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Two extreme cases of regeneration in *Testudo graeca ibera* Pallas, 1814

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Abstract. It is generally considered that terrestrial chelonians often cope surprisingly well with carapace trauma and it is common to encounter animals with chronic healed shell deformities resulting from previous traumatic episodes. Terrestrial chelonians may incur traumatic shell injuries as a result of being run over by cars or lawnmowers, burned as consequence of wrong pasture management, or gnawed by predators, or they may merely have suffered a significant fall. Here I present the description of two extreme cases of regeneration in *Testudo graeca ibera* in nature. In one case the tortoise survived an injury that covered more than 50 % of the carapace. The possible causes of injuries are also listed.

Keywords: *Testudo graeca ibera*, extreme injuries, clinical description, regeneration, Romania.

The spur-thighed tortoise, *Testudo graeca* Linnaeus, 1758, has a broad, but patchy distribution range on three continents; it can be found in northern Africa, in the Middle East, in south-eastern Europe and Asia (e.g. Kuyl et al. 2005, Fritz et al. 2007). According to the IUCN classification the species is considered to be Vulnerable in all of its distribution ranges (Cox &Temple 2009, Baillie et al. 2004), the Washington Convention has listed it as globally threatened (Annex II), it is vulnerable according to CITES and it is included in the EU Wildlife Trade Regulation (3626/82, Annex C1, Appendix II; Cogălniceanu et al. 2010). The species is mostly threatened by habitat destruction and fragmentation with its specific threats, and partially by over-collecting for the pet trade and regionally for food consumption (Lambert 1979, Pérez et al. 2004, Anadon et al. 2007, Türkozan et al. 2008, Ljubisavljevic et al. 2011).

In Romania, the subspecies *T. g. ibera* Pallas, 1814, occurs only in Dobrudja region (Fuhn & Vancea 1961). Here is mostly connected to the sylvo-steppic areas of Dobrudja, being a representative species of this ecosystem. Rarely, it can appear in open lands, with grassy vegetation or at the limit of some agricultural fields (Covaciu-Marcov et al. 2006). According to the present pattern of its distribution, the tortoise is restricted to the available habitats. Its habitats have been fragmented in the past – and the process continues also today – under the pressure of agricultural land use and infrastructure development. The tortoises from marginal areas and which cross the unfavorable landscapes are frequently victims of traffic and agricultural or mining activities. It is not uncommon to find dead tortoises with broken shells and surviving tortoises with less extensive injuries. Tortoises are injured and road-killed by traffic, thus the road network is a significant threat, with many cases of traffic accidents being recorded (Rozylowicz & Dobre 2010, pers. obs.). Injuries are common occurrences in tortoise populations near farming communities, where the tortoises are injured by agricultural machinery (Soler et al. 2009). Bayley & Highfield (1996) reported that change from traditional to mechanized ploughing techniques in Morocco threaten aestivating Mediterranean spur-thighed tortoises. Hailey (2000) calculated that the Hermann's tortoise (*T. hermanni*) mortality resulting from ploughing and bulldozing was approximately 50% in affected areas in northern Greece. Some tortoises may have sustained damage by falling off the drystone walls that were to be found in the scrub, as in case of *T. hermanni* (Meek & Inskeep 1981). Similar high walls could be the result of mining activities, another of its side effects (Sos 2005). In mining areas the main threat is the high traffic level of heavy vehicles which transport rocks from the quarries and kill, cripple or crash the turtle carapace (e.g. Andrei 2002). Another threat is the common practice of burning large expanses of land to create pastures for sheep or cattle, which cause death or various carapace and extremities burns (Soler et al. 2009, Hailey 2000). In several cases people deliberately kill or wound individuals, as reported by Fuhn (1964) in the Hagieni forest, where tortoises were struck by axes for unknown reason. I have no knowledge about a study about the correlation between the presence of damaged shells and actual mortality rates in this species for moment.

The injured specimens sometimes survive and recover from incredible wounds. Here I present two cases of extreme regeneration of *T. g. ibera* in nature (Fig. 1, at left). The observed tortoises were captured only to take pictures for documentation and were released at the original site. The first example was encountered on 21.08.2007 in the Măcin Mountains area, near Măcin, Brăila county. The age of the turtle was estimated to slightly more than 10 years based on the visible growth rings (see Wilson et al. 2003), although according to Bertolero et al. (2005) this method gives an underestimate of age for older tortoises. The tortoise displayed a well-healed lesion on the right side of the carapace. The carapace was missing two marginal scutes and most of the fourth pleural and corresponding bone elements, thus the skin of the hind limb was visible up to the connection with the carapace. A distinct fissure started from the marginal area of the carapace to the last vertebral and marginal scutes and another across the fourth marginal. Other major injuries where visible on the second and third vertebrals. A similar wounded tortoise was reported by Andrei (2002; Figs 4.b and 6.b) from Canaraua Fetii, Tulcea County. There the carapace showed two similar injuries on both sides. The explanation given by the author was that the tortoise was in collision with a heavy vehicle. The lesions could have resulted from heavy wheel pressure on the posterior part of carapace, which separated the carapace in two in the case reported by Andrei (2002), and only into one section in the case reported here.

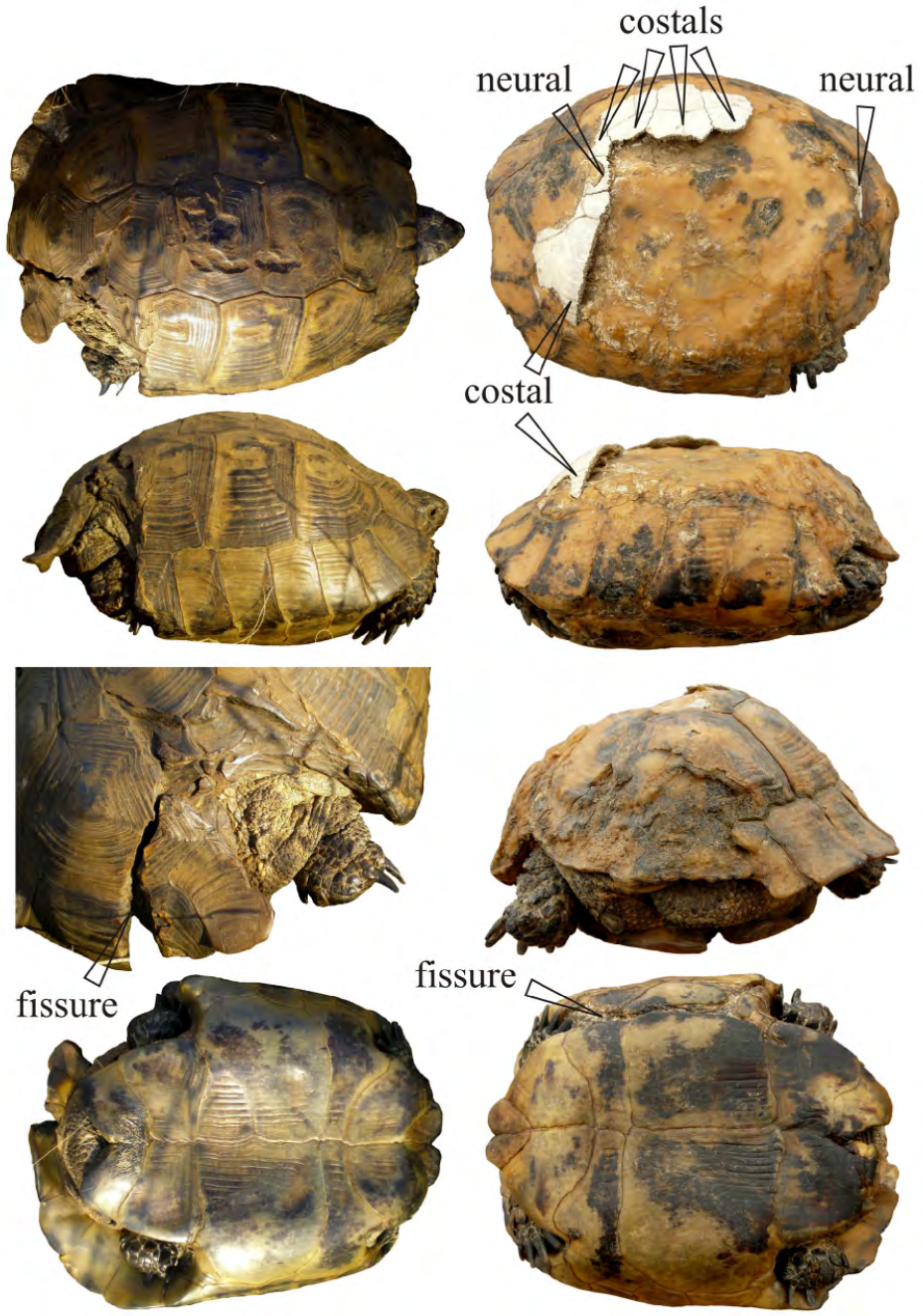

Figure 1. The two cases of *T. g. ibera* examined: at left the specimen encountered in Măcin Mountains, at right the tortoise from Enisala locality (Tulcea).

The second example showed an incredible recovery (Fig. 2, at right). This specimen was found in the vicinity of Enisala, Tulcea county, on 20.09.2010 in visible healthy condition without sign of discomfort during movement. Similarly, the age of the turtle was estimated to more than 10 years according to counting the visible growth rings. The tortoise lacked all the vertebral scutes but the last, which was partially damaged. The nuchal bone seemed to be missing at least the posterior part. The remains of the first and seventh neural bone were freely exposed, while the rest were missing. The first three pleural scutes from the left were missing their posterior part, where the first four right costal bones were exposed. The superior part of the fifth costal bone was missing and the succeeding costal bones were damaged at the apices except the last one. A separate wound was visible at the base of first and second pleurals, which also affected two marginal scutes and certainly the connected bone elements too. At the left side all the pleural scutes were missing. The almost intact first costal bone was again freely exposed. The forthcoming costal bones seemed also to be missing but the elevated part of the posterior indicates that the presence of costal bone remains is possible – a supposition which could be proved by radiography, a method unavailable in the field. The supracaudal scute and the corresponding pygal bone and the last fourth marginal scutes and corresponding peripheral bones were partly missing and viciously recovered, thus the left posterior limb was mostly uncovered and unprotected. The anterior left

Figure 2.. General aspect of Măcin Mountains in the vicinity of Măcin (**a**); Habitat of *T. g. ibera* in base of Enisala fortress; (**b**). The second specimen found one day later (21.09.2010.) after the first observation, resting in a natural rocky crevice (**c**).

marginal scutes presented their own injuries too. The injuries were not limited only to the carapace. A fissure that crossed the marginal parts of the left axilar, pectoral, abdominal and inguinal scutes, thus the connected hyo- and hypoplastron, similarly affected also the cranial and caudal bridge, consequently the connection of the carapace to the plastron was compromised. The two xiphoplastra also suffered injuries in the posterior parts, where the anal plates suffered the highest deformities. The spinal cord lies superficially below the carapace in a rudimentary protective bony structure created by the vertebra and connected to the carapace by dorsal spinal processes (McArthur & Hernandez-Divers 2004), however the injuries did not damaged the vertebral column. The positions of dorsal spinal processes partially could be located in the first picture from column two (Fig. 1). Logically the injuries exposed the internal organs of the tortoises over a huge area of the carapace, where the bony elements were totally missing. This kind of damage could be attributed to agricultural machinery (Soler et al. 2009). A rotary disc mower with blades bolted to each of a series of discs that rotate at high speeds could be the source of such inuries. In North America, Saumure et al. (2007) reported that angled blades, absence of blade guards, and high field and blade speeds in disc mowers resulted in extensive trauma and death of high number of adult wood turtles, *Glyptemys insculpta*. One might also add the possibility of deliberate and intentional harm to the tortoises, driven by malicious human intent.

The tortoise shell is an example of dermal ossification, where the thoracic and lumbar ribs also join the structure of the shell (McArthur et al. 2004). The shell is covered with epidermal tissue in the form of the keratinised plates known as scutes. In chelonians part of the damaged shell can be repaired and new osteoderms (dermal bones) are formed beneath the horny scutes (Bellairs & Bryant 1985). The healing process could take over a year, depending on the extent of injury, and the recovered area of the shell could be covered with atypical scales. Veterinary professionals often deal with traumatized tortoises (McArthur et al. 2004). It is generally considered that terrestrial chelonians often cope surprisingly well with carapace trauma. Because they lack a muscular diaphragm and depend instead on limb movements, which alter the carapacial volume and tensions the septum horizontale, chelonian breathing can normally continue despite extensive compromise of the carapace (McArthur & Hernandez-Divers 2004). Osteomyelitis is a common sequel to untreated shell injuries. Animals experiencing dorsal carapacial trauma may also develop a spinal neuropathy because of associated spinal-cord trauma. Compromise of the dorsal carapacial vault predisposes the underlaying lung and nerve tissue to contamination, inflammation and infection. Ultimately fibrosis, scar tissue and respiratory compromise are listed as consequences. It is likely to take several months for a non-surgically-created wound to become stable. After one to two weeks post-trauma the fibrous tissue can start growing, and after six weeks a substantial layer of fibrous tissue may cover the trauma site, as listed in the cases presented by McArthur & Hernandez-Divers (2004). New bones generally bridge shell defects after one to two years.

In the light of the complications described above which can develop after an injury to a tortoise and the length of the healing period of an open carapace wound, the survival and recovery of tortoises with such extensive lesions as in the second case is surprising. The self-defense in these cases could only be limited to retreating into shelter where the tortoise is physically defended by its environment. In both cases such an environment is provided by the rocky Măcin Mountains (Strugariu et al. 2008, Gavrilă et al. 2011) and the hill-side of Enisala Fortress (Fig. 2). Only a tortoise retreating into a rocky crevice with the preferred or appropriate thermal environment could survive with such remarkably grave injuries (Fig. 2.c). Inadequate provision of temperature will delay wound healing and compromise the immune response (Bradshaw, 1997). The presence of the right dietary plants close to the entrance in case of starvation or thirst can probably substantially raise the tortoise's survival chance.

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