

Epidemiological profile of ophidian accidents in the region of Las Montañas, Veracruz, Mexico (2003-2016).

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ABSTRACT

A study was carried out on the presence of snakes of medical importance in the region of Las Montañas, located in the central area of the state of Veracruz, Mexico, with the objective of identifying which species are located in that region, their geographic distribution and accidents in the ones that these kinds of animals are involved. Thirteen species were identified, of which 11 species are viperid and two elapids. The physiographic sub regions Sierra Zongolica and Sierra Pico de Orizaba present the highest number of species. It is observed that they are more frequent between the range of the 700 to 2,500 msnm, and a remarkable decrease of species after the 2,800 msnm. Three species presented a wide distribution, and the authors who support the research are the following: *Micrurus diastema* (Duméril, Bibron y Duméril, 1854), *Atropoides nummifer* (Rüppell, 1845) and *Bothrops asper* (Garman, 1883). In the period from January 2003 to November 2016, 886 snakebites have been registered, with the most frequent months from June to October. The municipalities with the highest number of accidents, as well as the incidence rate are Córdoba and Tezonapa.

Keywords: Snakes, distribution, records, bites, Veracruz.

RESUMEN

Se elaboró un estudio sobre la presencia de serpientes de importancia médica en la región Las Montañas, ubicada en la zona centro del estado de Veracruz, México, con el objetivo de identificar que especies se localizan en esta región, su distribución geográfica y accidentes en los que

estos animales se ven involucrados. Se identificaron 13 especies, de las cuales 11 especies son vipéridos y dos elápidos. Las subregiones fisiográficas Sierra Zongolica y Sierra Pico de Orizaba presentan el mayor número de especies. Se observa que son más frecuentes entre el rango de los 700 a 2,500 msnm, y una notable disminución de especies después de los 2,800 msnm. Tres especies presentan una amplia distribución: *Micrurus diastema* (Duméril, Bibron y Duméril, 1854), *Atropoides nummifer* (Rüppell, 1845) y *Bothrops asper* (Garman, 1883). En el periodo de enero de 2003 a noviembre de 2016, se han registrado 886 accidentes ofídicos, siendo los meses de junio a octubre los más frecuentes. Los municipios con mayor número de accidentes, así como la tasa de incidencia son Córdoba y Tezonapa.

Palabras clave: Serpientes, distribución, registros, mordeduras, Veracruz.

INTRODUCTION

There are approximately 3,619 snake species in the world, of which 19% are considered medically important because they have toxin-producing glands capable of causing poisoning (Campbell and Lamar 2004, Uetz et al. 2017). Venomous snake bites are a public health problem, due to venom inoculation that damages the tissues and / or causes a characteristic clinical picture that causes local or systemic pathophysiological alterations (Walteros and Paredes 2014), which can lead to death or disability physical. About 5 million snakebites occur each year (WHO

2013). Most occur in Africa, Asia and Latin America in tropical and subtropical areas where there is a great diversity of snakes because these reptiles of ectothermic body temperature prefer wet and warm places (Gutierrez et al. 2006, Waldez and Vogt 2009, Natera et al. 2005).

Accidents with snakes in Latin America are a public health problem, causing high rates of mortality and morbidity (Warrell 2004). The main species of medical interest belong to the family Viperidae, subfamily Crotalinae (nauyacas and rattles), these snakes are characterized by having a pair of thermoreceptor lore located between the eye and the nostrils, the neck is well formed, the head is large and triangular, have solenglia dentition, which are folded grooved fangs in the front of the mouth highly specialized to inject venom (Campbell and Lamar 2004, Vitt and Caldwell 2009). There is another relatively minor group of medically important snakes called "coral snakes" or "coralillos", included in the Elapidae family, Elapinae subfamily, their practical identification is more complex due to the pattern of body coloration in stripes or black colored rings, Red and yellow or white. The color, arrangement and number of rings are characteristic for each species. They have a protero-glyphic dentition whose fangs are small and fixed in the anterior part of the maxilla where the poison is inoculated (Roze 1996).

In the State of Veracruz there are approximately 124 species of snakes, of which 21 species are considered of medical importance (Guzmán-Guzmán 2011, Yañez-Arenas et al. 2014), is one of the five states of the Mexican republic with the highest prevalence of ophidian accidents (Zúñiga-Carrasco and Caro-Lozano 2013), with an incidence rate of 49.2 incidents per 100,000 inhabitants (Yañez-Arenas 2014). In the region of Las Montañas, approximately 83 species of snakes are known (Almaraz-Vidal and Cerón-De la Luz 2016), and this region is the second largest in incidence of ophidian accidents in the state of Veracruz (Yañez-Arenas 2014). The richness of venomous snakes in this

region is due to the variety of environments (tropical, temperate and dry), offered by the physiographic provinces Neovolcanic Axis, Coastal Plain of the Southern Gulf and Sierra Madre del Sur (Loeza-Corichi 2004).

Despite the importance as a health problem, there is a lack of studies on ophthalmology in the study region, only two epidemiological studies on this subject carried out by Luna-Bauza (2007) and Luna-Bauza et al. (2004) only for the municipality of Córdoba. The aim of this work is to expand the knowledge about the species of snakes of medical importance that occur in this area, considering their ecological aspects, geographic distribution and the epidemiology of ophidian accidents. Having a map that correlates the geographic distribution with the areas with the highest incidence of ophidian accidents, will help identify potential risk areas, the species that caused the accident and thus allow adequate medical care.

MATERIALS AND METHODS

Study area Las Montañas region is located in the south-central portion of the State of Veracruz, in the foothills of the Sierra Madre del Sur, the Neovolcanic Axis and the Southern Gulf Coastal Plain, between the geographic coordinates 18° 65' and 19° 15' north latitude and 96° 5' and 97° 25' west longitude. It limits to the west with the State of Puebla, to the southeast with the region Papaloapan and to the south with the State of Oaxaca. They are located at the confluence of the Sierra Madre del Sur, the Neovolcanic Axis and the Coastal Plain of the South Gulf. The region comprises 57 municipalities which in their totality have an area of 6,053 km²

Which represent 8.4% of the state territory, occupying the fifth place by its territorial extension (SEFIPLAN 2013). The altitudinal range ranges from 10 to 5500 meters above sea level. The types of vegetation that occur in this region are high evergreen

forest and high semi-evergreen forest, tropical dry forest, medium sub deciduous forest, pine forest, oak forest, pine-oak forest, oak- pine forest, Oyamel forest, Cloud forest, High Mountain Prairie, cultivated and Induced Grassland, Irrigated and temporal agriculture (INEGI 2015), however, some of these vegetation's have been replaced by agricultural crops, coffee cultivation (*Coffea arabica*), sugar cane sugar (*Saccharum officinarum*) and grain maize (*Zea mays*). Other important crops are beans, grasses, lemon, banana leaf (Velillo), potato, heave rubber and chayote (SEFIPLAN 2013).

The list of venomous snakes for the region of Las Montañas was elaborated based on the literature review available, the herpetological collection of the Faculty of Biological and Agricultural Sciences of the Veracruzana University Campus Peñuela was also consulted, field records of the authors and of working group in herpetology of the Faculty of Biological and Agricultural Sciences of Veracruzana University, Peñuela campus. Likewise, databases of EncicloVida portals of National Commission for Understanding and Use of Biodiversity (CONABIO) (www.enciclovida.mx), Open Data Portal of National Autonomous University of Mexico (UNAM) ([Http://www.datosabiertos.unam.mx](http://www.datosabiertos.unam.mx)), VertNet (<http://www.vertnet.org>) and Global Biodiversity Information Facility (GBIF) (<http://www.gbif.org>). Doubtful records, records without sufficient data, records that did not match the distribution of organisms and records in which the identity of the species was not counted were eliminated. The taxonomic classification of the species was reviewed according to Uetz et al. (2017).

The distribution of species in the region of Las Montañas was based on the classification proposed by Almaraz-Vidal and Cerón de la Luz (2016), which is divided into nine sub regions for its physiography and climate, which are Sierra Atoyac, Sierra Córdoba- Amatlan, Sierra Huatusco, Sierra Ixtaczoquitlán, Sierra Tezonapa, Sierra Pico de

Orizaba, Sierra Zongolica, Alpina Orizaba and Planicie.

Information on ophidian cases was obtained through the Single Automated System of Epidemiological Surveillance (SUAVE) of the Ministry of Health, from January 2003 to November 2016. Incidence rates were calculated for each municipality and as for all study area (sum of the cases of all municipalities divided by the total population of Veracruz per 100,000 inhabitants), using information from the National Institute of Statistics, Geography and Informatics (INEGI 2016) and Population Projections of the National Council of Population (CONAPO). Using the ArcGIS 10.3[®] program, geographic distribution maps of species of medical importance and areas with the highest incidence of ophidian accidents were developed.

RESULTS AND DISCUSSION

In the region of Las Montañas, the snakes of medical importance are divided into 13 species, six genera and two families: Elapidae and Viperidae. The richness of venomous snakes in this region is due to the variety of environments (tropical, temperate and dry), offered by the physiographic provinces Neovolcanic Axis, Coastal Plain of the Southern Gulf and Sierra Madre del Sur (Loeza-Corichi 2004).

In Table 1, the Sierra Zongolica physiographic subregion shows the highest number of species (nine species), followed by the Sierra Pico de Orizaba with seven species, Alpina Orizaba with six species and Sierra Córdoba-Amatlán subregions, Sierra Tezonapa and Planicie with four Species each. While the Sierra Atoyac, Sierra Huatusco and Sierra Ixtaczoquitlán recorded the lowest number of species with only three species in each (Table 1). These areas are a reference for the geographic distribution of the species, because the ecological conditions of each subregion are and in some cases unique, such is the case of the Sierra Zongolica subregion in which new

Table 1. Species of medical importance and distribution in the region of Las Montañas, Veracruz.

Species	Sub regions									Meters above sea level (masl)
	1	2	3	4	5	6	7	8	9	
Elapidae Family										
<i>Micrurus diastema</i>	x	x	x	x	x	x	x	-	x	10-1,850
<i>Micrurus elegans</i>	x	x	-	x	-	x	x	-	-	700-1,500
Viperidae Family										
<i>Atropoides nummifer</i>	x	x	x	x	x	x	x	x	-	700-2,000
<i>Bothrops asper</i>	x	x	-	x	x	-	-	-	x	10-1,800
<i>Cerrophidion petlalcalensis</i>	x	-	-	-	-	-	-	-	-	2,100-2,800
<i>Crotalus atrox</i>	-	-	-	-	-	-	-	-	x	100-250
<i>Crotalus intermedius</i>	-	-	-	-	-	-	-	x	-	2,500-2,900
<i>Crotalus molossus</i>	x	-	x	-	-	-	-	x	-	1,500-2,100
<i>Crotalus ravus</i>	-	-	x	-	-	-	-	x	-	1,900-2,400
<i>Crotalus simus</i>	-	-	-	-	-	-	-	-	x	260-550
<i>Crotalus triseriatus</i>	x	-	x	-	-	-	-	x	-	1,800-3,200
<i>Ophryacus smaragdinus</i>	x	-	x	-	-	-	-	-	-	1,350-2,400
<i>Ophryacus undulatus</i>	x	-	x	-	-	-	-	x	-	900-2,500

Subregions: 1. Sierra Zongolica, 2. Sierra Córdoba-Amatlán, 3. Sierra Pico de Orizaba, 4. Sierra Tezonapa, 5. Sierra Atoyac, 6. Sierra Huatusco, 7. Sierra Ixtaczoquitlán, 8. Alpina Orizaba, 9. Planicie.

species have been discovered *Cerrophidion petlalcalensis* (López-Luna et al. 1999) and *Ophryacus smaragdinus* (Grünwald et al. 2015), and range of distribution for *Crotalus intermedius* (Bryson and García-Vázquez 2007).

Another characteristic to locate the wealth of species is by means of the altitudinal distribution. Snakes of medical importance can be found at altitudes from 10 meters up to 3,200 meters above sea level, they are more frequent between the range of 700 and 2,500 meters above sea level, and a remarkable decrease of species after 2,500 meters above sea level, so they can be considered Like species of snakes that live in mountains. Three species present a wide distribution where *Bothrops asper* and *M. diastema* are distributed in low and moderate elevations, whereas *Atropoides nummifer* is distributed in zones of medium altitude (Fig. 1). Because they are ectothermic organisms,

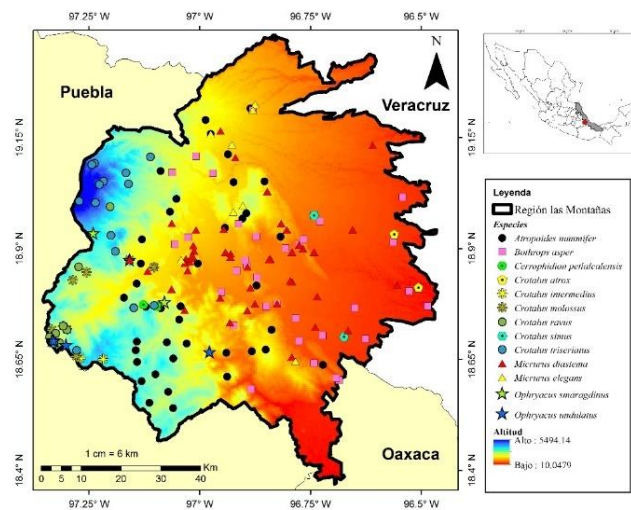


Fig. 1. Altitudinal distribution of species of medical importance in the region of Las Montañas.

their presence is less frequent in the highlands where temperatures are usually low. While in lower altitude

areas they are warm regions where their diversity increases (Fernández-Badillo et al. 2016).

In the period from January 2003 to November 2016 in the region of Las Montañas, there were 886 ophidian accidents with an incidence rate of 10.92 accidents per 100,000 inhabitants statewide. When analyzing the previous figures to a greater number of cases was registered in 2003, while in 2016 it was the one with the lowest number of cases (Table 2), the incidence rate of the ophidian accident had a decrease in the entire study area, Going from an incidence rate of 1.18 in 2003 to a rate of 0.28 x per 100,000 inhabitants in 2016.

Table 2. Records of ophidian accidents and incidence rate by year in the region of Las Montañas, Veracruz (2003-2016).

Year	Cases	Rate
2003	86	1.18
2004	65	0.88
2005	58	0.78
2006	55	0.74
2007	66	0.88
2008	69	0.91
2009	62	0.81
2010	61	0.79
2011	81	1.10
2012	82	1.05
2013	78	0.99
2014	64	0.81
2015	36	0.45
2016	23	0.28

The municipalities with the highest incidence rate were Córdoba and Tezonapa, followed by Zongolica, Río Blanco and the other municipalities presented less than 27 cases in the analyzed period (Table 3, Fig. 2). This number is probably higher or lower than what is recorded, since many of the municipalities transfer the victims of ophidian accidents to other cities with the provision of

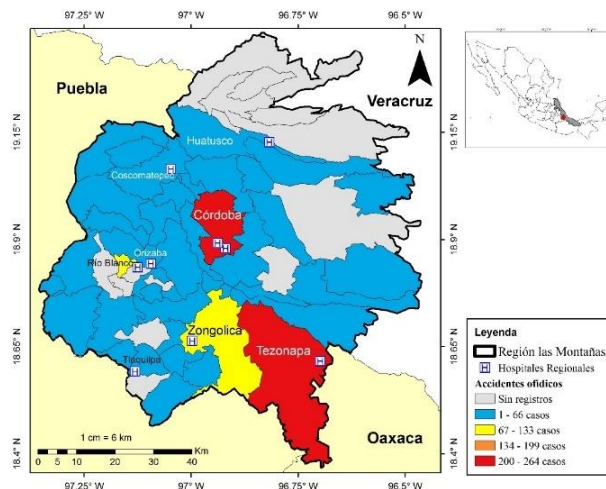


Fig. 2. Distribution of ophidian accidents recorded in the region of Las Montañas (2003-2016).

antivenom and/or more hospital care in the vicinity of the accident site, such as Case of the General Hospital of Zone No. 8 located in Córdoba, where 21 medical units are supported, concentrated in five zones: Omealca, Potrero, Tierra Blanca and Córdoba of the state of Veracruz, and to the municipality of Cosolapa that belongs to the state of Oaxaca -Bauza et al., 2004). According to Yañez-Arenas (2014), the municipalities of the most affected regions of the state of Veracruz are characterized by having a high rural population and marginalization, since agricultural and livestock activities are commonly developed by the rural population and increase the probability of Encounter between humans and snakes (Chippaux 2012).

Accidents were recorded during almost all months of the year; the highest number of cases occurs during the months that correspond to the period of rainy season (June to October) (Fig. 3). Some studies have revealed a clear relationship between monthly rainfall and the frequency of ophidian accidents (Nascimento 2000, Oliveira and Martins 2001, Romano-Hoge 2002, Moreno et al. 2005, Lima et al. 2009), due to the overflow of water

Tabla 3. Accidentes ofídicos y tasa de incidencia por municipio en la región Las Montañas, Veracruz (2003-2016).

Region	Cases	Incidence rate
Córdoba	264	3.25
Tezonapa	251	3.09
Zongolica	78	0.96
Río Blanco	68	0.84
Coscomatepec	58	0.71
Huatusco	26	0.32
Omealca	22	0.27
Tlaquilpa	16	0.20
Atoyac	9	0.11
Ixtaczoquitlan	8	0.10
Acultzingo	6	0.07
La Perla	6	0.07
Tequila	6	0.07
Ixhualtán del Café	5	0.06
Atzacan	4	0.05
Cuitláhuac	4	0.05
Mixtla de Altamirano	4	0.05
Naranjal	4	0.05
Orizaba	3	0.04
Amatlán de los Reyes	3	0.04
Chocamán	3	0.04
Cuichapa	3	0.04
Magdalena	3	0.04
Alpatláhuac	2	0.02
Aquila	2	0.02
Calchahualco	2	0.02
Camarón de Tejeda	2	0.02
Carrillo Puerto	2	0.02
Fortín	2	0.02
Los Reyes	2	0.02
Maltrata	2	0.02
Mariano Escobedo	2	0.02
Soledad Atzompa	2	0.02
Texhuacán	2	0.02

Xoxocotla	2	0.02
Tepatlaxco	1	0.01
Ixhualtancillo	1	0.01
Coetzala	1	0.01
Rafael Delgado	1	0.01
San Andrés Tenejapan	1	0.01
Tehuipango	1	0.01
Tomatlán	1	0.01
Zentla	1	0.01

bodies (rivers, streams and lagoons) in this period, causing the snakes to be forced out of their burrows in search of the driest places, increasing the possibility of encounter with the human being (Oliveira y Martins 2001, Bernarde y Abe 2006); in addition, this season there is increase in the availability of prey and is when snake's births occur with greater intensity (Natera et al. 2005).

In table 4 shows the cases of ophidian accidents by age group. The age at which this phenomenon occurs most frequently was between 25 and 44 years, with 31%, with male victims as the main victims. These data are consistent with those reported by Guzmán-Guzmán et al. (1993) and Luna-Bauza et al. (2004), where most ophidian accidents occur in males aged between 25 and 44 due to the fact that in this genre and age range the largest labor force is concentrated in the field. A considerable number is highlighted in the age group over 65 years of age, probably because there is a considerable number of elderly people among rural workers. Cruz et al. (2009) point out that bites from poisonous snakes in developing countries is an occupational disease that mostly affects young farm workers. The prevalence of accidents in people aged 15 to 19 may be due to the early entry into the agricultural work of people of this age group, most likely to contribute to family economy.

Several studies have suggested a strong relationship between ophidian accidents and patterns

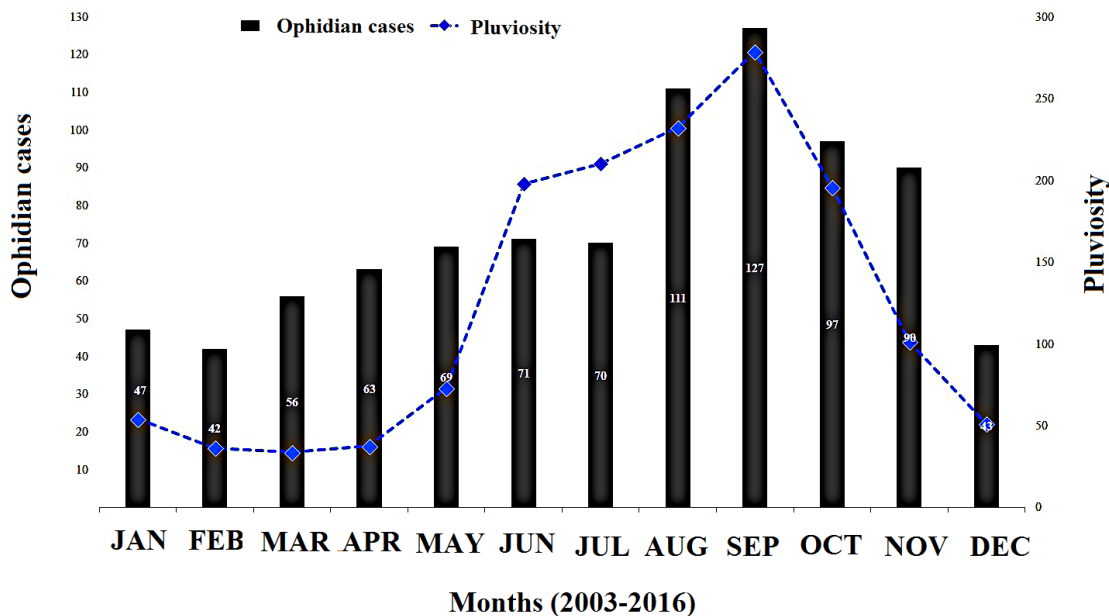


Fig. 3. Distribution ophidian accidents and rainfall recorded in the region of Las Montañas

of human activity. Chippaux (1988) and Sandrin et al. (2005) indicate that the occurrence of ophidian accidents is mainly related to factors such as economic activities mainly agricultural; since in these months of rains the activities in the field increase (planting and harvesting of the crops), being a greater exposition of risk of snake bite (Theakston et al. 2003).

Regarding the species that can cause ophidian accidents in the region of Las Montañas, it is not possible to state with precision which are those involved, since these data are not recorded in the statistics collected. According to the information obtained, the most important species involved in the number of accidents are *B. asper* and *A. nummifer* due to their wide geographical distribution in the study area. These data agree with Luna-Bauza et al. (2004), where *B. asper* and *A. nummifer* caused most of the snakebite accidents attended at the General Hospital of Zone No. 8.

B. asper is probably the most dangerous snake in Latin America, due to its wide distribution, nocturnal habits, although it can be found in activity during the day. Due to its cryptic coloration, similar to logs and leaf litter. Juvenile specimens are often semiarboreal and even adults are sometimes found in shrubs and low trees (Campbell and Lamar 2004). It has the capacity to adapt to disturbed areas such as pastures and agricultural crops (Sasa and Vazquez 2003). This species is irascible and its behavior is unpredictable when they are disturbed, it retracts the front of the body and launches the bite violently (Campbell and Lamar 2004, Pérez-Higareda et al. 2007, Ramírez-Bautista et al. 2014). *A. nummifer* is frequent in mountain areas, it is terrestrial and nocturnal, although sometimes it can be observed during the day. It usually tends to hide in cracks of stones, in the litter, inside or under old logs (Almaraz-Vidal 2001, Campbell and Lamar 2004).

recognize the species involved and incorporate this

Table 4. Distribution of ophidian accidents by age class and sex.

Age classes (years)	Gender				Total	
	Male		Female		No.	%
	No.	%	No.	%		
< 1	1	0	0	0	1	
1 a 4	6	1	8	3	14	2
5 a 9	18	3	20	8	38	4
10 a 14	47	8	19	7	64	7
15 a 19	72	12	30	11	101	12
20 a 24	61	10	21	8	81	9
25 a 44	178	29	100	38	266	31
45 a 49	59	9	20	8	77	9
50 a 59	77	12	29	11	104	12
60 a 64	42	7	9	3	50	6
>65	52	8	9	3	60	7
Not know	7	1	1	0	8	1
Total	620	100	266	100	886	100

CONCLUSIONS

The richness of medically important snake species occurring in the Las Montanas region may be underestimated as it is only based on information available in museum databases and bibliographic references. In addition, there are unexplored areas, either because of the difficulty of access and / or ignorance of the region. In this sense, research should be encouraged to have a current record of species and maps of geographic distribution. Knowing the geographic distribution of snakes of medical interest, as well as the distribution of snakebite accidents will serve to identify areas of higher ophidian risk, design environmental education campaigns prevention and availability of antidotes in the different opportune places of the region. As well as training health professionals, so that before an accident they can

data into the statistics collected by the Unified Automated System of Epidemiological Surveillance.

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