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A Study of Apical Pits Using Shed Snakeskins Revisited

Brian S. Gray
Natural History Museum at the Tom Ridge Environmental Center
301 Peninsula Drive, Suite 3
Erie, PA 16505
brachystoma@hotmail.com

Abstract

A total of 585 shed snakeskins of 31 genera, representing 54 species of North American snakes, were examined for the presence of apical pits. Twenty-three genera had at least one species with observable apical pits. Of the 54 species studied, 41 had observable apical pits on at least one section of shed snakeskin. Shed snakeskins from three species (*Chionactis occipitalis*, *Clonophis kirtlandii* and *Thamnophis proximus*) appeared to lack apical pits, despite these structures being reported present on the actual snakes. To increase the likelihood of observing apical pits several suggestions are provided, and include: use of both actual snakes and shed snakeskins; examination of all regions (nape, midbody and tail) of specimens (actual snakes or shed skins); the use of as large a sample as possible; and the use of various magnifications as well as variable intensity and angle of illumination.

Introduction

Apical pits are minute epidermal depressions found on or near the apex of dorsal scales of some snake species. They may be single or paired (Figure 1a, b), and in some instances three or more may occur on a single scale. In a previous publication, Gray (2006) presented data regarding the presence or absence of apical pits, acquired from the examination of 279 shed snakeskins. Represented in that publication were 32 species and 21 genera of North American snakes. Of the 32 species then examined, 25 (78%) had visible apical pits on at least one shed snakeskin. Herein, I wish to augment the findings of the previous report by presenting data that resulted from the study of an additional 306 shed snakeskins. Along with the original data, a total of 585 shed snakeskins representing 31 genera and 54 species of snakes were examined.

Materials and Methods

Shed snakeskins (n = 585) of 31 genera, representing 54 species of North American snakes, were examined for the presence of apical pits. Shed skins were acquired in the field or obtained from specimens held in captivity. Only shed skins containing material for study of the nape, midbody and tail regions were used. Suitable shed skins were cut, moistened with 70% isopropyl alcohol, spread on perforated plastic sheets, blotted dry, and then pressed in a plant press for approximately 24 hours (Gray, 2005). After being pressed, sections of the nape, midbody and tail were examined with a dissecting microscope at 10× and 30× magnification, and with incident fluorescent and transmitted fluorescent illumination.

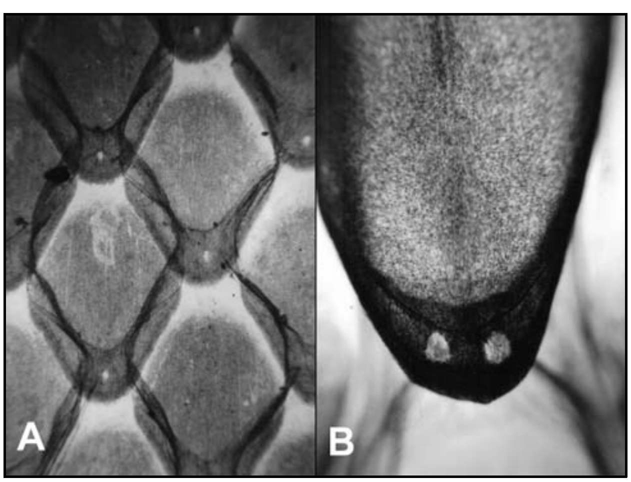

Figure 1. A) Single apical pits as seen on scales from a shed snakeskin of *Diadophis punctatus* (BG 140) 50× magnification. B) Paired apical pits as seen on a scale from a shed snakeskin of *Scotophis spiloides* (BG 085) 50× magnification.

Results and Discussion

Of the 31 genera studied, 24 (77%) had at least one species with apical pits observed, while 41 of the 54 species (76%) had apical pits present on at least one section of shed snakeskin (Table 1). The location of scales with apical pits on the body varied both within and between species. For example, of the 41 species with apical pits, 30 had apical pits on all regions (e.g., nape, midbody and tail); six had them on the nape and midbody; three species had apical pits on only the nape; one (*Opheodrys aestivus*) had them restricted to midbody; and one (*Thamnophis butleri*) had them restricted to the scales above the vent on the base of the tail (Gray, in prep.). In regards to genera, *Thamnophis* displayed the greatest diversity of conditions present, with three species (*T. brachystoma*, *T. ordinoides* and *T. proximus*) lacking apical pits; one species, *T. butleri* (1 of 8), displaying apical pits on only the tail; and four species (*T. elegans* [100%], *T. marcianus* [100%], *T. radix* [75%], and *T. sirtalis* [47%]) having apical pits present on scales of all regions examined. All five *Thamnophis sauritus* shed skins had apical pits present on scales of both nape and midbody, but absent on the tail. Although apical pits were not observed on the *T. proximus* shed skin that was examined, Conant (1961) reported that this species has them present on scales of the nuchal (= nape) region. Similarly, apical pits were not observed in *Chionactis occipitalis* and *Clonophis kirtlandii* shed skins despite these structures being present in actual snakes (Cope, 1900; Wright and Wright, 1957; Ernst and Ernst, 2003). Both *T. butleri* and *T. radix* had been reported to lack apical pits (Marx and Rabb, 1972). In the 41

Table 1. Presence or absence of apical pits in selected North American snakes. Location codes: A = apical pits obseved on all dorsal regions (nape, midbody and tail); M = apical pits observed on dorsal scales at midbody; N = apical pits observed on scales of the nape. T = apical pits observed on dorsal scales of the tail. O = apical pits not observed.

Taxon	# examined	# (%) with pits	Location of pits
Family Boidae			
Charina bottae	12	0 (0%)	O
Family Colubridae			
Clonophis kirtlandii	5	0 (0%)	O
Coluber constrictor	10	4 (40%)	A
Chionactis occipitalis	2	0 (0%)	O
Drymarchon melanurus	1	1 (100%)	A
Lampropeltis alterna	1	1 (100%)	A
L. calligaster	2	2 (100%)	A
L. getula	5	5 (100%)	A
L. pyromelana	2	2 (100%)	A
L. triangulum	45	44 (98%)	A
L. t. amaura	1	1	A
L. t. annulata	1	1	A
L. t. campbelli	2	2	A
L. t. elapsoides	4	4	A
L. t. gentilis	1	1	A
L. t. syspila	2	2	A
L. t. triangulum	34	33	A
Liochlorophis vernalis	10	3 (30%)	N
Masticophis flagellum	8	8 (100%)	A
Mintonius gloydi	2	2 (100%)	M
Opheodrys aestivus	6	1 (17%)	A
Pantherophis guttatus	8	8 (100%)	A
Pituophis catenifer	4	2 (50%)	A
P. melanoleucus	10	10 (100%)	A
Rhinocheilus lecontei	2	2 (100%)	N, M
Scotophis spiloides	15	15 (100%)	A
Sonora semiannulata	1	0 (0%)	O
Tantilla coronata	1	0 (0%)	O
Family Crotalidae			
Agkistrodon contortrix	7	7 (100%)	A
A. piscivorus	5	4 (80%)	A
Crotalus horridus	5	3 (60%)	N, M
C. viridis	5	3 (60%)	A

Table 1 (cont'd).

Taxon	# examined	# (%) with pits	Location of pits
Sistrurus catenatus	5	3 (60%)	N, M
S. miliarius	9	9 (100%)	A
Family Dipsadidae			
Carphophis amoenus	7	5 (71%)	N, M
Contia longicauda	1	1 (100%)	A
C. tenuis	2	2 (100%)	A
Diadophis punctatus	33	33 (100%)	A
Rhadinaea flavilata	1	0 (0%)	O
Family Elapidae			
Micrurus fulvius	2	0 (0%)	O
Family Natricidae			
Nerodia clarkii	1	1 (100%)	A
N. erythrogaster	2	2 (100%)	N, M
N. sipedon	27	26 (96%)	A
Regina septemvittata	7	4 (57%)	A
Storeria dekayi	107	29 (27%)	N
S. occipitomaculata	22	7 (32%)	N
Thamnophis brachystoma	47	0 (0%)	O
T. butleri	8	1 (12%)	T
T. elegans	1	1 (100%)	A
T. marcianus	1	1 (100%)	A
T. ordinoides	2	0 (0%)	O
T. proximus	1	0 (0%)	O
T. radix	4	3 (75%)	A
T. sauritus	5	5 (100%)	N, M
T. sirtalis	90	42 (47%)	A
Virginia pulchra	8	0 (0%)	O
V. valeriae	1	0 (0%)	O
Family Xenodontidae			
Farancia abacura	1	0 (0%)	O
Heterodon nasicus	13	9 (69%)	A
H. platirhinos	2	2 (100%)	A
H. simus	1	1 (100%)	A
Totals	585	314 (54%)	

species with apical pits, the percentage of shed snakeskins with observable pits varied between 12% in *Thamnophis butleri* to 100% in 28 species (see Table 1). Apical pits were relatively more common in species with keeled scales (81.8% had apical pits) compared to smooth scaled species (66.7% had apical pits). Marx and Rabb (1972) previously noted a relatively greater number of species with aquatic or secretive habits lacked apical pits. In support of this they also cited the complete absence of apical pits in the Elapinae and the aquatic Hydrophiinae.

The function of apical pits in snakes has remained elusive. Chiasson (1981) speculated that apical pits served a functional role by anchoring the old stratum corneum to the inner epidermal layer, thereby preventing the outer layer from being shed prematurely during ecdysis. Incidentally, however, apical pits are not necessary for preventing premature shedding. If they were, one might expect snakes without apical pits (e.g., elapids) to prematurely shed their stratum corneum. This certainly is not the case. In common garter snakes (*T. sirtalis*) individuals without apical pits appear to shed just as well as conspecifics with apical pits. Furthermore, merolepid (partially scaleless) *T. sirtalis*, which lack not only apical pits, but also most of the dorsal scales (Figure 2a, b), tend to shed normally; the only exception being the occasional tendency for the shed skin to roll up as it is sloughed, subsequently causing a constriction at midbody. The shed skin in these snakes does not, however, prematurely detach ahead of the cleaving region of stratum corneum (pers. obs.).

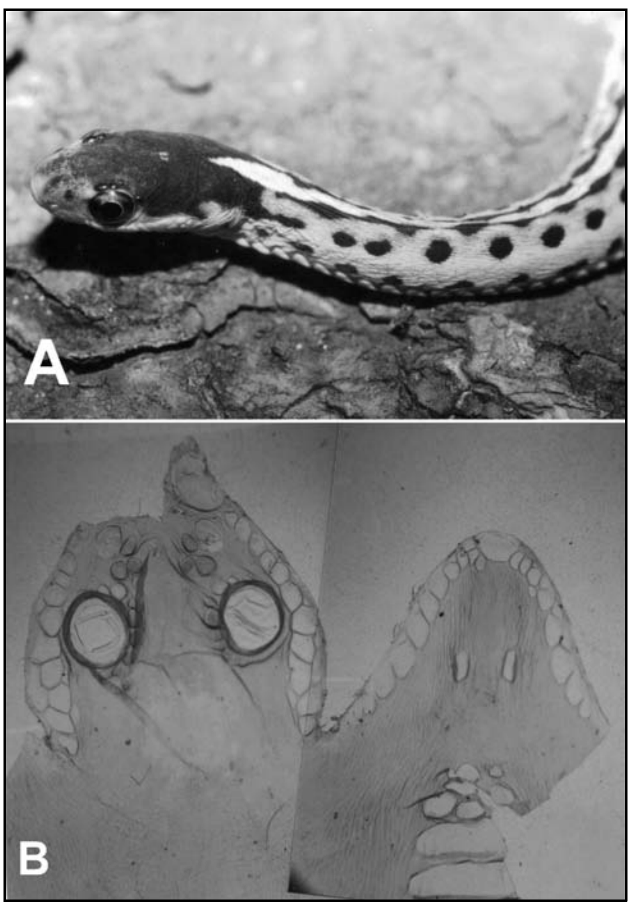

Figure 2. A) Merolepid *Thamnophis sirtalis*; note the lack of most dorsal scales; B) Shed skin of a merolepid *T. sirtalis*.

Parker and Grandison (1977) noted that the keratinous layer in the region of apical pits was much thinner and that the underlying epidermis was richly provided with bundles of nerve fibers. They speculated that apical pits may act as heat receptors; Underwood (1967) proposed a similar claim. Many snakes besides pit vipers and pythons are capable of sensing infrared radiation via nerve endings in the skin of the head (Breidenbach, 1990, cited in Pough et al., 2001). It is rather interesting to note that in several species (e.g., *Diadophis punctatus*, *Liochlorophis vernalis*, *Nerodia sipedon*, *Thamnophis sauritus*) the apical pits are non-pigmented in the stratum corneum, while in the dermis below the pits there is a concentration of melanin (see Figure 1 in Gray [2006]). It seems reasonable to assume that the darkly pigmented area would absorb more infrared radiation than the lighter surrounding area. Another possibility is that they are light receptors, which might allow a basking snake to detect a predator by its shadow, if it should happen to fall upon an area with apical pits. In at least one seasnake, a light-sensitive region on the tail has been described (Vitt and Caldwell, 2009). Seasnakes, however, lack apical pits.

Smith (1964) noted that in some extant species of lizards a tiny hair-like filament (an apical bristle) protrudes from the bottom of each pit and is presumably of tactile function. Examples of the variation of apical pits in lizards can be seen in Scortecci (1940) and Fuchs and Fuchs (2003). In appearance, the sensory pits on the scales of varanid lizards most closely resemble the apical pits of snakes. In *Varanus*, however, sensory pits are also present on the ventral scales; conversely, apical pits have never been found on the ventral scales of any snake. Finally, Proske (1969) found vibration sensitive mechanoreceptors in the skin of an elapid, *Pseudechis porphyriacus*. The responses to vibration were identified in simple nerve endings in the belly and dorsum, as well as in the mandibular and maxillary branches of the trigeminal nerve. While elapids may lack apical pits, the existence of vibration-sensitive mechanoreceptors in the skin of *P. porphyriacus*, the discovery of a light-sensitive region in the tail of a seasnake, and the supposed tactile function of apical pits in lizards, all suggest that the possibility of a sensory or tactile function for apical pits in snakes should not be ruled out. Regardless of their function, the enormous amount of inter- and intraspecific variation in the occurrence of apical pits is puzzling. Much more work is needed before we can claim a definite function for these structures.

In order to maximize the likelihood of verifying the presence of apical pits in a given taxon, the following recommendations are provided. Although apical pits are usually more easily observed in shed snakeskins (Gloyd and Conant, 1990), this is not true of all species (e.g., *Chionactis occipitalis* and *Clonophis kirtlandii*). Therefore, shed skins as well as actual snakes (preferably live or recently preserved) should be examined. The nape, midbody and tail regions should be examined, as some species may have apical pits restricted to certain areas of the body. The sample size should be as large as possible. Butler's garter snake exemplifies why sample size is so important; of eight shed snakeskins of this species examined, only one was found to have pits. Since apical pits are more difficult to observe in juvenile specimens, it is recommended that adult snakes and/or their shed skins be utilized in studies documenting the presence or absence of apical pits. Furthermore, because the ability to observe apical pits on shed snakeskins can be affected by the method used for preservation (e.g., laminating); it may be beneficial to use both mounted and unmounted material. Similarly, apical pits can be difficult to locate in specimens that have been preserved in alcohol or formalin for a long period of time. Finally, the use of variable light intensities and angles of illumination, along with different magnifications, should be tried in order to increase the chances of observing apical pits in those species whose pits may be difficult to detect.

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Literature Cited

Breidenbach, C. H. 1990. Thermal cues influence strikes in pitless vipers. J. Herpetology 24(4):448-450.

Chiasson, R. B. 1981. The apical pits of *Agkistrodon*. Journal of the Arizona-Nevada Academy of Science 16(3):69-73.

Conant, R. 1961. A new water snake from Mexico, with notes on anal plates and apical pits in *Natrix* and *Thamnophis*. American Museum Novitates 2060.

Cope, E. D. 1900. The crocodilians, lizards, and snakes of North America. Pp. 153-1270. *In*: Report of the U. S. National Museum for the year ending June 30, 1898.

Ernst, C. H., and E. M. Ernst. 2003. Snakes of the United States and Canada. Washington, D.C.: Smithsonian Books.

Fuchs, K., and M. Fuchs. 2003. The reptile skin: A key feature in the identification of lizards and snakes. Frankfurt am Main, Germany: Edition Chimaira.

Gloyd, H., and R. Conant. 1990. Snakes of the *Agkistrodon* complex. Oxford, Ohio: Society for the Study of Amphibians and Reptiles. Contributions to Herpetology Number 6.

Gray, B. S. 2005. The serpent's cast: A guide to the identification of shed skins from snakes of the Northeast and Mid-Atlantic states. The Center for North American Herpetology Monograph Number 1.

————. 2006. A study of apical pits using shed snakeskins. Bull. Chicago Herp. Soc. 41(5):85-88.

————. In prep. Natural history notes: *Thamnophis butleri* (Butler's Garter Snake). Morphology. Herpetological Review.

Marx, H., and G. B. Rabb. 1972. Phyletic analysis of fifty characters of advanced snakes. Fieldiana Zoology 63:1-321.

Parker, H. W., and G. C. Grandison. 1977. Snakes: A natural history. Ithaca, New York: Cornell University Press.

Pough, F. H., R. M. Andrews, J. E. Cadle, M. L. Crump, A. H. Savitzky and K. D. Wells. 2001. Herpetology. Second edition. Upper Saddle River, New Jersey: Prentice Hall.

Proske, U. 1969. Vibration-sensitive mechanoreceptors in snake skin. Experimental Neurology 23(2):187-194.

Scortecci, G. 1940. Recettori degli Iguanidi e di altri Sauri. Atti della Soc. Ital. di Scienze Naturali, Vol. LXXVIX (1940). Pp 1-10, 2 plates. Milano.

Smith, H. M. 1964. Evolution of chordate structure: An introduction to comparative anatomy. New York: Holt, Rinehart and Winston.

Underwood, G. 1967. A contribution to the classification of snakes. London: Trustees of the British Museum (Natural History), Publication No. 653.

Vitt, L. J., and J. P. Caldwell. 2009. Herpetology: An introductory biology of amphibians and reptiles. Third edition. Burlington, Massachusetts: Elsevier, Academic Press.

Wright, A. H., and A. A. Wright. 1957. Handbook of snakes of the United States and Canada (2 volumes). Ithaca, New York: Cornell University Press, Comstock Publishing.