Scute Anomalies of Ornate Box Turtles in Kansas

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Deviations from the normal scute formulae of turtles are thought to result from embryonic mutations, the specific causes of which are unknown. We examined the shells of 127 ornate box turtles (Terrapene ornata) from central and eastern Kansas; 14 (11%) of which had scute anomalies. The frequency of anomalies was greater in central than eastern Kansas. The greater number of scute anomalies in central Kansas may be the result of temperature or moisture stress during egg development or incubation, or the mutagenic effects of excess salinity during those periods.

The number and arrangement of epidermal scutes in turtles are remarkably consistent within major taxa, particularly at the family level (Ernst and Barbour, 1989). Within species, however, individuals may deviate from the normal scute formulae. The cause of additions (= supernumerary scutes) or reductions in the number of scutes remains unclear and efforts to quantify the degree to which anomalies are present in wild populations are rare.

Ancestral turtles had larger numbers of scutes than modern turtles. Gadow (1899, 1905) believed that supernumerary scutes represented instances of orthogenetic variation in which scute anomalies represented recurrences of ancestral turtle traits. Gadow (1905) reported that supernumeraries were more abundant in young turtles. Under the orthogenetic variation hypothesis, extra scutes were thought to be lost through fusion with other scutes, by crowding out other scutes, or by simply dropping off the shell. The concept of orthogenetic variation was rejected eventually (Coker 1905, 1910; Grant 1937). Coker (1910) also was unconvinced that there were age-related differences in the occurrence of anomalies and believed that if such differences were real, they were the result of differential survival between normal and anomalous individuals. Coker (1910) was the first to speculate that scute anomalies were the result of embryonic mutations, an idea that has been supported by others (Frye, 1991; Lynn, 1937; Lynn and Ullrich, 1950).

In 1992 and 1993, we examined 127 live ornate box turtles (Terrapene

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ornata) collected in central and eastern Kansas to determine if scute anomalies were present in the population. Turtles were collected opportunistically along roads and trails with no attempt at randomization or equalizing search effort across central and eastern Kansas. More intensive search effort on the Konza Prairie Biological Station (Riley County) and the Quivera National Wildlife Refuge (Stafford County) resulted in about half of the turtles being collected in those two counties. Fifty-seven of the turtles were females, 43 were males, and the sex of 27 was not determined. Epidermal scutes were counted on each turtle and deviations from the normal complement of 50 scutes (38 on the carapace; 12 on the plastron) were noted. Type of scute in which the anomaly occurred also was noted. All turtles were released at the site of capture after their shells were examined.

Fourteen anomalous turtles were encountered: nine (64%) from the Quivera National Wildlife Refuge in Stafford County (seven females and two males), one female (7%) from Ellsworth County, one female (7%) from Linn County, one male (7%) from Riley County, one female (7%) from Rooks County, and one female (7%) from Shawnee County (Table 1). Eleven (79%) of the 14 anomalous individuals were females. Types of shell anomalies encountered were primarily supernumerary in nature; however, two individuals had reduced marginals (one with 23; one with 22). Eight of the 14 turtles (57%) had extra vertebrals, five (36%) had extra costals, and three (21%) had extra marginals. Marginals did not differ by more than two scutes from the norm, whereas maximum numbers of supernumeraries in the costals and vertebrals were three and four extra scutes, respectively. No turtle was noted with an anomalous plastron. When the two counties with the largest numbers of turtles examined were compared, Riley County had a 4% (N = 25) and Stafford County a 25% (N = 36) incidence of scute anomalies.

Knoll (1935) argued that supernumerary scutes in eastern box turtles (Terrapene carolina) were the result of improper healing after burns from brush fires. The ornate box turtles we examined had supernumerary scutes that appeared to have grown normally when compared to neighboring, typical scutes and numbers of scute annuli from anomalous scutes corresponded well with numbers of annuli from adjacent, normal scutes. Fire damage left a distinctive type of scarring, and physical damage resulting from farm machinery, automobiles, and other equipment also was distinctive. Therefore, we do not believe that the anomalies we observed were the result of injuries. Extreme inbreeding has produced a variety of scute anomalies in a captive population of desert tortoises (Gopherus agassizii) (Frye 1991). However, there is no reason to suspect that inbreeding is occurring in any of the wild turtle populations sampled in Kansas.

Suboptimal moisture during certain stages of egg development and incubation can result in hatchlings with scute anomalies (Lynn and Ullrich, 1950; Frye, 1991). These observations could be useful in explaining the
Table 1. Numbers of ornate box turtles examined by county and sex of individuals with scute anomalies, Kansas 1992–93.

<table>
<thead>
<tr>
<th>County</th>
<th>Turtles examined</th>
<th>Turtles with scute anomalies</th>
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<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
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<tr>
<td>Barton</td>
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* Fifty-seven females, 43 males, and 27 sex not determined.

Anomalies we observed. Riley County generally has deep, loamy soils whereas Stafford County is characterized by sandier soils. Stafford County also experiences lower rainfall (40.5 cm) than Riley County (50.0 cm) during the April–August nesting period of ornate box turtles (Kansas State Board of Agriculture, 1948). Because of lower moisture retention by soils and lower rainfall, it is likely that eggs in turtle nests in Stafford County would be more moisture-stressed than eggs in turtle nests in Riley County. Such dehydration may increase the incidences of scute anomalies (Lynn and Ullrich 1950).

Mean air temperatures vary little between the two counties during the
April-August period of ornate box turtle activity, being 21.5°C for Riley County and 21.9°C for Stafford County. However, during the April-August period, Riley County experiences 50–60 days when temperatures exceed 32°C, whereas Stafford County has 70–80 such days (Kansas State Board of Agriculture, 1948). The greater temperature extremes coupled with soils holding less moisture and supporting sparse vegetation in Stafford County might allow turtle nests to become warmer there than in Riley County. Box turtles exhibit temperature sex determination (TSD) with higher temperatures producing more females (Ewer and Nelson 1991). Therefore, if turtle nests become excessively warm, embryos may develop anomalies (Frye 1991) and survivors are more likely to be females because of TSD. This might partially explain the higher incidence of scute anomalies in females that we noted in the study [11 (19.3%) of 57 known females verses 3 (7.0%) of 43 known males].

Although it is possible that the high proportion of anomalous turtles in Stafford County is the result of egg dehydration or high incubation temperatures, the potential effects of other factors should not be ignored. For example, the effects of salinity on the development of turtle embryos has not been addressed. High levels of scute anomalies have been reported from both the brackish water diamondback terrapin (*Malaclemys terrapin*) and the marine loggerhead turtle (*Caretta caretta*) (Coker 1910). Because the Quivira National Wildlife Refuge (site where most turtles were collected in Stafford County) consists of a series of saline marshes and saline soils, the potential mutagenic effect of salinity on turtle embryos, either directly or indirectly by osmotically dehydrating eggs, is worthy of investigation.

**Acknowledgments**

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**Literature Cited**

Gadow, H. 1899. Orthogenetic variation in the shells of *Chelonia*. Willey Zoological Results, part 3:207–222.