EYE LENS WEIGHT AS AN INDICATOR OF AGE IN THE COLLARED PECCARY (PECARI TAJACU)

by

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ABSTRACT

In order to evaluate the usefulness of eye lens weight as an indicator of age in the collared peccary (Pecari tajacu) the lenses of 345 hunter-killed and 18 captive known-age peccaries were collected in 1962, 1963 and 1965. Eyes were fixed in ten per cent formalin or Bouin's solution, desiccated at 80°C. for seven days in a gravity convection oven and weighed to 0.1 or 0.01 milligram with a Mettler analytical balance. Young hunter-killed peccaries were aged by the pattern of tooth emergence and replacement; adults were placed in classes according to the degree of tooth wear. The influence of sex, body weight, habitat type, nutrition, length of time preserved, and fixatives on the lens weight-age relationship was examined. The equation $Y = a + b \log X$ suitably represented the relationship for statistical analyses. Female peccaries had significantly heavier lenses. Animals with lower than average body weight had significantly lighter lenses. Nutritional plane significantly affected the lens weight-age relationship. Fixation in Bouin's solution caused significant increases in weight over formalin-fixed eye lenses. Habitat type and length of time preserved did not significantly alter the relationship. Lenses of left and right eyes were not significantly different in weight. Eye lens weight became an unreliable indicator of age during and after the 13 to 18 month age class.

INTRODUCTION

The collared peccary, *Pecari tajacu*, has become an important game animal in Arizona. Two subspecies occur in the United States: *P.t. sonoriensis* in southern Arizona and southwestern New Mexico; and *P.t. angulatus* in Texas and southeastern New Mexico.

The increasing popularity of the peccary with sportsmen has necessitated more intensive management. Knowledge of the age structure of populations is basic to their management. Peccaries can be aged by the pattern of tooth emergence and replacement until they have a complete set of permanent teeth (Kirkpatrick and Sowls, 1962). Thereafter animals can only be placed in groups according to the degree of wear of the permanent teeth (Sowls, 1961). The chronological age corresponding to each wear class has not been determined. This study was designed to evaluate the usefulness of eye lens weight as an indicator of age in the peccary.

It has long been known that in humans the eye lens continues to grow after sexual maturity (Smith, 1883; Burden-Cooper, 1914). Hatai in 1923 observed the correlation of age and lens weight in the laboratory rat (*Rattus norvegicus*) (Donaldson, 1924). Krause (1934) observed the same relationship in laboratory rabbits (*Oryctolagus cuniculus*).

Lord (1959) was the first to study this relationship as a possible technique for aging wild mammals. He found the eye lens weight technique suitable for aging captive cottontail rabbits (Sylivilagus floridanus). His work has since been confirmed by studies in Missouri, Ohio and Wisconsin (Wight and Conaway, 1962; Edwards, 1962; Rongstad, 1966).

Since Lord's initial work, the lens-weight method has been applied to many species with varying degrees of success. Martinson et al. (1961) found that lens weight was a valid criterion for distinguishing young from adult swamp rabbits (Sylvilagus aquaticus). The method was found to be valid until about 150 days after birth in the Australian wild rabbit (Oryctolagus cuniculus) (Dudzinski and Mykytowycz, 1961). It was superior to age determination techniques based on total weight, body size and closure of the epiphysis and diaphysis of the humerus in the black-tailed jack rabbit (Lepus californicus) (Tiemeier and Plenert, 1964).

Lord (1961) successfully used the lens weight method to age the gray fox (Urocyon cinereoargenteus). Sanderson (1961) was able to age young raccoons (Procyon lotor) by this method, but the lens weight increase in adults was low and individual variation too great to permit age determination. Beale (1962) reported that eye lens weight of fox squirrels (Sciurus niger) collected in the fall could be used to distinguish adults, first litter juveniles and second litter juveniles. He speculated that adults could be separated into yearly age classes up to at least the age of 2.5 years. Adult and juvenile red foxes (Vulpes fulva) could be distinguished by eye lens weight, but year classes in adults could not be reliably separated (Friend and Linhart, 1964).

Kirkpatrick (1964) found the method satisfactory as an aging tool for captive cotton rats (Sigmodon hispidus) up to the age of 180 days. Perry (1965) reported that the lens weight method was invalid for individuals or small samples of guano bats (Tadarida brasiliensis mexicana). Davis (1964) arrived at the same conclusion after studying the lens weight age relationship in the woodchuck (Marmota monax).

The lens weight technique has also been applied to larger mammals. The growth curve of the crystaline lens in the pronghorn (Antilocapra americana)has been plotted (Kolenosky and Miller, 1962). Longhurst (1964) found the lens weight technique satisfactory for aging the Columbia blacktail deer (Odocoileus hemionus columbianus) at least through five years. Bauer, Johnson and Scheffer (1964) reported that "except in the one and two year olds, variation in lens weight within the age class is greater than yearly growth" in the fur seal (Collarhinus ursinus). Lord (1962) studied a small sample of eye lenses from known-age whitetail deer (Odocoileus virginianus) and found that lens weight increased through ten years of age. The sample size was too small to determine variation within age groups.

Eye lens weight seems to have little value as an indicator of age in birds. Payne (1961) found it to be valid only up to the age of two months in the house sparrow (Passer domesticus). He also reported that the method had been found unsatisfactory in the ring-necked pheasant (Phasianus colchicus), the scaled quail (Callipepla squamata) and the red-winged blackbird (Agelaius phoeniceus). The lens weight method was unsatisfactory for aging bobwhite quail (Colinus virginianus)

(Roseberry and Verts, 1963). The method was also unsatifactory for determining year classes among adult Turkish chukars (Alectoris graeca) (Campbell and Tomlinson, 1962) and sharp-tailed grouse (Pedioecetes phasianellus) (Dahlgren et al., 1964). The lens growth curves of the birds studied were similar in that the lens grew rapidly until maturity and negligibly thereafter.

Several authors have attempted to evaluate factors that might affect the eye lens weight-age relationship. Montgomery (1963), Longhurst (1964) and Friend (1965a) investigated the effect of freezing and reported contradictory findings. Montgomery found that raccoon lenses which were frozen for more than one day before fixation lost weight. Longhurst found no significant weight change in domestic sheep (Ovis aries) lenses which were frozen four days before fixation. Friend reported that freezing alone did not seem to cause significant changes in lens weight.

The effect of decomposition has been studied by Montgomery (1963), Friend (1965a) and Rongstad (1966). Montgomery found that exposure to decomposition for more than two days prior to fixation led to significant weight losses in dried juvenile raccoon lenses. Friend found significant weight losses in fresh lenses after 24 hours of decomposition but no significant losses in dried lenses. Rongstad found that 2 - 6 days of decomposition at 4.5 - 5.5 C caused significant weight losses in dried lenses. A combination of freezing and decomposition has caused significant weight losses to occur in two studies (Friend, 1965a; Rongstad, 1966).

The effect of formalin fixation time was studied by Friend (1965a). He found that the weight of dried rat lenses initially declined, but after two weeks of fixation began to increase, reached a peak at six weeks and declined to nearly the initial weight at 36 weeks. He did not follow the curve after 36 weeks. Chambers (1962) noted that alcohol fixation caused lenses to increase in weight.

The effect of nutritional plane on lens growth has interested many workers. Several authors have noted that pen-reared animals have heavier lenses as adults than their wild counterparts (Lord, 1959 and 1962; Chambers, 1962; Friend and Linhart, 1962; Dudley, 1963). Longhurst (1964) found that the lens weight-age relationship of below average, average and above average body weight blacktail deer was not adequately described by a single regression line, and that the lens weight of penned blacktail deer did not differ significantly from those of wild deer. Friend (1965b) found no significant differences among the dried lens weights of laboratory rats maintained from weaning until ten weeks of age on diets of varying nutritional levels. Body growth was markedly affected in some groups, however. Friend (1966) found marked differences in the lens weight-age relationship among three separate populations of whitetail deer in New York. The population with the lower nutritional level had lower lens weights and more variation within age groups than the populations with higher nutritional levels.

Some authors have found significant differences between the lens growth curves of males and females of the same species (Longhurst, 1964; Bauer et al., 1964). In species without marked sexual dimorphism, lens growth seems to be similar in the sexes.

Sanderson (1961) noted that castrated raccoons had lens weights similar to uncastrated individuals of the same age. He castrated two females and three males in the study.

Several methods other than dry weight have been investigated for measuring lens growth. Friend (1965a) evaluated dried and wet weights of fixed lenses and the specific gravity of fresh lenses. He concluded that dry fixed weights gave the most dependable measure of lens size. Lord (1959) evaluated wet and dry weight measurements of fixed lenses and recommended the use of dry weights.

MATERIALS AND METHODS

Most of the eye lenses used in this study were obtained from hunter-killed peccaries; the remainder were collected from known-age experimental animals sacrificed in the course of other studies. Eyes were removed at hunter check-stations in Tucson (Sowls, 1961) and at the Fort Huachuca Electronic Proving Grounds during the 1962, 1963 and 1965 hunting seasons. They were also collected at John Doyle's Taxidermy Shop and at the Insured Frozen Food Locker in Tucson during the 1965 season.

At the checking stations information on sex, weight, age and location of kill was obtained. The hunter's name and address were also recorded. Animals were weighed to the nearest pound. Age of immature peccaries was determined by tooth replacement and emergence (Kirkpatrick and Sowls, 1962); adult animals were placed in classes according to the degree of tooth wear (Sowls, 1961). Complete data often could not be obtained at the taxidermy shop and locker plant.

The eyes were removed with a curved scissors and placed in 10 per cent formalin. Animals had rarely been dead for more than 48 hours when the eyes were removed. Eyes of animals dead longer than this were usually discarded. In 1965 the right eye from each individual was marked by placing a thread through the segment of optic nerve that remained with the eyeball. Occasionally an eyeball would rupture during removal and vitreous humor would escape. In nearly every case the lenses in these eyes were damaged. Ruptured eyes were discarded in the 1965 collections.

The peccary hunting season in Arizona usually begins on the last weekend in February and ends after the first weekend in March. The eyes collected in 1962 and 1963 were preserved until August 1964, approximately 29 and 17 months respectively. The eyes collected in 1965 were preserved until June 1965, approximately 3.5 months.

In processing, the eye lens was removed by cutting through the sclera and retina with a pair of scissors and gently squeezing the lens out into a dissecting pan filled with water. The surface of the lens was then rinsed gently and swabbed with wet paper toweling to remove remaining bits of ciliary body and vitreous humor. The lenses were then placed in aluminum cupcake pans and dehydrated in a gravity convection oven at 80 C for seven days. Preliminary tests with a sample of eight lenses showed that daily per cent weight loss was constant after seven days (Figure 1). After dehydration the lenses were taken, a few at a time, from the oven and placed in plastic weighing bottles that had been dried in the same oven and transported to the weighing room. The lenses were removed from the plastic bottles for weighing because it was believed that the container introduced more error than would the short-time exposure to the air. Friend (1965a) came to a similar conclusion. The eye lenses were not as highly hydroscopic as has been indicated in the literature (Tiemeier and Plenert, 1964; Lord, 1959; Kolenosky and Miller, 1962). Exposure to the air for one hour at 26 C and a relative humidity of 27 per cent caused a series of 24 lenses to increase from an

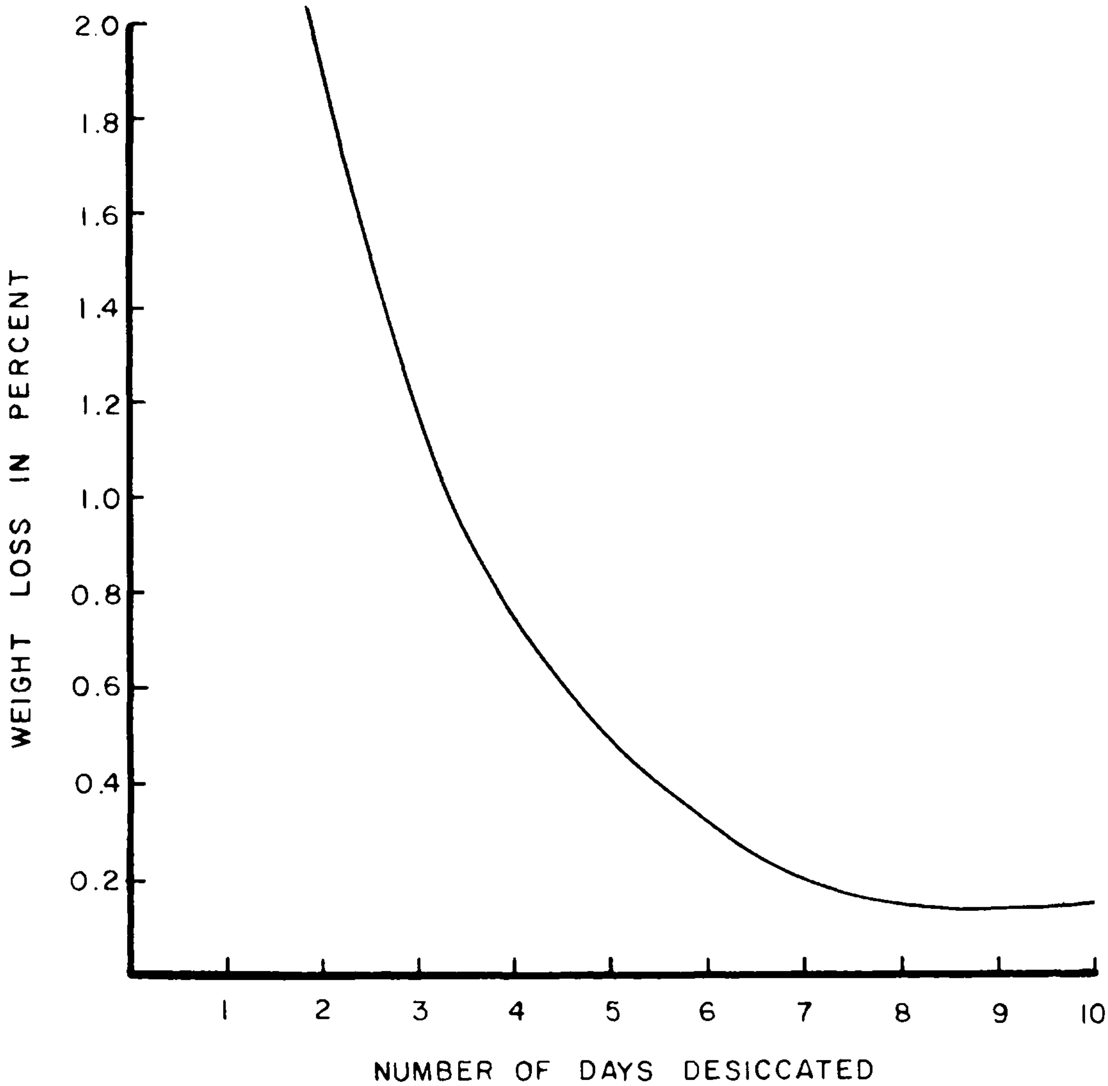


Figure 1. Average daily per cent weight loss of eye lenses desiccated at 80 C. in a gravity convection oven.

average weight of 203.07 milligrams to 203.58 milligrams. This increase was not significant ($\dagger$ = 0.052). Friend (1965a) reported similar findings.

Lenses were weighed to 0.1 milligrams in 1964 and 0.01 milligrams in 1965 on Mettler analytical balances. Whenever possible both lenses of an individual were weighed. It was felt that errors were prevented by weighing both lenses. Since they usually have about the same weight, a great disparity between lenses immediately suggested that an error may have occurred, and they could be reweighed. Lenses that appeared damaged or deformed were discarded. The average of both lens weights of an individual was used in analysis when possible.

Statistical Methods

In order to evaluate the lens weight method as an aging technique it was necessary to examine various factors which might influence the lens weight-age relationship. The effects of sex, nutrition, habitat types, time of preservation and fixative were considered. Statistical evaluation of these factors required a mathematical expression of the lens weight-age relationship. Average ages, based on limited data from repeated trapping of marked wild javelina over a number of years, were assigned to wear classes to facilitate analysis.

A sample of the data was fitted to the following regression models: (Y = lens weight in milligrams; x = age in months; common logarithims were used).

1. $Y = a + bX$

2. $X = a + bY$

3. $Y = a + b\text{Log}X$

4. $X = a + b\text{Log}Y$

5. $\text{Log } Y = a + bX$

6. $\text{Log } X = a + bY$

7. $\text{Log } Y = a + b\text{Log}X$

8. $\text{Log } X = a + b\text{Log}Y$

The equation $Y = a + b \text{ Log } X$ gave a good representation of the data; correlation coefficients calculated for various sub-groups of data ranged from 0.99 to 0.83. Longhurst (1964) found that this equation satisfactorily represented the lens weight-age relationship in Columbia blacktail deer.

After the $Y = a + b \text{ Log } X$ regression model had been selected, the sample was broken down into subgroups. Regressions were calculated for each subgroup in order to evaluate the significance of the following factors.

1. Differences between male and female peccaries. Samples of male and female peccaries were compared to test the significance of the sex factor in the lens weight-age relationship.

2. The effect of body weight on lens weight. In order to subdivide the sample, it was necessary to determine weight ranges for below average, average and above average animal weights in each age class. This was complicated by the fact that the hunting season weights are directly related to summer and fall range conditions. Therefore weights

were not always comparable from year to year. Average dressed weight and standard deviations were calculated for each age class in samples obtained during the 1961, 1962, 1963 and 1965 hunting seasons. Samples that did not differ significantly were combined, and new means and standard deviations were calculated. The standard deviation was then multiplied by the table $t_{.30}$ value for the degrees of freedom in each age class sample. The resulting values were added to and subtracted from the mean weights to establish upper and lower limits of average body weight in each age class (Table 1). No differences were observed between average dressed weights of males and females. These parameters (Table 1) were then used to classify the individuals into these dressed weight categories: below average, average or above average.

3. The effect of habitat on lens weight. Peccaries usually inhabit five vegetational types in southern Arizona: desert shrub, desert grassland, chaparral, oak-woodland, and pinyon-juniper woodland. Areas in chaparral type are restricted and usually interspersed with woodland or desert grassland types, and since few peccaries were killed in this type, it was not included in the analysis. Oak and pinyon-juniper woodland were combined in the analysis since available vegetational type maps did not adequately distinguish the two types. Approximate location of kill was used to subdivide the sample into groups taken in desert shrub, desert grassland, and woodland areas.

4. The effect of nutrition on lens weight. The lens weights of eight known-age penned animals were compared with the lens weights of the wild peccaries.

Table 1

DRESSED WEIGHT RANGES IN POUNDS FOR BELOW AVERAGE, AVERAGE AND ABOVE AVERAGE WEIGHT PECCARIES

Age class	Below average	Average	Above average
	less than		more than
1961-2-5			
2 - 6 mo.	---	12	---
7 - 10 mo.	14.4	14.4 - 17.8	17.8
11 - 12 mo.	18.0	18.0 - 21.5	21.5
13 - 18 mo.	21.9	21.9 - 26.5	26.5
19 - 21.5 mo.	27.4	27.4 - 31.3	31.3
Wear class			
1	30.0	30.0 - 33.2	33.2
2	32.7	32.7 - 35.7	35.7
3	33.9	33.9 - 36.8	36.8
4	35.3	35.3 - 38.0	38.0
5	32.7	32.7 - 35.3	35.3
1963			
2 - 6 mo.	9.9	9.9 - 11.5	11.5
7 - 10 mo.	13.8	13.8 - 16.7	16.7
11 - 12 mo.	16.4	16.4 - 20.2	20.2
13 - 18 mo.	20.5	20.5 - 24.9	24.9
19 - 21 mo.	23.7	23.7 - 28.9	28.9
Wear class			
1	28.4	28.4 - 31.1	31.1
2	29.4	29.4 - 32.4	32.4
3	31.6	31.6 - 34.6	34.6
4	33.2	33.2 - 35.6	35.6
5	30.9	30.9 - 35.5	35.5

5. <u>Differences between yearly samples and effects of fixation time</u>. The samples collected in 1962, 1963 and 1965 were compared. The eyes had been preserved approximately 29, 17 and 3.5 months, respectively.

6. <u>The effect of fixatives on lens weight</u>. A small sample of eye lenses from known-age peccaries was preserved in 10 per cent formalin. A second sample was inadvertently stored in Bouin's solution. This provided an opportunity to evaluate the effect of this fixative on lens weight.

The differences between subgroups in each comparison were tested for significance by analysis of covariance (Snedecor, 1956) and Duncan's Multiple Range Test (Li, 1964). The steps listed below were followed:

1. The regression for each subgroup was calculated.
2. The regression for pooled subgroups was calculated.
3. An analysis of covariance was performed.
4. Where there was a significant difference and more than two subgroups, Duncan's Multiple Range Test was applied to determine which pairs differed significantly.

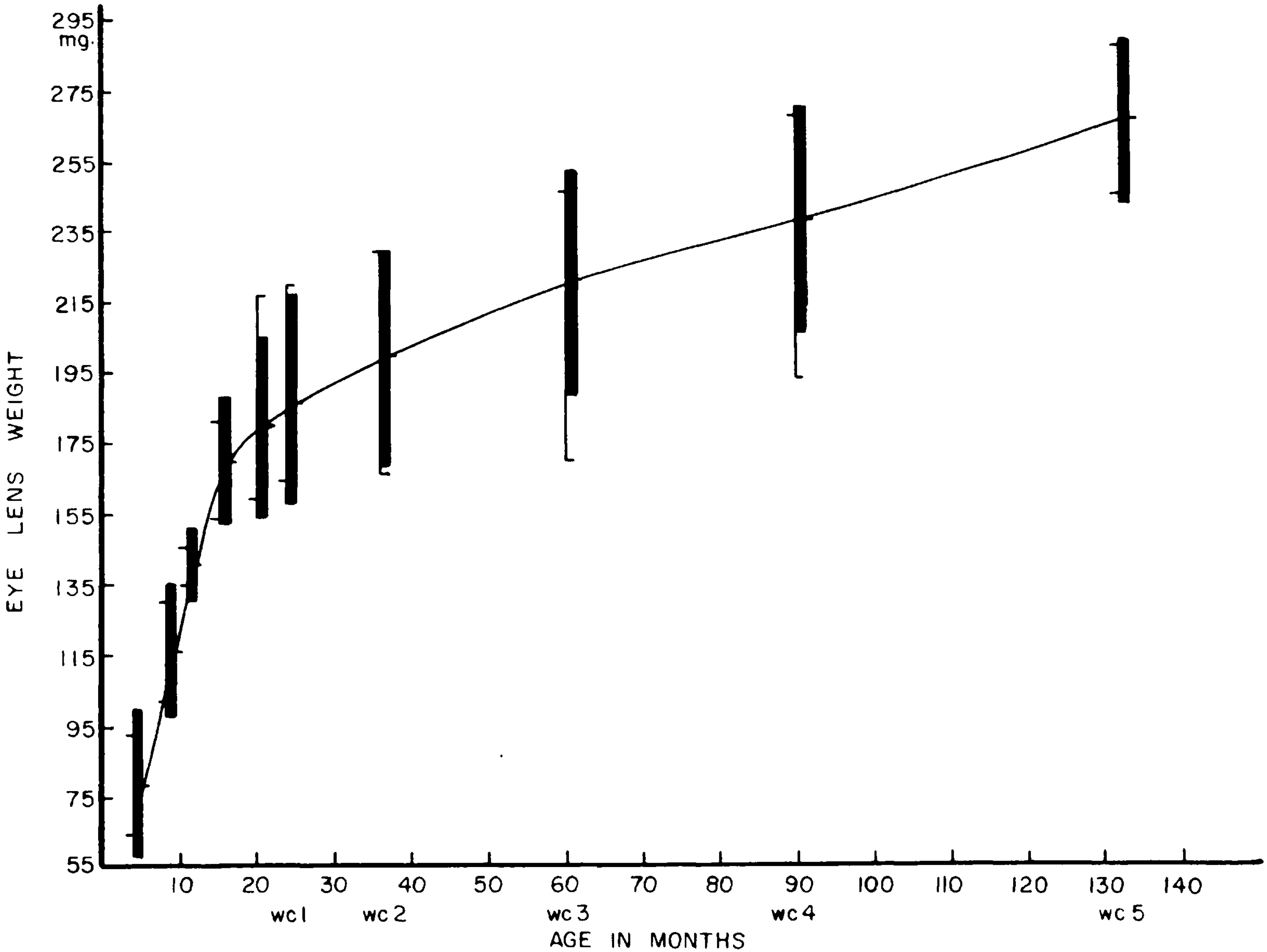
RESULTS AND DISCUSSION

The pertinent data for each of the 345 wild and 18 penned peccaries included in this study are presented in Appendices A and B. The lens weight-age relationship is illustrated in Figure 2. Sample mean, 95 per cent confidence interval and range in each age class are included. The sample variation caused lens weight to become an unreliable indicator of age during and after the 13-18 month age class. The average ages assigned to each wear class are, of course, subject to revision in the future, but changes in these values will not alter the sample range overlap between classes. The accuracy with which tooth wear has been interpreted has important bearing on the observed variation within age classes. However, there is serious overlap between the 13-18, 19-21.5, and 24 (Wear Class 1) month age classes which are quite distinct and not easily confused. Since javelina are born during each month of the year, there are no distinct yearly cohorts in the population as there are in species with restricted breeding seasons. If wear could be classified more exactly or a series of known-age wild peccaries was available, natural variation in lens weight could be more exactly determined.

Sex

Figure 3 illustrates the eye lens weight-age relationship of male and female peccaries. There was a significant difference between these

Figure 2. Eye lens growth curve with mean, range and 95 per cent confidence limits for each age class as determined by tooth replacement, eruption and wear.



295 mg.
275
255
235
215
195
175
155
135
115
95
75
55
EYE LENS WEIGHT
10
20
30
40
50
60
70
80
90
100
110
120
130
140
wc1
wc2
wc3
wc4
wc5
AGE IN MONTHS

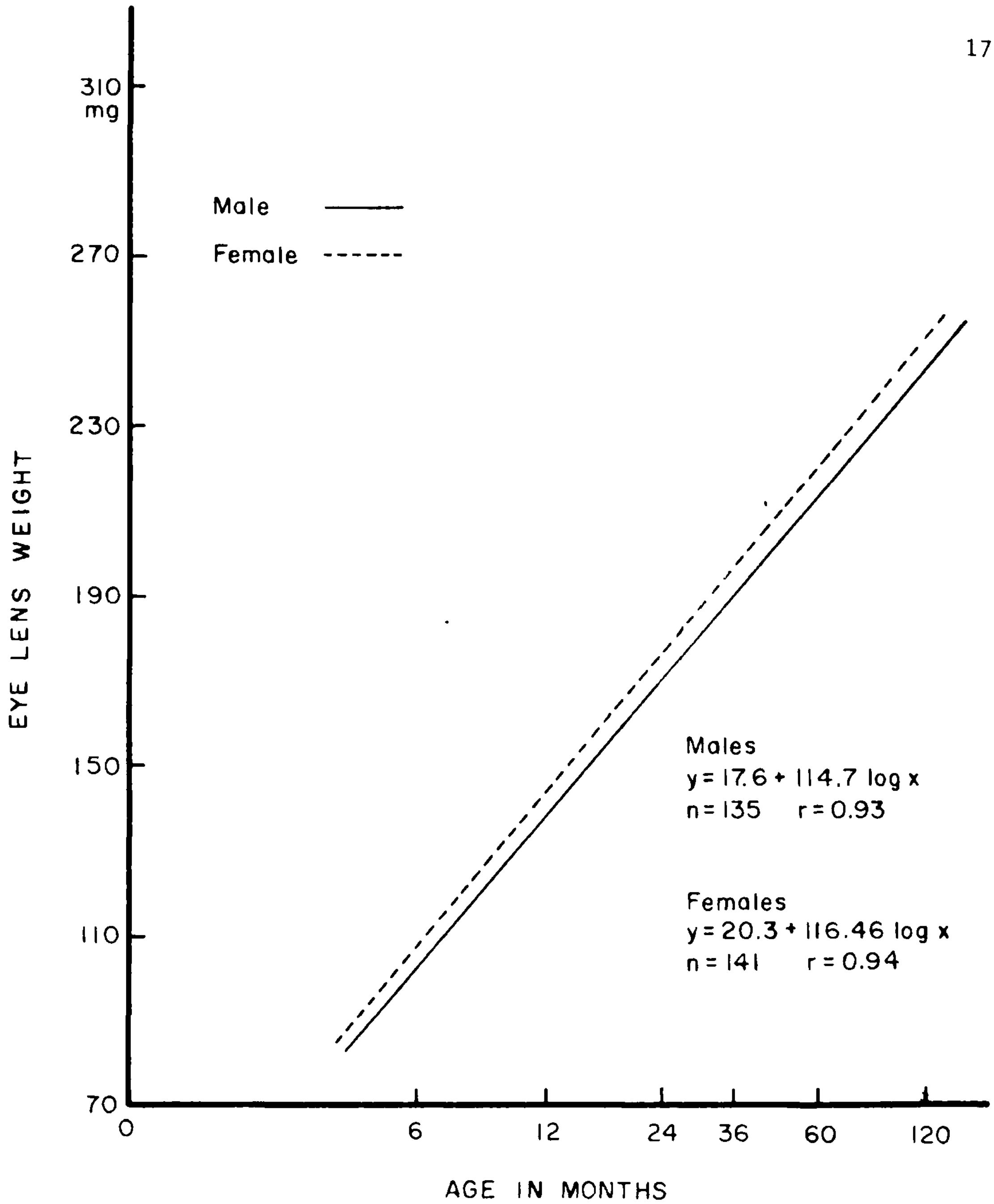


Figure 3. Lens weight-age relationships of male and female peccaries.

lines (Appendix C). Sexual dimorphism is not apparent in peccaries. Dressed weights recorded at checking stations over a seven year period indicated that males averaged slightly heavier than females, but this difference was far from significant. Dressed weights recorded at checking stations may not be comparable in a strict sense. The care with which animals are dressed, the amount of flesh and skin removed by the bullet, the degree of dehydration, whether or not the scent gland has been removed and other factors affect the dressed weight recorded. These factors may contribute enough variation to mask real differences in weight between the sexes.

Body Weight

The regression lines representing the lens weight-age relationships in below average, average and above average weight animals are illustrated in Figure 4. The regression for below average weight animals was significantly different from the others, but the above average and average regressions were not significantly different (Appendix D). The lines were nearly parallel in ascending order as would be expected. Longhurst (1964) found that the regression of above average weight blacktail deer had a less steep slope than the regressions of average and below average weight deer. Inadequate numbers of above average weight deer in young age groups may have caused the change in slope; however, his correlation coefficient didn't seem to have been affected. Certainly a portion of the difference observed in the below average weight groups was caused by selection of young peccaries in these groups. The youngest animals in an age group, particularly younger age

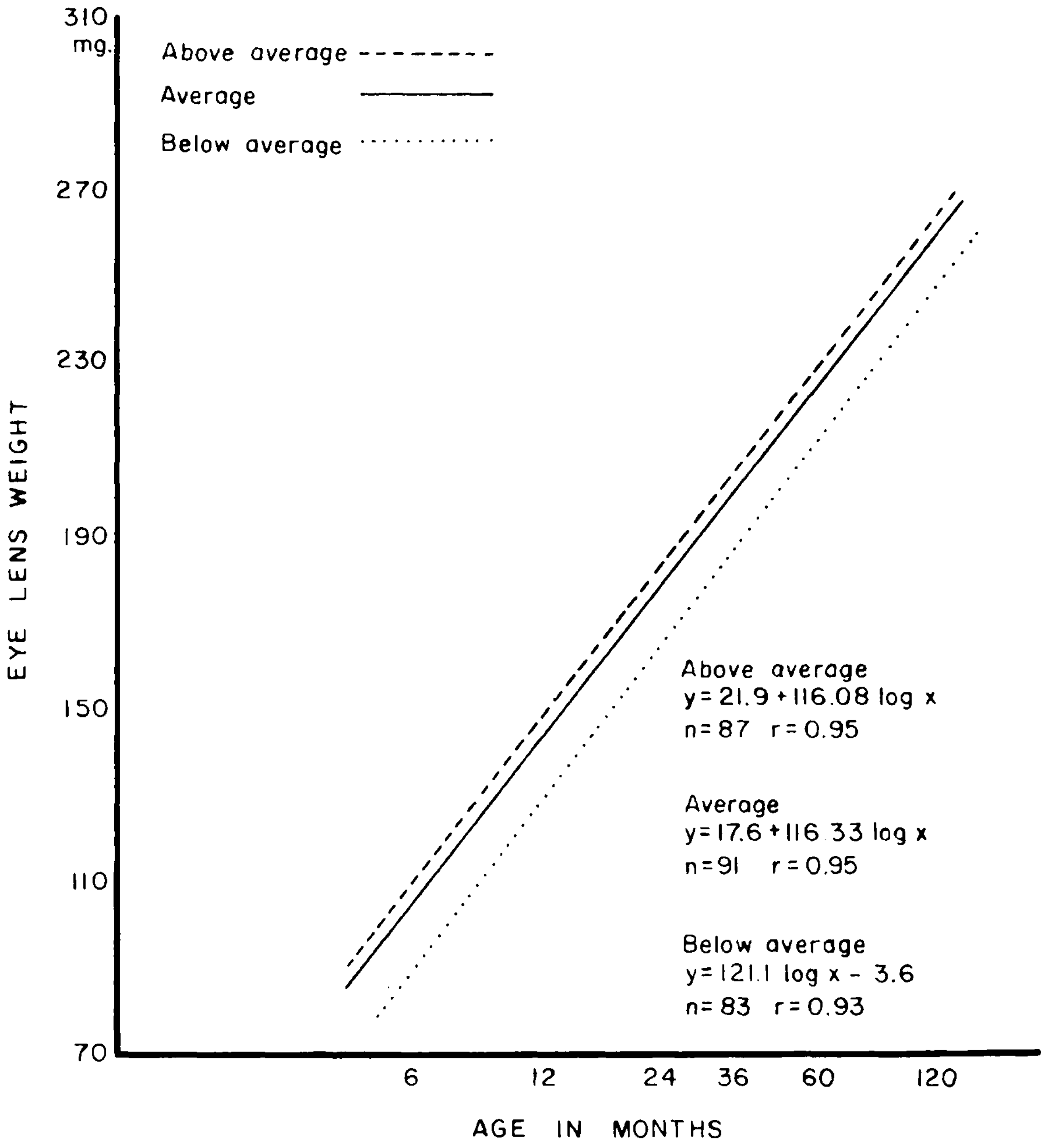


Figure 4. Lens weight-age relationships of above average, average and below average weight peccaries.

groups, may not have grown as large as the oldest individuals in the group causing the youngest ones to be placed in the below average body weight class and the oldest in the above average weight class. Average weight does not increase rapidly in adult age classes; however, the regression lines do not converge as would be expected if selection of younger animals within age groups caused the observed differences in regression. In adults dressed weight may reflect a nutritional or genetic factor that is related to lens growth. This same factor may contribute to the observed difference in immatures also.

There is also the possibility that individuals were not correctly placed in weight classes because the weights recorded at the check stations were not comparable for the same reasons mentioned above. It was felt that error from this source did not contribute significantly to the observed differences in regressions.

Habitat Type

The regression lines calculated for animals taken in desert shrub, desert grassland, and woodland vegetational types are presented in Figure 5. There were no statistical differences between these regressions (Appendix E). The kill locations recorded at the checking stations were often not exact and two or more vegetational types were often closely interspersed making it difficult to decide which vegetational type was representative of the animal's probable home range. In many cases these animals were not included in the calculations.

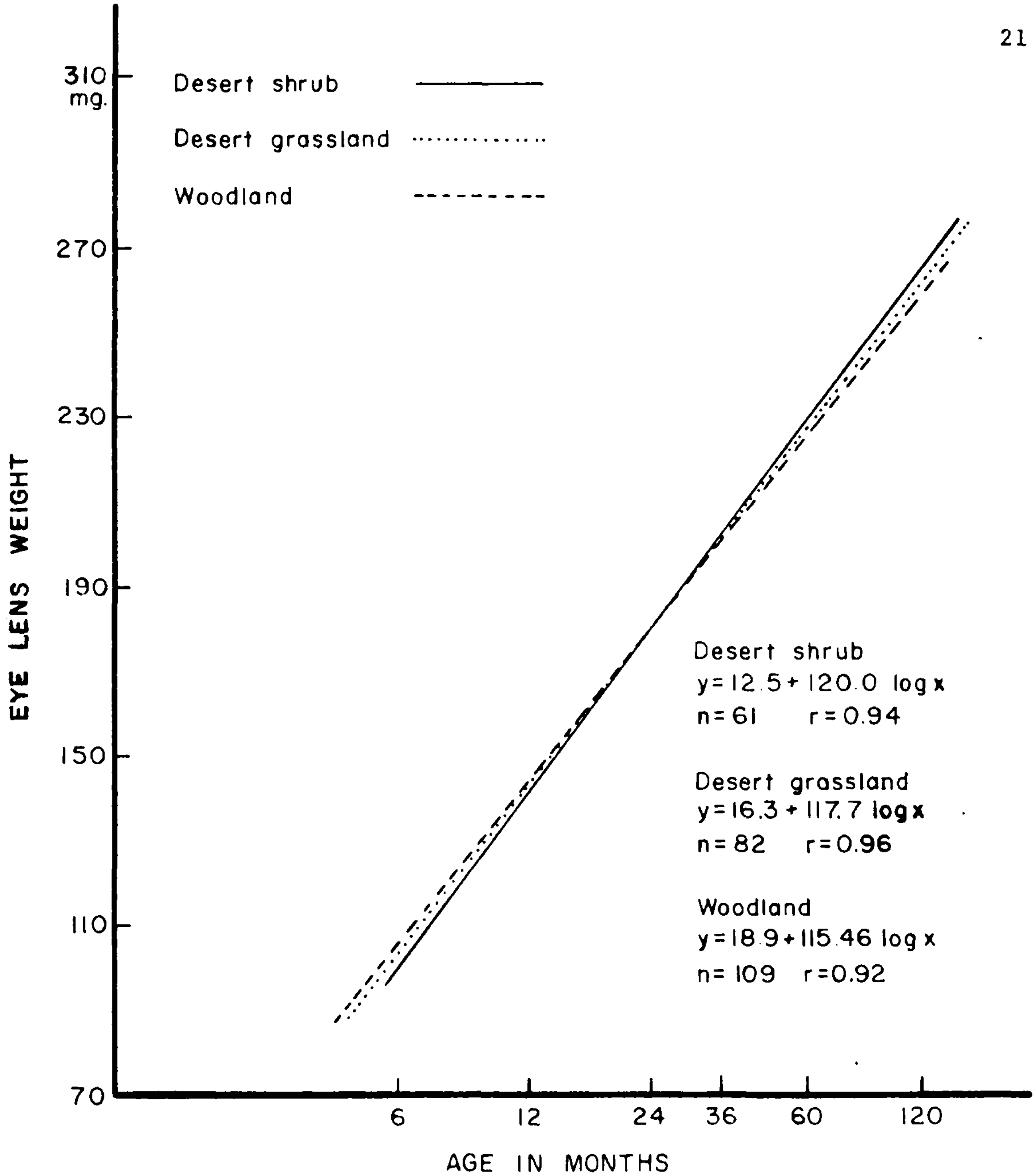


Figure 5. Lens weight-age relationships of peccaries collected in desert shrub, desert grassland and woodland habitats.

It is safe to conclude from the data available that general habitat types do not markedly affect the lens weight age relationship in southern Arizona. Local conditions not adequately described by general habitat types might affect the relationship.

Nutrition

The two preceeding categories may be but are not necessarily associated with nutrition. The lens weights of eight known-age penned animals maintained throughout life at a fairly high nutritional plane along with the lens growth curve for wild peccaries are presented in Figure 6. These animals were fed commercial feed containing not less than 16 per cent crude protein, two per cent crude fat and six per cent crude fiber most of their lives. Occasionally individuals were placed on a 100 per cent prickly pear cactus (Opuntia spp.) diet for periods of up to five months. The weight of these animals was far greater than most wild peccaries of a similar age.

The lens weights of penned animals were significantly heavier (Appendix F), but after maturity the growth curve of the wild peccaries had a steeper slope (Figure 6). Since the two curves tend to converge at old age, it is possible to speculate that the ultimate size of the lens may be limited. Optimum nutrition may increase lens growth early in life until near ultimate size is reached at which point other mechanisms inhibit growth causing the decreased growth rate observed after maturity. This would explain Longhurst's (1964) nonparallel slope in above average weight deer. Lord (1959, 1962) noted that nutrition did not affect lens weights of immature cottontail rabbits and whitetail deer but did

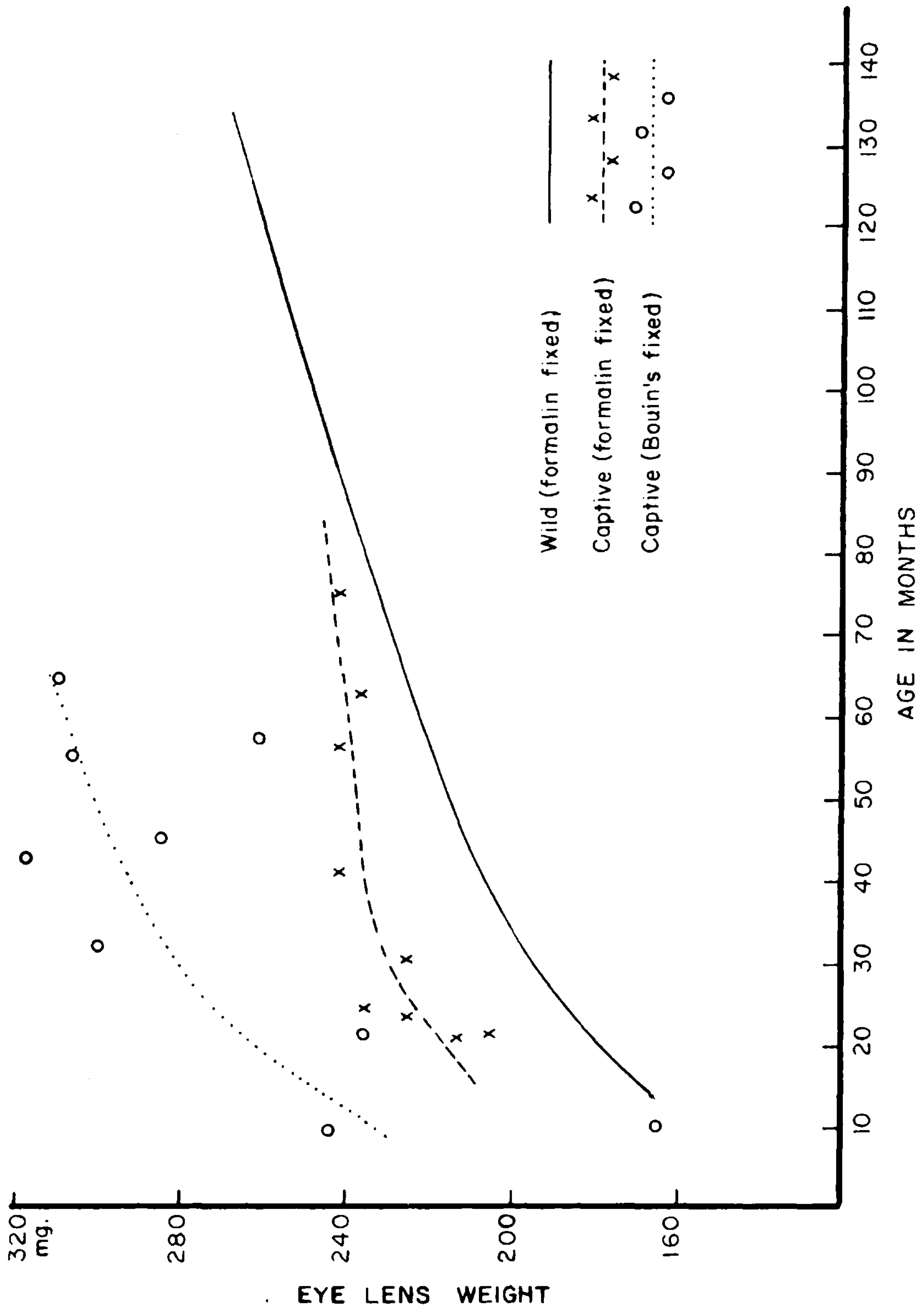


Figure 6. Lens weight-age relationships for the total sample of wild peccaries and the samples of captive known-age peccaries whose eyes were fixed in 10 per cent formalin or Bouin's solution.

increase adult lens weights. This may be the reason Friend (1965b) was not able to show lens weight differences caused by nutrition in his ten week old rats. There appears to be a need for a definitive study of the relationship of lens weight and nutrition in mammals.

Fixatives

The lines plotted for samples of known-age eye lenses preserved in 10 per cent formalin and in Bouin's solution are illustrated in Figure 6. Although the samples are small there was a significant difference in the elevation of the lines (Appendix F). Bouin's solution stained lenses yellow throughout but did not seem to alter their external characteristics. It is clear that Bouin's solution does act differently than 10 per cent formalin and cannot be interchanged with it as an eye lens fixative.

Yearly Samples

The regression lines representing the samples of eye lenses collected in 1962, 1963, and 1965 are presented in Figure 7. There were no statistically significant differences between these regressions (Appendix G). These lenses were preserved in 10 per cent formalin for periods of approximately 29, 17 and 3.5 months respectively. Time of preservation had little affect on observed lens weight.

Right and Left Lenses

The right eye of each pair collected in 1965 was marked. A paired T-test (Simpson, Roe and Lewontin, 1960) performed on two randomly

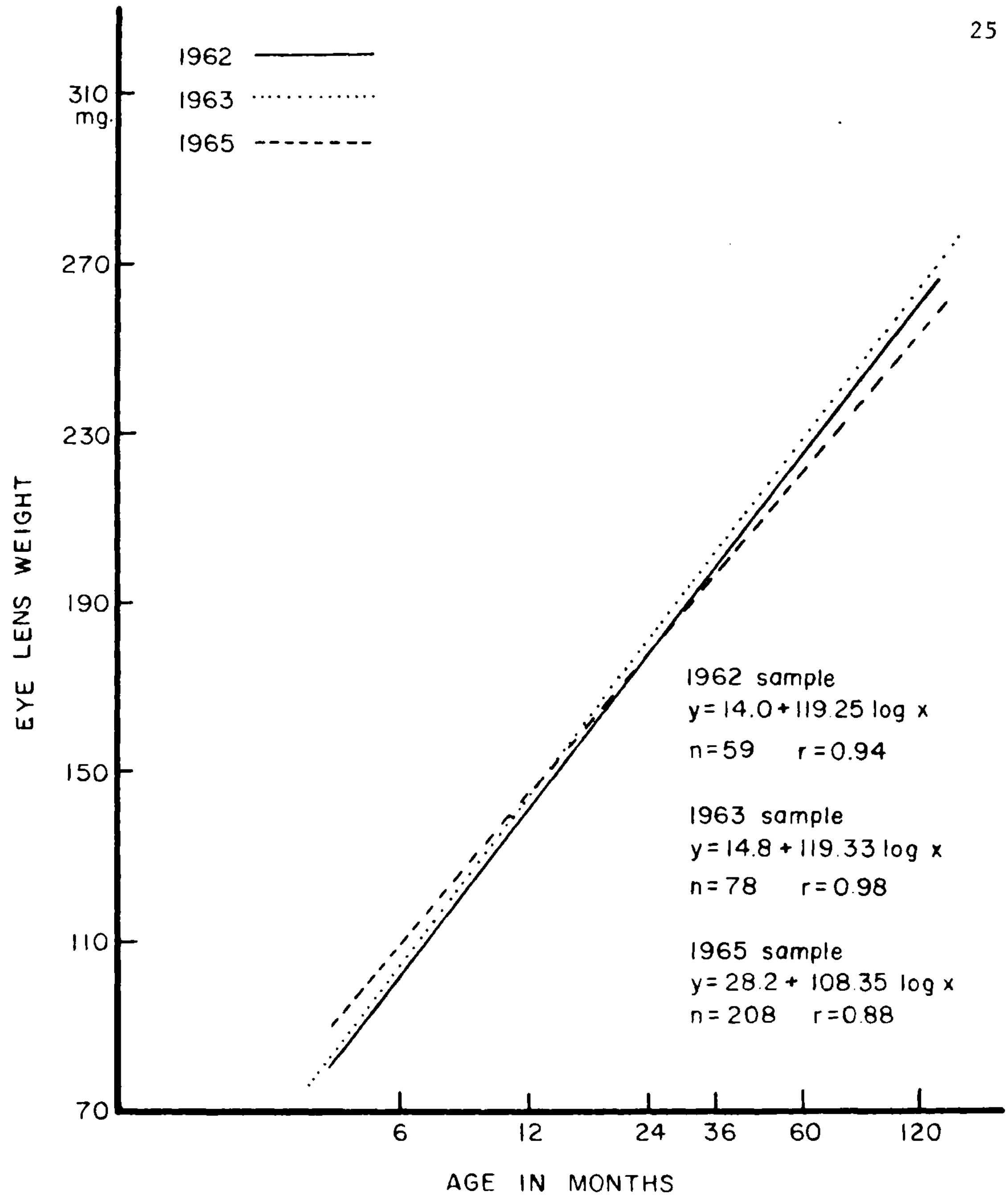


Figure 7. Lens weight-age relationships of peccaries collected during 1962, 1963 and 1965.

selected samples of 30 and 35 pairs of dried lens weights indicated that there were no significant differences in weight between right and left lenses. In both samples mean weight of right lenses was slightly heavier (0.5 and 0.18 milligrams) than mean weights of left lenses.

SUMMARY

1. Variation within age classes caused eye lens weight to become an unreliable indicator of age during and after the 13 to 18 month age class. Tooth wear would appear to offer more potential as an aging technique for management purposes.

2. Female peccaries had significantly heavier eye lenses than males. There was no apparent difference in body weight between males and females.

3. Animals below average in body weight had significantly lighter lenses. It is not known whether this was a reflection of poor nutrition, genetic factors, or uncontrolled bias in the analysis.

4. General habitat types did not markedly affect the lens weight-age relationship. Other ecological factors not adequately described by general habitat types may influence the relationship.

5. High nutritional plane significantly increased lens weights in young adults but did not seem to increase lens weights in older adults. The affect of nutrition on lens growth in immature peccaries is unknown.

6. Bouin's solution stained eye lenses yellow throughout and significantly increased their weight. Bouin's solution can not be interchanged with 10 per cent formalin as an eye lens fixative.

7. No significant differences were found between the lens weight-age relationships of samples of lenses stored in 10 per cent

formalin for periods of approximately 29, 17 and 3.5 months. These samples were collected during three different years indicating that the eye lens weight-age relationship does not vary from year to year.

8. Lenses of right and left eyes were found to be statistically similar.

APPENDIX A

Age or wear class, collection number, lens weight, sex, dressed weight and habitat type in which collected of the wild peccaries included in the analyses.

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
		1965 Collections			
7-10 mo.	33	102.0	M	12	woodland
	47	117.8	F	26	desert shrub
	55	107.0	F	35	woodland
	59	114.5	M	12	desert grassland
	60	119.0	F	10	desert grassland
	68	95.9	M	13	desert shrub
	118	108.5	-	--	---
	120	129.4	-	13	---
	145	119.6	M	13	woodland
	168	116.0	F	15	woodland
	C-9	100.4	F	12	woodland
	C-15	116.4	M	16	woodland
	T-1	108.5	M	18	desert shrub
	H-18	111.9	M	20	woodland
	H-26	93.3	M	16	woodland
11-12 mo.	121	133.5	-	--	---
	T-23	139.0	M	--	desert shrub
	H-22	140.6	F	30	woodland
13-18 mo.	35	166.0	M	24	desert grassland
	46	173.4	M	16	woodland
	50	181.6	F	28	woodland
	53	170.4	F	29	---
	84	169.4	M	--	woodland
	191	176.0	-	--	---
	T-12	178.4	F	23	desert shrub
	H-1	152.7	M	24	woodland
	H-24	180.1	F	34	woodland

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
19-21.5 mo.	3	186.0	F	34	desert grassland
	25	177.0	M	25	desert grassland
	44	183.1	M	30	desert grassland
	52	176.2	F	31	---
	92	168.4	-	--	---
	109	186.5	-	--	---
	125	216.2	-	--	---
	136	181.8	F	--	desert grassland
	139	167.0	F	28	desert grassland
	147	188.4	M	28	woodland
	153	159.2	-	--	---
	158	171.2	F	33	desert grassland
	164	185.8	F	34	desert shrub
	170	178.6	-	--	---
	T-6	185.4	F	29	desert shrub
	H-30	185.8	F	30	woodland
	H-31	168.7	M	27	woodland
	C-13	169.0	F	36	woodland
Wear Class 1	41	193.3	F	30	desert grassland
	42	199.0	M	34	---
	70	177.2	M	37	woodland
	71	189.3	F	33	woodland
	75	194.8	F	--	woodland
	89	182.6	-	--	---
	181	169.8	-	--	---
	183	171.6	-	--	---
	C-1	188.4	M	--	desert grassland
	C-3	205.7	F	--	woodland
	C-10	170.4	M	26	woodland
	T-22	173.3	M	24	desert shrub
	H-11	185.5	M	35	woodland
Wear Class 2	8	189.5	F	34	woddland
	9	230.5	M	32	woodland
	10	226.5	F	36	desert shrub
	11	188.3	F	27	desert shrub
	12	216.4	F	40	desert shrub
	14	175.2	M	29	woodland
	24	186.5	M	37	desert grassland
	29	208.8	F	35	woodland
	36	207.0	F	34	desert grassland
	66	216.5	F	39	desert shrub

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
	73	200.6	F	31	woodland
	77	182.6	F	30	---
	79	206.1	M	35	desert grassland
	83	196.0	-	--	---
	86	179.3	-	--	---
	97	188.6	M	36	desert grassland
	98	209.4	M	29	woodland
	104	211.0	-	--	---
	110	198.7	-	--	---
	111	183.8	-	--	---
	114	192.9	-	--	---
	128	200.9	-	--	---
	129	197.1	-	--	---
	133	213.7	M	40	---
	134	192.8	M	30	desert grassland
	141	175.3	F	34	woodland
	149	226.8	-	--	---
	154	187.8	-	--	---
	171	208.2	-	--	---
	180	185.2	-	--	---
	T-5	170.1	M	--	desert shrub
	T-10	165.1	F	31	desert shrub
	C-2	214.7	F	--	desert grassland
	C-4	180.3	M	--	woodland
	C-5	193.0	F	--	woodland
	C-12	207.8	F	34	woodland
	H-3	212.6	M	37	woodland
	H-4	204.2	F	40	woodland
	H-15	184.2	M	29	woodland
	H-17	223.2	F	38	woodland
	H-29	208.8	F	35	woodland
Wear Class					
3	5	217.0	M	30	desert grassland
	15	219.2	M	37	desert grassland
	16	229.6	F	40	---
	17	193.2	M	37	woodland
	18	179.8	M	31	woodland
	20	239.7	F	40	---
	21	209.3	M	31	woodland
	27	233.2	F	37	woodland
	31	194.8	M	28	woodland
	32	211.6	M	37	woodland
	34	216.0	M	40	woodland
	39	238.6	M	38	desert shrub
	43	204.2	M	33	---

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
	45	225.4	M	37	desert shrub
	48	230.2	F	39	desert shrub
	51	240.6	M	31	woodland
	54	241.2	M	38	---
	56	227.6	F	36	woodland
	57	234.7	M	46	desert shrub
	58	232.0	M	34	desert grassland
	74	224.0	F	34	woodland
	80	193.5	-	--	---
	81	223.9	-	--	---
	82	194.0	-	--	---
	85	241.0	-	--	---
	91	198.0	-	--	---
	94	230.4	-	--	---
	95	197.6	M	37	desert shrub
	100	233.2	-	--	---
	101	210.6	-	--	---
	102	226.1	-	--	---
	106	170.4	-	--	---
	108	203.2	M	30	woodland
	116	215.9	-	--	---
	117	192.0	-	--	---
	119	215.2	-	--	---
	122	236.2	-	--	---
	124	207.5	-	--	---
	126	224.6	-	--	---
	127	219.0	-	--	---
	130	205.9	-	--	---
	131	223.5	M	44	desert shrub
	135	238.2	M	41	desert grassland
	138	200.8	F	37	woodland
	140	225.2	M	35	desert grassland
	144	239.0	F	36	woodland
	146	203.0	F	30	desert grassland
	150	207.6	-	--	---
	151	229.2	-	--	---
	152	194.4	-	--	---
	156	233.0	M	31	woodland
	160	207.4	M	35	woodland
	161	204.9	F	35	woodland
	172	194.9	-	--	---
	173	213.2	-	--	---
	175	248.9	-	--	---

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
	176	224.7	-	--	---
	179	207.9	-	--	---
	185	238.9	M	34	---
	187	239.6	F	32	---
	188	219.0	-	38	---
	190	225.0	-	35	---
	C-6	222.6	M	--	woodland
	H-2	217.9	F	39	woodland
	H-19	210.1	M	36	woodland
	H-25	219.4	F	25	woodland
	T-2	239.4	F	29	desert shrub
	T-3	220.2	M	38	desert shrub
	T-24	199.7	F	30	desert shrub
	T-25	214.2	F	30	desert shrub
Wear Class 4	4	251.2	M	32	---
	6	248.4	F	37	desert grassland
	7	237.0	F	34	woodland
	13	228.8	F	35	woodland
	19	202.4	M	35	---
	22	255.5	M	35	woodland
	26	245.8	F	39	desert grassland
	28	218.3	M	36	desert grassland
	30	213.9	M	34	woodland
	38	216.8	M	37	woodland
	40	234.0	F	37	desert grassland
	64	239.2	F	35	---
	67	259.8	F	40	desert shrub
	78	230.2	M	35	desert grassland
	87	233.9	-	--	---
	88	233.2	-	--	---
	90	233.7	-	--	---
	112	242.4	-	--	---
	113	225.4	-	--	---
	115	242.4	-	--	---
	123	229.4	-	--	---
	132	193.4	-	--	---
	137	255.0	F	35	woodland
	166	234.5	F	40	desert grassland
	169	240.2	-	--	---
	174	236.6	-	--	---
	177	247.6	-	--	---
	182	250.2	-	--	---
	184	236.2	-	--	---

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
	C-8	258.8	M	34	desert grassland
	T-11	251.0	F	36	desert shrub
	H-16	267.0	F	38	woodland
Wear Class 5	93	264.8	-	--	---
	96	270.0	M	29	desert grassland
	103	279.4	-	--	---
	178	276.4	-	--	---
	C-7	278.8	F	--	woodland
	T-20	275.1	F	34	desert shrub
	H-5	260.9	F	40	woodland
		1963 Collections			
2-6 mo.	27	79.8	M	8	desert grassland
	45	92.1	F	13	desert grassland
	64	72.0	M	10	desert grassland
	113	83.0	F	10	desert shrub
	H-17	78.1	F	12	woodland
7-10 mo.	9	117.5	F	18	woodland
	31	123.2	M	16	desert grassland
	37	121.5	M	17	desert grassland
	38	115.1	M	20	desert grassland
	66	126.8	-	11	desert grassland
	67	124.3	M	20	desert shrub
	70	118.1	F	14	woodland
	91	125.3	M	15	woodland
11-12 mo.	42	136.5	F	18	desert grassland
	52	143.4	M	24	desert shrub
13-18 mo.	19	167.0	M	32	desert shrub
	68	167.5	F	28	desert grassland
	H-7	156.2	F	23	woodland
	H-8	170.0	M	25	woodland
	H-22	157.4	F	25	woodland
19-21.5 mo.	4	181.8	F	24	desert grassland
	24	164.8	M	22	woodland
	49	186.0	M	30	woodland
	50	184.0	M	35	desert shrub
	87	171.5	M	30	desert grassland

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
Wear Class 1	14	165.5	M	31	desert grassland
	30	191.8	M	30	desert grassland
	48	188.5	M	26	desert grassland
	54	163.0	M	32	desert grassland
	55	189.4	F	30	desert shrub
	88	194.2	M	32	woodland
	90	176.4	M	25	desert grassland
	118	174.0	M	30	woodland
	H-10	188.5	M	23	woodland
	H-24	176.1	F	25	woodland
Wear Class 2	17	198.0	M	30	desert grassland
	21	207.0	F	28	desert shrub
	25	210.5	M	36	desert grassland
	33	224.0	M	30	desert grassland
	46	200.0	F	23	desert grassland
	60	193.7	F	30	desert shrub
	69	199.6	M	26	woodland
	84	207.0	F	37	desert shrub
	92	202.4	F	29	woodland
	93	174.3	M	26	desert grassland
	111	220.8	F	29	desert grassland
	112	183.2	M	26	desert grassland
	H-1	204.5	M	35	woodland
	H-3	221.5	M	36	woodland
	H-21	214.7	F	36	woodland
Wear Class 3	1	211.1	M	32	woodland
	10	231.5	M	35	woodland
	22	224.7	M	40	desert shrub
	23	224.3	F	33	woodland
	26	226.3	F	33	desert grassland
	40	245.5	M	30	desert grassland
	43	219.8	F	32	woodland
	47	215.9	M	--	desert grassland
	51	233.8	M	38	desert shrub
	65	231.5	M	40	desert grassland
	74	217.3	M	36	---
	96	219.8	F	32	---
	104	231.9	M	30	woodland
	120	221.0	M	32	desert shrub
	121	246.5	F	33	woodland
	H-6	230.0	F	36	woodland

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
Wear Class					
4	15	250.5	F	28	desert grassland
	16	233.0	M	38	desert grassland
	20	245.5	F	34	desert shrub
	56	242.3	F	32	desert grassland
	58	242.2	M	35	woodland
	63	238.7	F	34	desert grassland
Wear Class					
5	3	268.6	F	33	woodland
	28	265.4	F	25	desert grassland
	61	260.0	F	35	desert grassland
	83	259.1	M	36	desert shrub
	106	260.3	M	33	desert shrub
	107	264.2	M	26	desert grassland
		1962 Collections			
2-6 mo.	128	71.0	M	12	desert grassland
7-10 mo.	27	111.8	M	12	desert shrub
	28	119.4	F	16	desert shrub
	45	116.7	F	19	---
	48	118.5	M	14	desert shrub
	54	115.0	F	15	desert grassland
	80	115.6	F	15	---
	86	121.8	M	16	desert grassland
	97	125.6	F	22	desert grassland
	107	129.8	F	28	---
	120	127.9	F	14	desert grassland
	121	103.0	F	16	desert grassland
	174	112.7	F	16	desert shrub
13-18 mo.	44	167.0	F	26	woodland
	53	179.2	F	31	desert grassland
Wear Class					
1	49	209.0	F	38	desert shrub
	52	220.5	M	32	desert shrub
	55	192.0	F	32	woodland
	90	214.8	M	32	desert grassland
	94	194.8	F	32	woodland
	165	166.3	M	26	woodland
	H-19	188.4	F	29	woodland

Age Class	Collection Number	Lens Weight (milligrams)	Sex	Dressed Weight (pounds)	Habitat Type
Wear Class					
2	25	174.6	F	32	desert grassland
	56	192.6	M	24	woodland
	67	188.0	M	28	woodland
	79	219.5	F	36	---
	87	209.8	F	33	desert grassland
	89	190.0	F	38	---
	104	220.5	F	--	desert grassland
	155	188.0	M	34	desert shrub
	159	186.1	M	34	---
	164	182.7	F	30	desert grassland
	166	230.9	F	--	woodland
	172	196.6	F	36	desert shrub
Wear Class					
3	46	230.8	F	36	desert shrub
	93	233.0	M	38	woodland
	144	219.0	F	--	desert grassland
	153	223.6	M	37	desert shrub
	154	231.5	M	40	desert shrub
	160	199.4	F	34	desert shrub
	162	194.9	F	32	desert shrub
	167	233.0	M	--	woodland
	170	240.5	M	36	desert grassland
	184	245.5	F	32	woodland
	186	247.0	F	34	desert shrub
	H-5	232.5	F	36	woodland
	H-23	219.0	F	35	woodland
Wear Class					
4	88	224.7	M	38	---
	91	247.9	F	34	desert grassland
	109	225.9	M	45	---
	111	248.2	F	32	---
	152	273.1	F	38	desert grassland
	156	221.5	F	37	woodland
	161	258.3	F	41	desert shrub
	173	218.2	M	34	desert shrub
	185	249.5	F	34	desert shrub
Wear Class					
5	163	245.6	M	34	desert grassland
	175	252.1	F	35	desert shrub
	187	288.6	F	32	desert shrub

APPENDIX B

Age, number, lens weight, sex and fixative of the captive peccaries included in the analyses.

Age (months)	Number or Name	Lens Weight (milligrams)	Sex	Fixative
9.5	1111	242.9	F	Bouin's
10.0	1116	162.0	F	Bouin's
20.0	Sancho	212.3	M	formalin
21.0	1175	204.2	M	formalin
21.0	Louisa	235.1	F	Bouin's
23.0	Lucia	224.5	F	formalin
24.0	1109	234.2	M	formalin
32.0	1110	298.8	F	Bouin's
35.0	Cary	224.8	M	formalin
41.0	Lucero	240.7	M	formalin
42.5	1104	316.5	F	Bouin's
45.0	1103	284.1	F	Bouin's
55.0	1589	305.2	F	Bouin's
56.0	Maria	240.4	F	formalin
57.0	1596	259.6	F	Bouin's
62.0	1149	235.6	F	formalin
64.5	1597	308.6	F	Bouin's
74.5	Pedro	241.6	M	formalin

APPENDIX C

Analysis of covariance for eye lens weight-age relationships of male and female peccaries.

Treatment	N-1	Ex^2	Exy	Ey^2	Reg. Coef.	Deviations from Regression N-2	S. of S.	Mean Squ.	F
Males	134	16.94	1961.0	255,859.7	115.8	133	28,842.1		
Females	140	19.00	2212.9	294,646.5	116.5	139	36,914.6		
within						272	65,756.7	241.8	
reg.coef.						1	3.4	3.4	0.014 n.s.
common	274	35.94	4173.9	550,506.2		273	65,760.1	240.9	
adj.means						1	6,936.0	6,936.0	28.8 **
total	275	36.00	4161.8	553,827.9		274	72,696.1	265.3	

n.s. = not significant
** = significant at 1% level

APPENDIX D

Analysis of covariance and Duncan's multiple range test comparing eye lens weight-age relationships for above average, average and below average weight peccaries.

Analysis of covariance						Deviations of regression			
Treatment	N-1	Σx^2	Σxy	Σy^2	Reg. Coef.	N-2	S. of S.	Mean Squ.	F
Above avg.	86	10.40	1214.4	155,319.9	116.8	85	13,503.7		
Average	90	14.35	1668.9	212,889.6	116.3	89	18,787.8		
Below avg.	82	9.99	1209.5	168,512.3	121.1	81	22,076.9		
within						255	54,368.4	213.2	0.35 n.s.
reg.coef.						2	150.0	75.0	
common	258	34.74	4092.9	536,721.8		257	54,518.4	2212.1	11.18 **
adj.means						2	4,744.2	2372.1	
total	260	35.32	4116.9	539,137.8		259	59,262.6		

Duncan's multiple range test

Adjusted means: above average = 199.84, average = 195.86, below average = 182.34.
Average mean square = 213.87

g	Treatment	Difference	S.S.R.
3	A. avg. - B. avg.	17.50	3.80(1.58) = 6.00 **
2	A. avg. - Avg.	3.98	2.77(1.55) = 4.30 n.s.
2	Avg. - B. avg.	13.52	3.64(1.57) = 5.71 **

n.s. = not significant
** = significant at the 1% level

APPENDIX E

Analysis of covariance for eye lens weight age relationships of peccaries collected to desert shrub, desert grassland and woodland habitats.

						Deviations of regression			
Treatment	N-1	Ex^2	Exy	Ey^2	Reg. Coef.	N-2	S. of S.	Mean Squ.	F
Desert shrub	60	8.61	1032.1	139,845.0	119.9	59	16,127.3		
Desert grassland	81	13.32	1568.8	199,705.8	117.8	80	14,926.6		
Woodland	108	11.37	1313.2	178.143.8	115.5	107	26,475.5		
within						246	57,529.4	233.9	0.20 n.s.
reg.coef.						2	95.1	47.6	
common	249	33.30	3914.1	517,694.6		248	57,624.5	232.4	0.13 n.s.
adj.means						2	-59.6	-29.8	
total	251	33.46	3933.0	519.872.2		250	57,564.9		

n.s. = not significant

APPENDIX F.

Analysis of covariance and Duncan's multiple range test for eye lens weight-age relationship of wild formalin-fixed, captive formalin-fixed, and captive Bouin's solution fixed peccaries.

Analysis of covariance						Deviations from regression			
Treatment	N-1	Ex^2	Exy	Ey^2	Reg. Coef.	N-2	S. of S.	Mean Squ.	F
Wild formalin	344	42.30	4792.7	636,108.2	113.3	343	93,073.8		
Captive formalin	8	0.38	18.4	1,437.5	47.9	7	547.5		
Captive Bouin's	8	0.81	100.2	19,608.5	123.4	7	7,218.3		
within						357	100,839.6	282.5	2.98 n.s.
reg.coef.						2	1,682.1	841.0	
common	360	43.49	4911.3	657.154.2		359	102,521.7	285.6	106.9 **
adj.means						2	61,076.0	30,538.0	
total	362	43.54	4861.8	706,480.1		361	163,597.7		

Duncan's multiple range test

Adjusted means: captive Bouin's = 276.30, captive formalin = 230.21, wild formalin = 198.29.
Average mean square = 285.78

g	Treatment	Difference	S.S.R.
3	C. Bouin's - Wild	78.01	3.80(4.04) = 15.3 **
2	C.form.-C. Bouin's	46.09	3.64(5.63) = 20.5 **
2	C. form. - Wild	31.92	3.64(4.04) = 14.7 **

n.s. = not significant
** = significant at the 1% level

APPENDIX G

Analysis of covariance and Duncan's multiple range test for eye lens weight-age relationships of peccaries collected in 1962, 1963 and 1965.

Analysis of covariance						Deviations from regression			
Treatment	N-1	Ex^2	Exy	Ey^2	Reg. Coef.	N-2	S. of S.	Mean Squ.	F
1962	58	9.04	1078.4	146,137.5	119.25	57	17,493.0		
1963	77	12.50	1498.7	186,329.9	119,90	76	6,639.4		
1965	207	19.50	2118.2	294,956.2	108.60	206	64,863.2		
within						339	88,995.6	262.52	2.39 n.s.
reg.coef.						2	1,248.6	624.30	
common	342	41.04	4695.3	627,423.6		341	90,244.2	264.65	3.47 *
adj.means						2	1,838.6	919.30	
total	344	42.30	4792.7	636,108.2		343	92,082.8	268.46	

Duncan's multiple range test

Adjusted means: 1963 = 200.8, 1962 = 199.8, 1965 = 197.4.
Average mean square = 268.7

g	Treatment	Difference	S.S.R. (5%)
3	1965 - 1963	3.4	2.92(1.54) = 4.49 n.s.
2	1965 - 1962	2.4	2.77(1.72) = 4.76 n.s.
2	1963-- 1962	1.0	2.77(2.01) = 5.57 n.s.

n.s. = not significant
* = significant at the 5% level

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