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The presence of snakes in croplands: A serious conflict threat to the local farmers in Bertoua municipality, Eastern region, Cameroon

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Abstract
Human historical experience with venomous snakes has probably shaped our responses to them. In African continent, where venomous snakes are common, most people consider all snake species to possess deadly venom and should be avoided. However, the focus of this survey was to exam the presence of snakes in Bertoua municipality. The research data collection was done by the use of check-sheets for a period of one month from 7:30am-5:30pm each day at the peripheral zone of the municipality. A random spot observation of 444 snakes was made on 6 species, black cobras (*Naja melanoleuca),* green mambas (*Dendroaspis viridis),* vipers *(Bitis gabonica),* green-tree snakes (*Dendrelaphis punctulatus*), small brown snakes (*Dendrelaphis shokan),* and python *(Python regius)*. Ecological factors such as weather condition, vegetation, landscape, location, and day-period were also taken into account. The results of this study revealed that vegetation of the study area and weather condition have an association, $\chi^2 = 6.789$ df=4, $P<0.05$. Additionally, vegetation showed a significant relationship on the snake species $\chi^2 = 13.158$ df=10, $P<0.05$. Also, vegetation showed an association on the snake location, $\chi^2 = 6.910$ df=2, $P<0.05$. Furthermore, vegetation revealed a significant relationship on day-periods, $\chi^2 = 12.221$ df=4, P=0.016. Human encroachment into wildlife habitat due to population increase has been the main reason for human-wildlife conflict in Cameroon. Unsustainable crop-farming in most parts of Cameroon due to poverty resulting to shifting cultivation, a longstanding farming tradition believed to have destroyed the rainforest most. The presence of snakes in farmlands in Bertoua municipality might be partly due to a high snake population in the area, or the cropland harboring a high population of rodents, birds and amphibians preyed upon by snakes. Conflicts of this nature are expected to take a much heavy death toll on the snake population, either through direct killing or pesticides used on insect pest. The wildlife conservation stakeholders in Cameroon would need to educate local crop-farmers in Cameroon, especially in the Eastern Region on the management strategies of this kind of wildlife conflict.

Keywords: Bertoua municipality, snakes species, ecological factors, crop-farmers, wildlife conflicts

Introduction
Habitat loss and fragmentation are the greatest general threats to conserving biodiversity (Meffe and Carroll 1997; Wilcove *et al.* 1998) [26, 39] and there is every reason to expect these to be the major threats for snakes as well (Shine 1991; Gibbons *et al.* 2000) [31, 7]. As habitat is lost, ecologica studies could be relevant in evaluating the value of the habitat that is left, particularly if only some of it can be saved. Furthermore, understanding snake ecology could help us evaluate the effects of fragmentation of the remaining habitat. The essence of behavioral thermoregulation is that snakes can move between habitats or microhabitats to find appropriate temperatures. Although female snakes use temperature as a cue in choosing where to lay their eggs (Blouin-Demers *et al.* 2004) [1]. A common outcome of habitat loss is that the remaining habitat is not only reduced in areas, but also fragmented into patches, separated by a new type of habitat that might be totally unsuitable for species that used the original habitat. Some snake species might benefit from the increased availability of the new habitat (Urbina-Cardona *et al.* 2006) [36], but those that depend on the original habitat will not. Snakes in the remaining habitat can be further negatively affected depending on their response to the size of the remaining habitat patches (Hager 1998) [11] and their response to the interface between the original and new habitats, edge effects.

When an area of forest is cleared, the remaining forest is affected by the adjacent cleared area. The greater penetration of light and wind modifies the microclimate of the forest edge, which in turn affects plant communities. These effects can extend more than 50 m into the forest (Harper *et al.* 2005) [10]. For species that avoid the modified habitat in the forest edge, the suitable area of a given forest fragment is reduced, presumably increasing their risk of local extinction (Lehtinen *et al*. 2003) [17]. For some species, however, the forest edge can be beneficial because the range of microclimates available for thermoregulation is much greater than in either the forest or the open habitat (Blouin-Demers and Weatherhead 2001b) [2]. Rat snakes preferentially use forest edges (Blouin-Demers and Weatherhead 2001b; Carfagno and Weatherhead 2006) [2, 41].

Human historical experience with venomous snakes has probably shaped our responses to them. In Africa, where hominids evolved, venomous snakes are common and there are no simple rules for visually discriminating harmless from truly dangerous species. Thus, detecting and indiscriminately avoiding all snakes was probably favored by natural selection. Based on neurological data, Isbell (2006) [13] suggested that the detection and avoidance of predatory and venomous snakes might have played a pivotal role in the evolution of the primate brain. Some snake species require multiple habitat types within their range, either to fulfill basic needs or because of phenological shifts in habitat selection. For these species, habitat may be managed for land-cover diversity (Smith and Stephens 2003) [33]. Creating and maintaining land-cover diversity need not be expensive or time consuming; a well-designed prescribed fire regime should result in a mosaic of seral stages, which can be favorable for reptile communities (Litt *et al.* 2001; Smith and Stephens 2003) [19, 33]. Maintaining a mosaic of patch types may also function to increase ecosystem resilience. An Australian study indicated that, although the diversity and abundance of reptiles (mostly lizards) was low on recently burned plots, these patches were likely to serve as fire-breaks, benefiting the integrity and resilience of the reptile community as a whole (Masters 1996) [23]. Semi-aquatic snakes may benefit from created wetlands or the creation of a mosaic of wetland and upland habitats. In an Ohio study, snakes were frequently associated with mine-reclamation wetlands (Lacki *et al.* 1992) [17]. Constructed wetlands were used readily by the state-recognized endangered Copper-bellied Watersnake (*Nerodia erythrogaster neglecta*) in Indiana (Lacki *et al*. 2005) [16]. In central California, wetlands were created on former agricultural land to benefit the giant garter snake (*Thamnophis. gigas*); although giant gartersnakes have used the created wetlands, population-level management success has not yet been demonstrated (Wylie *et al*. 2002) [39]. In Germany, the management of *Natrix tessellata* habitat featured the restoration of a mosaic of natural habitat features to a heavily disturbed riverine system.

Snakes possess several attributes characterized with fear, unfamiliarity, movement, abruptness, rapidity of change and visual (chromatic) intensity. Instead of positing an innate recognition of snakes per se, theory shifted toward a polyvalent feature detection (PFD) concept in which the combination of fear-eliciting cues was critical (Haslerud 1938) [43]. This shift occurred slowly and some writers continued to adhere to the theory of innate snake recognition; but this notion was essentially considered passé by the middle of the twentieth century, when innate or instinctive components of virtually all aspects of human behavior were discounted in mainstream psychology. Many predatory animals present stimuli that can be used by other species in avoiding them (Isbell 2006) [13]. Some animals avoid and flee from snake odors; for human and nonhuman primates, visual cues eliciting avoidance are more relevant. Malagasy lemurs, evolving in the absence of highly venomous snakes (viperids and elapids) or large boids, show little or no fear of them compared to most old and new world monkeys (Mitchell and Pocock 1907) [26]. The historical hostile conflict humans have had with snakes especially in croplands attracts research whenever the snake population is found to increase. The study of snakes in Bertoua municipality was to examine the ecological factors favoring the presence of snake population.

Materials and Methods

Description of the study area

Bertoua is the capital of Eastern Region of Cameroon, with a land surface area of 100km^{2}and a human population of about 95000, it is well known in timber wood and mining exploitations. Geographically, Bertoua is located on latitude $4^0$35’0’’ north and longitude $13^0$41’0’’, east (fig.1). The climate is described as wet equatorial climate (also known as a Guinea type climate), meaning that it experiences high temperatures (24˚C on average). The climate is greatly influenced by the monsoon and Harmattan winds resulting in four characteristic seasons: a long dry season from December to May, a light wet season from May to June, a short dry season from July to October, and a heavy wet season from October to November. Humidity and cloud cover are relatively high, and precipitation averages 1500–2000 mm per year (SEBC, 2002, SEFAC, 2005) [30, 31]. The vegetation type in the study site is described as semi-deciduous Guinea-congolaise dense tropical rainforest and is characteristically a mixture of evergreen forest and semi-deciduous forest which is stratified into several layers. In this forest type, trees can grow as tall as 70m and as big as 150 cm in diameter or more. Available literature indicates that the species richness and diversity in this area is very high; about 1500 different plant species grow in the area. The tree species present are mostly hardwood evergreens species and the dominant ones include: *Alstonia boonei, Celtis zenkerii, Entandrophragma angolense, Entandrophragma candollei, Entandrophragma cylindricum, Entandrophragma utile*, Eribroma oblongum, *Erythropleum ivorense, Guarea spp, Guibourtia ehié, Khaya sp, ansonia altissima, Milicia excelsa, Pericopsis elata, Pterocarpus soyauxii, Swartzia fistuloides, riplochyton scleroxylon* (SEBC, 2002) [30].

Fig 1: The map of Bertoua Municipality (Source: SEBC, 2002) [30].

Although there are no specific studies on wildlife in Bertoua, literature on the east region of Cameroon indicates that this region is very important in terms of its diversity and abundance of wildlife resources, testified by the creation of many protected areas in this region. The region contains a variety of large mammals, small mammals, and avifauna. Large mammal populations include threatened species listed on the IUCN Red list of species, such as elephants (*Loxodonta africana cyclotis*), chimpanzees (*Pan troglotydes*), gorillas (*Gorilla gorilla*), buffalos (*Syncerus caffer nanus*), giant pangolins (*Manis gigantea*) antelopes (*Panthera pardus*). The population of small mammals is dominated by numerous species of monkeys and rodents, including: *Cercopithecus spp*, *Antherurus africanus*, *Cephalobus spp, Tragelaphus spekki and Colobus guereza.* The avifauna population is dominated by dense forest species, including globally threatened species such as *Bradypterus grandis*, *Lobotos oriolinus*, *Pteronetta hartlaubii* and many other bird species (SEBC, 2002, SEFAC, 2005) [30, 31].

Data collection

The data collection started with a brief pilot study to test the methods in the study area. The research team comprised of 10 local farmers who took interest in the research topic and decided to volunteer in its field data collection program. This team was divided into five groups, deployed to different bush areas of the municipality for snake observation. The observation of snakes in the study area was done for one month from 7:30 am – 5:30 pm each day. Additionally, all the observers were dressed in protective shoes and clothes to avoid snakebites. Radom spot observations were done on forest, grassland, streams, and farmlands (Crump & Scott, 1994) [4]. Every snake or snake sign encountered during this process was recorded in the check-sheet by each observer. This survey recorded 444 snake encounters, and the species encountered black cobras (*Naja melanoleuca),* green mambas (*Dendroaspis viridis),* vipers *(Bitis gabonica),* green-tree snakes (*Dendrelaphis punctulatus*), small brown snakes (*Dendrelaphis shokan),*and python *(Python regius).*

Data analysis

The research data was analyzed by the use of SPSS statistical tool. Variables such as snake species, vegetation, weather condition, location, day-period were statistically tested to have a comprehensive knowledge on their degree of association. The results obtained from this statistics were hence displayed on figures and pie-chats.

Results

In this survey, 444 snake encounters were made, 32.9% on black cobras (*Naja melanoleuca),* 25.9% on green mambas (*Dendroaspis viridis),* 17.3% on vipers *(Bitis gabonica),* 14.6% on green-tree snakes (*Dendrelaphis punctulatus*), 5.0% on small brown snakes (*Dendrelaphis shokan),*and 4.3% on python *(Python regius)* respectively (fig.2). The cobra species population may be higher comparatively from the encounter rate observations made than other snake species in this area. Cobras such as *Naja* and *Dendroaspis* species are very shy, venomous, and flee immediately they sense human presence in their environment. Hence, the significant presence of these very venomous snake species in the farming areas, including *Bitis gabonica,* might make farming extremely dangerous to the local crop-farming population. Nonetheless, there is a high expectation of snake-bite victims in this part of the country than elsewhere, creating an urgent need for safety educational programs for these local farmers.

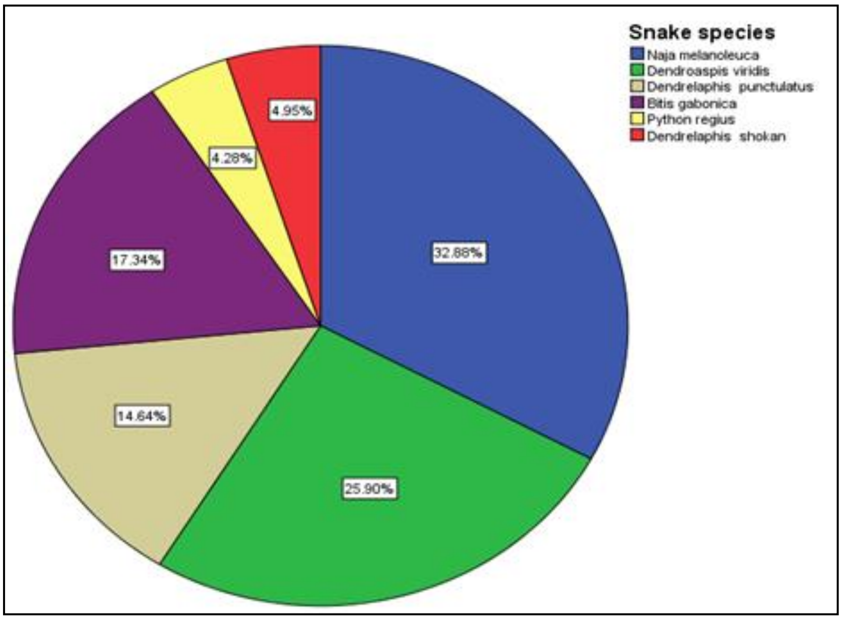

Fig 2: Snake species

The vegetation of the study area and the weather condition have shown an association, $\chi^2 = 6.789$ df=4, $P<0.05$ (fig. 3). In this study, the sunny weather witnessed the highest snake encounter rate in all the vegetation types. Snakes in places like Bertoua are believed to reduce in population due the human population increase, leading to encroachment farmland construction, a key factor to the human-wildlife conflict relationship. Snake-hunting for bushmeat is not frequent in Cameroon, but the killing of snakes for human safety, especially in farms and roads is the most welcome tradition. Notwithstanding, snake phobia has been the major reason for high mortality rate of snakes in Cameroon and other countries in Sub Saharan Africa. Snakes are hated by the human population in Cameroon, and anybody known to show love, sympathy, and care for snakes is considered as a witch or sorcerer. Also, snakes are neither considered as a touristic element nor conservation target by the conservation stakeholders and the local population. Whoever meets a snake face-to-face either on the road or farmland is instantly driven into a dreadful psychological freight, manifested sometimes in shouting, crying, and running into an area of safety. The potency of snake venom released into a single bite by venomous snakes such as cobras and vipers has been the main reason for the uncontrolled fear generated into the human population in Cameroon. Nobody would accept that many snake species encountered in our environment are non venomous.

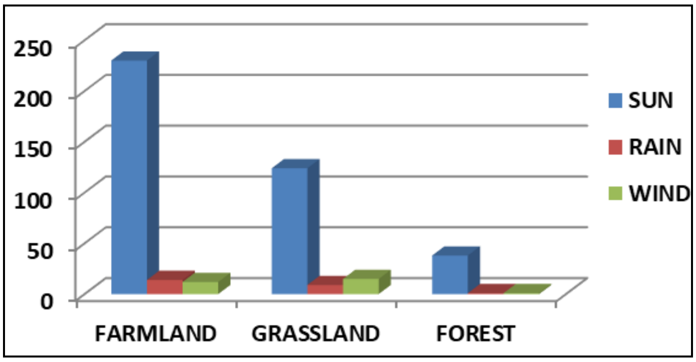

Fig 3: Vegetation and weather conditions

Additionally, vegetation showed a significant relationship on snake species $\chi^2 = 13.158$ df=10, $P<0.05$ (fig.4). The vegetation type determines the animal species niche in the wild. The three vegetation types used in this study were farmland, grassland and forest. However, the farmland area recorded the highest snake encounter rate 57.7% while the forest showed the least 9.0% (fig.5). The snake ecology in the tropics in general is very much linked to the forest environment, the home for snakes and other wildlife. Nonetheless, the human encroachment into the rainforest for crop-farming in countries such as Cameroon seems to have created a behavioral ecological adaptation to these snakes for farmland preference, a more serious conflict zone with humans. Crop-farmers in Cameroon have had a historic conflict with wildlife in farmlands resulting to the rampant killing of these wild animals. Wildlife crop-raiding has been a trauma to the local crop-farmers in Cameroon and other countries in Sub Saharan Africa. The longstanding hostile relationship has been the main reason for poor crop-harvest in most parts of Cameroon. Also, the death of most snakes has been met in the farming zones where they are killed not for their crop-destruction ability, but for human health safety consideration.

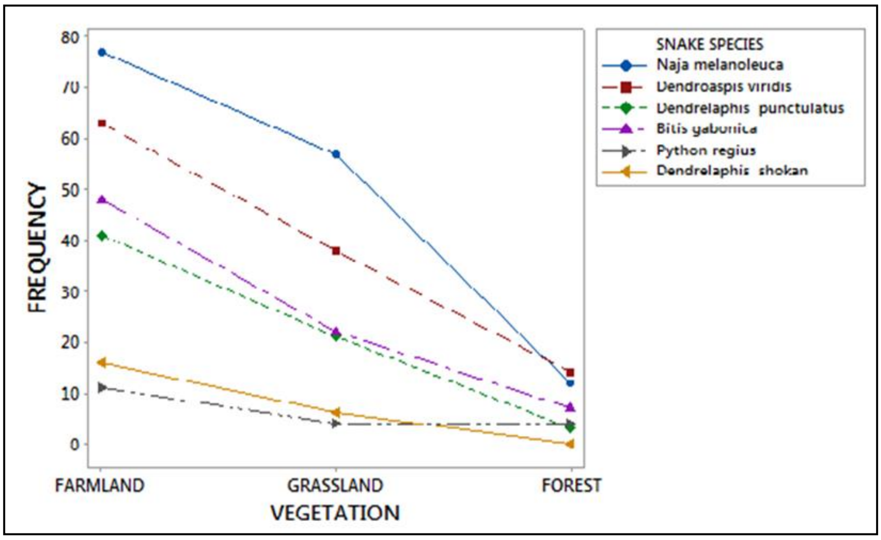

Fig 4: Vegetation and snake species

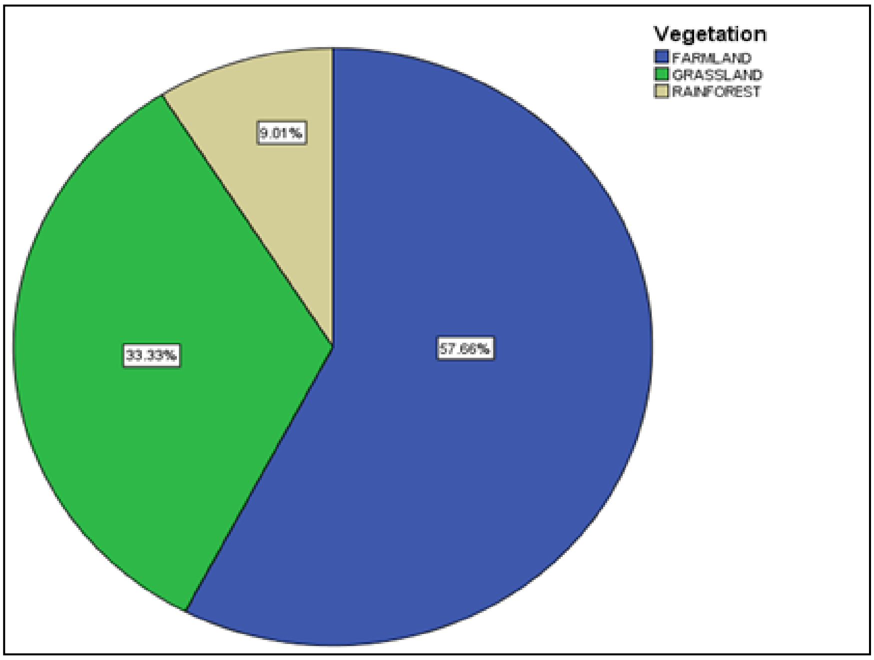

Fig 5: Vegetation

Vegetation also showed an association on snake location, χ^2 = 6.910 df=2, $P<0.05$ (fig. 6). The farmland vegetation witnessed snake observations on the ground than other vegetation types. The target for rodents and insects in farmlands makes this ecology an enriched feeding habitat for the snakes, a conflict extremely difficult to be avoided by farmers. The need for seminars and workshops to teach the local crop-farmers on how to manage human-snake conflicts in farmlands should be an important consideration for the wildlife conservation authorities to help these local farmers. So many farmers might have been victims of snake-bites in these areas, hence, reciprocally many snakes killed. It must also be noted that most local farmers kill the serpents for safety reasons, and not because they enjoy killing them. Though, some people in Cameroon still display snakes such as cobras to show-case spiritual powers in small local social gatherings like the market areas, the conservation stakeholders, especially the Ministry of Forestry and Wildlife is against these illegal wildlife possessions.

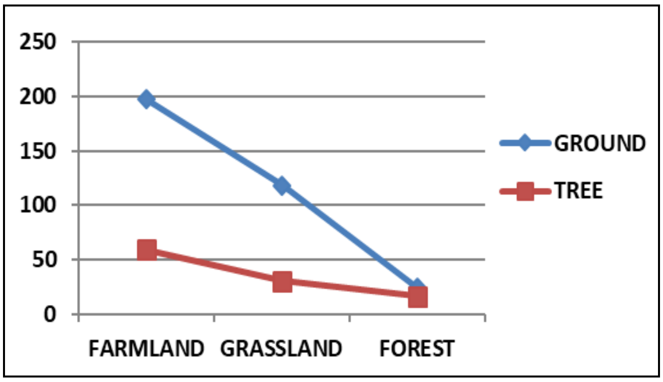

Fig 6: The snake location and vegetation type

Moreover, vegetation significantly associated with day periods, χ^2 = 12.221 df=4, P=0.016 (fig.7). The afternoon period of the day witnessed the highest snake encounter rates certainly due to the atmospheric temperature increase, an environmental condition these animals always use to acquire body temperature. Ectodermic animals need atmospheric warmness; however, their body-heat consciousness provokes the desire for a warmer afternoon sun-bath 67.74%, than the morning and evening periods 9.01% and 27.25% respectively, experiencing a comparative little sun-shine (fig.8).

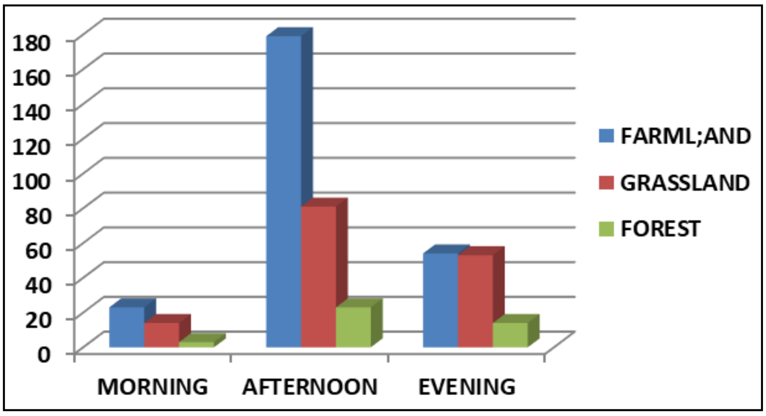

Fig 7: The day-periods and Vegetation

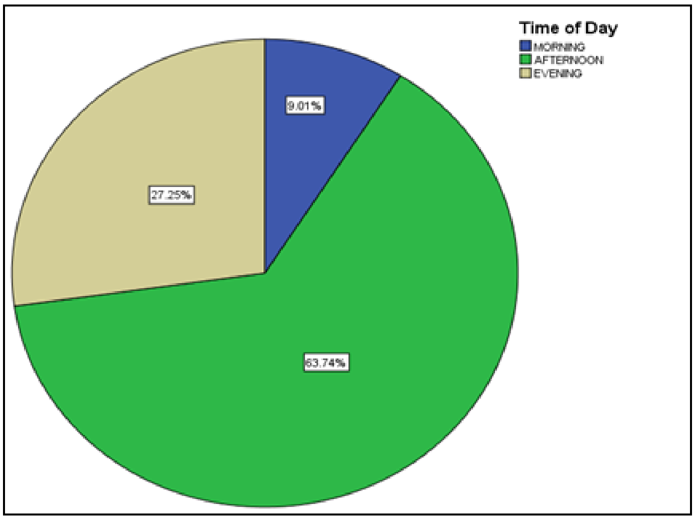

Fig 8: The day-period

Discussion

One of the greatest threats to conserving biodiversity is anthropogenic behavioral changes, leading to the destruction of habitats. For most snake taxa, such alterations will almost certainly have a negative impact on prey abundance, reducing the probability of long-term survival of this group of predators (Ujvari *et al.* 2000) [48]. For some species, however, human alteration of habitats may in fact have positive effects. In Sweden, human-made landscapes that are mosaics of agricultural and natural habitat support large populations of small rodents and also large populations of European Adders, one of their main predators. Similar positive effects of human-made habitat alterations have been recorded in Africa. In the Kakamega District in western Kenya, small fragments of secondary rainforest habitats exist as patches in an area used for intensive agriculture. A survey was conducted to compare the abundance of common rainforest snake taxa in the forest fragments with numbers encountered in the Kakamega Forest National Park. Approximately ten times more snakes were encountered per night in the forest fragments than in the national park. Similar results were also obtained in a survey of snakes in Nigeria. In the swamp forest in the Niger Delta and in the dry forest in the Cross River State, approximately five times more snakes were encountered in secondary habitats compared to primary forest habitats. These results suggest that several snake taxa were more abundant in the secondary forest fragments than in primary forests.

One of the reasons for the higher snake densities in forest fragments could be that prey densities are higher. The agricultural landscape in the Kakamega District supported large numbers of rodents that were often observed during the nocturnal surveys in the forest fragments, whereas no rodents were observed in the park. Another factor explaining the higher abundance of snakes in the fragments could be the virtual absence of snake predators, such as mongoose and birds of prey, which are killed by the farmers because these predators also prey on their chickens. Unfortunately, since 1984 when the survey was conducted in the Kakamega District, these forest fragments have been cleared at an alarming rate and converted to agriculture, and hence, the future survival of the snake populations is doubtful. Predation is a major ecological force influencing population dynamics, species distributions, and community structure (Kerfoot and Sih 1987) [14]. The most obvious direct effect of predation is the killing of prey, but a variety of indirect effects of predators on the behavior and life histories of prey and on dynamics at other trophic levels have been recognized (Kerfoot and Sih 1987) [14]. Thus, understanding predator-prey interactions is critical for management and conservation of species, and it relies in part on understanding the ecological and evolutionary processes at work.

As with all predators, many aspects of snake biology are affected by the abundance of their prey. Low prey availability may result in reduced growth rate and low reproductive output and, hence, low population densities (Fitzgerald and Shine 2004) [42]. Conversely, areas with high prey densities have been demonstrated to harbor very large snake populations (Bonnet *et al.* 2002b; Madsen *et al.* 2006) [6, 20]. Compared to mammalian predators, the lower metabolic rate and, hence, reduced energy requirements of snakes may make populations less sensitive to temporal changes in prey numbers (Madsen and Shine 1999a) [44]. Nevertheless, large temporal variation in prey abundance can still have a dramatic impact on snake population demography. In *Vipera berus*, a massive reduction in prey density resulted in substantially higher adult mortality (Forsman and Lindell 1997) [5].

The declines of amphibian populations reported worldwide (Houlihan *et al.* 2000) [12] will almost certainly have important negative effects on predators specialized for feeding on this group of vertebrates, such as many natricine snakes. In the Sierra Nevada, United States, amphibian declines are well documented (Knapp and Matthews 2000) [15], and the decline of amphibians has indeed resulted in a concomitant decline of terrestrial gartersnakes *Thamnophis elegans* (Matthews *et al.* 2002) [24]. Furthermore, food availability early in life has a disproportionate effect on later growth and maximum body size in some snakes (Madsen and Shine 2000a) [21]. Because body size influences many aspects of a snake's interaction with the environment, including food habits, vulnerability to predation, and reproductive output (Grafen 1988) [9] seem likely to have an impact on snake population demography. In contrast to many other predators, snakes often show an ontogenetic shift in diet (Brito 2004; Quick *et al.* 2005; Webb *et al.* 2005b) [3, 29, 36]. Due to morphological constraints, juveniles often feed on small prey such as lizards or juvenile frogs, whereas adults often feed on large prey such as mammals (Mackessy *et al.* 2003) [22]. The habitats used by such disparate prey are often very different. Hence, to maintain viable snake populations it is not sufficient to protect the habitat needs of only one of the major types of prey.

The most recent position taken by many researchers concerning snake phobia in humans is that, while humans are not necessarily born with a fear of snakes, they are salient stimuli and humans can rapidly acquire a fear of them. This view is based on the famous Mineka lab experiments and others that seemed to discount instinctive recognition of snakes and emphasized conditioning, especially of a social nature (Öhman and Mineka 2001) [28]. This reaction could even be mediated through second-hand experiences such as scary stories (Wilson 1994) [37]. Wilson did not distinguish between the broad and narrow concepts of snake fear outlined by Morris and Morris (1965) [27], but he asserted that there is probably a genetic foundation for the attitudes that we end up with and for the fact that we can acquire these attitudes very quickly.

Conclusion

Humans are hardly friendly to snakes, due to their venom, a defensive mechanism used in killing enemies and preys. This lethal power possessed by most snakes has been the main reason for the uncontrollable phobia manifested in human behavior whenever a snake of any species is spotted nearby. The snake-hate relationship in humans has an aged history, right from the genesis chapter of the bible; the snake has been described as a deceptive organism, for the reason which humans are suffering till date. Nonetheless, some human traditions still consider these wild animals as gods to be worshipped, while to others they are a source of spiritual power in sorceration and other related organizations. Any story generated on snakes might be rooted into their potent lethal venom, hence, the presence of a high number of snakes as discovered by this study in the peripheral zone of Bertoua municipality, especially in croplands needs an urgent wildlife conservation attention. Secondly, cobra species, found to have the highest encounter rate in the survey are known to be shy to human sight, but the neurotoxic, hematoxic, and cardiotoxic venomous chemistry possessed by some cobras and vipers could create a more deadly conflict with the local farmers in the farming areas, resorting to carrying out snake-hunting drives to reduce their population.

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