SEX AND AGE DETERMINATION OF THE COLLARED PECCARY

(*DICOTYLES TAJACU*) BY SKULL CHARACTERISTICS

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

In order to evaluate the usefulness of skull measurements as an indicator of age and sex in the collared peccary, Dicotyles tajacu, 90 complete skulls (upper and lower jaws) and 61 lower jaws of adult peccaries were collected during the 1969 hunting season in Arizona. Information on the sex of the animal was obtained from the hunter and skulls were placed in wear classes according to the degree of tooth wear.

Significant differences at the 95 per cent level were found between male and female skulls on the following measurements: (1) greatest skull length, (2) greatest skull width, (3) ratio of skull length/skull width, and (4) angle of skull. No age or sex criterion could be formulated from any single measurement.

A potential criterion for determining sex of peccary skulls was formulated using the skull length/skull width ratios plotted against the angle of the skulls. The discriminant function was used as the criterion of classification.

A potential criterion for estimating age was indicated by the lower canine anterior-posterior width measurement. The five wear class width means were significantly different from each other when tested at the 95 per cent level using the Duncan's multiple range test.

INTRODUCTION

The collared peccary, Dicotyles tajacu (Linnaeus 1758; Woodburne 1968) has become an important game animal in Arizona. The increasing popularity of the peccary with sportsman has necessitated more intensive management. A knowledge of the age and sex structure of wild populations is basic for their intelligent management. Age of young peccaries can be estimated by the sequence of tooth emergence and replacement (Kirkpatrick and Sowls 1962). Tooth wear classes have been used to estimate the relative age of adult animals after all permanent teeth are in (Sowls 1961) but no chronological ages have yet been assigned to these wear classes. Sexual dimorphism is not readily apparent in the field and sex determination is possible only when the external genitals can be seen. Data on the sex of hunter-killed animals can be obtained by examination of the peccaries' genitals or by questioning the hunter. This study was designed to determine if sex and age of the collared peccary could be determined on the basis of skull characteristics.

The objectives were:

1. To determine if there are any significant differences between male and female skulls of the collared peccary.
2. To use this information, if possible, to formulate sex determination criteria based on the differences.

3. To evaluate the usefulness of skull measurements as an indicator of age.
4. To determine at what age the lower and upper canine teeth cease to grow.

MATERIALS AND METHODS

All of the skulls used in this study were obtained from hunter-killed peccaries. A total of 150 skulls were collected during the 1969 hunting season from two hunter-check-stations in Tucson, Arizona. The stations were located at the Cash Box Sporting Goods Store and at John Doyle's Taxidermy Shop. Although 150 skulls were collected, only the adult skulls were used in this study. After all skulls which had either been shot or were from immature animals were discarded, 73 complete skulls (upper and lower jaws) and 18 lower jaws could be used. Another 17 complete skulls and 43 lower jaws from previous collections were obtained from the Cooperative Wildlife Research Unit.

At the checking stations an individual record sheet indicating sex and wear class of teeth on each animal was filled out; skulls were then tagged and frozen until cleaned.

During the months of April and May all of the skulls were cleaned by boiling them approximately five hours in a solution of water and common laundry soap. All flesh was removed, and the skulls were then dried for sixty days. At the end of the drying period, the skulls were separated by sex and then placed in wear classes according to the degree of tooth wear (Sowls 1961).

The following measurements were made with a large caliper that had been constructed from two combination squares welded together, a 38 cm. steel rule, a protractor, and a small pair of dividers:

1. Greatest skull length
2. Greatest skull width
3. Ratio of greatest skull length/greatest skull width
4. Height of skull
5. Angle of skull
6. Least interorbital width
7. Length of lower mandible
8. Right upper and lower canine length
9. Right upper and lower canine anterior-posterior width
10. Right upper and lower canine latero-medial width

All measurements were in millimeters, except the angle measurement. The basic features of the peccary skull with which this paper is concerned are shown in Figures 1 through 6.

Statistical Methods

To determine if there were any significant differences between male and female peccary skulls, the means of seven sets of measurements were tested by a Student's t test. I assumed that all skull growth had ceased at wear class one so the skull measurements were grouped together regardless of wear class. When a significant difference was indicated between means, the means of the five wear classes of both sexes for that particular measurement were plotted and a 95 per cent confidence interval on the means was established. From this graph the extent to which variation was correlated with age or sex and the

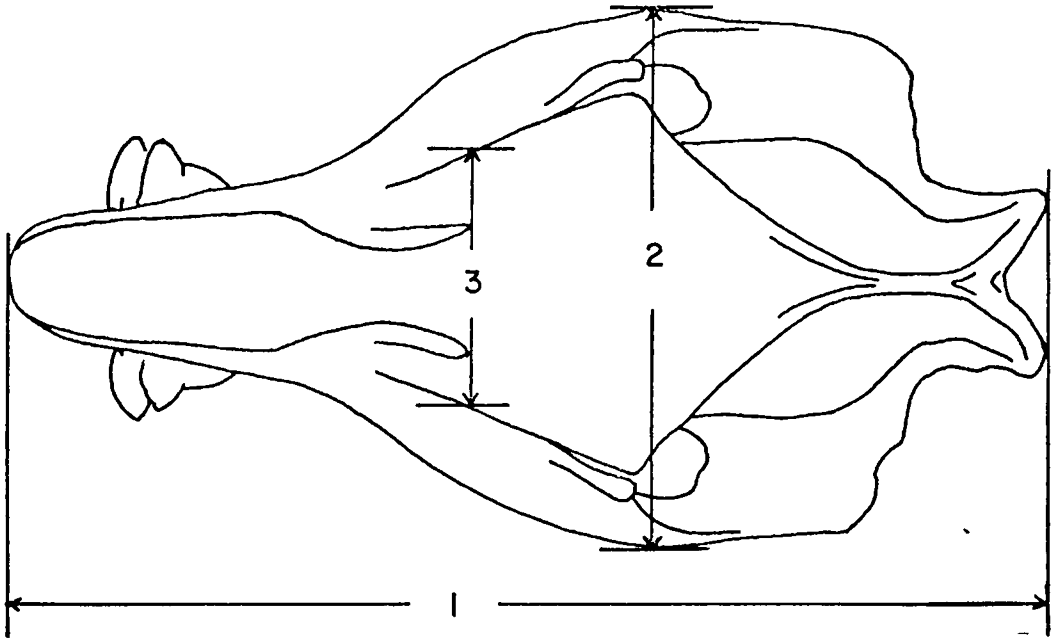

Figure 1. A dorsal view of a peccary skull. -- 1. greatest skull length; 2. greatest skull width; and 3. least interorbital width.

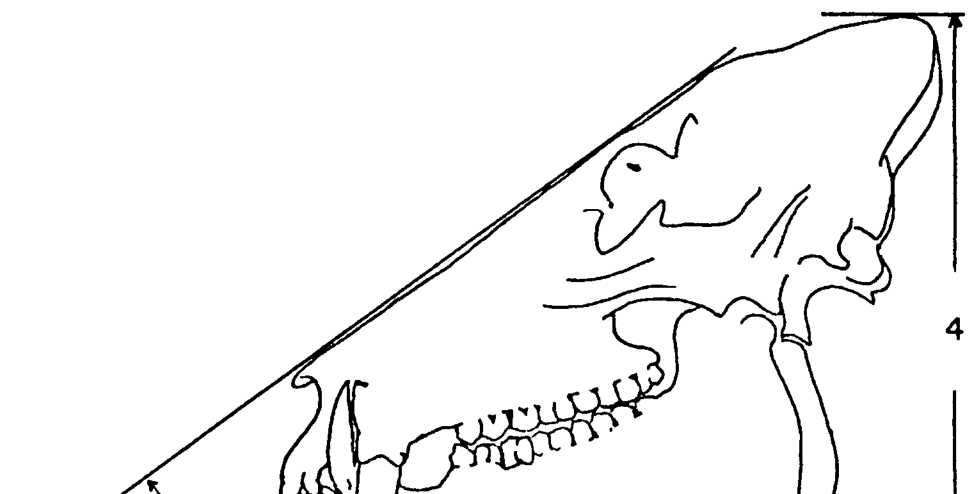

Figure 2. A lateral view of a peccary skull. -- 4. height of skull; and 5. angle of skull.

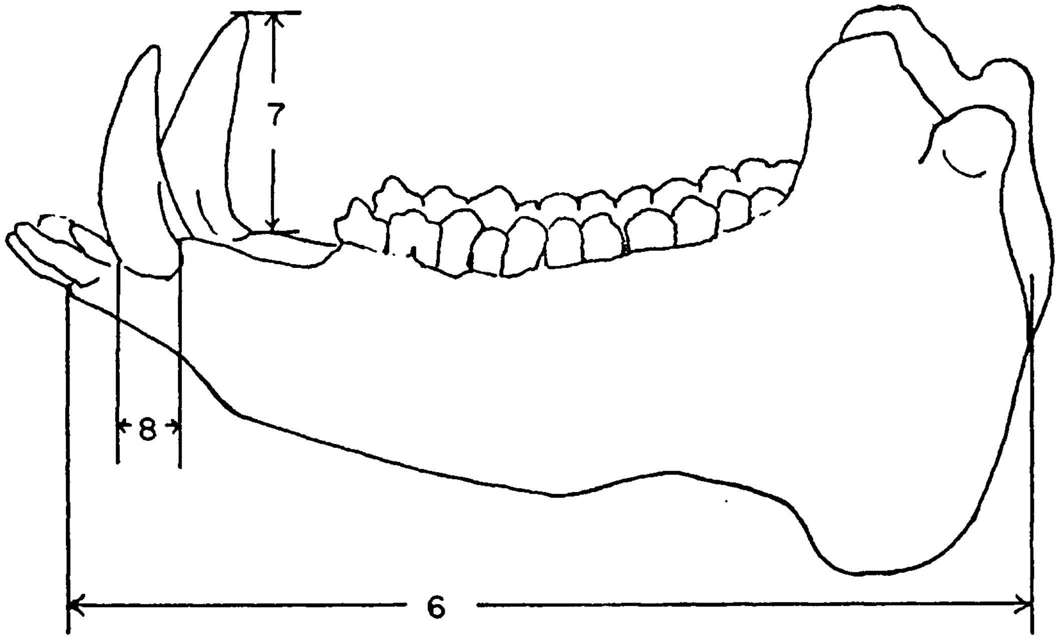

Figure 3. A lateral view of a lower jaw. -- 6. length of lower mandible; 7. length of the lower canine tooth; and 8. lower canine latero-medial width.

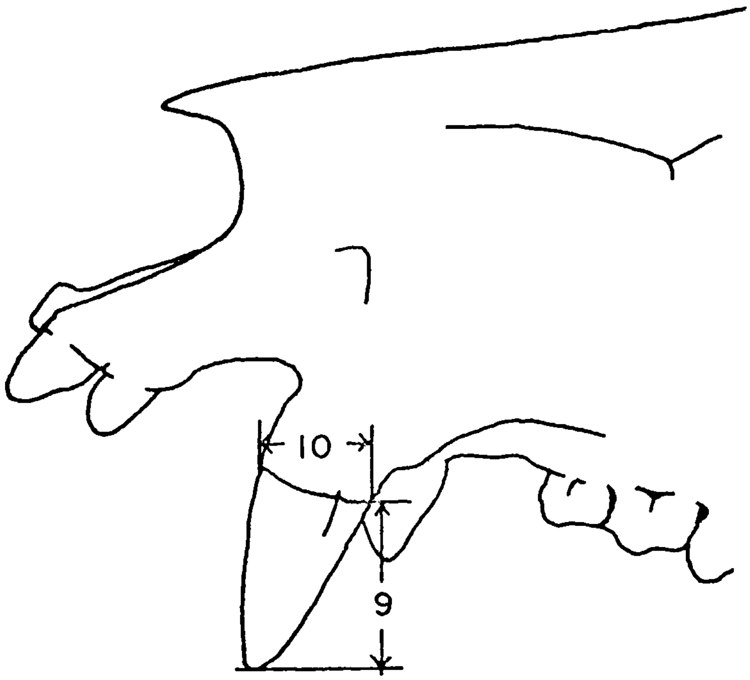

Figure 4. A lateral view of the anterior part of a peccary skull. -- 9. length of the upper canine tooth; and 10. upper canine latero-medial width.

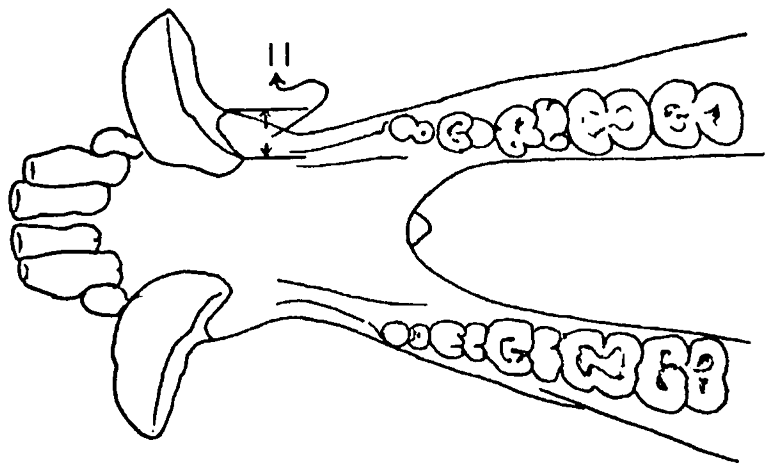

Figure 5. A dorsal view of the anterior of a lower jaw. -- 11. lower canine anterior-posterior width.

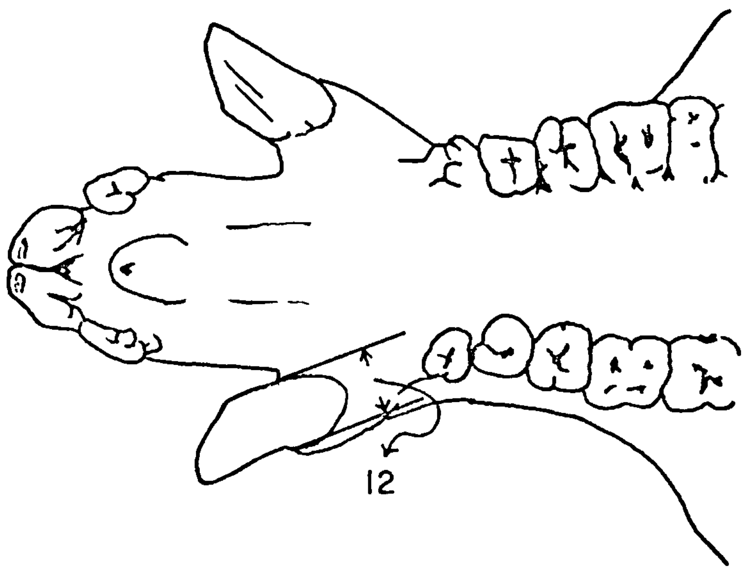

Figure 6. A ventral view of the anterior part of an upper jaw. -- 12. upper canine anterior-posterior width.

possibility of establishing criteria for age or sex determination were determined.

To determine at what age the canine teeth ceased to grow, a Student's t test was first run between male and female canine teeth on the three measurements taken on the teeth in wear class one. This test was made in order to strengthen my assumption that there was no significant difference between male and female canine teeth so that both male and female canine teeth measurements could be combined. This wear class was chosen because less interpretation of the degree of tooth wear was needed to place the skull in that class.

Statistical procedures used in analysis of the seven sets of measurements presented in this report were adapted from those of Simpson, Roe, and Lewontin (1960). Differences between means were tested by the Student's t test at the 95 per cent level. The statistical procedures used in analysis of the ratio-angle relationship were adapted from Anderson (1958). The statistical procedures used for the analysis of variance and Duncan's multiple range test were adapted from Fryer (1966).

RESULTS AND DISCUSSION

Greatest Length

When all wear classes were grouped together, a significant difference (<u>t</u> = 2.07, df = 87) was observed between the lengths of male and female skulls. From these data I concluded that female peccary skulls are longer than male peccary skulls. Table 1 gives the Student's <u>t</u> test of the difference in lengths between male and female skulls.

Table 1. Student's <u>t</u> test of the difference in lengths between male and female skulls expressed in millimeters.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\overline{X}$	s^2	N	$\overline{X}$	x^2	<u>t</u>	P .05
Greatest length	34	233.8	45.2	55	237.0	53.0	2.07	2.00

N: number of observations
$\overline{X}$: arithmetic mean
s^2: variance $= \dfrac{\Sigma X - \dfrac{(\Sigma X)^2}{N}}{N-1}$

The small observed difference in lengths between male and female peccary skulls was of little value as a sex criterion for determining the sex of an individual skull.

The grestest length-age relationship is illustrated in Figure 7. Sample mean, 95 per cent confidence interval on the mean, range, number of observations, and standard error of the mean in each wear class are included. The sample variation indicated that greatest length was an unreliable indicator of age or sex but small sample sizes have important bearing on the observed variation within age classes.

Greatest Width

A significant difference (t = 3.67, df = 86) was observed between the widths of male and female skulls. From these data I concluded that male skulls are wider than female skulls. Table 2 gives the Student's t test of the difference in widths between male and female skulls.

Table 2. Student's t test of the difference in widths between male and female skulls expressed in millimeters.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\overline{X}$	s^2	N	$\overline{X}$	s^2	t	P .05
Greatest width	33	103.7	32.8	55	100.1	12.3	3.67	2.00

The observed difference between means of male and female skull widths was so small that the sex of no individual animal could be determined by the width of the skull.

Figure 8 illustrates the greatest width-age relationship. Because of sample variation this relationship was of little value as an indicator of age or sex.

Figure 7. The greatest skull length-wear class relationship of male and female skulls giving the minimum, mean, and maximum skull lengths in each wear class.

The 95 per cent confidence interval on the means is shown graphically and the standard error of the mean is given below each sample, while the sample size is given above each sample.

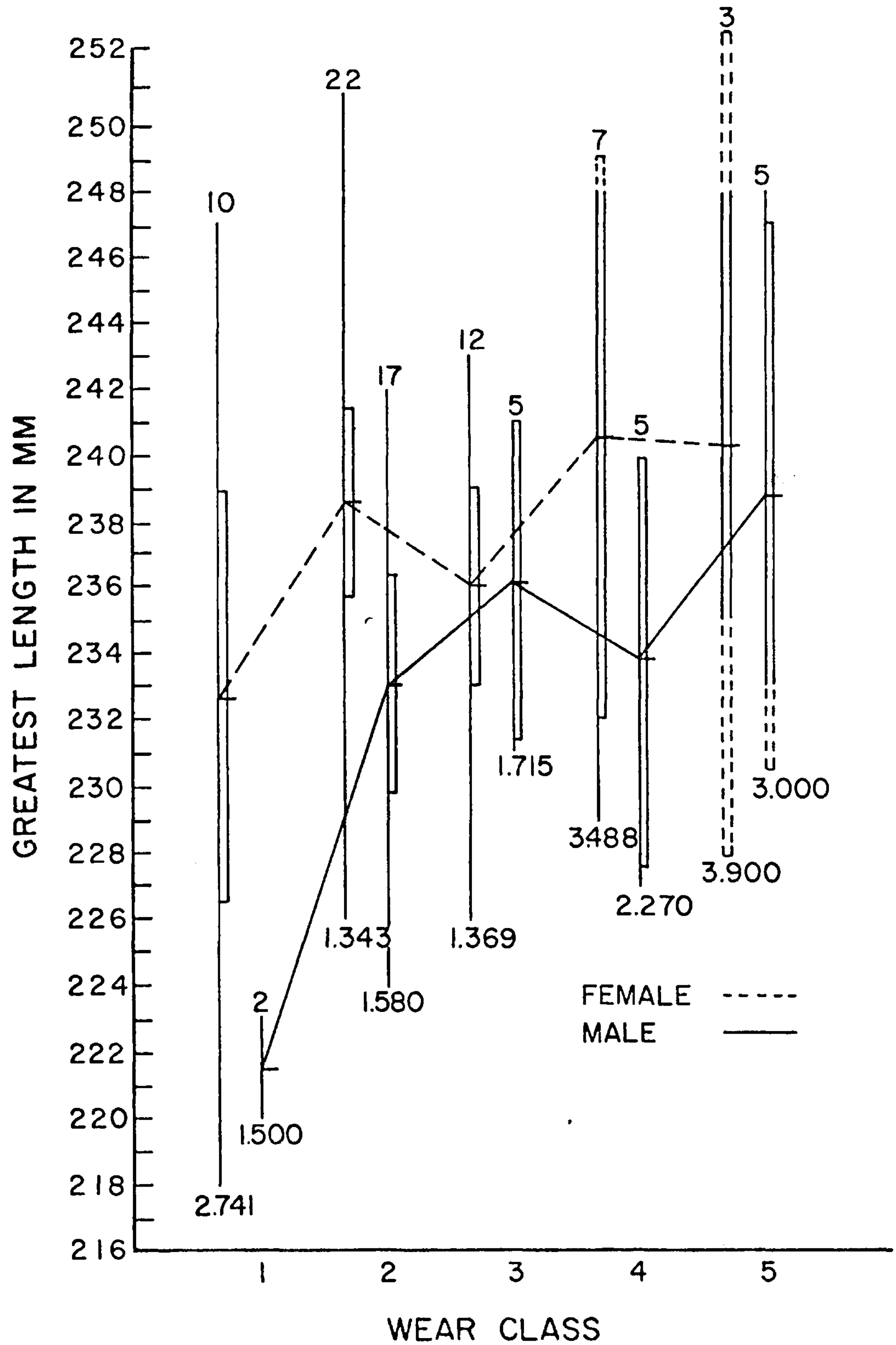

Figure 7. The greatest skull length-wear class relationship of male and female skulls giving the minimum, mean, and maximum skull lengths in each wear class.

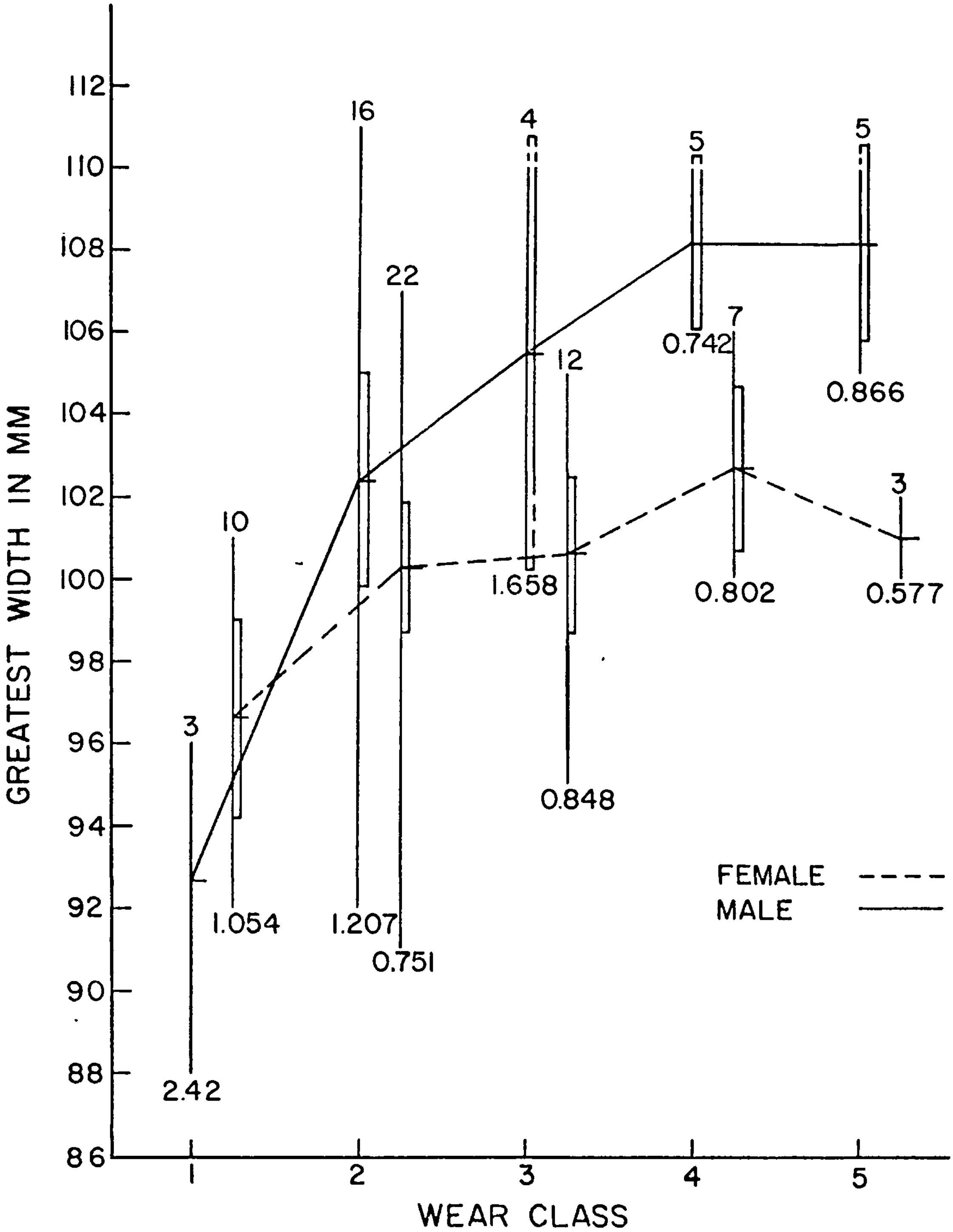

Figure 8. The greatest skull width-wear class relationship of male and female skulls in each wear class. -- Refer back to Figure 7 for explanation of the graph's numbers.

Ratio of Skull Length/Skull Width

A ratio was obtained by dividing the skull length by the skull width. This was done for each observation in each wear class of both male and female skulls. A significant difference between the sexes (t = 5.49, df = 85) was found. Table 3 gives the Student's t test of the difference in ratios between male and female skulls.

Table 3. Student's t test of the difference in skull length/skull width ratios between male and female skulls expressed in millimeters.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\bar{X}$	s^2	N	$\bar{X}$	s^2	t	P .05
Ratio	32	2.26	.01	55	2.37	.007	5.49	2.00

The observed differences between the two means were of little value in determining the sex of an individual skull.

The ratio-age relationship is shown in Figure 9. Figure 9 indicates that there was a significant difference between the means of male and female ratios in wear classes two and four, however, sex or age of individual animals could not be determined reliably by this relationship.

Height of Skull

The differences between height of male and female skulls were not significant (t = 1.38, df = 69). Table 4 gives the Student's t test of the difference in heights between male and female skulls.

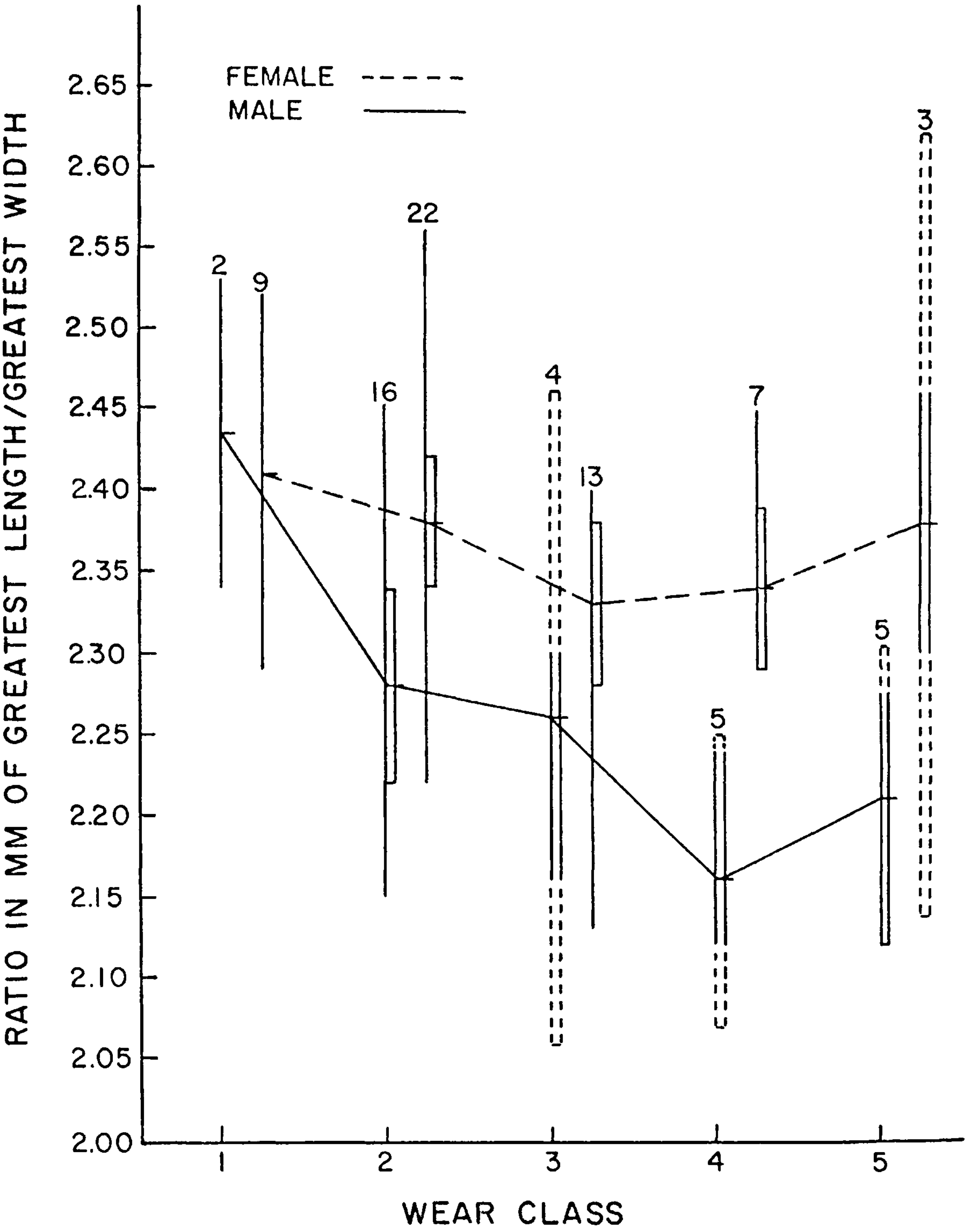

Figure 9. The skull length/skull width ratio-wear class relationship of male and female skulls in each wear class. -- Refer back to Figure 7 for explanation of graph's numbers.

Table 4. Student's t test of the difference in heights between male and female skulls expressed in millimeters.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\bar{X}$	s^2	N	$\bar{X}$	s^2	t	P .05
Height	27	152.5	61.4	44	149.8	64.8	1.38	2.00

Angle of the Skull

The angle of the complete skull (Figure 2) was taken and the means of this measurement for the two sexes were compared. A significant difference ($t = 2.41$, df = 68) was observed. I concluded that male skulls had a higher angle of skull slope than female skulls. Table 5 gives the Student's t test of the difference in angles between male and female skulls.

No angle-age relationship was considered for this measurement because of small sample sizes in some of the wear classes.

Table 5. Student's t test of the difference in angles between male and female skulls expressed in degrees.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\bar{X}$	s^2	N	$\bar{X}$	s^2	t	P .05
Angle	27	26.2	10.7	43	24.4	8.44	2.41	2.00

Least Interorbital Width

No significant differences were found between the least interorbital width of male and female peccary skulls ($t = 0.694$, df = 87).

Table 6 gives the Student's t test of the difference in least interorbital widths between male and female skulls.

Table 6. Student's t test of the difference in least interorbital widths between male and female skulls expressed in millimeters.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\bar{X}$	s^2	N	$\bar{X}$	s^2	t	P .05
L interorbital width	34	50.2	6.78	55	48.9	7.88	0.694	2.00

Length of Lower Mandible

I found no significant differences (t = 0.481, df = 143) between the lengths of lower mandibles of male and female peccary skulls. Table 7 gives the Student's t test of the difference in lengths of lower mandibles between male and female skulls.

Table 7. Student's t test of the difference in lower mandible lengths between male and female skulls expressed in millimeters.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\bar{X}$	s^2	N	$\bar{X}$	s^2	t	P .05
Mandible length	70	155.2	26.0	75	154.8	24.0	0.481	1.98

Ratio-angle Relationship

The length/width ratios and angle of skull were plotted (Figure 10). A grouping into two sex "populations" can be seen. The

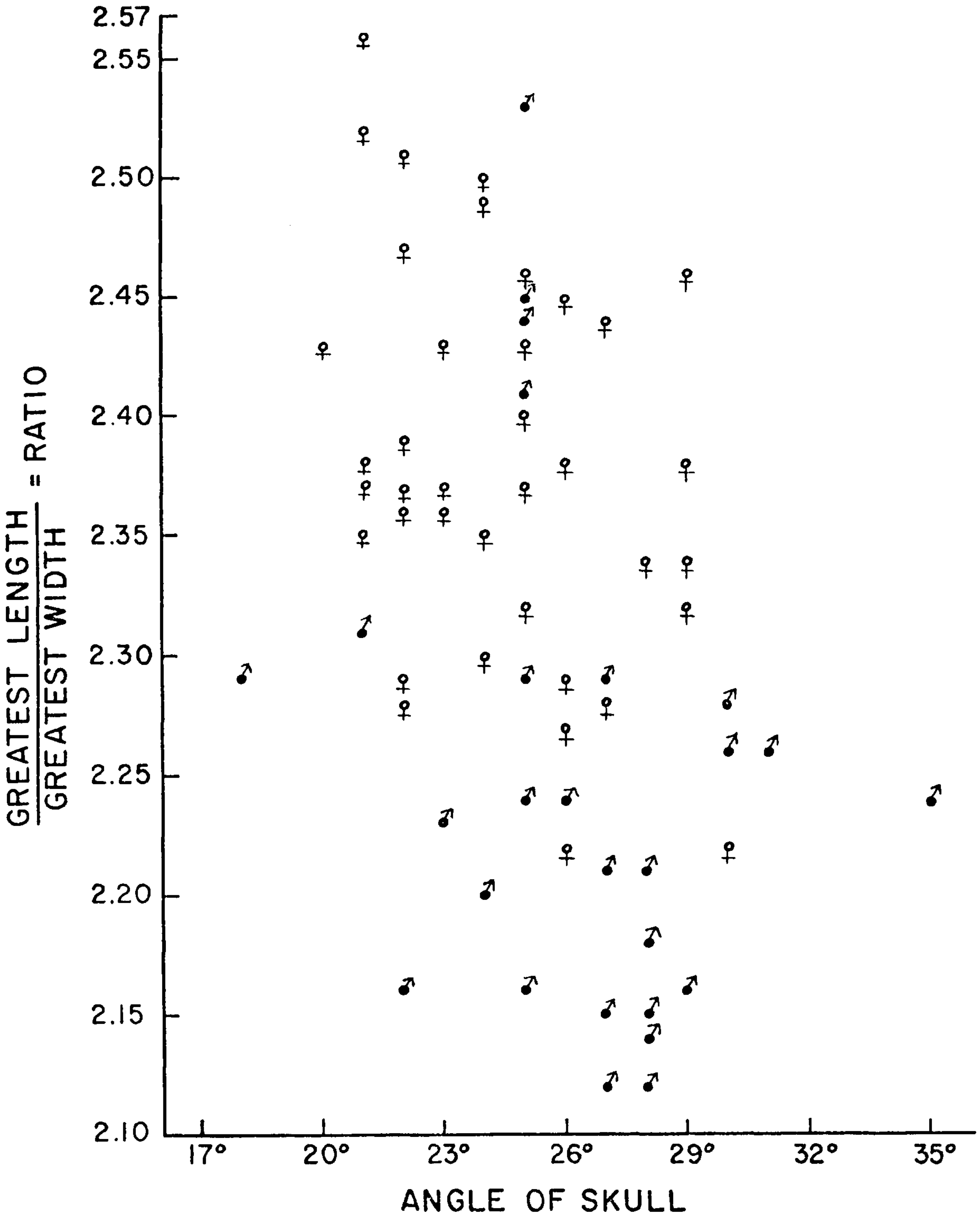

Figure 10. The skull length/skull width ratio-angle relationship of peccaries involved in this study.

problem was: given a skull with certain measurements, with which population does it share the greatest similarities?

The problem thus stated involves a classification of a skull into one of two multivariate normal populations when the parameters are estimated. One population was skulls from males and the other was females. The discriminant function which was defined as the linear function that has greatest "variance between samples" relative to the "variance within samples" was proposed as the criterion of classification into one of the two populations. Based on the data illustrated in Figure 10, the discriminant function was calculated to be X(-.132) + Y(11.669) - 23.682 where X was equal to the angle of the skull and Y was equal to the ratio.

The discriminant function D was then related to zero, such that if D was less than or equal to zero, the skull was a male. If D was greater than zero, the skull was female. The above was based on the assumption that the probability of selecting a male skull was equal to the probability of selecting a female skull to be classified. Also the assumption was made that the probability of classifying the skull as female when it really was male was equal to the probability of classifying the skull as male when it really was female. This probability of misclassification was calculated to be 0.2877. For further details refer to Anderson (1958).

Because all skulls were obtained from hunter-killed peccaries, it was necessary to accept the hunter's word on the sex of the animal he shot and in some instances errors may have been entered because of this.

Assuming that there were sex errors, the discriminant function calculated from Figure 10 does not represent a true classification criterion. Because of this, the discriminant function calculated from Figure 10 should only suggest that the ratio-angle relationship has the potential of becoming a sexing criterion of peccary skulls. A future study with known sex skulls and a larger number of observations should be considered before constructing a sex criterion from the ratio-angle relationship.

Growth of Canine Teeth

Three measurements were taken on the right canine tooth of the upper and lower jaws of peccaries. These were the canine length, canine anterior-posterior width, and canine latero-medial width. Before combining the same male and female canine measurements, a Student's *t* test was run on the six sets of measurement means between male and female canines in wear class one. Table 8 gives the Student's *t* test of the differences in canine tooth measurements between male and female. Even though some sample sizes are rather small, I concluded that there was no significant difference in canine tooth measurements between the two sexes. The same measurements on male and female canines were combined.

The six combinations of male and female measurements with means and 95 per cent confidence interval on the means were plotted against the five wear classes. When the means were plotted against

Table 8. Student's t test of the differences in canine teeth between males and females in wear class one expressed in mm.

	Male skulls			Female skulls			"t" test	
Measurement	N	$\overline{X}$	s^2	N	$\overline{X}$	s^2	t	P .05
Upper CL	2	27.5	13.00	9	27.2	3.50	1.79	2.228
Lower CL	7	33.6	8.33	9	33.6	9.75	0.62	2.131
Upper LM width	2	12.5	0.50	9	12.3	0.38	1.02	2.228
Lower LM width	9	10.1	0.25	10	10.0	0.44	0.37	2.101
Upper AP width	2	7.0	0.00	9	7.1	0.50	1.92	2.228
Lower AP width	9	6.9	0.63	10	6.8	0.89	0.25	2.101

CL: canine length
LM width: latero-medial width
AP width: anterior-posterior width

the wear classes, the sample variation caused the results to be unreliable in determining the point at which growth ceased except for the measurement of the lower anterior-posterior canine width (hereafter abbreviated AP width). In order to save space these plotted means are not included in this report. The statistical criteria for these six measurements can be obtained from appendices A, B, C, D, E, and F.

The measurement of the lower AP width proved to be of value when the five wear class means were plotted with a 95 per cent confidence interval on the means. This tooth width-wear class relationship is illustrated by Figure 11. Table 9 gives the summary of the analysis of variance and Duncan's multiple range test comparing the five wear class means of the lower AP width. All five means differed significantly from each other.

A regression analysis was conducted on the width-age relationship. The data were fitted to the following regression model: (Y = the mean of the distribution of canine widths of all peccaries within a wear class; X = wear class). The correlation coefficient was .99. The regression line calculated from the data is presented in Figure 12 The means for the Y values were used because no chronological ages are known for the wear classes. Apparently the lower AP width continues to increase throughout the life of the peccary.

A future study should be considered in order to determine the possibility of establishing an age criterion based on the lower AP width.

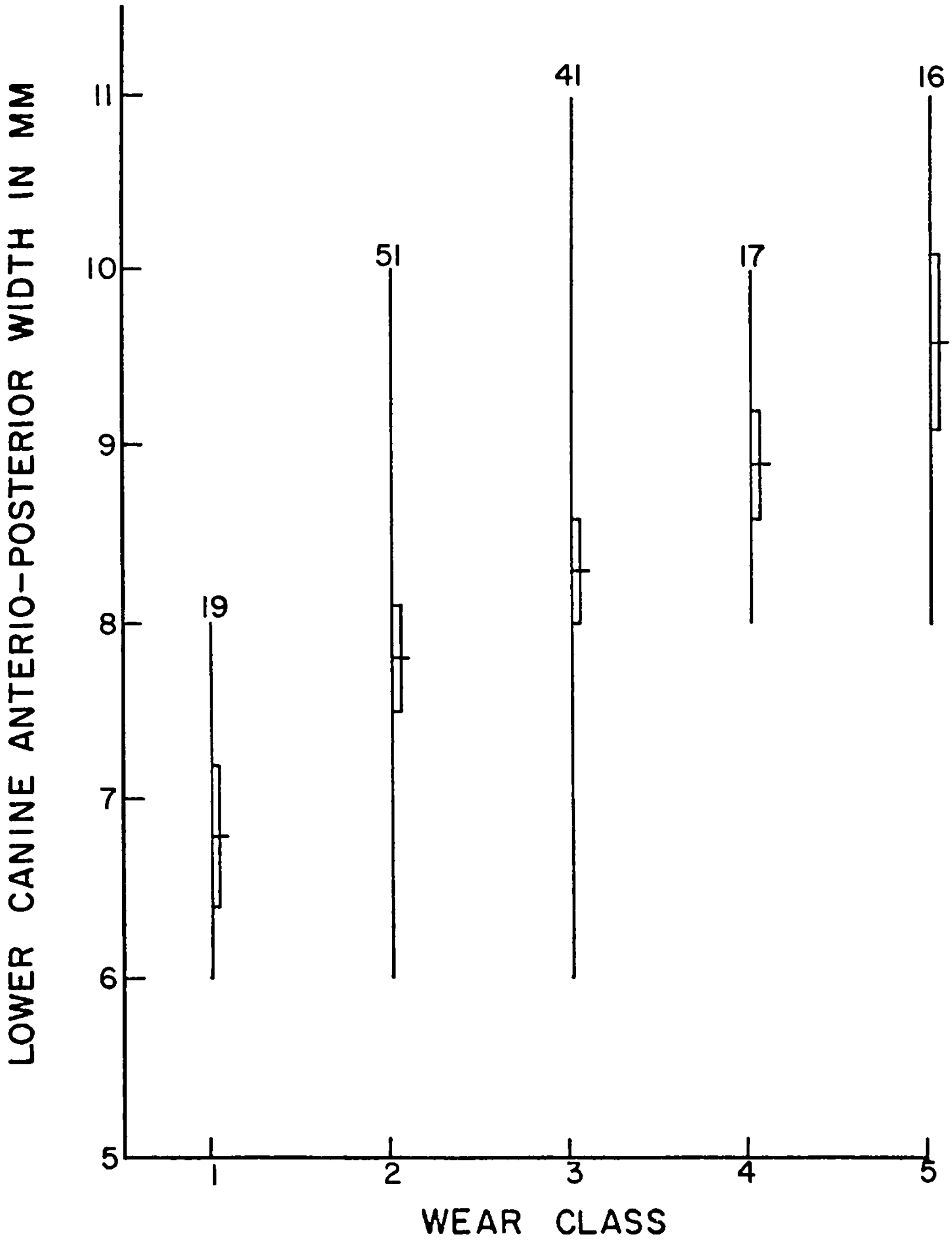

Figure 11. The lower anterior-posterior canine width-wear class relationship giving the minimum, mean, and maximum in each wear class. -- The 95 per cent confidence interval on the means is shown graphically and the sample size is given above each sample.

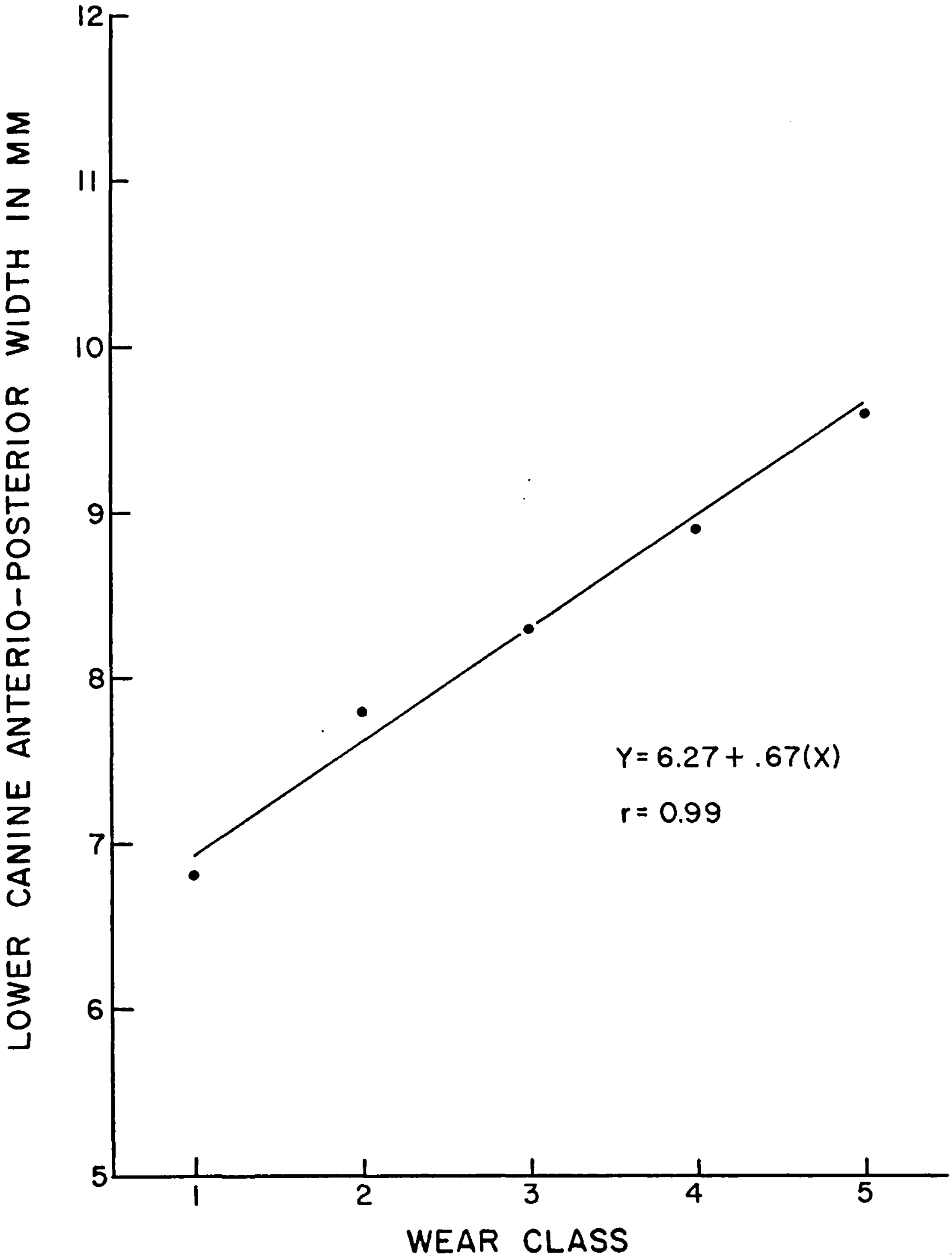

Figure 12. Regression line of lower anterior-posterior canine width-wear class relationship of peccaries involved in this study.

Table 9. Analysis of variance and Duncan's multiple range test comparing the five wear class means of the lower AP width.

Analysis of variance

	Sum of squares	df	Mean squares	F
Category means	79.8	4	19.950	25.16
Within	110.2	139	.7928	$F_{.95} = 2.45$
Total	190.0	143		

Duncan's multiple range test

Ordered array of lower AP width sample means of wear classes and indications of significance among the means at the 95 per cent level.

Wear class	1	2	3	4	5
Means	6.8	7.8	8.3	8.9	9.6

The means lying over different lines are significantly different at the 95 per cent level.

SUMMARY

1. Female peccaries had significantly longer skull than males, but no reliable age or sex criterion could be constructed from skull length.

2. Male peccaries had significantly wider skulls than females, but no reliable age or sex criterion could be constructed from skull width.

3. Female peccary skulls had significantly higher skull length/skull width ratios than males. An analysis of ratio-wear class relationships indicated the possibility of using this as a sex criterion, but a larger sample size might show this to be invalid.

4. Male peccaries had significantly higher skull angles than females, but no reliable age or sex criterion could be constructed from skull angle.

5. No significant difference was found between skull heights of male and female peccaries.

6. No significant difference was found between least inter-orbital widths of male and female peccaries.

7. No significant difference was found between the lengths of the lower mandibles of male and female peccaries.

8. A potential sexing criterion was formulated using the ratio-angle relationship with the discriminant function being used as the criterion of classification.

9. At some age, canine teeth ceased to grow in all dimensions, except for right lower anterior-posterior canine width. This width of the canine apparently continues to increase throughout the life of the peccary. Additional study might show that a sexing criterion could be developed from this canine width.

APPENDIX

STATISTICAL CRITERIA OF COMBINED MALE AND FEMALE MEASUREMENTS

Statistical criteria of combined male and female measurements of the upper canine length expressed in millimeters.

Wear class	N	Range	$\overline{X}$	s^2	S.D.	S.E.
1	11	25 - 30	27.3	4.02	2.005	0.604
2	35	20 - 37	29.0	11.40	3.376	0.571
3	17	17 - 30	27.0	12.70	3.564	0.864
4	12	13 - 32	22.0	31.30	5.595	1.615
5	8	11 - 27	20.9	21.00	4.583	1.620

N: number of observations

$\overline{X}$: arithmetic mean

s^2: variance = $\dfrac{\Sigma X - \dfrac{(\Sigma X)^2}{N}}{N-1}$

S.D.: standard deviation

S.E.: standard error of the mean = $\dfrac{s}{\sqrt{N}}$

Statistical criteria of combined male and female measurements of the lower canine length expressed in millimeters.

Wear class	N	Range	$\overline{X}$	s^2	S.D.	S.E.
1	16	29 - 38	33.6	8.53	2.921	0.730
2	44	30 - 44	36.4	17.50	4.183	0.630
3	38	18 - 44	37.1	18.10	4.254	0.690
4	17	22 - 48	36.3	47.10	6.863	1.664
5	16	19 - 40	32.9	46.50	6.819	1.705

Statistical criteria of combined male and female measurements of the right upper canine lateromedial width expressed in millimeters.

Wear class	N	Range	$\overline{X}$	s^2	S.D.	S.E.
1	11	11 - 13	12.1	0.49	0.70	0.211
2	37	12 - 15	12.8	1.44	1.20	0.197
3	18	11 - 15	12.2	0.97	0.98	0.232
4	12	12 - 15	13.1	0.63	0.79	0.229
5	8	12 - 15	13.7	1.07	1.03	0.366

Statistical criteria of combined male and female measurements of the right lower canine lateromedial width expressed in millimeters.

Wear class	N	Range	$\overline{X}$	s^2	S.D.	S.E.
1	19	9 - 11	10.1	0.38	0.616	0.141
2	51	9 - 13	11.2	0.74	0.860	0.120
3	41	9 - 14	11.3	1.70	1.304	0.204
4	17	11 - 14	12.5	0.89	0.942	0.228
5	16	11 - 14	12.4	0.92	0.959	0.240

Statistical criteria of combined male and female measurements of the right upper canine anterioposterior width expressed in millimeters.

Wear class	N	Range	$\overline{X}$	s^2	S.D.	S.E.
1	11	6 - 8	7.1	0.69	0.831	0.250
2	37	6 - 10	8.1	0.95	0.975	0.160
3	18	7 - 11	8.3	1.04	1.020	0.247
4	12	8 - 9	8.4	0.26	0.510	0.147
5	8	8 - 10	8.5	0.57	0.755	0.267

Statistical criteria of combined male and female measurements of the right lower canine anterioposterior width expressed in millimeters.

Wear class	N	Range	$\overline{X}$	s^2	S.D.	S.E.
1	19	6 - 8	6.8	0.69	0.831	0.191
2	51	6 - 10	7.8	0.85	0.922	0.129
3	41	6 - 11	8.3	0.93	0.964	0.151
4	17	8 - 10	8.9	0.36	0.600	0.145
5	16	8 - 11	9.6	0.79	0.889	0.222

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