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Characterization of Human-snake Encounters in the Houet District of West Burkina Faso

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Abstract.—**In Burkina Faso, envenomation caused by snake bites is a persistent public health challenge. More data than are currently available are needed, however, to evaluate the assemblages and the species composition of venomous snakes in the region. We conducted community-based surveillance examining snake species across 10 health districts of the Houet Province of Bobo-Dioulasso to update the local species assemblages and further understand envenomation risk in these communities. Herein we describe the snake assemblage from the human habitations in 10 health districts of the Houet Province. Local communities collaborated with our research team and local healthcare professionals to collect snake data. Snake specimens were collected from villages and brought to the Institut de Recherche en Sciences de la Santé. We described and identified snakes using taxonomic keys. Villagers collected 124 specimens comprising 28 species belonging to 18 genera. The West African Carpet Viper (*Echis ocellatus*) and the Katian Spitting Cobra (*Naja katiensis*) were the most common species collected, representing 22% and 13% of our sample, respectively. A high proportion (48.38%) of specimens were killed by people working in fields, whereas 39.51% were killed within households or similar domestic areas and 12.1% in transit and crossing roads. Most recorded snake species were non-venomous; however, some venomous snakes such as Elapidae and Viperidae were abundant in households, representing an extreme risk of dangerous encounters.**

Key Words.—Bobo-Dioulasso; circumstance; herpetological inventory; intentional killing; snakebite; snakebite risk; snake species assemblage.

Introduction

Urbanization and landscape development through human activities significantly reduces the size and distribution of natural biotopes and ecosystems, which directly increases the possibility of contact between humans and wild animals (Piédallu et al. 2016; Akaffou et al. 2019). These encounters highlight biodiversity and conservation challenges due to recurrent conflicts between humans and wildlife that often oppose conservation efforts in non-protected areas (Marchand 2013). This problem is pronounced in the ophidians because of the fear that humans have of snakes, which does not favor their cohabitation with humans and is exacerbated because some species pose a significant threat (Nonga and Alex 2015). Furthermore, snakebites from venomous species can often lead to death due to a lack of healthcare access in Africa, a reluctance to seek treatment at health centers, or a combination of these factors (Chippaux 2011). In many savannah regions of West Africa, the annual incidence of snakebite deaths exceeds one per 10,000 people (Chippaux 2015; Gampini et al. 2016; Lam et al. 2016; Ameh et al. 2019; Alcoba et al. 2020).

In Burkina Faso, according to the 2018 statistical report of the Health Ministry (https://fr.pmadata.org/publications/burkina-faso-ministry-health-statistical-bulletin-2018-fr), 20,947 cases of snakebites were reported with a fatality rate of 3%. Snakebites were the fifth most common cause of visits to primary healthcare facilities (Kyelem et al. 2012). Similarly, Bamogo et al. (2021) emphasized the prominence of snakebite envenomations in 10 primary health centers in the Hauts-Bassins region. Therefore, for management of envenomation cases, it is essential

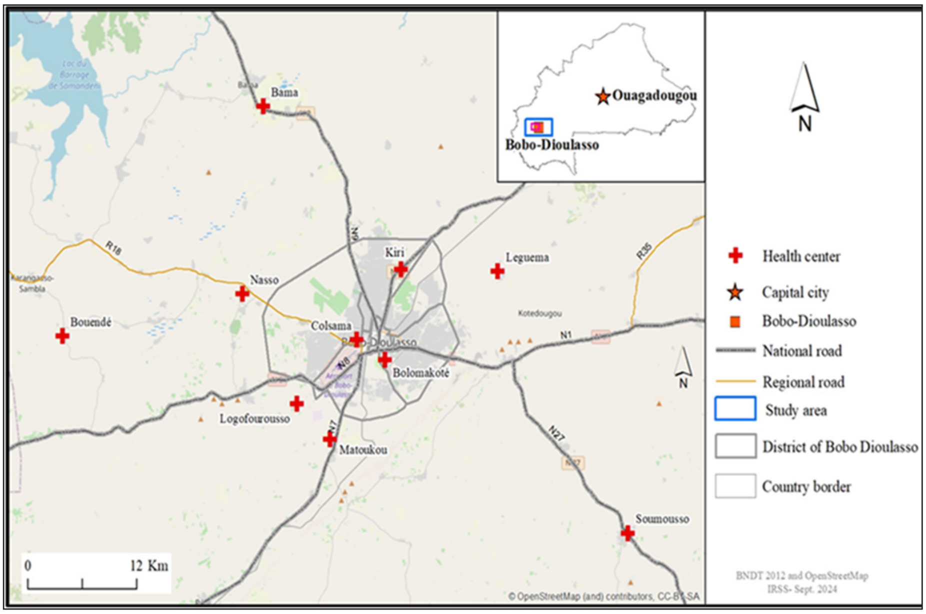

Figure 1. Study site locations in the health district of Bobo-Dioulasso (Hauts-Bassins), Burkina Faso.

to know which species are present in the region to appropriately identify an effective antivenom serum. Updating herpetological data for a region is a critical strategy to attenuate the adverse effects of envenomation. We think that the diversity of snake species that frequently make contact with humans is currently underestimated. An understanding of the species distribution and ecology in populated regions allows the development of individual and collective information sharing and education strategies to prevent envenomations and promote conservation initiatives.

Over the last three decades, little research has documented rates of snake bites and envenomation in the Bobo-Dioulasso region of Burkina Faso. It is important to identify, record, and share species data with locals because the majority of the snake species are either completely harmless or not venomous to humans and play a critical role in various ecosystems (Trape and Mané 2006). Most of the available herpetological information for Burkina Faso comes from Roman (1980), who published basic results detailing 20 y of data collection. Therefore, there is a crucial need to update the herpetological inventory of Burkina Faso to better characterize the range of snake species in the area to build upon the pioneering work of Roman (1980). We aimed to record the snake species present across the Bobo-Dioulasso region of Burkina Faso. The overall goal of this work was to report the presence, frequency, and circumstance of encounter of snake species across the Bobo-Dioulasso region of Burkina Faso.

Materials and Methods

Study sites and design.—We carried out the study was in western Burkina Faso, in the Hauts-Bassins region (11°11′00″N; 4°17′00″W; Fig. 1). In this region, the rainy season extends from June to September and the dry season from October to May. We selected the 10 villages in this study (Bolmakoté, Bouendé, Colsama, Kiri, Leguema, Logofourousso, Vallée du Kou, Matoukou, Nasso, and Soumousso) based on access to a health office. We selected these sites to identify both the venomous and non-venomous snake species frequently implicated in bites. The Bolmakoté and Colsama health districts are urban areas located in the city of Bobo-Dioulasso. The health districts of Nasso, Matourkou, and Logofourousso are more rural and located in a wooded area composed of gallery forests and human-altered habitats including mango, eucalyptus, and shea trees, and banana and oil palm plantations. The understory is composed of evergreen shrubs and the ground is covered by a discontinuous herbaceous carpet. The Kiri and Leguema health districts are peripheral to Bobo-Dioulasso city. Urbanization has damaged the natural vegetation cover of these two health areas, which have been reduced to food crop hamlets. The Vallée du Kou health district encompasses rice paddies with associated permanent swamps. The Bouendé health area is a wooded savannah with trees and shrubs scattered throughout the grass cover with some areas of rocky soil.

We arranged snake collection efforts across the Houet District between January 2019 and December 2020. After first having discussions with relevant healthcare staff, we selected community volunteers to collect all snake specimens that were killed by the local populace. We did not encourage locals to kill any snakes; however, they typically kill all snakes that they encounter. We requested that any snakes that were killed be retained to allow us to record basic information about the location and time of collection. Snake specimens were collected opportunistically as the study did not require living specimens and included: (1) snakes that were killed by villagers during chance encounters; (2) snakes that were killed after biting someone; and (3) snakes that were accidentally killed, such as by road traffic. Occasionally, some specimens were deteriorated or decomposed beyond the point at which they could be preserved. We identified specimens in the Institut de Recherche en Sciences de la Sante Direction Regionale de L'Ouest (IRSS-DRO) laboratory using the morphological keys of Trape and Mané (2006) before storing them in 96% ethanol. We checked species names at http://www.reptile-database.org/.

***Incidence of human activities on encounter rate and diversity*.—**Habitat factors likely influence snake encounter rates with humans. We lacked sufficient replication within habitats to perform quantitative analysis, but we attempted to classify sites along an urban-rural gradient. In addition, specimens were collected during both the wet season (non-breeding season; Roman 1980) and the dry season (breeding season; Roman 1980).

***Data analysis*.—**We analyzed the data using IBM SPSS Statistics (Version 26; https://search.app/KigBb3HyWJ5Lc11A). We compared site-specific (rural or urban habitat) counts using a Chi-squared Test of independence with an α of 0.05. We also used Chi-squared tests to conduct relational analyses between categories.

Results

***Snake species diversity*.—**Villagers collected 124 specimens between January 2019 and December 2020. The specimens belonged to 28 species and 18 genera within nine families: Atractaspididae, Colubridae, Elapidae, Lamprophiidae, Leptotyphlopidae, Pythonidae, Psammophiidae, Typhlopidae, and Viperidae (Supplemental Information Figs. S1, S2, S3, and S4; Appendix Table). Lamprophiidae was the most represented with 33% (41/124) of specimens, followed by Viperidae and Elapidae with 27% (34/124) and 15% (19/124) of specimens, respectively. The most frequently collected species were the West African Carpet Viper (*Echis ocellatus*) and the Katian Spitting Cobra (*Naja katiensis*) at 22% (27/124) and 13% (16/124), respectively (Appendix Table). Overall, more females (52%, n = 65) than males (25%, n = 31) were collected. Specimens for which sex could not be determined represented 23% of snakes collected.

Overall, Lamprophiidae and Psammophiidae were represented by four species each (Supplemental Information Fig. S1). Snakes in the family Lamprophiidae are nonvenomous and were killed in various contexts, including in houses, in fields, on roads, and at night. Snakes in the family Psammophiidae are mildly venomous and not dangerous to humans. These snakes were encountered during the day in agricultural work. Colubridae was represented in our sample by three species and Atractaspididae was represented by two species (Supplemental Information Fig. S2). Snakes in the family Colubridae are nonvenomous and were killed in various contexts, including in houses, in fields, on roads, and at night. Snakes in the family Atractaspididae are venomous and dangerous to humans. These snakes were encountered during the day in agricultural work.

Leptotyphlopidae, Typhlopidae, and Pythonidae were represented in our study by two species each (Supplemental Information Fig. S3). Snakes in the family Leptotyphlopidae and Typhlopidae are nonvenomous and were killed in various contexts, including in houses, in fields, on roads, and at night. Snakes in the family Pythonidae are mildly venomous but not dangerous to humans. These snakes were encountered during the day during agricultural work. The Elapidae and Viperidae were represented in our study by three species each (Supplemental Information Fig. S4). Snakes in the families Elapidae and Viperidae are venomous and dangerous to humans and were killed in various contexts, including in houses, in fields, on roads, and at night. These snakes were encountered during the day during agricultural work.

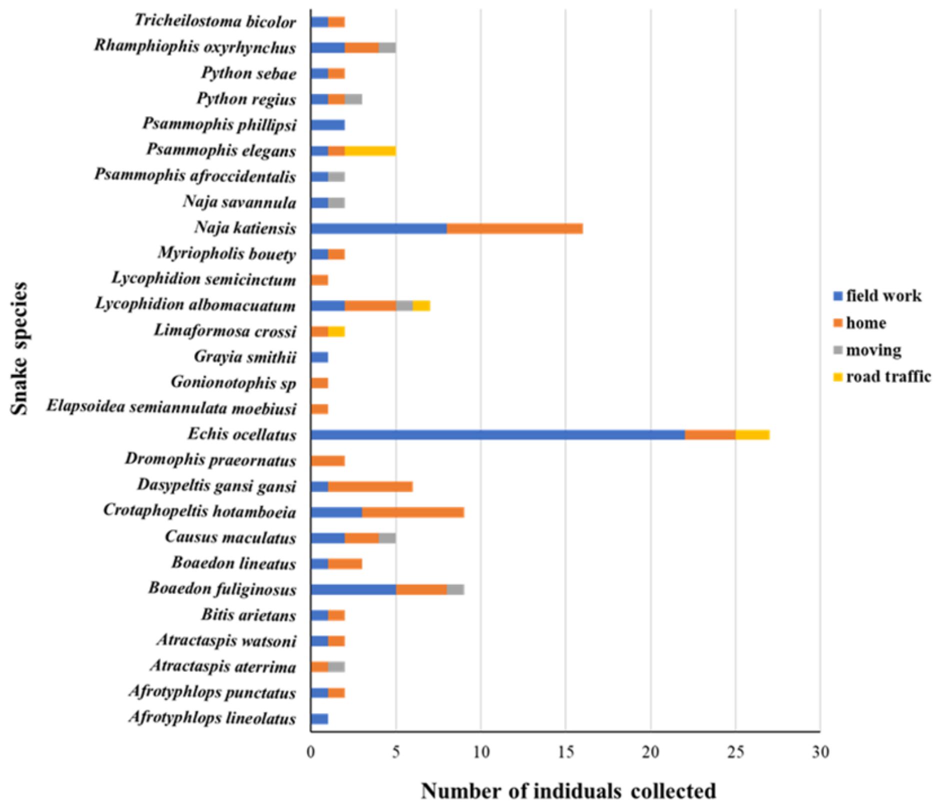

Figure 2. Distribution of snake species collected according to the circumstance under which they were encountered in the Houet District of West Burkina Faso from 2019 to 2020. Common names of each species are in the Appendix Table.

***Influence of human activity on encounter rate and diversity*.**—Of the 124 specimens collected, 60 individuals across 22 species were killed during agricultural work, 49 individuals of 24 species were collected in human habitats, and 15 specimens from 12 species were killed accidently by humans or in the road by vehicles or motorbikes (Fig. 2). The likelihood of encountering a snake in the field was significantly greater than during other circumstances involving human activity (Z = 12.31, df = 3, P = 0.006). The 2% (3/124) of specimens obtained in human habitations (e.g., the city center) was significantly lower than those collected in rural environments (Z = 1,139.8, df = 1, $P < 0.001$). Of the 124 individuals collected, 17 (13.7%) were responsible for envenomation incidents. These 17 were collected in the Bouendé, Leguema, Matourkou, and Nasso centers, respectively.

Among 17 cases of recorded snake bites, 14 cases occurred while people were working in their fields, two while the person was walking at night, and one case occurred in a home. The Viperidae were responsible for the most bites: 76% (13/17) for *Echis ocellatus* and 12% (2/17) for West African Night Adder (*Causus maculatus*), respectively. Atractaspids, Slender Burrowing Asp (*Atractaspis aterrima*) and Lamprophids, Striped Sand Snake (*Psammophis afroccidentalis*) were responsible for fewer bites overall (5.9% each). The risk of envenomation by *Echis ocellatus*, a potentially dangerous species, was significantly greater during daylight hours (χ^2 = 22.35, df = 1, $P < 0.001$).

People encountered 103 individuals (83% of all snakes) during the day (0600–1800), nearly five times as many as the nocturnal count (21 individuals; 17%; Fig. 3). The peak of human-snake encounters was between 1000 and 1300. Regardless of the year, most specimens were collected during the rainy season (June to September), as opposed to the dry season (October to May; Fig. 4), with nearly double the number of specimens during the rainy season (73.4%, n = 91) as during the dry season, (26.6%, n = 33; Z = 24.26, df = 1, $P < 0.001$). Most of the snakes were collected in the two most forested areas: Matourkou and Nasso.

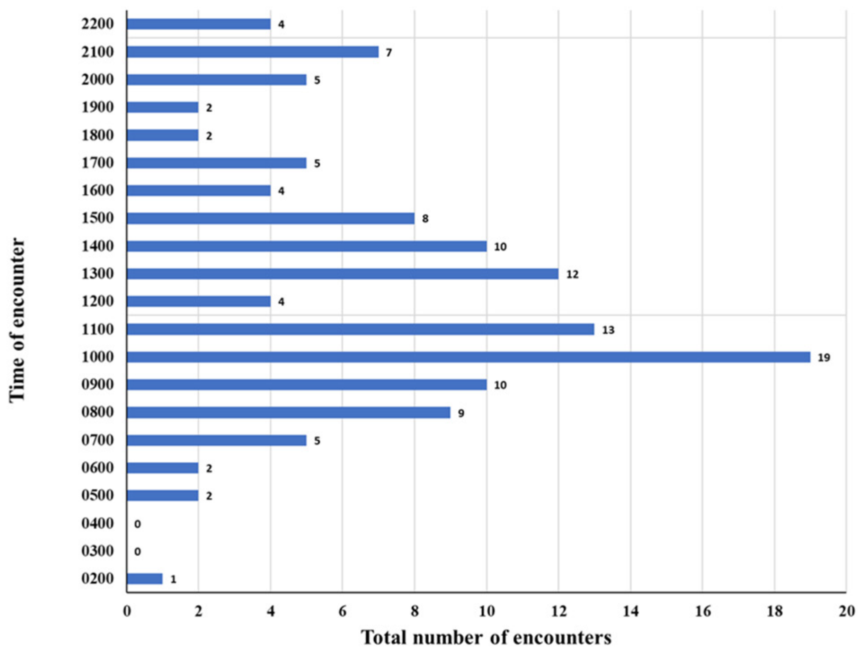

Figure 3.. Frequency of human-snake encounters in Houet District, Burkina Faso, 2019 – 2020, as a function of the time of day.

Discussion

Species composition and encounter rate.—The herpetological fauna of the Hauts-Bassins region includes common species also found in other regions of Burkina Faso (Roman 1980; Trape and Mané 2006). Some common species, however, were absent from our sample and may occur in other regions of Burkina Faso in future surveys, such as Black-necked Spitting Cobra (*Naja nigricollis*) and Irregular Green-snake (*Philothamnus irregularis*). Nevertheless, some highly venomous snake species, such as *Naja katiensis* and *Echis*, were found in the region and are frequently encountered in the villages of Nasso and Matourkou.

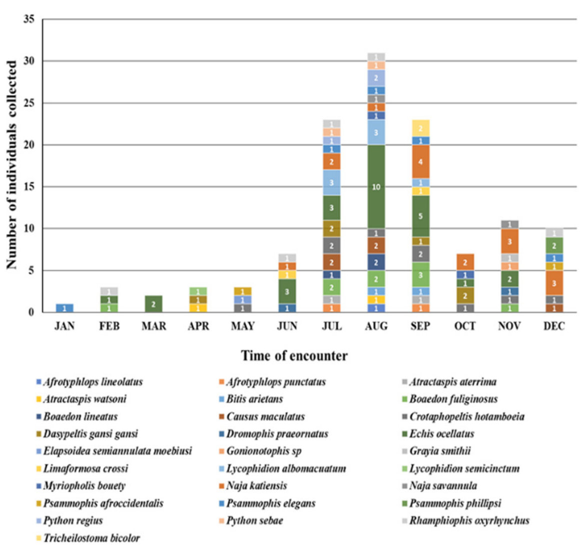

Figure 4. Seasonal frequency of human-snake encounters in Houet District, Burkina Faso, 2019–2020, by species. Common names of each species are in the Appendix Table.

Of the 28 species encountered across the 10 health areas included in this work, fewer than a dozen present a significant danger to humans. The most dangerous snakes collected belong to two large families, Elapidae and Viperidae, which are responsible for almost all fatal envenomation (Roman 1980; Gampini et al. 2016). Some snake families collected in this study are harmless because they never bite (e.g., Typhlopidae and Leptotyphlopidae), and other families are responsible for serious, though not usually fatal, envenomation incidents (e.g., Atractaspididae; Trape and Mané 2006).

On the one hand, the differences in species observed between urban and rural health areas may be related to the degree of human alteration because snakes are secretive animals that may avoid the city due to light, pollution, and disruptive vibrations caused by human activity (Chirio 2009). Conversely, the encounters of prey and the natural biotope of the countryside facilitates their survival (Akaffou et al. 2019). For example, the very dense vegetation cover of the Nasso and Matourkou areas favors the adapted camouflage of snakes and their evasion of their predators. Similarly, roadways in urban areas fragment snake habitats and pose a significant threat to snake survival (Cabrera et al. 2020). The warm surface offered by roads may attract snakes for thermoregulation purposes, and many snakes are killed by vehicles, often intentionally (Cabrera et al. 2020).

Agriculture is the main human activity among the populations of the Bobo-Dioulasso region, similar to other regions in Burkina Faso. The conversion of land for agricultural, urban, and industrial uses in the Houet District may remove the natural cover required by snake populations. Snakes are largely absent from large cities because their habitat has been made unsuitable. This habitat conversion may also cause a change in the snake community when, for example, habitat-specialist snakes become locally extinct while habitat generalists such as Striped House Snake, (*Boaedon*), Puff Adder (*Bitis arietans*) and some *Naja* (forest cobra) species) become more common (Trape and Mané 2006). People in health care areas that collected at least one snake specimen include diversified agricultural activity with highly homogeneous vegetation cover. Snakes are associated with crops, human dwellings, and abundant prey leading to high diversity in their environment (Akaffou et al. 2019). Some authors demonstrated how different farms can favor different populations of snakes (Somé et al. 2002; Chirio 2009). The alteration of the environment surrounding the city of Bobo-Dioulasso includes the development of housing, banana plantations, rice cultivation in the Kou Valley, and mango orchards in the general Hauts-Bassins region, and particularly in the villages of Nasso and Matourkou. This could explain the large number of specimens obtained in these two villages compared to the other sites. This highlights the vulnerability of rural populations, particularly farmers, to the risk of snake encounters and subsequent bites. The accurate species identification and proportion estimates across the population allows us to systematically evaluate the risks of bites and envenomation and propose preventive measures for locals to implement. The two most commonly encountered venomous snake species during this study were *Echis ocellatus* and *Naja katiensis.* Because these two species are highly venomous, we believe it is necessary to educate the more vulnerable rural population about the presence and danger presented by these snakes and provide them with effective precautions, such as wearing high-topped shoes to help prevent bites (Chippaux 2002a; Mensah et al. 2010).

***Snakebites and envenomation*.—**Most of the specimens that were collected were intentionally killed by people during chance encounters. The rate at which snakes are killed intentionally shows how much snakes are feared in these populations. Due to their secretive habits, snakes are often overlooked as contributors to their ecosystems and considered to have little ecological value (Chippaux 2002b; 2006; Akaffou et al. 2019). In fact, all snakes are predators and it is likely that many species serve a key purpose in the dynamics of energy flow in ecosystems, are useful to the overall ecological balance, and can be of service to humans (Trape and Mané 2006). For example, snakes can contribute to limiting the spread of rats that ravage crops, proliferate in granaries, or act as reservoirs for diseases transmissible to humans (Trape and Mané 2006). Therefore, it is essential to increase awareness around the critical role of snakes in the overall ecological balance so the local human population refrains from excessive elimination of snakes following each encounter.

Although the number of snake envenomation cases was relatively low (13.93%) in our study, several authors previously have shown that vipers, especially *Echis ocellatus*, are a major contributor to envenomation cases in West Africa, particularly in Burkina Faso (Trape and Mané 2006; Chippaux 2011; Hamza et al. 2016; Allali and Coulibaly 2017). A survey conducted by Bamogo et al. (2021) also showed that rural populations, particularly farmers, were much more vulnerable to snake bites than populations living in the Hauts-Bassins region (Bamogo et al. 2021).

***Incidence of human activities on encounter rate and diversity*.—**Human activities not only impact the environment but also affect snakes. In particular, clearing fields of their natural vegetation before the rainy season likely reduces snake encounters. Snake bites are consequences of human-snake encounters. The most effective means to lower snakebite risk is to work toward preventing bites and subsequent envenomation. The study of human and snake interactions with respect to economic, demographic, and ecological factors may further our understanding of bite risks and their consequences. For example, the destruction of natural snake habitats across peri-urban areas and for agricultural exploitation may significantly increase the count and frequency of encounters with various snake species during these activities. Indeed, deforestation has profound and lasting consequences because it contributes to the displacement of many forest species, including snakes, allowing other wildlife to occupy these newly formed habitats (Akaffou et al. 2019). This partly explains the large number of *Naja katiensis* commonly found in human dwellings as opposed to its preferred habitats of savannahs and open forests in Sudanian zones (Trape and Mané 2006). Common features of human dwellings (e.g., unkempt vegetation, piles of wood) and specific human activities (e.g., raising domestic chickens) generates piles of household garbage and poorly maintained piles of bricks, which provide shelter for both snakes and their potential prey (Akaffou et al. 2019). These observations demonstrate how many snake species generally live in very close proximity to humans, roaming near homes to feed on rodents, birds, and sometimes chicken eggs and some, such as *Naja katiensis*, Elegant Sand Snake (*Psammophis elegans*), and Common Herald Snake (*Crotaphopeltis hotamboeia*), actively enter houses in search of poultry, toads, lizards, and eggs (Chippaux 2006). To reduce snakebite incidents, it is essential to teach people to accurately identify venomous snakes to prevent bite incidents with potentially tragic consequences for humans and for snake preservation against fear-based elimination.

Of the 124 specimens collected in our study, we were able to determine the sex of 96 snakes, of which 50 were females (52.08%) and 46 were males (47.91%). Interestingly, most specimens were collected during the rainy season, a period corresponding to the non-breeding season when males are more active than females (Akaffou et al. 2019). Our results differ from those generally observed in the literature, which report an increase in the activity and encounter rate of males during the breeding season due to mate-searching behavior (Trape and Mané 2006; Akaffou et al. 2019). If more females are being killed than males, however, then there are fewer females remaining that can breed, and ultimately the population may decrease. Additionally, females tend to have larger home ranges than males because of their additional requirements owing to egg production and deposition (Chippaux 2002a), which could partly explain their count compared to males. Conversely, males traveling more is thought to increase their encounter rate, which would counteract any possible lower density (Blouin-Demers and Weatherhead 2001). In short, the human-snake encounter is far from coincidental, and could be linked to a number of the mechanisms mentioned above.

The peak observation period between 1000 and 1300 corresponds to hours when field activities are more common, and this could explain the frequency of human-snake encounters. Therefore, it is essential to raise awareness among rural populations, especially farmers, of the potential risk posed by these species during daytime agricultural work in fields. The use of machines and other technologies in agricultural activities could contribute towards reducing the direct risk of dangerous bites. We observed a relationship between snake activity patterns and snake bite incidences, as evidenced by the corresponding spikes in snake encounters and incidents in the region during the rainy season (June to September). Several authors identified similar rates of rainy season snakebites within the same region (Somé et al. 2002; Rugiero et al. 2018; Ahmed et al. 2021; Bamogo et al. 2021).

***Study limitations*.—**The collection method employed in our study is subject to a few limitations. We did not receive funding to cover costs such as travel for community members from the village who collected and transported snake specimens, which significantly reduced local participation across health areas, with the exception of Nasso and Matourkou. This paucity of resources may provide a rationale for the limited number of specimens collected at the other study sites and could have biased the number of human-snake encounters low in those locations. If the species composition of encounters also differed among locations, then the distribution of species encountered might also exhibit bias.

In conclusion, we characterized the species of snakes encountered by humans in the health areas of the Houet District, revealing herpetological richness, in which we documented 28 species. Although the list of snakes identified in this study is not comprehensive, it provides key information on the diversity and encounter rate of snakes in this region. This information allows for greater prevention of snake encounters and decreased bite risk. More extensive studies, including direct bio-ecological investigations with additional resources, are crucial to fully developing our understanding of the species distribution in these regions, which can help protect both local people and snake populations from unwanted encounters.

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Appendix

Appendix Table. Meristic data and abundance of snakes collected in the Houet District of Burkina Faso, 2019–2020.

Family	Scientific name / Common name	Number	Total length (mm)	Total length of Tail (mm)	Midbody scale rows	Ventrals	Subcaudals	Temporal formula
Atractaspididae	*Atractaspis aterrima* / Slender Burrowing Asp	2	360–420	23–25	19–21	237–249	21–22	1+2
	Atractaspis watsoni / Watson's Burrowing Asp	2	380	30	27	170	25	2+3
Colubridae	*Crotaphopeltis hotamboeia* / Common Herald Snake	9	260–650	34–90	19	161–175	36–42	1+2
	Dasypeltis gansi / Gans' Egg-Eater	6	455–940	82–130	21	232–249	68–78	2+3
	Grayia smithii / Smith's Water Snake	1	750	250	17	147	97	2+3
Elapidae	*Elapsoidea semiannulata moebiusi* / Half-banded Garter Snake	1P						
	Naja katiensis / Katian Spitting Cobra	16	300–850	50 -140	25	167–182	46–55	2+3 - 3+4
	Naja savannula / Forest Cobra (broadley)	2	480–580	90–100	19	210–216	71	1+2
Lamprophiidae	*Boaedon fuliginosus* / Black House Snake	7	440–1030	40 -130	29	166–237	46–64	1+2
	Boaedon lineatus / Striped House Snake	3P	580–780	100–110	29	226–240	62–67	1+2
	Limaformosa crossi / Crosse's File Snake	2	653–1560	81–140	17	224–235	33–52	1+2
	Lycophidion semicinctum / Semi-annulated Wolf Snake	9	460–600	60–82	17	188–201	35–57	1+2
Typhlopidae	*Afrotyphlops lineolatus* / Lineolate Blind Snake	1	220	2				
	Afrotyphlops punctatus / Spotted Blind Snake	2	385–580	7–12				

Family	Scientific name / Common name	Number	Total length (mm)	Total length of Tail (mm)	Midbody scale rows	Ventrals	Subcaudals	Temporal formula
Leptotyphlopidae	*Tricheilostoma bicolor* / Bicolor Worm Snake	2	100–105	3–4				
	Myriopholis boueti / Bouet's Worm Snake	2	110–130	4–8				
Psammophiidae	*Dromophis or Psammophis praeornatus /* Ornate Olympic Snake	2	310–610	100–200	15	127–180	52–111	1+2
	Psammophis elegans / Elegant Sand Snake	5	600–1 550	225–670	17	188 -203	128–159	2+2
	Psammophis phillipsi / Phillips' Sand Snake	2	860–1100	270–320	17	166–171	84–103	1+2
	Psammophis afroccidentalis / Striped Sand Snake	2	830–980	160–270	17	176–185	56–94	2+3
	Rhamphiophis oxyrhynchus / Rufous Beaked Snake	5	540–1070	150–300	17	164–177	80–94	2+3
Pythonidae	*Python regius* / Royal Python	3	455–600	38–60	53	200–204	33	
	Python sebae / Central African Rock Python	2	680–770	85–103	83–86	275	71–73	
Viperidae	*Bitis arietans* / Puff Adder	2	350–1300	24–90	31–33	138–142	15–20	
	Causus maculatus / West African Night Adder	5	460–690	48–55	19	132–143	20–23	2+3
	Echis ocellatus / West African Carpet Viper	27	250–520	30–50	25–31	132–164	18–26	