

Hemipenial microornamentation in *Algyroides marchi* VALVERDE, 1958

(Squamata: Sauria: Lacertidae)

Hemipenis-Oberflächenfeinstrukturen bei *Algyroides marchi* VALVERDE, 1958
(Squamata: Sauria: Lacertidae)

OSCAR J. ARRIBAS

ABSTRACT

The hemipenial microornamentation of *Algyroides marchi* VALVERDE, 1958 is described. It consists of crown-shaped tubercles, as in *A. fitzingeri*, but different from the spiniform tubercles of the Balkan species *A. moreoticus* and *A. nigropunctatus*. Possible phylogenies and intrageneric relationships are discussed.

KURZFASSUNG

Die Oberflächenfeinstrukturen des Hemipenis von *Algyroides marchi* VALVERDE, 1958 werden beschrieben. Sie bestehen aus kronenförmigen Tuberkeln wie bei *A. fitzingeri* und unterscheiden sich von den stachelförmigen Tuberkeln der Balkan-Arten *A. moreoticus* und *A. nigropunctatus*. Mögliche Phylogenien und Beziehungen innerhalb der Gattung werden diskutiert.

KEY WORDS

Reptilia: Squamata: Sauria: Lacertidae: *Algyroides*, *Algyroides marchi*, hemipenis microornamentation, phylogeny, systematics, taxonomy, morphology, Spain

INTRODUCTION

Gross morphology of the everted hemipenis is comparatively homogeneous in lacertid lizards, but the study of the microornamentation of the hemipenial epithelium during the reproductive period reveals the existence of some small microscopic tubercles, which can differ in form among the different species. The development of this epithelium is controlled by hormonal changes during the reproductive cycle, as a result of which tiny protuberances develop. Each protuberance is a unique epithelial cell (BÖHME 1971, 1993) that can have the form of a thorn, more or less rounded or curved (called finger-shaped, hooked, or spiniform microornamentation), fork (forked microornamentation), or small tubercle with minuscule spiniform prolongations on the apex (crown-shaped microornamentation) (KLEMMER 1957; BÖHME 1971; ARNOLD 1973, 1986, 1989; ARRIBAS 1994, 2001). Moreover, it was shown that these epithelia are shed every day during the reproductive cycle (IN DEN BOSCH 2001). The use of hemipenial microornamentation for taxonomic and sys-

tematic purposes in lacertids dates back to KLEMMER (1957) and BÖHME (1971). The latter author reviewed the microornamentations of a great number of species. Subsequently, other authors such as ARNOLD (1973, 1986, 1989), ARRIBAS (1994, 2001), BÖHME (1993), and LEPTIEN & BÖHME (1994) used this information for taxonomic purposes.

Regarding the Mediterranean genus *Algyroides* BIBRON & BORY DE SAINT-VINCENT, 1833, BÖHME (1971) described the microornamentation of the Balkan species *A. moreoticus* BIBRON & BORY DE SAINT-VINCENT, 1833 and *A. nigropunctatus* (DUMÉRIL & BIBRON, 1839), both with thorn-shaped tubercles, and the Tyrrhenian species *A. fitzingeri* (WIEGMANN, 1834), with crown-shaped tubercles. However, comparative information lacks for *A. marchi* VALVERDE, 1958 (see e. g., HARRIS et al. 1999). In addition to results presented in a general account of *Algyroides* (ARNOLD et al. 2007), the author describes the hemipenial microornamentation of *A. marchi* in comparison with the structures found in its congeners.

MATERIALS AND METHODS

Two specimens of *Algyroides marchi* fixed with everted hemipenes were studied. The specimens were captured on April 21, 1989 in Calar del Mundo, Riopar, Albacete Province (Spain) at 1100 m a.s.l.

For the study of the microornamentation, the procedure described in ARRIBAS (2001) was followed. The hemipenes were dehydrated in a series of increasing ethanol concentrations (70%, 90%, 100%, 12 hours in total). After this, the material was transferred to xylene for two to six hours, then to

paraffined xylene for the same period and finally immersed and soaked in melted paraffin for eight hours for embedding.

The solidified blocks were cut with a hand microtome; slices (as thin as possible) were deparaffined with xylene (15 min), and rehydrated with ethanol of decreasing concentration (100%, 90%, 70%) and finally distilled water (five to ten min), prior to microscopic observation at a magnification of 1000 times. No staining.

RESULTS AND DISCUSSION

The hemipenis microornamentation of *Algyroides marchi* can be classified crown-shaped. Thus, apart from some immature tubercles similar to hook or finger shaped protuberances, the majority was ampulliform (bottle-shaped), fairly elongate with truncate tips and spiny prolongations in their fine apices (Fig. 1).

It is difficult to decide whether this constitutes a primitive or derived character state. The hook or finger-shaped type (which is very common in the Eremiadini) is considered primitive by the ontogenetic criterion and its lesser complexity. Among Lacertini, however, both states (crown-shaped and finger-shaped) coexist in parallel and some of the latter seem to be secondary regressions (ARRIBAS 2001). Moreover, both types of microornamentation appear in closely related species, like *Omanosaura cyanura* (ARNOLD, 1972) versus *Omanosaura jayakari* (BOULENGER, 1887), the species of *Algyroides*, or *Iberolacerta (Pyrenesaura)*. Prudence is required in the use of this character for phylogenetic reconstruction, apart from the mere species diagnoses.

The hemipenial microornamentations of *A. marchi* and *A. fitzingeri* are very similar to each other, which coincides with the position of both species in the most recent phylogenetic reconstructions of the genus (HARRIS et al. 1999; PAVLICEV & MAYER 2009). According to HARRIS et al. (1999), the relationships of the species within the genus, based on a combination of morpho-

logical and molecular (mitochondrial 12S and 16S rRNA sequences) information are (((*marchi*, *fitzingeri*) *moreoticus*) *nigropunctatus*), without distinct groupings. PAVLICEV & MAYER (2009) who obtained their results from a combination of nuclear and mitochondrial genes (cyt b, 12S rRNA, 16S rRNA, rag1, and c-mos; 3600 bp in total) presented an interesting topological detail in their phylogeny of the subfamily Lacertinae: Although not fully supported, especially for nuclear genes, close relationship between *Dinarolacerta* [*D. mosorensis* (KOLOMBATOVIĆ, 1886) and *D. montenegrina* LJUBISAVLJEVIĆ, ARRIBAS, DŽUKIĆ & CARRANZA 2007] with *Algyroides* was suggested. Of the two trees in PAVLICEV & MAYER (2009), the tree derived from all studied genes together, had the topology ((*marchi*, *fitzingeri*) (*mosorensis*, *montenegrina*)) (*moreoticus*, *nigropunctatus*), suggesting that *Algyroides* was paraphyletic, whereas the analysis of nuclear genes alone supported monophyly of *Algyroides*. However, a tree topology alternative to a monophyletic *Algyroides*, could not be rejected (PAVLICEV & MAYER 2009).

These authors suggested to investigate the relationship between *Dinarolacerta* and *Algyroides*, although the results were not sufficient to conclude paraphyly of *Algyroides*. These studies must include, from the current author's point of view, different approaches and all the species involved. Also *Dinarolacerta mosorensis* has crown-shaped protuberances (BÖHME 1971).

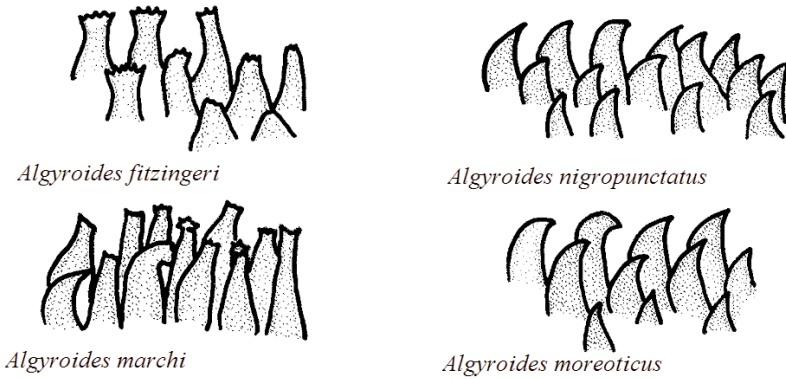


Fig. 1: Hemipenial microornamentation of *Algyroides* species: *Algyroides marchi* VALVERDE, 1958 (original), *Algyroides fitzingeri* (WIEGMANN, 1834), *A. nigropunctatus* (DUMÉRIE & BIBRON, 1839) and *A. moreoticus* BIBRON & BORY, 1833 (the last three redrawn from BÖHME 1971).

The author's preferred hypothesis is *Dinarolacerta* being the sister group of all *Algyroides*. In the hypothetical case that *Algyroides* is paraphyletic, two procedures are possible: 1) *Dinarolacerta* is synonymized with *Algyroides*, which is problematic as both would not share any of the characters diagnostic of *Algyroides* (see below); 2) *Algyroides* is split into two entities. If this latter approach is adopted, the East Mediterranean (Balkan) group should retain the name *Algyroides* s. str. (type species: *Algyroides moreoticus* BIBRON & BORY DE SAINT-VINCENT, 1833), and for the West Mediterranean (Ibero-Tyrrhenian) group, a new name had to be chosen after a careful study of synonymies.

It is important to bear in mind that the nominal genus *Algyroides* was polyphyletic until the systematic review by ARNOLD (1973), and included both European and African *Algyroides*-like species. ARNOLD (1973) clearly showed that there were enough osteological, hemipenial and morphological differences to place the African species into a separate genus, *Adolfus* STERNFELD, 1912, but retained the European species in the somewhat heterogeneous genus *Algyroides* (ARNOLD et al. 2007). Recently, a new genus was splitted from *Adolfus*: *Congolacerta* GREENBAUM, VILLANUEVA, KUSAMBA, ARISTOTE & BRANCH, 2011 (type species: *Lacerta vauereselli* TORNIER, 1902) including *C. asukului* GREENBAUM, VILLA-

NUEVA, KUSAMBA, ARISTOTE & BRANCH, 2011).

European *Algyroides* have some characteristics in common: M-NORs (Medium-sized Nucleolus Organizer Regions) in the karyotype, more or less enlarged dorsal scales and a characteristic scale microornamentation showing "raised pustulate swellings projecting among the upturned posterior edges of the strap-shaped cell surfaces that constitute the oberhautchen" (HARRIS et al. 1999; ARNOLD 2002; ARNOLD et al. 2007). The M-NORs character seems to have developed independently (by chromosomal fragment rearrangement) in different groups among Lacertini: It is shared by *Hellenolacerta graeca* (BEDRIAGA, 1886), a pair of Central Spanish *Iberolacerta*, namely *I. cyreni* (MÜLLER & HELLMICH, 1937) and *I. martinezricai* (ARRIBAS, 1996), all *Podarcis* species and *Timon lepidus* (DAUDIN, 1802), but not by *Dinarolacerta*. The characteristic above mentioned pustulate swellings of the "oberhautchen" appear only in one of the African *Algyroides*-like *Adolfus* viz. *A. africanus* (BOULENGER, 1906) but not in *Dinarolacerta* nor in other Lacertini species apart from *Algyroides* (ARNOLD 2002). About the enlarged and keeled scales present in *Algyroides*, there is a lot of literature that suggests that this character is habitat-linked (see for instance ARNOLD 1973 and ARNOLD et al. 2007). On the other hand, morphological variability

within *Algyroides* is very high, the different species presenting different numbers of vertebrae and premaxillary teeth, marginated or emarginated clavicles, and spiny hemipenial ornamentations or crown-shaped tubercles (Fig. 1).

If *Dinarolacerta* was included in *Algyroides*, the group would lose all its main diagnostic characteristics mentioned above (enlarged scales, M-NOR and oberhautchen). On the contrary, if *Algyroides* was split in two groups, there would be several diagnostic characters for each entity: *Algyroides* s. str. (Balkan species) would have (usually) pterygoid teeth, supraocular osteoderms that are complete in adults, and

hook-shaped hemipenial tubercles; the Ibero-Tyrrhenian group (in the sense expressed here, including the species *fitzingeri* and *marchi*) on the other hand, would lack pterygoid teeth, have the supraocular osteoderms incomplete (fenestrated) in adults, and crown-shaped hemipenial tubercles.

Whereas the above considerations are open to further discussion, it seems rather clear at the moment that there is a close relationship between *Algyroides* and *Dinarolacerta*. New phylogenetic studies, including more genes and analyses are needed in order to clarify the relationships between *Algyroides* and *Dinarolacerta* and among the species of *Algyroides*.

REFERENCES

- ARNOLD, E. N. (1973): Relationships of the palaeartic lizards assigned to the genera *Lacerta*, *Algyroides* and *Psammadromus* (Reptilia: Lacertidae).- Bulletin of the British Museum (Natural History) / Zoology, London; 25: 289-366.
- ARNOLD, E. N. (1986): The hemipenis of lacertid lizards (Reptilia: Lacertidae): structure, variation and systematic implications.- Journal of Natural History, London; 20: 1221-1257.
- ARNOLD, E. N. (1989): Towards a phylogeny and biogeography of the Lacertidae: relationships within an Old-World family of lizards derived from morphology.- Bulletin of the British Museum (Natural History) / Zoology, London; 55 (2): 209-257.
- ARNOLD, E. N. (2002): History and function of scale microornamentation in lacertid lizards.- Journal of Morphology, Malden; 252 (2): 145-169.
- ARNOLD, E. N. & ARRIBAS, O. & CARRANZA, S. (2007): Systematics of the Palearctic and Oriental lizard tribe Lacertini (Squamata: Lacertidae: Lacertinae), with descriptions of eight new genera.- Zootaxa, Auckland; 1430: 1-86.
- ARRIBAS, O. (1994): Una nueva especie de lagartija de los Pirineos Orientales: *Lacerta (Archaeolacerta) aurelioi* sp. nov. (Reptilia: Lacertidae).- Bolletino del Museo regionale di Scienze naturali di Torino, Torino; 412 (1): 327-351.
- ARRIBAS, O. J. (2001): - Hemipenial morphology and evolutionary inferences on Pyrenean Mountain Lizards (Squamata: Lacertidae).- Butlletí de la Societat Catalana d'Ictiologia i Herpetologia, Barcelona; 15: 32-44.
- BÖHME, W. (1971): Über das Stachel epithel am Hemipenis lacertider Eidechsen und seine systematische Bedeutung.- Zeitschrift für zoologische Systematik und Evolutionsforschung, Hamburg; 9: 187-223.
- BÖHME, W. (1988): Zur Genitalmorphologie der Sauria: Funktionelle und stammesgeschichtliche Aspekte.- Bonner Zoologische Monographien, Bonn; 27: 1-176.
- BÖHME, W. (1993): Hemipenial microornamentation in *Lacerta brandtii* DE FILIPPI, 1863: Falsification of a systematic hypothesis? (Squamata: Sauria: Lacertidae).- Herpetozoa, Wien; 6 (3/4): 141-143.
- HARRIS, D. J. & ARNOLD, E. N. & THOMAS, R. H. (1999): A phylogeny of the European lizard genus *Algyroides* BIBRON & BORY, 1833 based on DNA sequence, with comments on the evolution of the group.- Journal of Zoology, London; 249: 49-60.
- IN DEN BOSCH, H. A. J. (2001): Male lizards change their genital skin almost every day: squamate pan-epidermal synchrony refuted.- Canadian Journal of Zoology, Ottawa; 79 (4): 512-516.
- KLEMMER, K. (1957): Untersuchungen zur Osteologie und Taxonomie der europäischen Mauereidechsen.- Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft, Frankfurt am Main; 496: 1-56.
- LEPTIEN, R. & BÖHME, W. (1994): First captive breeding of *Lacerta (Omanosaura) cyanura* ARNOLD, 1972, with comments on systematic implications posed by the reproductive pattern and the juvenile dress (Squamata: Sauria: Lacertidae).- Herpetozoa, Wien; 7 (1/2): 3-9.
- PAVLICEV, M. & MAYER, W. (2009): Fast radiation of the subfamily Lacertinae (Reptilia: Lacertidae): History or methodical artefact? - Molecular Phylogenetics and Evolution, San Diego; 52: 727-734.

DATE OF SUBMISSION: December 12, 2011

Corresponding editor: Heinz Grillitsch

AUTHOR: Oscar J. ARRIBAS, Avda. Fco. Cambó 23; 08003 – Barcelona, Spain <oarribas@xtec.cat >