Biologia, Bratislava, **59**/Suppl. 14: 85—88, 2004

Asymmetries and accessory scutes in *Emys orbicularis* from Northwest Spain

César Ayres Fernández & Adolfo Cordero Rivera

Grupo de Ecoloxía Evolutiva, Departamento de Ecoloxía e Bioloxía Animal, Universidade de Vigo, E.U.E.T. Forestal, Campus Universitario, E–36005 Pontevedra, Spain; tel: +34 986 801926, fax: +34 986 801907, e-mail: adolfo.cordero@uvigo.es

Ayres Fernández, C. & Cordero Rivera, A., Asymmetries and accessory scutes in *Emys orbicularis* from Northwest Spain. Biologia, Bratislava, **59/Suppl. 14:** 85—88, 2004; ISSN 0006-3088.

Emys orbicularis is rare in the north of the Iberian peninsula. Since 1996 we have investigated morphology and ecology of turtles from three pond systems in the Louro river basin (Northwest Spain). We found that most individuals (75%; $n = 131$) had accessory and asymmetrically arranged carapacial scutes. In late 2001, we discovered in about 80 km distance from the former site another population with a lower percentage of scute anomalies (40%; $n = 55$). However, also in this population scute anomalies are more frequent than in other parts of the species' range. We discuss three hypotheses to explain this finding.

Key words: *Emys orbicularis*, shell anomalies, asymmetries, Spain.

Introduction

The European pond turtle, *Emys orbicularis* (L., 1758), has a fragmented distribution in the Iberian peninsula. It is still common in the southwest, but restricted to some coastal localities on the Mediterranean coast, and absent from the arid zones of the southeast (Keller & Andreu, 2002). In Galicia (Northwest Spain), only two populations are known, and therefore it is considered as the most endangered reptile species of this region (Galán, 1999).

A previous study (Ayres Fernández & Cordero Rivera, 2001) revealed that Galician *E. orbicularis* differ in several morphological characteristics from southern and eastern Iberian turtles that were described as different subspecies (Fritz, 1993; Fritz et al., 1996). This fact led us to suggest that Galician populations might represent a new, undescribed subspecies (Ayres Fernández & Cordero Rivera, 2000).

During these investigations we realized that most turtles in the Louro river basin have conspicuous carapacial scute anomalies, including accessory scutes and asymmetries. In late 2001, we discovered in approximately 80 km distance another population, exhibiting also scute anomalies. Here we present for both populations a description of these anomalies, and discuss possible explanations.

Methods

We studied 131 turtles (including 21 hatchlings) from the Louro river basin (Pontevedra province, NW Spain; 42°10′ N, 8°37′ W) captured between 1996 and 2003. All individuals except hatchlings were marked using plastic labels attached to their carapace. This population inhabits a series of abandoned clay pits and a large wetland near the Louro river. This area is heavily industrialized (see Fig. 2 in Cordero Rivera & Ayres Fernández, 2004) and polluted (Alvarez-Campana Gallo, 1996; González Rodríguez, 1999).

Table 1. Scute anomalies in Galician *Emys orbicularis*. P: pleural scute; V: vertebral scute; n refers to the number of individuals, but turtles with more than one anomaly are included in several categories. An interior scute is an accessory scute within a regular carapacial scute.

Type of anomaly	Louro river ($n = 131$)	Arnoia river ($n = 55$)
Accessory scute between left P1–V1	14	3
Accessory scute between right P1–V1	15	2
Accessory scute between left and right P1–V1	23	4
Accessory scute between V1–V2	0	1
Accessory scute between V2–V3	1	0
Accessory scute between V3–V4	3	1
Accessory scute between V4–V5	61	9
Vertebral divided	15	1
Interior scute	17	5
Accessory pleural scute	6	4
Lack of one pleural scute	2	0
Accessory gular scute	5	0

A second population in the Arnoia river (Ourense province, NW Spain; 42°13′ N, 7°40′ W) was investigated from 2001 to 2003. This river is in a rural area and, as far as we know, has no sources of pollution. We studied here 55 juvenile and adult turtles, which were marked by marginal notching. All captured animals were measured, photographed and all scute asymmetries and anomalies of carapace and plastron were recorded.

Results

We found that 75% of the individuals in the Louro population ($n = 131$) had conspicuous carapacial scute anomalies, with accessory and asymmetric scutes in most cases. In five individuals was an accessory plastral scute present. Figure 1 illustrates for adults some types of anomalies, which are summarized in Table 1. The most common anomaly was the presence of an extra scute between the 4^{th} and 5^{th} vertebrals. All hatchlings showed accessory scutes ($n = 21$), except one hatchling captured in 2003 (Fig. 2). In the Arnoia population, 40% of the individuals ($n = 55$) had at least one accessory scute.

Discussion

In his review of the turtle shell, Zangerl (1969) found that accessory or asymmetric scutes occur in approximately 15% of individuals of many turtle species. Scute anomalies are rare in *Emys orbicularis* populations (Cherepanov, 1994; Najbar & Maciantowicz, 2000; Mosimann, 2002; Fritz, pers. comm.). Such a conspicuous feature is unlikely to pass unnoticed. The high rate of scute anomalies in Galician terrapins was therefore unexpected.

The observed abnormalities could be due to at least three different causes (not mutually exclusive):

(i) Negative effects of chemicals from the highly industrialized area, where these populations survive. High concentrations of heavy metals (As, Pb) and pesticides (DDT, lindane, B-HCH) have been detected in the area of the Louro river (Alvarez-Campana Gallo, 1996; González Rodríguez, 1999).

(ii) Inbreeding depression, due to small population size, or outbreeding depression, i. e., the contact of genetically very dissimilar genomes. If the Galician populations have differentiated due to a long history of isolation (compare Fritz et al., 1996), then a secondary contact with individuals from other subspecies (e. g. released pets) could result in genetic problems.

(iii) Suboptimal temperature or humidity during incubation (Gardner & Ullrich, 1950; MacCulloch, 1981).

Initially we interpreted the scute anomalies as a consequence of a natural but suboptimal environment. Suboptimal incubation conditions are known to cause such anomalies. This has been shown experimentally in embryos of the painted turtle, *Chrysemys picta* (Schneider, 1783) and of the snapping turtle, *Chelydra serpentina* (L., 1758), which were exposed to suboptimal moisture at various times during their development (Gardner & Ullrich, 1950). Moreover, scute anomalies are more common at the northern edge of the

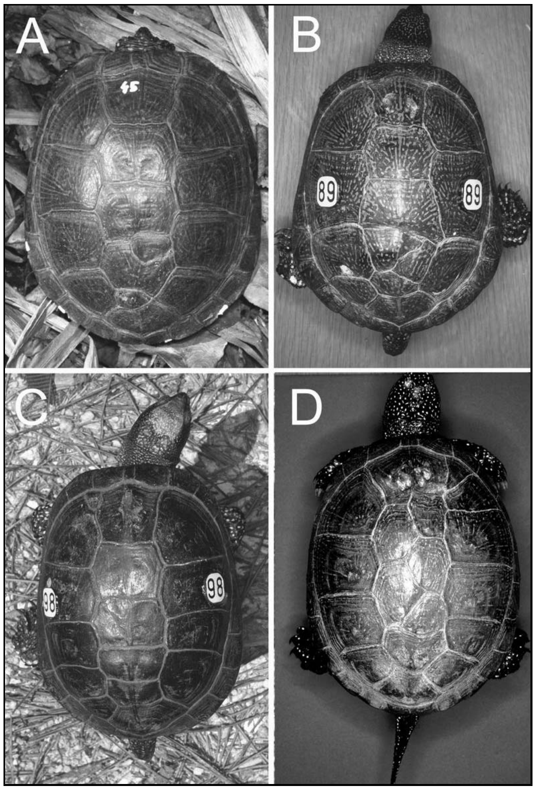

Fig. 1. Galician *Emys orbicularis* with scute anomalies. (A) Female Arnoia 45, with accessory scutes between V3–V4 and V4–V5; (B) male Louro 89, with V4 divided, accessory scute between V4–V5 and three instead of four right pleurals; (C) male Louro 98, with accessory scute between left P1–V1, accessory scute between V4–V5 and accessory pleural scute; (D) female Louro 102, an example of a highly asymmetric turtle with V2 and V3 divided. Abbreviations are explained in Table 1.

range of *Chrysemys picta*. There, this phenomenon is thought to be the result of a suboptimal temperature regime during incubation (MacCulloch, 1981). One particular type of asymmetry, fluctuating asymmetry, has been recognized as an indicator of environmental stress in many kinds of organisms (Palmer & Strobeck, 1986).

Nevertheless, as the Louro basin has an extremely high concentration of pesticides (mainly lindane) and heavy metals (González Rodríguez, 1999), the anomalies might also be caused by pollution. The difference in the rates of scute anomalies between Louro (75% of anomalies) and Arnoia (40%) could be due to the high pollution levels in the first river that are absent from the second. This interpretation is supported by the effects of pesticides (especially polychlorinated hydrocarbons) on abnormal development in eggs of *Chelydra serpentina* in the Great Lakes region (Bishop et al., 1991, 1998).

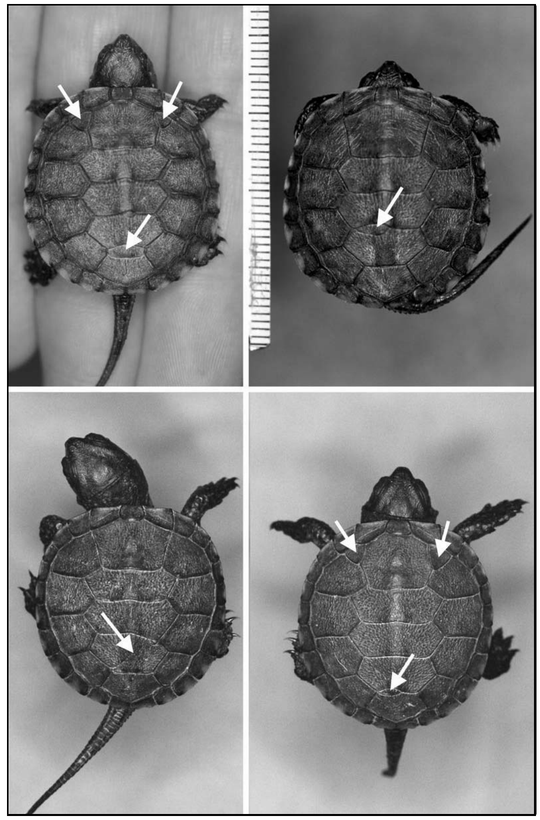

Fig. 2. Four hatchlings with scute anomalies (arrows), Louro river population.

It is obvious that an experimental approach is needed to distinguish between the above hypotheses. Eggs from the Louro population should be incubated under controlled conditions to exclude that these anomalies result from suboptimal temperature or humidity. Unfortunately we were unable to find the nesting sites of this population, and until now this experimental approach could not be undertaken. Preliminary data indicate that scute anomalies are rare in areas of the Iberian peninsula where *E. orbicularis* has higher population densities and more favourable environmental conditions. This fact is in agreement with the idea that incubation conditions might be partially responsible for the anomalies.

Finally, *E. orbicularis* might also suffer from genetic problems associated to inbreeding or outbreeding in Galicia, which might be indicated by abnormal development. In fact, Galician terrapins occur at low density and in small populations, and genetic drift or a negative genetic impact of released allochthonous turtles might be important under these conditions. Again, we need additional studies to test this hypothesis, and we are now establishing a project to compare genetic diversity of Galician populations with other high density, non-threatened populations of the Iberian peninsula.

Acknowledgements

We are grateful to the Dirección Xeral de Medio Ambiente Natural of the Galician Government (Xunta de Galiza) for providing funding and permission to capture and mark the turtles. Part of this work (2001–2003) was funded by a research project to ACR from Xunta de Galiza (PGIDT01MAM37101PR).

References

Alvarez-Campana Gallo, M. 1996. La contaminación de las aguas subterráneas en Galicia. Caso del entorno hidrogeológico del río Louro. Tierra y Tecnología **12**: 57–66.

Ayres Fernández, C. & Cordero Rivera, A. 2000. A new subspecies of *E. orbicularis* in the Iberian peninsula? pp. 20–22. In: Proceedings of the 2^{nd} International Symposium on *Emys orbicularis*, Chelonii **2**.

Ayres Fernández, C. & Cordero Rivera, A. 2001. Sexual dimorphism and morphological differentiation in European pond turtle (*Emys orbicularis*) populations from northwestern Spain. Chelon. Conserv. Biol. **4**: 100–106.

Bishop, C. A., Brooks, R. J., Carey, J. H., Ng, P., Norstrom, R. J. & Lean, D. R. 1991. The case for a cause-effect linkage between environmental contamination and development in eggs of the common snapping turtle (*Chelydra s. serpentina*) from Ontario, Canada. J. Toxicol. Environ. Health. **33**: 521–547.

Bishop, C. A., Ng, P., Pettit, K. E., Kennedy, S. W., Stegeman, J. J., Norstrom, R. J. & Brooks, R. J. 1998. Environmental contamination and developmental abnormalities in eggs and hatchlings of the common snapping turtle (*Chelydra serpentina serpentina*) from the Great Lakes-St. Lawrence river basin (1989–91). Environ. Pollut. **101**: 143–156.

Cherepanov, G. O. 1994. Anomalii kostnogo pantsirya cherepakh [Anomalies of bony carapace in turtles]. Zool. Zhurnal **73**: 68–78.

Cordero Rivera, A. & C. Ayres Fernández. 2004. A management plan for the European pond turtle (*Emys orbicularis*) populations of the Louro river basin (Northwest Spain). Biologia, Bratislava **59**, Suppl. 14: 161–171.

Fritz, U. 1993. Zur innerartlichen Variabilität von *Emys orbicularis* (Linnaeus, 1758) 3. Zwei neue Unterarten von der Iberischen Halbinsel und aus Nordafrika, *Emys orbicularis fritzjuergenobsti* subsp. nov. und *E. o. occidentalis* subsp. nov. Zool. Abh. Mus. Tierkd. Dresden **47**: 131–153.

Fritz, U., Keller, C. & Budde, M. 1996. Eine neue Unterart der Europäischen Sumpfschildkröte aus Südwestspanien, *Emys orbicularis hispanica* subsp. nov. Salamandra **32**: 129–152.

Galán, P. 1999. Conservación de la Herpetofauna Gallega. Universidade da Coruña, A Coruña, 286 pp.

Gardner, L. W. & Ullrich, M. 1950. Experimental production of shell abnormalities in turtles. Copeia **1950**: 253–262.

González Rodríguez, M. O. 1999. Informe-resumen de los trabajos realizados con relación a la investigación de detalle de la contaminación por HCH en el entorno del polígono de Torneiros –O Porriño– (Pontevedra). Unpublished report available at www.xunta.es/conselle/cma/CMA04d/CMA04dh/p04dh03b.pdf

Keller, C. & Andreu, A. C. 2002. *Emys orbicularis* (Linnaeus, 1758). Galápago europeo, pp. 181–186. In: Atlas y Libro Rojo de los Anfibios y Reptiles de España, Organismo Autónomo Parques Nacionales, Madrid.

MacCulloch, R. D. 1981. Variation in the shell of *Chrysemys picta bellii* from southern Saskatchewan. J. Herpetol. **15**: 181–185.

Mosimann, D. 2002. Situation einer Population von Europäischen Sumpfschildkröten, *Emys orbicularis* (Linnaeus 1758), 50 Jahre nach der ersten Ansiedlung in Moulin-de-Vert (Genf, Schweiz). Testudo **11** (4): 25–39.

Najbar, B. & Maciantowicz, M. 2000. Deformations and damage to carapaces of the European Pond Turtle – *Emys orbicularis* (L.) in Western Poland, pp. 88–94. In: Proceedings of the 2^{nd} International Symposium on *Emys orbicularis*, Chelonii **2**.

Palmer, A. R. & Strobeck, C. 1986. Fluctuating asymmetry: measurement, analysis, patterns. Annu. Rev. Ecol. Syst. **17**: 391–421.

Zangerl, R. 1969. The turtle shell, pp. 311–339. In: Gans, C., Bellairs, A. D. & Parsons, T. S. (eds) Biology of the Reptilia. Vol. 1, Morphology A, Academic Press, London.