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RESEARCH ARTICLE

Sacred groves and serpent-gods moderate human–snake relations

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Abstract

1. Serpent-god worship is an ancient tradition still practiced in many sacred groves across the Western Ghats of India. Although sacred groves there hold ecological conservation value, few studies have focused on arguably the most iconic taxon in the region, snakes.
2. We thus investigated the impact of sacred groves and snake deity worshipping on attitudes towards snakes by conducting surveys with people who had entered sacred groves in the past.
3. We found that very few participants who had encountered snakes inside sacred groves in the past harmed them during these encounters. However, nearly a quarter of all participants do harm snakes if encountered outside sacred groves.
4. We also found that a larger proportion of participants who do not harm snakes outside sacred groves worship snake deities, relative to those that do harm them.
5. Our work thus highlights the influence of sacred groves and snake deity worshipping on pacifistic human–snake relations in Southwestern India.

KEYWORDS
biocultural landscape, environmental perception, human–snake relation, religion, sacred grove, snakebite, The Western Ghats

1 | INTRODUCTION

Overshadowed by growing concerns over contemporary human-induced threats to ecosystems associated with global urbanization, numerous cultures throughout the world have upheld the preservation of natural sites for generations by valuing their sanctity (Dudley, Higgins-Zogib, & Mansourian, 2009; Verschuuren, Wild, McNeely, & Oviedo, 2010). By preventing the development or extensive degradation of sacred natural sites, such beliefs and traditions have helped maintain local biodiversity despite ongoing nearby urban growth and land-use changes (Verschuuren et al., 2010). There has consequently been a sharpening focus on their value in current conservation biology (Mcleod & Palmer, 2015; Waylen, Fischer, Mcgowan, Thirgood, & Milner-Gulland, 2010), perhaps as an ideal for the prosperity of both nature and society (Pardo-de-Santayana & Macía, 2015). Although found throughout the world (Verschuuren et al., 2010), the potential role for sacred natural sites in modern conservation practices has garnered significant attention in places such as Ethiopia (Aerts et al., 2016; Teketay et al., 2010), Ghana (Decher, 1997; Sarfo-Mensah, Oduro, Antoh Fredua, & Amisah, 2010), Tanzania (Kideghesho, 2008; Mgumia & Oba, 2003), and Southwestern China (Salick et al., 2007; Shen, Lu, Li, & Chen, 2012), where studies have exemplified their efficacy in safeguarding native flora and fauna.

But perhaps the most prominent case of environmental protection resulting as a by-product of traditional beliefs is to be found in India, where relatively undisturbed patches of forest, or "sacred groves", have been sites of worship towards gods, deities and ancestral spirits (Freeman, 1999; Gadgil & Vartak, 1976). As a consequence of the values placed on these forests by local communities, many have been preserved for extensive periods of time, with some having persisted for as long as 400 years (Bhagwat, Nogué, & Willis, 2014). Sacred groves are especially common in the Western Ghats (Bhagwat, Kushalappa, Williams, & Brown, 2005), the mountain range straddling the South-Western edge of the Indian subcontinent widely known as one of the world's top "hotspots" for biodiversity (Myers, Mittermeier, Mittermeier, Fonseca, & Kent, 2000). Located in an ecologically distinct region, the sacred groves of the Western Ghats have fortuitously served as sanctuaries for local flora and small to medium-sized fauna (Bhagwat et al., 2005; Bhagwat & Rutte, 2006; Ray, Chandran, & Ramachandra, 2014). They have also been shown to host a high number of endemic plant species (Chandrashekara & Sankar, 1998), and to maintain this richness relative to nearby areas, including disturbed forests and, occasionally, government-managed protected areas (Dudley et al., 2009; Ormsby & Bhagwat, 2010).

Although the extent of the Western Ghats spans six states, a significant region of interest for such forests is Southwestern India, where Kerala is the Indian state with the most sacred groves (Khan, Ashalata, & Tripathi, 2008; Rajendraprasad, 1995) and borders Southern Karnataka state, itself displaying the densest distribution of sacred groves (Khan et al., 2008; Kushalappa, Bhagwat, & Kushalappa, 2001). Known as *kavu* in Malayalam and *devarakadu* in Kannada, these forests are usually visited by local inhabitants for the worship of one or many gods in particular (Ballullaya et al., 2019). However, what is especially unique for the sacred groves of this region is the frequent presence of idols, shrines or temples devoted to serpent-gods, often known as *Nāga* in Sanskrit, or by a variety of other local names. While the origins of this tradition in sacred groves in particular are obscure, serpent depictions in art pre-date the presence of the Indo-Aryan culture in South Asia, where the "earliest evidences of the topic of snakes are to be found in the pictorial representations from Harappa, Mohenjo-Daro and Lothal, that is from the time of about 2000 BC" (Härtel, 1976:664). Härtel further reports that "the oldest images of *Nāgas* after the Harappa times appear as late as the end of the second century BC" (1976:667). Referring to early disseminations on the antiquity of serpent worship in the region by architectural historian James Fergusson, Wake writes "he supposes it not to have been adopted by any nation belonging to the Semitic or Aryan stock; the serpent worship of India and Greece originating, as he believes, with older peoples" (1873:373). Such ideas from the 19th century Western thinkers still hold some relevance today, as the worship of snake deities in sacred groves is thought to potentially be the resulting blend of deeply rooted indigenous folk traditions with later rituals and beliefs of devotion towards *Nāgas* (Murugan, Ramachandran, Swarupanandan, & Remesh, 2008), in the same way that representations and traditions surrounding local folk deities in sacred groves have been assimilated with other pan-Indian gods over time (Ormsby, 2011; Tomalin, 2004).

Inside sacred groves in which serpent-gods are among the deities revered, or *sarpa kavu* in Malayalam (roughly translating to "snake garden"), locals perform rituals of worship out of devotion for the *Nāgas*. These serpent-gods in question are not necessarily synonymous with actual living snakes, but are divine beings or deities which are depicted as displaying the same physical features as snakes, with a specific allusion to cobras. According to early 20th century art historian Jean Philippe Vogel, "the *Nāga* of Indian mythology and folklore is not really the snake in general, but the cobra raised to the rank of a divine being" and it is thus "evident that the *Nāga* in his animal form is conceived as the hooded snake" (1995[1926]: 27). Therefore, any following mention of "snake deity" or "serpent-god" in this study will be in reference to these divine beings, while the term "snake" alone will be in reference to actual living snakes. Nonetheless, the two are inexorably connected in the sense that any affliction posed towards snakes, whether intentional or accidental, is believed to bring forth the wrath of the *Nāgas* in various forms; as Allocco writes, referring to contemporary South India, "A number of authors note that killing a snake is regarded as a sin and detail the lengths that individuals may go to in order to avoid injuring a snake, as *nāgas* are believed to deliver formidable curses with far-reaching implications" (2013:231).

But beyond their relationship with actual living snakes, *Nāgas* also symbolize human fertility and childbirth, as a reflection of the forest's productivity (Das & Balasubramanian, 2017). The perception of these life-giving powers is perhaps rooted in the association of *Nāgas* with water, one of the limiting factors of agricultural production. As Vogel suggested, "though easily moved to anger, [the *Nāgas*] are worthy of being propitiated, as their activity is, on the whole, beneficial to the welfare of man, especially in connexion with their power over the element of water." (1995[1926]: 3). With both fear and admiration at play, snake deity worshipping is therefore polarized in its motivations, and is not restricted to *sarpa kavu*, with such beliefs stretching across the Western Ghats as well as many other parts of India (Nair, 2017).

Yet, despite the prevailing devotion towards snake deities in the sacred groves of Southwestern India in particular, the vast majority of diversity assessments in such forests have focused on flora, with few studies concerning reptiles (Ray et al., 2014). With an estimated 45,900 human deaths annually in India, the country has one of the highest rates of deadly venomous snake bites globally (Mohapatra et al., 2011; Warrell, 2010). Thus, recognized as life-threatening animals, this awareness permeates into the daily lives of people, whom simultaneously respect and revere snake deities (Allocco, 2013). At the crossroads of danger and devotion, how do such beliefs and perceptions translate into the way locals co-exist with mortal, physical snakes (Narayanan & Bindumadhav, 2018)?

Accordingly, in this case study, our aim was to explore the relationship between visitors of sacred groves and snakes in Southwestern India within the context of a prevalent snake deity worshipping tradition, and its potential implications for current conservation

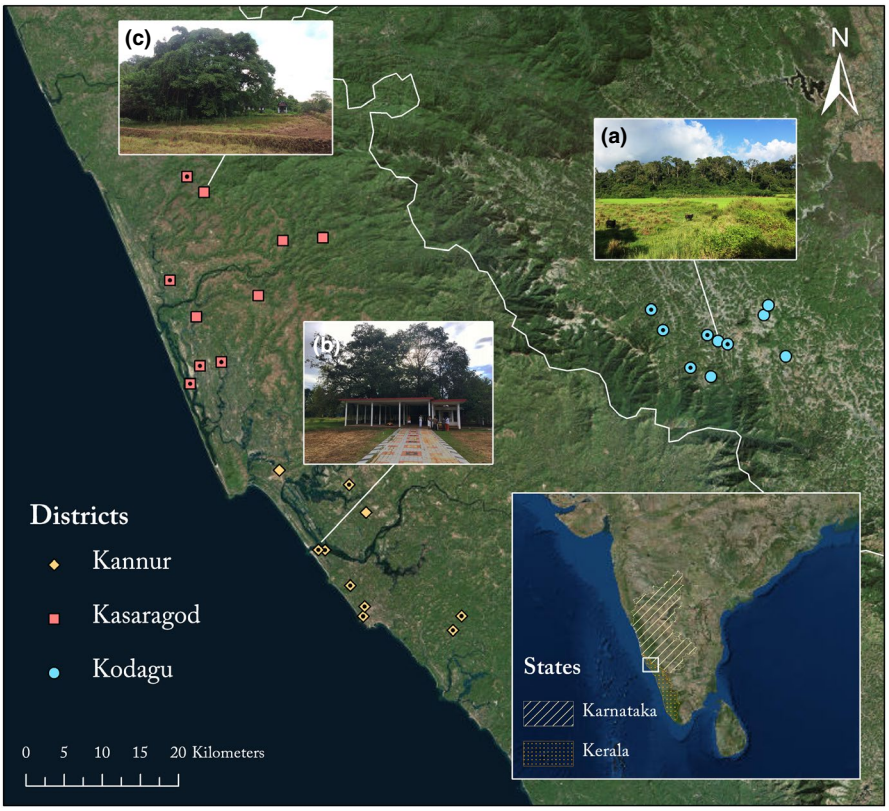

FIGURE 1 Map of the portion of Southwestern India, including Northwestern Kerala and Southern Karnataka states, where we conducted our surveys. The 30 sacred grove sites we have visited are indicated by the points, and coded according to the districts of Kannur (yellow diamonds), Kasaragod (red squares) and Kodagu (blue circles). The 18 sacred groves devoted to snake deities are demarcated by a black circle at the centre of each point. Panels (a), (b) and (c) each depict examples of sites visited which were, respectively, rural, urban, and intermediary

strategies. For this inquiry, we visited sacred groves which did or did not host snake deities and conducted surveys using questionnaires (Moon, Brewer, Januchowski-Hartley, Adams, & Blackman, 2016). Our main objectives were (a) to determine if attitudes and reactions towards snakes depended on the presence of a snake deity in the sacred grove, and (b) whether snake deity worshipping was associated with more pacifistic reactions to snake encounters inside or outside sacred groves. We also aimed (c) to investigate if reactions to snakes were more pacifistic inside sacred groves than outside of them, regardless of the presence of a snake deity. As one of the oldest examples of nature worship still in existence today, the beliefs surrounding *sarpa kavu* have long been understood to preserve its native species (Murugan et al., 2008), yet this study is the first to quantify just how this reflects the views of visitors towards the snakes inhabiting them.

2 | MATERIALS AND METHODS

2.1 | Study area

The focal area for our work comprised the Southwestern portion of the Western Ghats of India. Located in the coastal Malabar region of the state of Kerala, the districts of Kasaragod and Kannur are predominantly inhabited by various castes belonging to Thiyya communities, which themselves have unique customs and rituals associated with its sacred groves (Chandrashekara, Joseph, & Sreejith, 2002). Although the floral communities within these sacred groves can be quite diverse, they are usually surrounded by urbanized areas or agriculture such as rubber plantations and rice paddies (Chandrashekara & Sankar, 1998).On the other hand, in the south of Karnataka state, the predominant cultural group found throughout the district of Kodagu is that of the indigenous Kodava people. Found at slightly higher elevations, the landscapes there are more sparsely urbanized and dominated by sacred groves alongside coffee plantations (Bhagwat et al., 2005; Kushalappa et al., 2001). We thus identified sites in these regions based on our prior knowledge of their existence as a result of past research, or through information obtained from local inhabitants.

In October 2018, we visited 10 sacred groves in each of the three districts varying in how urban or rural the sites generally were: Kannur for the most urban sacred groves, Kodagu for the most rural ones and Kasaragod for the more intermediary sites (Figure 1). While varying in their structure, these sacred groves always contained a central worshipping compound for the performance of rituals by designated priests. To accommodate more visitors, the more urban sacred groves tended to contain larger areas covered by man-made infrastructure such as cement, cobblestone, halls and temples. On the other hand, the more rural sacred groves were more comparable to relatively undisturbed forest, with the only built structures being smaller worshipping compounds and the occasional shrine or temple. Accordingly, the average tree cover percentage within 1 km from the centroid for our sites visited were 25.96 ± 4.90%, 30.72 ± 6.15% and 41.42 ± 5.35% for Kannur, Kasaragod and Kodagu, respectively (based on an analysis using the forest cover dataset described in Hansen et al., 2013). We also aimed to cover a wide range of sacred grove sizes, with

sites ranging from 0.17 to 104 acres, and the overall mean size of all 30 sacred groves visited being 11.01 acres.

Serpent-gods were among the deities worshipped in 18 of the 30 sites (Figure 1). To be certain of whether snake deities were among the acknowledged deities in each sacred grove or not, we always consulted associated elders or priests. This is because by visiting alone, the representation of a snake deity inside a sacred grove is not always evident. They can sometimes be depicted by statues showing typical snake-like features one could expect of serpent-gods, while they can also be symbolized by more abstract idols, such as rounded stones, with little indication of their significance.

2.2 | Questionnaires for participants

For each sacred grove visited, we surveyed 10 people opportunistically, between the daytime hours of 9:00 and 17:00, when encountered either inside the forests or within 1 km, and conducted these in either Malayalam, Kannada or Tulu, in addition to one in Hindi. To be considered as a participant, each individual must have had visited the sacred grove in question in the past. Therefore, both devotees of the sacred grove's deity and non-devotees could be considered. Although the vast majority of the 300 participants identified as devotees (96%, n = 289), we also surveyed some non-devotees identifying themselves as visitors (3%, n = 8), management members (1%, n = 2), as well as one local resident (<1%, n = 1). Notably, as well as being devotees, 5% of total participants were also priests or assistant priests (n = 15), while 26% were either the owner's family, management, committee or former committee members (n = 77). Additionally, the participants we surveyed varied in other demographic characteristics, such as age, which ranged from 11 to 87, and gender, where 34% were female (n = 101) and 66% male (n = 199). Regarding religious or caste association, teasing apart the two terms is not a simple task, since some castes carry their own unique religious beliefs. Accordingly, 18% of participants identified only as Hindu (n = 53), 17% as Hindu Thiyya (n = 52), 6% as Hindu Kodava (n = 18) and 15% as Hindu in addition to another caste or religious identity (n = 45). Without mention of being Hindu, 14% of participants identified only as Kodava (n = 41), 10% as Thiyya (n = 30) and 16% as other less common groups (n = 47). Of the total, 5% chose not to comment on their religious or caste identity (n = 14).

These surveys consisted of a questionnaire made up of a combination of closed and open-ended questions (Appendix S1; Moon et al., 2016), and lasted 10–25 min. For the purpose of the analyses presented in this study, we focused on the answers given for the questions outlined in Table 1.

The purpose of questions (a) and (b) was to deduce the attitudes of participants towards snakes, while questions (c) and (d) were to gain a sense of how participants co-exist with snakes. For question (e), we asked whether, in general, participants worshipped snake deities, without contextualizing the question as cultural, religious or spiritual, thus leaving it open to interpretation by the participant.

Although we surveyed a total of 300 participants, question f) was only posed to 268 (Table 1). This question is distinct from question (e), which was to determine whether the participant worships any snake deity. Rather, question (f) was meant to determine in parallel whether participants considered any actual living snake species to be sacred. For question (f) (ii) (Table 1), participants first responded by describing or giving the local names of snakes they believed to be sacred. We then showed them photos of 15 commonly found snake species in the region (Palot, 2015; Sathish, 2008) for them to visually identify these sacred snakes. All surveys were conducted by the same researchers for consistency (UPB), and informed verbal consent was received before each survey from participants to be included in this research. Surveys were conducted with approval by The University of Hong Kong's Human Research Ethics Committee (EA1806029),

TABLE 1 Sample of closed and open-ended questions asked during the surveys and for which answers were included within the analyses of this study

Questions for which answers were analyzed in this study
a) Do you like snakes? □ Yes □ No □ Do not like or dislike
b) In the future, would you like to see: □ More snakes in the sacred grove □ Fewer snakes in the sacred grove □ No change in the number of snakes in the sacred grove
c) How do you react upon encountering a snake inside the sacred grove?
d) How do you reach when encountering a snake outside the sacred grove?
e) i) Do you ever pray/show worship towards a snake deity? ii) Why? iii) If yes to ei): Could you describe any rituals or prayers you typically perform towards this/these snake deity/deities?
f) i) Do you consider snakes as sacred? ii) Which ones?

2.3 | Data analysis

We applied qualitative content analysis to quantify answers and collate them according to connecting themes (Hsieh & Shannon, 2005). We categorized answers based on a code designed according to the nature of the statements with regard to attitudes towards snakes (Erlingsson & Brysiewicz, 2017). For answers given according to questions (a) and (b) (Table 1), we collated any extra clarifications according to the nature of the attitude implied towards snakes as either "positive", "negative", "neutral", or as a "warning sign", with the latter implying a conditional statement, that the response could change depending on the circumstance, or that there was the possibility for human-snake conflict (Appendix S2; McMillan, Wong, Hau, & Bonebrake, 2019). We similarly collated answers to question (e) (ii) according to their interpreted attitude towards snakes (Appendix S2). We also collated answers to each questions (c) and (d), based on whether reactions to snake encounters implied harm to snakes. For both questions, these consisted of three categories; "Yes", "No" or "Maybe" (Appendix S3).

In order to test for differences in answer proportions, we applied either the parametric chi-square test or non-parametric Z-test

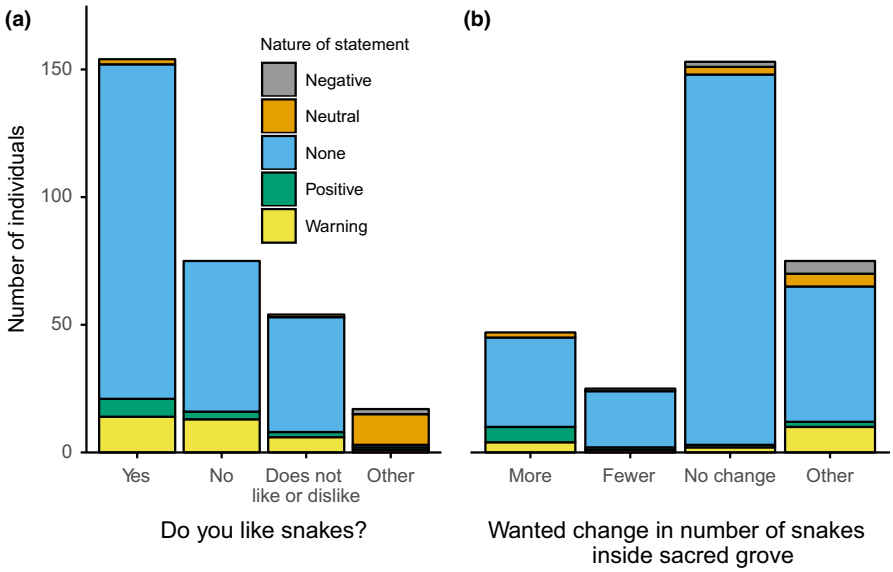

FIGURE 2 Responses of participants on whether they liked snakes (a) and what change in the number of snakes inside sacred groves they would want to happen (b), with bars representing the numbers of individuals per response type. Where extra clarifications were added to responses, these were categorized according to the nature of the statement regarding attitudes towards snakes

depending on the nature of the comparison. To examine whether there were social determinants of participants harming snakes outside sacred groves, we built a generalized linear model with type of visitor (devotee and non-devotee), Hindu class (upper and lower class), as well as gender (male and female) as the predictors, and snake deity presence, sacred grove size, district, and number of years of association with the sacred grove added as covariates. We used a binomial error distribution as the response variable consisted of a binary outcome ("Yes" or "No").

We conducted all statistical analyses in R version 3.4.1 (R Core Team 2017).

3 | RESULTS

3.1 | Attitudes towards snakes

We found the general sentiment of participants towards snakes to be of tolerance and, to a lesser degree, endearment rather than antipathy. Most said they liked actual living snakes (51%, $p < .01$, $\chi^2_3 = 133.95$, $n = 154$), a trend which did not differ between sacred groves with or without snake deities present ($p = .46$, $Z = -0.09$), while a quarter said they did not like snakes (25%, $n = 75$) and 18% did not like or dislike snakes ($n = 54$, Figure 2a). The remaining 6% specified the kinds of snakes they did or did not like ($n = 17$), with most of these explicitly expressing a dislike for venomous snakes, only liking non-venomous snakes, or both statements (65%, $n = 11$).

Although the vast majority of those that said they liked snakes did not add any clarifications regarding their attitudes towards snakes (85%, $n = 131$, Appendix S2), we found that a moderate proportion of participants still expressed a fear of snakes (9%, $n = 14$). Intuitively, fear was slightly more prevalent for those that did not like snakes (17%, $n = 13$, Appendix S2). In both cases, added expressions of fear made up most of the "warning sign" clarifications for both "yes" or "no" responses. The one exception for a "warning sign" not explicitly mentioning fear was a participant who said, in a tone evoking a newly found vigilance, that although she liked snakes, her son was bitten by one in the past.

On the other hand, some participants were particularly enthusiastic about how much they liked snakes (5%, $n = 7$), adding positive clarifications explaining that "they are innocent", or that they "will not harm them (snakes)". In a similar sense, within the minority of participants that did not like snakes, three added to their responses to the question that despite this, they "will not harm them".

Moreover, there were a few cases of responses avoiding a polarized "yes" or "no" answer, for which the perceived sanctity of living snakes was the apparent cause. Among clarifications which we classified as "positive", one participant said that they did not like or dislike snakes but had "devotion towards them", while another simply said "I do not dislike them because I worship them". There were also two other response clarifications which evoked a clear distinction between actual living snakes that are sacred, and others that are not, such as "I like sacred snakes but dislike venomous snakes", which we classified as a "warning sign" given there was a specific dislike for one type of snake, or "I only like sacred snakes", which we classified as "neutral" since it did not explicitly express a dislike for specific snakes.

This sense of a tolerant attitude towards snakes was further represented by a larger number of participants wanting more snakes in sacred groves than those who wanted there to be fewer ($p < .01$, $\chi^2_1 = 6.72$, $n = 47$ and $n = 25$ respectively, Figure 2b), implying a sense of will to co-exist with them. This trend also stood regardless of the presence of snake deities within sacred groves, as we found no difference in the proportion of those wanting to see more snakes inside the sacred groves in the future across those with or without snake deities ($p = .09$, $Z = -1.36$). Despite this, we still found the majority of participants to not want to see any changes in the number of snakes in the respective sacred groves in the future (51%, $p < .01$, $\chi^2_3 = 124.91$, $n = 153$).

In some instances, these responses were motivated by the awareness of a certain ecological importance of snakes. Among those that

wanted more snakes in the sacred groves, clarifications to such responses expressed a support for the livelihood of snakes, which we thus classified as "positive" (n = 6). Examples include one participant who explicitly stated that snakes "play an important ecological role", while others vouched for their protection and the prevention of their extinction. There were also "neutral" clarifications to responses which hinted towards an ecological knowledge of snakes, such as one participant saying that, despite wanting more snakes in sacred groves, the "space and conditions are not good for snakes to thrive" there. Other "neutral" clarifications amongst both those that wanted to see no change in sacred grove snake numbers and those that did not specifically answer the question spoke about the natural fluctuation in snake numbers; a recognition that these populations are variable over time regardless of human intervention.

In parallel to this, however, there were clear concerns for the safety of people within the hypothetical case of larger snake numbers in sacred groves. For example, while wanting there to be more snakes in sacred groves, 9% of these participants clarified that this was under the condition that they "should not harm people" or "should not come out of the sacred grove", which we interpreted as a "warning sign" (n = 4, Appendix S2). Such caution in light of the potential dangers of higher snake numbers was also represented among the remaining quarter of participants that either gave specific answers to the question, or no comment whatsoever. Notably, 3% of total participants specifically said that they either wanted there to be fewer venomous snakes (n = 3), more non-venomous snakes (n = 1), or both more non-venomous and fewer venomous snakes (n = 6).

3.2 | Co-existence with snakes inside and outside sacred groves

Moreover, concerns about venomous snakes were especially featured in responses to question (d) (Table 1), which dealt with reactions to snake encounters outside of sacred groves. While we found the proportion of participants implying harm to snakes outside sacred groves to be 23% (n = 68), nearly half of these responses consisted of killing them under the condition that the snake was venomous (43%, n = 29). Similarly, amongst reactions maybe implying harm to snakes outside sacred groves (18% of total participants, n = 53), 17% (n = 9) of these involved a conditional statement pertaining to whether the snake was venomous, with a common response explaining that they would "inform others if venomous". However, we also found that a minority of responses implying harm to snakes did not bother to make such discrimination, and outright killed them unconditionally during encounters, regardless of whether they were or venomous or not (13%, n = 9).

In stark contrast, out of the participants that had encountered snakes inside sacred groves at least once in the past (46%, n = 139), the distinction between venomous and non-venomous snakes was nearly absent in their responses to question (c) (Table 1). Only one of the two participants that did imply harm to snakes upon encountering them inside sacred groves, a proportion significantly lower than for reactions outside sacred groves implying harm (1%, p < .05, Z = −5.63, n = 2, Figure 3), said they would "kill it if it is venomous". There was no such condition for those maybe implying harm to snakes inside sacred groves (2%, n = 3), which was also in a proportion significantly lower than for those maybe implying harm to snakes when encountering them outside of sacred groves (p < .05, Z = −4.51, Figure 3). In fact, most responses to question (c) consisted of responses which were pacifistic towards snakes and did not imply harm to them (96%, n = 133), in a proportion significantly higher than for participants with the same type of reaction to snake encounters outside sacred groves (60%, p < .05, Z = −7.88, n = 179, Figure 3). This was apparently true regardless of the type of deity or god worshipped in the sacred grove, as we found no difference between the proportions of participants which did not imply harm to snakes inside sacred groves with (95%, n = 82) or without (98%, n = 51) a snake deity present (p = .20, Z = −0.83).

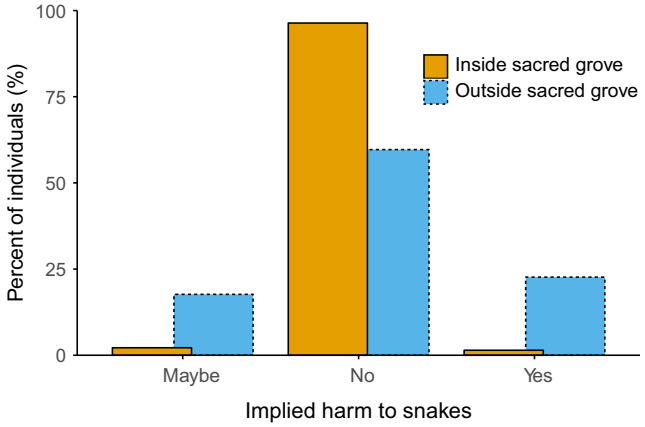

FIGURE 3 Proportion of participants which would either harm, not harm, or maybe harm snakes when encountering them either inside (orange with solid lines; n = 139) or outside (blue with dotted lines; n = 300) sacred groves

3.3 | Snake deity worshipping, the perceived sanctity of actual living snakes, and their influence on non-harmful human–snake relations

In addition to its prevalence inside versus outside sacred groves, we also found pacifism towards snakes to be associated with devotional beliefs. While the vast majority of participants said they worshipped snake deities (84%, p < .01, χ^2_1 = 138.72, n = 252), a significantly larger proportion of those which did not imply harm to snakes outside sacred groves said they worshipped snake deities (87%, n = 155) than those that did imply harm (75%, p = .01, Z = −2.19, n = 51, Figure 4a). In parallel to this, while most participants said they considered actual living snakes to be sacred (69%, p < .01, χ^2_2 = 89.24, n = 186), this belief was shared in larger proportion by those that did not imply harm to snakes outside sacred groves (73%, n = 124) than by those that did (64%, n = 38), although this difference was not significant statistically (p = .09, Z = −1.37, Figure 4b).

We should note, however, that we are not necessarily outlining a direct cause and effect relationship here, as there are multiple layers

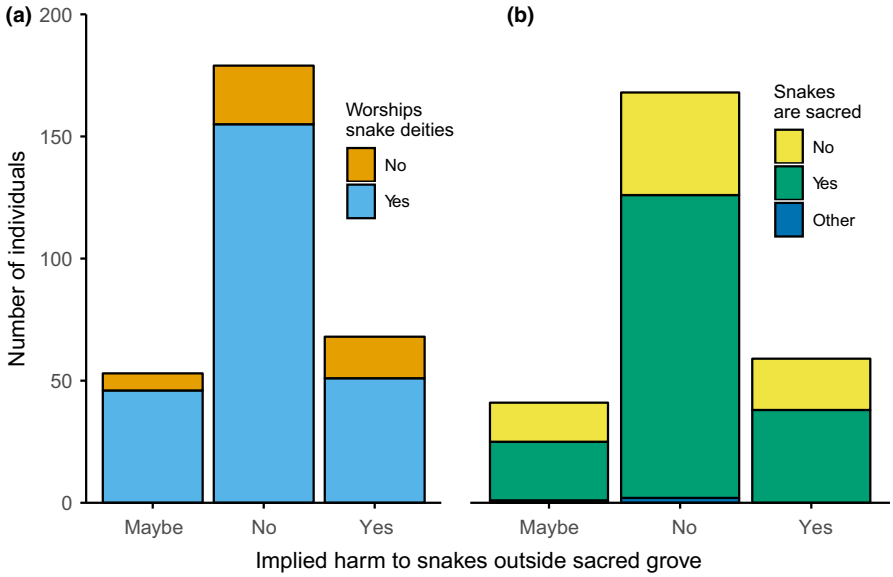

FIGURE 4 Responses of participants on whether they implied harm to snakes when encountering them outside sacred groves where bars represent numbers of individuals per response type. Categories within response types represent the proportion of individuals that worship snake deities (a, where orange and blue indicate no and yes, respectively; *n* = 300) or believe actual living snakes to be sacred (b where yellow, green and dark blue represent no, yes, and other responses, respectively; *n* = 268)

of social strata at play, especially for reactions to snake encounters outside sacred groves. For instance, in this case, gender had a significant effect on whether participants implied harm to snakes outside of sacred groves ($p < .01$, Table 2). More specifically, we found harmful human–snake interactions to be mostly driven by the male demographic, where there was a much higher tendency for males to imply harm to snakes outside of sacred groves (31%, $n = 61$, $p < .05$, $Z = -4.64$) than females (7%, $n = 7$). This was despite there being no difference in the proportion of females (75%, $n = 65$) versus males (67.97%, $n = 121$) considering actual living snakes as sacred ($p = .26$, $Z = 1.13$), and only a slightly higher proportion of females worshipping snake deities (90%, $n = 91$) than males (81%, $n = 161$).

Although the worship of snake deities and the perception of the sanctity of actual living snakes may be easy to confuse from an outsider's point of view, these were self-evidently understood to be distinct by the participants. Given, they are not entirely mutually exclusive, as both were relatively more common in sacred groves containing snake deities, where the proportion of snake deity worshipping participants was slightly larger for sacred groves with snake deities present (88%, $n = 159$) than absent (78%, $p < .01$, $Z = -2.51$, $n = 93$). The proportion of participants that considered snakes to be sacred was also significantly larger for sacred groves with snake deities (75%, $n = 121$ of 162) than for those without (61%, $p = .01$, $Z = -2.32$, $n = 65$ of 106). However, in this case, the worshipped snake deities are assumed to be ethereal beings transcending the physical world, with rituals performed at temples, shrines or idols devoted to them. Frequently mentioned snake deities said to be worshipped included *nāgakanni* and *nāgakandan* for the participants in the Kannur district, *nāgakanyaka* for the Kasaragod district, the serpent-gods associated with *subramanya* for the Kodagu district, as well as *nāga* and *nāgaraja* throughout all districts. Based on responses to question (e) (iii) (Table 1), most participants explained how they would visit sites of supplication to offer items such as milk, hen eggs, tender coconuts, eggs and snake statues made of silver or gold, as well as money. Many participants mentioned the rituals of *nāga puja*, a ceremony of worship towards a serpent-god, as well as *abhishekam*, the cleansing of the deity at the beginning of a *puja* by pouring a mixture of liquids on the idol (Malley & Barrett, 2003), and *sarpa bali*, a ritual involving chants and mantras performed by priests in order to ward off serpent-god curses (Das & Balasubramanian, 2017).

TABLE 2 Results of generalized linear model analyzing the potential determinants of participants implying harm to snakes outside of sacred groves, which was compared against the reference level of each factor, where a negative "Slope" indicates the level has a lower estimate (regardless of their significance) relative to their reference

	Reference level	Slope	*p* value
Intercept	n.a.	−3.59	**<.001**
Non-devotee visitors	Devotees	0.58	.591
Upper class Hindu	Lower class Hindu	−0.57	.195
Male	Female	1.46	**.001**
Snake deity present	Snake deity absent	0.42	.284
Size of sacred grove	n.a.	0.01	.572
Kasaragod district	Kannur district	1.68	**<.001**
Kodagu district	Kannur district	0.94	.059
Number of years of association with sacred grove	n.a.	0.01	.145

Note: p values below the threshold of .05 are bolded to indicate statistical significance. "n.a." under the "Reference Level" column indicates the variable is continuous rather than nominal.

Contrastingly, the snakes that are believed to be sacred are corporeal and thus visually tangible while inhabiting the same world as humans. Within this context, when asked to specify which snakes were sacred, 33% of those that perceived snakes as sacred implied this to mean all living snakes ($n = 61$), whereas 14% said only snakes

in or around sacred groves, temples, or other places of worship were sacred (*n* = 26). 28% and 14% made mention of the Indian cobra, *Naja naja* (*n* = 57), and king cobra, *Ophiophagus Hannah* (*n* = 26), respectively, as sacred, via identification from either the photos shown or by local names. 17% included in their answers a type of sacred snake, often named as *sarpa*, which could not be identified from photos, but could be described as small, shining, golden or yellow coloured, and hooded (*n* = 32), with occasional similarities explicitly drawn to the Indian cobra but with the insistence that it was not the same. Therefore, pooled together, we found nearly half (42%, *n* = 79) of the participants that believed snakes to be sacred to have described what could be interpreted as cobras, arguably the most recognizably venomous snakes in South Asia. In spite of the descriptive similarities though, a few of the participants gave us the impression that sacred snakes are not dangerous to people. In effect, one participant emphasized that these "will not harm us", whereas two others specified that the sacred snake "does not bite people". On the other hand, two participants alluded to these snakes, despite their sanctity, not being wanted in the vicinity, as these "listen" and "go away when told to".

Accordingly, herein lies another connection between actual living snakes and the worshipping of snake deities, to the effect that the latter belief was often said to be motivated by the hopeful aversion of snake encounters. In this respect, a combined 22% of participants gave reasons for worshipping snake deities which we classified either as a "warning sign" (*n* = 43) or "negative" (*n* = 12) regarding attitudes towards snakes (*n* = 55). All answers classified as "negative" explicitly mentioned worshipping for the sake of gaining "protection from snakes", whereas "warning sign" reasons mostly involved the wish to "avoid snakes", or the prevention of serpent-god curses known as *nāga dosha* (Appendix S2). Yet the significant majority of reasons given for the worship of snake deities in general, were "neutral" with respect to attitudes towards snakes, with simple answers including "belief", "tradition", "for prosperity", "for blessings" and "out of devotion" (74%, $p < .01$, $\chi^2_1 = 56.29$, $n = 183$, Appendix S2). On the other hand, a minority of participants said they worshipped snake deities for reasons suggesting "positive" attitudes towards snakes (2%, *n* = 5), with the occasional reference towards the sanctity of actual living snakes, such as "snakes are sacred" or "snakes are gods". In one response exuding profoundness, one participant said they worshipped snake deities to attain the "mindfulness not to harm snakes"; a reflection of the role this belief is playing on the pacifism towards snakes overall.

4 | DISCUSSION

As important predators of early anthropoids, snakes have influenced contemporary human psychology across evolutionary time (Isbell, 2006). Although it is not certain to what extent stigmas and fears about snakes are innate, learned, or a combinatory result of both, we know that humans are predisposed to the recognition of snakes relative to other stimuli (LoBue & DeLoache, 2008; Rakison, 2018; Thrasher & LoBue, 2016). In South India, natural and societal environmental factors have been conducive to an exceptionally high rate of human mortality by snake envenomation (Mohapatra et al., 2011; Warrell, 2010), consequently inspiring the reverence of serpent-gods in ancient folk beliefs still in existence today (Allocco, 2013). Nearly one century ago, Vogel supposed that "Indian ophiolatry had its first cause in the dread inspired by the poisonous reptiles", and that for those communities, serpent-gods "possessed no doubt as much reality, as the creeping things of the earth which constantly endangered their lives" (1995[1926]: 7). This suggestion may not be entirely outdated, since the fear of encountering or being harmed by actual living snakes as the principal motive behind the worshipping of snake deities is something we have found to be prevalent amongst a portion of the participants. Yet there is of course a rich mix of motives for this devotion beyond fear or dread. For example, and for the most part, participants tended not to include allusions to snakes in their reasons for worshipping snake deities. Rather, their primary motives where a combination of the continuation of an age-old custom which they have been raised with, and a genuine sense of reverence for serpent-gods, which agrees with Fergusson's optimistic view on the matter of snake deity worship not only in India, but across the ancient world, as far as he perceived it in the mid-19th century. He thought that "if fear were the…principal characteristic of Serpent Worship, it might be sufficient, in order to account for its prevalence, to say, that like causes produce like effects all the world over" and that rather, "love and admiration, more than fear or dread, seem to be the main features of this faith" (2004[1847]: 3). Indeed, the tolerance and fondness expressed towards actual living snakes by the surveyed participants reflect this idea. But of course, in this case, the relationship between humans and snakes is a complicated one. For example, venomous snakes featured heavily in responses to our surveys despite there being no questions making such a distinction. While there inevitably are day-to-day concerns about the dangers of snakebite, there is still an eagerness to co-exist with snakes. A relevant example of this is the specific reverence for cobras which frequently came up in our surveys. Although they are usually recognized as being dangerous, the beliefs about cobras are most likely inspired by the common depictions of serpent-gods in the forms of hooded snakes in Hindu art, such as the snake coiled around Lord Shiva's neck, or Ananta, a multiple-headed serpent serving as the bed of Vishnu. Yet, these representations typically include elements unique to deities, such as a multiple yet uneven number of heads (Vogel, 1995[1926]). Whether in the forms of statues, carvings or paintings, portrayals of snake deities were ubiquitous in most temples, villages and even cities of the regions we visited. Even in Bangalore, known as the "Silicon Valley of India" for its emergence in software technologies on the global front (Parthasarathy, 2004), it is easy to notice the presence of idols dedicated to snake deities throughout the city despite its ongoing "modernization".

While there is evidence for the existence of serpent worship throughout the ancient world (Wake, 1873), very few instances of it lasting through to contemporary society remain as it has in the Western Ghats region, where this belief translates into the pacifist

views towards snakes portrayed in this study. Yet we should note that societal roles are at play as well, especially that of gender, where males were more predisposed to harm snakes than females. This corroborates Allocco's observations in the state of Tamil Nadu that "men are less capable of recognizing a snake as the goddess and thus more likely to harm or kill it" (2013:245). Nonetheless, the tendency to allow snakes to live is seemingly the underlying factor conducive to a society in which humans and snakes can co-exist with minimal detriment to the latter.

This overall societal taboo against the harming or killing of snakes of course benefits conservation efforts on local snake species (Baker, Tanimola, & Olubode, 2018; Saraswat, Sinha, & Radhakrishna, 2015). Yet the importance of sacred groves in promoting pacifistic interactions with snakes is integral to this concept, since our results show that harm to snakes by people is exceptionally rare in these forests. While the idea of sacred groves as havens for the conservation of native species is often noted (Chandrashekara & Sankar, 1998; Ormsby & Bhagwat, 2010; Verschuuren et al., 2010), some would say that the traditions surrounding them are completely misaligned in respects to their natural preservation which would have occurred as an unintentional side effect. Freeman argues that "there is little correlation between the concerns and depictions of the modern environmentalist's models, and the actual local reasons for instituting and maintaining sacred groves" (1999:262). Tomalin further adds that the "belief that religious practices have preserved sacred groves intact" blinds people from realising "the extent of their decline" (2004:279). With modern conservation strategies hailing from the Western dichotomous view pitting pristine wilderness versus urban society, careful attention should be paid as to not instrumentalize indigenous taboos in a near colonial, top-down manner.

Sacred groves in Southwestern India are not always pristine primary forest and many are rapidly degrading and shrinking, often to the point where they are reduced to just the central sacred compound containing the deities (Murugan, 2008). To this point, in a conversation we had with a Brahmin priest not as part of the survey, he explained how the occasional land owner would hire tantric priests to conduct a ceremony to lift up and displace the local snake deity of their sacred grove to another location so as to justify the implementation of plantations or other development in the area. Despite this, the influence of the reverence shown towards snake deities permeates across all sacred groves, since we found the participants' general attitudes and pacifistic behavior towards snakes to be largely independent of the presence of a snake deity inside a given sacred grove. Perhaps more importantly is that although local beliefs may not preserve nature under the modern conservation model, sacred groves in the Western Ghats permit the persistence of the snakes inhabiting them.

While the detrimental exploitation of indigenous values for the advancement of conservation should be avoided, so should the overly cynical generalizations about the ecological awareness of these societies. Although there is a rich history of natural preservation with religion and spirituality globally (Lowman & Sinu, 2018), wildlife awareness by local inhabitants is often underestimated by researchers (Ulicsni et al., 2018). Their perceptions on conservation as it pertains to their daily lives, and especially their relationships with local fauna, form a key component for the improvement of implemented strategies (Bennett, 2016). In our surveys, although few in number, some participants did mention the ecological importance of snakes for sacred groves. We also encountered a case of societal ecological awarness at one of the sacred groves we visited in the Kasaragod district, where the inhabitants of the areas surrounding it had convinced the local council to construct a fence demarcating the forest to raise it up a certain height from the ground so as to allow the passage of animals. We should thus reconcile the goal of preserving biodiversity together with the respect towards and welfare of local communities. This is especially relevant during the laying out of urban infrastructure, where the continued, bottom-up valuation of a co-existence between humans and other non-human animals relies on a shift in the mentality of authorities (Narayanan & Bindumadhav, 2018).

Given the nature of the information we collected with the surveys, we should note that there are limitations to our interpretations regarding attitudes towards snakes. Chiefly is the assumption that participants which did not imply harm to snakes when encountering them actually respond in this way in reality. Together with the perceptions we measured, we recognize that these do not necessarily equate to actual attitudes in a 1:1 manner. But all in all, it is apparent that there is a social taboo against harming snakes inside sacred groves and that this could be pushed forward as leverage for the integrative conservation of both snakes and sacred groves in the face of encroachment by development and plantations (Bhagwat & Rutte, 2006; Khan et al., 2008; Ormsby & Bhagwat, 2010). Documented cases where traditional taboos in sacred sites have successfully led to the protection of species otherwise considered as dangerous or pests include the Sclater's monkey (*Cercopithecus sclateri*) in Nigeria (Baker et al., 2018), rhesus macaques (*Macaca mulatta*) in India (Saraswat et al., 2015), as well as the snow leopard (*Panthera uncia*) in China (Li et al., 2014). This is especially important for snake species which are currently at risk either in the Western Ghats or in other parts of their distribution due to the direct harvest of individuals for international trade. Notably, the King cobra is listed as vulnerable with a decreasing population trend by the IUCN Red list (Stuart et al., 2012). It is also included in the CITES Appendix II list together with the Indian cobra, Indian rat snake (*Ptyas mucosus*), Russell's viper (*Daboia russelii*) and the checkered keelback (*Xenochrophis piscator*), while the Indian rock python (*Python molurus*) is listed under CITES Appendix I.

However, despite generating potential conservation benefits for native snake species, their co-existence with people cannot be thoroughly discussed without also prioritizing the protection of human lives. As in many other tropical regions of the world, the danger of venomous snakes in Southwestern India is a preeminent day-to-day concern over other threats to safety. Yet, despite this and the fact that deaths by snake envenomation make up a significant proportion of all injury deaths across India (Mohapatra et al., 2011), snakebite remains a globally neglected tropical disease (Warrell, 2010).

Therefore, moving forward, we wish to highlight the role of sacred groves in promoting non-harmful human–snake relations for the conservation of both snakes and sacred groves, all while stressing the importance of the beliefs, perspectives and safety of local communities in their co-existence with snakes.

5 | CONCLUSIONS

The co-existence of humans and snakes in the Western Ghats in this case appears to be largely supported by the devotional beliefs of local communities in regards to snake deities as well as sacred groves. This has proved to be mostly independent of the presence or absence of snake deities in the specific sacred groves we visited, and is thus not restricted as a localized perspective. Rather, by transcending the scale of individual sacred groves, the tolerance and pacifistic behaviour towards snakes across our sites demonstrate how deeply traditions related to serpent-gods permeate across communities in Southwestern India.

Although this taboo against harming snakes has been discussed in the past literature (Allocco, 2013; Narayanan & Bindumadhav, 2018), this is the first study to exhibit the intensification of it within the confines of sacred groves. Accordingly, this taboo against harming snakes inside sacred groves would be a key component to be integrated as a biocultural strategy (Gavin et al., 2015) for the future preservation of not only snakes which could be at risk locally or in other parts of their range, but also of other faunal and floral species relying on the persistence of sacred groves (Bhagwat & Rutte, 2006; Chandrashekara & Sankar, 1998; Ray et al., 2014). Importantly, this approach also includes the human dimension, where the cultures and traditions from which these beliefs originate are simultaneously protected (Pardo-de-Santayana & Macía, 2015). While the risks to safety imposed by snakes to people are real and should be critically dealt with, the acknowledgement of the valuation of snakes as their own social entity by local communities during future development could prove to be instrumental in bolstering the advocacy of biodiverse environments in Southwestern India.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

We wish to thank the reviewers and editors for their helpful comments during the revising of this manuscript. All authors contributed in conceiving the ideas and designing the methodology; F.L.Y., U.P.B. and R.R. collected the data; F.L.Y. and P.A.S. analysed the data; F.L.Y. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

The survey data we have collected for this study are available from the Dryad Digital Repository: https://doi.org/10.5061/dryad.1rn8pk0pd (Landry Yuan et al., 2019). The distribution of these data is in line with the participants and protects their privacy.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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