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INTRASPECIFIC VARIABILITY IN CRANIAL AND POSTCRANIAL FEATURES OF *BLARINA BREVICAUDA* IN TENNESSEE

George D. Baumgardner
Memphis State University
Memphis, Tennessee 38152
and
Jean M. McPherson[1]
Southwestern at Memphis
Memphis, Tennessee 38112

Abstract

Age, individual, and sexual variation was statistically assessed for a maximum of 11 cranial and 11 postcranial characters in a sample of 84 short-tailed shrews *(Blarina brevicauda)* from a limited geographic area in Tennessee. No distinct trend for size variation with age was evident for cranial characters while postcranial features exhibited a moderate trend for size increase with age. Of the statistically significant age variation observed (three cranial, eight postcranial instances), young adults and adults formed the largest nonsignificant age subset. Individual variation in cranial characters was low and similar to other studies. For postcranial characters, individual variation was only slightly higher. Males tended to be larger than females; however, only one cranial and two postcranial characters exhibited statistically significant differences. As evidenced by relatively low to moderate levels of age, individual, and sexual variation, the postcranial characters appear to be adequate for use in morphometric studies.

Introduction

The short-tailed shrew, *Blarina brevicauda,* is a small insectivore distributed across the eastern half of the United States and southeastern Canada. Two species and 15 nominal subspecies are recognized for the genus by Hall (1981). However, the systematics of this group is not well understood and has been the subject of recent investigations (George et al., 1981, 1982; Moncrief et al., 1982; Braun and Kennedy, in press). Braun and Kennedy (in press) summarized much of the available literature concerning *Blarina* in Tennessee.

Previous morphologic studies of *Blarina* have been hampered somewhat by problems encountered due to within population differences in age and sex. While former investigations have addressed these problems in a limited fashion, they have not attempted to clarify such differences by examining them in a sample from which the effect of geographic variation has been removed. Also, these previous morphologic studies have utilized only external and cranial characters. No attempt has been made to use postcranial characters to delineate intraspecific morphologic relationships. The purpose of this study was to: (1) define the extent of intra-sample variation in cranial and postcranial features of *B. brevicauda;* (2) compare variation in postcranial characters to that of cranial features; (3) assess the usefulness of postcranial features in morphologic studies relating to *Blarina.* This study should contribute new information which could provide insight into a better understanding of soricid systematics.

Methods

Values of 29 characters (18 cranial, 11 postcranial; Table 1) were determined to the nearest 0.1 mm using dial calipers. Unless noted, cranial and postcranial characters were measured following Braun and Kennedy (in press) and Best (1978), respectively. Remaining characters were measured as follows:

Basal Length—From the medial junction, at the palate, of the first upper incisor and upper unicuspid one to the anterior edge of the foramen magnum.

Palatal Length—From the medial junction, at the palate, of the first upper incisor and upper unicuspid one to the posterior edge of the bony palate.

Zygomatic Plate Length—Equivalent to Breadth of Zygomatic Plate of Choate (1972).

Least Humerus Width—Width across shaft of humerus at its smallest diameter.

Greatest Width Radius and Ulna—Greatest distance across the fused radius and ulna just distal to the semilunar notch.

Axis Height—From the ventral base of the centrum to the dorsal tip of the spinous process.

Axis Foramen Width—Greatest width of the anterior opening of the axis foramen.

Length Ilium—From the anterior edge of the acetabulum to the crest of the ilium.

Least Width Pelvis—Least width of the fused halves of the pelvis measured across the iliums.

Femur Length—Greatest length of the femur from its head to the distal edges of the epicondyles.

Measurements were obtained from 84 specimens of *B. brevicauda* from three localities within eight miles of La Follette, Campbell County, Tennessee. All specimens are housed in the Memphis State University Museum of Zoology, Memphis State University, Memphis, Tennessee.

In order to test for age variation and to circumvent problems of size variation due to season (Dehnel's phenomenon; see Kirkland, 1978), each specimen was assigned to one of four age classes (juvenile—I, young adult—II, adult—III, old adult—IV) following the methods of Pearson (1945) and Guilday (1957). Specimens were examined to define the degree of various types of variation. Once determined, such variation was controlled for by excluding those characters or subsamples from further analyses. Characters with any sample represented in a comparison by one or fewer individuals could not be tested across all samples and were eliminated. Samples that were not significantly different from one another were combined to increase sample size for following tests. Age variation within each sex was assessed for specimens from the collecting locality with the most complete age class samples. Inter-collecting locality variation was then examined by testing the largest nonsignificant age subset across collecting sites for each sex. Individual variation of characters in samples pooled by

[1]Present address, University of Oklahoma, Norman, OK 73609

TABLE 1. *Basic statistics of age variation examination. Abbreviations are as follows: N = sample size, $\overline{X}$ = mean, 2 SE = two standard errors, ANP = ANOVA not possible, D = depth, G = greatest, L = length, W = width, *denotes significant difference at the .05 level.*

CHARACTER	SEX	AGE CLASSES I N	I $\overline{X}$ ± 2 SE	II N	II $\overline{X}$ ± 2 SE	III N	III $\overline{X}$ ± 2 SE	IV N	IV $\overline{X}$ ± 2 SE	F-ratio
1 Occipito-premaxillary L.	M	1	28.8 ± —	4	22.2 ± .42	1	22.8 ± —	0	— ± —	ANP
	F	0	— ± —	6	22.8 ± .38	1	22.0 ± —	1	21.8 ± —	ANP
2 G. Cranial L.	M	1	21.7 ± —	4	21.1 ± .50	1	21.5 ± —	0	— ± —	ANP
	F	0	— ± —	6	21.7 ± .36	1	21.1 ± —	1	21.2 ± —	ANP
3 Basal L.	M	1	18.5 ± —	5	17.9 ± .33	1	18.5 ± —	0	— ± —	ANP
	F	0	— ± —	6	18.5 ± .30	1	18.0 ± —	1	18.0 ± —	ANP
4 Palatal L.	M	3	8.6 ± .07	11	8.5 ± .19	4	8.7 ± .29	2	8.5 ± .00	.485
	F	4	8.4 ± .32	22	8.6 ± .12	6	8.4 ± .10	3	8.3 ± .07	1.605
5 Post-palatal L.	M	1	9.8 ± —	5	9.5 ± .25	1	9.8 ± —	0	— ± —	ANP
	F	0	— ± —	6	9.7 ± .29	1	9.6 ± —	1	9.5 ± —	ANP
6 Palatal W.	M	3	3.3 ± .13	11	3.2 ± .11	4	3.3 ± .13	2	3.3 ± .20	.398
	F	4	3.1 ± .13	22	3.2 ± .06	5	3.2 ± .08	3	3.2 ± .12	1.643
7 Cranial W.	M	2	12.3 ± .50	5	11.7 ± .22	1	11.9 ± —	0	— ± —	ANP
	F	1	11.4 ± —	8	12.2 ± .32	4	11.7 ± .50	2	12.1 ± .40	ANP
8 Occipital W.	M	2	8.7 ± .50	6	8.5 ± .20	0	— ± —	0	— ± —	ANP
	F	2	8.2 ± .30	8	8.5 ± .21	5	8.5 ± .28	2	8.7 ± .60	1.093
9 Cranial D.	M	2	6.2 ± .10	6	6.4 ± .14	0	— ± —	0	— ± —	ANP
	F	0	— ± —	9	6.5 ± .10	5	6.2 ± .15	2	6.4 ± .20	ANP
10 Maxillary Arch Spread	M	3	7.6 ± .07	11	7.6 ± .18	4	7.6 ± .26	2	7.8 ± .40	.490
	F	4	7.4 ± .06	21	7.5 ± .11	5	7.6 ± .19	2	7.4 ± .00	1.358
11 Intermaxillary W.	M	3	7.0 ± .00	11	6.9 ± .11	4	7.1 ± .13	2	7.0 ± .20	1.215
	F	4	7.0 ± .15	21	6.9 ± .09	6	7.1 ± .07	2	6.9 ± .20	1.306
12 Interorbital W.	M	2	5.8 ± .00	9	5.7 ± .09	3	5.9 ± .13	2	6.0 ± .30	2.312
	F	3	5.6 ± .13	14	5.8 ± .16	3	5.8 ± .07	2	5.8 ± .10	.631
13 Least Interorbital W.	M	3	3.8 ± .18	11	3.9 ± .10	4	3.9 ± .22	2	4.1 ± .30	.667
	F	4	3.9 ± .10	21	3.9 ± .05	6	4.1 ± .04	2	3.8 ± .00	4.243 *
14 Zygomatic Plate L.	M	3	2.6 ± .13	11	2.6 ± .07	4	2.6 ± .10	2	2.8 ± .10	1.876
	F	4	2.4 ± .12	22	2.6 ± .04	7	2.7 ± .09	3	2.6 ± .18	4.838 *
15 Nasal W.	M	3	2.8 ± .18	10	3.0 ± .07	4	3.2 ± .10	2	3.2 ± .10	5.697 *
	F	4	2.9 ± .08	22	3.0 ± .06	7	3.0 ± .11	3	3.0 ± .00	.847
16 Maximum Foramen Magnum W.	M	2	3.1 ± .20	5	3.3 ± .12	1	3.2 ± —	0	— ± —	ANP
	F	1	3.0 ± —	13	3.2 ± .08	5	3.1 ± .06	2	3.2 ± .30	ANP
17 Mandible L.	M	2	11.5 ± .20	11	11.6 ± .15	4	11.8 ± .08	2	11.7 ± .20	1.684
	F	4	11.3 ± .26	19	11.5 ± .15	7	11.3 ± .22	2	11.6 ± .10	1.521
18 Mandible H.	M	3	6.1 ± .13	11	6.2 ± .15	4	6.4 ± .21	2	6.3 ± .20	.980
	F	4	6.0 ± .13	22	6.1 ± .10	8	6.0 ± .12	3	6.1 ± .13	1.108
19 Humerus L.	M	3	9.0 ± .18	10	9.1 ± .14	4	9.2 ± .10	2	9.3 ± .20	1.080
	F	4	8.7 ± .13	22	9.1 ± .14	8	8.9 ± .15	3	8.9 ± .18	2.719
20 Least Humerus W.	M	3	1.0 ± .13	10	1.0 ± .05	4	1.1 ± .08	2	1.3 ± .10	3.509 *
	F	4	1.0 ± .08	22	1.1 ± .03	8	1.1 ± .06	3	1.0 ± .07	1.013

TABLE 1. *(cont.)*

CHARACTER	SEX	AGE CLASSES I		II		III		IV		
		N	$\bar{X} \pm 2$ SE	N	$\bar{X} \pm 2$ SE	N	$\bar{X} \pm 2$ SE	N	$\bar{X} \pm 2$ SE	F-ratio
21 G. W. Radius & Ulna	M	3	1.6 ± .00	9	1.8 ± .07	4	1.8 ± .06	2	1.9 ± .20	4.128 *
	F	4	1.8 ± .21	22	1.8 ± .07	8	1.8 ± .13	3	1.8 ± .12	.050
22 G. Scapula L.	M	3	9.3 ± .18	9	9.3 ± .22	4	9.8 ± .46	2	10.0 ± .00	4.027 *
	F	4	9.2 ± .17	21	9.5 ± .21	8	9.4 ± .21	3	9.5 ± .41	.599
23 Axis H.	M	3	4.0 ± .13	9	4.0 ± .07	4	4.1 ± .15	2	4.4 ± .10	5.231 *
	F	4	4.0 ± .29	20	4.1 ± .09	8	4.1 ± .15	2	4.2 ± .10	.341
24 Axis Foramen W.	M	3	1.8 ± .13	9	1.8 ± .05	4	1.8 ± .08	2	1.8 ± .20	.122
	F	4	1.8 ± .10	21	1.8 ± .03	8	1.8 ± .05	2	1.8 ± .00	2.955 *
25 G. L. Pelvis	M	2	12.5 ± .10	9	12.7 ± .31	4	13.2 ± .18	2	13.6 ± .10	4.403 *
	F	4	12.4 ± .37	20	12.8 ± .26	7	12.6 ± .27	3	12.8 ± .47	1.174
26 L. Ilium	M	3	6.4 ± .07	11	6.5 ± .18	4	6.6 ± .16	2	7.0 ± .30	2.398
	F	4	6.3 ± .25	22	6.5 ± .12	8	6.4 ± .14	3	6.7 ± .35	2.023
27 Pelvic Foramen L.	M	2	4.2 ± .30	11	4.3 ± .13	4	4.4 ± .24	2	4.4 ± .40	.481
	F	4	4.4 ± .26	18	4.4 ± .12	7	4.2 ± .19	3	4.1 ± .18	2.114
28 Least W. Pelvis	M	3	3.1 ± .24	11	3.2 ± .09	3	3.6 ± .12	2	3.8 ± .00	14.467 *
	F	4	3.2 ± .16	21	3.3 ± .09	8	3.5 ± .15	3	3.5 ± .13	4.834 *
29 Femur L.	M	2	9.8 ± .60	8	9.9 ± .27	4	10.2 ± .05	2	10.5 ± .40	2.658
	F	4	9.6 ± .24	21	10.0 ± .19	8	10.1 ± .20	3	10.3 ± .12	2.164

sex was assessed using coefficients of variation (C.V.), and these samples were compared to determine extent of sexual dimorphism.

Statistical analyses were performed using the UNIVAR program of Power (1969). This program generates standard statistics and tests for significant differences between samples using single classification analysis of variance. If significant differences are found, UNIVAR determines where they exist via multiple range tests employing Gabriel's (1964) Sums of Squares Simultaneous Test Procedure (SS-STP). Statistical tests were performed at the .05 significance level and all computer analyses were conducted on the UNIVAC 1100/62 computer at Memphis State University.

RESULTS AND DISCUSSION

Twenty-two characters could be tested for age variation (Table 1). No trend was observed for size change in cranial features. For postcranial characters, size tended to increase with age in male samples; though this trend was not as evident in female samples. Eleven characters displayed no significant age variation in either sex. Character eight showed no such variation for females (males could not be tested). The remaining 10 characters exhibited 11 instances of age variation in one or both sexes (Table 1, Figure 1). Three instances of age variation were for cranial features (13, 14, in females; 15 in males) none of which have previously been shown to vary with age. Postcranial features displayed eight occurrences of age variation. Five such instances occurred only in characters in the male sample (20, 21, 22, 23, 25); one (24) occurred only in that of the female. One character (28) displayed age variation in both sexes. In five of eight instances of postcranial age variation, old adults were significantly larger than juveniles and young adults. The most consistently formed age subset with the highest sample size was composed of young adults and adults. This agrees with other studies in which young adults and adults have been considered similar and juveniles and old adults have been excluded from analyses (Choate, 1972; Braun and Kennedy, in press).

Characters with significant differences between young adults and adults in either sex (24, 28), or for which there were incomplete samples for both sexes (8) or for collecting localities (4, 12) were excluded from further analyses. The remaining 17 characters were then tested for inter-collecting locality variability within each sex. Mandible length (17) in males was the only character to display such variation (F = 3.642), and it was also eliminated.

Individual variation, as represented by coefficients of variation, are presented in Table 2. For cranial characters, the male sample has values ranging from 2.61 to 4.70 with a mean ($\bar{X}$) of 3.84. For females, these C.V.'s are 2.81 to 4.73 with $\bar{X}$ = 3.71. These values are comparable to those of cranial characters reported for *Blarina* sp. by Guilday (1957), Long (1968), Choate (1972), and Moncrief et al. (1982). Corresponding C.V.'s for the nine postcranial characters were 2.34 − 7.88, $\bar{X}$ = 4.47 for males and 3.37 − 8.77, $\bar{X}$ = 5.08 for females. As observed in numerous studies, these C.V.'s tend to increase with the decrease in size of the character measured. While these postcranial values are higher than the cranial ones, they are still relatively low.

Simpson et al. (1960) and Long (1968, 1969) discuss the use of coefficients of variation to measure individual variation. Simpson et al. (1960) states that such values normally range between 4.00 to 10.00 and gives reasons why values which much exceed these limits denote unsatisfactory measurements. Long (1968) states that cranial C.V.'s for mammals usually range from 2.00 to 8.00 and that

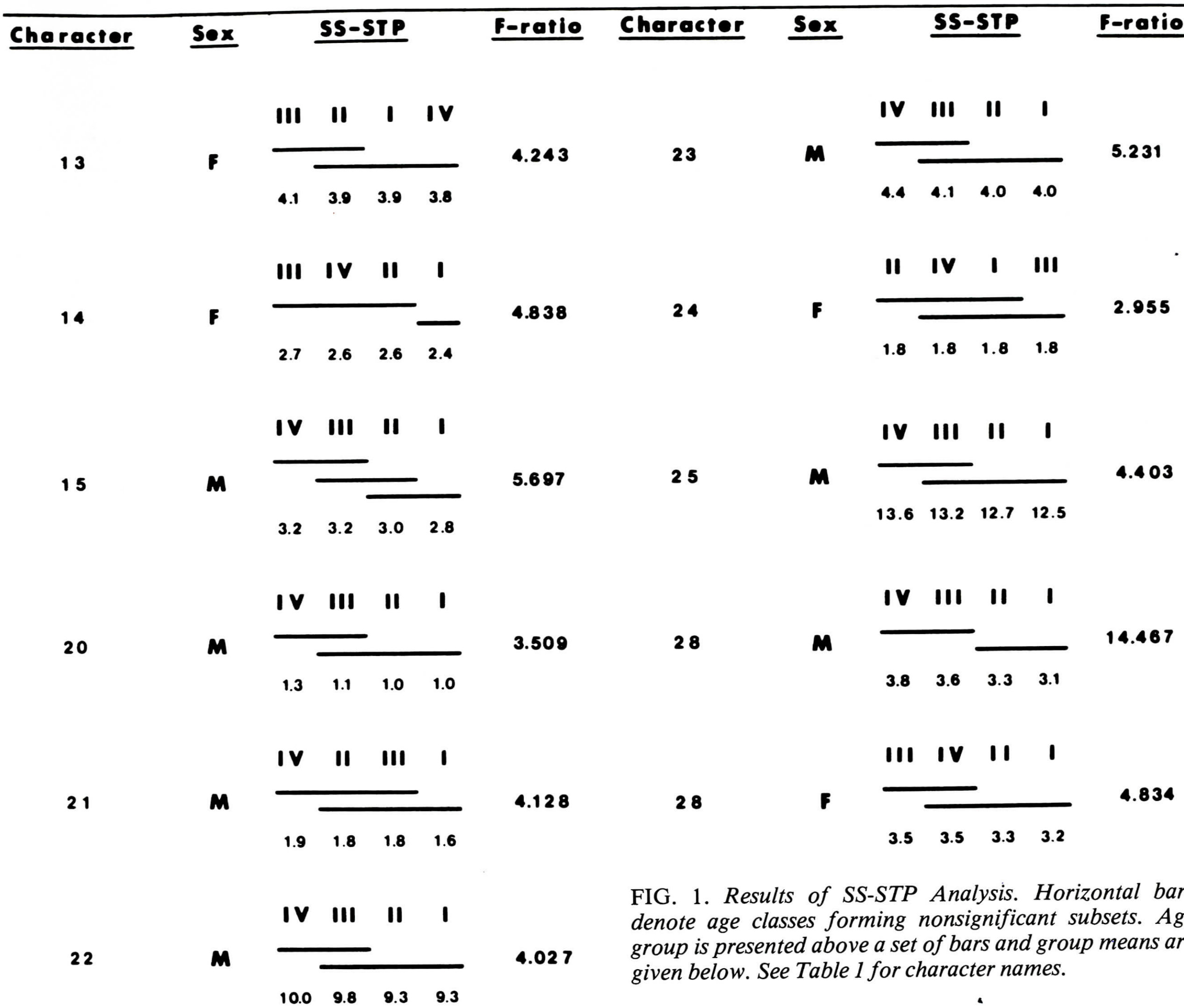

FIG. 1. *Results of SS-STP Analysis. Horizontal bars denote age classes forming nonsignificant subsets. Age group is presented above a set of bars and group means are given below. See Table 1 for character names.*

TABLE 2. *Basic statistics of individual variation and sexual dimorphism examination. C. V. = coefficient of variation. See Table 1 for all other abbreviations.*

CHARACTER	MALE			FEMALE			
	N	Mean ± 2 SE	C.V.	N	Mean ± 2 SE	C.V.	F-ratio
6 Palatal W.	24	3.20 ± .061	4.70	43	3.18 ± .038	3.96	.292
10 Maxillary Arch Spread	23	7.58 ± .101	3.20	42	7.52 ± .067	2.89	1.088
11 Interorbital W.	24	6.95 ± .074	2.61	43	6.93 ± .059	2.81	.295
13 Least Interorbital W.	24	3.92 ± .066	4.12	44	3.93 ± .042	3.54	.055
14 Zygomatic Plate L.	25	2.58 ± .047	4.52	44	2.58 ± .036	4.60	.039
15 Nasal W.	22	3.02 ± .056	4.32	47	2.95 ± .041	4.73	3.866
18 Mandible H.	25	6.22 ± .085	3.43	48	6.05 ± .060	3.43	10.856*
19 Humerus L.	24	9.16 ± .088	2.34	48	9.04 ± .088	3.37	3.117
20 Least Humerus W.	24	1.07 ± .031	7.14	48	1.06 ± .021	7.02	.311
21 G. W. Radius & Ulna	22	1.79 ± .060	7.88	48	1.82 ± .046	8.77	.568
22 G. Scapula L.	22	9.58 ± .174	4.26	46	9.42 ± .124	4.48	2.247
23 Axis H.	23	4.07 ± .055	3.24	45	4.05 ± .055	4.58	.393
25 G. L. Pelvis	23	13.00 ± .178	3.29	44	12.71 ± .155	4.06	5.305*
26 L. Ilium	25	6.56 ± .103	3.93	48	6.43 ± .078	4.22	4.196*
27 Pelvic Foramen L.	25	4.34 ± .087	5.02	43	4.31 ± .073	5.54	.278
29 Femur L.	22	10.13 ± .136	3.15	47	9.97 ± .107	3.68	3.137

insectivore C.V.'s are generally low (Long, 1968; 1969). None of these values in the current study greatly exceed the ranges of these previous works; thereby, these characters are considered to have acceptable amounts of individual variation.

Results of the analyses of sexual dimorphism in cranial characters (Table 2) agree with previous investigations in that most features are larger in males (Guilday, 1957; Dapson, 1968; Ellis et al., 1978; Kirkland, 1978; Kirkland and Hench, 1980) with only mandible height being significantly greater (Choate, 1972). For the nine postcranial characters, males were larger in eight instances, of which, only two characters (25, 26) displayed significant difference (Table 2).

CONCLUSION

Age, individual, and sexual variation in the cranial characters examined agreed with most previous studies. Young adults and adults formed the largest nonsignificant age subset; individual character variation was low; and while males are generally larger than females there is little such statistical difference. Postcranial characters, all previously unreported for *Blarina* sp., exhibit trends similar to the cranial characters. While their individual variation is somewhat higher and they exhibit slightly more age and sexual variation they, nontheless, appear acceptable for use in morphometric investigations.

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OCCURRENCE OF THE ROTIFER *TROCHOSPHAERA SOLSTITIALIS* (THORPE 1893) IN REELFOOT LAKE, TENNESSEE.

JACK D. MCCULLOUGH, TIMOTHY E. VENNEMAN,
AUGUST A. HARTUNG, AND DENNIS M. WEDDING
Stephen F. Austin State University
Nacogdoches, Texas 75962

ABSTRACT

Trochosphaera solstitialis was collected from two sites on eutrophic Reelfoot Lake in western Tennessee, during June, 1982. These collections mark the first report of this rotifer species in Tennessee. Both sites were relatively shallow and were characterized by low dissolved oxygen concentrations, and high values for orthophosphate, ammonium-nitrogen, and apparent color. Large standing crops of aquatic vegetation, much of it decomposing, were found at both sites. Reduced water quality, apparently resulting from decomposing vegetation, probably favored the occurrence of the rotifer species.

INTRODUCTION

Trochosphaera solstitialis is a rotifer (Order Flosculariacea) first reported in China (Thorpe 1893, 1895). It has been reported three times in the United States by Kofoid (1896) in Illinois, Jennings (1898) in Ohio, and McCullough and Lee (1980) in Texas. Other collections include those by Valkanov (1936) in Bulgaria, and Rahm (1956) in Africa. Rousselet (1899) described the anatomy