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Outline of an Anthropological Contribution to the Study of Snake Venom Variability: The Case of *Echis* sp. Envenomation

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Abstract: *An understanding of the variability of snake venom composition is of high relevance for adequate treatment of snakebites. Clinical observations of bite victims are considered as a first step in the study of venom variability. The present paper suggests the study of local clinical observations made by healers as an anthropological contribution to the interdisciplinary research of venom variability on a species and subspecies level. Such an anthropological contribution will take into account cultural particularities of a region. In order to illustrate his approach, the author describes his ethnozoological and ethnomedical fieldwork among Zarma and Tuareg in western Niger where he studied envenomation by* Echis leucogaster. *This species is of particular interest, as no medical descriptions of envenomation resulting from its bites seem to exist.*

Key Words: snake venom, snakebites, ethnozoology, ethnomedicine, *Echis leucogaster*, Niger

Introduction

The present paper outlines an ethnozoological and ethnomedical approach to snake venom variability as a contribution to interdisciplinary research.[1] First, in a brief theoretical overview, the anthropological input to such research, as well as to the topic of venom variability, will be discussed. Then follows, as an example of how an anthropological contribution could be realized, a short case study of *Echis leucogaster* Roman Viperidae envenomation carried out in western Niger.

Medical descriptions of *E. leucogaster* envenomation do not seem to exist, and scholars tend to reference, in the case of this species, descriptions of envenomation by *Echis ocellatus* Stemmler Viperidae. This may be problematic, as snake venom can show high variability on several levels (species, subspecies, etc.). Thus, these *local* descriptions of *E. leucogaster* envenomation are, in the following discussion, contrasted to existing descriptions of envenomation by *E. ocellatus* in order to show possible differences in symptoms which may be due to interspecies variability.

Theory

Snake venom variability is of high relevance when developing adequate treatments for envenomation. Natural sciences apply several methods in order to study variability: biochemical and electrophoretic analyses, toxicity and lethality studies on animals or in vitro, as well as clinical observations of envenomation symptoms. Chippaux et al. consider clinical observations as an important method in the identification of venom variation and as a "first clue to composition variability" (1999:1283).

Particularly in the African context, in the case of snakebites, clinical observations are seldom made by medical practitioners or hospital staff, as the majority of people prefer to seek the assistance of "traditional" healers in such cases. The dispensary of Bonkoukou, Niger, for example, which, theoretically, all sick people of the present research area may attend, treats only an insignificant number of bites (one or two in a month), whereas each interviewed healer, "responsible" for a much smaller community, may treat one to three snakebite victims in one month.[2] This preference for "traditional" healing is also confirmed in literature (e.g., Chippaux 2006:26). For example, 80% of bite victims in Benin (Chippaux 2002) and 95% in Senegal (Chippaux et al. 2005) refer themselves to local healers. Observations of envenomation symptoms made by medical personnel may thus not be representative when studying venom variability in the African context. Furthermore, hospital or dispensary staff often has a different cultural background to the local population and may thus also have a different understanding of "illness" caused by snakebites.

The present research seeks to contribute to the above mentioned method of observing clinically in order to study venom variability. It proposes a decisively *anthropological* approach, as it discusses descriptions of envenomation given by *local* people. It is supposed that such local knowledge assembled during decades or even transmitted through generations can provide important information which is closely linked to a specific region and to the local particularities of its snake fauna.

The composition of snake venom, which is genetically determined, presents a high variability among species, as well as a wide range of variations on interfamily, individual, seasonal, geographic or other levels (e.g., Chippaux et al. 1991; Currier et al. 2010; Nkinin et al. 1997). In several cases, the scientific discovery of venom variability in one presumed species provided evidence for classification into two species or into a further subspecies.

Jimenez-Porras (1967) used variation in venom composition to differentiate between *Bothrops nummifer* Viperidae Hoge and *Bothrops picadoi* Dunn Viperidae. The two species are closely related in shape and color patterns but show marked differences in the composition and electrophoretic properties of their respective venom (e.g., the absence of a coagulant effect in the venom of *B. picadoi*). In terms of symptoms, lethal proteases of *B. nummifer* venom, for example, produced massive lung hemorrhages in mice, whereas this effect was not observed from venom of *B. picadoi*. Evidence for the existence of two different species was also found in the venoms of *Montivipera bornmulleri* Werner Viperidae and *Montivipera latifii* Mertens, Darevsky, Klemmer Viperidae. In this case it was shown that immunological differences between the venoms of the species correspond to their wide spatial separation. This allowed the suggestion of an important separation in evolutionary development (Weinstein and Minton 1984; Nilson and Sundberg 1981). One example of inner-specific variability is *Vipera aspis* Linnaeus Viperidae. Differences in the venom of snake specimens led here to the zoological classification of the new subspecies *V. aspis zinnikeri* Kramer Viperidae (Bouquet 1948; Chippaux et al. 1991). The discussion of venom properties in *Echis carinatus* Schneider Viperidae and *Echis coloratus* Günther Viperidae ultimately led to the conclusion that venoms, even within the same species, can vary considerably and may cause contradictory physiological or biochemical test results (Schaeffer 1987).

E. leucogaster, the white-bellied carpet viper and *E. ocellatus*, the West African carpet viper, are very similar in shape and coloration. As sympatric species, they occupy neighboring environments (e.g., Chippaux 2006:257), but the latter prefers a more humid habitat. It was only in the 1970s that *E. leucogaster* was classified as a species of its own. Whereas numerous papers discuss the effects of *E. ocellatus* envenomation (e.g., below), no scientific report seems to exist concerning envenomation by *E. leucogaster*, as is also stated by Phelps (2010:386). Bites of the latter are often considered to have the same effects on the human organism as those of other *Echis* spp. (e.g., Mion et al. 2002a). The assumption that *E. leucogaster* venom may act in the same way as venom from other *Echis* spp. is nevertheless surprising when considering the wide range of venom variability, in particular on an interspecies level. One may thus ask if *E. leucogaster* envenomation should still *a priori* be considered as similar to envenomation by other *Echis* spp. As will be shown below, local descriptions of *E. leucogaster* envenomation significantly differ in some aspects from medical observations of envenomation by *E. ocellatus*, and a further biochemical study would seem to be useful.

Case study: *E. leucogaster* envenomation

The aim of the following case study is to exemplify how an anthropological contribution to snake venom variability research could be realized. The study was carried out in a precise and well-circumscribed area of western Niger with which the author is very familiar as a result of carrying out several periods of fieldwork on rural habitat since 2007. The analysis doesn't attempt to be exhaustive, as still more features of variability may be present in other places of the Sahel where *E. leucogaster* can be found.

Methods and geographical context

The present research was carried out near the village of Bonkoukou (Department of Filingué, Republic of Niger).[3] The research area is located in Dallol Bosso, a fossil valley leading from the south of Gaya, Niger, up to the Malian Adrar. It belongs to the Sahelian belt. Two settlements on a plateau bordering the valley slightly westwards of Bonkoukou were chosen as field sites: Sanayan, Tilobi, a Zarma village, and Tigalalen, inhabited by now highly assimilated Tuareg.[4] The latter mostly adopted the Zarma language. Whereas these two communities of settled agriculturalists have a different historical ethnic background, the patterns

of their contemporary every-day-life are rather similar to each other.

The two field sites can be considered as an ecologically coherent micro environment (Ellen 1989:81) with the inhabiting Zarma and mostly assimilated Tuareg as its ecological population (Ellen 1989:77f.). The very dry area is located on a rocky plateau, marked by erosion and scarce and shrubby vegetation, whereas one can encounter lower and damper places to its south, east and west. In the north, a landscape increasingly resembling the Sahara is found, populated by other ethnic groups. The choice of this relatively small dry area allows the study of local representations of *E. leucogaster* bites and, at the same time, avoids the habitat of *E. ocellatus*, which prefers more humid places, as the occurrence of the latter species could have falsified the descriptions obtained.

In cases of snakebites, locals appeal to specialized healers.[5] The number of healers is very limited; only five were identified in the research area. Ordinary locals here have quite poor knowledge of snakes and snakebites, as became clear during the fieldwork, thus, choosing a random sample among the whole population would not have made sense. In order to provide scientifically reliable data despite the small number of healers, the information given by any one person was cross-checked by "triangulation" (Flick 2009:53f) with the other informants.

In order to discuss with the healers *E. leucogaster* envenomation and its symptoms, semi-structured interviews were held, leading to open-ended conversation[s] (Martin 1995:109ff.). The Zarma language was mostly used, but some answers were given in Tamashek. Snake species were determined by means of dead samples, scientific descriptions and photographs (e.g., Chippaux 2006; Phelps 2010; Trape et al. 2006).[6]

In order to give an example of how the healers represent envenomation symptoms, a selection of short quotations in local languages is listed below in an annex (numbers given in brackets). No relevant differences could be detected in the descriptions of the five healers.

Local knowledge of E. leucogaster *envenomation*

E. leucogaster can be distinguished from *E. ocellatus* by the coloration of its ventral face; the former has an immaculate ivory white belly, whereas the latter has a pale-colored one with brownish spots (Chippaux 2006; Phelps 2010., Hughes 1976; Roman 1972; Stemmler 1970). The informants were aware of these differences between *E. leucogaster* and *E. ocellatus* and also of their different habitats and contrast them in the Zarma language by secondary color terms: the former is called "red *Echis*" (*hayni dooru ciray*) and the latter "black *Echis*" (*hayni dooru bi*).[7] Thus, each of the species represents not only a different scientific taxon, but one can also consider them as two different folk-taxa (Berlin 1992). The generic name *hayni dooru* and its equivalent *ta-masangu* in Tamashek allude to the noise made by the snake's scales when menaced and which is said to resemble trickling millet (*hayni dooru* = "pour millet"; *ta¯masangu* = "that one from the millet grains").

The informants underlined the relatively slow action of the venom of *E. leucogaster*. All of them mentioned local edema around the bite, which two of the informants compared to a scald: "The place [of the bite] looks like as if hot water has been poured on it" [01]. Later on, necrosis develops. Necrosis was described as "fouling flesh" with bad odor [02, 03]. Envenomation was described by all informants as very painful. First, pain is felt as a local symptom around the bite [04], but then it is felt throughout the whole body [05]. Three informants associated the venom directly with pain: Pain and venom spread at the same rate progressively around the person's body. The venom/pain tries to reach the heart [07, 08], and "good" medicine, on the other hand, prevents it from doing so [11]. Without immediate treatment however, the pain "comes to your heart" [07], and the person wants to vomit [08].

Hemorrhage, especially of the nasal mucosa, was also mentioned [06] by all the healers. Three healers also said that the blood-circulation does not go the "right" way and that blood "assembles in one place" [10, 09]. Affected blood and the affected heart are sometimes seen by them as closely linked to each other [10].

All healers described the "closure" of the heart which can lead to death [11, 12, 14] as the most salient symptom. They also linked it directly to asphyxia: When the heart "closes", breathing is not possible [12]. As the "closure" of the heart is considered to be the most important symptom, healing in particular focuses on this cardiac affliction. Thus, four healers explained the interaction of venom and remedy as follows: the venom tries to "mount" up to the heart (a bite often occurs on the feet), and the remedy tries to prevent it from doing so [13]; if the venom has already

reached the heart and the remedy is given only then, the latter should provoke vomitus[8] in order to make the former leave the person's body [15]; if the venom leaves in such a way, the heart will not close [14, 15].

Discussion

As already mentioned, medical reports of *E. leucogaster* envenomation do not seem to exist. Concerning envenomation by *E. ocellatus* and *E. carinatus*, scientific descriptions emphasize the high potency of the venom and the high mortality (e.g., Warrell and Arnett 1976). Symptoms such as edema and necrosis, which the informants mentioned for *E. leucogaster*, are present in other *Echis* spp. too, and sometimes the importance of the edema as well as the high necrotizing activity of the venom are emphasized (Mion et al. 2002b; Warrell and Arnett 1976).

Several authors describe persistent and abnormal bleeding, hemorrhages, non-clotted blood and death from bleeding for *E. ocellatus* (Chippaux and Goyffon 1991; Chippaux et al. 1999; Einterz and Bates 2003; Pugh et al. 1979). The healers mentioned bleeding and hemorrhages as well. Some of them underscored the affected blood circulation. It can be supposed that the images linked to "affected blood" represent for them also a symbolic way to express "illness." In fact, the "right" or "wrong" circulation of blood expresses, in Songhay,[9] representations of illness, well-being or disease (Bisilliat 1979).

The fact that cardiac problems and asphyxia were mentioned by all informants seems to be of great interest, as these symptoms are not recorded in scientific observations of envenomation by other *Echis* spp. The conspicuous nature of these symptoms in the descriptions of the healers may allow the hypothesis that particularities in the composition of *E. leucogaster* venom could differentiate it from the venoms of other *Echis* spp., thus representing a case of intraspecies variability. However, as the "heart," "cardiac troubles," and "breathing" may be culturally variable concepts, this hypothesis should be further tested by biochemical analyses searching in particular for supposed cardio- or neurotoxic components of the venom.

Conclusion

Knowledge of venom variability is of high importance for the treatment of snakebites, and clinical observations are considered as a first step in the analysis of composition variability. Clinical observations made by local healers seems to be highly relevant, as they take into account the particular cultural background of a specific population and the possible regional particularities of snake fauna. Studying such local clinical observations of snakebite envenomation from ethnomedical and ethnozoological viewpoints could be an anthropological contribution to the interdisciplinary study of snake venom variability.

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Declarations

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Biosketch

Tilman Musch works at Bayreuth University on topics of spatial anthropology and ethnobiology in West Africa and Central Asia.

Annex

[01] *nango gate danga hari dungo no munu boro boŋ* [Zarma] – "the place [of the bite] looks like as if hot water has been poured on it".

[02] *nango ga fumbu* [Za.] – "the place is rotten / smells bad".

[03] *edăg-di ad irsaḍ* [Tamashek] – "this place will be rotten".

[04] *edăg ən nagi-nes ikkûs* [Ta.] – "the place of the poison [of the bite] is hot [very painfull]".

[05] *ni gaham mo kulu no ga dooru* [Za.] – "your whole body is painful".

[06] *tinžar n ăwedem a dd-igâmăḍ azni* [Ta.] – "the nose of the person, blood comes out [from it]"

[07] *dooro ga koy ni bina do* [Za.] – "the pain comes to your heart".

[08] *dooro no ga koy boro bina ga*, *bora ga ceeci kayeeri* [Za.] – "the pain goes to the heart, the person wants to vomit".

[09] *kuro ga margu nangu fallan* [Za.] – "the blood is assembling in one place".

[10] *as tədăd awedam awəl-nes a ibâddăɣăn, yas azni a itâssin awəl eqqâmu isâylăy kunduba ibâddaɣan n əwəl ad ənkərăn dăɣ ăwedam* [Ta.] – "when it bites [a person], his heart closes, then blood goes to the heart, it goes around until closures of the heart are happening in the person".

[11] *da i mana tarka bora safar, bora bina ga daabu, bora mabu* [Za.] – "if you haven't provided rapid healing to the person, the heart of person closes, the person dies".

[12] *bina ga daabu, boro si hin ka fulanzam* [Za.] – "the heart will close, the person cannot breathe".

[13] *a ga gandji naadjo makoy beene* [Za.] – "it prevents the venom from mounting [up to the heart]".

[14] *dinna bora haŋŋgandi enda, a ga yeeri bina si daabu* [Za.] – "if you make the person drink [the water] with it [the remedy], he will vomit, the heart will not close".

[15] *bora yeeri nadjo aga fatta* [Za.] – "the person vomits, the venom leaves".

Notes

[1]Research on venom variability has to be interdisciplinary, and the present paper outlines the anthropological *contribution* to such research. Whereas the anthropological input lies in the study of local conceptions on how the venom of a respective species or regional subspecies may act on the human organism, only a biochemical analysis of the venom will allow the exact molecular agent of symptoms provoked by a venom to be determined (for example: respiratory paralysis can be due to neurotoxins as well as to phospholipase A_2 enzymes).

[2]The village of Bonkoukou, to which the research area belongs administratively, has about 20,000 inhabitants (as compared to 1,400 for the research area itself). The dispensary provides only symptomatic treatment, as immunotherapy would be too expensive and is not available there.

[3]Three periods of fieldwork, each of about 6 weeks, were spent on this topic (July-August 2011, October-December 2012, and March-April 2013).

[4]Sanayan is located around N 14° 07.275', E 003° 09.087' (227 m). Tigalalen is a wide area located around N 14° 03.727', E 003° 12.756' (238 m). The former has about 1,000 and the latter about 400 inhabitants.

[5]Healers are called *zima* (Zarma language) and have a special relationship with spirits which confer on them the knowledge of plants and healing (Rouch 1989:56 ff., 204ff.). The interviewed healers are considered by the local population as specialists in snakebites.

[6]People of the area relatively often encounter snakes and kill them. The inhabitants were not required to search for snakes for the present scientific purpose. Discussing the matter by handling living animals was not possible – venomous snakes are considered a serious danger to humans and animals. Nobody would have tried to capture a snake alive and, if captured alive, nobody would have released it after examination. Due to the small number of venomous snake-species relevant in the area (*Bitis arietans* Merrem Viperidae, *E. leucogaster*, and *Naja nigricollis* Elapidae Reinhardt; and, rarely, *Naja haje* Elapidae Linnaeus), an exact scientific determination of *E. leucogaster* was possible without examination of living samples.

[7]These color terms may not allude to real coloration. "Black" and "red" are used by Zarma also in order to

mark contrast, particularly in a hierarchical sense between social classes (Olivier de Sardan 1982:67f.).

[8]Informants did not mention a possible diuretic effect of their respective treatments, which can, however, be of high relevance in the elimination of snake-venom.

[9]Songhay are an ethnic group culturally and geographically close to Zarma, sharing with them the same language.