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Let the rat out of the bag: A case study on stress–induced regurgitation in Spectacled Cobra, *Naja naja* Linnaeus 1758 as a consequence of human–confrontation

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ABSTRACT

Snakes, being ecologically, medicinally, mythologically and culturally important limbless creeping vertebrates under class reptilia, are among the most misunderstood and widely disliked animals globally since time immemorial. In Indian folklore, religion and art, snakes, especially Spectacled cobras, hold a significant and enduring presence. Due to their frequent interactions with humans, snakes are among the most commonly rescued wild animals across the globe. Thus, human-snake conflict (HSC) poses significant stress to wildlife, particularly in venomous species like the Spectacled cobra (Naja naja). This case study investigates stress-induced regurgitation behavior in Spectacled cobra following direct confrontation with humans. On October 18, 2020, a Spectacled cobra (Naja naja) was rescued from the kitchen of a residential premises at S. K. Nagar area of Motihari town, the headquarter of East Champaran District of Bihar. The snake was rescued, bagged, and relocated to a safe and suitable natural habitat. Post-release, the snake rapidly escaped from the cotton bag, but a semi-digested rat was found inside the bag, indicating regurgitation likely induced by the stress of capture, confinement, and transportation, highlighting the physiological impacts of handling on venomous snakes. This study suggests that the regurgitation behaviour in rescued spectacled cobra was due to a defensive response linked to acute stress which potentially impacting the snake's energy reserves and survival. The ecological and physiological implications of this behavior highlight the need for mitigation strategies to reduce human-snake conflicts and their adverse effects, particularly on Spectacled cobras. These findings contribute to our understanding of stress responses in reptiles, informing conservation efforts in human-dominated landscapes. To improve outcomes, recommendations include refining relocation techniques to minimize stress and conducting further research on regurgitation as a stress response in elapid snakes, like Spectacled cobra.

Keywords: *Human-snake conflict, Confrontation, Snakebite, Spectacled cobra, Rescue, Relocation, Prey, Regurgitation, Stress-induced behavior.*

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1. Introduction

Snakes, being ecologically, medicinally, mythologically and culturally important cold-blooded limbless creeping vertebrates under class reptilia, play crucial role in our ecosystem by balancing & maintaining the ecological food web. As urbanization expands, snakes and other wildlife are increasingly considered as outsiders in human-dominated ecosystems. Human-snake encounters are among the commonest and deadliest human-wildlife conflicts in the tropics [1,2,3] and is a major conservation challenge, particularly in regions where apex predators coexist with human settlements [4]. The incidence of interaction is not only increasing because of continuing encroachment of humans on snake habitats but also the adaptive capability of snakes to persist in human-modified landscape [5]. In India, snakebite is a prominent problem in rural and peri-urban areas and the high burden states includes Bihar, Jharkhand, West Bengal, Madhya Pradesh, Odisha, Uttar Pradesh, Andhra Pradesh, Telangana, Rajasthan, and Gujarat [6,7]. Due to their adaptability to various habitats, snakes often venture into human-dominated areas, sparking conflicts and alarming situation. Consequently, snake rescue and relocation efforts have become a common practice to mitigate these conflicts. Despite their vital ecological functions and services, including pest control [8] and secondary seed dispersal [9,10], snakes are often un wanted in urban areas [3,11]. As a result, snakes encountered in human settlements are frequently killed [12,13] or relocated [3,14,15]. As a measure to reduce human-snake conflict, for the past several years, rescue and release of snakes from urban, rural and forest fringe areas is being followed [16]. Translocation, or the intentional release of individuals of a species into a site different from their origin [17], is used for the conservation and management of wildlife [18]. Snakes may exhibit seasonal changes in their spatial use of landscapes, and understanding these patterns is crucial for improving management strategies that reduce human–snake conflict [19].

Understanding stress ecology in snakes is important to anticipate individual and population-level consequences of different types of stressors and plan for conservation efforts [20]. Stressors can be defined as stimuli that put the individual in a state of uncertainty, lack of information and/or lack of control [21].

The stress of confrontation, capture, confinement, transportation and relocation can induce regurgitation, where a snake expels recently consumed prey. Regurgitation is a known stress response in snakes, potentially linked to handling, transport, or environmental changes, but it is rarely documented in field-based rescue circumstances. The Spectacled cobra *(Naja naja)* is one of India's commonest medically important Big-4 snakes [22]. The Spectacled cobra feeds principally on rats, frogs, toads, lizards, other snakes, birds and eggs [23]. Snakes, including cobras, often exhibit stress-induced behaviors when captured or handled. Regurgitation is one such behavior, where the snake expels its stomach contents, often as a response to stress or discomfort. Regurgitation in snakes can be caused by various factors, including environmental stress (extreme or unfavorable temperatures, handling too soon after feeding, or insecure surroundings), improper feeding practices (inadequate prey size, overfeeding, or contaminated prey), and underlying health issues (parasites, cohabitation stress) etc.

2. Materials and Methods

This study is based on a snake rescue and relocation operation from Motihari town of Bihar, India. Approximately, at 08:05 h Indian Standard Time (IST) on October 18, 2020, the author received a distress call regarding the presence of a venomous serpent in a residential premises at S. K. Nagar area of Motihari town, requiring prompt rescue and relocation operation. It was subsequently informed to the Divisional Forest Officer (DFO) of East Champaran (Bihar) for his kind information and record. Upon arrival at the site, a snake was found cornered in the kitchen of the house. The snake was identified by its characteristic hood mark and morphology and was verified by using standard literatures and field guides [22,24,25,26]. The spectacled mark on the hood is usually well defined in Spectacled cobra [27]. The snake was identified as Spectacled cobra *(Naja naja)*, one of the most venomous (Big-4) snake of India belonging to family Elapidae. The cobra was found cornered inside the kitchen of the house and was likely attracted by the presence of prey (rodents). A snake hook (36-inch length), PVC pipe (6-inch length & 2.5-inch diameter) and a black cotton bag were used to capture the cobra, ensuring safety for both the rescuer and the snake. Once the snake completely entered the bag, the same was tied (knotted) properly after removing the pipe from the open end. The tight knot ensures further safety and prevents escape during transportation to release site. The snake was released in a safe natural habitat within 3.5 km distance from the rescue site. The snake's behavior, such as, health condition, rapid movement, escape etc. were observed and noted. The entire process of rescue and relocation followed ethical wildlife handling protocols ensuring rescue and release of snake in a safe and scientific manner. Sufficient safety precautions were adopted during rescue, handling and translocation operation. No family members were permitted to watch the rescue operation from close proximity as there are high chances for accidents during the rescue operations. The time from capture to relocation was recorded approximately 55 minutes.

Entire rescue and relocation process was photographed and filmed by Nikon D5300 Camera and the geo-coordinates of both, rescue and relocation sites, were recorded by a handheld Garmin etrex GPS.

3. Result and Discussion

Global urban expansion has multiple impacts on biodiversity and ecosystem functioning. Still, urban centres may play an important role in the conservation of reptiles, an undersampled, megadiverse and unevenly distributed group especially vulnerable to anthropogenic impacts [28]. Reptiles– an undersampled, megadiverse and unevenly distributed vertebrate group across the globe, play a crucial role in ecosystems, as plant gene dispersal agents, nutrient transporters, trophic agents (both as food sources or as apex predators) and ecosystem engineers [28,29,30,31]. Climate change is anticipated to significantly impact the biogeographic distribution of snakes, leading to notable shifts in their habitats toward anthropogenic landscapes [32]. As in other animals, distress and impaired welfare have a deleterious effect on the mental, physical and behavioral health of snakes in the wild and in captivity. Besides anthropogenic disturbance, the availability of food and shelter, the presence of predators, and environmental factors, such as seasonality and climatological changes, are important factors that affect the stress level and subsequent welfare in wild snake populations [33]. Snakes are globally threatened due to anthropogenic pressures. Conflicts between snakes and people occur when residents encounter snakes in their home environments [14]. Bites by venomous snakes can cause acute medical emergencies involving shock, paralysis, hemorrhage, acute kidney injury and severe local tissue destruction that can prove fatal or lead to permanent disability if left untreated [6]. By understanding something about the habits of snakes, simple precautions can be adopted to reduce the chance of encounters and consequently bites [34]. Snakes, typically are carnivorous with various species consuming a variety of invertebrate and vertebrate prey, often in accordance with size of predator and prey [35,36]. Moreover, in the case of medically important species, such as cobras, dietary studies can be critical in understanding variation in venom action [37,38] with important implications for ameliorating the impacts of human snake conflict [39]. Spectacled Cobra is active by day & night and feeds on rodents, toads, frogs, birds and snakes [22]. Empirical documentation of the post-feeding behaviors of snakes from field experiments is extremely sparse [40]. Likewise, studies on regurgitation behaviour in snakes are also relatively scarce.

Fig. 1 Spectacled cobra cornered in the kitchen (Photo © Niraj Kumar)

Approximately, at 08:05 h Indian Standard Time (IST) on October 18, 2020, the author received an emergency call regarding the presence of a venomous serpent in a residential premises at S. K. Nagar area of Motihari town, the headquarter of East Champaran District of Bihar, requiring prompt rescue and relocation operation. At 08:30 h IST, an adult healthy Spectacled cobra *(Naja naja)*, approximately 3.7 ft. long and 395 g in weight, was rescued from the kitchen (Fig. 1) of the residential premises (26.64347°N and 84.91917°E). The snake was successfully rescued, bagged and relocated to a nearby suitable natural habitat (26.62865°N and 84.89179°E) within 3.5 km distance from the rescue site to ensure a safe release away from human habitation. The release site was properly evaluated for suitability before release. No harm was imposed on the snake, and the release site was chosen to ensure its survival. Upon release, the snake rapidly escaped into the nearby natural habitat and disappeared (Fig. 2). Post-release, when the cotton bag carrying the snake, was inspected carefully for residual contents, surprisingly and unexpectedly, a regurgitated semi-digested rat was found inside the bag. Photographs were taken of the bag and regurgitated contents for documentation (Fig. 3 & 4). Thus, this case study confirms that the cobra regurgitated a semi-digested rat after its release, likely as a stress response to capture, confinement in cotton bag, transportation and relocation. The semi-digested condition of the rat also suggests that it was consumed shortly prior to rescue. The observation also suggested that the semi-digested rat was regurgitated after rescue and before release, i.e., during the transportation to release site. The rapid escape of the cobra post-release also indicates induced stress or flight response, consistent with behaviors observed in snakes under duress. Thus, the stress of human confrontation, capture, manipulation with a snake hook, confinement in a cotton bag, and transportation likely triggered this response in Spectacled cobra. The cotton bag, while a standard tool for snake rescue, may have restricted movement and increased stress, contributing to regurgitation of rat.

Fig. 2 Spectacled cobra emerging out from the bag at relocation site (Photo © Niraj Kumar)

Fig. 3 Regurgitated rat by Spectacled cobra (Photo © Niraj Kumar)

Presence of spectators caused the cobra to regurgitate its prey during rescue operations in Surat, Gujarat [41]. Beside Spectacled Cobra, Indian Rat snake *Ptyas mucosa* was also reported to regurgitate instantly after a rescue operation from a house near Thirupparankundram, Madurai, Tamil Nadu, India [42]. A *Natrix natrix* (Common European Grass Snake) was also reported to regurgitate an adult female *Bufo bufo* (Common European Toad) after being disturbed by an observer trying to photograph it in Germany [43]. Thus, this study emphasizes several crucial factors to consider in effective snake rescue operations. First, handling techniques must minimize physical and psychological stress to prevent adverse physiological responses like regurgitation, which can deplete the snake's energy reserves and affect post-release survival. Second, the choice of relocation site is critical; rapid release without acclimatization may exacerbate stress. Third, the presence of prey attractants in human habitats underscores the need for better waste management to reduce human-snake conflicts.

Fig. 4 Close-up of head region depicting regurgitated semi-digested rat (Photo © Niraj Kumar)

4. Conclusion

This observation highlights the regurgitation behavior exhibited by the Spectacled cobra in response to stress or discomfort associated with capture and handling. The regurgitated rat suggests that the snake had fed recently, possibly shortly before being rescued. The regurgitation was likely induced by the stress of capture, confinement, and transport, highlighting the physiological impacts of handling on venomous snakes. The findings emphasize the need for stress-minimizing protocols in wildlife rescue, such as gentle handling, shorter confinement periods, and gradual release techniques. Additionally, preventing human-snake conflicts through improved waste management in residential areas can reduce the need for such interventions. Future research should focus on optimizing rescue protocols and mitigating attractants in human habitats to promote coexistence with venomous species.

5. Recommendations

Snakes, whether venomous or non-venomous, should be handled gently and with maximum care to minimize stress and discomfort. Snakes should be monitored closely during and after rescue and relocation operations to observe any unusual behaviors. Understanding snake behavior and ecology can inform conservation efforts and improve human-snake conflict management. This observation contributes to our understanding of the behavior and ecology of Indian cobras, highlighting the need for careful handling and consideration of their physiological and behavioral responses during rescue and relocation operations.

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Conflicts of interests
The author declares that there are no conflicts of interests.

Declaration on ethical approval
The entire process of identification, rescue, bagging, transportation and relocation strictly followed ethical wildlife handling guidelines and protocols. The study was based on non-invasive observation.

Data and materials availability
All data associated with this study are available in the paper.

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