AGE DETERMINATION OF KANSAS DEER BY ANNULI COUNT

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INTRODUCTION

The validity of age determination of white-tail deer, *Odocolieus virginianus* (Rafinesque), and mule deer, *Odocolieus hemionus* (Rafinesque), based on tooth wear and development (TWD) is being questioned as a reliable and accurate means of determining the proper age of such animals. Age determination of deer by this method appears to have some serious limitations. At present, Kansas biologists do not attempt to determine the exact age of deer over 3.5 years of age because of the difficulty of interpreting tooth wear of animals beyond this age. Teeth are also known to be worn down at varying rates depending upon the amount of abrasive material on the vegetation upon which deer feed. Ransom (1966) stated that Severinghaus and Cheatum (1956) found deer from a sand-blown area of Massachusetts and a dusty area of Texas showed tooth wear to be approximately double that of deer from New York. It would seem reasonable to assume that similar conditions would also be found in Kansas deer. Soil conditions and habitat vary greatly between eastern and western sections of the state. There is also the problem of varying interpretations of wear by individual biologists.

Recently biologists have been using a new aging technique (Low and Cowan 1963, Gilbert 1966, and Ransom 1966). This consists of examining thin sections made from the teeth and counting what has been determined to be annular structures in the dental cementum of the teeth. Research by Low and Cowan (1963), working with known-age deer, revealed that these structures could be directly related to the animals' age.

The primary objective of this study was to develop a relatively fast reliable technique by which deer may be aged, and to ascertain

the differences between ages assigned by the tooth wear and develop-
ment method as compared to ages assigned by the annuli count (AC) method.

METHODS AND MATERIALS

Various techniques have previously been used in preparing deer teeth for age determination examination. Most of these techniques were time consuming and, for this reason, were not considered as practical game management tools by Kansas Forestry Fish and Game personnel.

Obtaining Deer for the Study

Sixty teeth used for this study were obtained from mandibles collected by the Kansas Forestry Fish and Game Commission during the 1968 and 1969 Kansas firearms deer seasons. In addition, 970 teeth from deer killed during the 1971 Kansas firearms season were also aged. The larger group contained teeth from both white-tail and mule deer. All teeth were contributed by Bill Peabody, Big Game Project Leader of the Kansas Forestry Fish and Game Commission.

Twenty mandibles from white-tail deer were selected from each of three different age groups, 2.5 years, 3.5 years and 3.5+ years, for a total of 60 deer. The deer had previously been assigned these ages by biologists using the TWD method. This technique was described by Severinghaus (1949).

Jaws were selected randomly, with the only criterion being that the I-1, or primary incisor, not be extensively damaged. These same jaws were later examined individually and aged by five experienced biologists, so that ages could be compared with ages determined by the AC method.

Preparing Teeth for Examination

Primary incisors were removed from the jaw by using a diamond trim saw. Cuts through the jaw were made parallel to the long axis of the teeth, posteriorly to slightly past the root tip, then laterally just behind the root tip to free the two teeth. Teeth were then soaked in water and any flesh adhering to the tooth surfaces was carefully removed with a razor blade.

Ground sagital sections of the teeth were then prepared. While holding the tooth crown, opposite sides of the root area were flattened with a medium grade electric grinder wheel until the tooth was approximately one-third its original width. Any remaining flesh was removed and the crown severed after making small notches with the wheel edges at the crown base; slight pressure caused the crown to break off easily. It is advisable to perform the above procedure under a fume hood as some odor and dust particles are produced.

Ground sections of the flattened tooth root were made by using moist 100-grade carborundum grinding powder on glass plates. A small cork stopper was held on the flattened tooth and by using a circular motion, the initial grinding of the section was completed. Sections were then rinsed to remove the grinding powder. Final polishing of the section was done in the same manner using 280-grade powder. Sections of .008 mm. thickness can be quickly prepared in this manner.

Finished sections were rinsed in tap water. Any remaining carborundum powder or foreign materials were removed with a camel hair brush, and sections then allowed to air dry. Final rinsing of the section was in xyleen. No further dehydration was necessary if all flesh had previously been removed. Kleermount was used to mount sections on microscope slides under cover glasses. Sections were observed with a transmitted light microscope. A section can be prepared and analyzed with this technique in less than 15 minutes.

A Wild Photomicrographic camera, I model, loaded with Polaroid type 107 film, and mounted on a Wild M-20 phase microscope was used to take tooth photographs. Exposure time varied from two to seven seconds.

Standard deviation and t-tests at the .05 significance level were calculated to analyze variations between TWD ages and AC ages.

RESULTS AND DISCUSSION

Tooth Structure

The general structure of a deer's primary incisor is shown in Figure 1. In the cementum of these teeth there are usually alternating light and dark lines. Previous studies (Gilbert 1966, Low and Cowan 1963, and Lockard 1972) found that the number of these lines is directly correlated with the deer's age. Each dark line represents the end of one year in a deer's annual cycle; a light area between dark lines represents time which elapsed between the deposition of any two dark lines.

Time of Annuli Formation

There is a difference of opinion as to the period in the deer's annual cycle which is represented by the dark line. Low and Cowan (1963), as well as Gilbert (1964), have attributed dark line formation to seasonal differences in food availability and growth rate. Light areas were thought to represent summer growth while the darker areas were assumed to be laid down during the restricted winter growth periods.

Lockard (1972), while working with known-age deer from Ohio, found no evidence of annuli beginning to form in deer in the ninth and tenth months of their annual cycle. Because of this, he concluded that the dark lines were more probably laid down during the eleventh and twelfth months of the annual cycle. In Ohio, as in Kansas, the eleventh and twelfth months are March and April.

These months are usually well past any prolonged winter stress period which would suggest that the dark lines are not indicative of slowed winter growth as previously assumed.

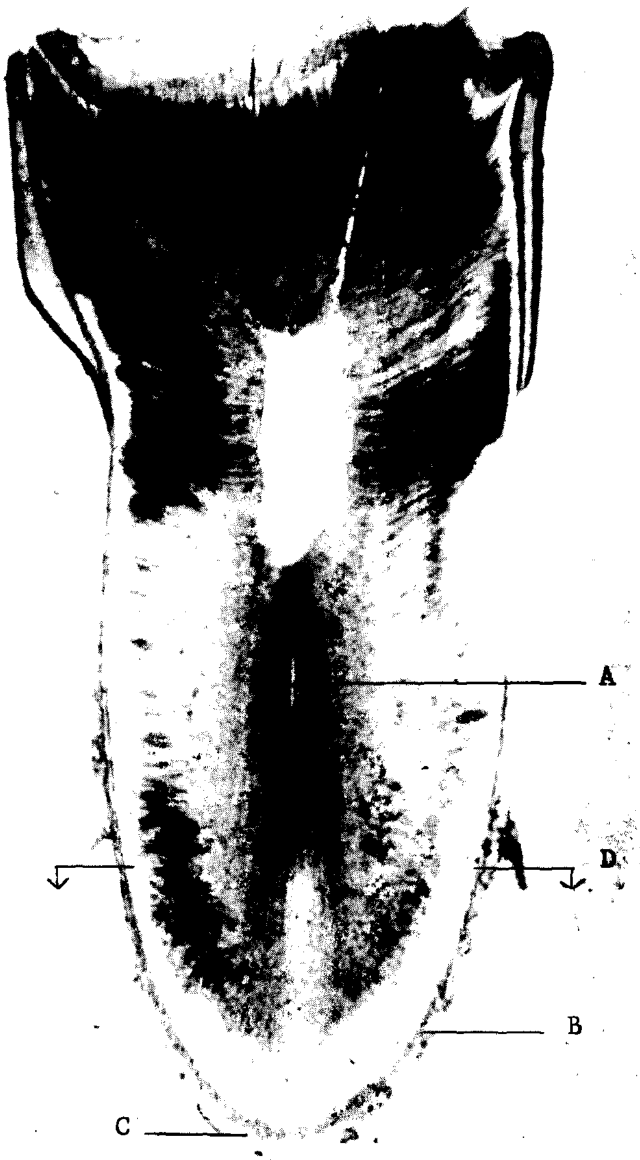


Figure 1. Ground section of a deer incisor. A. Pulp cavity. B. Dentine-cementum interface. C. Cementum. D. Area of cementum from D to root tip was found best for annuli examination.

There are, however, two events which might evoke sufficient stress to cause formation of the dark lines during the eleventh and twelfth months. In Kansas, the peak fawning period is in June. Taylor (1956) noted that Nichol (1938) found during pregnancy and periods of heavy nursing that females have an increased food requirement and that pregnant does have a higher food requirement than unbred does. In males, this is the period when antlers are beginning to form. Taylor (1956) refers to Nichol's findings that the food requirement of bucks increases to meet the heavy demands of antler production. It would seem plausible that these two periods of high nutritional requirements, particularly the increased demands for minerals, could cause the deposition of the dark annuli.

If the annuli are formed in this spring-early summer period, then failure to successfully breed or poor antler development could cause the absence or reduction of dark lines. This would be particularly true in yearlings (1.5 years of age) of both sexes. A few tooth sections from 1.5 year old deer were observed during this study as well as by Ransom (1966) but because of lack of breeding evidence or knowledge of antler development no conclusion can be reached. More research on the time and cause of annuli formation seems merited.

The amount of time required for the formation of the dark lines is also uncertain. Lockard (1972) observed that when compared to the light areas, the darker lines represent two months' growth. The size of the darker areas in this study were highly variable; too variable, in fact, to give any accurate indication as to the length of time required for their deposition.

Interpretation of Annuli

The criteria established for age determination of deer using ground sections are illustrated in Figure 2. Six dark lines can be distinguished which indicate that the deer was in his sixth year of life and not yet into his seventh. Since the deer used in this study were all collected during the December hunting season, and June is the peak fawning period in Kansas, one-half year was added to all ages.

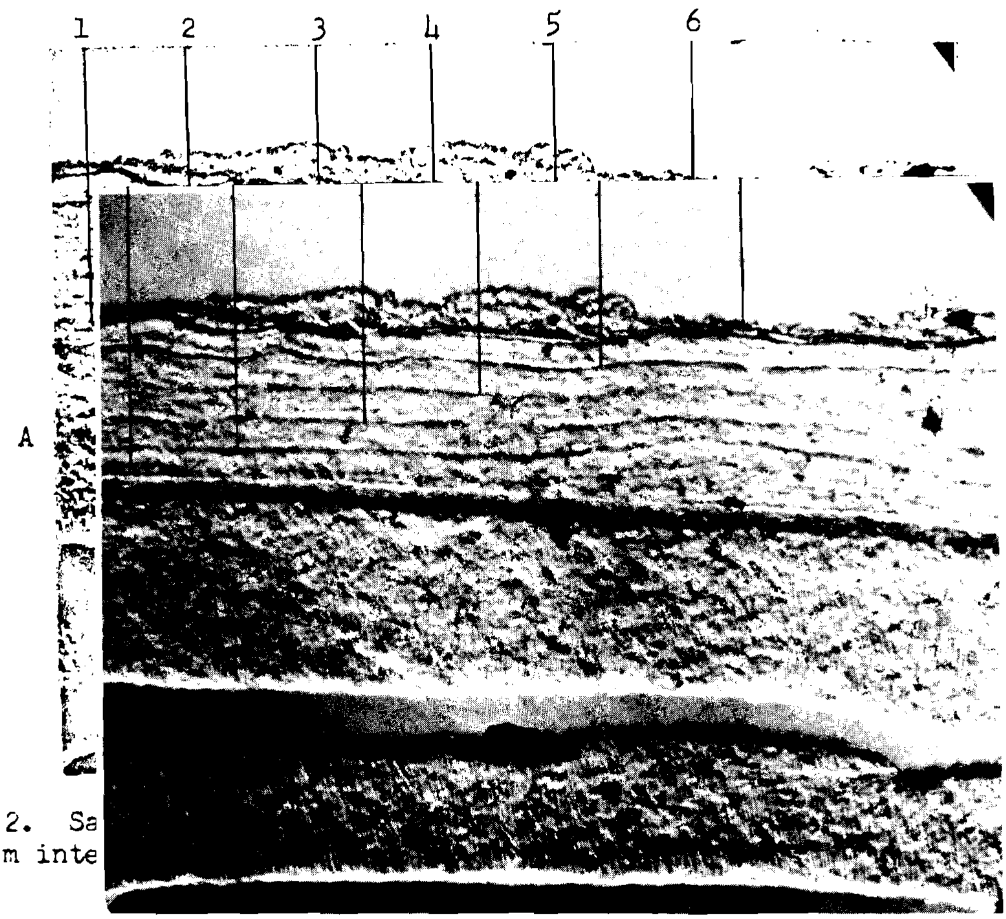


Figure 2. Sa ... ne-
cementum inte ... bered.

Examples of annuli count age determination are shown in Figure 3. Annuli in these sections are readily discernible, however, interpretation of the annuli can be difficult and individual interpretations can vary. Any time an animal's age was uncertain, the annuli were re-examined by more than one researcher. Annuli were not always easily discernible and this necessitated more than one examination of some sections. In several cases, both primary incisors were sectioned before a final age was ascertained.

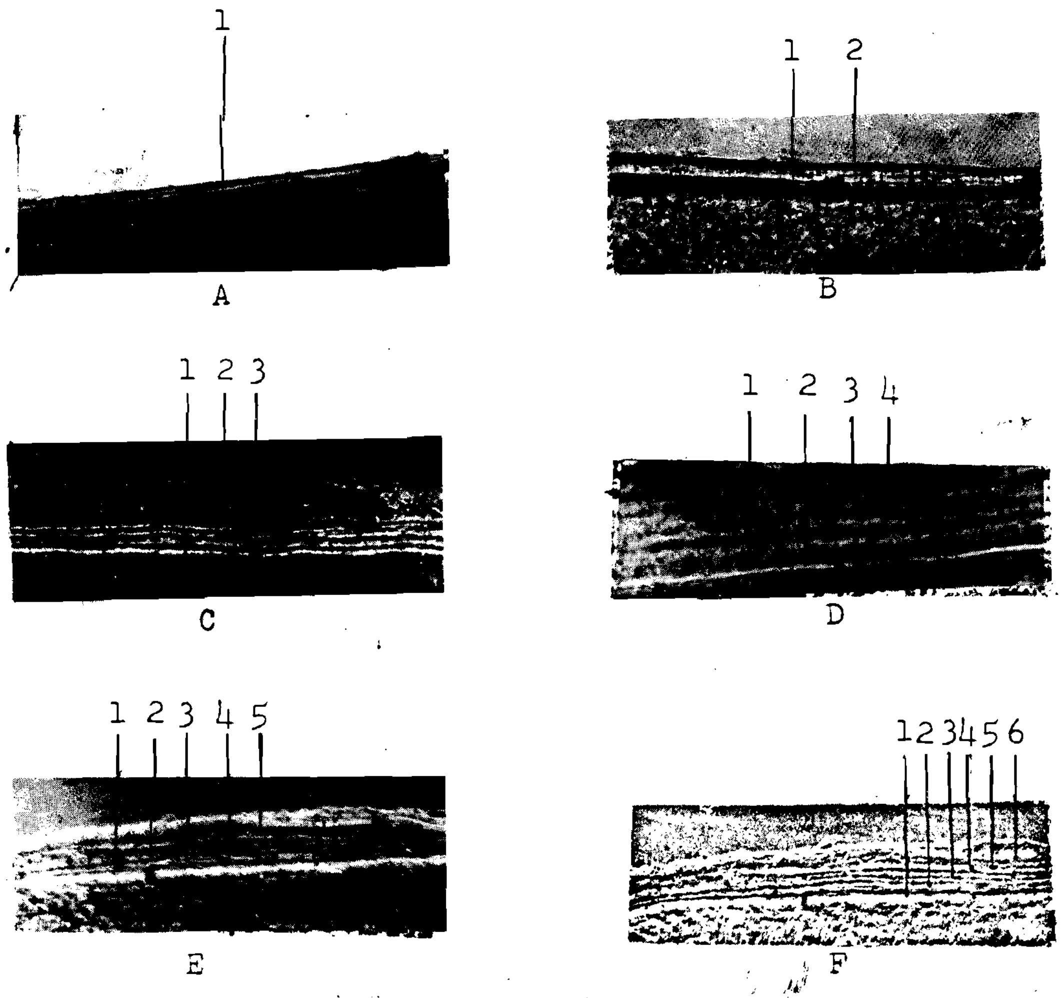


Figure 3. Series of tooth sections from 1.5 through 6.5 year old deer. Each numbered line represents one year.

Split Annuli

Divided dark lines, or split annuli, as in Figure 4, can lead to problems of interpretation. Most often such lines were not separated for their entire length and the distance of the separation was less than that of the light areas between well-defined annuli. On other occasions, as shown in Figure 5, the distance between such lines (A) was comparable to the distances between separated annuli. If these dark lines were of a width similar to adjacent annuli, they were then considered to be joined annuli rather than a split annulus.

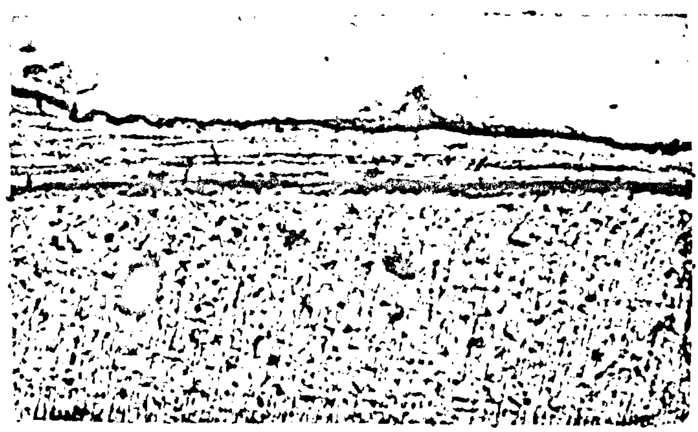
A


Figure 4. Ground section of incisor from a 6.5 year old deer. "A" depicts the divided dark line. Other annuli are also split.

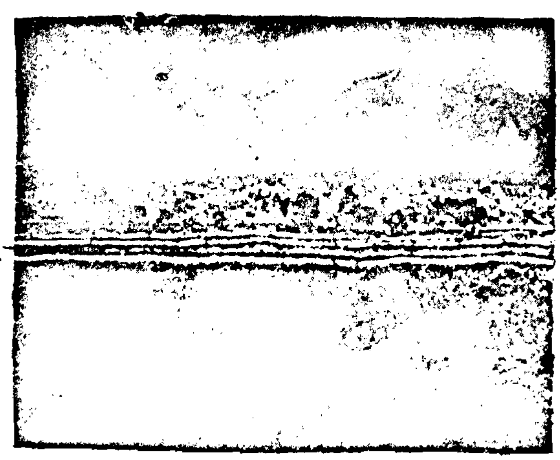
A


Figure 5. Joined annuli (A) in tooth from a 3.5 year old deer.

Low and Cowan (1963) believed the split lines are exemplary of the rutting season and termed them "rut lines." However, Lockard (1972) found split annuli in the incisor of a castrated buck, as well as in 39 percent of a known-age female sample. Split annuli were also found in the incisors of both sexes during this research. From this it would seem evident that the lines are not rut lines. There is still no evidence to explain why some annuli are divided. In a few sections there were faint lines of unknown origin, although they provided little interference in annuli interpretation.

All readings of the annuli were taken in the area of the cementum with the greatest width. This was done to insure that the maximum number of annuli were observed. Both sides of the teeth were examined to insure accuracy.

Most sections exhibit easily readable annuli, but as previously noted, several sections presented some difficulty (Figure 6). The difficult sections were usually from older age deer, where the outermost annuli were more closely grouped than were the inner annuli. The age assigned to this deer was 12.5 years.

Figure 6. Tooth from deer considered to be 12.5 years old. Dots are used to depict each annulus.

The state-wide sample of 970 deer was also aged by the annuli count method. The technique worked equally well on both white-tail and mule deer incisors. During the processing of teeth it was found that incisors removed from mule deer were generally of a harder texture than were those from white-tails, and they required more time to prepare.

In addition, both mule deer and white-tails from the western two-thirds of the state generally possessed incisors of a harder substance than did deer collected in the eastern one-third of Kansas. A possible explanation for this is that ground water in western Kansas has a greater flouride content than does that of eastern Kansas and would, therefore, result in harder teeth in deer that drink water with the greater flouride content (Bridge 1972). Whether teeth of a harder nature would show sufficiently less wear to be incorrectly aged by the TWD method is not known. Incisors from deer in the eastern one-third of Kansas did show more visible wear than the incisors from deer of corresponding ages in western Kansas.

Discussion of Results

Ages determined by TWD were compared to those ages ascertained by annuli count. All age data were grouped according to ages assigned by the AC method.

Comparison of TWD Ages to AC Ages

Table I shows the mean ages determined by each of the biologists as compared to those ages assigned by the AC method. Note that variations among ages estimated by biologists increase as deer ages increase. In the 2.5 year age class, ages range from 2.57 to 2.96 with the mean age assigned by the five biologists being 2.77. The 3.5 age class ranges from 3.5 to a high of 3.73, the mean being 3.62. For 4.5 year olds, the biologists' range was from 4.31 to 5.50 with an average of 4.80. In the 5.5 age group they ranged from 5.16 to 7.16, the mean age being 5.82. For the 6.5 year old deer, the range was from 6.16 to 8.50 with the mean at 6.86 years.

TABLE I. Comparison of average ages (in years) estimated from TWD method by biologists with ages assigned by AC method. Letters A through E indicate individual biologists.

AC AGE	A	B	C	D	E	BIOLOGISTS' AVERAGE	NO. IN SAMPLE
2.50	2.96	2.96	2.65	2.57	2.73	2.77	13
3.50	3.73	3.73	3.59	3.50	3.59	3.62	21
4.50	5.50	4.95	4.31	4.86	4.40	4.80	11
5.50	7.16	5.83	5.16	5.83	5.16	5.82	3
6.50	8.50	7.16	6.16	6.83	5.66	6.86	6

For the total of the 60 deer, the biologists were in agreement with the annuli count method 161 of 300 times (60 deer x 5 biologists = 300 age estimation) or 53 percent. Biologists' estimated ages exceeded the annuli count age 85 times, 28 percent, and were less than annuli ages 54 times, 18 percent (Table II). The discrepencies between over aging and under aging would not balance each other.

Gilbert and Stolt (1970) found that ages determined by tooth wear reflected a tendency to over-estimate ages in young deer and under-estimate those in older age groups when compared to the AC method. A similar tendency was shown in this study. Deer determined to be 6.5 years or less by annuli count were under-estimated 33 times, 12 percent, and over-estimated 84 times, 31 percent, by the five biologists. However, deer determined to be older than 6.5 years were over-estimated only one time, .02 percent, and underaged by the biologists 21 times, 84 percent.

TABLE II. Number of deer correctly aged, over-aged and under-aged by five biologists for each age group determined by annuli count.

AGE GROUP	CORRECTLY AGED	OVER AGED	UNDER AGED	NUMBER IN SAMPLE
1.5	5	0	0	5
2.5	47	18	0	65
3.5	70	25	10	105
4.5	24	20	11	55
5.5	6	7	2	15
6.5	6	14	10	30
7.5	2	0	8	10
8.5	1	1	8	10
8.5+	0	0	5	5
TOTAL	161	85	54	300

The t-test at the .05 significance level was applied to analyze variations between TWD ages and AC ages (Table III). For each age group determined by the AC method, calculated t was figured for the average of ages assigned by individual biologists to the same group of teeth. There was a significant difference between ages in only six instances.

Figure 7 illustrates the average percentage of agreement of TWD assigned ages with AC determined ages. Note that in the higher age groups the percent of agreement decreases and the range of agreement and standard deviation increase.

Percent of agreement by each of the biologists with the annuli count method is depicted in Figure 8. The tendency of decline in agreement with increase in age can be seen.

TABLE III. Results of t-test at the .05 significance level calculated to analyze difference between ages assigned by each of five biologists using TWD method with ages determined by AC method. Columns A through E represent calculated t for each biologist in age groups 2.5 - 6.5 years. Figures less than or equal to table t indicate no significant difference; figures greater than table t show a significant difference in ages.

AGE	A	B	C	D	E	TABLE t	NO. IN SAMPLE
2.5	4.00*	4.00*	2.06	1.30	2.67*	2.06	13
3.5	1.79	2.39*	0.26	0.0	1.10	2.09	21
4.5	4.76*	1.80	1.31	2.11	0.05	2.23	11
5.5	1.32	0.71	0.27	0.26	0.27	4.30	3
6.5	3.33*	1.55	0.80	0.77	2.11	2.57	6

* indicates significant difference

The total of 53 percent agreement by biologists with the AC method is somewhat less than the agreement found in other studies. In similar studies the percentage of agreement between the two aging methods was found to be 58 percent (Gilbert and Stolt 1970), and 72 percent (Boozer 1970). Kerwin and Mitchell (1971), working with pronghorn (Antelocapra americana), found a 60-percent agreement between the two techniques. A significant factor in this study, however, is the practice of Kansas biologists of not aging deer older than 3.5 years. This would probably have a tendency to lessen the agreement figure due to the lack of the Kansas biologists' experience in aging older deer.

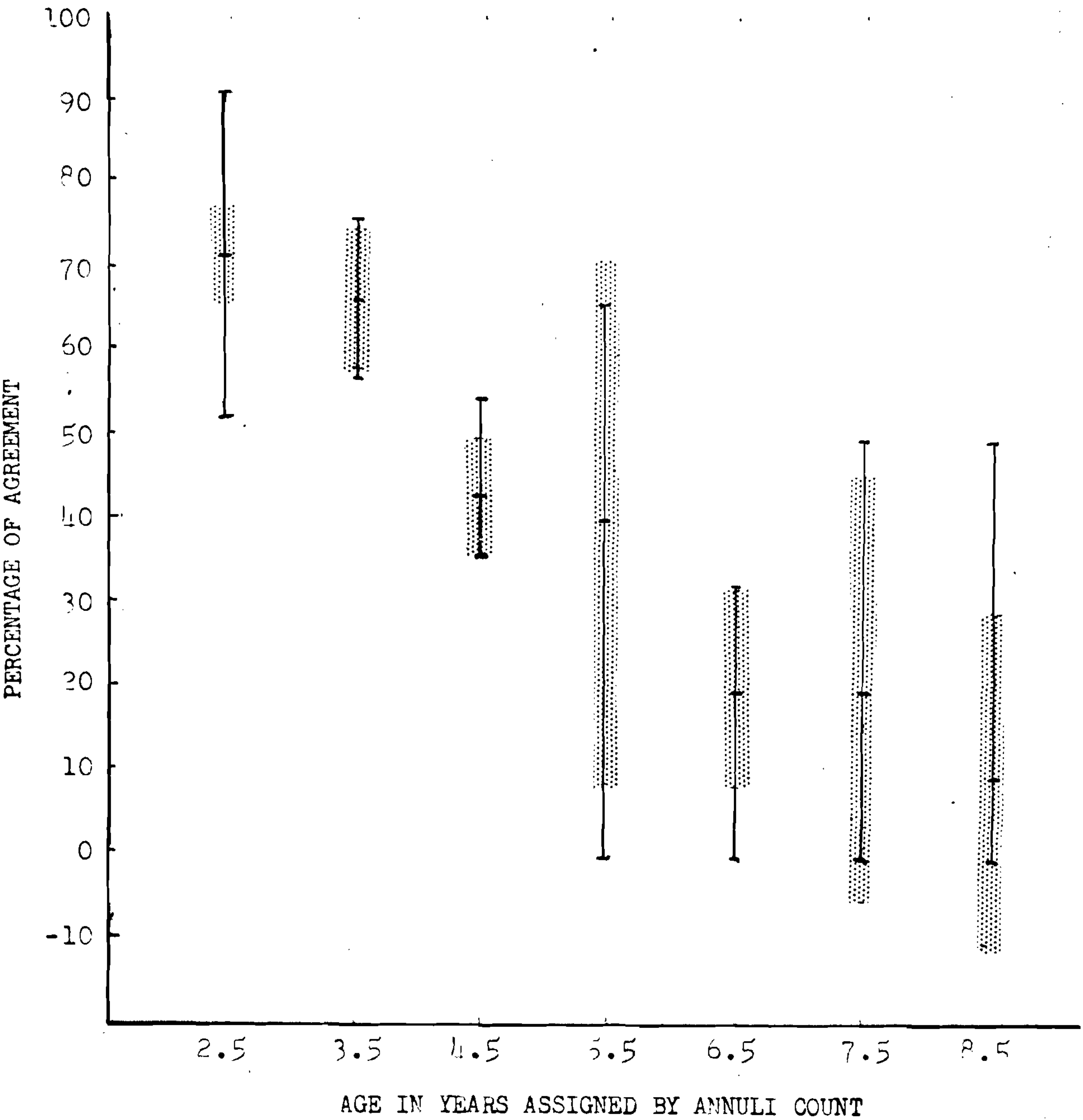


Figure 7. Average percent of agreement of TWD ages with ages determined by AC method. Horizontal bars represent mean percent of agreement by five biologists with AC ages; vertical lines the range in percentage of agreement; columns the standard deviation.

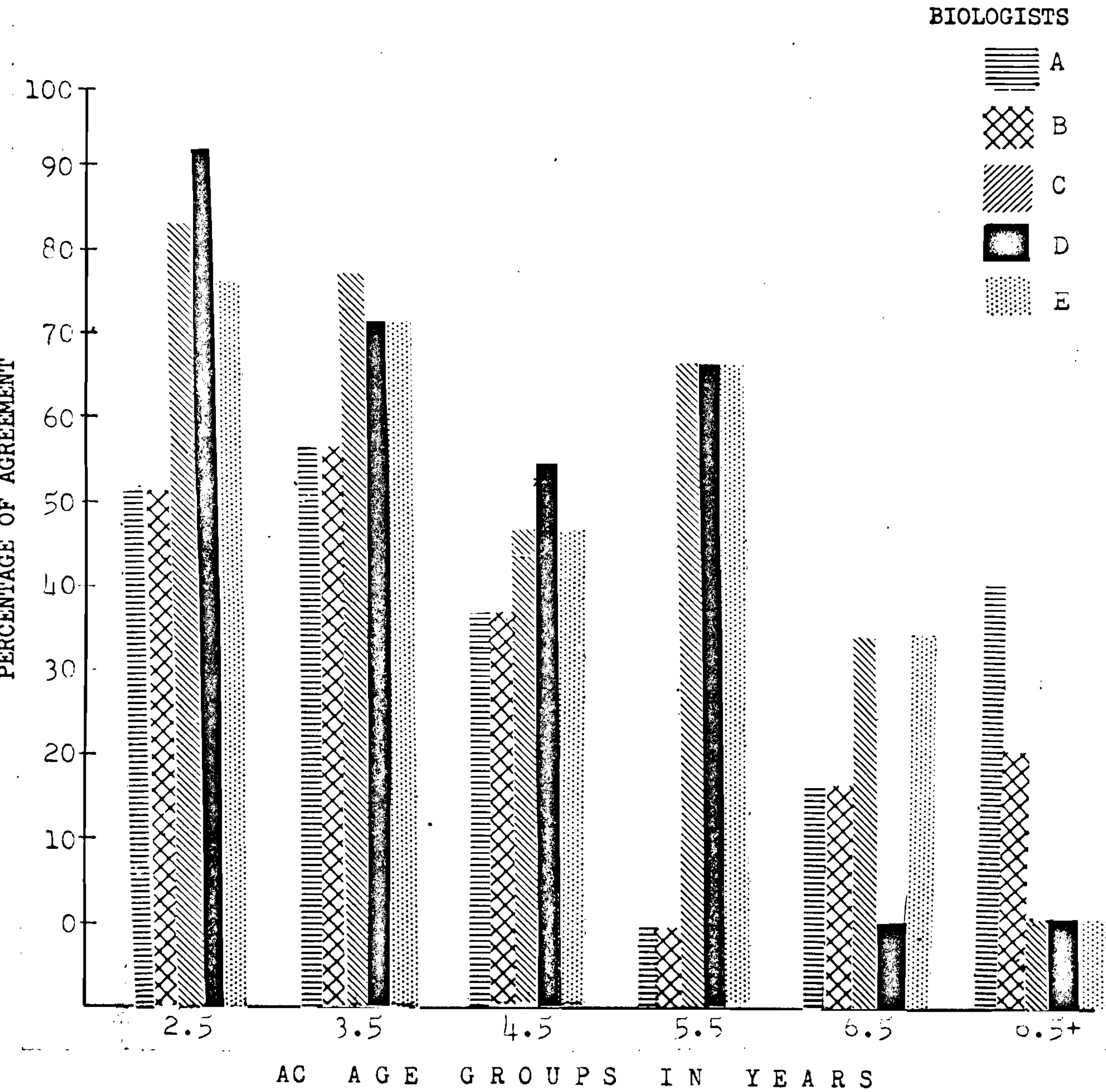


Figure 8. The percent of deer assigned by each of five biologists using TWD method to the same age class as that determined by AC method.

Limitations of TWD Method and Advantages of AC Method

Ages assigned for each of the 59 deer by the five biologists (Appendix A) also reveal the variations in aging by the TWD method. The total of the ages assigned by one biologist (A) was 294 years for the 59 deer, while another biologist's (E) total was 240 years. This range between the two of 54 years represents almost one year of difference for each deer aged. These variations in individual interpretation point out the lack of reliability and consistency in the TWD method of aging.

In addition to the limitations of the TWD method as an aging technique, there is also the problem of maintaining stations to check the deer brought in by hunters. Such stations are costly and also require that the men running each station be absent from their previously assigned duties during the deer hunting seasons.

Another problem, especially serious in Kansas, is the great number of access roads and travel routes in the state. It is difficult to locate check stations at points where a sufficient number of deer may be checked. If an insufficient number of deer are reported, the data received have only a limited value.

During the 1971 firearms deer season, specially prepared envelopes were sent to all hunters and hunters were asked to remove the primary incisors from any deer they killed. During the 1971 season, 2,568 deer were harvested in Kansas. Hunters returned the incisors of 2,314 of the animals, a response of 90 percent. This was, of course, a more than adequate number of teeth for a valid sample. From these incisors, 970 were aged by the AC method in less than two months by two researchers working for approximately 400 hours.

Due to the high percentage of response from successful hunters, the relatively short time required to process the teeth, and the accuracy of the AC method, the Kansas Forestry Fish and Game Commission has decided to abandon deer check stations for the 1972 season (Peabody 1972). All ages will be determined by the AC method.

One of the most important features of population dynamics of a deer herd is the age structure. It is a reliable indicator of a herd's productivity in a given area and age structure is the basis for many of the biologist's management recommendations.

In Kansas, the optimum age ratio of a season's deer harvest is as follows: 50 to 60 percent, 1.5 year old deer; 20 to 25 percent, 2.5 year old deer, with the remainder being 3.5 years and older (Peabody 1972). Should an area show a substantially higher percent of 1.5 year old deer harvested it would serve as an indication that a reduction of hunting pressure in this area is warranted. Conversely, if the age structure of an area was to show few deer 1.5 years of age and less, it would indicate poor productivity or a poor survival rate. The wildlife biologist might then choose to make such an area a "bucks only" hunting area, or he might wish to determine if other factors such as disease are inhibiting production.

For whatever purpose the biologist uses age data, the more accurate his information, the more accurate are his management recommendations. Because of variations in age results when using the TWD method, plus the tendency of over-aging young deer and under-aging older ones, it would appear that such data could bias the information the wildlife biologist receives. The greater reliability of the AC method can, therefore, be of great significance to the wildlife biologist.

SUMMARY

Ground sections from white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*) incisors from Kansas were examined for annular rings. Ages for 60 deer were determined in this manner and compared to ages assigned by five biologists using the tooth wear and development method. Comparison of these data revealed that biologists tended to over-estimate the ages of young deer and under-estimate the ages of older deer when compared to ages determined by the AC method. The percentages of agreement of the biologists with the AC method decreased as ages increased, with the biologists being in agreement with the annuli count ages in 53 percent of the sample. An additional 970 deer, not included in this study were aged by this technique.

Annuli count ages are generally easy to determine, but in some cases interpretation can be difficult. In some ground sections divided or joined dark annuli were observed in males and females from both species. There is also a lack of conclusive evidence as to the time of year in which the dark line is formed.

As opposed to the tooth wear and development method, the annuli count technique is quicker, less expensive and more accurate. It is also easily adaptable to a large hunter response. Because of these advantages, the deer harvested in the 1972 Kansas firearms season will be aged exclusively by the AC method.

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APPENDIX A

TABLE IV. Comparison of ages assigned by biologists to annuli count ages. Ac - Annuli count age; A through E - Biologists.

2.5 YEAR OLD DEER

JAW #	Ac	A	B	C	D	E
2	2.5	2.5	2.5	2.5	2.5	2.5
5	2.5	3.5	3.5	2.5	2.5	2.5
7	2.5	3.5	2.5	2.5	2.5	3.5
13	2.5	3.5	3.5	3.5	2.5	2.5
16	2.5	2.5	2.5	2.5	2.5	2.5
18	2.5	3.5	2.5	2.5	2.5	2.5
28	2.5	2.5	3.5	2.5	2.5	3.5
36	2.5	3.5	2.5	3.5	3.5	3.5
40	2.5	2.5	3.5	2.5	2.5	2.5
46	2.5	2.5	2.5	2.5	2.5	2.5
50	2.5	2.5	3.5	2.5	2.5	2.5
55	2.5	3.5	3.5	2.5	2.5	2.5
56	2.5	2.5	2.5	2.5	2.5	2.5
TOTAL	32.5	38.5	38.5	34.5	33.5	35.5

3.5 YEAR OLD DEER

JAW #	Ac	A	B	C	D	E
1	3.5	3.5	3.5	3.5	3.5	3.5
3	3.5	4.5	3.5	3.5	3.5	3.5
10	3.5	4.5	4.5	3.5	3.5	3.5
14	3.5	3.5	3.5	4.5	3.5	3.5
15	3.5	3.5	3.5	3.5	3.5	3.5
19	3.5	3.5	4.5	3.5	3.5	3.5
20	3.5	3.5	4.5	3.5	3.5	3.5
21	3.5	4.5	4.5	4.5	4.5	3.5
23	3.5	3.5	3.5	3.5	3.5	4.5
24	3.5	3.5	4.5	3.5	3.5	4.5
25	3.5	3.5	3.5	4.5	4.5	3.5
26	3.5	4.5	3.5	3.5	3.5	3.5
35	3.5	2.5	2.5	2.5	2.5	2.5
37	3.5	3.5	3.5	3.5	3.5	3.5
38	3.5	4.5	3.5	3.5	3.5	3.5
41	3.5	4.5	4.5	4.5	4.5	4.5
42	3.5	4.5	3.5	3.5	3.5	3.5
47	3.5	3.5	2.5	3.5	3.5	3.5
45	3.5	2.5	3.5	2.5	2.5	2.5
49	3.5	3.5	3.5	3.5	3.5	4.5
32	3.5	3.5	4.5	3.5	2.5	3.5
TOTAL	73.5	78.5	78.5	75.5	73.5	75.5

TABLE IV. Cont'd.

JAW #	Ac	A	B	C	D	E
4.5 YEAR OLD DEER						
4	4.5	4.5	5.5	4.5	4.5	4.5
9	4.5	5.5	4.5	4.5	4.5	3.5
12	4.5	5.5	5.5	4.5	5.5	4.5
33	4.5	6.5	6.5	5.5	6.5	5.5
34	4.5	4.5	4.5	3.5	4.5	3.5
39	4.5	5.5	4.5	5.5	4.5	4.5
43	4.5	7.5	6.5	4.5	5.5	6.5
44	4.5	6.5	5.5	4.5	5.5	4.5
31	4.5	4.5	3.5	3.5	4.5	4.5
57	4.5	4.5	4.5	3.5	3.5	3.5
54	4.5	5.5	3.5	3.5	4.5	3.5
TOTAL	49.5	60.5	54.5	47.5	53.5	48.5

5.5 YEAR OLD DEER

JAW #	Ac	A	B	C	D	E
17	5.5	7.5	6.5	4.5	5.5	5.5
29	5.5	7.5	4.5	5.5	6.5	5.5
58	5.5	6.5	6.5	5.5	5.5	4.5
TOTAL	16.5	21.5	17.5	15.5	17.5	15.5

6.5 YEAR OLD DEER

JAW #	Ac	A	B	C	D	E
6	6.5	10.5	8.5	7.5	8.5	7.5
11	6.5	10.5	8.5	7.5	7.5	6.5
22	6.5	6.5	5.5	5.5	5.5	4.5
30	6.5	9.5	8.5	6.5	7.5	6.5
48	6.5	5.5	5.5	3.5	4.5	3.5
51	6.5	8.5	6.5	6.5	7.5	5.5
TOTAL	39	51	43	37	41	34

7.5 YEAR OLD DEER

JAW #	Ac	A	B	C	D	E
53	7.5	6.5	5.5	5.5	5.5	4.5
52	7.5	7.5	7.5	6.5	6.5	5.5

TABLE IV. Cont'd.

JAW #	Ac	A	B	C	D	E
8.5 YEAR OLD DEER						
8	8.5	9.5	7.5	7.5	7.5	6.5
59	8.5	8.5	7.5	6.5	7.5	5.5
TOTAL	16	18	15	14	15	12
13.5 YEAR OLD DEER						
JAW #	Ac	A	B	C	D	E
60	13.5	10.5	9.5	9.5	11.5	7.5
TOTAL ALL AGES *	258	294	271	247	259	240

*Does not include 1.5 year old deer