VENOMOUS OR NOT?

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INTRODUCTION

In August 1982 the Reptile Zoo Iguana in Vlissingen (the Netherlands) obtained two snakes from a fellow snake keeper. They were about 1 metre long. The entire body and the upper side of the head was glossy black, the chin and throat dirty-white. The body was slender and the head just a little separated from the neck. The eyes were black, large and had round pupils. The scales were smooth and the anal scale divided. Identification showed the snakes to be Northern Black Racers (*Coluber constrictor constrictor*). Literature supposes that this snake doesn't kill its prey (mice, rats, lizards and snakes) by constriction, (which is suggested by its latin name) but that they press their prey against an obstacle until it dies. Our snakes killed their prey in another way. They would bite the prey (usually a mouse) somewhere on the body, hold fast and chew. The mouse would die within 15 to 45 seconds, after which it would be swallowed. This unexpected action made us cautious. The snakes were only handled with gloves, as you never know.

In this article I sum up the literature about this phenomenon of "non-poisonous", colubrid snakes. Much of the material is adapted from the article "Venomous or not?" by Harold F. DeLisle (1981). Colubrid snakes must have a Duvernoy's gland to be able to produce toxic saliva.

DUVERNOY'S GLAND

Duvernoy's gland is a modified salivary gland. It is named after the French anatomist Duvernoy, who first described it in 1832. The gland is found bilaterally above the back of the mouth. It is a branched tubular gland. In many species it consists of only a few tubules, becoming enlarged in others and is even lobed in a few. The secretory units are tubes of various lengths which open into a central or other collecting duct. This collecting duct is rather short. It begins at the centre of the gland and travels down towards the posterior maxillary teeth, where it discharges through an opening into the furrow or fold between the lips and the lateral sides of the teeth. Taub (1967) distinguished three basic types of Duvernoy's gland.

Type a contains mixed serous, protein secreting cells and mucus producing cells.
Type b contains, purely serous, protein secreting cells.
Type c contains, purely serous, protein secreting cells, but its secretory surface and storage space is enormous, which is the result of hypertrophy. Type c is only found in the Boomslang (*Dispholidus typus*).

The secretory mechanism in Duvernoy's gland is not really understood. There is thought to be a prolonged resting stage when the gland is inactive and a short active period connected with feeding, which lasts for several hours. This period is possibly controlled by parasympathetic innervation as part of the overall digestive regulation. The serous secretion leaves the cells during the active stage and then a renewed production begins.

The following are the Colubrid genera examined which have a purely mucus-secreting parotis gland and therefore are presumed to produce no toxic secretions of any kind: *Arizona, Boaedon, Eirenis, Elaphe, Lampropeltis, Pituophis, Pseudaspis, Pseustes, Rhinocheilus, Scaphiodontophis, Scaphiophis, Spilotes* and *Tropidodipsas*.
The genera which have a Duvernoy's gland, are: (The characters behind each name indicate the type of Duvernoy's gland).

1. *Abastor* (a)
2. *Ahaetulla* (b)
3. *Alsophis* (b)
4. *Amphiesma* (a)
5. *Aparallactus* (b)
6. *Apostolepis* (b)
7. *Boiga* (b)
8. *Bothrophthalmus* (a)
9. *Brachyophis* (b)
10. *Calamaria* (a&b)
11. *Calamelaps* (b)
12. *Cerberus* (b)
13. *Chironius* (b)
14. *Chrysopelea* (b)
15. *Clelia* (b)
16. *Coluber* (b)
17. *Coniophanes* (a&b)
18. *Conophis* (b)
19. *Conopsis* (b)
20. *Coronella* (b)
21. *Crotaphopeltis* (b)
22. *Cyclocorus* (b)
23. *Cyclagras* (b)
24. *Dendrelaphis* (b)
25. *Diadophis* (a)
26. *Dinodon* (b)
27. *Dipsadoboa* (b)
28. *Dipsadomorphus* (b)
29. *Dipsas* (a&b)
30. *Dispholidus* (c)
31. *Dromicus* (b)
32. *Dryadophis* (b)
33. *Drymobius* (a&b)
34. *Drymarchon* (a)
35. *Dryocalamus* (b)
36. *Duberria* (b)
37. *Elapomorphus* (b)
38. *Enhydris* (b)
39. *Erpeton* (b)
40. *Erythrolamprus* (a&b)
41. *Farancia* (a)
42. *Fordonia* (b)
43. *Gastropyxis* (b)
44. *Geophis* (a)
45. *Gonyophis* (b)
46. *Gyalopion* (b)
47. *Haldea* (b)
48. *Helicops* (b)
49. *Heterodon* (a&b)
50. *Homalopsis* (b)
51. *Hydrodynastes* (b)
52. *Hydrops* (b)
53. *Hypsiglena* (b)
54. *Imantodes* (b)
55. *Leimadophis* (b)
56. *Leptodeira* (b)

57. *Leptophis* (b)
58. *Liophis* (b)
59. *Lycodon* (b)
60. *Lystrophis* (b)
61. *Macroprotodon* (b)
62. *Macropisthodon* (b)
63. *Malpolon* (b)
64. *Masticophis* (a&b)
65. *Mehelya* (b)
66. *Micrelaps* (b)
67. *Miodon* (b)
68. *Myron* (a)
69. *Natriciteres* (a)
70. *Natrix* (a)
71. *Nerodia* (a&b)
72. *Oligodon* (b)
73. *Opheodrys* (b)
74. *Opisthotropis* (b)
75. *Oxybelis* (b)
76. *Oxyrhopus* (b)
77. *Pareas* (a)
78. *Philodryas* (b)
79. *Pliocercus* (b)
80. *Psammodynastes* (a)
81. *Psammophis* (b)
82. *Psammophylax* (b)
83. *Pseudoboa* (b)
84. *Pseudoeryx* (b)
85. *Pseudoxenodon* (b)
86. *Ptyas* (b)
87. *Rhabdophis* (a)
88. *Rhadinea* (a)
89. *Rhamphiophis* (b)
90. *Rhinobothryum* (b)
91. *Salvadora* (a&b)
92. *Sibon* (a)
93. *Sibynomorphus* (b)
94. *Sibynophis* (a)
95. *Spalerosophis* (b)
96. *Stegonotus* (a)
97. *Stenorhina* (b)
98. *Storeria* (b)
99. *Tachymenis* (b)
100. *Tantilla* (b)
101. *Telescopus* (b)
102. *Thamnophis* (a)
103. *Thelotornis* (b)
104. *Toluca* (b)
105. *Tomodon* (b)
106. *Trachischium* (b)
107. *Tretanorhinus* (a)
108. *Trimorphodon* (b)
109. *Tripanurgos* (b)
110. *Uromacer* (b)
111. *Xenochrophis* (a)
112. *Xenodon* (a&b)
113. *Zaocys* (b)

VENOM

Very little research has yet been done on the nature of the serous secretions of Duvernoy's gland. Most of the enzymes in these secretions are classified as proteolytic enzymes. They break down cellular structures.
Some enzymes in these secretions are:

- Hemolytic enzymes which break down red blood cells. They are common to many species.
- Anti-coagulants which prevent blood from clotting and are as common in colubrid venoms as they are in viperid venoms.
- Cholinesterase which prevents nerve transmission and thus paralyses. Has been identified in the Duvernoy's secretion of some species.

The variability of the venoms secreted is illustrated by the differing effects they have on different classes of animals. Venoms were tested by forcing the snake to bite mice or frogs and the results compared.

- Mice, bitten by *Psammophis schokari* and *Macroprotodon cucullatus* became ill but did not die.
- Mice, bitten by *Spalerosophis diadema* and *Malpolon monspessulanus* died within 24 hours.
- Mice, bitten by *Telescopus fallax* did not die, while geckoes died within minutes.
- Frogs, bitten by *Natrix natrix* died within a couple of hours.
- The venom of *Fordonia leucobalia* is effective only on the crabs on which it feeds.

The potency of secretions from Duvernoy's gland, especially its effect on mice and men, is also highly variable. Some, such as *Dispholidus typus, Thelotornis kirtlandii* and *Rhabdophis tigrinus* have proved to be very potent. These venoms seem to have major hemorrhagic activity, causing bleeding from small capillaries. This effect is often delayed 24 hours or more in humans. These same venoms have anticoagulant properties.

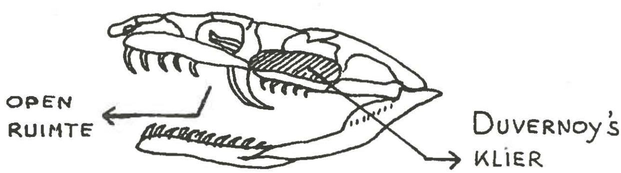
Another comparison can be gained from the following analysis.

- To kill a 20 g mouse it takes only 0.008 mg of venom from *Crotalus atrox*.
- To kill a 20 g mouse it takes 0.2 mg of venom from *Dispholidus typus*.
- To kill a 20 g mouse it takes 1 mg of venom from

Leptodeira annulata. It will take the mouse 2 to 3 days to die.
Leptodeira's gland is typical of the majority of rear-fanged snakes in size and structure.

FANGS

The teeth associated with Duvernoy's gland range from absense of any specialized teeth at all on the maxilla to one, two or three large teeth containing grooves down which the venom can run from the opening of the duct. Ditmars (1960) considered only the snakes with enlarged teeth with grooves as "rear-fanged" snakes. But now true envenomations have been reliably recorded by snakes without specialized rear teeth, they must be considered as "rear-fanged". All the *Natrix-* and *Thamnophis* species fall in this latter, intermediate category.
Most species that have enlarged rear teeth have a diastema or gap between them and the anterior



maxillary teeth. If all the teeth are alike the condition is termed isodont. If no grooves are present on the rear teeth, the term aglyphous is used. If the enlarged rear teeth are grooved, the snake is said to be opisthoglyphous.
All snakes that possess enlarged rear teeth (that have been studied) engage in a chewing action when they capture prey. In many cases of human envenomation there is mention of a chewing action involving the whole mouth of the snake.

The next 24 examples are adopted from DeLisle (1981). The cited literature can be found in his article.

ACCOUNTS OF HUMAN ENVENOMATIONS

1. J.R. Brown reported (1939) being bitten on two occasions by *Coniophanes imperialis*. The first time the bite was between two fingers. It produced itching and burning followed by numbness, swelling and red discolouration. The pain disappeared in a couple of hours, but the swelling remained for three days. The second bite was also between the fingers but more chewing action occurred. Pain, likened to a bee sting, occurred immediately. His hand perspired, was swollen, numb, and discoloured, again for about three days.

2. Shaw and Campbell (1974) report a bite by *Diadophis punctatus* which produced a burning sensation.

3. Green and McDiarmid (1981) report "substantial pain and swelling" from a bite by *Erythrolamprus sp.*

4. A.N. Bragg (1960) reports a bite from *Heterodon nasicus*. After two hours some swelling and itching was noticed. The swelling increased until the hand could not be closed. After 24 hours the swelling receded.
   Minton (1973) reports a 16-year old boy that was bitten by a *Heterodon platyrhinos* with similar symptoms.

5. J.D. Romer (1979) reports that *Rhabdophis subminiatus* has been responsible for envenomations in Hong Kong. This year (1981) a specimen bit a 20-year old man on the thumb in Los Angeles, California. The only early symptom reported

was nausea. Seventy hours after the bite he started to vomit blood. Physicians noted extensive hemorrhagic and anticoagulant effects of the venom.

H. Kono and Y. Sawai (1975) report that a *Rhabdophis tigrinus* bit a 13-year-old boy on the hand in Japan. He suffered pain for several days, swelling and hemorrhaging under the skin. He was given blood transfusions during treatment. Minton reports that in 1969 a California snake keeper was bitten on the finger while offering food to a yamakagashi. Within a few minutes his finger swelled and he developed a severe head-ache. Later his gums began to bleed; he had pain over his kidneys and there was blood in his urine. The symptoms subsided in about 48 hours. In 1973, a 61-year old man, a Japanese professional snake catcher was bitten twice the same day by a yamakagashi, and shortly thereafter experienced headache, nausea, vomiting, bleeding and swelling at the site of the bite, bleeding gums and blood in his urine. He was hospitalized two days later and his blood clotting factors were said to be totally inactivated. He was put on renal dialysis and given transfusions and drugs to stimulate clotting factors. His blood factors returned to normal in about 48 hours.

He was still voiding bloody urine one month after admission to the hospital. A biopsy was performed which showed that his kidneys were almost totally destroyed. He died about 2½ months after the bite, in spite of twice weekly dialysis. Thus *Rhabdophis tigrinus* is the third species of Colubrid snake to have caused fatality.

6. In 1975 a 31-inch western aquatic garter snake, *Thamnophis couchi*, bit an 11-year-old boy in Camarillo, California. The snake chewed the

boy's hand and was pried loose after about 10 minutes. Swelling and discolouration of the hand and arm resulted and the boy was hospitalized for several days.

7. B.W. Gooneratne (1968) reported from Ceylon that the bite from an *Ahaetulla sp.* caused local effects, by which is usually meant swelling, pain and discolouration.
   Neill (1949) reported a bite by *Ahaetulla papuae* that caused pain and swelling of the hand and arm which lasted for 4 days.

8. Heatwole reported in 1966 of being bitten by the West Indian Snake *Alsophis portoricensis* while feeding the animal. He was bitten on the left index finger and there was immediate swelling and itching followed by pain. These symptoms progressed up the whole arm and into the shoulder. He was hospitalized. Some hemorrhaging under the skin of the hand was noted. He was better on the 5th day and released from hospital 11 days after the bite.

9. There are several vague reports of envenomation from large *Boiga sp.* These usually produced systemic hemorrhaging and anticoagulant problems. A neurotoxic fraction may be present in the venom of some *Boiga*. Burger (1974) reported of local swelling being the only effect of a bite from *Boiga dendrophila*. The author has been bitten several times by *Boiga dendrophila* and *Boiga cyanea* with no noticeable effects.

10. Douglas March of the Serpentarium in Tela, Honduras, was bitten by an 18 inch Guarda Camino, *Conophis lineatus*. There was an immediate burning pain and swelling of the hand. The symptoms continued for several hours.

11. Beyond doubt the bite of the boomslang (*Dis-*

pholidus typus) is far and away the worst of all the rear-fanged snakes. At least seven deaths have been reported from Africa of people handling this snake. It apparently is not a danger to ordinary people who meet it in the field and do not try to pick it up. The most famous fatality of the boomslang was the distinguished herpetologist Karl P. Schmidt of the Chicago Natural History Museum. He experienced nausea, bleeding from the mouth, bladder and rectum. The immediate cause of death, twenty-four hours after the bite, was respiratory failure, but the autopsy revealed internal hemorrhages of the brain, kidneys and intestines. Death probably resulted from blood clots in the pulmonary vessels. He received no hospital treatment for the bite.

12. D'Abreu (1913) reported a bite by *Enhydris enhydris* which produced local inflammation and pain that lasted for an hour.

13. Crimmins (1937) reported a bite by *Oxybelis aeneus*. A man was bitten on the finger, the snake chewing for 15-20 seconds. Localized itching was the first symptom, succeeded later by numbness, slight reddening and swelling. A blister formed and lasted for 24 hours. This blister is noted also in another account of *Oxybelis* bite.

14. Nickerson and R.W. Henderson (1976) reported a bite on Henderson's thumb by a *Philodryas olfersi*. The snake held on for about 4 seconds. Swelling occurred within 10 minutes and the entire hand was swollen in 7 hours. His axillary lymph nodes became enlarged and painful. The symptoms subsided in 48 hours. No treatment was given except aspirin.

15. Seib (1980) reported a bite on the left index

finger by a *Pliocercus elapsoides*. The bite was very brief and the site incised and made to bleed. Swelling began in 3 minutes and extended to the whole hand in 10 minutes. A very severe pain was noticed at first gradually changing to a mild aching pain. An hour after the bite the axillary lymph nodes became swollen and tender and waves of burning pain passed over the arm. Pain killers were administered and five hours after the bite crotalid antivenom was injected. Some bleeding under the skin occurred. The swelling was gone after 5 days but the arm pains persisted for 15 days.

16. D.C. FitzSimons reported that a game ranger in Tanzania was bitten in 1953 on the left hand after an evening dinner party while putting on a snake demonstration with a *Thelotornis kirtlandii*. The next day he complained of headache diarrhea, and vomiting which were diagnosed as hangover. The following day he began vomiting blood and was hospitalized. He lapsed into coma and died on the fourth day after the bite. The autopsy revealed extensive internal hemorrhaging.
A second case reported by FitzSimons occurred to the Curator of Herpetology of the National Museum of Southern Rhodesia. He was bitten on the right index finger. A few hours later the finger had swollen and continued to bleed. Bleeding also began from several scratches he had experienced in catching the snake. Blood clotting returned to normal 24 hours after the bite and the swelling lasted 5 days.
There are a few other accounts of envenomation by *Thelotornis* but all of them are on the mild side. The one fatality attributed to this snake may have been from complications due to alcohol in the man's system or other special factors.

17. Sherman Minton reports that a *Leptophis ahaetulla* he had collected in Costa Rica and given to a friend bit the friend on the hand. The hand became swollen but returned to normal within a few hours.
Zwinenberg (1977) reports a very painful bite from the same species.
Zweifel (1954) and McDiarmid (1969) report bites from *Leptophis diplotropis* as a mild sting which persisted for some time.

18. In 1893 a museum clerk at the natural history museum in Georgetown, Guyana, was bitten on the finger by a *Dryadophis (= Mastigodryas) bifossatus* which subsequently became swollen and painful.

19. Marmonov (1976) reported of a man bitten several times by a *Coluber ravergieri*. Intense pain extended all the way up the arm to the shoulder. Some symptoms lasted as long as 3 days.

20. Chapman (1968) and Broadley (1959) report bites from *Crotaphopeltis hotamboeia* which produced local pain and swelling.

21. Schemone and Reyes (1965) report of a bite by *Dromicus chamissonis* producing radiating local pain, swelling, and some systemic symptoms lasting 4 to 7 days.

22. Gans (1978) reported that major symptoms followed the bite of an *Elapomorphus lemniscatus* to someone he knew. He does not specify what the symptoms were.

23. Chapman (1968) reported local pain and swelling from the bite of *Micrelaps microlepidotus*.

24. Gans (1978) reported local pain and edema as well as systemic symptoms from a bite of *Tachymenis peruviana*.

CONCLUSIONS

Any trait possessed by an animal that makes it more capable of obtaining food will be strongly favoured by natural selection. There is no doubt that those snakes which develop toxic saliva possess an advantage in their predatory way of life. It now seems that the development of venom has occurred several times in the course of snake-evolution.

It seems highly significant that among the major genera that possess only mucus-secreting supra-labial glands (*Pituophis, Lampropeltis, Spilotes, Elaphe* and *Boaedon*) all are powerful constrictors for whom toxic saliva or weak venom would probably add no advantage important enough to be favoured by selective pressures.

Now that it has been shown that so many Colubrid snakes possess venom of varying potencies, the question arises as to why there have been so few human envenomations over the years with many herpetologists handling so many thousands of these snakes. The answer to this question is still theoretical.

It has been noted by many authors that many, if not a majority of envenomations have involved the snake being allowed to get some portion of the victim's anatomy, usually a finger, well inside its mouth and to commence a chewing action. The chewing action has been demonstrated in the lab of DeLisle to engage the rear maxillary teeth and put a squeezing pressure on the roof of the mouth where Duvernoy's gland is located. Most people bitten by a snake probably do not allow the snake time enough to engage in such an activity.

However, there are many reports and experiments which prove that the above theory is not the whole answer. Experiments have been conducted by DeLisle and others in which the snake was allowed to continue its biting, chewing action for several

minutes with no signs of envenomation occurring. The venomous *Rhabdophis subminiatus* is one species which demonstrated such non-venomous aggressive activity. On the other hand some authentic envenomations have occurred when the snakebite lasted only a few seconds.
A second theory is based upon observations that many envenomations by Colubrid snakes occur while someone is feeding the animal, or just after feeding. It has been pointed out previously that feeding reflexes are believed to stimulate nervous control of secretion from Duvernoy's gland and to commence that active phase. Almost nothing is known of the functions of the autonomic nervous system in reptiles, but if it is at least somewhat homologous to that in higher vertebrates this may be a major explanation why most Colubrid snakebites do not produce any symptoms of envenomation. With mammals, if the animal (or human) sees or smells food, there is a stimulation of the salivary glands. The composition of the saliva is different in this situation. When such a thing happens in Colubrid snakes, it seems logical, that the bite of such a snake is venomous only during or after feeding. Envenomation would occur only when toxic substances happened to be in the mouth or the duct.
Some of the symptoms, listed in the 24 examples, can perhaps be explained in the following way. Traumatic bites of animals (and also humans) can cause swelling as described after bites of snakes. The histamine released by cell damage is responsible for this. Examples 2, 3, 7, 10, can fall under this head. As the victim makes contact with proteins from the saliva of the perpetrator, there would possibly be a mobilization of leukocytes and other immune components. This reaction can look like symptoms of envenomation:
pulsations, pain, inflammation, etc. as in

examples 12 and 14.
It seems wise to be very careful with Colubrid snakes, especially during and after feeding them.

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