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Tackling Snakebite Through Training: an Indian Example

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Abstract.—**India leads the world in the annual number of snakebite deaths, with the latest available figures indicating about 58,000 deaths per year. A few groups, largely Non-Governmental Organizations (NGOs) and registered not for profit societies, conduct snakebite education and awareness programs to risk groups across India. Limited snakebite training and awareness, however, is being conducted for groups that act as advisors or custodians of snakes. In this study, we worked with the State Forest Departments of Himachal Pradesh and Sikkim to provide training workshops on snakebite awareness and mitigation. We administered a questionnaire prior to and upon completion of training. Our research confirmed that knowledge, attitude, and behavior in relation to snakebite were intrinsically linked in the participating Indian Forest Department officers. Our study further revealed that those presenting high knowledge scores were those who also expressed the most environmentally friendly behavior and attitudes. This important finding highlights the need to improve knowledge, which would contribute towards more environmentally friendly behavior and favorable attitudes towards snakes. Training improved the knowledge of Forest Department officers about snakebite management and significantly increased their confidence to undertake snake rescue and apply snakebite first aid. To assist the Indian Forest Department in discharging its responsibilities for the protection of its wildlife and assisting in the reduction of snakebite, we recommend that in-depth and hands-on training is provided to all front-line staff of the Indian Forest Department that deals with snakes and snakebite incidents.**

Key Words.—attitude; behavior; first aid; handling; knowledge; questionnaires

Introduction

Snakebite remains one of the most neglected of all tropical (so-called) diseases (NTDs) and a common health problem in India (Mohapatra et al. 2011; Ralph et al. 2019; Togridou et al. 2019). India leads the world in the annual number of snakebite deaths, with the latest available figures indicating about 58,000 deaths per year (Suraweera et al. 2020), mainly afflicting the most impoverished inhabitants of rural areas (Warrell 2010). In addition, a large number of non-fatal bites lead to long-term disability and consequent economic hardship in terms of the treatment costs and long-term effects on health and the ability of survivors to work (Vaiyapuri et al. 2013).

Despite the recent increase in attention to this public health issue, it is not an easy problem to solve. The historical disinterest in snakebite has resulted in a marked lack of environmental education and awareness among communities in rural areas regarding measures to improve their everyday life, work, and healthcare as a result of snakebite (Balakrishnan 2010; Togridou et al. 2019). Lack of education and awareness has further increased public fear of all snake species, resulting in frequent human-snake conflicts (Pandey et al. 2016, 2020). Harmless snake species are confused with venomous species because of similarities in their appearance or prevalent belief in myths (Pandey et al. 2016). This leads to the unnecessary killing of harmless snakes (Balakrishnan 2010). Additionally, the failure to distinguish venomous and non-venomous species helps to entrench belief in the curative healing power of charms and other traditional treatments, such as application of herbs and roots, when victims appear to recover but had not been envenomated (Whitaker and Whitaker 2012). Lack of knowledge and species misidentification also leads to accidents (often fatal) among snake rescuers. Even when the snake is correctly identified, poor handling techniques and lack of proper equipment can place rescuers in unnecessary danger (Malhotra et al. 2016). Furthermore, rescued snakes are usually translocated to new, what is believed to be,

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Figure 1. Training locations (red dots) for snakebite awareness and mitigation in Himachal Pradesh and Sikkim, India (blue area indicates Sikkim and orange area indicates Himachal Pradesh).

suitable habitats with unknown effects on their survival (Vyas 2013), but are often released in unsuitable habitats or killed in some cases to collect their skin (pers. obs.).

Many studies (Sharma et al. 2004a,b; Mohapatra et al. 2011; Sharma et al. 2013; Mahmood et al. 2019) suggest that improving community education and knowledge could reduce incidences of snakebite and speed up the transfer of bitten patients to medical care. Increased knowledge of the environment is assumed to change environmental attitudes (Arcury 1990) and improving both knowledge and attitudes are further assumed to be important for changing human actions toward the environment (Ramsey and Rickson 1976). Studies on snakebite by Pandey et al. (2010) indicate that first aid training changes attitudes in the management of snakebite victims and is one effective way to decrease mortality.

A few groups, largely Non-Governmental Organizations (NGOs) and registered not-for-profit societies, conduct snake rescue and snakebite education and awareness programs for risk groups, rescuers, and local communities across India, with varying content and methods of delivery. NGOs typically lack scientific guidance by professionals (Vyas 2013) and the effectiveness of these programs are not known; a similar experience has been shared for New South Wales, Australia (Shine and Koening 2001). Effective written protocols should be maintained by each NGO (Vyas 2013), which should be controlled and directed (in India) by the Forest Department, which has primary responsibility for resolving human-wildlife conflict. An excellent example was set by the Maharashtra Forest Department, which published standard operating procedures for the regulation of snake rescues and documentation of every rescue in 2018 (https://kedarbhide.com/wp-content/uploads/2018/01/Guidelines-for-Snake-Rescue-and-Release-in-Maharashtra.pdf), along with the creation of a registered network of rescuers. It was developed and written in consultation with an expert and follows recognized best practice. Training is provided and is required for all registered snake rescuers. It is illegal for persons not authorized by the Forest Department to handle snakes. This example is being taken up in other states (e.g., Kerala: https://forest.kerala.gov.in/images/flash/whatsnew/guidelineswlw.pdf).

In most places, however, snakebite is often not recognized as a form of human-wildlife conflict, and most Forest Department staff have no special training or appropriate equipment to handle snake conflict situations. Instead, they rely on amateur snake rescuers, who often possess more bravado than skill. Most of the snake rescuers do not receive appropriate training from authorized professionals and they do not carry any certifications from relevant authorities: they just claim themselves as professionals and show off on social media and in front of people.

We selected the State Forest Departments of Himachal Pradesh (in the north of India) and Sikkim (in the northeast) for this study (Fig. 1) because of existing research collaborations and relevant permits. Although little is known about the reptile species found in these two states, we have a good understanding of which species are responsible for bites and given the differences between Himalayan regions and non-Himalayan regions, understanding snakebite in one does not necessarily equate to understanding snakebite in the other. Our rationale for selecting these two states is that there is much anecdotal information on snakebite in these states with very few to no scientific articles or case studies. Recently, Rai et al. (2021) published an article on the epidemiology of snakebite along with mapping of potential risk areas from Sikkim. This study was done in conjunction with a survey of the venomous snakes of these states. Unlike Maharashtra and Kerala, there is no established voluntary rescue network in Sikkim, so it falls to the Forest Department officials to perform this role. We chose the locations for the interventions based on the Forest Department ranges, with an aim of providing the training in the main range office in every range and where necessary, the Divisional Forest Office.

Forest Department officers are responsible for the ecological stability of the country through the protection and participatory sustainable management of its natural resources, along with the protection of its wildlife (Ministry of Environment, Forest and Climate Change [MEFCC]. 2019. MEFCC Division. Available from http://moef.gov.in/division/forest-divisions-2 [Accessed 10 May 2020]). Forest Department offices are found across all districts of Himachal Pradesh and Sikkim. Both states are situated in the Himalayan region, with Himachal Pradesh situated in the western Himalayas and Sikkim in the eastern Himalayas (Fig 1). Himachal Pradesh covers an area of about 55,780 km2 (Raghavan and Bhardwaj 2020), mostly in the foothills of the Dhauladhar Range in the western Himalayas. At the last census in 2011, the population of the state was 6,864,602 (http://censusindia.gov.in/2011census/censusinfodashboard/stock/profiles/en/IND002_Himachal%20Pradesh.pdf). The main languages spoken are Hindi and Pahari. Sikkim is a much smaller state than Himachal Pradesh, with an area of about 7,096 km2 and a population of 610,577 (http://www.census2011.co.in/census/state/sikkim.html). The main languages are Nepali and Bhutia.

The Himalayan region is also a global biodiversity hotspot. Relatively little is known, however, about the reptiles of the Himalayas, with reports being patchy and collections being concentrated in particular regions (Saikia et al. 2007; Chettri et al. 2010; Pan et al. 2013). Genetic surveys, which have the potential for not only verifying identifications made on the basis of external morphology, but also for assessing the degree of differentiation from existing species, are currently being carried out in both these states, alongside a project to collect venom from venomous snakes in this region to assess their cross-reactivity with available antivenom. Alongside the scientific program, we provided training workshops on snake biology and ecology and snakebite to Forest Department officers in both Himachal Pradesh and Sikkim. We evaluated the level of knowledge possessed by these Forest Department officers on snake biology and ecology, snake handling and rescue, and snakebite first aid. We also investigated their attitudes towards snakes, snakebite, and general issues of environmental concern; their behaviors towards snakes; and the effectiveness of the training program on the improvement of the above items.

Materials and Methods

We obtained free, prior, written, and informed consent from the respondents of the study. Participation in this study was voluntary. We provided training workshops on snake ecology and snakebite at four Forest Department locations in Sikkim and seven Forest Department locations in Himachal Pradesh, India. We provided training workshops to all grades of Forest Department officers from Forest Guard to Conservator of Forests. The training (by four authorized authors of this paper) consisted of two parts: a theoretical part focusing on snake biology and ecology, snake handling and rescue, and snakebite first aid; and a practical part in which safe handling of venomous and non-venomous snakes was demonstrated by the trainers.

Research protocols should be adapted to effectively measure environmental literacy of the target population in terms of age, socioeconomic background, institutional framework, environmental priorities, and the environmental subjects (Leeming et al. 1995; Schindler 1999). In the absence of suitable research protocols, we developed a questionnaire to investigate the knowledge, behaviors, and attitudes of Forest Department officers about snakes and snakebite. We based our research design on previous peer-reviewed studies (Arcury 1990; Pe'er et al. 2007; Madeni et al. 2011). To assess the knowledge, environmental attitudes, and behavior of Forest Department officers concerning snakes and snakebite, we administered a pre-training questionnaire to officers before the start of the training. We explained the purpose of the research and the use of the data to the participants, we gave a brief description of the questionnaire, and we highlighted the voluntary participation in this research. We gave a written form to sign to those that agreed to take part in the research. The questionnaire was completed prior to the training session (pre-training questionnaire). We asked participants to repeat the questionnaire on the same day upon completion of the training (post-training questionnaire).

The questionnaire was divided into six sections. The first section obtained demographic data, the second section explored information sources used by the participants on environmental issues and on snakebite, and the third section explored their knowledge about snake ecology, snake handling and rescue, and snakebite first aid. The fourth section explored their environmental attitudes, while the fifth section explored how frequently they had performed a given list of environmental tasks and their behavior in situations relevant to snakes and snakebite. Finally, in the sixth section, we asked participants to self-assess their knowledge about the above three knowledge items (snake ecology and biology, snake handling and rescue, and snakebite first aid).

We asked the participants to record their sources of information on environmental issues and on snakebite by choosing from a list of 10 information sources (e.g., internet, television, newspaper). We asked participants to record all sources of information relevant to them on the above issues. We measured knowledge of Forest

Department officers about snake biology and ecology using seven items related to common myths about snakes in India, snake morphology and ecology, and their role in the ecosystem. We measured their knowledge about snake handling and rescue techniques using five items. Finally, we measured their knowledge about snakebite first aid techniques using four items. In each case, we asked participants to indicate whether a statement was true or false. We scored correct replies 1 and incorrect replies 0. Additionally, we asked participants to evaluate their level of knowledge about snake biology and ecology, snake handling and rescue, and snakebite first aid using a 5-point Likert scale varying from very low (1) to high (5). We obtained overall knowledge about snake biology and ecology scores for each participant by combining the correct answers to the seven knowledge items, ranging from 0 to 7, with high values indicating high knowledge. We used the same combining protocol for overall snake handling and rescue knowledge (range, 0–5), for overall snakebite first aid knowledge (range, 0–4), and cumulatively estimated total knowledge on all above items (range, 0–16).

We measured the environmental attitudes of Forest Department officers using seven items. Questions included items compatible with the New Environmental Paradigm (NEP) Scale (Dunlap and Van Liere 1978; Kanagy and Willits 1993) and included items evaluating their perspective on major environmental issues (climate change, water pollution). We provided the participants with a 5-point Likert scale to indicate the degree of agreement or disagreement to these seven items. For attitude items, a favorable attitude towards the environment response was given a high score (2), where an unfavorable towards the environment response was scored low (0). Neutral responses were scored 1. By combining coded responses for each attitude item, we obtained the overall attitude score for each participant. Higher attitude scores represented favorable attitudes, whereas lower scores indicated unfavorable attitudes towards the environment, ranging from 0 to 14. We also measured the behavior of Forest Department officers using seven items. We provided to participants two 5-point Likert scales to indicate the degree of likelihood of four behaviors and the degree of agreement or disagreement to three items. For behavior items, we gave a favorable (towards snakes and the environment) response a high score (2), whereas we scored an unfavorable response low (0). We scored neutral responses 1. To ensure that a score on each item has the same meaning, we applied reverse coding to some items. Scores ranged from 0 to 14.

Because there were a few missing values in the responses of Forest Department officers, we adopted a sample mean approach, and with internal-level variables, we replaced missing values with the value of the mean of that variable for that sample. We analyzed data in SPSS (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, New York, USA). We calculated descriptive statistics (percentages, mean, standard deviation) to investigate their knowledge on snakes and snakebite, attitudes, and environmental behaviors pre- and post- training. We compared pre- and post- training responses with a paired *t*-test. We performed χ^2 tests of independence to investigate relationships between demographic variables. For both tests, $\alpha = 0.05$.

Results

There were 429 questionnaires (228 pre-training and 201 post-training) fully completed by the participants in this research. We randomly selected 201 pre-training questionnaires that we used in the statistical analysis. Forty-two percent of all Forest Department officers who participated were 18–31 y old and 35.1% were 31–40 y old. More than half of officers (58%) held a higher education degree (Bachelors, Master's (M.Sc./M.A.) or Doctor of Philosophy (Ph.D.). They predominately (87.7%) lived in small (< 500 people) to medium size villages (500–2,000 people). Families of most officer consisted of 3–5 members (61.4%), although 34.6% consisted of 5+ members. Half of officers declared they lived in joint families (52.2%), and the vast majority (92.1%) of officers considered that they were likely or highly likely to encounter a snake within their work boundary. Officers lived in joint families more in Himachal Pradesh than in Sikkim ($\chi^2 = 11.75$, df = 1, $P < 0.001$) and the larger the family, the higher the likelihood of it being a joint family ($\chi^2 = 61.92$, df = 2, $P < 0.001$). Officers in Himachal Pradesh lived in smaller villages than those in Sikkim ($\chi^2 = 36.192$, df = 3, $P < 0.001$).

Fifty-eight percent of participants declared that they obtain their primary information on environmental issues from TV, and 57.5% declared social media as a primary source. Internet and newspapers also scored highly (46.9% and 43.4%, respectively), and workshops and work-based material were poorly represented (14.5% and 8.8%, respectively). Half of participants (51.3%) declared that their main source of information on snakebite is social media, while 45.2% of participants reported TV as a source of information. Again, workshops and work-based material were poorly represented (5.3% and 5.7%, respectively).

We subsequently divided samples into equal groups according to total scores of respondents on knowledge, attitude, and behavior (1 = low, 2 = moderate, and 3 = high scoring groups) and the results indicated that the majority of Forest Department officers belonged to the low and moderate knowledge, attitude, and behavior

scoring groups (mean = 1.81 ± (standard deviation) 0.79; 1.89 ± 0.845; and 1.89 ± 0.761, respectively). Pre-training mean scores for overall knowledge on snake biology, snake handling and rescue, and snakebite first aid were 5.06 ± 1.414, 3.42 ± 0.930, and 2.21 ± 0.804, respectively (Appendix Table 1). Post-training mean scores for the above items were 5.90 ± 1.218, 4.11 ± 0.944, and 3.15 ± 0.853, respectively (Appendix Table 1). Pre-training mean of self-assessed knowledge on the three individual knowledge items (snake biology and ecology, snake handling and rescue, and snakebite first aid) were 2.06 ± 0.941, 1.62 ± 0.791, and 1.99 ± 1.039, respectively (Appendix Table 1). Post-training mean scores were 2.41 ± 0.826, 2.64 ± 0.939, and 2.86 ± 1.164, respectively (Appendix Table 1).

Mean total score for environmentally friendly behaviors pre-training was 9.36 ± 1.831, increasing to 9.81 ± 2.028 post-training (t = -2.35, df = 200, P < 0.05); however, the attitude score did not show a significant difference between pre- (12.54 ± 1.311) and post-training (12.38 ± 1.267; Appendix Table 2). The post-training mean score for total knowledge on snake biology and ecology (5.90 ± 1.218) was significantly higher than the pre-training mean (5.06 ± 1.414; Appendix Table 3). Similarly, the post-training mean score for total knowledge on snake handling and rescue (4.11 ± 0.944) was significantly higher than the pre-training mean (3.42 ± 0.930; Appendix Table 3). The post-training mean score for total knowledge on snakebite first aid (13.16 ± 2.248) was significantly higher than the pre-training mean (10.69 ± 2.292; Appendix Table 3). Finally, the post-training mean self-assessed knowledge on the three individual knowledge items of snake biology and ecology (2.41 ± 0.826), snake handling and rescue (2.64 ± 0.939), and snakebite first aid (2.86 ± 1.164) was significantly higher that the pre-training mean self-assessed knowledge (2.06 ± 0.941, 1.62 ± 0.791, and 1.99 ± 1.039, respectively) which represent significant increases in knowledge following training (Appendix Table 2). The post-training mean score for total environmental behavior (9.81 ± 2.028) was significantly higher than the pre-training mean (Appendix Table 3). Mean scores for environmental attitude before and after the training did not differ significantly (Appendix Table 3).

Discussion

To our knowledge, this is the first study to investigate sources of information on snakebite in India. Our findings are in line with previous studies that identified television and internet as the major sources of information on environmental news and governmental sources as the least-used sources (Krewski et al. 2006). With an ever-expanding use of the internet, social media platforms, and television as sources of information on snakebite, we must look to ways to bridge the gap between experts and journalists and seek ways to use internet, social media, and TV effectively to address real or perceived environmental health scares (Nicholson et al. 2000). Because the quality and factuality of information disseminated by these media forms is not regulated, caution must be employed when considering using these media forms to inform about snakebite. Government information and training courses should be more widely promoted. Although less widely consulted, government information and training courses provide information that can be centrally amended and distributed when new practices and scientific research are published.

Our objective was to evaluate a snake awareness program using a questionnaire assessing the knowledge, attitudes, and behavior of Indian Forest Department officers. It was undertaken to understand the knowledge levels, attitudes, and behavior of those responsible for protection of the environment in India. This is the first study to assess the knowledge of Forest Department officers on snakes and snakebite in India.

The findings indicated overall knowledge was low to moderate, which is higher than that recorded in similar studies with health care professionals (Inthanomchanh et al. 2017). Study findings indicated an increase in knowledge and environmentally friendly behavior that showed a significant difference between pre- and post-training. Improving knowledge has been highlighted as one of the main challenges for snakebite treatment (Alirol et al. 2010). Practices to prevent snakebite are well implemented by most Forest Department officers, with most of them using a torch to walk at night, which could significantly reduce the incidence of bites (Pe et al. 1998).

The attitude scores, however, did not show a significant difference between pre- and post-training. Similarly, a pre- and post-test research design showed an increase in knowledge, but no significant difference in attitude between groups in the evaluation of an AIDS education program (Bellingham and Gillies 1993). In addition, a study evaluating a reproductive health awareness program for adolescents in Tanzania did not record a significant difference in attitude pre- and post-test (Madeni et al. 2011). Therefore, the training program was effective for knowledge and behavior improvement, but attitudes may be more difficult to change.

The majority of Forest Department officers reported poor confidence in treating snakebites, handling snakes, and applying snake rescue and first aid. Similar findings have been made in Lao People's Democratic Republic (Lao PDR), India, Pakistan, Malaysia, and Hong Kong (Fung et al. 2009; Inthanomchanh et al. 2017), where the majority of healthcare providers, who play an important

role in snakebite management, had poor confidence in treating snakebite patients. The geographical size and terrain of Himachal Pradesh makes repeated studies unachievable for a small team operating with limited funds (Togridou at al. 2019). Travelling from one Forestry Department location to another could take more than 8 h. Lack of substantial funding that would allow researchers to spend long periods in the area limits research opportunities. Although limitations in this research were not considered significant regarding the research outcomes, there is an urgent requirement for a collaborative approach between existing and new groups.

This training addressed the need to improve knowledge regarding snakebite management and to encourage the use of appropriate rescue and first aid techniques among Forest Department officers. Our results show there is a need to provide all Forest Department officers with hands-on training in snake handling and rescue techniques, first aid, and courses to further increase their knowledge of native venomous and non-venomous snakes, to improve knowledge of Forest Department officers about snakebite management and increase their confidence to apply snake rescue and snakebite first aid. To assist the Forest Department in discharging its responsibilities for the protection of its wildlife and assisting in the reduction of snakebite as a human-wildlife conflict situation, we recommend that more in-depth and hands-on training is provided to front-line staff. This can also help to establish a baseline for knowledge transfer to additional relevant stakeholders such as snake rescuers, healers, and local communities. Engagement and knowledge transfer with traditional healers and rescuers could be crucial for snakebite management as they could be effective agents to encourage prompt use of formal government healthcare facilities (Harrison and Gutiérrez 2016). The Forest Department could then develop small, appropriately trained teams in every district within the state to respond to human-snake encounters. The fact that most deaths in rural India occur at home, prior to coming to the attention of any qualified healthcare worker, enhances the perception that prevention of snakebite should be the top priority, and is in line with the move from the curative to the preventative approach to public health in India (Jha et al. 2006; Kumar and Preetha 2012; Togridou et al. 2019). Lastly, our conservation priority and forest department attitude towards larger charismatic creatures should be extended to other vertebrate groups so that these groups also get attention.

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Anatoli Togridou is a member of the Biodiversity Information and Technology Exchange for Snakebite Management (BITES) project, Bangor University, Bangor, UK. Anatoli earned a Ph.D. in Ecology from Aristotle University of Thessaloniki, Greece. Her main area of interest focuses on community research, working with key stakeholders and research into effective training and risk mitigation. Anatoli believes that snakebite education could provide affordable and appropriate prevention tools. (Photographed by Stuart Graham).

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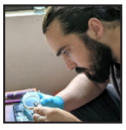
Vishal Santra is the Co-founder and Secretary of the Not for Profit (NFP) Society for Nature Conservation Research and Community Engagement. During the formative years, Vishal was mentored by Dr. Anita Malhotra, Dr. Wolfgang Wuster, Dr. Stuart Graham, Romulus Whitaker, and Gerard Martin placing him squarely on the path to research. Constantly involved in herpetological expeditions, Vishal also engages actively in snakebite research to understand taxonomy, ecology, and venom variation both within and between species across the range. (Photographed by Stuart Graham).



John Benjamin Owens is a Ph.D. student at Bangor University, Bangor, UK, developing low-coverage whole-genome methods to investigate the population genetics of British herpetofauna. Ben is also the Founder of Captive & Field Herpetology and is a member of the BITES project in Bangor University. His research concentrates primarily on Indian snakebite from an ecological perspective, Indian taxonomy, and the socioeconomic mechanisms surrounding snakebite. (Photographed by Maya Master).

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Anita Malhotra is a Reader at Bangor University, Bangor, UK. Anita earned a Ph.D. in Evolutionary Biology at the University of Aberdeen, UK. She began her specialist research focusing on a revision of the systematics of Asian pitvipers. This work was based on the integration of multiple methods and led to a radical shift in the systematic arrangement of the group at both species and generic levels. In more recent years, her focus has shifted to addressing the human suffering and death toll that these snakes can bring. (Photographed by Anita Malhotra).

Appendices

Appendix Table 1. Forest Department officers' knowledge scores pre- and post-training (Sikkim and Himachal Pradesh, June to August 2019).

	Pre-questionnaire correct answers n = 201		Post-questionnaire correct answers n = 201			
	SD	Mean	SD	Mean	*t* value	*P* value
Snake Biology						
Snakes drink milk	0.59	0.493	0.98	0.140	-10.818	0.001
Snakes sway to the sound of the charmer's flute	0.69	0.463	0.88	0.325	-4.861	0.001
Snakes seek revenge	0.80	0.400	0.93	0.255	-3.719	0.001
Snakes are helpful to control rodent pests	0.94	0.247	0.92	0.271	0.576	0.565
All venomous snakes have vertical pupils	0.69	0.463	0.72	0.449	-0.662	0.509
All cobras have the image of a smile on their hood	0.56	0.497	0.80	0.404	-5.377	0.001
Wolf snakes are venomous	0.79	0.408	0.67	0.473	2.983	0.003
Total knowledge about snake biology	5.06	1.414	5.90	1.218	-6.260	0.001
Snake Handling and Rescue						
You should confirm the identity of the snake before handling so that you use the right handling method	0.96	0.207	0.93	0.255	1.043	0.298
You should handle snakes only when you are alert and healthy	0.91	0.293	0.94	0.238	-1.302	0.194
You should try to persuade the householders to allow non-venomous snakes to remain in their territory	0.65	0.478	0.88	0.325	-5.586	0.001
You should always release a snake away from its capture site	0.26	0.442	0.67	0.473	-8.695	0.001
A snake rescue is an emergency that should be handled immediately with whatever tools are at hand and however you are dressed.	0.64	0.481	0.70	0.461	-1.129	0.260
Total knowledge about snake handling and rescue	3.42	0.930	4.11	0.944	-7.335	0.001

Appendix Table 1 (continued). Forest Department officers' knowledge scores pre- and post-training (Sikkim and Himachal Pradesh, June to August 2019).

	Pre-questionnaire correct answers n = 201		Post-questionnaire correct answers n = 201			
	SD	Mean	SD	Mean	*t* value	*P* value
Snake Bite and First Aid						
After a snakebite you should cut the wound and suck the venom out	0.74	0.442	0.95	0.228	-6.230	0.001
After snakebite, you should apply tourniquets to stop the venom spreading	0.19	0.396	0.79	0.408	-15.669	0.001
You should keep the snakebite victim calm to slow the spread of venom	0.94	0.247	0.87	0.342	2.360	0.019
Capturing the snake for identification is essential for correct treatment of the snakebite patient.	0.34	0.476	0.55	0.499	-4.296	0.001
Total knowledge about snakebite first aid	2.21	0.804	3.15	0.853	-11.532	0.001
Self-Assessed Knowledge						
snake biology	2.06	0.941	2.41	0.826	-4.021	0.001
snake handling and rescue	1.62	0.791	2.64	0.939	-10.995	0.001
snakebite first aid treatment	1.99	1.039	2.86	1.164	-7.392	0.001

Appendix Table 2. Forest Department officers' environmental attitude and behavior scores pre- and post-training, (Sikkim and Himachal Pradesh, June to August 2019).

	Pre-questionnaire correct answers n = 201		Post-questionnaire correct answers n = 201			
	SD	Mean	SD	Mean	*t* value	*P* value
Environmental attitude						
Sustainable development is development that meets the needs of the present without affecting the future	1.93	0.274	1.98	0.172	-2.384	0.018
Humans are part of, rather than the rulers of, nature	1.86	0.448	1.77	0.598	1.725	0.086
Plants and animals primarily exist to be used by humans	1.03	0.866	0.91	0.873	1.517	0.131
I am very concerned about water pollution	1.95	0.268	1.95	0.303	0.000	1.000
Humans should live in harmony with nature	1.97	0.209	1.93	0.324	1.259	0.209
Climate change is a major threat for the planet	1.94	0.294	1.96	0.242	-0.755	0.451
I am in favor of protecting the natural environment over economic growth	1.87	0.365	1.88	0.355	-0.288	0.774
Total environmentally friendly attitude	12.54	1.311	12.38	1.267	1.384	0.168
Environmental behavior						
If a member of my family gets bitten, I will take them to a healer for treatment	1.22	0.918	1.38	0.904	-1.765	0.079
I see snakes as a sacred animal	0.70	0.770	0.89	0.832	-2.278	0.024
I will always move snakes away from where I find them	0.93	0.830	1.06	0.884	-1.693	0.092
I will encourage people to treat snakes with respect	1.85	0.437	1.90	0.400	-1.290	0.199
I will use a torch when walking at night	1.98	0.172	1.99	0.100	-0.706	0.481
I will gather garbage in my neighborhood	0.73	0.893	0.66	0.887	0.837	0.404
I will protect all animals	1.96	0.242	1.94	0.284	0.928	0.354
Total environmentally friendly behavior	9.36	1.831	9.81	2.028	-2.350	0.020

Appendix Table 3. Results of Student's *t*-test comparing knowledge, behavior and attitude items before and after the training provided to Forestry Department officers (Sikkim and Himachal Pradesh, June to August 2019).

Items Pairs of pre- and post- training responses	Mean	SD	*t*-value	df	*P*-value
Snake Biology					
Snakes drink milk	-0.388	0.036	-10.818	200	0.001
Snakes sway to the sound of the charmer's flute	-0.189	0.039	-4.861	200	0.001
Snakes seek revenge	-0.129	0.035	-3.719	200	0.001
Snakes are helpful to control rodent pests	0.015	0.026	0.576	200	0.565
All venomous snakes have vertical pupils	-0.030	0.045	-0.662	200	0.509
All cobras have the image of a smile on their hood	-0.234	0.043	-5.377	200	0.001
Wolf snakes are venomous	0.124	0.042	2.983	200	0.003
Total knowledge on snake biology and ecology	-0.831	1.882	-6.260	200	0.001
Snake Biology and Handling					
You should confirm the identity of the snake before handling so that you use the right handling method	0.025	0.338	1.043	200	0.298
You should handle snakes only when you are alert and healthy	-0.035	0.379	-1.302	200	0.194
You should try to persuade the householders to allow non-venomous snakes to remain in its territory	-0.229	0.581	-5.586	200	0.001
You should always release a snake away from its capture site	-0.403	0.657	-8.695	200	0.001
A snake rescue is an emergency that should be handled immediately with whatever tools are at hand and however you are dressed.	-0.055	0.687	-1.129	200	0.260
Total knowledge on snake handling and rescue	-0.697	1.346	-7.335	200	0.001
Snakebite and First Aid					
After a snakebite you should cut the wound and suck the venom out	-0.209	0.476	-6.230	200	0.001
After snakebite, you should apply tourniquets to stop the venom spreading	-0.672	0.531	-17.943	200	0.001
You should keep the snakebite victim calm to slow the spread of venom	0.070	0.418	2.360	200	0.019
Capturing the snake for identification is essential for correct treatment of the snakebite patient.	-0.204	0.673	-4.296	200	0.001
Total knowledge on snakebite first aid	-0.940	1.156	-11.532	200	0.001
Total Knowledge	-2.468	3.256	-10.746	200	0.001
Self-Assessed Knowledge					
snake biology and ecology	-0.348	1.228	-4.021	200	0.001
snake handling and rescue	-1.020	1.315	-10.995	200	0.001
snakebite first aid	-0.866	1.660	-7.392	200	0.001

Appendix Table 3 (continued). Results of Student's *t*-test comparing knowledge, behavior and attitude items before and after the training provided to Forestry Department officers (Sikkim and Himachal Pradesh, June to August 2019).

Items Pairs of pre- and post- training responses	Mean	SD	*t*-value	df	*P*-value
Knowledge of Behavior					
If a member of my family gets bitten, I will take them to a healer for treatment	-0.159	1.278	-1.765	200	0.079
I see snakes as a sacred animal	-0.189	1.176	-2.278	200	0.024
I will always move snakes away from where I find them	-0.139	1.166	-1.693	200	0.092
I will encourage people to treat snakes with respect	-0.055	0.602	-1.290	200	0.199
I will use a torch when walking at night	-0.010	0.200	-0.706	200	0.481
I will protect all animals	0.025	0.380	0.928	200	0.354
Total environmental behavior	-0.453	2.731	-2.350	200	0.020
Attitude Knowledge					
Sustainable development is development that meets the needs of the present without affecting the future	-0.050	0.296	-2.384	200	0.018
Humans are part of, rather than the rulers of, nature	0.090	0.736	1.725	200	0.086
Plants and animals primarily exist to be used by humans	0.119	1.116	1.517	200	0.131
I am very concerned about water pollution	0.000	0.412	0.000	200	1.000
Humans should live in harmony with nature	0.035	0.392	1.259	200	0.209
Climate change is a major threat for the planet	-0.020	0.374	-0.755	200	0.451
I am in favor of protecting the natural environment over economic growth	-0.010	0.490	-0.288	200	0.774
Total Environmental attitude	0.164	1.682	1.384	200	0.168