Namibian Journal of Environment

Environmental Information Service, Namibia for the Ministry of Environment and Tourism, the Namibian Chamber of Environment and the Namibia University of Science and Technology.

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ISSN: 2026-8327 (online).

Editor: BA CURTIS

SECTION A: PEER-REVIEWED PAPERS

Recommended citation format:

Hauptfleisch ML & Theart F (2018) A spatial and temporal assessment of human-snake conflicts in Windhoek, Namibia. *Namibian Journal of Environment* 2 A: 128-133.

A spatial and temporal assessment of human-snake conflicts in Windhoek, Namibia

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URL: http://www.nje.org.na/index.php/nje/article/view/volume2-hauptfleisch
Published online: 5th December 2018

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Date received: 21st May 2018; Date accepted: 4th December 2018.

ABSTRACT

Conflict between snakes and people in urban areas is a problem Windhoek shares with many cities around the world. Surrounded by farm and natural land, the capital city of Namibia experiences regular snake occurrence in and around houses, gardens and industrial sites. We analysed snake removal data from the city's designated snake removal institution, Snakes of Namibia, in order to determine abundance and diversity of snakes occurring in the city during the summer of 2015-2016, and identify possible reasons for conflicts. Over the period August 2015 to April 2016, 182 snakes of 12 species were removed from homes, gardens and industrial sites in the city. Puff adder (*Bitis arietans arietans*) and zebra snake (*Naja nigricincta*) which represented 35% and 29% respectively of all removal incidents. Of the other species, only brown house snake (*Boaedon capensis*) and boomslang (*Dispholidus typus viridis*) accounted for more than 6% of removals. Monthly snake removals correlated highly with monthly total rainfall, with highest number of incidents reported in January 2016 (23%, n=41). Incidents were concentrated in the eastern and southern suburbs, as a result of garden irrigation although the study could not measure whether reporting diligence was consistent across all suburbs. Although 81% (n=147) of snake incidents involved venomous species no snakebite incidents were reported during the period.

Keywords: human-snake conflict; Namibia; Serpentes; snakes; spatial; Windhoek

INTRODUCTION

Human-wildlife conflict is rising globally as wildlife populations increase in urban environments, mainly as a result of the expansion of urban areas which encroach on wildlife habitat (Madden 2004). This results in increased competition for resources such as food and space (Kaplan et al. 2011). Mostly seen as a rural problem in Namibia, research and management of human-wildlife conflict focuses on predator-livestock conflict (Dickman et al. 2013, Weise et al. 2015) and mega-herbivore-cultivation agriculture conflict (Hoare 2015). No studies have been published on urban snake occurrences in Namibia, which are perceived as a safety concern to humans, as 16% (n=14) of Namibia's snake species are known to be highly venomous and life threatening. Historically, the most commonly observed response to snake occurrences in and around Windhoek has been people killing snakes in homes, gardens and workspaces. This, together with habitat destruction and fragmentation in the fast-growing city and surrounding areas (Namplace 2016), could be a conservation concern for populations of endemic snake species known to occur in the area. In addition, attempting to kill snakes increases the risk of humans being bitten, by threatening snakes into defensive envenomation.

There are 1,654 described species of reptiles in Africa (Reptile Database 2016) with the highest diversity being in southern Africa (Branch 1999). Of these, 261 species occur in Namibia (Simmons et al. 1998), and 78 in the greater Windhoek area (Envirodynamics 2009). Snakes account for 86 species (Herrmann & Branch 2013) of which 36 are expected to occur in the larger Windhoek area (this includes blind, thread, python, burrowing and typical snakes) (Envirodynamics 2009). Of these, eight are regarded as endemic to Namibia, but none are known to be under threat (Simmons et al. 1998).

Snakes and humans cohabitate in many parts of the world, from rural to urban environments (Butler et al. 2005). In some cases snakes may even prefer areas with human activity over truly natural habitats (Shine & Fitzgerald 1996, Clemann et al. 2004). In order to reduce persecution of snakes, and reduce human envenomation risk, a voluntary group (Snakes of Namibia) removes and relocates snakes from potential conflict sites in and around Windhoek.

This study analysed ecological and morphological data from human-snake conflict events over a nine-month period (August 2015 to April 2016) to provide insight into the possibility of deriving scientifically sound ecological and biometric information about this understudied taxon. This helps to improve the knowledge of reptiles in Namibia, a subject largely neglected in ecology of the continent (Tolley et al. 2016). The study further explored the value of the information in reducing human-snake conflict in and around Windhoek.

METHODS

Study Area

Windhoek has a rapidly growing population of over 350,000, with a growth rate of 40% between 2001 and 2011 (Namibia Statistics Agency 2011). It is situated in the Highland Shrubland vegetation type of the Tree and Shrub Savanna Biome, which is characterised by low, unpredictable rainfall (350-400 mm) (Mendelsohn at al 2002). Dominant woody species include a number of *Acacia* (*sensu lato*) species (e.g. *Acacia mellifera*, *A. hebeclada*, *A. hereroensis*) while climax grass species are dominated by *Anthephora pubescens*, *Brachiaria nigropedata*, and *Heteropogon contortus* (Joubert et al. 2008). It is surrounded by the Auas and Eros mountains, areas identified as hosting a high number of endemic vertebrates (Griffin 2000).

Methodology

The non-profit organisation, Snakes of Namibia, has been removing reptiles from urban areas in greater Windhoek since late 2013. With the service well known by 2015 and officially reported as such in local media and by Windhoek emergency services as well as the Ministry of Environment and Tourism (Windhoek Observer 30 April 2015, Travel News 22 January 2015), snake reports from Snakes of Namibia as of the spring of 2015 were considered to be relatively representative of overall human-snake conflicts during this period. Relying on reporting to accurately reflect incident frequency and density should, however, be considered with caution as not all incidents are reported. Another human-wildlife conflict activity (bird strikes) in greater Windhoek, found only 25% of all incidents were reported even though reporting was a statutory requirement (Hauptfleisch et al. 2013). The true number of human-snake conflict incidents are likely to therefore be much higher than those reported.

Biometric data captured were snout-vent length, maximum girth and mass, while the air and ground temperature at the point of capture were also recorded.

RESULTS

Species Captured

Between August 2015 and April 2016, 182 snakes of 12 species were removed from residential and industrial sites in and around Windhoek. Species most encountered were *Bitis arietans arietans*, which represented 36% (n=65) of incidents and *Naja nigricincta*, 29% (n=53) (Table 1). Of the other species, only *Boaedon capensis*, 12% (n=21) and *Dispholidus typus viridis*, 9% (n=17) accounted for more than 9% of incidents. Of the above, 177 individuals were sexed, of which 57% (n=101) were females and 43% (n=76) were males. Of particular interest was the preponderance of males in *B. a. arietans* (63%) and females in *N. nigricincta* (83%).

Temporal Patterns

The highest numbers of snakes were removed in January 2016 (23%, n=41), with a clear increase from August 2015, which had the lowest number removed (2%, n=4), and a decreasing trend after January 2016, generally following the monthly rainfall pattern (Figure 1). For the five most reported species, the numbers correlated significantly with monthly

Table 1: *Snakes relocated from residential and industrial sites in the greater Windhoek area between August 2015 and April 2016*

Common name	Scientific name	n	%	Un-sexed	Female n	Male n	Female %	Male %
Anchieta's Cobra	*Naja anchietae*	9	5.0	0	8	1	88.9	11.1
Anchieta's Dwarf Python	*Python anchietae*	1	0.6	0	1	0	100.0	0.0
Black Mamba	*Dendroaspis polylepis*	3	1.7	0	1	2	66.7	33.3
Boomslang	*Dispholidus typus viridis*	17	9.3	0	10	7	58.8	41.2
Brown House Snake	*Boaedon capensis*	21	11.5	1	9	11	45.0	55.0
Leopard Whip Snake	*Psammophis leopardinus*	1	0.6	0	1	0	100.0	0.0
Mole Snake	*Pseudaspis cana*	3	1.7	0	0	3	0.0	100.0
Puff Adder	*Bitis arietans arietans*	65	35.7	2	22	41	34.9	65.1
Southern African Python	*Python natalensis*	2	1.1	0	1	1	50.0	50.0
Spotted Bush Snake	*Philothamnus semivariegatus*	3	1.7	0	2	1	66.7	33.3
Western Stripe-bellied Sand Snake	*Psammophis subtaeniatus*	4	2.2	0	2	2	50.0	50.0
Zebra Snake	*Naja nigricincta*	53	29.1	2	44	7	86.3	13.7
	Total number relocated	**182**		**5**	**101**	**76**		

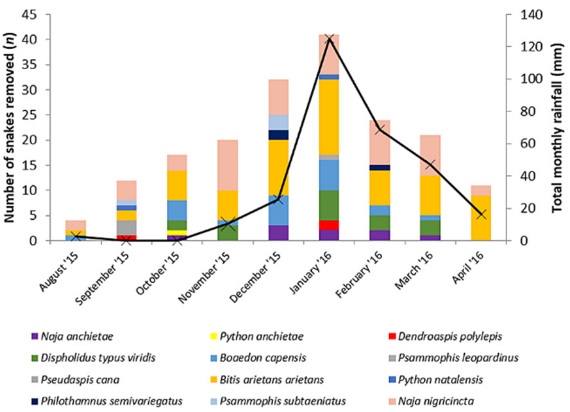

Figure 1: *Monthly variations in species and numbers of snakes removed from residential and industrial sites in the greater Windhoek area and monthly rainfall for the same period.*

rainfall for *B. a. arietans* (r=0.76, df=7, p<0.05) and *D. t. viridis* (r=0.82, df=7, p<0.01). For *N. anchietae* (r=0.58, df=7, p>0.05), *N. nigricincta* (r=0.55, df=7, p>0.05) and *B. capensis* (r=0.51, df=7, p>0.05) the correlation was positive but not significant.

Bitis a. arietans was the most commonly removed species in four months of the nine-month period (October, December, January and March), and jointly highest number with *N. nigricincta* in February (n=8). *Naja nigricincta* was the second most abundant species, dominating removals in August, September, November and February. There was no temporal trend to the dominance of either species.

Spatial Patterns

Figure 2 displays the location and Figure 3 the density of human-snake incidents over the study period. Only 18% (n=33) of snakes were found in buildings, with the remaining being found in gardens, on pavements or roads, as well as unspecified locations. Of 163 recorded locations, the suburb of Eros had the highest occurrence (n=26, 16%), followed by Ludwigsdorf (n=16, 10%) and all other suburbs between one and ten incidents each.

Morphological and Environmental Findings

Table 2 summarises the environmental temperature and biometric data of the five most commonly removed species. The high standard deviation in mass and measurements indicates that juveniles and adults were removed. Of the five most commonly removed species *B. a. arietans* favoured the coolest ground temperatures, significantly cooler ($Z_{4,128}=3.05$, p=0.005) than *N. nigricincta*. A similar trend was noted with air temperature, although this was marginally not statistically significant ($Z_{4,128}=1.64$, p=0.058). *Naja anchietae*, *D. typus viridis* and *B. capensis* were captured in a wide variety of air (24.3˚C to 39.1˚C) and ground (22.1˚C to 44.1˚C) temperatures.

DISCUSSION

The 12 species involved in human-snake conflict incidents during the nine-month reporting period represent 33% of the 36 species of snakes expected to occur in the greater Windhoek area (Envirodynamics 2009). The only previously published data on reptile observations in the area (Envirodynamics 2009) confirmed 12 out of the 36 expected species. Five species observed by Envirodynamics (2009) which were not reported during this study were *Lycophidion capense* (Cape wolf snake), *Psammophylax tritaeniatus* (striped grass snake), *Psammophis namibensis* (Namib sand snake), *Telescopus semiannulatus polystictus* (Damara tiger snake) and *Naja nivea* (Cape cobra). We were, however, able to add *Psammophis leopardinus*, *Philothamnus semivariegatus* and *D. typus viridis* to confirmed observations from the area. *Psammophis subtaeniatus*, *N. anchietae* and *Dendroaspis polylepis* had not been observed or reported previously in Windhoek or surrounding areas (Envirodynamics 2009). The dissimilarity between this study and the previously published records may be indicative of the low intensity of sampling and research of Namibian reptiles (Bauer 1992). It may also be due to changes in the snake community of the area, a factor that will only be confirmed after a few years of similar analysis, as this study presents the baseline.

Of the 182 snake conflict incidents reported, 81% (n=147) were with venomous species, indicating the potential impact of the conflict on human safety. Despite this, none of the incidents led to bites (Dr. C. Buys pers. comm.). An estimated 1.8 million snakebites occur annually throughout the world, and sub-Saharan Africa is, together with South and South-east Asia, responsible for most incidents (Kasturiratne et al. 2008). Envenomation risk is often highest for humans deliberately exposing themselves to the snakes in order to catch or kill them without the necessary equipment and training (Morandi & Williams 1997). By reporting snake observations to Snakes of Namibia, it likely prevented homeowners from this deliberate exposure and risk of envenomation. Envenomation risk to snake handlers was reduced through regular snakebite handling refresher training and mandatory use of approved snake handling tools (hooks, tongs, tubes).

Overall, 101 female snakes of all species were removed compared to 76 males. This may be attributed to differences found in the movement patterns of sexes in some species in relation to

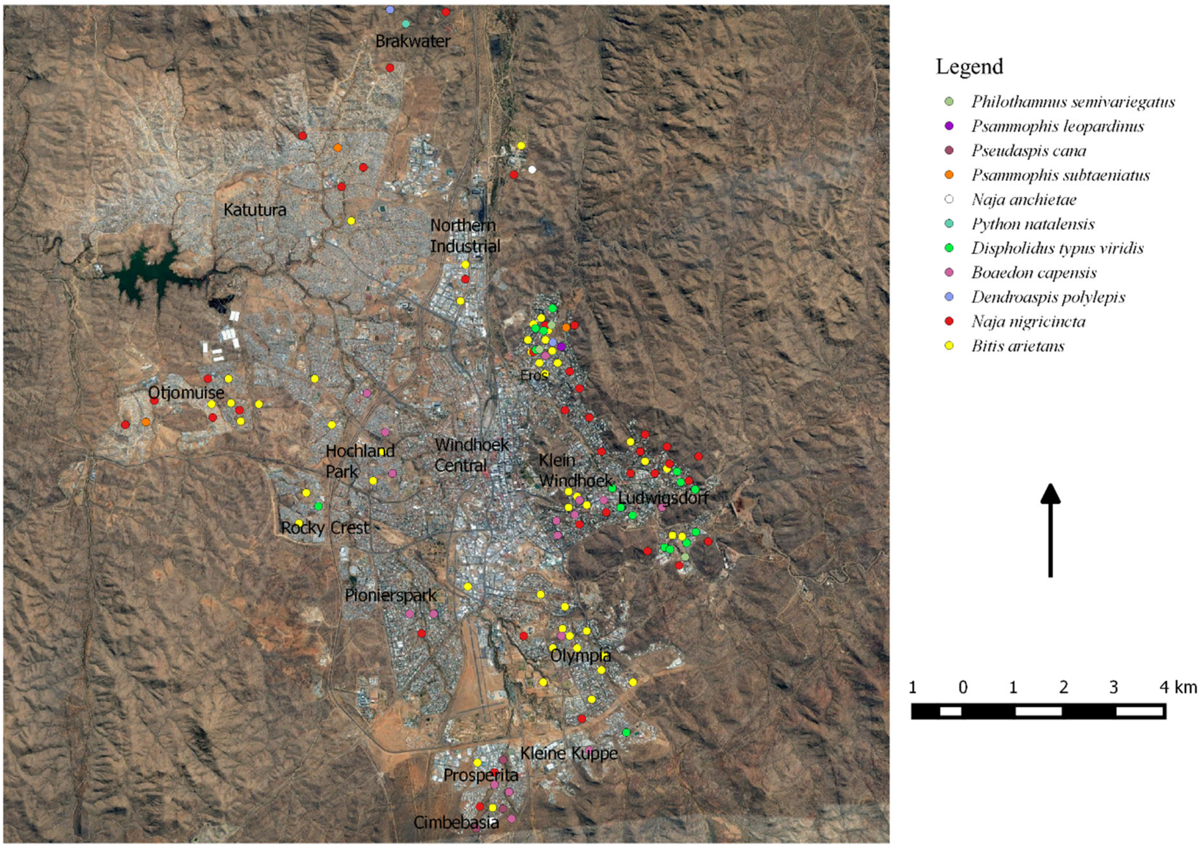

Figure 2: *Location of snake removals in Windhoek (August 2015 to April 2016)*

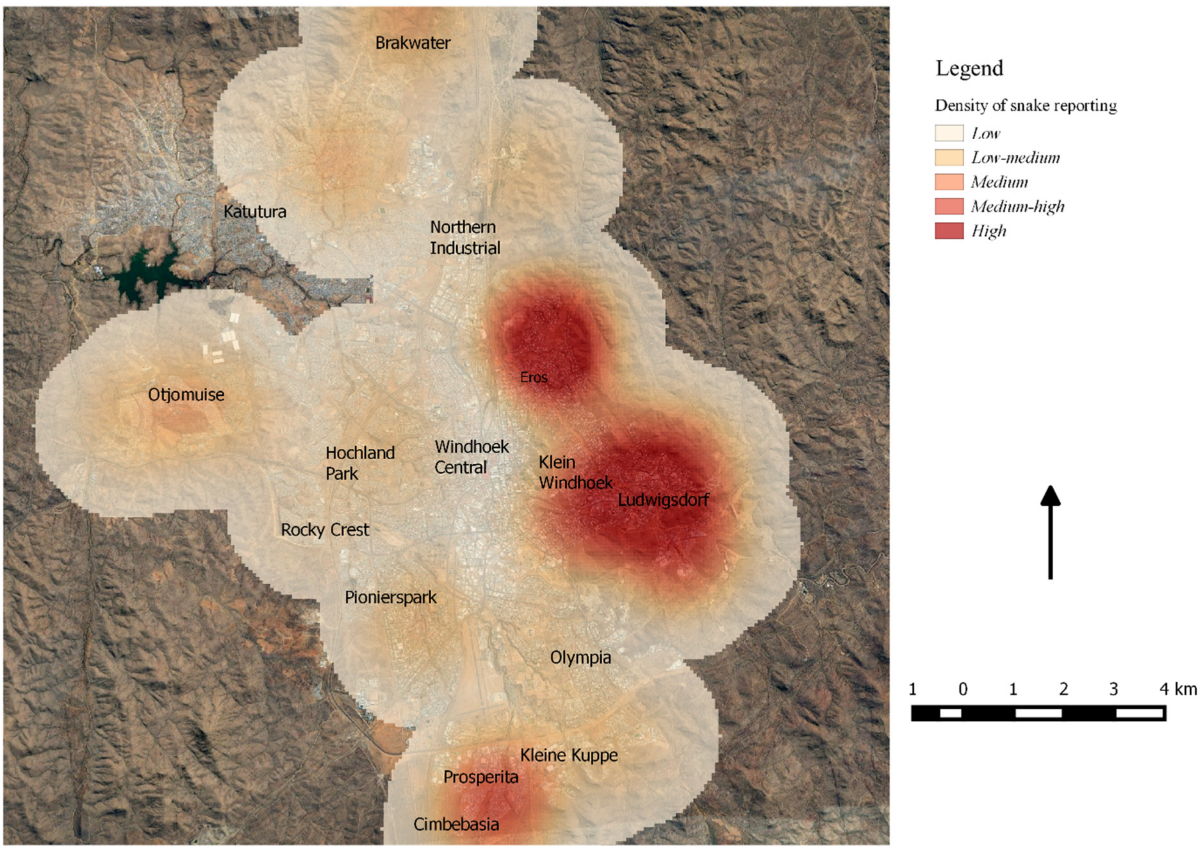

Figure 3: *Density of snake removals in Windhoek (August 2015 to April 2016)*

climate and food availability (Shine 1987, Shine & Lambeck 1990). For the most commonly removed snake, male *B. a. arietans* were removed twice as often as females. This may be a result of their higher activity in search of mates or in defence of territory (Shine & Lambeck 1990). For the next most common species found in this study, *N. nigricincta*, female removals were six times more common than males. This disparity may be attributed to females seeking sheltered nesting sites.

The strong correlation between snake conflict incidents and rainfall could be attributed to reptiles' inactivity in times of drought (Shine & Lambeck 1990, Whitaker & Shine 2002, Luiselli 2008) when food is scarce. This is particularly appropriate in Windhoek's xeric climate.

A concentration of incidents in the eastern suburbs corresponds with high income housing areas (New Era Newspaper 2015) such as Eros and Ludwigsdorf, characterised by large irrigated gardens on the outskirts of town. The third area of concentrated reportings in the south is varied land use (light industrial in Prosperita, and middle income residential in Cimbebasia). Artificial habitat diversity as a result of the mixed land use could explain the high concentration of snake occurrence, with species richness being high (n=5) in relation to the number of incidents (n=11). Prosperita also borders the Windhoek golf course, where the irrigation and vegetation cultivation has been found to result in an increased abundance of rodents (Hauptfleisch & Avenant 2015). The spatial distribution of snake incidents in Windhoek may, however, be heavily influenced by the diligence of residents to report such incidents. Although the city raises awareness regarding the snake removal service (Nhongu 2015), people are still likely to kill snakes (Envirodynamics 2009) and not alert the authorities.

A high variance in the mass, snout-vent length and girth of the five most commonly reported species indicates that both young and adults of a particular species frequented the urban habitats. *Naja anchietae* endured the highest variance in air and ground temperature, indicating that they were not particularly seeking the urban habitats for thermoregulation. *Bitis a. arietans* showed a significant preference for cool air and ground temperatures in or around the shelter of garden and building structures.

The analysis of snake removal data may be useful in reducing human-snake conflict or its consequences in the Windhoek area. Understanding snake activity patterns in relation to environmental factors can inform changed human behaviour and activity to minimise snakebite risk (Akani et al. 2013). Similarly, co-occurrence data can be used to predict areas where venomous species are likely to be encountered. Annual snake community occurrence (spatial and temporal) can also inform antivenom development, production and storage for most commonly encountered venomous species. Antivenom production is costly (Morais & Massaldi 2006) and has not yet been developed for *N. nigricincta* (Muller et al. 2012), the second most commonly reported snake in Windhoek. The city is severely water stressed (van Rensburg 2016) and hydrophilic lawns and gardens are discouraged. The indicated preference of snakes for the irrigated gardens of wealthier suburbs provides an added incentive to residents and landscapers to promote xerophytic garden development

We did not consider the fate of the relocated snakes, however Butler et al. (2005) found that relocated snakes would still often occupy areas with human habitation, although their home ranges were found to be considerably larger post-relocation. This aspect will need to be addressed to determine the conservation benefit snake relocation holds. The rapid expansion of Windhoek (Namibia Statistics Agency 2011) will likely have a negative impact on its biodiversity (Envirodynamics 2009). Comparing future "snake season" removal data for the city with this study will supplement biodiversity monitoring for the city, as snakes are known to be useful indicators of community structure (Luiselli 2008) and as ectotherms, climate change (Herrmann & Branch 2013). Furthermore, analysing the genomics of removed snakes would provide a valuable baseline of population genetic structure, as no such information is available at population level in Namibia (Herrmann & Branch 2013).

CONCLUSION

With 182 human-snake conflict incidents reported over the summer of 2015-2016, and over 80% of incidents involving venomous snake species, it is clearly a serious type of human-wildlife conflict, generally ignored by the conservation and wildlife community in Namibia. Puff adder (*B. a. arietans*) and zebra snake (*N. nigricincta*) were by far (64%) the most common snakes removed, with a further 10 species being responsible for the remaining 36% of urban snake removals. Most removals were from the eastern and southern high-income and multiple-use suburbs of Windhoek, and were most frequent in high-rainfall months.

ACKNOWLEDGEMENTS

We thank the residents of Windhoek and the Windhoek City Municipality, particularly Mr. Martin Shikongo of the Environmental Department for collaboration, Snakes of Namibia for use of the snake incident data, the Namibian Ministry of Environment and Tourism for allowing the research to be conducted, the Windhoek public for alerting

Snakes of Namibia about snake occurrences. We also thank Dr. Christo Buys, Windhoek health-care practitioner, for information on snake-bite incidents in Namibia.

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