Delineating Age and Species of Harvested Cottontail and Swamp Rabbits

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Abstract: Age structure of harvested populations is important to wildlife biologists to adequately observe effects of harvest and management regimes. We aged harvested cottontail *(Sylvilagus floridanus)* and swamp *(S. aquaticus)* rabbits by eye lens weight. We developed 2 logistic regression equations based on external morphometrics (mass [N=213] and hind foot length [N=209]) to predict age and species. Our model used to delineate species had high correct classification rates (>89%). Hind foot length and mass were significant predictors of age class for both species and correct classification rates were high (>78%). These predictive equations will allow wildlife biologists to determine species and age of rabbits in the field for less cost compared to other methods. Therefore, we believe our models will assist wildlife biologists in estimating age structure and determining species of harvested rabbits.

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Often cottontail and swamp rabbits are sympatric, thereby requiring correct species identification. Although wildlife biologists can adequately identify species, data

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are often collected by moderately trained technicians. In areas where cottontail and swamp rabbits are sympatric, delineating between species for technicians and hunters becomes difficult. Typically delineation of these 2 species is based on the nape of the neck and top of hind foot coloration (Burt and Grossenheider 1980). Therefore, a system of easily obtained morphometrics would facilitate greater accuracy and information of harvest data.

Rabbits are commonly categorized into young or old age classes by hind foot length, dry weight of eye lenses, and epiphyseal closure (Larson and Taber 1980). Hind foot length and dry weight of eye lens are used to classify rabbits into young-of-the-year and adults whereas epiphyseal closure partitions individuals as less than or greater than 10 months old (Bothma et al. 1972). Eye lens weight provides the most accurate technique to age cottontail and swamp rabbits (Martinson et al. 1961; Lord 1963; Hill 1967, 1972; Palmer et al. 1991). Processing rabbits to obtain eye lens weight takes almost 3 weeks from harvest to weighing lenses (Lord 1963, Hill 1972). Although accurate, aging based on eye lens weight may not be practical for many wildlife managers. Rabbits also can be aged by examining epiphyseal closure of the proximal and distal ends of the humeri using visual inspection or by x-ray (Thomsen and Mortensen 1946, Hale 1949, Petrides 1951, Martinson et al. 1961, Lord 1963, Hoffmeister and Zimmerman 1967, Bothma et al. 1972). Similarly, aging by epiphyseal closure requires dissection and expensive x-ray equipment.

A simple, cost-effective aging technique that could be used in the field would be useful to wildlife biologists at hunter check stations. Previous studies have used univariate morphological measurements such as hind foot length (Beule and Studholme 1942, Petrides 1951, Bothma et al. 1972) and body mass (Schwartz 1941, Haugen 1942, Lord 1963, Bothma et al. 1972) to determine age with some success. If different morphometric characteristics provide non-redundant information, than simultaneous use of this information in a multivariate context should provide greater discrimination than univariate approaches. No study has reported simultaneous use of morphometric measurements to accurately and quickly predict age of cottontail and swamp rabbits. Therefore, we collected external morphometrics that are easily collected in the field during the harvest season and developed logistic regression equations using these measurements to predict species and species-specific age. We used cross-validation to evaluate the efficacy of these morphometrics to differentiate species and age of harvested rabbits, within a population of sympatric cottontail and swamp rabbits.

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Methods

Rabbits were collected on Trim Cane Wildlife Management Area (320 ha) located in Oktibbeha County, Mississippi. This area was converted from hardwood forests to soybean fields in the early 1970s and farmed until 1986 (Taylor 1996). Then, the area naturally succeeded into primarily oldfield and hedgerow habitats. Because of flat topography, poorly drained soils, and bordering Trim Can Creek, the area periodically floods in winter and spring (Taylor 1996).

Rabbit harvest was regulated by the Mississippi Department of Wildlife, Fisheries and Parks and personnel of the Department of Wildlife and Fisheries, Mississippi State University. The rabbit harvest season was the Saturday closest to October 15 until the last day in February. Rabbits used in this study were harvested in the 1997–98 and 1998–99 seasons. Hunters were selected by a lottery system. Hunts were conducted 2 weekends for October, December, January, and February, and 3 weekends in November. Hunters were required to check in all harvested rabbits.

For each harvested rabbit, we determined the species, sex, hind foot length, live body mass, and collected eyes. We determined species by the nape of the neck and top of hind foot coloration (Burt and Grossenheider 1980), and sex by primary sexual characteristics (Petrides 1951). We measured hind foot length to the nearest mm with a 2 m Lufkin measuring tape that was graduated into mm. Rabbits were weighed to the nearest 5 g using either a 2 or 5 kg Homs laboratory scale for cottontail and swamp rabbits, respectively. Because of our extensive experience with cottontail and swamp rabbits, we assumed that we correctly identified rabbit species.

Eye lenses were extracted, placed in 10% formalin for 2 weeks, oven-dryed at 80 C for 7 days, and weighed to the nearest 0.0001 g. We classified rabbits as adult or juvenile (young-of-the-year) from eye lens weight. Rongstad (1966) proposed a north-south gradient in lens weights. However, Hill (1972) noted that there appeared to be less of a difference in lens weights between Illinois and Alabama, than between Illinois and Wisconsin. Therefore, we used a known-age eye lens chart from Alabama (Hill 1972). Hill (1967) and Martinson et al. (1961) charted eye lens weights of swamp rabbits harvested in Alabama and Missouri, respectively. Hill (1967) observed no overlap of eye lens weights at 200 mg and Martinson et al. (1961) observed no overlap at 205 mg, a difference of only 5 mg; thus, they used those lens weights to discern between adult and juvenile swamp rabbits. We used 200 mg to delineate age of swamp rabbits (Hill 1967); if we had used Martinson et al. (1961) it would only have changed the age of 1 rabbit. We assumed that lens weights we collected did not deviate significantly from data obtained by Hill (1967, 1972). This research was conducted under Mississippi State University Institute of Animal Care and Use Committee (Approval No. 97–022).

We developed predictive logistic regression models to age rabbits (adult and juvenile) by species and to predict species (cottontail and swamp rabbit). We used hind foot length and body mass as predictor variables. We used the forward variable selection procedure (α=0.05) in SAS to determine significant variables (SAS Inst. 1989). Each model (for age or species) was derived from the first year of data and then validated using the second year of data; then the process was reversed. Finally, all data were regressed to compute a total model for species and age classification for each species.

Results

We obtained 213 hind foot lengths and 209 body masses from 215 harvested rabbits during the 2 hunting seasons. Because mass was the only significant predictor variable to delineate between species, we were able to calculate the cut-off mass between cottontail and swamp rabbits; i.e., rabbits that weighed ≥1,387 g were classified as swamp rabbits; lighter rabbits were classified as cottontail rabbits (Table 1). Our model correctly classified the species of 89% and 96% of rabbits for the 1997–98 and 1998–99 hunting seasons, respectively (Table 1). During the 1997–98 season, the model misclassified 14 swamp rabbits as cottontails but correctly classified all cottontails. During the 1998–99 season, the model misclassified 3 cottontails as swamp rabbits but correctly classified all swamp rabbits.

Hind foot length and mass were significant predictors of age class for both cottontail and swamp rabbits (Table 1). Our age classification model correctly classified the age of 79% of cottontail rabbits for each of the 2 seasons, and 81% and 84% of swamp rabbits for the 1997–98 and 1998–99 seasons, respectively. For cottontail rabbits, the model misclassified 5 rabbits as adults and 4 as juveniles during the 1997–98 season and 8 rabbits as adults and 6 as juveniles during the 1998–99 season. For swamp rabbits, the model misclassified 1 rabbit as an adult and 5 as juveniles during the 1997–1998 season and misclassified 8 rabbits as adults and 6 as juveniles during the 1998–99 season.

Discussion

The best aging techniques should be accurate, easy to use, and cost effective. Previous aging methods for rabbits have not met all these criteria. We evaluated the effectiveness of easily collected morphological measurements to predict age and species of harvested rabbits on an area where cottontail and swamp rabbits were sympatric.

The only way to distinguish cottontail and swamp rabbits is by coloration of the nape of the neck and top of hind foot (Burt and Grossenheider 1980). However, we have observed biologists and hunters having difficulty in delineating between species. Inability to differentiate species is problematic in areas of sympatric populations of swamp and cottontail rabbits. Concern exists in numerous states regarding the need to protect swamp rabbit populations from harvest. Allowing liberal harvest regimes for cottontails while conservatively harvesting declining swamp rabbit populations will require good regional data on the constitution of local harvests. Missouri is experiencing this dilemma in the boot-heel region (T. V. Dailey, Mo. Dep. Conserv., pers. commun.). Accurate but quick field identification is particularly important for establishing regulations, assessing compliance by hunters, and for enforcement by conservation officers. It is imperative that state wildlife agencies begin

Table 1. Logistic regression equations to determine species (cottontail or swamp rabbit) and age class (adult or juvenile) of harvested rabbits on Trim Cane Wildlife Management Area, Mississippi, 1997–1999.

	Parameter estimates						Percentage classification		
Model	Intercept	(SE)	Hind foot length	(SE)	Body mass	(SE)	Correct	False Pos[a]	False Neg[b]
Species[c]									
1997–98	–26.501	(8.919)			0.018	(0.003)	89%	0%	11%
1998–99	–18.989	(3.989)			0.014	(0.003)	96%	4%	0%
All	–19.417	(3.277)			0.014	(0.002)			
Age Class[d]									
Cottontail rabbit									
1997–98	–20.849	(11.880)	0.038	(0.126)	0.014	(0.004)	79%	9%	12%
1998–99	–13.928	(9.532)	0.014	(0.119)	0.010	(0.004)	79%	9%	12%
All	–15.984	(7.287)	0.008	(0.083)	0.013	(0.003)			
Swamp rabbit									
1997–98	8.096	(14.808)	–0.410	(0.216)	0.017	(0.007)	81%	16%	3%
1998–99	4.516	(14.973)	–0.231	(0.166)	0.009	(0.003)	84%	0%	16%
All	2.542	(9.662)	–0.234	(0.114)	0.011	(0.003)			

a. Percentage of rabbits classified as swamp rabbit that were actually cottontail, or percentage classified as adult that were actually juvenile.

b. Percentage of rabbits classified as cottontail that were actually swamp rabbit, or percentage classified as juvenile that were actually adult.

c. Predicted logit values for classifying a rabbit as a swamp rabbit.

d. Predicted logit values for classifying a rabbit as an adult.

to better monitor swamp rabbit population trends, because this species is thought to be declining throughout its native range (Sole 1994). Therefore, we provide a species classification model using body mass that is quite accurate (>89%).

Our age class models yielded high correct classification rates using mass and hind foot length from harvested rabbits. The lowest classification rate (>78%) we observed was for the model aging cottontail rabbits. For comparison to other aging classification rates for other species of wildlife, we chose the white-tailed deer *(Odocoileus virginianus)* because of the commonality and wide-spread use of aging for this species. The 2 most used aging criteria methods for white-tailed deer are tooth wear and replacement and cementum annuli (Jacobson and Reiner 1989). Jacobson and Reiner (1989) reported correct classification rates of 75% and 71% for tooth wear and replacement and cementum annuli, respectively. Jacobson and Reiner (1989) also reported that 55 biologists in the southeastern United States had a correct classification rate for 98 known-age deer mandibles of 63% using wear and replacement. Therefore, in comparison to age classification rates of white-tailed deer, our models with their correct classification rates of 79%–84% appear acceptable for field use.

Both hind-foot length and body mass are easily collected in the field. The only supplies needed are a measuring tape and a scale. There is no need for containers, formalin, oven, or collection of legs and eyes. Additionally, rabbits can be aged if the eyes have been damaged. Our logistic regression models resulted in high classification rates for delineating species and species-specific age. Therefore, we believe that external measurements collected for this study were effective and would be an asset to wildlife biologists to estimate age structure and delineate species of rabbits.

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