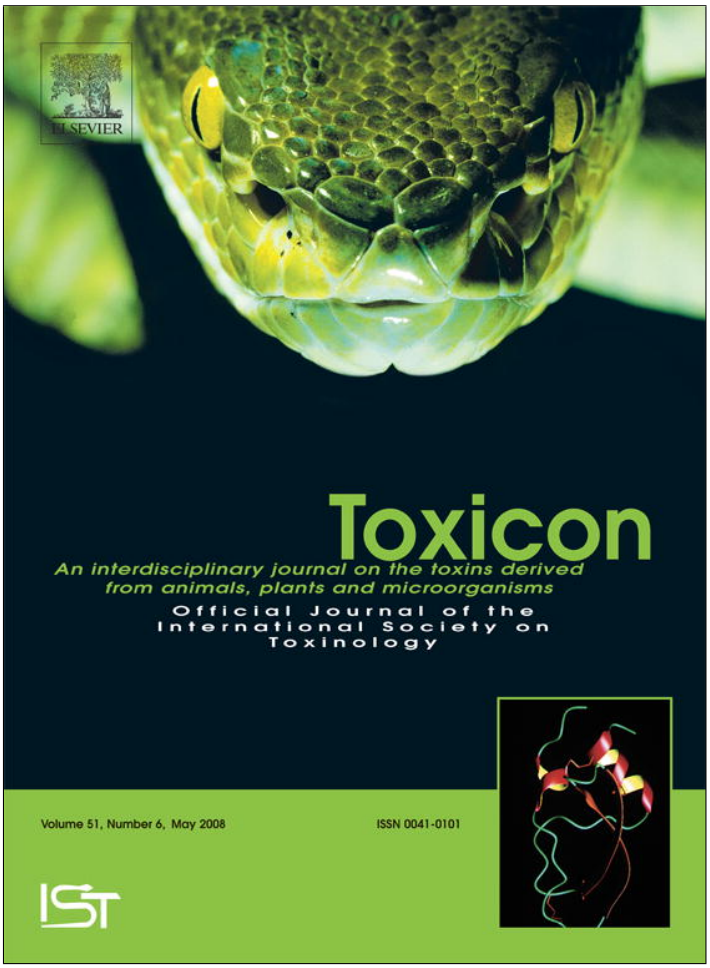

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Review

Snakebites in Hungary—Epidemiological and clinical aspects over the past 36 years

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Abstract

Epidemiological and clinical aspects of snakebites in Hungary between 1970 and 2006 were surveyed. A total of 97 cases were recorded from 21 species, including the two native vipers, *Vipera berus* and *Vipera ursinii*, and various exotic species represented by Viperidae, Elapidae, and Colubridae. Bites by native species on laymen are uncommon (17 cases) and present trivial clinical manifestations. Compared with the consequences of native *Vipera* cases, bites by exotic species often resulted in severe or life-threatening envenomations. These cases were treated with antivenom administration, plasmapheresis, fasciotomy, and amputation. There were two fatalities caused by *V. berus* and *Agkistrodon contortrix*. Both of these cases were inflicted in snake-handlers with a previous history of Viperidae bites and the cause of deaths are attributed to anaphylactic reactions as a consequence of hypersensitivity to the venom. Snake-handlers and their physicians face a major challenge due to the diversity and severity of signs and symptoms following exotic venomous snakebites, and the risk of anaphylaxis or anaphylactoid reactions in patients with repeated exposure to snake venom and antivenom. Highly dangerous venomous snake species continue to appear in collections of Hungarian snake-handlers.

Keywords: Envenomation; Antivenom; Anaphylaxis; Snake keeping; *Vipera berus*; *Vipera ursinii rakosiensis*

Contents

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1. Introduction

In most of Europe, snakebites by native venomous species are relatively uncommon and severe consequences or fatalities are rare (Reid, 1976; Gonzalez, 1982; Schroth et al., 2003; Karlson-Stiber et al., 2006). However, keeping exotic venomous snakes has become an increasingly popular practice throughout Europe involving both amateur and professional snake-handlers. As a consequence, presentations for treatment of exotic snakebites at some European hospitals are now more common, and produce more serious consequences than bites caused by native species (Warrell, 2005a).

The native herpetofauna of Hungary includes two venomous species, the Common adder (*Vipera berus*) and the Meadow viper (*Vipera ursinii*), both with a restricted distribution in the country (Fig. 1). *V. berus* occurs in three, more or less separated, regions: in the NE (Zemplén Hills, Tokaj Hill), the E (valley of Upper Tisza River), and in the SW of the country (Somogy and Zala Counties) (Korsós and Krecsák, 2005). *V. ursinii*, represented by its rarest subspecies *V. u. rakosiensis*, had a widespread distribution but its habitats have decreased dramatically over the last two decades. Remaining small populations survive only in limited areas of the Hanság and between the River Danube and River Tisza (Újvári et al., 2000). Bites inflicted on laymen by both species in their native habitats are rare (Virágh and Tass, 1986; Takács et al., 1987).

The keeping of exotic venomous snakes has become popular in Hungary over the last 10–15 years (following the demise of communism and restrictions on foreign travel), creating a situation familiar to many other European nations. Currently all major groups of venomous snakes (except Laticaudinae and Hydrophiinae) are found in private collections and these exotics are responsible for a far greater morbidity than the native species, resulting in unique and challenging medical emergencies (Turchányi et al., 2000). Since 1999, the keeping of "dangerous" animals in Hungary has been regulated by a nationwide legislation that requires a permit along with on-site storage of antivenom for the legal possession of venomous snakes, defined in the law as "Viperidae, Crotalidae, Hydrophiidae, Laticaudidae, Elapidae, *Atractaspis*, *Balanophis*, *Dispholidus*, *Rhabdophis*, and *Thelotornis*"; although possessing "sea snakes" is prohibited outright (Anonymous, 1999).

The present study surveys the epidemiological and clinical aspects of snakebites in Hungary between 1970 and 2006. Including both native and exotic species, we provide data on snakebite incidence, as well as summarise the various signs and symptoms and treatments applied. Bites by native *Vipera* on laymen are extremely rare, while venomous snake keeping and exotic venomous snakes pose a major, often life-threatening, medical challenge.

2. Materials and methods

Retrospective questionnaires were sent to (i) major county hospitals throughout Hungary, (ii)

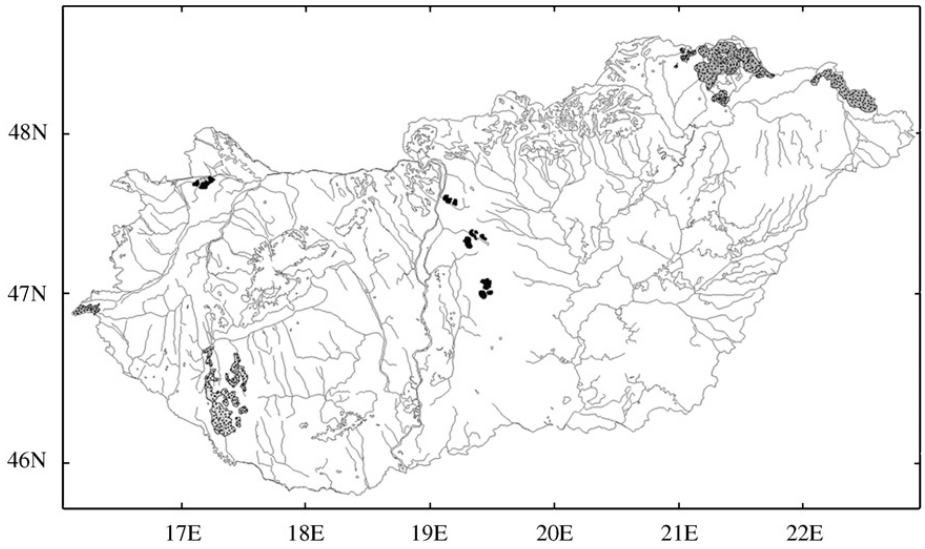

Fig. 1. Distribution of venomous snakes in Hungary. Snake distributions are shown by the shaded areas: *Vipera berus* (dark grey with black centre spots), *Vipera ursinii rakosiensis* (solid black spots).

hospitals within the distribution area of *V. berus* and *V. ursinii*, (iii) members of various amateur herpetological associations, and (iv) zoos, universities, and museums. Data collected covered the period from 1 January 1970 to 30 September 2006, and was performed in two series, in 1986 and 2006, using the same methods. The data collected included various information on patient demographics, snake species involved, activity at time of the bite, local and systemic signs and symptoms; laboratory findings; and first-aid and hospital treatments including antivenom therapy. Allergic reactions and previous histories of snakebites and antivenom administration were also recorded. Even though all data were treated anonymously, questionnaires returned by private snake-handlers may have slightly under-reported actual cases by exotic venomous snakes, but not those of native vipers, due to fear of prosecution since the legislation came into effect in 1999. Patients categorised as "snake-handlers" comprise both amateur herpetoculturalists and professional herpetologists or biologists, while "laymen" comprise victims who normally are not involved in any type of snake-related activity.

3. Results

A total of 97 snakebites caused by native and exotic venomous species were recorded from 1 January 1970 to 30 September 2006 in Hungary (Table 1). In all, 17 (17.5%) cases were inflicted on laymen by either the native *V. berus* (15 cases) or *V. ursinii* (2 cases) with a mean annual incidence rate (combined for the two species) of 0.46 or 0.0046/100,000 inhabitants. Patient age for laymen ranged between 3 and 56 years, with a median age of 42 years, and all but four patients were males.

A total of 80 (82.5% of the total snakebites in Hungary) cases of snakebite were recorded among snake-handlers, and 61 (61/80, 76.3%) of these involved various exotic species of Viperidae, Elapidae, or Colubridae. The number of exotic snakebites and diversity of species involved showed a rise over the last 10–15 years, a direct consequence of the increased popularity of amateur snake keeping. The overall mean annual incidence rate for all snakebites (native and exotic species, laymen and snake-handler patients) in Hungary was 2.64 or 0.0265/100,000 inhabitants. There were two fatal cases, both involving snake-handlers, yielding a mean annual fatality rate of 0.05 or 0.0005/100,000 inhabitants.

Table 1
Venomous snakebites in Hungary between 1970 and 2006

Species	No. of bites (%), $n = 97$	No. of fatalities (% native/exotic)
Native	36 (37.1)	1 (2.8)
Viperidae: Viperinae		
Vipera berus	18 (18.6)	1 (2.8)
Vipera ursinii	18 (18.6)	–
Exotic	61 (62.9)	1 (1.6)
Viperidae: Viperinae		
Vipera ammodytes	29 (29.9)	–
Vipera palaestinae	1 (1.0)	–
Bitis arietans	5 (5.2)	–
Bitis nasicornis	1 (1.0)	–
Atheris squamiger	1 (1.0)	–
Viperidae: Crotalinae		
Crotalus atrox	4 (4.1)	–
Crotalus durissus	2 (2.1)	–
Agkistrodon contortrix	4 (4.1)	1 (1.6)
Agkistrodon piscivorus	1 (1.0)	–
Bothrops mattogrossensis	1 (1.0)	–
Cryptelytrops purpureomaculatus	1 (1.0)	–
Viridovipera stejnegeri	1 (1.0)	–
Calloselasma rhodostoma	1 (1.0)	
Elapidae		
Naja kaouthia	1 (1.0)	–
Naja haje	1 (1.0)	–
Colubridae		
Malpolon monspessulanus	4 (4.1)	–
Hydrodynastes gigas	1 (1.0)	–
Leioheterodon madagascariensis	1 (1.0)	–
Philodryas baroni	1 (1.0)	–

Snake-handler patients' ages ranged between 15 and 61 years, with a median age of 24 years (Table 2). Young men between the ages of 15 and 23 accounted for 42.7% of all bites involving a captive snake. Only one snake-handler patient was female. Among snake-handlers, 42 snakebite incidents (12 patients) had histories of snakebites over time; the maximum number of total bites per patient was 13. The median number of previous venomous bites for all snake-handlers was 1, and for snake-handlers with repeated bites it was 3.

Most snakebites in snake-handlers happened while attempting to catch a snake in the field (native *Vipera*), or in private homes during routine captive-care operations, such as snake handling, feeding, and cage cleaning (Table 3). Generally, different parts of the hand and lower arm (fingers, dorsum of

hand, palm, or wrist) were bitten, with just three bites to the leg, and one bite through a collecting bag into the patient's back. A single patient had his snakes perform ''test-bites'' in order to ''observe symptoms'' and ''acquire immunity''. This person had received a total of 13 snakebites including six of these ''test-bites'' and died from venom-induced anaphylaxis after his 13th bite by a *V. berus* (see below).

First aid was applied by the patients in 28 of the 61 (45.9%) exotic snakebites, and included several traditional but contraindicated methods such as incision, suction by mouth, $KMnO_4$ or H_2O_2 washing, and the use of tourniquets (Table 4).

Exotic snakebites resulted in the hospitalisation of 36 of the 61 victims (59.0%) with a median hospital stay of 4 days (range = 1–18 days). Most of these cases (33) were treated in the Toxicological Ward of Erzsébet Hospital in Budapest, with one each treated in county hospitals in Eger, Győr, and Pécs. Antivenom was administered to 18 of the 36 (50.0%) hospitalised patients (including self-administration before arrival to hospital). The following antivenoms were used for exotic species: Ipser Europe-Serum Antivenimeux Aspis Berus Ammodytes, Serum Antivenimeux Bitis Echis Naja Pasteur (Sanofi Pasteur, France), Anti Vipera Palaestinae (Felsenstein Medical Research, Israel), Wyeth Antivenin (Crotalidae) Polyvalent (Wyeth Laboratories, USA), and Cobra Antivenin (Thai Red Cross, Thailand).

There was a tendency by the physicians to administer antivenom routinely, rather than await the onset of systemic signs or indicators pointing to the development of severe local effects. Overall (native and exotic species, laymen and snake-handler patients), of the 97 snakebites, antivenom was administered in 36 cases. Of these patients, 16 (16/36, 44.4%) received antivenom therapy despite the fact that they did not show any systemic signs or symptoms of poisoning and local effects were not serious. Five patients developed late reactions (serum sickness type) to antivenom commonly presenting as fever, urticaria, and pruritus. In addition to urticaria, in one patient bitten by *Vipera ammodytes*, temporomandibular arthralgia and

Table 2
Demography of snake-handler patients bitten by captive-kept snakes (exotic and native species)

Age (years)	No. of patients (%), $n = 75$		
	Female	Male	Total
15–17	–	8 (10.7)	8 (10.7)
18–20	–	13 (17.3)	13 (17.3)
21–23	–	11 (14.7)	11 (14.7)
24–26	1 (1.3)	3 (4.0)	4 (5.3)
27–29	–	6 (8.0)	6 (8.0)
30–32	–	4 (5.3)	4 (5.3)
33–35	–	10 (13.3)	10 (13.3)
36–38	–	3 (4.0)	3 (4.0)
39–41	–	2 (2.7)	2 (2.7)
42–44	–	–	–
45–47	–	–	–
48–50	–	–	–
51–53	–	–	–
54–56	–	–	–
57–59	–	1 (1.3)	1 (1.3)
60–62	–	1 (1.3)	1 (1.3)
Unknown	–	12 (16.0)	12 (16.0)
Total	1 (1.3)	74 (98.7)	75 (100)

Table 3
Location of snakebites, and activity involved during an accident with exotic snakes

Activity during bite	No. (%) and location of bites, $n = 61$						Total
	Finger	Dorsal hand	Palm	Wrist	Leg	Back	
Handling the snake	20 (40.8)	1 (25.0)	1 (33.3)	1 (100)	–	–	23 (37.7)
Bagging and transporting the snake	4 (8.2)	–	2 (66.7)	–	1 (33.3)	1 (100)	8 (13.1)
Photographing	3 (6.1)	1 (25.0)	–	–	–	–	4 (6.6)
Treating a sick specimen	4 (8.2)	–	–	–	–	–	4 (6.6)
Daily routines: feeding, cleaning, etc.	14 (28.6)	2 (50.0)	–	–	1 (33.3)	–	17 (27.9)
Force-feeding	2 (4.1)	–	–	–	1 (33.3)	–	3 (4.9)
Teasing the snake	2 (4.1)	–	–	–	–	–	2 (3.3)
Total	49 (80.3)	4 (6.6)	3 (4.9)	1 (1.6)	3 (4.9)	1 (1.6)	61 (100)

Table 4
Treatment of patients following exotic venomous snakebite

Therapy	Hospitalised cases (%), $n = 36$	Unhospitalised cases (%), $n = 25$	Total (%), $n = 61$
First aid	22 (61.1)	6 (24.0)	28 (45.9)
Incision	17 (47.2)	5 (20.0)	22 (36.1)
Wound suction	7 (19.4)	3 (12.0)	10 (16.4)
Bleeding out	18 (50.0)	6 (24.0)	24 (39.3)
Wound washing (water/$KMnO_4$/H_2O_2)	10 (27.8)	4 (16.0)	14 (23.0)
Tourniquet	10 (27.8)	3 (12.0)	13 (21.3)
Hospital treatment			
Antivenom	18 (50.0)	1 (4.0)	19 (31.1)
Previous antivenom therapy	5 (13.9)	–	5 (8.2)
Allergic reactions (urticaria, fever, pruritus)	5 (13.9)	–	5 (8.2)
Anaphylaxis/anaphylactoid reaction	1 (2.8)	1 (4.0)	2 (3.3)
Plasmapheresis	2 (5.6)	–	2 (3.3)
Fasciotomy	3 (8.3)	–	3 (4.9)
Local resection	5 (13.9)	–	5 (8.2)
Necrotomy	4 (11.1)	–	4 (6.6)
Amputation	1 (2.8)	–	1 (1.6)
Blood transfusion	1 (2.8)	–	1 (1.6)
Plastic surgery	2 (5.6)	–	2 (3.3)
Fatal outcome	–	1 (4.0)	1 (1.6)

partial trismus developed 8 days after the administration of 5 ml Ipser Europe antivenom. In another patient with *Naja kaouthia* envenoming, anaphylactoid reaction (diffuse urticaria, itching, tachycardia) resulted 16 min following the administration of 10 ml of Cobra Antivenin antivenom.

In two cases of *Crotalus atrox* bite, the patients refused antivenom therapy due to a history of antivenom allergy. In these two patients plasmapheresis (therapeutic plasma exchange) was instituted as an alternative (Turchányi et al., 2000).

Symptomatic and supportive treatment consisted of immobilisation of the bitten limb, wound care (excision, washing with physiological solution or aluminium acetate), and administration of intravenous fluids, analgesics, adrenaline, diuretics, and corticosteroids. Systemic antibiotics and tetanus prophylaxis were administered in most hospitalised cases.

Surgical intervention was performed on 13 hospitalised patients including local resection (5 cases), local necrotomy (4), fasciotomy (surgical decompression for rapid compartment syndrome; 3), and amputation (1). Dermatoplasty or plastic surgery was performed on two patients.

3.1. Bites by native venomous snakes

V. ursinii was responsible for 18 cases including two laymen. Bites typically resulted in local pain, erythema, and minor to moderate swelling, with spontaneous resolution within 1–3 days. No systemic signs or symptoms were recorded. In two cases, involving a snake-handler with a history of *Vipera* bites, swelling extended to the entire arm, and the patient complained of gout and tenderness in the regional lymph nodes for 6 days. Following both accidents, the patient received one ampoule of antivenom (Ipser Europe). Local necrosis of about 1 cm of the bitten finger occurred in one of these cases. In the same patient and in another snake-handler also with a history of *Vipera* bites, generalised urticaria developed within 30–60 min following the bite.

V. berus was responsible for 18 bites, including one fatal case. All *V. berus* bites except one occurred in the snake's natural habitat. Of the 18 bites, 15 involved laymen (including two children aged 3 and 5 years). One patient showed no signs of envenomation. Seven patients presented with only local symptoms, including pain, minor to moderate swelling, erythema, haemorrhage, and regional lymphadenopathy. Nausea, vomiting, dizziness, and hypotension were the most common systemic symptoms for the rest of the cases. Two patients bitten in SW Hungary showed neurological symptoms, one with urinary incontinence and another with ptosis. Of the 18 patients, 15 were hospitalised and 12 received antivenom therapy.

The single fatal *V. berus* accident occurred on 29 April 2001 in NE Hungary: a 37-year-old snake-handler was bitten on both hands (one bite each) while photographing a snake (Tóth, 2003). As systemic allergic symptoms started to develop within a few minutes, he self-administered an unknown dose of adrenaline (Tonogen, Richter, Hungary). He died approximately 15 min post-bite. Antivenom was not administered. Based on witness reports and the victim's prior history of 12 different bites (Viperidae and Elapidae), along with his known history of snake venom allergy, the cause of death was attributed to anaphylaxis as a result of hypersensitivity to the snake venom, rather than the venom's toxic effect *per se*.

3.2. Bites by exotic venomous snakes

V. ammodytes was the most common cause of exotic snakebites, being involved in 29 cases. Characteristic local symptoms included pain, swelling, inflammation, and erythema, while less frequently, extensive oedema and haemorrhage. Collectively, systemic symptoms included abdominal pain, nausea, vomiting, hypotension, tachycardia, coagulation abnormalities, bladder tension, and diplopia. One victim developed shock 1 h after the bite (before antivenom administration). Necrosis around the bite site developed in three patients. In one case where the patient applied a local incision through the fang marks on the fingertip, reconstructive plastic surgery was necessary.

A single *Vipera palaestinae* bite was followed by immediate pain, massive oedema, and local haemorrhage of the bitten arm. Systemic symptoms included hypotension, moderate tachycardia, circulatory disturbances, and coagulopathy. Fasciotomy was performed to relieve the compartment syndrome due to massive oedema that spread up to the shoulder within 7 h of the bite.

Five patients were bitten by *Bitis arietans*. In one case a newborn specimen's single fang penetrated the patient's (a snake-handler's father) fingertip. Moderate swelling extending up to the elbow area and regional lymphoedema were the only symptoms lasting for 4 days, without medical intervention. Two other patients bitten by juvenile specimens showed local pain, mild swelling, and erythema around the bite site, one patient experiencing dizziness. Adult specimens were responsible for the other two *B. arietans* envenomations. In one case, haemorrhage and extensive swelling developed. The other case presented with severe local symptoms including pain, extensive haemorrhage, and massive oedema. Gross swelling of the affected arm led to compartment syndrome for which ultimately fasciotomy had to be performed. Systemic manifestations included abdominal pain, dizziness, and vomiting followed by loss of consciousness. Seizures had occurred approximately 15 min after the bite. The patient became hypotensive (80/40 mmHg) and tachycardic (140/min). Lab tests showed a partial thromboplastin time (PTT) of 91 s, an international normalised ratio (INR) of 3.79, and a thrombocyte count of 112×10^9/litre. The bitten thumb become necrotic and, as a result, was amputated. The patient received antivenom therapy.

One 30-year-old male patient was bitten by a subadult *B. nasicornis* with one fang on the index finger and admitted to the hospital an hour after the accident. Upon admission, there was no bleeding from the fang mark; the patient had local pain and slight livid discolouration around the bite site. Swelling from the bite site spread to the hand and other fingers, extending to the wrist, and the entire arm had become painful. Moderate tachycardia (105/min) and hypertension (155/80 mmHg) were observed. Lab tests showed PTT: 32 s and INR: 1.30. The patient received no antivenom.

A bite by an adult *Atheris squamiger* resulted in local symptoms, including pain of the bitten limb and swelling with slight erythema. Local arthralgia lasted for 4 days.

There were six *Crotalus* envenomations, two by *C. durissus* and four by *C. atrox*. One *C. durissus cumanensis* bite produced local pain, swelling, erythema, and a necrotic bitten finger. The patient performed an incision as a first-aid measure. This patient developed neurological symptoms, including muscle fasciculation, diplopia, and the characteristic "broken neck" syndrome. Liver function tests showed mild abnormality. The other *C. durissus* bite caused erythema and moderate swelling with no apparent systemic symptoms. *C. atrox* bites were characterised by extensive oedema of the bitten hand along with livid infiltrations, and one patient had to undergo fasciotomy. In the most severe case, headache, pallor, temporary blindness, singultus, and oedema of the face were the systemic manifestations. This patient received blood transfusion. Episodic haematuria lasting 4 h occurred, followed by spontaneous resolution.

A fatal snakebite involving *Agkistrodon contortrix* occurred on 21 May 1989. The victim was a

27-year-old healthy male, photographing the snake at home. He was alone when the accident occurred and was found dead after 3 days with an opened but unused antivenom kit near his body. The snake had been placed back into its cage. According to the autopsy report, the bite entered the flexor area of the left forearm and typical viper-like fang marks of 1 cm apart were visible. One fang penetrated the underlying vein where it left a "pinprick-like" mark on the continuity of the vessel. The cause of death was attributed to anaphylactic reaction along with possible contributory effect of intravenous injection of the venom. The victim had been bitten twice previously by *V. ammodytes*. Three other *A. contortrix* bites resulted in pain and swelling, one causing haemorrhage and minor local necrosis around the bite site.

Upon admission to hospital, a patient bitten by a subadult *Viridovipera stejnegeri* was pale, enervate, and perspiring. Local symptoms included, pain, erythema, and oedema that extended to the whole forearm requiring surgical intervention. Systemic symptoms were dizziness, hypotension, and mild tachycardia.

Agkistrodon piscivorus, *Bothrops mattogrossensis*, *Cryptelytrops purpureomaculatus*, and *Calloselasma rhodostoma* bites resulted in local symptoms including pain and limited swelling. Slight haemorrhage and minor necrosis at the bite site occurred only in the *C. rhodostoma* bite.

Only two patients were bitten by elapid (Elapidae) snakes. One case involving a bite by an adult *N. kaouthia* (unknown geographical origin) caused severe envenoming (Benke, 1991). The bite was on the superior phalanx of the left thumb, the snake having to be forcibly removed from the digit. No local pain was reported in the first 6–8 min; however, there was profuse bleeding from the fang marks. The patient experienced paraesthesia of the bitten limb and the swelling progressed to the hand and elbow. The whole hand became haemorrhagic accompanied by throbbing pain. Systemic symptoms included myalgia, neurotoxicity, vomiting, vertigo, hypotension (90/60 mmHg), bradycardia (66/min), and fainting. The neurological symptoms involved auditory hallucinations, blurred vision, respiratory distress, dilated pupils, dysphagia, and aphonia. Proteinuria lasted for several days. Extensive necrosis developed on the bitten thumb requiring plastic surgery correction.

The other elapid snakebite involving a *Naja haje* bite was to the patient's thigh, which became oedematous and haemorrhagic. Systemic neurological symptoms were drowsiness, respiratory distress, and hypersalivation. Unspecified temporary mental disturbances were reported. The patient was intubated to enable assisted ventilation.

Of the four *Malpolon monspessulanus* bites, three were asymptomatic, while one resulted in pain and local swelling with erythema of the affected arm lasting for 4 days. Similarly, pain around the bite site, local swelling, and erythema occurred in a *Philodryas baroni* bite, with spontaneous resolution within 3 days. Accidents caused by *Hydrodynastes gigas* and *Leioheterodon madagascariensis* resulted in local pain and mild swelling.

4. Discussion

Bites by native venomous snakes inflicted on laymen in Hungary are rare, with only 17 cases reported between 1970 and 2006. The last fatal case by *V. berus* that involved a layman occurred prior to 1956 in Somogy County, SW Hungary (Marián, 1956). The last fatal *V. ursinii* bite was recorded from the early 1900s (Méhely, 1912). For both species, we attribute this fact to the limited distribution area and low population density of the snakes, along with infrequent snake–human contact as the habitats are in sparsely populated areas or inside national parks. Hungary's mean annual snakebite incidence on laymen (0.0047/100,000 inhabitants) remains very low compared with some other parts of Europe, e.g., southern Croatia (~5.2/100,000; Lukšić et al., 2006), and Sweden (~2.6/100,000; Karlson-Stiber et al., 2006).

Exotic venomous snake keeping is a popular hobby/practice in Europe (Schaper et al., 2004; Warrell, 2005a) and serious or life-threatening envenomation by foreign species has been reported on several occasions (Bernheim et al., 2001; Chew et al., 2003; Schneemann et al., 2004). Ironically, it is information obtained from bites by exotic snakes kept in captivity that remains a main source of information about the clinical effects of the bite of some taxa (e.g., *Eristicophis*; Van den Enden and Emmanuel, 2005), or provides well-documented case histories (e.g., *Atheris*; Top et al., 2006) that normally are unavailable from the snake's natural habitat. Today in Hungary, snake keeping and exotic venomous snakes clearly pose a far greater medical risk than the two native vipers to the lay population. Venomous snake keeping has resulted in two deaths and debilitating consequences such as

fasciotomy and amputation. At present, private collections include a large number of medically important taxa (~58 venomous species in 2007) including *Bitis*, *Daboia*, *Echis*, *Crotalus*, *Bothrops*, *Acanthophis*, *Dendroaspis*, and *Naja*. Furthermore, as result of inappropriate legislation, the illegal keeping of venomous snakes may lead some individuals to delay in seeking proper medical treatment following bites for fear of prosecution.

The two fatalities in our survey illustrate the inherent danger arising from venomous snake keeping. Both patients have had several snakebites prior to the fatal event and in both cases the cause of death had been attributed to snake venom-induced anaphylaxis (a complication specific to snake-handlers) rather than the direct toxic effect of the venom *per se*. Repeated exposure to snakebites or other forms of venom contact is known to cause hypersensitivity that can lead to life-threatening anaphylaxis (Parrish and Pollard, 1959; Schmutz and Stahel, 1985; Warrell, 2005a). Snake-handlers and their physicians need to be aware of these risks and prepared to manage (i) the venom toxic effect *per se*, (ii) the possible allergic reactions to the snake venom (pre-hospital anaphylaxis), and (iii) the possibility of adverse reactions to snake antivenoms, if antivenom therapy is implemented. Snake-handlers need to be aware that emergency management of pre-hospital anaphylaxis is not always successful, as highlighted here by the death of a snake-handler following a *V. berus* bite. The patient was fully aware of his hypersensitivity and had adrenaline on hand, yet his apparently correct steps to save his own life still failed.

First-aid methods, such as incision, wound washing with $KMnO_4$ or H_2O_2 solutions, and tourniquet use, have long been contraindicated (Warrell, 1993) but were still applied in several cases. These methods are delaying expedite transport to hospitals and could easily be a contributing factor to some of the extensive local tissue damage we observed. For snake-handlers in Hungary, in conjunction with the accepted and established first-aid measures (e.g., Warrell, 2005b), we advocate seeking immediate medical care after any venomous snakebite while supporting vital functions as priority. Among our patient population, a mobile phone seems to be one of the best ''first-aid'' responses.

Antivenom for the native *Vipera* is stocked in six of the 19 county hospitals located in the endemic areas, two regional pharmacies, the National Public Health and Medical Officer Service, and the Toxicological Ward of Erzsébet Hospital (the main snakebite treatment centre in Hungary) in Budapest (Anonymous, 1991). However, it is often used inappropriately by physicians who administer it upon suspicion of a snakebite, rather than waiting for signs of systemic poisoning or indicators of severe local symptoms (Virágh and Tass, 1986). In some cases patients received antivenom for what may have been, or was in fact confirmed to have been, injuries by non-venomous snakes *Coronella*, *Elaphe*, or for wasp- or bee-stings.

Past exposure to antivenom may place snake-handlers at a higher risk of adverse reactions if antivenom needs to be given in the future (e.g., Warrell, 2005a), and this is reflected in both early and later allergic responses in our patient population. In order to circumvent possible antivenom reaction, as an alternative treatment, two patients in our survey received non-specific plasmapheresis (Turchányi et al., 2000). Plasmapheresis has been applied in a few, isolated snakebite incidents (Kornalík and Vorlová, 1990; Laothong and Sitprija, 2001; Pantanowitz and Andrzejewski, 2006; Yildirim et al., 2006; Isbister et al., 2007). Its risk–benefit for snakebites in general or for specific clinical presentations remains to be evaluated.

We recommend that there should be a single dedicated medical facility to treat snakebites in Hungary, staffed by medical personnel with an extensive understanding of snake venoms and management of exotic snakebites. It should be properly stocked with antivenoms and have an established network of domestic and foreign physicians and herpetologists in case consultation is needed. This would be feasible given the small distances within Hungary, good telecommunication and transportation network, and the availability of emergency air transport. While we clearly understand the difficulties involved, there should also be relevant education of amateur snake-handlers, perhaps as a condition of permit issue. According to current regulations, the type of glass and size of cage is more important than the keeper's basic knowledge in emergency handling of a snakebite.

In conclusion: (i) for laymen, the risk of being bitten by a native venomous snake in Hungary is extremely low; (ii) however, captive exotic species are responsible for life-threatening bites and present a unique and challenging medical emergency; and (iii) repeated exposure to venoms and antivenoms in snake-handlers may increase the risks of both

venom-induced and antivenom-induced anaphylaxis or anaphylactoid reactions.

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