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RICHARD J. MCCLOSKEY. Accuracy of Criteria Used to Determine Age of Fox Squirrels. Proc. Iowa Acad. Sci., 84 (1):32-34, 1977. This study was undertaken to determine the relative accuracy of fox squirrel (*Sciurus niger rufiventer* (Geoffroy) age indicators commonly used in the field and laboratory. Previous reports indicated that determination of age of squirrels by external morphological characteristics was inaccurate. Estimation of the ages of 211 squirrels indicated that the most accurate field methods were coloration and appearance of nipples of females and tail pelage and scrotal pigmentation of males. Estimating age by X-ray determination of the presence or absence of an epiphyseal line was the most accurate technique for dead specimens while change in tail pelage was the most accurate technique for living animals.
INDEX DESCRIPTORS: Fox Squirrel, *Sciurus*, Aging Techniques, Age Criteria.

Kline (1964) stated many studies showing a preponderance of adults in tree squirrel populations are based on aging techniques which are not accurate. Estimating age by external morphological characteristics is difficult at best when a large portion of the population is composed of juvenile squirrels that have reached adult size (Kidd 1955, Kirkpatrick and Hoffman 1960, Kline 1964).

Accuracy in determining age structures of mammal populations depends heavily upon the criteria used for estimating age. The objective of this study was to determine the accuracy of various indicators used in estimating the age of fox squirrels.

Criteria used to determine the age of live squirrels (field techniques) are varied. Chapman (1938) separated young from adult squirrels by weight. Allen (1943) and Brown and Yeager (1945) used subjective impressions, body weight, Cowper's gland palpation and scrotal pigmentation. Uhlig (1956) presented a more detailed description of characteristics of external genitalia and mammary glands of all age classes. Sharp (1958) believed juvenile, subadult, and adult classes were rapidly separable by differences in the pelage of the underside of the tail and tail shape.

Indicators of age of dead tree squirrels (laboratory techniques) include weights and measurements of testes and baculum (Allen 1943), skeletal measurements (Kirkpatrick and Barnett 1957), development and coloration of the reproductive tract (Deanesley and Parkes 1933) eye lens-weights (Beale 1962, Fisher and Perry 1970) and X-raying long bones for the presence or absence of an epiphyseal line or groove (Carson 1961, Nixon 1965). Baculum weight and histological studies of the testes in males and uterus development in females are considered the most accurate methods of estimating age in squirrels (Kirkpatrick and Barnett 1957, Hoffman and Kirkpatrick 1956, 1959).

No comparison of all age criteria using the same animals is reported in the literature. This study evaluates the accuracy of the most commonly used squirrel age indicators and suggests the most useful technique under field or laboratory conditions. The eye lens-weight method was not included in this study because it is impossible to use this technique to determine ages of individual squirrels (Fisher and Perry 1970) and the population age structures are comparable to those obtained by use of the X-ray technique (Beale 1962).

METHODS

Ages of live squirrels were estimated by tail development, tail shape and body weight. Additional criteria used were size and development of testes, scrotal pigmentation and Cowper's gland palpation for males and coloration and appearance of nipples for females.

Ages of dead specimens of both sexes were estimated by X-raying one forefoot from each individual and by humerus and femur length. Additional criteria used to estimate ages of dead squirrels were length and weight of testes and bacula and presence or absence of sperm in the testes in males and color and development of the uterus and the presence or absence of placental scars in females.

Ages of both living and dead juveniles weighing less than 400 grams were estimated by weight using criteria described by Allen (1943) and Uhlig (1955).

The age of each squirrel, as estimated by each technique, was recorded. The most frequently determined age was considered the most probable age of the specimen and is referred to as the "consensus age" in the remainder of this paper. The various techniques and the consensus age were compared using correlation analysis.

RESULTS

The ages of 112 female and 99 male squirrels were estimated using all techniques previously mentioned. The most frequently recorded age was considered the most accurate age of each specimen.

Criteria applicible to live specimens that correlate most highly with the "consensus age" are nipple appearance and coloration in females ($r=.85$; $t=32.1$; $p<.001$) and scrotal pigmentation ($r=.68$; $t=12.4$; $p<.001$) and tail pelage ($r=.68$; $t=12.4$; $p<.001$) in males (Tables 1 and 2). Tail pelage correlates most highly ($r=.78$; $t=14.5$; $p<.001$) when the sexes are not separated (Table 3). The lowest correlation with the consensus age is Cowper's gland palpation ($r=.06$. $t=.59$; $p<.05$) in males and body weight ($r=.38$; $t=4.6$; $p<.01$) in females.

Of the criteria applicable to dead squirrels, the X-ray method correlates most highly with the "consensus age" whether the sexes are pooled or treated separately. Field techniques correlating most highly with the X-ray method are scrotal pigmentation ($r=.74$; $t=16.1$; $p<.001$) in males and nipple coloration ($r=.86$; $t=34.7$; $p<.001$) in females.

DISCUSSION

Nipple appearance and coloration in females and scrotal pigmentation in males appear to be the most accurate of the criteria applicable to living specimens. These techniques, however, depend heavily on the reproductive cycles of the animals. In years when squirrel populations are small, animals are known to reproduce at a younger age. The earlier age of reproduction may distort the results of these techniques.

The determination of age by tail pelage as viewed from below is not influenced by population size or reproductive cycle. Tail pelage is also

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TABLE 1.
Correlation coefficients for consensus age and techniques used to determine age of female fox squirrels.

Technique	X-ray	Femur Length	Body Weight	Humerus Length	Tail Pelage	Reproductive Tract Color	Nipple Color	Consensus Age
X-ray	1.00							
Femur length	.57	1.00						
Body weight	.19	.18	1.00					
Humerus length	.56	.33	.12	1.00				
Tail Pelage	.71	.53	.07	.53	1.00			
Reproductive Tract Color	.42	.36	.10	.31	.34	1.00		
Nipple Color	.86	.59	.23	.47	.65	.38	1.00	
Consensus Age	.88	.72	.38	.68	.79	.60	.85	1.00

TABLE 2.
Correlation coefficients for consensus age and techniques used to determine age of male fox squirrels.

Technique	X-ray	Baculum Weight	Femur Length	Testes Weight	Cowper's Gland Palpation	Scrotum Color	Body Weight	Testes Length	Baculum Length	Humerus Length	Tail Pelage	Testes Smear	Consensus Age
X-ray	1.00												
Baculum Weight	.84	1.00											
Femur Length	.50	.49	1.00										
Testes Weight	.17	.00	.04	1.00									
Cowper's Gland Palpation	−.19	−.11	−.04	−.14	1.00								
Scrotum Color	.74	.62	.40	.11	−.04	1.00							
Body Weight	.08	.12	.05	.14	.06	−.18	1.00						
Testes Length	.23	.06	−.01	.86	−.15	.21	.16	1.00					
Baculum Length	−.12	.04	.01	.02	.12	−.09	.06	−.04	1.00				
Humerus Length	.45	.45	.14	−.14	.12	.27	.10	−.20	.15				
Tail Pelage	.72	.59	.28	.00	−.03	.54	.04	.06	.00	.41	1.00		
Testes Smear	.84	.71	.44	.24	−.21	.58	.03	.31	−.04	.33	.55	1.00	
Consensus Age	.86	.79	.51	.36	.06	.68	.26	.41	.19	.51	.68	.79	1.00

Table 3. Correlation coefficients for consensus age and techniques applicable for determining age in both sexes of fox squirrels

Technique	X-ray	Femur Length	Body Weight	Humerus Length	Tail Pelage	Consensus Age
X-ray	1.00					
Femur Length	.53	1.00				
Body Weight	.14	.07	1.00			
Humerus Length	.51	.24	.12	1.00		
Tail Pelage	.71	.41	.06	.47	1.00	
Consensus Age	.86	.66	.40	.69	.78	1.00

a criterion applicable to both sexes and is the recommended technique for determining age of live specimens.

The X-ray technique is the most accurate of the methods tested for determining fox squirrel age. The X-ray method compares favorably with the baculum weight, testes, and uterus coloration techniques previously reported to be the most accurate laboratory criteria for estimating age of squirrels. The primary advantage of the X-ray method is that forefeet can be collected and stored for later analysis without fear of bias due to tissue deterioration. The minimal training necessary for hunter cooperators to correctly remove a forefoot and submit it for analysis provides a method that is readily adaptable to statewide studies of age structure of small mammal populations.

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