Journal of the Minnesota Academy of Science

Volume 46 | Number 3 Article 2

1980

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Recommended Citation

Simon, D. E., & Frydendall, M. J. (1980). Age Study of Minnesota Red Fox Using Cementum Annulae Counts and Tooth X-Rays. *Journal of the Minnesota Academy of Science, Vol. 46 No.3*, 2-5. Retrieved from https://digitalcommons.morris.umn.edu/jmas/vol46/iss3/2

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Age Study of Minnesota Red Fox Using Cementum Annulae Counts and Tooth X-rays

DENNIS E. SIMON* and MERRILL J. FRYDENDALL**

ABSTRACT—A prerequisite to the proper management of an animal species is understanding of its population dynamics. Attempting this, the age structure of 297 red fox trapped or shot in southern Minnesota was investigated, using the techniques of tooth sectioning and x-ray. Results from two seasons (1977 and 1978) were similar, with 76.8 percent of the harvested population being juveniles (78.4 percent, 1977 and 74.6 percent, 1978), whereas only 0.6 percent of the total were in the 4½ year old class. The percentage of juveniles corresponds closely to the numbers predicted by a Department of Natural Resources model developed by Al Berner of the Farmland Research Unit. If a population reacts in a density-dependent manner, an increase in the breeding density should reduce the reproductive rate, and vice-versa. Data of this paper tend to support the premise that the reproductive rate in Minnesota red fox is affected in a density-dependent manner.

In recent years, the fashion trend towards long-haired furs has made the red fox, *Vulpes fulva,* the most economically valuable furbearer in Minnesota. The thousand percent increase in the average price for red fox pelts, from $6.50 in 1969 to more than $65 in 1979, produced a notable increase in harvest by hunters and trappers. The potential effects of increased harvest on the Minnesota fox population must be determined to help proper management of the species.

Only limited data are available on how fox populations respond to increased hunting and trapping pressure. Schofield (1958) in Michigan, Lemke *et al.* (1967) in Wisconsin, Andres *et al.* (1967) in Iowa and Trautman (1972) in South Dakota all observed increased productivity as response of the species to mortality increases. All suggested that fox densities are regulated by the carrying capacity of the land, thus increased harvest results in increased reproduction.

This implies that as a fox breeding population exceeds the carrying capacity of the habitat, the reproductive rate is reduced in a density-dependent manner. It will increase only if the habitat's carrying capacity increases or the breeding population decreases. Therefore, productivity of Minnesota fox populations should be expected to increase if increased harvest reduces the breeding population.

Paramount to the understanding of any wildlife population is an accurate estimate of the population age structure. The ability to separate juvenile from adult animals is particularly important. As the reproductive rate changes, so will the juvenile-adult ratio, thus yielding an index to the reproductive rate of the population.

A preliminary population model has been developed for the red fox using harvest data from hunter and trapper report cards and changes in the spring fox population index from survey routes reported by A. Berner of the Minnesota Department of Natural Resources (DNR) in a 1979 communication. The model estimates spring and fall population densities and the juvenile-adult ratio. One aid in verifying the model is to compare the predicted juvenile-adult ratio with that obtained from a sample of the population.

Many methods of determining fox age have been used with varying degrees of success, including tooth wear (Wood, 1958) eye lens weight (Friend and Linhart, 1971), and ossification of the epiphyseal region (Reilly and Curren, 1971). In recent years, the counting of annular rings in the cementum of teeth of red fox has proven to be an accurate means of determining age (Jensen and Nielsen, 1968, Monson et al. 1971, Grue and Jensen, 1973). Grue and Jensen demonstrated the feasibility of using size of the pulp cavity of red fox to separate juvenile from adult animals.

There has been much discussion about the time of year that annuli are laid down in the cementum of mammal teeth. One consensus among several researchers (Sergeant and Pemlatt, 1959, Mansfield and Fisher, 1960, Low and Cowan, 1963) is that dense layers are formed during winter and early spring due to nutritional stress. Craighead *et al.* (1970), investigating cementum layering in grizzly bears, concluded that dense zones are formed independent of nutritional stress. Grue and Jensen (1973) also concluded from a study of fox in Denmark that the dense dark areas were formed between March and October. All researchers agree that the lines are an annual phenomenon. For figures of tooth sections and for a detailed discussion on aging tooth sections, the reader is referred to Jensen and Nielsen (1968) and Monson *et al.* (1971).

The purpose of this study was to demonstrate the application of recent developments in age determination techniques to Minnesota red fox populations and to produce a data base to verify the DNR population model to assist in management decisions.

Procedures and Comparisons of Teeth

Lower jaws were clipped from carcasses of 167 red foxes trapped or shot in southern Minnesota during the 1977 season and from 130 carcasses during the 1978 season

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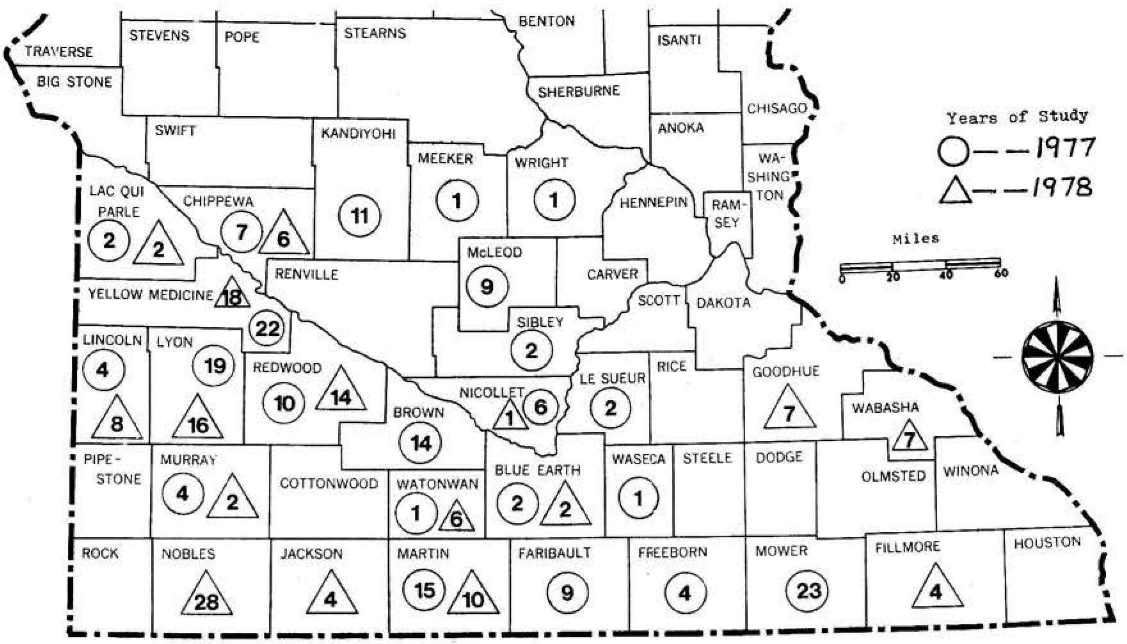
Figure 1. — Southern Minnesota Counties of Red Fox Project



(Fig. 1). Jaws were boiled for 1 hour and canine teeth, premolars and incisors were extracted. The canines, one from each animal, were glued in groups of 10 to 2 x 3 inch cards to facilitate x-raying on occlusal film at the Mankato State University Dental Hygiene Department. X-rays were viewed under a dissecting scope fitted with an ocular micrometer. Maximum width of the pulp cavity was calculated as a percentage of the maximum tooth width (Fig. 2).

A canine and premolar from each specimen were decalcified in 5 percent nitric acid (HNO_3) for 24 to 36 hours, then rinsed in running tap water for 24 hours. Longitudinal sections cut from the root tip using a clinical, freezing microtome with a razor blade attachment were mounted on slides as described by Grue and Jensen. Sections were stained 10 to 12 min. with Delafield's hematoxylin (Sherhan and Hrapshach, 1973), and rinsed in a solution of distilled water and several drops of ammonia until the sections turned blue. Sections were read under a microscope at 100x magnification. A determined age was considered accurate if agreement between two teeth from the same animal was obtained.

PULP CAVITY WIDTHS

The range and distribution of pulp cavity percentages were very similar for the two years (Fig. 3). Teeth from 1977 had pulp widths that ranged from 12 to 77 percent of the total tooth width, while the 1978 teeth ranged from 13 to 76 percent.

Samples from both years are clearly divided into two groups: those that have pulp widths greater than 35 percent, presumed to be juveniles less than 1½ years old; and those with pulp widths less than 35 percent, presumed to be adults. This clear division between juveniles and adults was confirmed by sectioning all those teeth that had pulp widths of 40 percent or less. The first distinct annulus did not show up until the pulp width had dropped below 35 percent.

CEMENTUM ANNULAE

Of the 297 teeth sampled from both seasons, only 0.6 percent were 4½ years old (Table 1). This corresponds with Pils and Martins (1978) and Storm *et al.* (1976). However, the 3½ and 4½

the 3½ and 4½ year age classes are probably not representative of the true population due to their ability to avoid trappers and hunters. Ages could not be determined for 16 (23 percent) of the adult animals primarily due to broken or missing teeth from improper collection. Probably, the addition of these animals would not significantly alter the adult age structure.

SEX RATIOS

Caution must be used in interpreting sex ratio data of red fox. This study revealed a preponderance of males in the juvenile age classes. This agrees closely with Eber (1975) who, after reviewing the available literature, concluded that although sex ratios at birth tended to favor females, fall harvest samples strongly favored males because of their increased vulnerability. Among adults in harvested samples, Eber found more females than males. This study indicated the same trends, but the sample was too small to draw statistical conclusion on this aspect (Table 1).

Project Implications

Grue and Jensen's technique of separating juveniles from adults using x-rays of the canine teeth has proven to be reliable for red fox studies in Minnesota.

Under this method, the observed ratios of juveniles were 78 percent in 1977 and 75 percent in 1978. These also correspond closely to the predicted values from the DNR population model (79 percent for 1977 and 74 percent for 1978; Berner, per. comm. 1979). This drop in percent juveniles was not statistically significant ($p > .05$), possibly due to small size.

Although caution must be exercised in weighing this aspect, preliminary DNR results indicate that the model is valid for predicting current trends in the Minnesota fox population.

Counts along spring census routes indicate a 65 percent decline in the breeding population during the period of 1974 to

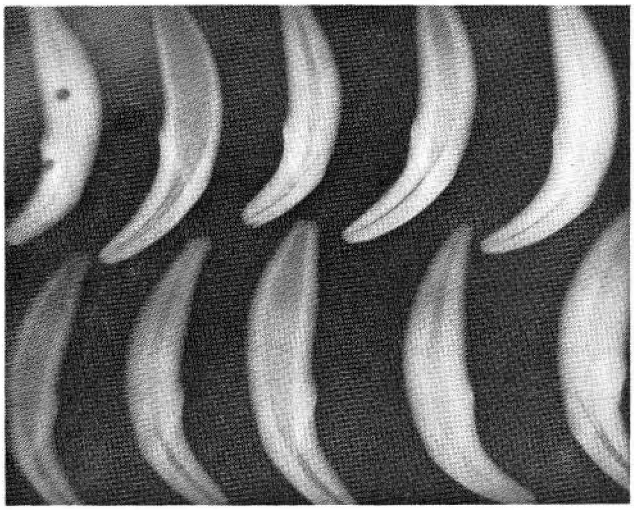


Figure 2. An x-ray of fox canines showing a variety of pulp cavity widths.

1977 (from 4.0 to 1.4 fox/1,000 mi. traveled). Modeling indicates that at maximum reproduction, 78 percent to 80 percent juveniles would be expected in a fall sample. The 1977 sample of 78 percent juveniles, suggests that this low breeding population was at or near maximum reproduction.

The 1978 counts indicate an approximate 60 percent increase in breeding population from 1977; this is probably due to a 50 percent drop in harvest because of poor trapping conditions and the first restricted fox season as a game animal during the fall of 1977. If the fox population reacts in a density-dependent manner, this sudden increase in breeding population should be accompanied by a reduced reproductive rate and in turn reduce the proportion of juveniles in the population. The percent data seem to bear this out, indicating a drop of 4 percent in the proportion of juveniles, which is very close to the 5 percent predicted by the DNR model.

If the breeding population again declines to or below the 1977 levels because of high harvest numbers, the percentage of juveniles should rise again towards the maximum of 78 to 80 percent. If this holds true, then the data suggest that the reproductive rate of red fox in Minnesota will decrease in response to increasing spring population densities.

ACKNOWLEDGEMENTS

This project was supported partially by a Mankato State University Graduate Research Fund Grant. Appreciation is extended to Dr. F.J. Vande Vusse and the students of Gustavus Adolphus College for the collection of fox samples and to Dr. Robert W. Fonda of the M.S.U. Dental Hygiene Department for his assistance in x-raying the teeth. We would like to offer our sincere thanks to Al Berner and John Ludwig of the Minnesota Department of Natural Resources for their critical review of the manuscript.

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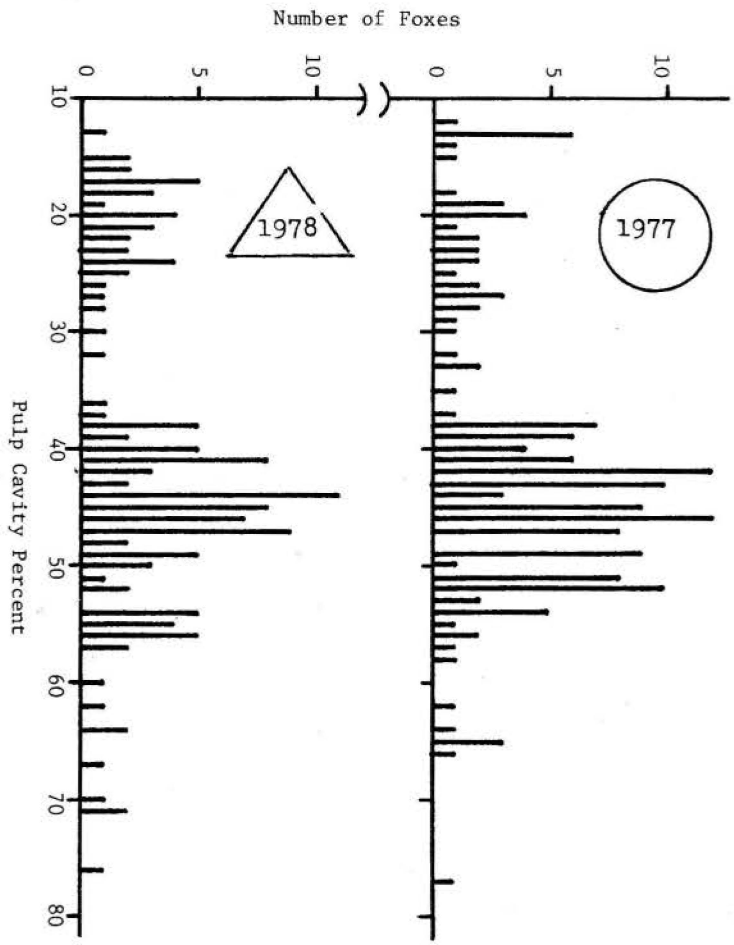
Table 1. Age structure of southern Minnesota red fox.

	No. of Foxes	Juv-Adult Ratio	No. of Foxes in Each Age Class Juv.	1½	2½	3½	4½	Unkn.
1977	91	4.87	73	11	3	1	-	3
Males	91	4.87	73	11	3	1	-	3
Females	74	4.00	56	8	3	2	1	2
Combined	167[a]	4.37	131[a]	19	6	3	2[a]	6[a]
% of Total			78.4	11.4	3.6	1.8	1.2	3.6
1978								
Males	75	3.41	48	8	1	-	-	8
Females	54	2.60	39	7	5	2	-	1
Combined	130[a]	2.99	97[a]	15	6	2	-	10[a]
% of Total			74.6	11.5	4.6	1.5	-	7.8

[a] Sex data not available for one or more samples

Figure 3. Pulp cavity percentages.



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