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Cranial Variation and Age Distribution in an Illinois Population of *Cryptotis parva*

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ABSTRACT

1) An unusually large sample of 113 least shrews (*Cryptotis parva*) was collected over a seven-day period in Moultrie County, Illinois.

2) The only cranial difference among age groups was maxillary toothrow length, which decreased with age, presumably from toothwear.

3) Females were significantly larger than males for three of seven cranial characters.

4) Females outnumbered males in younger age classes; however, this trend was reversed in older age classes, and the foraging behavior of females may account for this occurrence.

INTRODUCTION

Little is known about populations of least shrews (*Cryptotis parva*) because they are infrequently captured by conventional methods. Shrews of the genus *Cryptotis* have been found in greater numbers in owl pellets (Davis, 1938, 1940) than in most studies using mousetraps, perhaps indicating less susceptibility to trapping compared to other small mammals (Whitaker, 1974). However, large, localized concentrations of *C. parva* have been reported from sites in Michigan (Getz, 1962) and Florida (Kale, 1972) using live and snap traps, respectively. Both studies found sudden increases in *C. parva* numbers without any apparent cause. A large sample of *C. parva* from Illinois was studied to determine the influence of age and sex on morphology and population structure.

MATERIALS AND METHODS

A sample of 113 least shrews was captured in snap traps in the vicinity of Kirksville, Moultrie County, Illinois over a seven-day period (25 September to 1 October 1985) during a faunal survey conducted by the U. S. Army Construction Engineering Research Laboratory (USACERL). Skins and skulls of these *C. parva* from the USACERL Biological Inventory Collection maintained at the University of Illinois Museum of Natural History were examined. Five age classes were apparent by evaluating toothwear (after Choate, 1970): subadult, adult(-), adult, adult(+), and old adult (referred to as 1 to 5, respectively, in this study). None of the specimens fit the description of Choate's "young" category.

Five cranial characters were measured following Choate (1970): maxillary toothrow, palatal length, cranial breadth, least interorbital breadth, and maxillary breadth. In addition, skull height (illustrated as "braincase depth" by Huggins and Kennedy --1989) and basilar length were measured. Skull height was taken with Helios dial calipers (to 0.1 mm) whereas other skull characters were measured with a Zeiss ocular dial micrometer (to 0.01 mm). Sex and reproductive condition previously had been recorded on skin tags.

Statistical analyses used SAS (SAS Institute, 1985) procedures MEANS, GLM, STEPDISC, DISCRIM, and FREQ. The analysis of cranial characters utilized 110 individuals with complete skulls. Initially, three main effects (sex, age, and capture area) were tested using Wilk's criterion for the seven cranial characters. If capture area was non-significant, then a two-way interaction model would be implemented to allow nine individuals from unknown capture areas to be included and to eliminate the empty cells in the three-way model. Because of the unbalanced nature of the sample, analysis of variance tests were based on type III sums of squares. Discriminant analysis was used to determine if sexual differences can be used to classify skulls of *C. parva* of unknown sex (e.g., from owl pellets). The Goodman and Kruskal gamma statistic was used to test if a non-random association exists between sex and age class.

RESULTS AND DISCUSSION

Least shrews were captured in four areas of Moultrie County, Illinois, three located 1.75 mi ESE Kirksville (designated as east prairie, west prairie, and old field), and the other 2 mi SW Kirksville (open thicket). All four areas featured big bluestem (*Andropogon gerardii*) and milkweeds (*Asclepias* sp.), both reaching heights of two meters: typical *C. parva* habitat (Whitaker, 1974). *Cryptotis parva* was the predominant species where it occurred, constituting 66% to 88% of the mammals collected (Table 1). *Peromyscus leucopus*, *Microtus ochrogaster*, and *Mus musculus* were each collected in three of the four areas where *C. parva* occurred.

Analysis of cranial variation indicated capture area and all interactions were statistically non-significant ($P > 0.05$), whereas significant differences were found for the sex and age main effects. Significant differences for both sex and age class were also found using the two-way model (Table 2). The discordance among age groups was limited to maxillary toothrow, which was the only significant character in analysis of variance tests. Choate (1970) also found this to be the only significant difference between age groups of 85 *C. mexicana* from the vicinity of Jalapa, Veracruz, Mexico. He stated that maxillary toothrow is longest early in life and decreases with age. Apparently, toothwear creates age class differences for other soricid species as well, because the same pattern of significant reductions in toothrow length with increased age has been found in *Blarina brevicauda* (Choate, 1972) and *Sorex hoyi* (Diersing, 1980). Because averages for other cranial characters, such as palatal and basilar lengths, also peaked in the youngest age classes in our sample of *C. parva*, an analysis of covariance was performed to account for overall size and to determine the pattern of toothwear. Least square means resulting from this analysis indicated the significance of changes from the preceding age class (Table 3). Maxillary toothrow length increases from age class 1 to 2, remains the same in class 3, and decreases during age classes 4 and 5 when significant wear occurs.

Besides the effect of toothwear, age classes are not distinct; *C. parva* attains adult cranial size before their susceptibility to trapping, as is the case with *C. mexicana* (Choate, 1970), *B. brevicauda* (Choate, 1972), and *S. merriami* (Diersing and Hoffmeister, 1977). However, Diersing (1980) found several significant differences between young and old *S. hoyi*.

The Illinois *C. parva* demonstrated more secondary sexual variation than Choate (1970) found in *C. mexicana*. Females were significantly larger for three of the seven measurements: cranial breadth, maxillary breadth, and skull height (Table 2). Maxillary toothrow length was the only significant difference between sexes in *C. mexicana* (Choate, 1970), and this may have resulted from confounding age effects rather than differences between sexes. To illustrate, if maxillary toothrow length were tested in a one-way analysis of variance without accounting for age in our *C. parva* sample, the equality of sexes would be rejected ($P = 0.01$), which is not the case in the two-way model.

The importance of cranial sexual dimorphism in American shrews has been generally dismissed. Choate (1972) found only one of nine cranial characters (height of mandible) to be significantly different between sexes of *B. brevicauda*, and no sexual differences were found in *S. vagrans* (Findley, 1955), *S. cinereus* (van Zyll de Jong, 1980), and *S. hoyi* (Diersing, 1980). Huggins and Kennedy (1989) found "small" sexual differences in *S. cinereus* and *S. fumeus*. Stepwise discriminant analysis selected three variables for distinguishing males and females: least interorbital breadth, maxillary breadth, and skull height. The resulting linear discriminant function (LDF) correctly classified 73 of 110 (66.4%) of the individuals to the proper sex. Another LDF using all seven measurements only sexed 74 of 110 correctly, again not especially useful because 50% correct is expected from random classification. Sexual dimorphism of *C. parva* appears slight. However, the characters demonstrating sexual differences should be avoided or accounted for in systematic studies.

Sex ratios varied with age class in the *C. parva* sample (Table 4), as indicated by a non-random association between sex and age class (P = 0.001). Females outnumbered males by approximately 2:1 in age classes 1 to 3. In age classes 4 and 5, males outnumbered females (by approximately 2:1 in the latter). An indication of the relationship between age and sex is that average female age class was 2.8 compared to an average of 3.4 for males. Only 8 of 64 females were either carrying embryos or lactating. All four of the pregnant females were in age class 4: three of these had seven embryos, the other had five. Two of the lactating females were in age class 5 (50% of the class), and the others were in age classes 3 and 4.

Changes in sex ratios with age have been observed in other shrew studies. In a two-year study of *B. brevicauda*, Dapson (1968) trapped 48 males to 22 females in the older of two age classes, and a 1:0.98 female to male ratio in 341 younger individuals. Sex ratio varied monthly, and Dapson's August sample consisted of 37 young females and 23 young males, so the 2:1 ratio of young *C. parva* females to males that we found may be merely a deviation from an overall 1:1 sex ratio. Rudd (1955) found greater numbers of old females and young males, opposite the trend in our *C. parva* sample, in a two-year study of three *Sorex* species.

The foraging strategy of *C. parva* may create a trapping bias that affects observed age and sex distributions. Formanowicz et al. (1989) studied foraging in a laboratory colony of *C. parva* and found that females both killed and hoarded more prey than males, and the variance of the amount that females killed and hoarded was lower than males. Formanowicz et al. hypothesized that the hoarding behavior of females could be beneficial both as a hedge against low prey availability and by decreasing the time spent away from offspring by reducing the need to forage. Perhaps more females were captured during the week of trapping because their foraging activity increased the likelihood of capture. Also, if females hoard so that they will not have to leave offspring, this explains the change in the sex ratios of age classes 4 and 5. The older females may be more reproductively active and, therefore, are not part of the trappable population or have a lower capture probability, because they rely on food reserves. Therefore, the observations of Formanowicz et al. (1989) can explain both the greater frequency of capturing young females, and the reduction in older females observed.

In addition to trapping bias, the sexual differences in foraging could affect the demographics of *C. parva*. Two aspects of foraging may increase the mortality rates of females: foraging resulting in greater exposure to predators, and the pursuit of food especially taxing individuals of small shrew species because of their high metabolic rates. These factors could lead to reducing average longevity in females and explain the distribution of ages in our sample. However, Mock (1982) found no sexual differences in longevity in a laboratory colony of *C.*

parva. Unlike a laboratory colony with food provided, natural conditions may take a toll on females attempting to accumulate necessary resources, regardless of predation pressure.

Potential differences in toothwear rate between sexes cannot be dismissed as a cause for biased age classes. Formanowicz et al. (1989) did not find significant differences in the amount of prey eaten by males and females even though females killed and hoarded more prey; therefore, toothwear resulting from mastication should not differ between sexes. If the toothwear rate of females did increase due to their predation activity, more females in older age classes would be expected, which is not the trend that we found. Obviously, long-term studies, or at least the accumulation of data from successful trapping of *C. parva* in various places, are needed to further increase understanding of least shrew population dynamics, and the causes for occasional local increases in capture rates.

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Table 1.-- Summary of the mammals captured at six sites in Moultrie County, Illinois from 25 September to 1 October 1985. Two sites where *C. parva* was not taken are included, in addition to the four where this shrew was predominant. All specimens are from the USACERL Biological Inventory Collection.

	1.75 mi ESE Kirksville				2 mi SW Kirksville	
Species	East prairie	West prairie	Old field	Scout camp	Open thicket	Woods
C. parva	29	23	20		32	
B. brevicauda			4	2		
M. ochrogaster	2		5	1	4	1
P. leucopus	3	2		1	7	6
M. musculus	1	1	1			
% *C. parva*	85	88	66	0	76	0

Table 2.--Descriptive statistics for male and female _C. parva_ and the F values resulting from a two-way analysis of variance for each cranial character, in addition to Wilk's criterion for multivariate analysis of variance tests. The sex x age interaction was not significant (P > 0.05) for any character.

	Descriptive statistics (mm)				F values	
	Males		Females			
	n	mean+SD	n	mean+SD	Sex	Age
Basilar length	47	13.75+0.30	63	13.86+0.32	0.99	1.29
Maxillary toothrow	49	5.74+0.16	64	5.80+0.17	0.95	10.73****
Palatal length	49	6.50+0.20	64	6.55+0.20	0.76	1.21
Cranial breadth	48	7.95+0.16	63	8.04+0.17	8.44**	1.22
Least interorbital	49	3.52+0.12	64	3.51+0.11	0.08	2.13
Maxillary breadth	49	5.13+0.13	64	5.18+0.14	5.97*	0.68
Skull height	48	5.15+0.15	64	5.23+0.14	7.89**	1.05
Wilk's criterion for the cranial meas.					2.64*	2.42****

* P < 0.05; ** P < 0.01; *** P < 0.001; **** P < 0.0001

Table 3.--Results from analysis of covariance to determine patterns of toothwear in *C. parva*. The six cranial characters other than maxillary toothrow length were used as covariates for the computation of least squares (LS) means and standard errors (in mm).

Age (I)	Maxillary toothrow LS mean	LS mean SE	Prob > |t| H_0: LS mean(I) = LS mean(I-1)
1	5.80	0.03	
2	5.89	0.03	0.04
3	5.84	0.02	0.16
4	5.72	0.02	0.0001
5	5.62	0.03	0.01

Table 4.--Distribution of sex by age class in the *C. parva* sample. Gamma = 0.374 which indicates a nonrandom association between the two categories (P = 0.001). The number of pregnant and lactating females is noted by age class.

	Age Class					
Sex	1	2	3	4	5	Total
Males	6	4	12	18	9	49
Females	15	7	23	15	4	64
			(1 Lact)	(1 Lact)	(2 Lact)	
				(4 Preg)		
Total	21	11	35	33	13	113