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By Charles A. Ross
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Scalation of the American Alligator[1]

by

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Abstract

Examination of scalation of American alligators (*Alligator mississippiensis*) from populations in the eastern and western parts of the species range revealed several scale characteristics that varied between populations and significant variation in the number of transverse ventral rows, number of anterior nuchal scales, number of nuchal scales, number of scales in the anterior dorsal scale row, number of scales in the posterior transverse dorsal scale rows, and occurrence of caudal irregularity. Ventral ossification occurs in alligators longer than 165 cm from both the eastern and western parts of the species range. Because of a lack of material from the central part of the alligator's range (Alabama and Mississippi), the nature of this variation cannot be determined.

In the past 5 years more than 8,000 American alligators (*Alligator mississippiensis*) have been transplanted by State, Federal, and private wildlife organizations in the southeastern United States to restock populations depleted by hunting (T. Joanen, personal communication). Neill (1971) suggested that some races of the alligator can be distinguished by juvenile and adult coloration. In 1974, the U.S. Fish and Wildlife Service, Office of Endangered Species, was concerned by the volume of alligator transplant requests, and initiated an investigation of intraspecific variation in the alligator. The present study deals with one aspect of that investigation, scalation.

The extent of intraspecific variation in the Crocodilia has not been adequately studied. Recently, with increased legislative control of crocodilian parts and products, knowledge of intra- and inter-specific variation in the Crocodilia has become important to law enforcement personnel.

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Methods

Alligators from seven States throughout the species range (Fig. 1, Table 1), were caught from the wild; their scalation was examined and they were released unharmed in the vicinity of capture. Permits had been obtained from State and Federal agencies. Alligators were obtained from areas where there had been no official release of non-native alligators. Alligators from known localities held captive at Sea Arama, Galveston County, Texas, and the Savannah River Ecology Laboratory, Aiken County, South Carolina, also were examined. Preserved specimens were examined from the following institutions: California Academy of Sciences; Carnegie Museum; Duke University; Los Angeles County Museum of Natural History; Museum of Comparative Zoology, Harvard University; Museum of Natural History, University of Kansas; Museum of Vertebrate Zoology, Berkeley; North Carolina State Museum; Ohio State University; South Carolina State Museum; Texas Cooperative Wildlife Collection, Texas A & M University; National Museum of National History, Smithsonian Institution; Florida State Museum, University of Florida; and Museum of Southwestern Biology, University of New Mexico.

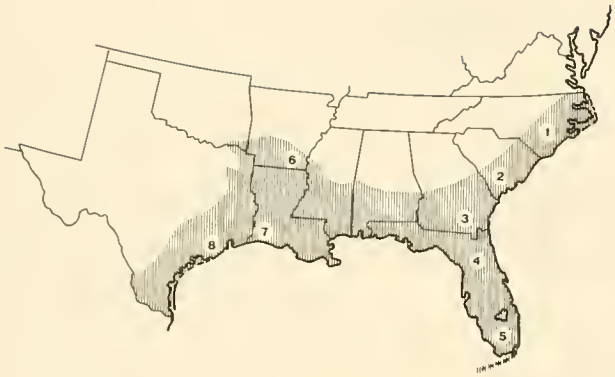

Fig. 1. Species range and sample localities of alligators used in this study. Numbers refer to samples listed in Table 1.

The scale terminology used is that of Deraniyagala (1939), King and Brazaitis (1971), and Ross and Ross (1974). In the examination of scales, we counted the following: post-occipital scales, anterior nuchal scales, nuchal scales, transverse throat scale rows, collar scales (including irregularly placed scales in the median part of the collar), transverse ventral scale rows, double-crested caudal whorls, single-crested caudal whorls (including the tail tip), anterior dorsal scales (a lateral series of enlarged scales in three groups, termed clusters A, B, and C which occur between the nuchal and dorsal body scales), and the contiguous ossified and non-ossified scales which occur in each of the 18 transverse dorsal body scale rows. We also determined the presence or absence of ventral ossification by applying pressure to the lateral margins of the ventral, pectoral, and anterior throat scales, resulting in a smooth or irregular curvature of the scale; an irregular curvature indicated scale ossification. Occurrence of caudal irregularity was noted. All scale counts were made by Ross.

During preliminary analyses, males and females from four localities (northern and southern Florida, Georgia, and Louisiana) were analyzed by sex but no differences in scalation between sexes were observed. Accordingly, the data for males and females are combined.

Continuous variables, other than the number of contiguous scales per transverse dorsal body scale row, were subjected to an analysis of variance (Nie et al. 1975) to determine significance ($P < 0.05$) of interpopulational variation and differences between the eastern and western samples. Central values are expressed as the mean plus or minus the standard error.

We subjected the number of contiguous scales per transverse dorsal body scale row to multivariate stepwise discriminant analysis using programs BMDØ7M (Dixon 1974) and BMDP7M (Dixon 1975). Sample sizes for the discriminant function analyses were as follows: North Carolina, 25; South Carolina, 47; northern Florida, 109; southern Florida, 38; Georgia, 46; Arkansas, 37; western Louisiana, 76; and Texas, 44, for a total of 422 alligators. No a-priori weightings were established, and the prior probability of any given animal having come from a sample was equal. F values were used to determine the magnitude of difference between populations. Although the usual F-test of statistical significance requires certain distributional properties, we make no claims for the significance levels of the reported F's. In this case, "normality" and other requirements are not needed. Since the calculations were derived from comparisons among variables of a similar type, the computed F's should be meaningful and appropriate. Samples were analyzed individually and by combining eastern and western

Table 1. *Localities, geographic grouping, and sample sizes of American alligators examined.*

Sample number	State and county or parish	Number of specimens: Per county or parish	Number of specimens: Per sample	Geographic grouping
1	North Carolina			
	Brunswick	1		
	Carteret	2	25	East
	Craven	16		
	Onslow	6		
2	South Carolina			
	Beaufort	42		
	Charleston	5	48	East
	Horry	1		
3	Georgia			
	Baker	46		
	Tatnall	1	47	East
4	Florida, north			
	Alachua	108		
	Lake	2	110	East
5	Florida, south			
	Dade	24		
	Palm Beach	14	38	East
6	Arkansas			
	Hempstead	37	37	West
7	Louisiana			
	Cameron	87	87	West
8	Texas			
	Colorado	1		
	Galveston	15		
	Jefferson	2		
	Leon	3	44	West
	Matagorda	2		
	Victoria	19		
	Wharton	2		

samples (Table 1) to test Neill's (1971) hypothesis that populations east and west of the Mississippi River drainage are distinct.

Results

The number of transverse throat scale rows varied from 25 to 38 ($\bar{x} = 30.0 \pm 0.09$). Variation between populations was not significant (Fig. 2).

The number of collar scales varied from 8 to 17 ($\bar{x} = 11.9 \pm 0.08$). Irregular scales at the mid-ventral part of the collar occur in some alligators. These scales were counted and the high number of collar scales of some alligators reflects this scale anomaly. No significant interpopulational or geographic variation was observed (Fig. 3).

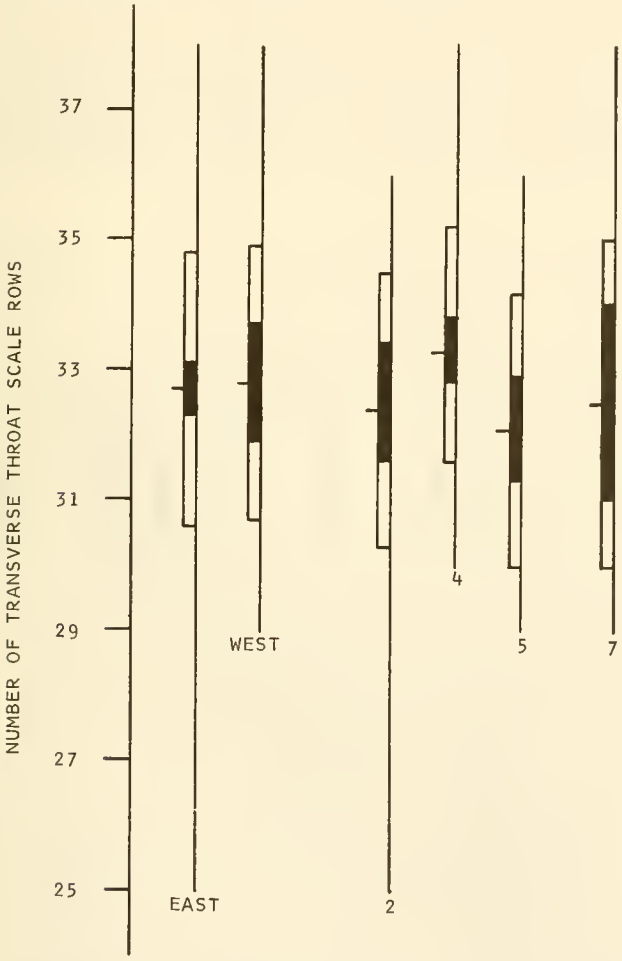

Fig. 2. Mean number of transverse throat scale rows for all samples where N ≥ 12 and the eastern and western groups compared. Numbers at the base of each vertical line represent samples as listed in Table 1. The vertical line represents the range, the rectangle is one standard deviation, the darkened part of the rectangle is the 95% confidence limit, and the horizontal line represents the mean.

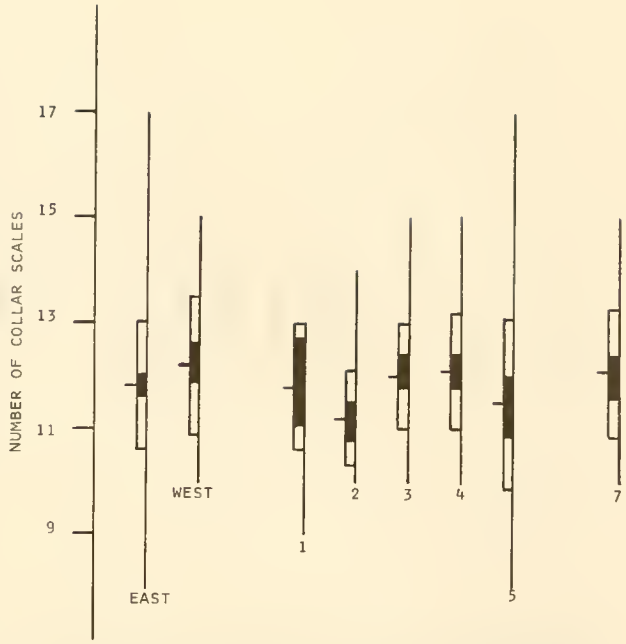

Fig. 3. Mean number of collar scales for all samples where N ≥ 12 and the eastern and western groups compared. Numbers at the base of each vertical line represent samples as listed in Table 1. The vertical line represents the range, the rectangle is one standard deviation, the darkened part of the rectangle is the 95% confidence limit, and the horizontal line represents the mean.

The number of transverse ventral scale rows varied from 25 to 35 ($\bar{x} = 30.0 \pm 0.09$). Although the range of scale rows was large, interpopulational variation in number of transverse rows within eastern and western groups was not significant. However, a significant difference between eastern and western groups was observed; the western group averaged 1.2 transverse ventral scale rows more than the eastern group (Fig. 4).

The presence of ventral ossification (buttons, cornmarkings) has been used to identify the origin of commercial alligator skins (Stevenson 1903; Arthur 1931; King and Brazaitis 1971). According to these authors, large skins with ventral ossification in the pectoral and throat scales were thought to have come from the eastern part of the species range (Florida, Georgia, and South Carolina) since the western skins they examined (Louisiana and Texas) lacked ventral ossification.

We found that no alligators smaller than 165 cm total length (N = 391) had ventral ossification. However, 68% of the alligators examined that were larger than 165 cm (N = 31) had ossification of the posterior throat, lateral collar, and anterior ventral scales. Fifty-three percent of the western sample and 84.5% of the eastern sample of alligators larger than 165 cm total length showed ventral ossification.

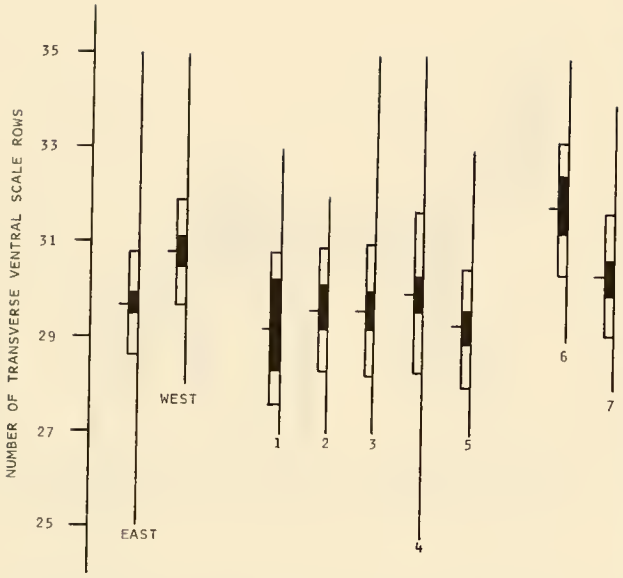

Fig. 4. Mean number of transverse ventral scale rows for all samples where N ≥ 12 and the eastern and western groups compared. Numbers at the base of each vertical line represent samples as listed in Table 1. The vertical line represents the range, the rectangle is one standard deviation, the darkened part of the rectangle is the 95% confidence limit, and the horizontal line represents the mean.

The number of anterior double-crested caudal whorls varied from 14 to 18 ($\bar{x} = 16.1 \pm 0.06$). The observed range within populations was large (Fig. 5). Although the western population averaged a half anterior caudal whorl less than the eastern group, the difference between the two populations was not significant. The number of posterior, single-crested caudal whorls was relatively constant and varied from 19 to 24 ($\bar{x} = 21.9 \pm 0.07$, Fig. 6). No significant interpopulational variation was observed.

Many alligators displayed irregularity of anterior lateral caudal scalation similar to caudal irregularity described in the Central American crocodiles, *Crocodylus acutus* and *C. moreletii* (Ross and Ross 1974). One alligator from the vicinity of Galveston County, Texas, exhibited extensive ventrolateral caudal irregularity. The percentage of alligators with caudal irregularity varied among populations and between the eastern and western groups (Table 2). Caudal irregularity was observed in 40.1% of the eastern alligators and 80.0% of the western alligators. Variation within geographic groupings was observed; caudal irregularity among alligators of the eastern samples varied

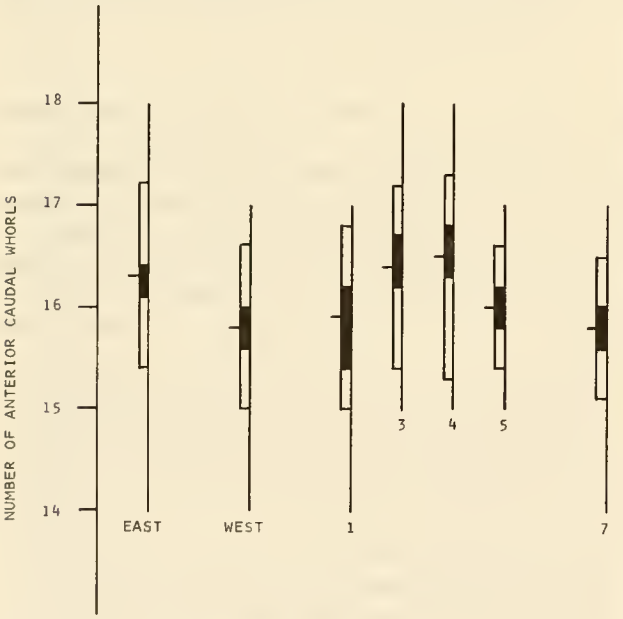

Fig. 5. The mean number of anterior caudal whorls for all samples where N ≥ 12 and the eastern and western groups compared. Numbers at the base of each vertical line represent samples as listed in Table 1. The vertical line represents the range, the rectangle is one standard deviation, the darkened part of the rectangle is the 95% confidence limit, and the horizontal line represents the mean.

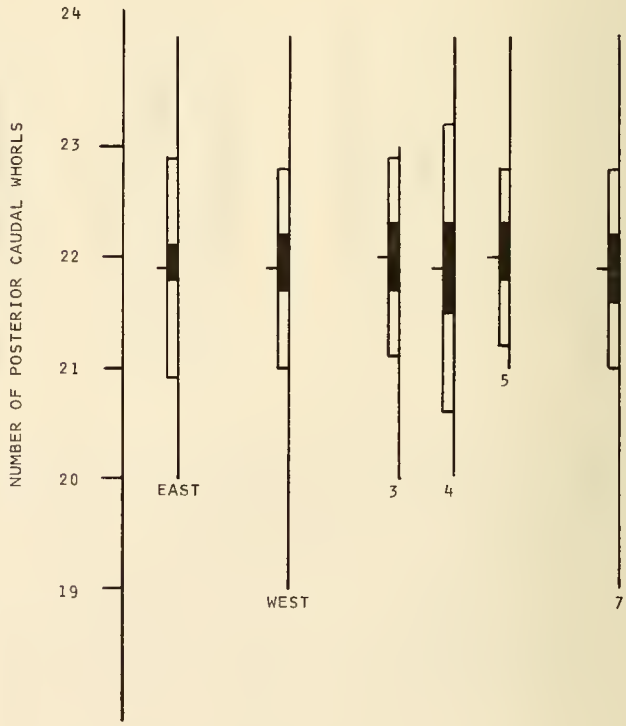

Fig. 6. The mean number of posterior caudal whorls for all samples where N ≥ 12 and the eastern and western groups compared. Numbers at the base of each vertical line represent samples as listed in Table 1. The vertical line represents the range, the rectangle is one standard deviation, the darkened part of the rectangle is the 95% confidence limit, and the horizontal line represents the mean.

Table 2. *Occurrence of caudal irregularities in alligators from eight localities throughout the species range, and both separately and combined for five localities from the eastern part of the species range and three localities from the western part of the range. Sample numbers are as in Table 1.*

Sample	Present	Absent
1	4	21
2	19	18
3	25	20
4	35	69
5	28	38
6	25	12
7	68	16
8	39	5
	Chi-square = 84.3 $P < 0.01$ 7 df	
1	4	21
2	19	18
3	25	20
4	35	69
5	28	38
	Chi-square = 15.9 $P < 0.01$ 4 df	
6	25	12
7	68	16
8	39	5
	Chi-square = 6.0 $P < 0.05$ 2 df	
East	111	166
West	132	33
	Chi-square = 66.6 $P < 0.01$ 1 df	

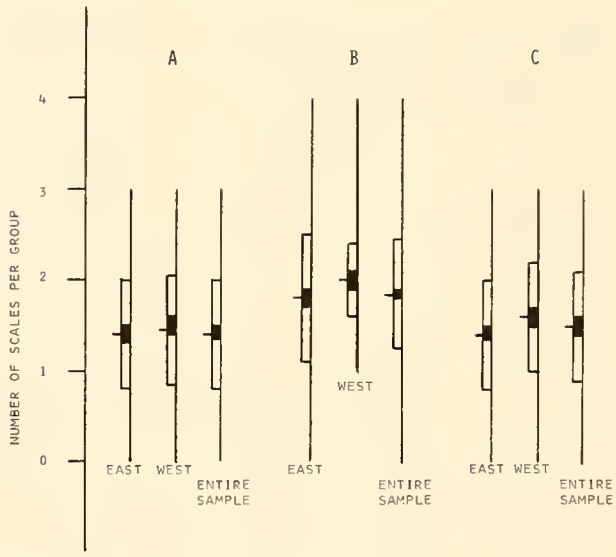

Fig. 7. Mean number of scales in each cluster of the anterior dorsal body scale row for the eastern and western groups, and the entire sample (N = 423). Large letters at the top of each figure refer to cluster designations. Numbers at the base of each vertical line represent samples as listed in Table 1. The vertical line represents the range, the rectangle is one standard deviation, the darkened part of the rectangle is the 95% confidence limit, and the horizontal line represents the mean.

from 16% (North Carolina) to 56% (Georgia), and among western samples from 68% (Arkansas) to 89% (Texas).

The number of post-occipital scales ranged from 1 to 3 ($\bar{x} = 2.0 \pm 0.01$). Variation among and between samples was slight. The number of anterior nuchal scales ranged from 0 to 4 ($\bar{x} = 2.2 \pm 0.06$). Differences between the eastern and western groupings were significant ($P < 0.01$); the western group averaged 0.4 scale more than the eastern group. Variation among samples within geographic groupings was small except that the Georgia sample had an average of 1.7 anterior nuchal scales, whereas the remainder of the eastern sample averaged 0.8 anterior nuchal scale. The mean number of anterior nuchal scales within the western sample ranged from 1.3 to 1.6 ($\bar{x} = 1.5$). The number of nuchal scales ranged from 4 to 8 ($\bar{x} = 6.0 \pm 0.02$). Interpopulational variation was slight. Significant difference between the eastern and western groups was observed even though the western group averaged only 0.6 nuchal scale more than the eastern group. From 0 to 4 scales occur in each of the anterior dorsal scale row clusters. Mean number of scales per cluster ranged from 1.4 to 1.8. The central cluster (B) had more scales than the lateral clusters (A and C). Significant differences in the number of scales in clusters B and C were observed between the eastern and western samples; the western group averaged 0.3 and 0.2 scale more than the eastern group per respective cluster (Fig. 7).

There are 18 transverse dorsal body rows (D1 to D18); D16 is at the level of the hind legs and invariably has 4 scales, as do D17 and D18. D16, D17, and D18 were deleted from analyses as no variation of number of scales in these rows occurs. The minimum number of contiguous scales per transverse row was 3 (western Louisiana, D1, N = 1). The maximum number of contiguous scales per row was 9 (western Louisiana, D8, N = 2; D9 and D10, N = 1; Texas, D5, D6 and D9, N = 1). The mean number of contiguous scales per transverse row ranged from 4.1 (D15) to 7.8 (D6, D7, and D8, Table 3).

Discussion

The number of contiguous ossified and non-ossified scales per transverse dorsal scale row was subjected to stepwise discriminant function analyses. In the first analysis, where the eight samples retained their identities and were considered distinct, the first variable entered was D14 ($F = 29$) which accounted for 20.5% of the total dispersion. The second variable entered was D11 ($F = 18$). The results of this analysis show poor separation between samples. The first two

Table 3. *Mean number of contiguous dorsal scales per body row of alligators from the eastern and western parts of the species range.*

Row (dorsal scale)	Eastern (N = 266) $\bar{X}$	Eastern Standard deviation	Western (N = 157) $\bar{X}$	Western Standard deviation
1	5.6	0.7	5.9	0.4
2	5.3	0.8	5.8	0.5
3	5.4	0.8	5.7	0.7
4	6.4	0.8	6.7	0.8
5	7.3	0.8	7.3	0.7
6	7.6	0.6	7.6	0.7
7	7.6	0.6	7.6	0.7
8	7.6	0.7	7.6	0.7
9	7.4	0.8	7.6	0.7
10	6.9	0.8	7.4	0.8
11	6.3	0.7	6.9	0.8
12	5.8	0.7	6.0	0.5
13	4.8	0.9	5.5	0.7
14	4.1	0.4	4.8	0.9
15	4.0	0.1	4.2	0.5
16	4.0	0.0	4.0	0.0

canonical variables accounted for 33% of the total dispersion and a 42% correct classification of alligators was obtained.

In the second stepwise discriminant function analysis, where samples were pooled according to their geographic locality into eastern and western groups, the first variable entered was D14 (F = 145) and the second was D11 (F = 88). The results of this canonical analysis show better separation of groups (Fig. 8). Although the first two canonical variables account for only 36.8% of the total dispersion, a 77.7% correct classification of alligators into groups was obtained when all 15 transverse dorsal scale rows were entered into the analysis (Table 4).

Table 4. *Posterior classification of alligators from the eastern and western parts of the species range by the number of contiguous scales in the anterior 15 dorsal body scale rows.*

Group	Number (%) of animals classified into group: Eastern	Western
East	232 (87.2)	34 (12.8)
West	50 (31.8)	107 (68.2)

Classification of alligators into groups was based on the relative number of contiguous dorsal body scales per transverse row. Differences between the two geographic groupings resulted in high F values. The number of dorsal scales is not influenced ontogenetically although the size, ossification, and shape of these scales is (C. A. Ross, personal observation). As such the first canonical variable, which accounts for size in most discriminant function analyses, in this instance represents dorsal body scale variation.

The results of the second stepwise discriminant function analysis show that the western group tends to have more contiguous dorsal body scales per transverse row than the eastern group (Table 3). This difference is most marked in the posterior transverse dorsal body scale rows D11, D13, and D14 where the western group averages 0.6 to 0.7 scale more per transverse row than the eastern group. This difference corresponds with the "heavier" neck scalation of the western sample where the mean number of anterior nuchal scales, nuchal scales, and number of scales in the anterior dorsal scale rows are higher than in the eastern group.

The geographic dispersion of localities used in this study is insufficient to define patterns of interpopulational and geographic scale variation throughout this species range. Samples were unavailable from the central part of the species range (Alabama and Mississippi) where alligator populations are depleted and introduction of non-native alligators had occurred before the initiation of this study. Museum specimens from this central range are insufficient to fill this void.

Analyses of the eastern and western samples suggest that interpopulational variation of some scale characteristics is chaotic. However, when samples are pooled into groups representing the eastern and western parts of the species range, significant geographic variation occurs in the number of transverse ventral scale rows, occurrence of caudal irregularity, number of nuchal scales, and the number of scales in the anterior dorsal body scale row clusters B and C. In addition, the number of scales per transverse dorsal body scale row varies geographically.

Because no samples are available from the central part of the species range, it is not known if intergradation is abrupt or if variation is clinal. Neill (1971) assumed that an abrupt zone of intergradation occurred and suggested that there are subspecies of the alligator. From data presented in the present study it is not possible to support or refute that assumption.

Additional work on the intraspecific variation of this species is needed. Analyses of blood parasite and protein variation of alligators are in progress. However, the lack of a sample from the central part of this species range must be rectified before variation in this species can be understood. It is evident that alligator populations exhibit geographic variation and that future alligator transplants should be carefully scrutinized to verify the similarity of the populations involved. The success of these transplants should be monitored.

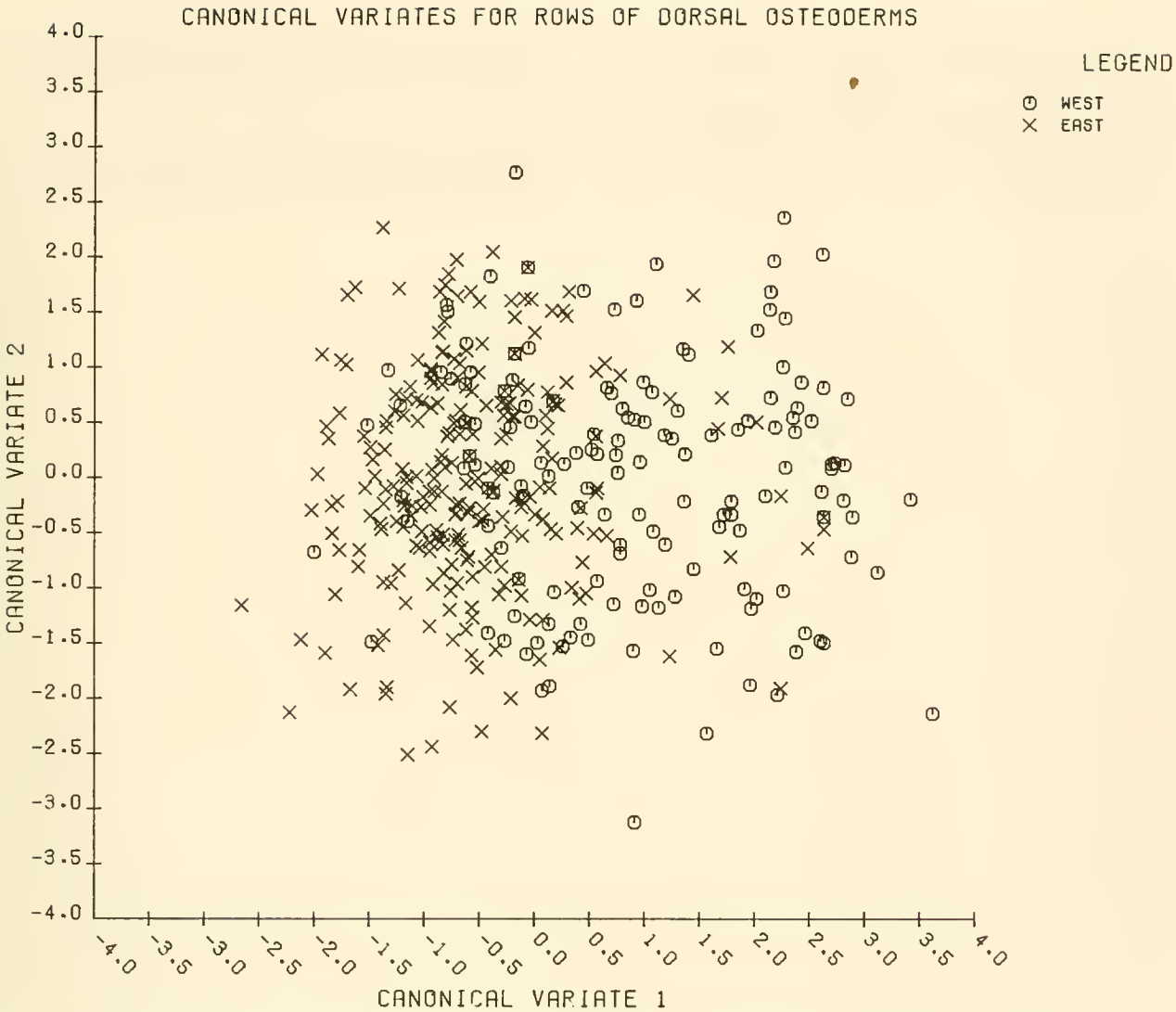

Fig. 8. Plot of canonical analysis of the number of scales in the anterior 15 transverse dorsal body scale rows of American alligators from the eastern and western parts of the species range. ⓘ represents western alligators, × represents eastern alligators.

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