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Gradual micro-ornamentation shifts on a single scale: A case of fossorial snake *Xerotyphlops vermicularis*

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Abstract

Purpose: The outermost surface of multilayered reptile epidermis is called oberhautchen. This hard layer has sub-cellular structures, often called micro-ornamentations. These microstructures have a wide, species-specific variety. This differentiating morphology leads the researchers to think that they might be correlated with either taxonomic state of the species or its ecological role. Even though many research has been conducted, up to date, the debate of whether micro-ornamentations are related to phylogeny or ecology has not resulted. Detailed scale micro-ornamentation research was lacking on *Xerotyphlops vermicularis*, and since the micro-ornamentations were found to be species-specific and even varying within a singular scale of the same specimen, we aimed to fulfil the lack with the present study.
Method: We examined dorsal skin samples with scanning electron microscopy (SEM) for surficial morphology and with light microscopy for the multilayered epidermis.
Findings: We found that different types of micro-ornamentations are present in different regions on a single scale surface, changing gradually; triangular cells with smooth edges and surfaces change into denticulated edges with pits on the cell surface.
Conclusion: It is clear that similar, detailed morphological studies need to be conducted in many different species to reveal the true nature of the correlation between micro-ornamentations and ecology/taxonomy.

Keywords: micro-ornamentation, epidermis, diversity, *Xerotyphlops*, morphology

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Tek bir pul üzerinde kademeli mikro-süsleme değişimleri: Fossorial yılan *Xerotyphlops vermicularis* örneği

Özet

Amaç: Çok katmanlı sürüngen epidermisinin en dış tabakası oberhautchen tabakasıdır. Bu sert tabaka, genellikle mikro-süslemeler olarak adlandırılan hücre altı yapılar taşır. Bu mikro yapılar, türe özgü geniş bir çeşitliliğe sahiptir. Bu farklılaştırıcı morfoloji, araştırmacıları bunların türün taksonomik durumu veya ekolojik rolüyle ilişkili olabileceğini düşünmeye yönlendirmektedir. Bugüne kadar birçok araştırma yapılmış olmasına rağmen, mikro-süslemelerin filogeni veya ekoloji ile ilişkili olup olmadığı tartışması sonuçlanmamıştır. *Xerotyphlops vermicularis* üzerinde ayrıntılı pul mikro-süs araştırması eksiktir ve mikro-süslemelerin türe özgü olduğu ve hatta aynı örneğin tek bir pulunda bile değiştiği bulunduğundan, bu çalışmayla bu eksikliğin giderilmesi amaçlanmıştır.
Metod: Sırt deri örnekleri yüzeysel morfoloji açısından taramalı elektron mikroskobu (SEM) ile, çok katmanlı epidermis açısından ise ışık mikroskobu ile incelenmiştir.
Bulgular: Tek bir pul yüzeyinde farklı bölgelerde farklı tipte mikro-süslenmelerin bulunduğu, bunların giderek değiştiği; düzgün kenarlı ve yüzeyli üçgen hücrelerin, hücre yüzeyinde çukurlar bulunan dişli kenarlı hücrelere dönüştüğü saptanmıştır.
Sonuç: Mikro süsler ile ekoloji/taksonomi arasındaki ilişkinin gerçek niteliğini ortaya koyabilmek için birçok farklı türde benzer, ayrıntılı morfolojik çalışmaların yapılması gerekmektedir.

Anahtar kelimeler: mikro-süsleme, epidermis, çeşitlilik, *Xerotyphlops*, morfoloji

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1. Introduction

Reptiles have a complex, multilayered epidermis. The deepest layer is stratum germinativum which is a single cell layer that generates the upper layers. The outermost layers consist of dead, keratinized cells as well as the cellular derivatives. Live, epidermal cells differentiate and die during maturation to compose the protective, hard, surface layer [1].

Reptiles shed their epidermis periodically with the process called the moulting or shedding cycle superintended by hormonal factors which has three main steps: resting phase, renewal phase and shedding (moulting), respectively. Snake epidermis in particular, comprises of six layers from stratum germinativum outwards at the time of renewal phase which are clear, lacunar, alpha, mesos, beta and oberhautchen, respectively. These layers are called the epidermal generation and during moulting, the outer epidermal generation is completely shed, exposing the young, inner generation. Snakes, unlike other squamates, shed their epidermis as a single piece [1].

The oberhautchen which is the outmost layer of the epidermis, constitutes structures on the surface. These sub-cellular microstructures were first discovered using light microscopy [2,3], and findings increased incrementally by the discovery and extensive use of scanning electron microscopy. The microstructures termed and classified variously through time such as “microornamentation” [4], “microdermatoglyphics” ([5], “ultradermatoglyphics” [6], “dermatoglyphics” [7], “microarchitecture” [8], “microsculpture” [9], and nanogratings [10].

Scale micro-ornamentations are studied in terms of cell shape, cell border, cell surface and ridges [10]. Different cell borders were termed differently such as echinate, plicate, dentate, lamellate, imbricate etc. due to their morphological features [11-13]. There have been two advocated hypotheses about the correlation of varied morphology of micro-ornamentations with evolution: One suggests a phylogenetic relationship [5, 7, 8, 10], and the other puts forward the idea of ecological role [14]. But since the micro-ornamentations differ interspecifically [15] as well as body parts of the same individual and even within singular scale [11-13], ecological adaptation has caught more attention [16]: It was found that micro-ornamentation morphology is related to locomotor behaviour [17], scale colour [18], skin cleaning (dirt-shedding) hydrophobicity [19], camouflage and thermoregulation [20]. Up to date, the debate of whether micro-ornamentations are correlated with phylogeny or ecology has not resulted.

Variation of micro-ornamentation morphologies among different parts of a singular scale was thought to be due to wearing [21]. It was also found that in some species, micro-ornamentations show gradient morphology from the base of the scale (cranial end) through the tip (caudal end) [10].

The findings of ecological role of micro-ornamentations let the scientist compare reptile species that have different life habits such as aquatic, arboreal or fossorial forms. Fossorial life habits have been shown most likely to be the ancestral habit of snakes, additionally, it was argued that different micro-ornamentation types might represent adaptations to varying life habits [10]. The members of Typhlopidae family are cylindrical, small, burrowing and harmless snakes that have similar cycloid scales at dorsal, lateral and ventral parts of the body. *Xerotyphlops vermicularis* (European Blind Snake) distributes from Albania to Afghanistan. This fossorial blind snake is widespread throughout most of Türkiye being more abundant in Western, Central, and Southern Anatolia, found under rocks and in worm burrows in damp, sparsely vegetated open areas and on slopes [22].

Although micro-ornamentations of *X. vermicularis* was included in a publication that examines 353 snake species [10] it was depicted with a single image, and singular-scale variation of micro-ornamentations was not considered. The present study reveals the detailed micro-ornamentation structure of this fossorial snake for the first time in Anatolian specimens, using skin histology and SEM images.

2. Materials and methods

Six adult individuals of Eurasian Worm Snake *X. vermicularis* from ZDEU Museum (Zoology Department, Ege University) were used to examine skin structures and micro-ornamentations. The museum numbers of the specimen are as follows: 1983/72_1-3, 2001/6_1-3 from Seferihisar, İzmir. We examined dorsal skin samples with scanning electron microscopy (SEM) for surficial morphology and with light microscopy for the multilayered epidermis.

For light microscopy, ethanol-preserved specimens were dehydrated in increasing alcohol series (80, 90, 100 %), made transparent with xylol, subjected to 3 series of paraffin baths and finally embedded in paraffin. 5-8 μm sections were taken and stained with Hematoxylin Eosin. They were analyzed under an Olympus CX31 light microscope. Photographs were taken with a CMEX 5.0 camera and analyzed using Image Focus 4 Vers. 2.9 and Image J Vers. 1.53j. To better illustrate the denticulations observed in histological sections, the relevant areas in the photographs were enlarged on the computer, and the enlarged images were desaturated using Corel Draw X6. This allowed for better visualization of the denticulations in the resulting black-and-white images and comparison with the originals (Figure 5).

For scanning electron microscopy, skin samples were post-fixed in 2.5% glutaraldehyde at room temperature for 2-8 hours, washed with Sorensen phosphate buffer, dehydrated in increasing alcohol series and dried using a Leica EMCPD300 critical point dryer. They were coated with gold-palladium using Leica-EM-ACE600 and analyzed with

Thermoscientific apreo8 at Ege University Central Research Testing and Analysis Laboratory. The terminology for micro-ornamentation is used from [10] and [23]. The graphics in Figure 1 were made using Corel Draw X6 in reference to the results.

Measurements were taken using scanning electron micrographs. For the aspect ratio (width/length ratio) of the microstructures (that is cell width/length) 10 cells were measured from each scale sub-region per individual. A total of 360 (10 cells x 5 sub-region x 6 individuals) measurements were taken.

3. Results

The findings of the dorsal skin samples of *X. vermicularis* show that different types of micro-ornamentations are present in different sub-regions on a single scale surface (Figure 1). In terms of this variation, the scale is divided into two main parts: the dorsal surface (DS), the surface where the scale comes into contact with the external environment and the other scales covering it; and the ventral surface (VS), the side facing the body and therefore the underlying scales (Figure 1).

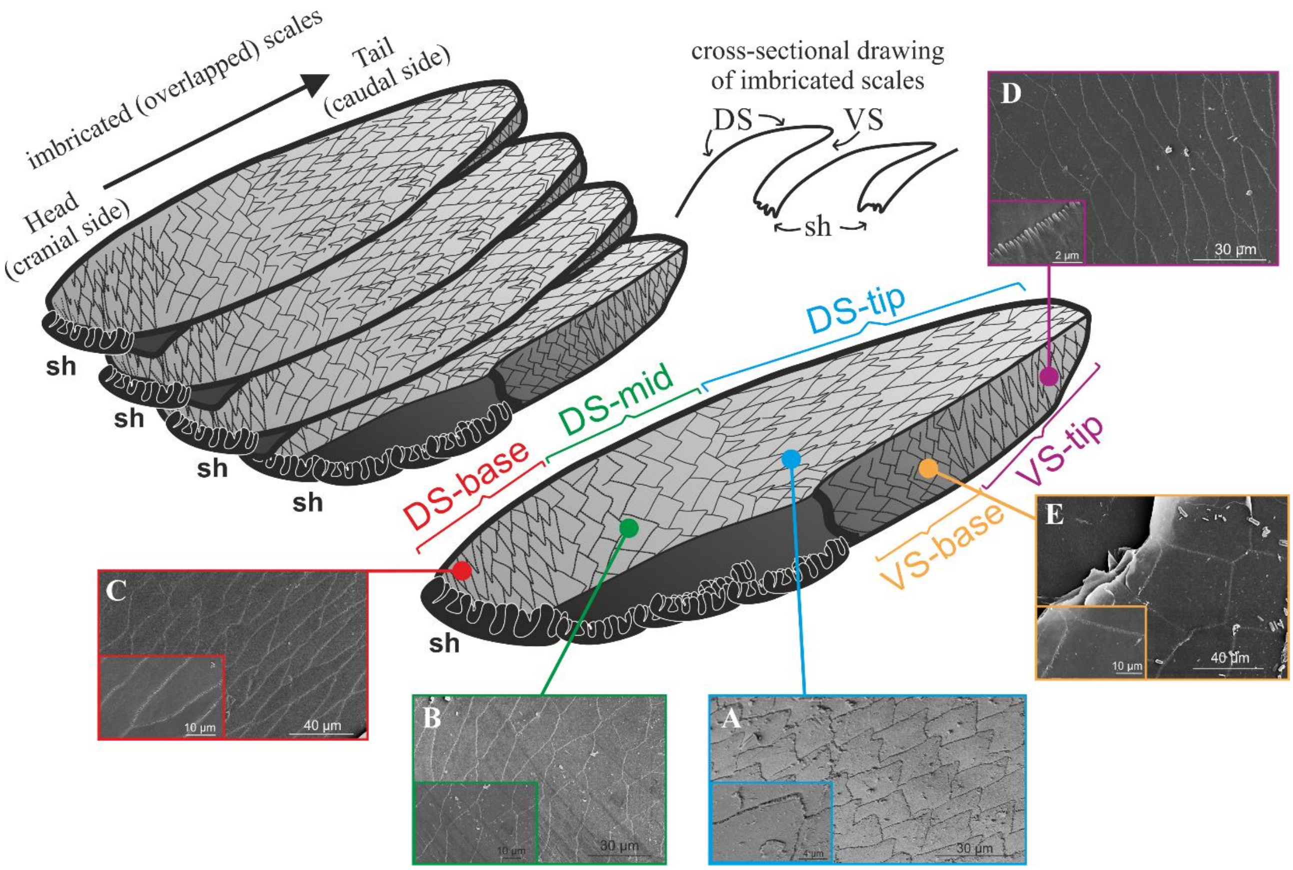

Figure 1. The diagram of the general scale arrangement and the microstructural regions on a single scale in *X. vermicularis* is shown, along with SEM images (A-E) of each scale sub-region. The small boxes within each SEM image show enlarged photographs of regions showing denticulated or smooth edges. A. Micro-ornamentations with smooth edges, arranged like imbricated scales, found on DS-tip. B. Denticulated edges, beginning to become apparent, with flat structures, found on DS-mid. C. Structures with greater width than length and distinct denticulated edges, found on DS-base. D. Structures with denticulated edges, found on VS-tip. E. Pentagonal structures with distinct denticulated edges, found on VS-base. sh: scale hinge

An examination of micro-ornamentations on the dorsal surface (DS) reveals that this surface is also divided into three distinct sub-regions (Figure1 A-C). The first is the caudal (tip) portion of the scale (DS-tip) (Figure 1 A). In this region, the micro-ornamentations are pointed and triangular, resembling small, imbricated scales. The borders of these structures are smooth and non-denticulated (Figure 2A-C). These structures are longer than they are wide (Table 1).

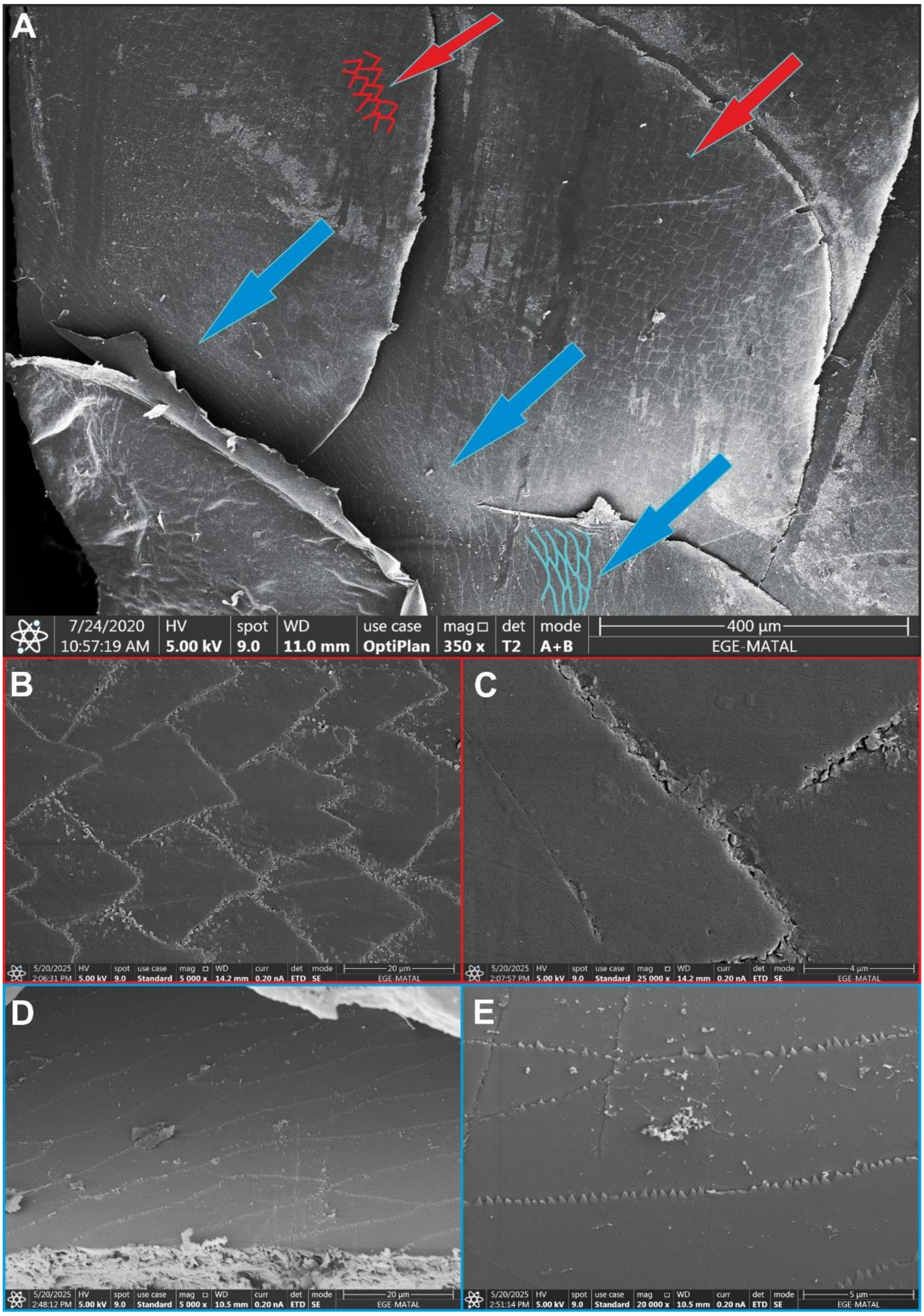

Figure 2. SEM images of the dorsal skin of *X. vermicularis*. A. Surface view of the scales showing imbricated orientation. Two of the three micro-ornamentation sub-regions of DS are visible: Red arrows show DS-tip micro-structures that are also shown with red outline while blue arrows and outline show DS-base region. B and C show smooth-edged DS-tip micro-ornamentations in higher magnifications. D. DS-base micro-ornamentations from a cross-sectioned view. E. Surface view of DS-base micro-ornamentations

The second sub-region of the dorsal surface is the middle region (DS-mid) (Figure 1 B). Here, the triangular pattern seen at the tip gradually becomes splayed and widened (from tip to base, respectively), while the denticulations at the edges gradually become more prominent. The imbricated-like pattern at the DS-tip micro-ornamentations is no longer visible in this region. The lengths and widths of these structures are similar (Table 1).

In the third sub-region of the dorsal surface, the cranial scale base (DS-base) (Figure 1C), the structures in the DS-mid are considerably expanded and much shorter in length than in width. Denticulate micro-ornamentations at the edges are clearly visible in this region (Figure 2D, E).

Table 1. Minimum and maximum values of the measurements and mean±stdDV of width/length ratio (all measurements are in µm)

Sub-region (n=10)		**min**	**max**	**mean±stdDV**
DS-tip	length	23.188	40.597	0.82±0.16
	width	17.053	32.794	
DS-mid	length	15.417	23.136	1.42±0.35
	width	19.365	35.425	
DS-base	length	9.038	20.219	3.16±0.8
	width	21.702	63.255	
VS-tip	length	11.098	19.062	4.35±1.1
	width	41.415	80.412	
VS-base	length	28.253	52.528	1.5±0.3
	width	46.006	69.033	

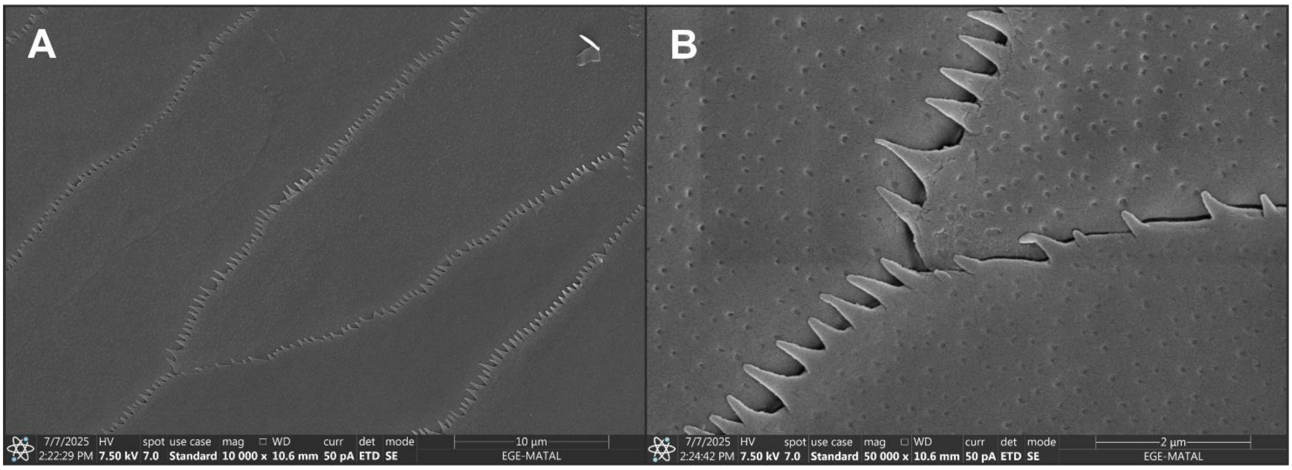

Figure 3. SEM images showing A. wide cells with denticulated edges of DS-base and B. pits in between the denticulations of the same region

On the ventral surface (VS), where the scale faces the body and the underlying scales, two sub-regions are distinguished (Figure 1D, E). The micro-ornamentations at the tip (VS-tip) are short, broad, and have denticulated edges, similar to those of DS-base, while at the base of the ventral surface (VS-base), they are broadened and widened, and mostly pentagonal (see Figure 1E). They resemble DS-mid micro-ornamentation patterns. Their edges also consist of denticulated projections. Cell surfaces of all regions examined were smooth except for DS-base sub-region. There are pits in between the denticulated edges of the cells (Figure 3). Additionally, no ridges were observed in any region or sub-region.

Histological sections showed highly imbricated scales. 3-5 scales are visible in one section on top of another like a “sandwich” (Figure 4). Oberhautchen layers are prominent on the outermost part of each scale (Figure 4). Denticulations of DS-base cell edges are distinct, and they are seen even more clearer on the magnified images, both with original color and desaturated ones (Figure 5 A-L).

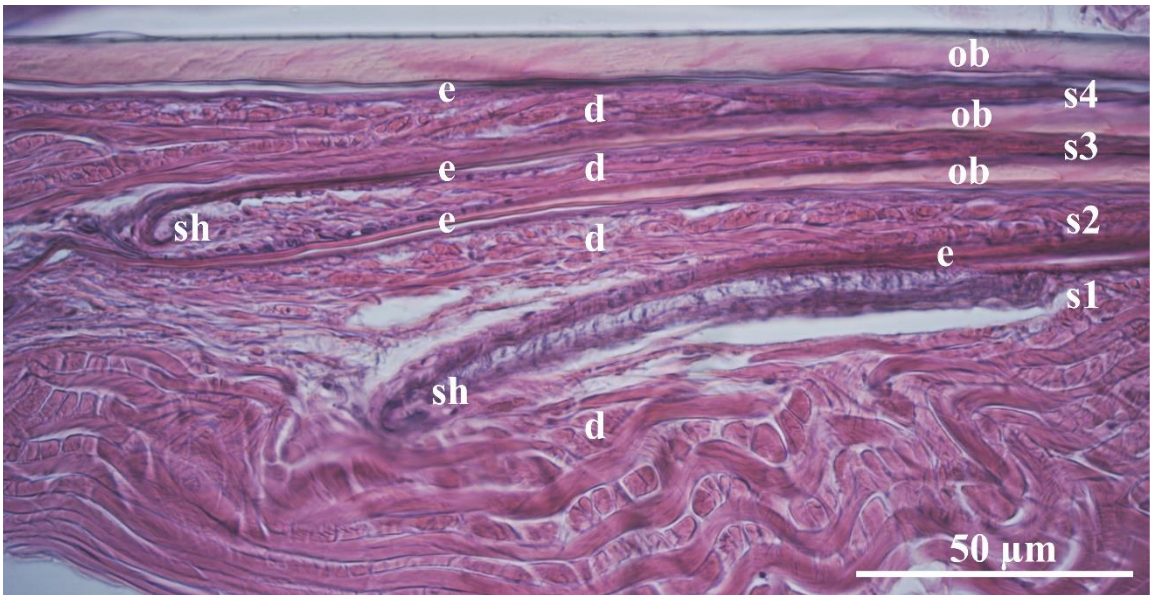

Figure 4. Histological section of the dorsal skin of *X. vermicularis* showing the "sandwich-like" scales that are highly imbricated. Four overlapping scales (s1, s2, s3 and s4; from inside out respectively) are visible. s: scale; sh: scale hinge; e: epidermis; ob: oberhautchen; d: dermis

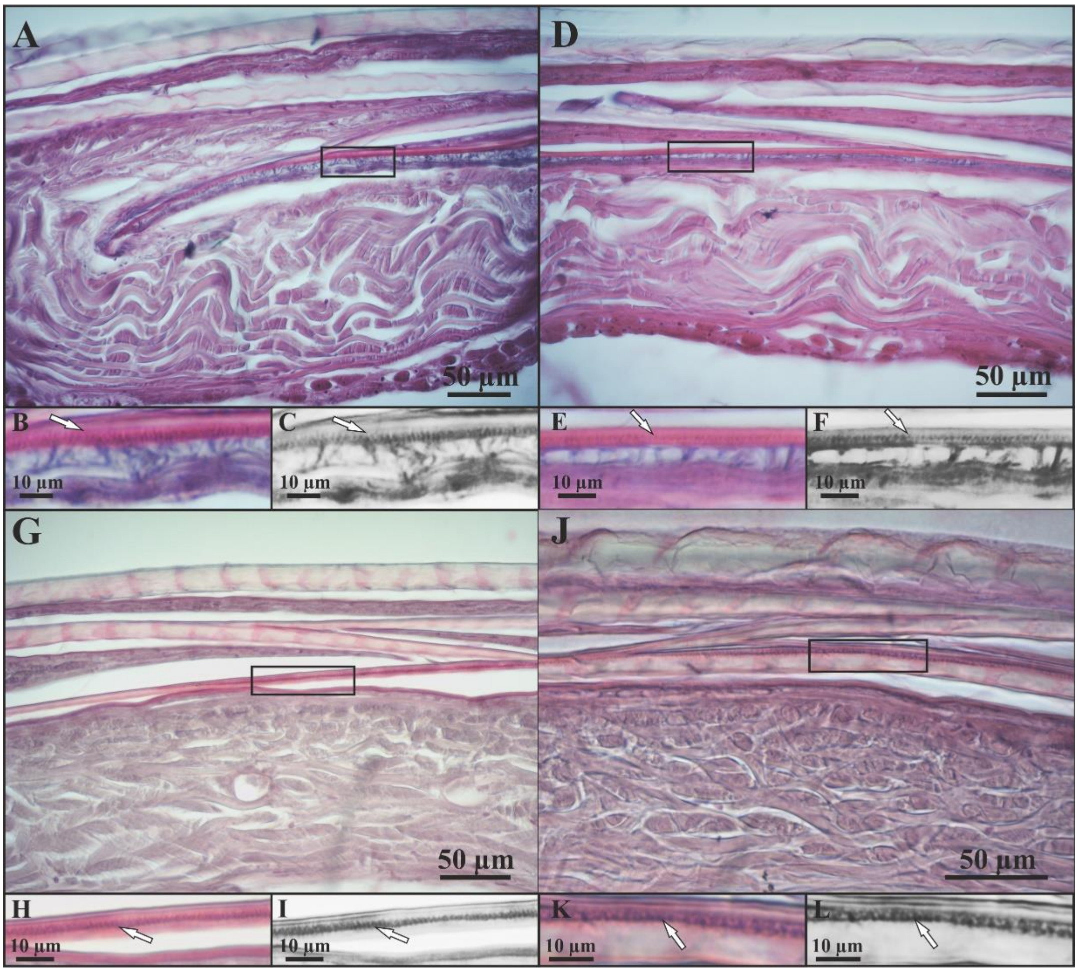

Figure 5. There are four different histological cross-section images (A, D, G, J) of dorsal skin of *X. vermicularis* showing the visible dentate structures of DS-base region. Magnified images of the parts shown in black boxes are given below every image with original coloring on the left (B, E, H, K) and artificially generated black-white ones on the right (C, F, I, L). Arrows showing the denticulated micro-ornamentations at the DS-base region

4. Conclusions and discussion

Micro-ornamentations in 353 snake species with different life habits such as aquatic, arboreal, terrestrial were examined including various fossorial families (e.g., Leptotyphlopidae, Anomalepididae, Uropeltidae, etc.) as well as species from the Typhlopidae family (e.g., *Acutotyphlops subocularis*, *Argyrophis diardii*, *Indotyphlops braminus*, etc.) [10]. But detailed scale micro-ornamentation research was lacking on *Xerotyphlops vermicularis* alone, and since the micro-ornamentations were found to be species-specific and even varying within a singular scale of the same specimen, we aimed to fulfil the lack with the present study.

We found out that individual scales of *X. vermicularis* have two main regions that have gradually changing micro-ornamentations: Dorsal (DS) and ventral (VS) surfaces DS has three sub-regions, DS-tip, DS-mid and DS-base from caudal end to cranial end (closer to scale hinge), respectively, and micro-ornamentations become wider and narrower, while the denticulated edges (short digits of [10]) become more prominent in this direction. Ventral surface of the scale (VS) has two distinct regions, VS-tip and VS-base, again from caudal end to cranial end of the scale where the cells are first wide and narrow then resembling hexagons with denticulated edges in both sub-regions.

Our findings of gradually changing aspect ratio of the cells on a single scale surface are consistent with [13] who showed that the cell widths vary greatly on a single scale. Additionally, [23] found and showed that basal region of lateral scale of fossorial *Melanophydium punctatum* (Uropeltidae) has a gradient change of micro-ornamentations similar to DS-mid to DS-tip of *X. vermicularis*. After comparison of SEM images, compatibility was found with the micro-ornamentations of some of the fossorial forms studied previously, yet it should be noted that the previous research mostly does not specify which scale region the photos were taken from. Therefore, we compared them by stating the similarity of cell shape and edge state (smooth/ denticulated) with the specific regions of *X. vermicularis* scales: *Leptotyphlops macrolepis* and *Liotyphlops ternetzii* similar to DS-base and VS-tip, *Typhlops mirus* similar to DS-mid [23], *Indotyphlops braminus* similar to DS-base and VS-tip (with less pronounced denticulations) [10], *Rhomphotyphlops braminus* also similar to DS-base and VS-tip [24]. The *X. vermicularis* image of [10] shows DS-base structure and is also similar to VS-tip but not the smooth edged, triangular DS-tip cells.

Even though, formerly mentioned *I. braminus* and *R. braminus* are also Typhlopidae members and showed similarities, micro-ornamentations of other Typhlopidae members have been found to carry quite different and varied structures from *X. vermicularis* such as *Acutotyphlops subocularis* which has smooth edges as DS-tip but the cell chape is not triangular [10]. Besides, some of the phylogenetically distinct snake species that also have a different lifestyle than *X. vermicularis* have been shown to have similar micro-ornamentation patterns such as terrestrial *Python brongersmai* [10] similar to DS-base and VS-tip of the present study.

These results and comparisons that seem contradictory are actually in line with [11] who stated that there is no singular micro-ornamentation morphology that outweighs in terms of habitat selection and life habits as well as taxonomical state in snakes even though some argue otherwise (e.g., [10], in favor of phylogenetic relationship while e.g., [14] in favor of ecological role).

But some questions still remain that require effort to be answered such as the correlation between micro-ornamentations and ecological adaptations. It was found that scale edges [25] as well as micro-ornamentations can be lost due to wear and abrasion. At first glance, it might seem that this situation is also valid for X. vermicularis with smooth edges and surfaces of the of DS-tip cells. However, this does not explain the triangular cell shape that looks imbricated and the gradual changing of this shape through DS-base.

It was also argued that regular micro-ornamentations such as cells with smooth surface and edges could be advantageous for burrowing life forms to reduce friction [15, 23, 24]. On this basis, it can be argued that the caudally pointed shape and smoothness of DS-tip cells of *X. vermicularis* is an adaptation to ease the serpentiform movement, especially underground.

It should be noted that among all these possible advantages, some other aspects have also been considered in terms of micro-ornamentation morphology such as scale color [18], hydrophobicity [19], camouflage and thermoregulation [20]. Furthermore, it was stated that in some lizards the morphology and pattern of micro-ornamentations may vary through development, scale generation, growth, or regeneration [21]. Besides, it was found that different body parts of a single individual may have varying types of micro-ornamentations [11, 12] which was not studied on *X. vermicularis*, yet. All these aspects should be evaluated with different sets of experiments for *X. vermicularis* and other snakes in the future to understand the ecological role of micro-ornamentations better. It is clear that similar, detailed morphological studies need to be conducted in many different species to reveal the true nature of the correlation between micro-ornamentations and ecology/taxonomy.

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Ethical statement: All the specimens were used from museum materials. No animals were captured from nature.

Author contributions: M.Y.:Conception or design of the work, data collection, data analysis and interpretation, drafting the article, final approval of the version to be published.

References

[1] Alibardi, L. (2013). Ultrastructural immunocytochemistry for the central region of keratin associated-beta-proteins (beta-keratins) shows the epitope is constantly expressed in reptilian epidermis. *Tissue and Cell*, 45(4), 241-252. https://doi.org/10.1016/j.tice.2013.01.003

[2] Leydig, F. (1873). Über die äußere Bedeckung der Reptilien und Amphibien. *Archiv Fur Mikroskopische Anatomie Und Entwicklungsgeschichte*, 9,753–794. https://doi.org/10.1007/BF02956189 (in German).

[3] Picado, T. C. (1931). Epidermal microornaments of the Crotalinae. *Bulletin of the Antivenin Institute of America*, 4,104–105.

[4] Ruibal, R. (1968). The ultrastructure of the surface of lizard scales. *Copeia*, 1968,698–703. https://doi.org/10.2307/1441836

[5] Dowling, H. G., Gilboa, I., Gennaro, J. F. & Gennaro, A. L. (1972). Microdermatoglyphics: a new tool for reptile taxonomy. *Herpetological Review*, 4,200.

[6] Larsen, K. N., Burstein, N. & Smith, H. M. (1973). Phylogenetic trends in the ultradermatoglyphics of the lizard genus *Sceloporus*. *HISS News*, 1,112.

[7] Burstein, N., Larsen, K. R. & Smith, H. M. (1974). A preliminary survey of dermatoglyphic variation in the lizard genus *Sceloporus*. *Journal of Herpetology*, 8, 359–369. https://doi.org/10.2307/1562907

[8] Peterson, J. A. (1984). The microstructure of the scale surface in iguanid lizards. *Journal of Herpetology*, 18(4),437–467. https://doi.org/10.2307/1564106

[9] Riedel, J., Vucko, M. J., Blomberg, S. P., Robson, S. K., & Schwarzkopf, L. (2019). Ecological associations among epidermal microstructure and scale characteristics of Australian geckos (Squamata: Carphodactylidae and Diplodactylidae). *Journal of Anatomy*, 234(6), 853-874. https://doi.org/10.1111/joa.12969

[10] Arrigo, M. I., De Oliveira Vilaca, L. M., Fofonjka, A., Srikanthan, A. N., Debry, A., & Milinkovitch, M. C. (2019). Phylogenetic mapping of scale nanostructure diversity in snakes. *BMC Evolutionary Biology*, 19(1), 91. https://doi.org/10.1186/s12862-019-1411-6

[11] Price, R. M. (1982). Dorsal snake scale microdermatoglyphics: ecological indicator or taxonomic tool?. *Journal of Herpetology*, 294-306. https://doi.org/10.2307/1563721

[12] Price, R. M. (1983). Microdermatoglyphics: the Liodytes- Regina problem. *Journal of Herpetology*, 17(3),292–294. https:// doi. org/ 10. 2307/ 15638 38

[13] Price, R. & Kelly, P. (1989). Microdermatoglyphics: basal patterns and transition zones. *Journal of Herpetology*, 244-261. https://doi.org/10.2307/1564446

[14] Yenmiş, M., Bayrakcı, Y. & Ayaz, D. (2022). Skin structure, coloration, and habitat utilization in typical and melanistic morphs of the grass snake (*Natrix natrix*). *The Science of Nature*, 109(2), 22. https://doi.org/10.1007/s00114-022-01794-w

[15] Žagar, A., Konc, K., Hočevar, M., Dajčman, U., Perc, V., Megia-Palma, R., ... & Novak, S. (2025). The microstructure of scales varies in four lizard species. *Amphibia-Reptilia*, *1*(aop), 1-6. https://doi.org/10.1163/15685381-bja10231

[16] Arnold, E. N. (2002). History and function of scale microornamentation in lacertid lizards. *Journal of Morphology*, 252(2), 145-169. https://doi.org/10.1002/jmor.1096

[17] Tingle, J. L., Garner, K. L. & Astley, H. C. (2024). Functional diversity of snake locomotor behaviors: a review of the biological literature for bioinspiration. *Annals of the New York Academy of Sciences*, *1533*(1), 16-37. https://doi.org/10.1111/nyas.15109

[18] Dhillon, D. S., Teyssier, J., Single, M., Gaponenko, I., Milinkovitch, M. C. & Zwicker, M. (2014). Interactive diffraction from biological Nanaostructures. *Computer Graphics Forum*, 33(8),177–88. https://doi.org/10.1111/cgf.12425

[19] Webb, H. K., Crawford, R. J. & Ivanova, E. P. (2014). Wettability of natural superhydrophobic surfaces. *Advances in Colloid and Interface Science*, 210,58–64. https://doi.org/10.1016/j.cis.2014.01.020

[20] Spinner, M., Kovalev, A., Gorb, S. N. & Westhoff, G. (2013). Snake velvet black: Hierarchical micro- and nanostructure enhances dark colouration in *Bitis rhinoceros*. *Scientific Reports*, 3,1846. https://doi.org/10.1038/srep01846

[21] Bonfitto, A., Randi, R., Ciubotaru, M. & Alibardi, L. (2025). Microscopic and ultrastructural observations on the regenerating scales of the lizard *Podarcis muralis* clarify the origin of the micro-ornamentation. *Protoplasma*, 262(4), 935-955. https://doi.org/10.1007/s00709-025-02040-6

[22] Budak, A., Göçmen, B. (2008). Herpetoloji. İzmir: Ege Üniversitesi Yayınları

[23] Gower, D. J. (2003). Scale microornamentation of uropeltid snakes. *Journal of Morphology*, 258(2), 249-268. https://doi.org/10.1002/jmor.10147

[24] Allam, A. A. & Abo-Eleneen, R. E. (2012). Scales microstructure of snakes from the Egyptian area. *Zoological science*, 29(11), 770-775. https://doi.org/10.2108/zsj.29.770

[25] Bonfitto, A., Randi, R., Magnani, M. & Alibardi, L. (2023). Micro-ornamentation patterns in different areas of the epidermis in the gecko *Tarentola mauritanica* reflect variations in the accumulation of corneous material in Oberhautchen cells. *Protoplasma*, 260(5), 1407-1420. https://doi.org/10.1007/s00709-023-01860-8