# Growth, sex-dimorphism and predation pressure in the Batuecan Lizard, *Iberolacerta martinezricai* (Arribas, 1996).

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## ABSTRACT

Sex dimorphism: Males and females of *Iberolacerta martinezricai* differ at $p < 0.001$ in Ventralia (M<F, males less than females), Femoralia (M>F), Forelimbs length (M>F), Hindlimb length (M>F), Pileus length (M>F) and at $p<0.05$ in Collaria (M>F) and Dorsalia (M>F). Batuecan lizards are overall less dimorphic than the three species of Pyrenean rock lizards.

Morphological variability: Variability Index calculated ($\Sigma CV$) for *I. martinezricai* was 6.8 in males and 6.0 in females. Results are very similar (although slightly smaller) to the obtained in the Pyrenean *Iberolacerta* spp. From two chosen characters, variation coefficient in Gularia falls also between the normal values for the bisexual species and it is a bit greater than in parthenogenetic species; or it is clearly greater as in Dorsalia. Nothing suggests a drastic reduction of the variability in the Batuecan lizard but some characters recall for a relatively small morphologic variability in some characters, in parallel with the lack of mitochondrial variability, perhaps due to its reduced effectives.

Allometry: Both in males and females, the most representative character of growth is the body length (SVL). Most other characters match very closely to this SVL with very similar coefficients: limbs, Parietal, Pileus length and the Anal plate width. Masseteric, Tympanic and Anal length also grow, but not in parallel with SVL. Anal length grows considerably and independently of body size. In the case of females, body limbs have a negative allometry respect to female's body length and Masseteric, and especially Tympanic plates have a negative allometry respect to the total growth.

Parallel variation in escalation: In males the most related characters of escalation are the two rows of Femoralia, and two characters that have contrary signs: Supraciliar Granula (but not very marked, as coefficients are very small) and specially Circumanalia (that varies with total independence). Also there is a small relationship of Supraciliar Granula with Gularia and even more distant with 4th-toe Lamellae and Circumanalia. In females on one side (first axis), both Supraciliar Granula rows are related to Femoral pores, 4th toe Lamellae, Ventralia and Femoralia; and on the other side (second axis) both sided Femoralia are lonely related with Dorsalia, Collaria and Gularia, and just inversely related to Supraciliar Granula.

Sexual maturation is probably reached when lizards are three years old (in his 4CY). Our smallest gravid female was 56.7 mm, and was probably reproducing in the spring of their 5 CY (when 4 years old). Although it is possible that some specimens (especially males, but also some females) reach maturity during 3CY, as it occurs in *I. monticola.* Growth rate (K) in the first years is $0.145696 \pm 0.0633135$ (95% confidence). Calculated length at infinite (maximum size if the same rate or growth curve was applied throughout the lifetime of the animal) would be: $L_\infty = 70.036 \pm 13.7598$ (95%). This estimate of the asymptotic size (70.036 mm) is very close to the true maximum size found in the total sample of adults (69.31 mm). Growth decreases progressively and the resulting curve is fairly straight, being the growth not far from linear and very similar in both sexes.

Longevity: The biggest male (SVL 68.15 mm) and the biggest female conserved (SVL 68.86 mm) had 7 growth rings (two big and five narrow) in the femur. The two wide rings correspond to the two first years of rapid growth (2CY and 3CY), but when lizards reach sex maturation growth decreases, being latter

rings very narrow and even difficult to count. Both specimens had presumably 8 years old (they are 9CY animals: the birth year and 7 growths seasons, and captured just in the beginning of their 9 CY).

Tail autotomy: *Iberolacerta martinezricai* hatchlings are able to break their tails from birth. Observed hatchlings (1CY) in nature had intact tails. In 2CY, 3CY and 4CY already appear broken and regenerated tails in some specimens. In adults, there are less than a quarter of specimens with apparently unbroken tails, and the others fall in the different categories of regenerated ones (tail tip, middle of the tail or the whole tail from basis) in proportions similar to one quarter. There are no differences between both sexes in the different categories of broken tails, but there are significant differences between juveniles and adults. Females have a slightly big percentage of broken tails from its basis. Bright colored tail in juveniles (bluish in *I. martinezricai*), is lost during their 2CY. It seems to be an antipredatory strategy. Hatchlings of the Batuecan lizard are able to attract attention on its tail by a striking whirl of its distal part, unlike adults that are unable with their stiffer tail (which can move only in very limited cases of danger or excitement).

## RESUMEN

Dimorfismo sexual: Los machos y hembras de *I. martinezricai* difieren (p < 0.001) en Ventralia (M<H, machos menor que hembras), Femoralia (M>H), extremidades anteriores (M>H), extremidades posteriores (M>H), longitud del píleo (M>H), y (p<0.05) en Collaria (M>H) y Dorsalia (M>H). Las lagartijas batuecas son globalmente menos dimórficas que las tres especies pirenaicas de *Iberolacerta*.

Variabilidad morfológica: El índice de variabilidad calculado (ΣCV) para *I. martinezricai* fue de 6.8 en los machos y de 6.0 en las hembras. Los resultados son muy similares (aunque algo menores) que los obtenidos en sus congéneres pirenaicas. De los CV de los dos caracteres concretos comparables directamente, Gularia cae también dentro de los valores normales para una especie bisexual y es un poco mayor que en las especies partenogenéticas (que son clones sin variabilidad); o por el contrario es claramente mayor que en bisexuales y partenogenéticas por lo que respecta a Dorsalia. Nada hace pensaren una drástica reducción de la variabilidad en la lagartija batueca, pero algunos caracteres sugieren que hay una variabilidad morfológica relativamente pequeña, consistente con la falta de variabilidad mitocondrial previamente conocida y que quizá deba achacarse a su reducido tamaño poblacional.

Alometría: Tanto en los machos como las hembras, el carácter más representativo del crecimiento es la longitud del cuerpo (SVL). Muchos otros caracteres siguen de cerca a esta SVL, con coeficientes muy similares, como por ejemplo las longitudes de las extremidades, escama parietal, píleo o la anchura de la placa anal. La masetérica, timpánica y la longitud de la placa anal también crecen pero no paralelamente a SVL. La longitud de la placa anal crece considerable e independientemente del tamaño corporal. En el caso de las hembras, los miembros corporales presentan una alometría negativa respecto al tamaño del animal; y las placas masetérica y especialmente la timpánica muestran también una alometría negativa respecto al crecimiento.

Variación paralela en la folidosis: En los machos los caracteres más relacionados son las dos hileras de poros femorales con dos caracteres que tienen valores contrarios: los gránulos supraciliares (pero no muy marcado, ya que los coeficientes son pequeños) y especialmente con Circumanalia (que varía con independencia total). Igualmente existe una pequeña relación de Supraciliaria con Gularia y de forma aún más distante con Lamellae y Circumanalia. En las hembras, están relacionadas por un lado (primer eje del FA), ambas hileras de Supraciliaria que están relacionadas con Femoralia, Lamellae, Ventralia y Femoralia; y por otro lado (segundo eje) la Femoralia de ambos lados está laxamente relacionada con Dorsalia, Collaria y Gularia, e inversamente relacionado con Supraciliaria.

La madurez sexual se alcanza probablemente cuando las lagartijas tienen tres años de edad (están en su 4CY). Nuestra hembra grávida más joven tenía 56.7 mm, y estaba reproduciéndose probablemente en la primavera de su 5CY (cuando alcanza 4 años de edad). Aunque es posible que algunos especímenes (especialmente machos pero también algunas hembras) alcancen la madurez durante su 3CY, como ocurre en *I. monticola.* La tasa de crecimiento (K) durante los primeros años es 0.145696 ± 0.0633135 (95% de intervalo de confianza). La longitud máxima teórica al infinito sería: $L_\infty$ = 70.036 ± 13.7598 (95% conf.). Esta estima de la longitud asintótica según el modelo de crecimiento (70.036 mm) está muy cerca de la verdadera talla máxima que hemos detectado (69.31 mm). El crecimiento decrece progresivamente y la curva de crecimiento resultante es bastante recta y prácticamente linear, muy similar en ambos sexos, que alcanzan además una talla prácticamente idéntica.

Longevidad:El mayor macho estudiado (SVL 68.15 mm) y la mayor hembra (SVL 68.86 mm) tenían 7 anillos de crecimiento (dos anchos y cinco estrechos) en el fémur. Los dos anillos anchos son de los dos primeros años, de acelerado crecimiento (2CY y 3CY), pero cuando las lagartijas alcanzan la madurez sexual la tasa de crecimiento decrece notablemente, siendo los últimos anillos muy estrechos e incluso difíciles de contar. Ambos especímenes tenían presumiblemente 8 años (estaban en su 9CY: el año del nacimiento, 7 periodos de crecimiento y fueron capturadas justo al inicio de su 9 CY).

Autotomía: Los neonatos de *Iberolacerta martinezricai* son capaces de romper sus colas desde el mismo momento del nacimiento. Las crías observadas en la naturaleza (1CY) tenían sus colas intactas. Durante sus 2CY, 3CY y 4CY empiezan a aparecer colas rotas y regeneradas en algunos ejemplares. En los adultos hay menos de un cuarto de especímenes con colas aparentemente intactas, mientras que los otros caen dentro delas distintas categorías de rotura (punta, mitad o cola completamente regenerada des de su base), cada una de ellas en proporción similar a un cuarto. No hay diferencias entre sexos pero si entre juveniles y adultos. Las hembras tienen un porcentaje algo mayor de colas rotas desde la base. La brillante coloración de la cola en las crías (azulada en *I. martinezricai*), que se pierde durante su 2CY, parece ser una estrategia antipredatoria. Estas crías de lagartija batueca son capaces de atraer la atención sobre su cola mediante un llamativo ondulado de su parte distal, una habilidad que los adultos no conservan con sus colas mucho más rígidas y que apenas pueden mover en caso de peligro o excitación.

**PALABRAS CLAVE:** *Iberolacerta martinezricai*, Lagartija batueca, Historia Natural, Crecimiento, Alometría, Variabilidad, Dimorfismo sexual, Autotomía.

## RESUM

Dimorfisme sexual: Els mascles i femelles d'*Iberolacerta martinezricai* difereixen a p < 0.001 en Ventralia (M<F, mascles menys que les femelles), Femoralia (M>F), extremitats anteriors (M>F), extremitats posteriors (M>F), píleus (M>F), i a p<0.05 en Collaria (M>F) i Dorsalia (M>F). Les sargantanes batueques són menys dimòrfiques que les especies d'*Iberolacerta* pirinenques.

Variabilitat morfològica: L'Índex de Variabilitat (ΣCV) calculat per a *I. martinezricai* va ser de 6.8 en els mascles i 6.0 a les femelles. Els resultats són molt similars (encara que una mica més petits) que els obtinguts per a les sargantanes pirinenques. Dels dos caràcters concrets seleccionats, el coeficient de variació a Gularia cau dins dels valors normals per a les especies bisexuals i és una mica més gran que a les partenogenètiques (que no tenen variabilitat genètica); o és clarament superior que les dos com passa a Dorsalia. Res suggereix la existència d'una dràstica reducció de la variabilitat a la sargantana batueca, tot i que alguns caràcters semblen tenir una variabilitat una mica reduïda, paral·lelament a la falta de variabilitat mitocondrial, que pot ser deguda al reduït nombre dels seus efectius.

Al·lometria: Tant en els mascles com les femelles el caràcter més representatiu del creixement és la longitud del cos (SVL). Molts altres caràcters varien de forma més o menys paral·lela a SVL: la longitud de les potes, la placa parietal, la longitud del píleus i l'amplada de la placa anal. La placa massetèrica, timpànica i la longitud de la placa anal també creixen , però no en paral·lel amb SVL. La longitud de la placa anal creix considerablement i independentment de la grandària corporal. En el cas de les

femelles, els membres del cos tenen una al·lometria negativa respecte al creixement de la grandària corporal; i la massetèrica i especialment la placa timpànica tenen també una al·lometria negativa respecte al creixement total.

Variació paral·lela en la escutelació: En els mascles els caràcters d'escutelació més relacionats són les dues rengleres de Femoralia, i dos caràcters que tenen signes contraris: els grànuls supraciliars (encara que no molt marcadament ja que els seus coeficients són molt petis) i especialment Circumanalia (que varia amb total independència). També hi ha una petita relació entre els grànuls supraciliars amb Gularia i fins i tot a més distància amb les lamel·les del quart dit i Circumanalia. A les femelles, per una banda (primer eix de l'anàlisi) els grànuls supraciliars estan relacionats amb els porus femorals, les lamel·les del quart dit, Ventralia i Femoralia; I per altra banda (segon eix) els Femoralia dels dos costats estan dèbilment relacionats amb Dorsalia, Collaria i Gularia, i inversament relacionats amb els grànuls supraciliars.

La maduresa sexual és assolida probablement quan les sargantanes tenen tres anys d'edat (en el seu quart any de calendari, 4CY). La femella amb ous més petita tenia 56.7 mm, i probablement estava reproduint-se a la primavera del seu 5CY (quan assoleix 4 anys d'edat). Encara que és possible que alguns espècimens (especialment mascles, però també alguna femella) arribin a l'edat de maduresa durant el seu 3CY, com succeeix a *I. monticola.* La Taxa de Creixement (K) en els primers anys és $0.145696 \pm 0.0633135$ (95% de confiança). La longitud asimptòtica (talla màxima si la mateixa taxa de creixement succeís durant tota la vida del animal) seria: $L_\infty = 70.036 \pm 13.7598$ (95%). Aquesta estimació de la talla asimptòtica (70.036 mm) està molt a prop de la màxima talla veritable del total d'adults mesurats (69.31 mm). El creixement decreix progressivament i la corba resultant es força rectilínia i no difereix gaire d'una recta. A més, és molt similar en ambdós sexes.

Longevitat : El mascle més gran (SVL 68.15 mm) i la femella més gran (SVL 68.86 mm) estudiats tenien 7 anells de creixement (dos amples i cinc estrets) en una secció del fèmur. Els dos anells amples són dels dos primers anys de ràpid creixement (2CY i 3CY), però quan els animals assoleixen la maduresa sexual el creixement decreix sobtadament , essent els darrers anells molt estrets i difícils de comptar. Ambdós espècimens tenien presumiblement 8 anys de vida (eren animals 9CY: l'any del naixement, 7 anells de creixement i capturats justament al principi del seu 9 CY).

Autotomia caudal: Els nounats d'*Iberolacerta martinezricai* són capaços de trencar la cua des del mateix moment del naixement. Les cries observades a la natura (1CY) tenien les cues intactes. Durant el seu 2CY, 3CY i 4CY apareixen ja cues trencades i regenerades. En els adults existeix menys d'un quart d'espècimens amb cues aparentment intactes, i els altres cauen dins de les diferents categories de cues trencades (punta de la cua, meitat o trencada des de la seva base) en proporcions similars a un quart cadascuna d'elles. No hi ha diferències entre ambdós sexes en les diferents categories de trencament, però hi ha diferències entre els juvenils i els adults. Les femelles tenen un percentatge una mica més gran de cues trencades des de la base. La cua brillant dels juvenils (blavosa a *I. martinezricai*), que es perd durant el seu 2CY, sembla ser una estratègia antipredadora. Les cries de sargantana batueca són capaces d'atreure la atenció sobre la seva cua mitjançant un moviment sinuós de la seva part distal, d'una manera que els adults són incapaços de fer amb la seva cua més rígida (que poden moure molt limitadament en cas de perill o excitació).

**PARAULES CLAU:** *Iberolacerta martinezricai*, Sargantana batueca, Història Natural, Creixement, Al·lometria, Variabilitat, Dimorfisme sexual, Autotomia.

## INTRODUCTION

Biometrics and escalation have been the main taxonomic tool in the study of lacertids up to the rise of genetics, and in general it can be argued without fear that morphology addressed by statistical techniques remained the main tool, if not the unique for the implementation of phylogenetic relationships (now by genetics), and now for the study of local variation, diagnosis of the taxa confirmed by other techniques as mtDNA se-

quencing and location of possible new taxa in field surveys.

However, some characters are redundant and associated in different degree to the animals and may be linked and constituting a single factor of variation. This parallel variation was showed for *Iberolacerta (Pyrenesaura)* in ARRIBAS (1999) and here we study it in *I. martinezricai* (Arribas, 1996).

Sexual dimorphism appears in both island (CIRER & MARTÍNEZ-RICA, 1990; CLOVER, 1975) and continental species (VIVES BALMAÑA, 1990; PÉREZ-MELLADO & GALINDO-VILLARDÓN, 1986; ARRIBAS, 1996, among others). Morphological differences between sexes have been interpreted as a response to the need to reduce intraspecific competition. It is therefore likely that under more competitive pressure (due to higher density or scarcity of resources) there is a greater sexual dimorphism, and in this sense it had been interpreted as the marked differences between males and females in several lacertids (see i.e. CLOVER, 1975; CIRER & MARTÍNEZ-RICA, 1990; MARCO, 1995).

Reptiles, like many other vertebrates (but not mammals) have continuous and unlimited growth. This means, in practice, that they grow quickly when they are young and when they reach adulthood growth diminishes suddenly, but the animals never stop growing during their life. Young adults do not differ much in size, although sometimes in color or appearance, from older adults. The latter growth in the end of their life is so little, that it is almost imperceptible.

Finally, predation is an important factor in the population dynamics and in general in the Natural History of whatever species. Although percentage of broken tails is not an exact measure of depredation (obviously lacks the totally successful predations in which the whole lizard disappears), but being a specific defense measure, it can yield an estimation of the predation pressure in a population. There is considerable disagreement to the importance of losses tails in intraspecific encounters (fights between individuals of the same sex, or males to females during chasing previous to copulation). These breaks must be pretty rare, because if not, most individuals would come autotomized during the breeding season, and it is not the case.

Longer tail is more likely that the predator will find it in an attack. These probabilities are increased due to the direction of movement of the animal. If lizard moves fast, in a few moments the site of the body is occupied by tail (lizards cannot go back down, and if they do, always turn their body) (ARRIBAS, 2007). Avian predators tend to attack the head of the lizards (VERSVUST, et al., 2011) but movement of lizard's intent to scape focuses the attack on the tail. Also, males of many lizard species have longer tails than similarly-sized females (BARBADILLO & BAUWENS, 1997).

The tail could in theory break up as many times as autotomic tail vertebrae has. The downside of this is that tail usually is broken in large pieces. The tail tip vertebrae are not autotomic. Also it is not uncommon to break tail from their same basis (more than a half of the complete lizard). The new regenerated tail, however, is quite different from the former one. External appearance of the regenerated tails differs from intact ones: it has a different texture (false scales that cover tail rings are different from the previous wide and narrow original rows, it has very simple nerves, it is more rigid and immobile, and most importantly, it has not vertebrae, but it has a sort of cartilaginous tube or chorda that will never break. So, from that moment, lizard tail can broke only between the old fracture point and the tail basis, in the intact region of the tail that still has their autotomic vertebrae intact. If a lizard breaks his tail from its basis, very close to the body, lost "all its lives" in only a single encounter.

Caudal appendage loss implies the need for regeneration, and this requires the diversion of reserves that are subtracted from animal growth and reproductive potential. The tail has energy storage functions (fat), contributes to balance during the race and it is involved in social status. Animals that suffer loss of tail, reduce their social status and dominance, and having lost much of its possibilities of a new escape to depredation, they procure do not expose. Also there are changes in diet and foraging rate to find food and socialize. In addition, loss of the tail will invalidate the fat reserves that may pose a serious loss for the next breeding season.

*Iberolacerta martinezricai* (Arribas, 1996) is the rarest and probably one of the most threatened

reptile species from continental Europe. A recent survey on the habitat and distribution of this stenoendemic lizard confirmed that its distribution area is very small (12-15 km²) inside three 10 km x 10 km UTM grid squares (29TQE48; 29TQE38; 29TQE39), with a total occupied area between 20-25 km² and a estimation of 1200 to 1500 individuals (LIZANA & CARBONERO, 2007; ARRIBAS, 2013).

The area of *I. martinezricai* occurs in the north of the Natural Park of Las Batuecas, at medium and high altitudes in the mountainous range of sierra de Francia (from 840 m to 1730 m). The first area is centered around the peak "Peña de Francia" (1723 m), extending northward to the peak "Pico de los Robledos" (1611 m) and surrounding areas, to the northeast as far as the "sierra del Guindo" ("Hastiala" Peak, 1735 m; "Alto del Copero", 1560 m), southward to the "Mesa del Francés" (1640 m), and toward the southeast, up to the northern slopes (and probably the south almost in summital areas) of the "sierra de la Grajera" ("Rongiero", 1627 m) reaching almost the limit with Extremadura (ARRIBAS, 2006; 2013; LIZANA & CARBONERO, 2007).The second environment where the Batuecan Rock Lizard occurs is called "Puerto El Portillo" ("El Portillo Pass", from 840 m to 1400 m a.s.l.) and the top of the Batuecas Valley, on the southern slope of a mountain range named "sierra de la Alberca" where these populations were discovered in 2004 (ARRIBAS, 2004, 2013).The species has not been found in other Western areas, as previously expected, and the Batuecan lizard is considered critically Endangered (Cr, B2ab(v) ;c2a(ii)) (ARRIBAS, 2006, 2013; PÉREZ-MELLADO *et al*., 2009). Despite the entire population occurs inside a protected area, namely the "Parque Natural de las Batuecas y sierra de Francia", a specific program and management for the recovery of this species is still without implementing.

Phenology, molts, thermoregulation, activity, distribution, habitat selection and other parameters of population dynamics as density or sex-ratio are in ARRIBAS (2013). The reproductive parameters are currently in process of publication (ARRIBAS, in prep). All these aspects and the ones here presented are small pieces for an acceptable knowledge of a species that are even not ever known, even in some widespread and well known species.

## MATERIAL & METHODS

A total of 82 specimens measured (37 males and 45 females) from OSCAR ARRIBAS' (OA) measurements database were used for calculations. Given that lizards present sexual dimorphism (ARRIBAS, 1996, 1999a, 1999b, and present study), analyses were carried out for males and females separately. For some characteristics, only a portion of these are available for data, like the tail regeneration state.

### Study area

Geology of the area is mainly of Paleozoic age (granites, quartzite and slate outcrops). The relief is generally smooth but shows active geological phenomena of meteorisation, which produces accumulations of large boulders and loose rocks (called "canchales", averaging 80-120 cm in diameter). The basal granite and quartzite surface in the peaks and crests forms large areas of boulders in the slopes of the valleys, where slates are more common in the area. Three bioclimatic stages are represented: the Oromediterranean belt (>1600 m a.s.l.), represented only in the summits, with broom shrubs (mainly *Cytisus balansae*); the Supramediterranean belt (approx. 1000-1600 m a.s.l.) originally vegetated with *Quercus pyrenaica* and a shrub stratum of *Erica arborea* and *E. australis*, as well as some pine stands (*Pinus nigra* and *P. sylvestris*) interspersed. The low altitudes are occupied by the Mesomediterranean belt (400-1000 m a.s.l.) typically constituted by open forests of *Quercus ilex* and *Quercus suber* in the wetter areas. Azonal vegetation includes saxicolous and riverine species in the ravines (ARRIBAS 2013).

Rainfall is concentrated during fall and winter and exceeds 1800 mm in the summit areas. Summers are sunny, with high insolation and lack of precipitation; drought is restricted to July-September. In the lizard habitats, annual and daily insolation cycles are relatively short (just a

few hours of direct sun per day), due to the relief of the mountains and the orientation and inclination of the slopes. The sun reaches the habitats late in the morning, especially the lowermost portions of the slopes (MARTÍN, 1998; ARRIBAS, 2013).

## Characters studied

Biometric characters: Body length (SVL); Forelimb length (FLL); Hindlimb length (HLL); Pileus length (PL); Pileus width (PW); Parietal length (PaL); Masseteric scale diameter (DM); Tympanic scale diameter (DT); Anal width (AW) and Anal length (AL). All linear measurements were made with a digital caliper to the nearest 0.01 mm by the author to avoid inter observer variability. For the study of sexual dimorphism, these measurements were transformed to the following more informative and not dimensional-depending ratios: FLL/SVL (relative forelimb length; "FLL index"); HLL/SVL (relative hindlimb length, "HLL index"); PL/PW (pileus shape, "Pileus index"); DM/PaL (relative masseteric plate size, "Masseteric index"); DT/PaL (relative tympanic size, "Tympanic index") and AL/AW (anal plate surface, "Anal-form index")(see ARRIBAS, 1996, 2001). Results of linear measurements and indexes yielded largely similar results. All ratios were given multiplied by 100 to avoid excessive decimal scores. For sex-dimorphism comparisons, only specimens with SVL greater than 48 mm were considered.

Escalation characters: Supraciliar Granula (GrS) for right and left sides; Gularia (GUL); Collaria (COLL); Dorsalia (DORS); Ventralia (VENT); Femoralia right (FEMr) and left (FEMl); 4th-toe Lamellae (LAM); and Circumanalia (CIRCA). The full presence (2), contact at one point (1) or absence (0) of contact between Rostral-Internasal (R-I), Supranasal-first Loreal contact (Sn-Lor), and Postocular-Parietal contact (Po-Pa) was also studied.

## Sex dimorphism

For detection of sexual dimorphism we used a Student's T-test to compare males and females. The sum of the values of T for all characters [Σ(T)],was taken as the estimated number of sexual dimorphism in a given species. We have used the same character set than in ARRIBAS (1997) for posterior comparison with the Pyrenean species results.

## (Morphological) Variation degree

The sum of the coefficients of variation [ΣCV] has been used as an intrinsic estimate of population variability (SOULÉ, 1972; CIRER & MARTÍNEZ-RICA, 1990). This has been taken into consideration several characteristics that had a degree of variation roughly similar and unambiguous within each OTU, in order to avoid statistical noise entering the estimates of variability. For the estimation, the average of six escalation characters (Gularia, Dorsalia, Ventralia, the two values of Femoralia and Lamellae) has been used. It has also been compared the Gularia, Femoralia and Dorsalia variability separately with data from other species in the literature (see eg. DAREVSKY, KUPRIYANOVA & UZZELL, 1985).The values of the coefficients of variation are given multiplied by 100 to avoid excessive decimal scores.

## Study of Allometry: Principal Components Analysis (PCA)

When dealing with the growth of *I. martinezricai*, Principal Components Analysis (PCA) is a suitable method for study. PCA is one of the most important methods of ordination analysis. It constructs a new set of orthogonal coordinate axes (also called factors) such that the projection of points onto them have maximum variance in as few dimensions as possible (ROHLF, 2000). If in the first axis (a lineal combination of all the original measurements set) all the coefficients show the same sign (positive or negative), this means that this first axis represents the size variation. In these cases, the second and subsequent axes mus thave mixed signs and represent variation in shape. In this later case represents the relative growth (allometry) among the different body parts: A negative sign for a coefficient of a given character simply means that this character develops much less than did the positive coefficient ones (JOLICOEUR & MOSIMANN, 1960; see BLACKITH & REYMENT, 1971 with references therein, and a mathematical demonstration in RAO, 1964).

## Study of parallel variation in escalation: Factor Analysis (FA)

To study the possible parallel variation among the different escalation characters, a Factor Analysis (FA) with Varimax rotation was run, whose principle is the same as in the PCA (see above),but posteriorly the orthogonal axes are rotated in the form that the most extreme values remain between and not around the new axes (factors). In this kind of analysis, every one of the underlying factors obtained, simplify in great measure the number of observed variables allowing their interpretation (GOULD, 1967; BLACKITH & REYMENT, 1971).

## Study of growth

In the Batuecan lizard, as in other mountain lizards, age of young is easy to discern in a random sample of lizards because there is only one annual clutch, and hence only one cohort of hatchlings (in other species there are several cohorts throughout the summer, and the ones from the earliest clutches differ from the last born ones in their body size). This unique clutch, coupled with the fact that during the long winter diapause growth is completely stopped and only restarts during the activity months, can be appreciated for various and well differentiated size classes that correspond to different ages (annual cohorts) during the first years of life.

The absolute age can be studied in two ways: a reliable only for the first two or three years, by counting the growth rings (such as in trees) of some scales like the first supratemporal or the parietal, or by long bone section of previously sacrificed specimens in which cuts are made in the femur, then stained and later counted as well as in the rings of trees. In some species it can be done even with phalanxes of fingers (or even nails), but in these lizards so small, the bone is reabsorbed in their central parts during growth and it hampers the rings counting. This may also happen in the inner part of long bones as femur, but are still the best for reconstructing the real age.

To study the growth from hatching until it reaches an adult size when is no longer possible to discern the age, we divided the samples into annual cohorts, and within them, to have two year values during the activity period, and we consider the existence of two periods (pre-reproductive and post-reproductive). The stopped growth periods (hibernation) are not considered. The curves (formulae) expressing the growth are only valid during the rapid size-increasing period of juvenile development (this is, the activity/growth period). The different age classes are: Hatchlings: From birth until the end of summer (age 1, 1CY -first calendar year-). Second year of life (age 2, 2CY): From spring until reproduction (mid-July), and the second half of summer until hibernation (age 3, 2CY). And so for successive years, at two periods per year until reaching adult size. These lizards reach adulthood at the age of three years, during their 4CY (males) and 4th or 5CY (females).

For growth study, we will use the von Bertalanffy model, widely used for the study of growth in lacertid lizards. If we assume that growth rate of an organism decreases with size, as occurs in Squamata, the rate of change of the size can be described as: $dl / dt = K (L_\infty - l)$, where $l$ is the length, K is the growth rate and $L_\infty$ the asymptotic length at which growth is zero. Integrating this appears: $l_t = L_\infty [1 - e^{-K (t - t0)}]$.

We have calculated only the growth curve until the reach of sexual maturity. Then adults vary slightly in size and are no longer classifiable ages, so they cannot be discriminated. The calculations are based only on this period of growth. We have tried several other approaches entering also the adult data, but the parameters that express the growth of juveniles (the unique sure) are distorted.

## Maximum longevity

Maximum longevity was estimated by skeletochronology. From the greatest conserved male and female specimens, fragments of the femurs were decalcified for 48 h in 3% $HNO_3$. Subsequently, rinsed in tap water (3 hours) and dehydrated through successive ethanol stages (96 and absolute; 24 hours each phase), diaphanized with Xylene (30 min) and then processed for paraffin embedding in small blocks (for 8 hours). Cross-sections, as thin as possible, but not of a standardized thick, were obtained by means of rotatory microtome. The sections were rehydrated with a series of decreasing alcohols (15 minutes each) and stained for 30 min in Ehrlich's haematoxylin. Later Xylene was added and

samples were mounted with D.P.X.® resin for permanent conservation and then observed though a light microscope. The analysis of lines of arrested growth (LAGs) was performed to estimate the age of the specimens (from CASTANET & SMIRINA, 1990; CASTANET *et al.,* 1993; ROYTBERG & SMIRINA, 2006, modified).

When lizards are young, there is a rapid growth and LAGs are extensive, but at maturity, growth decreases suddenly. These differences in ring's width can serve for a-posteriori estimation of sexual maturation in species in which this age is unknown, as growth decreases suddenly when reaching sex maturity.

## RESULTS AND DISCUSION

### Sexual dimorphism

Descriptive statistics of the escalation characters, biometric indexes and the T-tests searching for differences between males and females are in Table 1.Males and females differ at p < 0.001 in Ventralia (M<F, males less than females), Femoralia (M>F), forelimb length (M>F), hindlimb length (M>F), and comparative pileus length (M>F).Differences are near to be highly significant in 4th toe Lamellae (M>F) and are simply significant (p<0.05) in Collaria (M>F) and Dorsalia (M>F).Contacts among plates (rostral-internasal, supranasal-loreal and postocular-parietal) were equivalent in both sexes.

The differences in the escalation characters were yet studied in ARRIBAS (1999a) (Ventralia and Femoralia) and here we confirm them, adding some less marked (Collaria, Lamellae and Dorsalia) and also the differences in the body proportions (especially limb and head). These differences are typical in other lacertids and characteristic of the differences between both sexes in many species in which males have comparative longer legs, heads and tails than females, and also more femoral pori and less ventral scales. Apart of these usual lacertid differences, in our sample seems that males had more Collaria, Dorsalia and Lamellae than females.

The sum of the values of T for all characters, using the same character set than in ARRIBAS (1997) for comparison with the Pyrenean species is taken as the estimated degree of sexual dimorphism. In *I. martinezricai* Σ(T) is 48.37; thus, the Batuecan lizard is overall less dimorphic than the three species of Pyrenean rock lizards (55.69 in *I. aranica*; 69.38 in *I. aurelioi* and 61.23 in *I. bonnali*; ARRIBAS, 1997).

## Tail Autotomy and predation pressure

The percentage of regenerated tails has been used for estimation of the depredation pressure. We have distinguished four situations: 1) intact tail; 2) tail tip regenerated; 3) tail broken in their middle and 4) tail broken from the basis.

## Statistical procedures

Principal Components Analysis, Factor Analysis and calculations in general (T-tests and descriptive statistics) were calculated with NCSS-2007© (HINTZE, 2007).Growth was studied with Simply Growth II © (HENDERSON & SEABY, 2006).

## Morphological Variation degree (CV)

The sum of the coefficients of variation [Σ CV] has been used as an intrinsic estimate of population variability (DAREVSKY, 1967; DAREVSKY, KUPRIYANOVA & UZZELL, 1985; ARRIBAS, 1997). For the estimation the average of six escalation characters (Gularia, Dorsalia, Ventralia, the two values of Femoralia and Lamellae) had been used. Also, it has been taken separately Gularia, Dorsalia and Femoralia variability to compare with data from other species in the literature (see eg. DAREVSKY, 1967; and specially DAREVSKY, KUPRIYANOVA & UZZELL, 1985, figure 34) and Pyrenean *Iberolacerta* (ARRIBAS, 1997). The comparison is interesting not only with the bisexual and widespread species (as the Caucasian *Darevskia*), but also with bisexual but restricted species (as the Pyrenean *Iberolacerta*) or with Caucasian parthenogenetic *Darevskia* (with almost no genetic variability).

Average of chosen CV in *I. martinezricai* are 6.8 (0.068 x 100) in males and 6.0 in females. Results are very similar to obtained in the Pyrenean *Iberolacerta*: *Iberolacerta aurelioi* is the most variable species (7.3 and 6.98 in males and females, respectively), *I. aranica* the less variable (6.60 and 7.10, respectively) and *I. bonnali* has intermediate or fairly similar scores (7.12 and 6.6, respectively; ARRIBAS, 1997).The three

*Iberolacerta (Pyrenesaura)* have a bit more variable escalation than the Batuecan lizard.

In *I. martinezricai*, Gularia CV is 7 in males and 6 in females, values which fall in the normal variability of the Caucasian bisexual *Darevskia* (from 6 to 9 in DAREVSKY *et al.*, 1985). In *Iberolacerta (Pyrenesaura)*, values of Gularia in *I. bonnali* (8.2 and 7.9 in males and females, respectively), *I. aranica* (6.3 and 7.3) and *I. aurelioi* (7.5 and 7.1) that fall also between the normal values for the Caucasian bisexual *Darevskia*. In parthenogenetic *Darevskia* (with no genetic variation) values oscillate around 6, not very different from the lower values in the *I. martinezricai* females.

Dorsalia has a CV of 4 in males and 6 in females of *I. martinezricai*. This character shows the greater differences between unisexual (with no variation, oscillating between 2 and 3) and bisexual species (variable, between 4 and 6). In the Batuecan lizard, results fall well within bisexual (variable) species as well as occur in the Pyrenean species (*I. bonnali*, 5.6 and 5.2; *I. aranica*, 4.7 and 6.7, and *I. aurelioi*, 5.7 and 5.3; see ARRIBAS, 1997). Nothing suggests a drastic reduction of the variability in any of the *Iberolacerta* studied, but some characters recall for a small morphologic variability, especially in the ones with a more reduced area as is the case of the Batuecan lizard.

The relatively scarce variation is not surprising as the area of *I. martinezricai* is nowadays even more restricted that the ones of the two rare most Pyrenean species (*I. aranica* and *I. aurelioi*) and deep bottlenecks must be presumed in their population dynamics in the last two million years. The genetic study (ARRIBAS & CARRANZA, 2004) of a total of 1013 bp of mitochondrial (303 bp of cytb and 375 bp of 12S rRNA) and nuclear (335 bp of c-mos) DNA do not finded differences in the genetic sequences of specimens from neighborhood of El Maillo, the Peña de Francia mountain and the Puerto del Portillo (Salamanca, Spain).

*Iberolacerta martinezricai* is probably the raremost reptile in continental Europe, and current distribution inside its minute area, more than a fragmentation, simply the result of the precise choose of the concrete suitable areas, with a model of metapopulations more or less connected among them.

## Allometry

The results of the PCA are in Table 2. Both in males and females, the most representative character of the growth is the body length (SVL) which has the greatest coefficient (thus is, correlation between the original measurements and the "new" variable growth represented by the first axis). Most other characters match very closely to this SVL with very similar coefficients (limbs, parietal, pileus and the anal plate width). Slightly worse correlations have the masseteric, tympanic and the anal length, that also growth, but not so in parallel with the overall size (represented by SVL) of the lizard. As expressed in Material and methods section, all the variables coefficients have the same sign and this axis represents size.

In the second axis (Factor) these three discordant characters (masseteric, tympanic and anal length) are the unique ones with significant load. In the case of the males, the two plates appear with contrary sign to the SVL which means that grow very few and independently of the body length. In the case of the anal length, with negative sign but high load, grows considerably, but also independently of the body size. In the case of the females, this second axis shows moderate but significant loads (with contrary sign) in the limbs length. This means that the body members have a negative allometry in respect to the female's body length. The anal plate grows, but independently of the body size, and the masseteric and specially the tympanic plates have a negative allometry in respect to the total growth.

In the Pyrenaean lizards (ARRIBAS, 1999b) the first axis also reflects the overall growth of the lizard. And as in our case, the size of the anal plate especially in the females, follows but relatively independently, the overall growth of the lizard, and the masseteric and tympanic plates, are also independent of this growth. The masseteric and tympanic diameters are characters very variable among individuals; both present a more or less parallel growth between them, and independent from other variables.

## Parallel variability in escalation

In respect to the escalation characters, we run another multivariate analysis, a Factor analysis with a Varimax rotation, which changes the orien-

tation of the new axes in order that points remain around the new axes (a new variable linear combination of the other original variables) instead between these axes, which allows for a better interpretation of these new variables. The results are in Table 3.

In males escalation is explained in two significant axes (Eigenvalues greater than 1). First axis (Eigenvalue 1.82; 51.82 % of variability explained) shows a relationship of several variables that vary increasing or decreasing their number in a parallel form. The most related characters with this axis are the two rows of Femoralia, and two characters that have contrary signs: Supraciliar granula (but not very marked as coefficients are very small) and specially Circumanalia (that varies with total independence).The second factor (Eigenvalue 1.63; 46.51 % variability explained) has a more difficult explanation, as weakly relates the supraciliar granula with gularia and even more faintly with 4th-toe lamellae and Circumanalia.

In females there are also two significant factors. The first one (Eigenvalue 1.79; 54.82 % of variability explained) relates both supraciliar granula rows with femoral pores, 4th toe Lamellae, Ventralia and Femoralia whereas the second factor (Eigenvalue 1.40; 43.02 % of variability explained) relates both Femoralia values and less closely with Dorsalia, Collaria and Gularia, and just inversely related to Supraciliar Granula.

Results are less clear than in the Pyrenean lizards (ARRIBAS, 1999b) probably as the sample size is smaller and thus hidden correlations are more difficult to find. For comments about these parallel escalation characters and their usefulness for taxonomy and relation with climatic parameters, see ARRIBAS (1999b and references therein).

It has been suggested that the numbers of body scales vary in parallel with environmental parameters such as temperature and humidity (FOX, 1948, FOX *et al*., 1961; OSGOOD, 1978; WERNER & SIVAN, 1993; VICENTE, 1992; SCHMIDTLER, 1986; SCHMIDTLER *et al*., 2002; ARRIBAS *et al*., 2006), a fact that is often ignored in taxonomic studies and in which much importance has been given to the numerical values of escalation along all the last century. SOULÉ

(1966) indicates that populations with problems maintaining sufficiently high temperatures have numerous and small scales, while in warm areas have larger scales more intertwined between them. However, this model is not met at all in Europe, where there are the septentrional or mountain dwelling species, with large scales and lower in number. SCHMIDTLER (1986) finds in Turkish green lizards trends similar to those which appear in European species, with higher escalation values in warm oceanic locations than in moderate and continental climate ones, although variability occurs towards the ends away from what he calls the "climate center" of each taxon distribution, where values will be stable. This variability would be only between ssp. or ssp. groups but it is unknown whether is inherited or not, according to this author. Others, like MARTÍNEZ-RICA (1977) argue that the thermophile species have a greater number (and therefore smaller) dorsal scale than in the coldest places, and that these scales numbers may be related with the amount of radiation received. Similar results can be inferred from *Iberolacerta monticola* (ARRIBAS, 1996; ARRIBAS *et al.,* 2006). CIRER (1981) finds that higher values in *Podarcis pityusensis* escalation occur in the outer islands of the coast, where more radiation and more temperature variation area associated with melanic populations.

However, as we have said, the results are contradictory, almost between temperate-mesic and arid-desertic areas, and escalation characters (such as Dorsalia) are widely used in systematic and considered of neutral selection on genetic determination (RASOVANOVIC, 1954), concluding that at greater habitat heterogeneity, also greater genetic variability and hence morphological variation (SOULÉ & YANG, 1973; VAN VALEN, 1965; ROUGHGARDEN, 1974; DOBZHANSKY *et al.,* 1980). In our case, the distribution of Batuecan lizard is so small that its climatic-parallel influence shall be studied in the framework of all the *I. monticola* group species (as in ARRIBAS *et al.,* 2006) and not for this restricted taxa alone.

Growth

We have calculated only the growth curve until the reach of the sexual maturity (Fig. 1). Adults vary little in size and they are no longer classifiable within ages, so they cannot be used for cal-

culations with precise age. Calculations are based solely on this period of growth until the 4CY. We have tried several approaches entering the adult data, but parameters that express growth of juveniles (the only sure) are distorted.

In table 4 it is reflected as "period" the activity period (hibernation lapses were not considered because during them it does not produce any growth). Period = 1 corresponds to newborns or hatchlings (1CY), 2CY is distributed among Period 2 (April until mid-July) and Period 3 (mid-July, August, September) and 3CY is distributed between Period 4 and Period 5, and so on.

As in *l. monticola* the sexual maturity size must be near 48 mm (in males) and 53 mm (in females) and probably is reached in "Period 6", thus is, when lizards are three years old (in his 4CY). Our smallest gravid female was 56.7 mm, and it was probably reproducing in the spring of its 5 CY (when reaching 4 years old). Although it is possible that some specimens (especially males, but also some female) reach maturity during 3CY like in *l. monticola*, our evidence in females is from 4 CY, but 3CY cannot be discarded. In our case, we are dealing with inland and middle mountain populations, and data from *l. monticola* come from lowland populations.

In Table 4, "Period" is the sampling moment of the year (see above); "Observed Length" is the average SVL (Snout-vent length of animals);"Predicted Length" is derived from model of growth curve at that age. "Increase" is growth between two measurement periods. In general, the predicted length should be close to observed length, but the curve smooth the differences, so in some cases (as our sample), where the sample size is small, the curve can be more accurately marking size corresponding to that age. Another interesting aspect is that some periods (or ages) could have odd growth increments. This is because the second growth period (half July, August, September) in the year is just the continuation of the first part of the activity (and growth) period (April to mid-July) and it is not well separated from each other by hibernation, and specimen measures in some moments (i. e. late June and specially July) may overlap in part and seem to have small or no growth. Also, during winter (between odd and even) periods there is no growth.

Figure 1 shows the growth curve von Bertalanffy ("Age" represents the period and "Length" the SVL of different age-classes). Parameters include growth rate (K) which is $0.145696 \pm 0.0633135$ (95% confidence). The calculated length at infinity (maximum size if that same rate or growth curve was applied throughout the lifetime of the animal) would be: $L_\infty = 70.036 \pm 13.7598$ (95%). This estimate of the asymptotic size (70.036 mm) is very close to true maximum size found in the total sample of adults (69.31 mm).

As can be seen in Fig 1, growth is progressively decreasing and in Period 6 (first period of the 3CY) probably includes specimens already adult from the 4 CY. The result curve is fairly straight and the growth is not far from linear. A graphic representation of this linear growth including all the adults of undetermined age is represented in Fig 2 (green points are males and blue triangles females).There are two regression lines, one for each sex, but they are so similar (adults of both sexes are from same size) that result is almost indistinguishable. A detailed account of sizes of specimens in each year period and age (for males, females and both sexes together) is presented in Table 5.

In Croatian lizard (*l. horvathi*), which has a similar size to other *Iberolacerta*, offspring at birth measured $26.3 \pm 0.24$ mm (24.5 to 28.5 mm), at first year(2CY) $38.6 \pm 0.91$ mm (35.5-44.5 mm), at 22 months (3CY) $42.3 \pm 0.55$ mm (39-45 mm) and at 33 months (4CY) $49.8 \pm 1.01$ mm (47.5-54 mm). Sexual maturity reaches at (approximately 4 CY, as *l. martinezricai*) 50mm body length (LAPINI *et al*., 1993, reinterpreted).

In Cantabrian lizard (*l. monticola*) from Serra de Estrela (Portugal) at birth (1CY) males measures $31 \pm 0.87$ (27-34 mm) and females average is also $31 \pm 0.87$ (27-34 mm). At one year (2CY) males measure $49 \pm 0.70$ (48-51 mm) and females measure 46.62 (42-49 mm). At two years (3CY) males measure $58 \pm 0.48$ (56-60 mm) and females average is $56 \pm 0.85$ (50-60 mm) and they are yet adults. Sexual maturity is reached by males with 48 mm and by females with 53 mm SVL. Most females mature in their 3CY in Serra da Estrela (MOREIRA *et al.,* 1999). Also, In Galicia (NW Spain), near half of specimens are mature at the age of two years (3CY) and the rest

matures with three years (4CY) (RÚA y GALÁN, 2003).

In *I. cyreni* there is no estimation of growth or in the reaching of sexual maturity. The smallest female with developed gonads had 65.8 mm and 67.3 mm the smallest female with oviductal eggs. The smallest male had 61.2 mm (ELVIRA&VIGAL, 1985).

In Pyrenean lizards, *I. aranica* reaches maturation size when the animals are four years old (5CY). The smallest gravid female was 50.3 mm SVL. Thus, it appears that females reach sexual maturity at five years of age (in its 6CY), although it is possible that some may reach the 5CY and the rest during 6CY (ARRIBAS, 2007). The smallest *I. aurelioi* adult male known was 45.1 mm SVL. This size is reached when the animal is four years old (5CY). The smallest female found was 48.9 mm SVL. Thus, it appears that sexual maturity in females is achieved, as in *I. aranica* (and probably *I. bonnali*) when they are five years old (6CY), but perhaps some get to it in its 5CY (ARRIBAS and GALÁN, 2005; ARRIBAS, 2007).

## Maximum Longevity

The biggest male conserved (SVL 68.15 mm), a specimen captured just at beginning of the year activity (principle April) had 7 growth rings (two big and five narrow).Also, the biggest female conserved (SVL 68.86 mm), from the same data, had also 7 growth rings (two big and five narrow). The two wide rings are from the two first years of rapid growth (2CY and 3CY), but when lizards reach sex maturation growth decreases, being the latter rings very narrow and even difficult to count.

These results correspond in both sexes to 9CY animals: the birth year, 7 growths seasons and captured just in the beginning of their 9 CY. Almost 8 years of lifespan in these biggest specimens, but even older specimens can exist (but it is extremely rare).

In *I. monticola*, the maximum age estimated by skeletochronology is 10 years in Serra de Estrela (Portugal).In Galicia (Spain) full adult specimens have 5 to 7 years, but it is known almost one male that reached exceptionally up to 15 years, although the great part of specimens die off sooner (GALÁN, 2011a).In *I. cyreni* and *I. galani* longevity is unknown, but probably similar.

In *Iberolacerta (Pyrenesaura)* maximum longevity must be similar in the three species. Absolute age is only studied in *I. aurelioi*, in which the greatest male (57,18 mm) had 17 growth rings (almost 16 years), and the greatest female (62,21 mm) 11 growth rings plus probably another 4 (incomplete due to internal reabsorption) which corresponds to at least 14 years (ARRIBAS, 2007).

It seems to be a relationship between the duration of the activity period suitable for growth and the time lapse until the reach of sexual maturity. If the annual growth period is very short, as in the Pyrenean lizards, sexual maturation is delayed and corresponds also with a theoric longer lifespan. In the case of *I. martinezricai*, despite living in Mediterranean environments, due to the special colder expositions it selects, its year cycle is not too different to observed in other *Iberolacerta,* especially *I. monticola*. Its maturation is totally parallel to this species: In 4CY (three years old) and perhaps some specimens also in their 3CY (two years), as occurs with Galician *I. monticola* (RÚA y GALÁN, 2003).

## Tail autotomy and predation pressure

In *I. martinezricai*, as seems a priori reasonable, young specimens had less signs of depredation intents than adults (Table 6).Hatchlings are able to broke their tails from birth (own data, as in other *Iberolacerta* s. str., but not in subgenus *Pyrenesaura*). In wild observed hatchlings (1CY) no one had broken tail. In 2CY, 3CY and 4CY despite the scarce sample and as it can be expected, yet appear broken and regenerated tails in some specimens. In adults, there are less than a quarter of specimens with apparently unbroken tails, and the others fall in the categories of regenerated ones (tail tip, middle of the tail or all the tail from basis), all in proportions similar to one quarter ($\chi^2_3$=4.85, P =0.18 for all adults together). There are no differences between both sexes in different categories of broken tails ($\chi^2_3$ =0.2, P =0.97). However, there are significant differences between juveniles and adults ($\chi^2_3$ = 8.36, P =0.39). These differences arise mainly from hatchlings, as the percentage of broken and regenerated tails increase with age. Females have a few more broken tails from its basis (a similar phenomenon has been found in *Zootoca*

*vivipara* and attributed to the presence of more non-autotomic vertebrae in the males tail basis; BARBADILLO *et al.,* 1995).Also our juveniles had less autotomized tails than adults, contrary to species that live in very high densities, that force juveniles to dangerous areas where they are easily autotomized (BRANDL & VÖLKL, 1988).

The bright colored tail in juveniles (bluish in *I. martinezricai*), that is lost during its 2CY, seems to be an antipredatory strategy, as in other lizards (CASTILLA *et al.,* 1999; HAWLENA *et al.,* 2006; WATSON *et al*., 2012). Hatchlings of Batuecan lizard are able to attract attention on his tail by a striking whirling of its distal part, in a fashion that adults are unable with their stiffer tail (which can only move very limited in cases of danger or excitement). So in case of danger, they alternate extremely fast races with stops in which do loop the tail tip drawing attention to this. During races, speed and undulating body is such that almost blurs the outline of the lizard (somehow becomes "invisible"), reappearing during stops as an immobile body and a sinuous tail tip undulating. The same ability appears in *Iberolacerta aranica* and *I. aurelioi* (ARRIBAS, 2004; ARRIBAS, 2007). A similar behavior has been described in adults of *Takydromus tachydromoides* that often thrashed its tail rapidly from side to side for short intervals (less than 0.5 sec.) just before flee from a snake predator (MORI, 1990).

In other *Iberolacerta* studied, as *I. aranica*, percentage of preyed tails in adults is somewhat lower (38.6 and 42.7% in males and females respectively). The Aran lizard seems to have a lower predation pressure than other *Iberolacerta* s. str. and other lowland lacertids, as it is expectable in an animal of its low productivity, late sexual maturity and presumably high longevity (ARRIBAS, 2007). In *Podarcis liolepis atrata* regenerated tails appear in 83-85% of adults and 53% of young of the year (similar in other *Podarcis* gr. *hispanica*)(CASTILLA & BAUWENS, 1996) and in *Podarcis bocagei* in 76.8% of adults and 30% of the offspring (Galan, 1999), all them values greater than in *I. aranica*, but similar to the one here found for *I. martinezricai*. In the Caucasus mountain lizards (*Darevskia* spp.) the percentage of regenerated tails oscillated between 50 and 70%, slightly minor than the ones here commented (DAREVSKY, 1967) .In *I. horvathi* males escape at longer distances than females, which could help top avoid depredation (CAPIZZI *et al*., 2007), but in our case there are no differences in the percentages of autotomized tails between both sexes.

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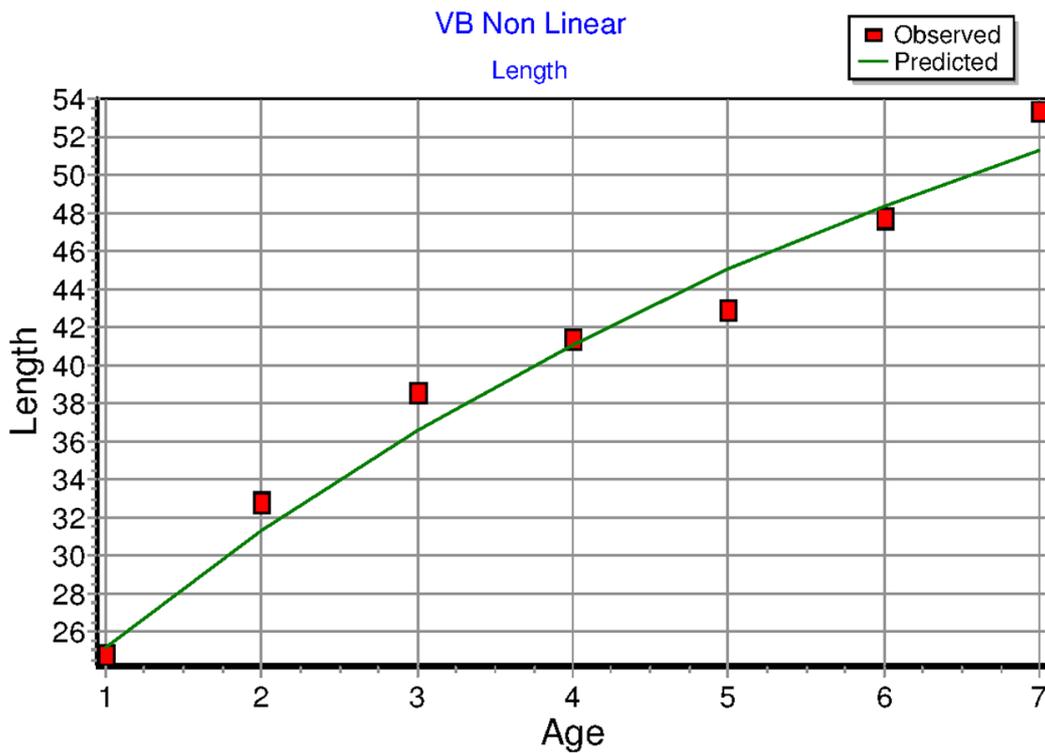
**Figure 1**: Von Bertalanffy growth curve. Calculated mainly until the reach of the sexual maturity (based solely on this period of growth until the 4CY). Age refers to periods; two by year, except the birth one (see text). As it can be seen, growth is progressively decreasing and our Period 6 (first period of the 3CY) probably includes specimens already adult from the 4 CY. Result curve is fairly straight and the growth is not far from linear (see Fig. 2).
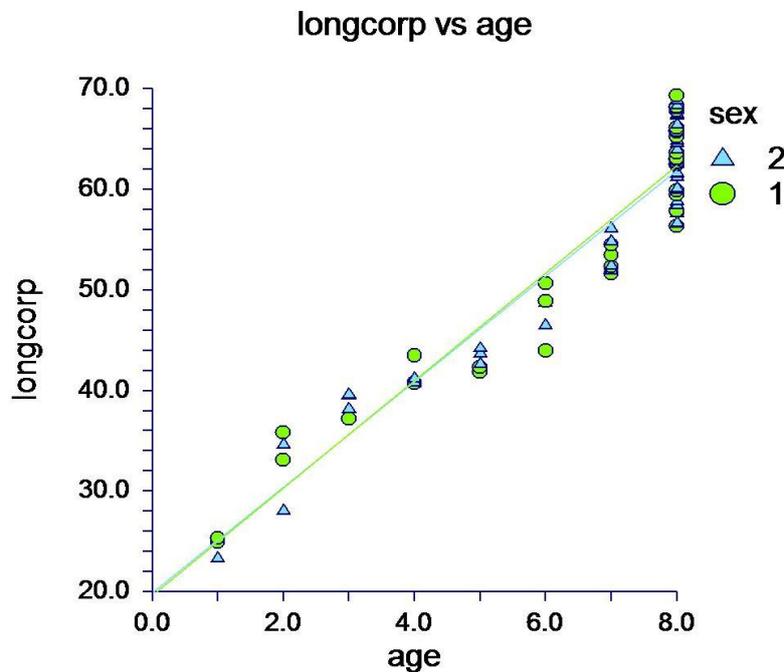


**Figure 2**: Linear growth curve. A graphic representation of this linear growth including all the adults of undetermined age (green points are males and blue triangles females). Ages are periods (as in fig 1). There are two regression lines, one for each sex, but they are so similar (adults of both sexes are from same size) that result is almost indistinguishable. A detailed account of sizes of specimens in each year period and age (for males, females and both sexes together) is presented in Table 5.

**Figure 3**: Specimens of *I. martinezricai* showing diverse grades of tail mutilation and regeneration. Photo 1 and 2: Male and female, respectively, with their autotomized tails from its basis (both of the green morph).Photos 3 and 4: The same, but with autotomized tails in its middle portion (both of the blue morph).Note in all cases the different aspect (color, scales, etc.) of the regenerated tail parts. Photo 5: Juvenile 2CY showing how the vivid color of the tail fades during the next year to its birth. Photo 6: Few hours hatchling of the species. Note the vividly blue colored tail that is able to whirl and break from birth.

*Iberolacerta martinezricai* - SEX-DIMORPHISM

| Character | Males (n=27) | | Females (n=30) | | T-test | P |
|---|---|---|---|---|---|---|
| SVL | 60.78±1.17 | 48.91-69.31 | 60.96±0.94 | 48.71-68.86 | 0.11 | 0.9065 NS |
| GrSr | 11.26±0.3 | 6-14 | 10.53±0.48 | 5-16 | 1.28 | 0.2060 NS |
| GrSl | 10.70±0.35 | 6-15 | 10.3±0.37 | 6-15 | 0.78 | 0.4366 NS |
| GUL | 24.85±0.37 | 20-28 | 24.83±0.29 | 21-29 | 0.03 | 0.9692 NS |
| COLL | 10.85±0.25 | 8-13 | 10.16±0.17 | 9-12 | 2.22 | 0.0308 * |
| DORS | 53.77±0.47 | 50-60 | 52.13±0.57 | 49-59 | 2.21 | 0.0310 * |
| VENT | 25.66±0.16 | 24-28 | 28.93±0.22 | 25-31 | 11.62 | 0.0000 ** |
| FEMr | 18.59±0.36 | 15-24 | 16.96±0.22 | 15-20 | 3.82 | 0.0004 ** |
| FEMl | 18.77±0.39 | 16-25 | 17.3±0.18 | 15-19 | 3.39 | 0.0016 ** |
| LAM | 24.25±0.33 | 21-29 | 23.03±0.33 | 20-27 | 2.60 | 0.0118 *(*) |
| CIRCA | 6.62±0.23 | 4-10 | 6.26±0.23 | 4-10 | 1.08 | 0.2837 NS |
| R-I | 0.85±0.15 | 0-2 | 0.58±0.12 | 0-2 | 1.40 | 0.1640 NS |
| Sn-Lor | 0.04±0.03 | 0-1 | 0±0 | 0-0 | 1.35 | 0.1834 NS |
| Po-Pa | 0.05±0.03 | 0-1 | 0.14±0.04 | 0-1 | 1.53 | 0.1290 NS |
| FLL/SVL | 34.83±0.004 | 30.12-38.7 | 30.68±0.005 | 25.64-36.13 | 5.82 | 0.0000 ** |
| HLL/SVL | 49.9±0.004 | 45.79-53.27 | 44.44±0.006 | 39.17-51.76 | 6.96 | 0.0001 ** |
| PL/PW | 222.94±0.003 | 200.46-280.72 | 211.61±0.01 | 195.35-224.68 | 3.15 | 0.0036 ** |
| DM/PaL | 30.89±0.02 | 13.93-44.13 | 31.60±0.01 | 17-43.57 | 0.28 | 0.7762 NS |
| DT/PaL | 35.57±0.08 | 26.32-43.95 | 35.40±0.01 | 24.4-54.47 | 1.08 | 0.2822 NS |
| AL/AW | 52.65±0.02 | 35.38-73.87 | 57.26±0.01 | 43.06-69.20 | 1.94 | 0.0590 NS |

**Table 1:** Sex dimorphism. Descriptive statistics of escalation characters, biometric indexes and the T-tests searching for differences between males and females.

MALES (n=42)
**CPA Eigenvectors**

| **Factors** | **Factor1** | **Factor2** |
| --- | --- | --- |
| **Eigenvalue** | 8.185693 | 0.836872 |
| **Individual Percent** | 81.86 | 8.37 |
| **CumulativePercent** | 81.869 | 0.23 |
| | | |
| **Variables** | | |
| Bodylength (SVL) | -0.342235 | -0.070054 |
| Forelimb (FLL) | -0.332944 | 0.026212 |
| Hindlimb (HLL) | -0.337392 | -0.042449 |
| Pileuslength (PL) | -0.338704 | 0.036853 |
| Pileuswidth (PW) | -0.338473 | -0.104618 |
| Parietal length (PaL) | -0.338967 | -0.037213 |
| Maseteric (DM) | -0.229325 | 0.736023 |
| Timpanic (DT) | -0.298126 | 0.263707 |
| Anal Width (AW) | -0.324162 | -0.080893 |
| Anal leght (AL) | -0.259724 | -0.600917 |

FEMALES (n=40)
**CPA Eigenvectors**

| **Factors** | **Factor1** | **Factor2** |
| --- | --- | --- |
| **Eigenvalue** | 7. 520528 | 0. 842729 |
| **Individual Percent** | 75.21 | 8.43 |
| **CumulativePercent** | 75.21 | 83.63 |
| | | |
| **Variables** | | |
| Bodylength (SVL) | -0. 349952 | -0. 079422 |
| Forelimb (FLL) | -0. 333909 | 0. 222168 |
| Hindlimb (HLL) | -0. 344851 | 0.123030 |
| Pileuslength (PL) | -0. 356003 | -0. 042557 |
| Pileuswidth (PW) | -0. 343758 | -0. 071414 |
| Parietal length (PaL) | -0. 348938 | -0.033550 |
| Maseteric (DM) | -0. 222333 | 0. 181494 |
| Timpanic (DT) | -0. 223032 | 0. 726211 |
| Anal Width (AW) | -0. 314805 | -0. 275407 |
| Anal leght (AL) | -0.286660 | -0. 533843 |

**Table 2**: Allometry. The results of PCA on the body measurements of *I. martinezricai*. Both in males and females, the most representative character of growth is the body length (SVL) which has the greatest coefficient (thus is, correlation between the original measurements and the "new" variable growth represented by the first axis). As expressed in Material and methods section, all the variables coefficients have the same sign and the first axis represents size. See text for interpretation of the results.

MALES
Eigenvalues after Varimax. Rotation

| Nº | Eigenvalue | Individual % | Cumulative % |
|---|---|---|---|
| 1 | 1.824649 | 51.82 | 51.82 |
| 2 | 1.637626 | 46.51 | 98.33 |

Eigenvector after Varimax. Rotation

| Variables | Factor 1 | Factor 2 |
|---|---|---|
| Gr_suprac (GrS) | -0.077148 | 0.710612 |
| Gr_supracx (GrS) | -0.066438 | 0.590625 |
| Gularia (GUL) | 0.166563 | 0.278435 |
| Collaria (COLL) | 0.019695 | 0.021807 |
| Dorsalia (DORS) | 0.048714 | 0.003699 |
| Ventralia (VENT) | 0.082079 | 0.077708 |
| Femoral (FEMr) | 0.691517 | 0.027795 |
| Femoralx (FEMl) | 0.630450 | 0.077009 |
| Laminasded (LAM) | 0.073364 | 0.180668 |
| Circanal (CIRCA) | -0.267109 | 0.150980 |

FEMALES
Eigenvalues after Varimax. Rotation

| Nº | Eigenvalue | Individual % | Cumulative % |
|---|---|---|---|
| 1 | 1. 796451 | 54.82 | 54.82 |
| 2 | 1. 409723 | 43.02 | 97.82 |

Eigenvector after Varimax. Rotation

| Variables | Factor 1 | Factor 2 |
|---|---|---|
| Gr_suprac (GrS) | -0. 624295 | 0. 216145 |
| Gr_supracx (GrS) | -0. 640593 | 0. 247150 |
| Gularia (GUL) | -0. 020426 | -0. 260137 |
| Collaria (COLL) | -0. 047496 | -0. 350247 |
| Dorsalia (DORS) | 0. 017761 | -0. 379186 |
| Ventralia (VENT) | -0.103263 | -0. 009166 |
| Femoral (FEMr) | -0. 184847 | -0. 505392 |
| Femoralx (FEMl) | -0. 305307 | -0. 543693 |
| Laminasded (LAM) | -0. 242586 | -0. 072231 |
| Circanal (CIRCA) | -0. 003938 | -0. 041797 |

Table 3: Parallel variability in escalation. Results from the Factor analysis with a Varimax Rotation. See text for interpretation of the results.

Von BERTALANFFY GROWTH MODEL

| PERIOD (Yearperiod/ Calendar Year) | OBSERVED LENGTH mm | PREDICTED LENGTH Mm | INCREASE Mm |
|---|---|---|---|
| 1 (Hatchlings / 1 CY) | 24.84 | 25.24 | - |
| 2 (1 year period / 2 CY) | 32.89 | 31.31 | 8.05 |
| 3 (2 year period/ 2 CY) | 38.63 | 36.56 | 5.74 |
| 4 (1 year period/ 3 CY) | 41.4 | 41.1 | 2.77 |
| 5 (2 year period/ 3 CY) | 42.93 | 45.2 | 1.53 |
| 6 (1 year period / 4 CY) | 47.74 | 48.41 | 4.81 |
| 7 (ADULT SIZE) | 53.42 | 51.35 | 5.68 |

**Table 4**: Von Bertalanffy growth curve. "Period" is the sampling moment of the year (see text and Fig 1); "Observed Length" is the average SVL (Snout-vent length of animals); "Predicted Length" is derived from the model of growth curve at that age. "Increase" is growth between two measurement periods.

**Growth. Descriptive Statistics Report**

## MALES

**period=1 (Hatchlings, 1 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 2 | 25.18 | 0.2687006 | 0.19 | 24.99 | 25.37 | 0.38 |

**period=2 (2 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 2 | 34.465 | 1.944544 | 1.375 | 33.09 | 35.84 | 2.75 |

**period=3 (2 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 1 | 37.23 | | | 37.23 | 37.23 | 0 |

**period=4 (3 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 2 | 42.13 | 1.92333 | 1.36 | 40.77 | 43.49 | 2.72 |

**period=5 (3 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 2 | 42.1 | 0.3535534 | 0.25 | 41.85 | 42.35 | 0.5 |

**period=6 (4 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 3 | 47.86 | 3.476047 | 2.006896 | 43.98 | 50.69 | 6.71 |

**period=7 (4 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 5 | 53.092 | 1.129766 | 0.5052465 | 51.61 | 54.51 | 2.9 |

**period=8 (ADULTS)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 19 | 63.86842 | 3.604234 | 0.826868 | 56.35 | 69.31 | 12.96 |

## FEMALES

**period=1 (Hatchlings, 1 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 3 | 24.61667 | 1.142118 | 0.6594021 | 23.3 | 25.34 | 2.04 |

**period=2 (2 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 2 | 31.33 | 4.63862 | 3.28 | 28.05 | 34.61 | 6.56 |

**period=3 (2 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 3 | 39.10333 | 0.817333 | 0.4718875 | 38.16 | 39.6 | 1.44 |

**period=4 (3 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 3 | 40.91333 | 0.2657693 | 0.153442 | 40.75 | 41.22 | 0.47 |

**period=5 (3 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 3 | 43.49667 | 0.817333 | 0.4718875 | 42.6 | 44.2 | 1.6 |

**period=6 (4 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 2 | 47.58 | 1.598061 | 1.13 | 46.45 | 48.71 | 2.26 |

**period=7 (4 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 4 | 53.83 | 1.967215 | 0.9836073 | 51.96 | 56.1 | 4.14 |

**period=8 (ADULTS)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 25 | 62.5956 | 3.781528 | 0.7563055 | 56.59 | 68.86 | 12.27 |

## TOTAL SPECIMENS

**period=1 (Hatchlings, 1 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 5 | 24.842 | 0.8749114 | 0.3912723 | 23.3 | 25.37 | 2.07 |

**period=2 (2 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 4 | 32.8975 | 3.421806 | 1.710903 | 28.05 | 35.84 | 7.79 |

**period=3 (2 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 4 | 38.635 | 1.150087 | 0.5750435 | 37.23 | 39.6 | 2.37 |

**period=4 (3 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 5 | 41.4 | 1.184989 | 0.5299434 | 40.75 | 43.49 | 2.74 |

**period=5 (3 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 5 | 42.938 | 0.9749205 | 0.4359977 | 41.85 | 44.2 | 2.35 |

**period=6 (4 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 5 | 47.748 | 2.589096 | 1.157879 | 43.98 | 50.69 | 6.71 |

**period=7 (4 CY)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 9 | 53.42 | 1.496897 | 0.4989656 | 51.61 | 56.1 | 4.49 |

**period=8 (ADULTS)**

| Count | Mean | Deviation | Error | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| 44 | 63.14523 | 3.718331 | 0.5605595 | 56.35 | 69.31 | 12.96 |

**Table 5**: Age classes sizes. Detailed account of sizes of the specimens in each year period and age (for males, females and both sexes together). See also Fig 2.

**Damaged tails in *Iberolacerta martinezricai***

| Sex/Tail | Intact (0) | Tip (1) | Middle (2) | Basis (3) |
|---|---|---|---|---|
| **MALES** | 4 (23.5 %) | 4 (23.5 %) | 6 (35.2 %) | 3 (17.7 %) |
| **FEMALES** | 2 (20 %) | 3 (30 %) | 3 (30 %) | 2 (20 %) |
| **Sub. 4CY** | 1 | 0 | 2 | 0 |
| **Sub.3CY** | 1 | 0 | 0 | 2 |
| **Sub.2CY** | 2 | 0 | 0 | 1 |
| **Sub. 1CY** | 4 | 0 | 0 | 0 |
| **ADULTS** | 6 (22 %) | 7 (25.9 %) | 9 (33.3 %) | 5 (18.5 %) |
| **Youngs** | 8 (61.5 %) | 0 | 2 (15.3 %) | 3 (23.1 %) |

**Table 6**: Autotomy. Number and percentage of individuals with intact or broken and regenerated tails (only tail tip, middle, or from the basis), separated by age and sex and clustered into young and adults.See also fig. 3.