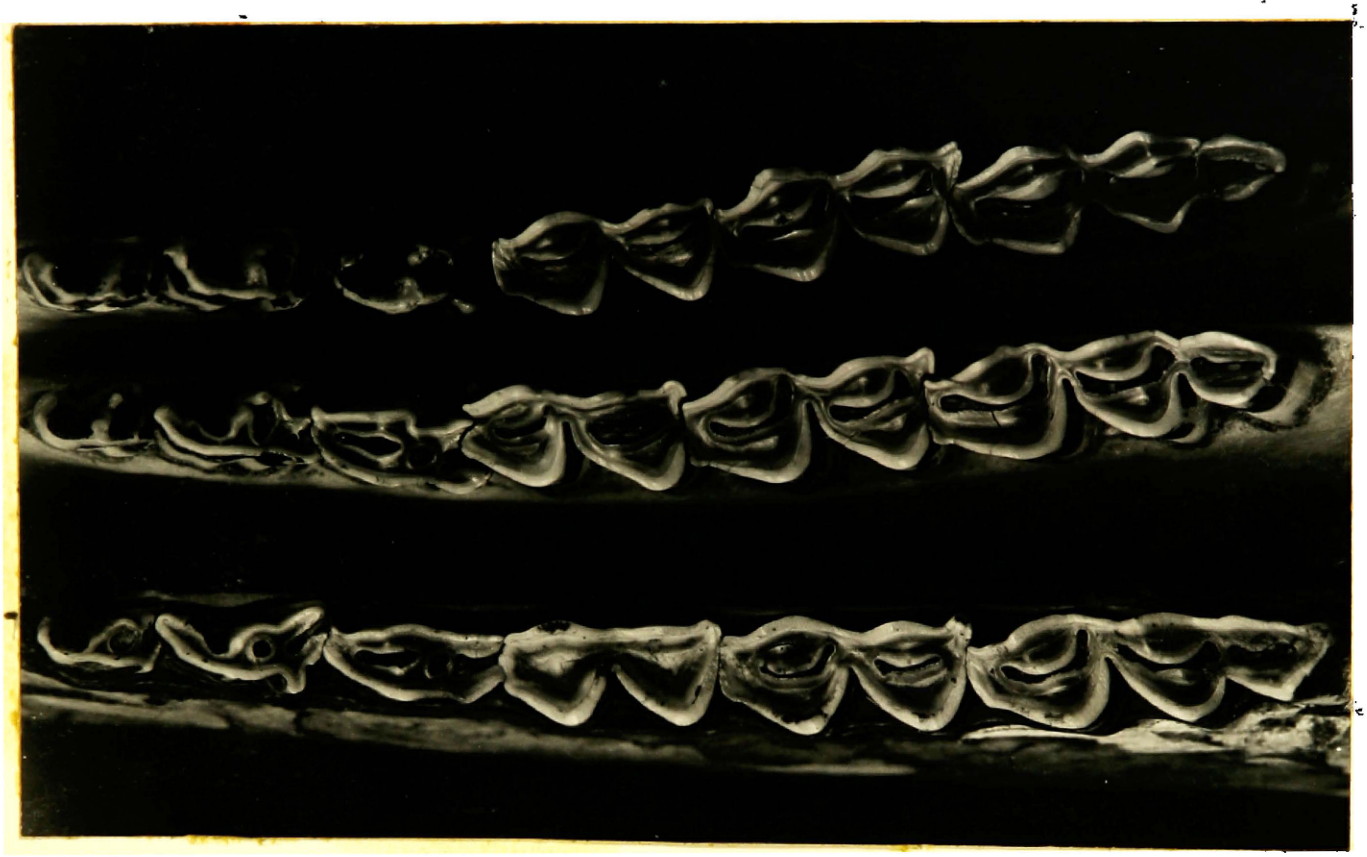


PLATE 17

$1\frac{1}{2}$ x Actual Size

Figure 59. A 27 months specimen showing unworn premolars.

Figure 60. A 39-41 months specimen showing 12 infundibula.

Figure 61. Specimen thought to represent $4\frac{1}{2}$ years, 10 infundibula present.

Figure 62. Specimen thought to represent $5\frac{1}{2}$ years, 8 infundibula present.

Figure 63. Specimen thought to represent $6\frac{1}{2}$ years, 6 infundibula present.

Figure 64. Specimen thought to represent $7\frac{1}{2}$ years, 3 infundibula present.

PLATE 18

$1\frac{1}{2}$ x Actual Size

Figure 65. Specimen thought to represent $8\frac{1}{2}$ years, 2 infundibula present.

Figure 66. Specimen also thought to represent $8\frac{1}{2}$ years, 1 infundibula remaining.

Figure 67. Specimen thought to represent $9\frac{1}{2}$ years or older, no infundibula remaining.