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Accessory scutes and asymmetries in European pond turtle, *Emys orbicularis* (Linnaeus, 1758) and Balkan terrapin, *Mauremys rivulata* (Valenciennes, 1833) from Vlora Bay, western Albania

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Abstract
This study aims to provide the first information about scute anomalies occurring in the population of *Emys orbicularis* and *Mauremys rivulata* in the understudied area of Vlora Bay, Albania. Two main different habitats, freshwater channels and ponds were monitored from March 2013 to October 2015. A total of 143 individuals of *E. orbicularis* and 46 individuals of *M. rivulata* were captured and checked for the presence of scute anomalies. We found that 3.5% of the captured individuals of *E. orbicularis* and 13.0% of *M. rivulata* had conspicuous carapacial scute anomalies. The most common anomaly in both populations of *E. orbicularis* and *M. rivulat*a was the accessory scutes (between vertebrals, between one costal and one vertebral, etc.) present in 36.3% of individuals. It was observed that 80% of anomalous individuals of *E. orbicularis* had more than one scute anomaly, while all anomalous individuals of *M. rivuata* had only one anomaly. Different hypotheses are discussed to explain this findings.

Keywords: *anomaly, accessory scutes, Emys orbicularis, Mauremys rivulata*, population

Introduction
European pond turtle *Emys orbicularis* (L., 1758) of the family Emydidae and Balkan Terrapin *Mauremys rivulata* (Valenciennes, 1883) from the family Geoemydidae are two of the hard-shelled freshwater turtles inhabiting in Albania. Although *E. orbicularis* spreads over all regions of Albania except of northeastern and eastern part of Albania, *M. rivulata* inhabits permanent water bodies limited only to the western lowlands, from the Shkodra field in the north to the Saranda field in the south (Fig. 1a,1b) (Haxhiu, 1998; Haxhiu and Buskirk, 2009) [21, 23]. While *E. orbicularis* is listed as "Near Threatened" (NT) (Tortoise, Freshwater Turtle Specialist Group, 1996) [43], there is no information about *M. rivulata*. However, these two turtle species are listed on Appendix II of the Bern Convention and it was stipulated that they should be completely protected. Regionally, *M. rivulata* is listed as Least Concern (LC) (van Dijk *et al*, 2004) [45] in view of its wide distribution, tolerance for habitat modification to a degree, while in Albania it is listed as vulnerable (VU), because of a continuous decline in suitable wetland habitats (Red List of Albanian Fauna, 2013) [33].
Although there is a number of ecological studies about *M. rivulata* and *E. orbicularis* in many parts of their range (Auer and Taskavak, 2004; Cadi and Joly, 2003; Chelazzi *et al*., 2007; Ficetola *et al*., 2004; Ficetola and Bernardi, 2006; Gasith and Sidis, 1983; Güçlü and Türkozan, 2010; Kaviani and Rahimibashar, 2015; Lebboroni and Chelazzi, 1991; Mitrus, 2005, 2006; Rifai and Amr, 2004; Rovero & Chelazzi, 1996; Sidis and Gasith, 1985; Vamberger and Kos, 2011; Velo-Anton *et al*., 2015, Wischuf and Busack, 2001; Zuffi, 2000; Zuffi *et al*., 2007; Zuffi and Foschi, 2015) [1, 5, 8, 11, 12, 14, 16, 24, 25, 28, 29, 34, 36, 41, 44, 46-50], studies which were carried out in Albania are very scarce, consisting of sporadic surveys or accidental observations, mainly concerning its distribution (Haxhiu 1981, 1985, 1995, 1997, 1998; Haxhiu and Buskirk, 2000, 2009) [17-23]. Recently, there has been much more interest in the population structure of these two freshwater turtle species in Albania (Saçdanaku and Haxhiu, 2015a, 2015b) [39-40].
In recent years there has been a growing interest in phenotypic plasticity and its relation to fitness (Pigliucci, 2001) [38]. It is generally assumed that when organisms are under suboptimal conditions they might develop abnormally, because their buffer ability might be exceeded (Cordero Rivera *et al*., 2008) [7]. Scute anomalies are more frequent in the carapace than in the plastron of the turtles (asymmetries, accessory scutes, etc.) (Zangerl, 1969) [51].

Since, this is a rare phenomenon, the studies are limited and belongs mostly to the *E. orbicularis* (Ayres Fernandez and Cordero Rivera, 2001, 2004, Balázs and Györffy, 2006; Cordero Rivera *et al*., 2008; Cherepanov, 1994; Drobenkov, 2005; Mosimann, 2002; Najbar and Maciantowicz, 2000; Najbar and Szuszkiewicz, 2005; Rollinat, 1934; Schneeweiss and Beckmann, 2005) [2-4, 7, 9-10, 30-32, 35, 42]. Zangerl (1969) [51]. Observed that a particular set of some scute abnormalities appear to be genetic; others result from accidents, injury, or other trauma during the embryonic stage.

We present here, for the first time in Albania a description of these anomalies in both populations of *E. orbicularis* and *M. rivulata* and discuss possible explanations.

Material and Methods

The study was carried out between March 2013 and October 2015. The study site consists of a small pond covered with dense vegetation with an area of about 0.5 ha in Narta Lagoon, Vlora Bay, called Zvernec pond, a wide area of the Orikumi wetland and some freshwater channels (Fig. 1c, Tab. 1).

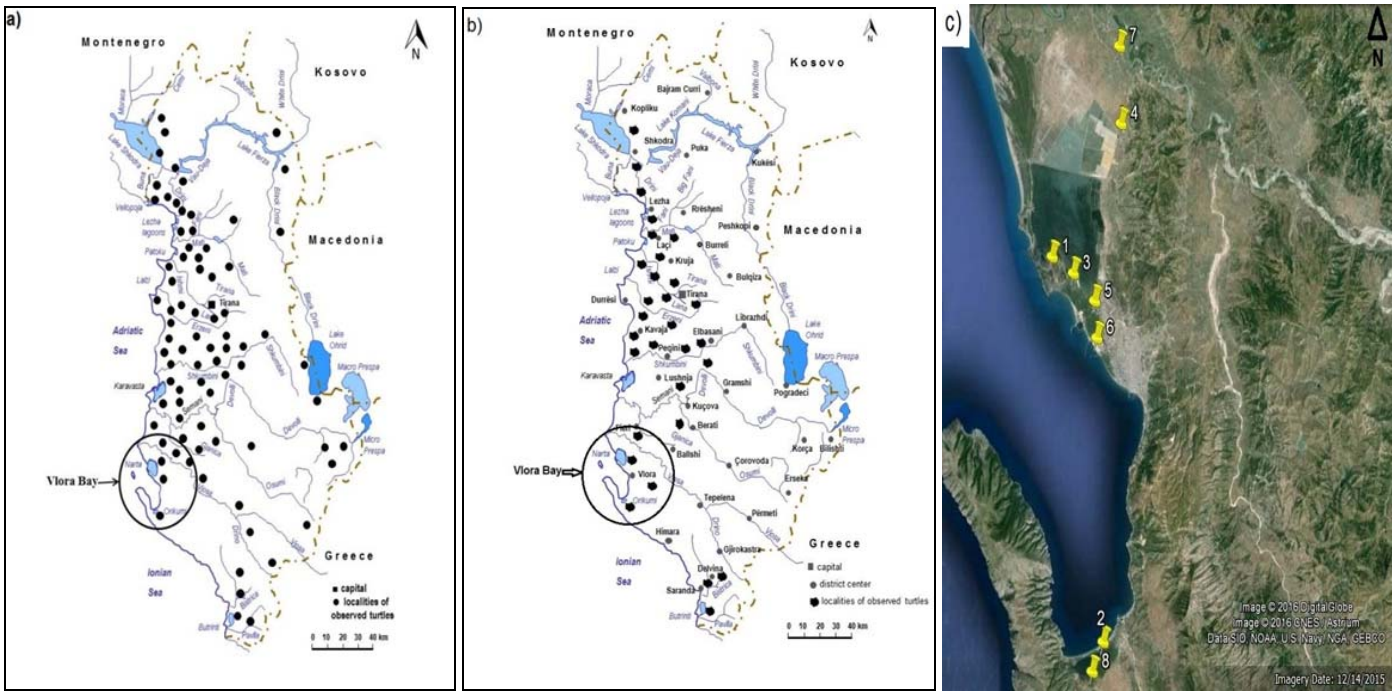

Fig. 1: (a) Distribution of the European Pond Turtle in Albania (Haxhiu, 1998) [21]. (b) Distribution of the Balkan Terrapin in Albania (Haxhiu, 1998) [21]. (Maps adapted by E. Saçdanaku, taken from Miho *et al*., 2005) [27]. c) Locations (1 – 8) where survey was conducted.

Table 1: A list of visited locations with coordinates (in WGS84 coordinate system) in the Vlora Bay area.

Locations	Coordinates (N)	Coordinates (E)
1. Zvernec pond	40°30'42.06"	19°24'23.46"
2. Orikumi pond	40°19'19.38"	19°27'14.10"
3. Near Zvernec village channel	40°30'12.72"	19°25'34.80"
4. Panaja channel	40°34'37.56"	19°28'15.18"
5. Kavalona Park channel	40°29'23.58"	19°26'46.26"
6. Soda forest channel	40°28'18.18"	19°26'53.52"
7. Novosel – Akerni channel	40°36'54.84"	19°28'9.84"
8. Marmiroi church channel	40°18'27.54"	19°26'37.80"

Dominant plants in the ponds and channels include *Phragmites australis, Typha angustifolia, Juncus sp., Carex sp.*, *Potamogeton sp.,* while the dominant algae species was *Chara sp.*, and other green algae. Turtles were observed by binoculars or free watching, and caught by hand using a simple hand net. Each captured turtle was individually marked by notching its marginal scutes (Cagle, 1939; Gibbons, 1990) [6, 15], measured with a caliper to the nearest 1.0 mm, photographed and released at the capture site. The carapace and plastron scutes were counted and observed for any possible anomalies. We considered as anomalous any individual showing at least one accessory scute on the carapace or plastron, the lack of at least one scute, asymmetries of pairs scutes and any possible deformation of carapace (Cordero Rivera *et al*., 2008) [7]. The normal configuration for carapace scutes in *E. orbicularis* and *M. rivulata* is the same. They have five vertebral scutes, four pairs of costals, a single small nuchal scute, 12 small marginal or peripheral scutes each side (22 marginal scutes) (Zangerl, 1969) [51]. The plastron also shows a remarkable lack of diversity, with six pairs of scutes (the gulars, humerals, pectorals, abdominals, femorals, and anals) being the norm for the vast majority of chelonian species (Zangerl, 1969) [51].

Results

We studied 189 turtles (143 *E. orbicularis* and 46 *M. rivulata*) from Vlora Bay area in eight different habitats (lentic and lotic habitats) (Fig. 1b) captured between March 2013 and October 2015. We found that 3.5% of the individuals of *E. orbicularis* (n = 143) and 13.0% of the individuals of *M. rivulata* (n = 46) had conspicuous carapacial scute anomalies with accessory scutes in most cases (75% of all anomlies observed). Table 2 summarizes the proportion of anomalous turtles (*E. orbicularis* and *M. rivulata*) captured in different habitats of the Vlora Bay area.

Table 2: Number of individuals of *E. orbicularis* and *M. rivulata* with carapace scute anomalies captured at each visited locations in Vlora Bay, Albania.

Habitat type	Location	No. of captured individuals		No. of individuals with scute anomalies	
		E. orbicularis	***M. rivulata***	***E. orbicularis***	***M. rivulata***
Freshwater ponds with dense vegetation dominated by *Ph. australis.*	1. Zvernec	87	1	3	0
	2. Orikum	1	2	0	0
Freshwater channels with vegetation dominated by *Ph. australis*, *Juncus sp*., *Tamarix sp*., ect.	3. Near Zvernec village	2	0	0	0
	4. Panaja	46	38	1	4
	5. Kavalona Park	0	2	0	2
	6. Soda Forest	0	3	0	0
	7. Novosel - Akerni	3	0	1	0
	8. Marmiroi church	4	0	0	0
Total		143	46	5	6

Table 3 and 4 shows the number of animals with each anomaly respectively for *E. orbicularis and M. rivulata*. The most common anomaly was an accessory scute between vertebrals 4th and 5th, present in 36.3% of individuals in both populations of *E. orbicularis* and *M. rivulata*, followed in the same proportion by: accessory scutes between left and right 1st costal and 1st vertebral (18.2%); right and left 4th costal and 5th vertebral (18.2%); accessory scutes in left and right marginals (ML13; MR13) (18.2%) and asymmetri of marginal scutes (18.2%).

We found that in *M. rivulata* population the percentage of individuals with scute anomalies was higher (13%) with only one scute anomaly observed for each anomalous individual, while in *E. orbicularis* population the percentage of individuals with scute anomalies was lower (3.5%), and it was observed that 80% of anomalous individuals had more than one scute anomaly. We did not find any plastral anomaly in the population of *E. orbicularis* and *M. rivulata.*

Table 3: Scute anomalies in *E. orbicularis* from Vlora Bay area, Albania. V: vertebral scute; CL: left costal scute; CR: right costal scute; ML: left marginal scute; MR: right marginal scute.

Individuals with observed anomalies	Date of capture	Type of anomaly
Male (♂)	06/05/2015	1. Nucal scute split in two. 2. Asymetri of marginal scutes with an extra scute on the left marginal (13ML; 12 MR).
Female (♀)	11/05/2015	1. Accessory scute between V4–V5 2. Accessory scute between CL4-V5.
Female (♀)	31/05/2015	1. Accessory scute between V1–CL1 2. Accessory scute between V1–CR1 3. Accessory scutes in left and right marginals (ML13; MR13).
Juvenile (2-3 years old)	11/10/2014	1. Asymmetri of marginal scutes with a lack of one right marginal scute (12ML; 11MR)
Male (♂)	14/06/2014	1. Accessory scute between V1–CL1 2. Accessory scute between V1–CR1

Table 4: Scute anomalies in *M. rivulata* from Vlora Bay area, Albania. V: vertebral scute; CL: left costal scute; CR: right costal scute; ML: left marginal scute; MR: right marginal scute.

Individuals with observed anomalies	Date of capture	Type of anomaly
Juvenile (one year old)	11/04/2015	Accessory scute between V4–V5
Female (♀)	11/04/2015	Accessory scute between CR4–V5
Female (♀)	18/05/2015	Accessory scute between V4–V5
Juvenile (3-4 years old)	18/05/2015	Accessory scute between V4–V5
Juvenile (3-4 years old)	12/09/2015	Accessory scutes in left and right marginal (ML13; MR13)
Female (♀)	03/04/2015	Deformation of the carapace on the top right side (V2,V3,V4,CR1,CR2,CR3)

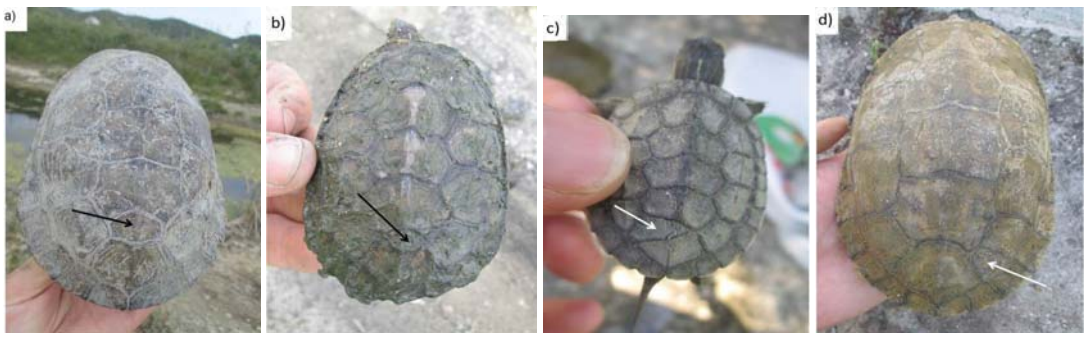

Fig 2: Four individuals of *M. rivualta* with scute anomalies. (a) A female turtle from Panaja channel with accessory scute between V4 – V5; b) A four years old juvenile turtle from Panaja channel with accessory scute between V4 – V5; c) A one year old juvenile turtle from Kavalona Park channel with accessory scute between V4 – V5; d) A female turtle from Kavalona Park channel with accessory scute between CR4–V5 (Photos: E. Saçdanaku)

Fig 3: Three individuals of *E. orbicularis* with scute anomalies. (a) A female turtle from Zvernec pond with accessory scutes between V4 – V5 and CL4 – V5; b) A male turtle from Novosel – Akerni channel with accessory scutes between V1 – CL1 and V1 – CR1; c) A four years old juvenile turtle from Panaja channel with asymmetri of marginal scutes with a lack of one right marginal scute (Photos: E. Saçdanaku)

Discussion and Conclusion

The results of this survey indicate that accessory scutes and other shell anomalies are presente in both population of *E. orbicularis* (3.5%) and *M. rivulata* (13%) of the Vlora Bay area. This is a low proportion when compared with the 40% and 75% that Ayres Fernández and Cordero Rivera, (2001, 2004) [2, 3] found for *E. orbicularis* population in Northwest Spain. In a later study (Cordero Rivera *et al*., 2008) [7]. it was found that the proportion of anomalous specimens oscillates between 3% to 69% in 10 different Iberian populations of *E. orbicularis.* Balázs and Györffy (2006) [4]. Found shell abnormalities in the case of 14, 2 % of the population of *E. orbicularis* in Southern Hungary. There is a lack of studies concerening the scute anomalies in *M. rivualta* populations. Our results of 13% may be considered as first records of scute anomalies (shell abnormalities) observed in the population of *M. rivulata*. Anyway, in his review of the turtle shell, Zangerl (1969) [51]. Found that accessory or asymmetric scutes occur in approximately 15% of individuals of many turtle species.

Scute anomalies are found probably in all populations of *E. orbicularis*. For instance, in his classic work Rollinat (1934) [35]. reports several individuals with one or more accessory scutes, but unfortunately does not indicate the proportion of animals showing these anomalies. Nevertheless they seem to be rare in non-Iberian *E. orbicularis* populations (Cherepanov, 1994; Schneeweiss & Beckmann, 2005) [9, 42], with the exception of Poland (Najbar & Maciantowicz, 2000; Najbar & Szuszkiewicz, 2005) [31, 32], Belarus (Drobenkov, 2005) [10]. and Switzerland (Mosimann, 2002) [30]. In the last case this could be due to the allocthonous origin of part of the population, and represent a case of outbreeding depression.

Initially we interpreted the scute anomalies as a consequence of a natural but suboptimal environment. Suboptimal incubation conditions are known to cause such anomalies (Cordero Rivera *et al*., 2008) [7]. 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 and Ullrich, 1950) [13]. Moreover, scute anomalies are more common at the northern edge of the range of *Chrysemys picta*. There, this phenomenon is thought to be the result of a suboptimal temperature regime during incubation (Macculloch, 1981) [26]. One particular type of asymmetry, fluctuating asymmetry, has been recognized as an indicator of environmental stress in many kinds of organisms (Palmer and Strobeck, 1986) [37]. Zangerl (1969) [51]. Observed that a particular set of some scute abnormalities appear to be genetic; others result from accidents, injury, or other trauma during the embryonic stage.

In conclusion, our study clearly shows that scute anomalies are present in Vlora Bay populations of *E. orbicularis* and *M. rivulata* and further studies are needed to be done in order to explain the real source of these anomalies.

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