Visitors' Knowledge of the Broad-headed Snake in Royal National Park

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Humans continue to have a negative impact on wildlife and habitat within protected areas. Anthropogenic disturbance to rock habitat within Royal National Park in southern Sydney is reducing the availability of vital retreat sites used by the endangered broad-headed snake (*Hoplocephalus bungaroides*). One approach that may reduce this disturbance is to educate Park users about the broad-headed snake and the threats to its habitat. We conducted questionnaire surveys of Park users during 2010 to determine their level of awareness of this snake, and to assess whether educating Park users about the snake may assist in its conservation. Only 14% of 181 respondents knew this snake occurred within Royal National Park. Some respondents (6%) had observed people tampering with rock habitats, while 85% of respondents believed that people would be more likely to report such activities if aware of its impact on the broad-headed snake. A majority (53%) of respondents believed rock disturbance would not continue if people were informed of its impact. These results suggest that conservation of the broad-headed snake in Royal National Park would benefit if Park users were better informed.

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KEYWORDS: Habitat disturbance; *Hoplocephalus bungaroides*; questionnaire survey

INTRODUCTION

Humans continue to have a detrimental effect on the natural environment, including National Parks. Protected areas are threatened by the anthropogenic influences of population growth, demand for natural resources, possible introduction of non-native species and climate change (Kessler 2008). Within protected area boundaries, increasing numbers of visitors are also exerting pressure on ecosystems (Buckley and Pannell 1990; Buckley 2003; Hadwen et al. 2007). Visitor impacts include: soil erosion and compaction; damage to vegetation; disturbance to wildlife; litter; water pollution; noise; increased fire frequency; and vandalism (Buckley and Pannell 1990; Marion and Read 2007; Kerbiriou et al. 2009). Wildlife mortality due to animal-vehicle collisions (e.g. Ramp et al. 2006) or illegal hunting also occur, while the collection of endangered species is a major concern (e.g. Webb et al. 2002). These impacts can lead to the loss of species if left unmanaged (Marion and Read 2007).

Royal National Park (NP), on the southern outskirts of the Sydney metropolitan area, is under increasing pressure from visitation. Approximately three million people visit Royal NP each year (NPWS 2000). The Park was established in 1879 primarily as an area for rest and recreation, with nature conservation gradually becoming incorporated into management practice (DEWHA 2009).

One species of conservation significance occurring in Royal NP is the broad-headed snake (*Hoplocephalus bungaroides*) (Fig. 1) (Goldingay 1998), which is recognised as Australia's most endangered snake (Webb et al. 2002). Anthropogenic disturbance to rock habitat within this Park (see Goldingay 1998; Goldingay and Newell 2000; Newell and Goldingay 2005) has impacted on vital rock retreat sites used by this snake during the cooler months of the year (Shine et al. 1998; Webb and Shine 1998a, b). While some studies have implicated bush-rock removal for use in landscaping as the cause of decline in habitat value (Shine and Fitzgerald 1989; Mahony 1997; Shine et al. 1998), others suggest that

Figure 1. The broad-headed snake (photo: Hayes 2009).

much of the rock disturbance is caused by vandals, hikers and reptile poachers (Goldingay and Newell 2000; Webb and Shine 2000; Webb et al. 2002; Newell and Goldingay 2005). Habitat restoration may ameliorate rock habitat degradation, but the cause of the decline must also be addressed. This requires the monitoring and management of visitors as well as public education to minimise their impacts (Eagles et al. 2002; Hadwen et al. 2007).

Visitor surveys can provide an important insight into understanding the behaviour of visitors. Moore and Polley (2007) note that the information visitors provide can greatly assist with the management of protected areas. Although visitor impacts consume a large proportion of resources for management and maintenance (Buckley 2003), few protected areas have current and accurate records on visitor loads (Hadwen et al. 2007). Therefore, periodic data collection is required to guide management, though this may be constrained due to inadequate funding and staffing levels (Buckley and Pannell 1990; Buckley 2003; Hadwen et al. 2007).

Several authors have noted the value of using visitor education programs as a conservation tool for protected areas (see Goldingay 1998; Papageorgiou 2001; Eagles et al. 2002; Marion and Reid 2007; Littlefair and Buckley 2008; Kerbiriou et al. 2009). Goldingay (1998) recommended that an education program be used in an attempt to reduce anthropogenic disturbance to the rock habitat of the broad-headed snake. Several methods can be employed to inform and educate Park users with a view to changing their behaviour to reduce impacts. Park information on ecology, geology, rules and regulations, and appropriate visitor behaviour may be provided to visitors via leaflets, maps, the internet, local radio, signs, visitor centres and face-to-face advice (Eagles et al. 2002). Studies indicate that interpretation can be an effective educational tool (Duncan and Martin 2002; Buckley and Littlefair 2007; Littlefair and Buckley 2008; Kim et al. 2011). Interpretation through nature trails, field guides, maps, guided walks or tours and interactive displays is seen as a way of providing a stimulated learning experience for visitors to gain an understanding and appreciation for the natural environment (Eagles et al. 2002).

Education/interpretation may not be sufficient in itself to reduce impacts. Regulatory strategies need to be enacted to control or restrict the actions or numbers of visitors (Papageorgiou 2001; Marion and Reid 2007). While law enforcement addresses illegal actions, effective communication of Park regulations and laws may prevent some of these actions from occurring in the first place (Roggenbuck 1992).

The broad-headed snake provides an excellent case study of a threatened species whose habitat is being degraded by users of protected areas and where education and visitor behavioural change may reduce this impact. However, educating the public and inducing behavioural change requires an initial understanding of the level of knowledge that visitors have of the broad-headed snake and its dependence on rock habitats. Thus, the aims of this study were to describe this knowledge for visitors to Royal NP and to evaluate the possible effectiveness of providing information designed to reduce habitat disturbance.

METHOD

Study area

This study was conducted in the Royal NP, which lies approximately 30 km south of Sydney, New South Wales. Broad-headed snakes have been recorded from the study area over a long period of time (Goldingay 1998; Newell and Goldingay 2005; Harris and Goldingay 2009). The Park is 15,068 ha in size, bounded by Port Hacking to the north, the South Pacific Ocean to the east, the Princes Highway, F6 Freeway and Illawarra Railway to the west and Garawarra State Recreation Area (900 ha) and the township of Helensburgh to the south (NPWS 2000). Visitation to Royal NP is high due to its close proximity to Sydney and accessibility by road to many areas within the Park. Due to the Park's location and visitation, it is highly susceptible to disturbance.

Questionnaire surveys

Questionnaire surveys were conducted in the Park in 2010. The Visitor Information Centre at Audley and the beginning of popular walking tracks were targeted to engage Park users. Visitors were approached and asked to complete the questionnaire in their own handwriting. It was made clear upon introduction that participation to complete the questionnaire was voluntary. No-one under the age of 18 was approached, so as to comply with the requirements of the Southern Cross University's Human Research Ethics Committee Guidelines.

The questionnaire was devised in consultation with the Parks and Wildlife Group (formerly National Parks and Wildlife) NSW, so as to be congruent with their conservation management needs. A short description of the snake, its habitat and conservation status were provided to each respondent, together with the aims of the project. The questionnaire comprised multiple-choice-answer questions (see Appendix A). The location and date of the survey were also recorded. The questionnaire was designed to not only provide an insight into patterns of knowledge but also inform Park users of the broad-headed snake, threats to the snake's habitat and Park rules that relate to the broad-headed snake. Questions related to activities undertaken by Park users, their frequency of visits, opinions on conservation measures, knowledge of and observation of the broad-headed snake and observation of disturbance events.

RESULTS

The questionnaires were completed by 181 Royal NP users across seven locations. This comprised 63% (n=114) at the Visitor Information Centre; 9% (n=17) at Karloo Track and 8% (n=15) at Garie Beach. Thirty-one people declined to participate. Males comprised 53% (n=95) of respondents and females 40% (n=72), while 14 did not note their gender. Some questions were not answered. Respondents were relatively evenly distributed across three age groups (20-30 years: 35%; 30-40 years: 27%; 40+ years: 37%) (n=63, 48, 67, respectively). One respondent represented the 18-20 year age-group while two did not indicate their age.

The 181 respondents reported a total of 1,748 visits per annum to Royal NP. Visits to the Park were reported as weekly (10% of respondents), monthly (33%), yearly (26%) or rarely (32%). There were 17 activities listed by respondents, with hiking (n=121; 71% of male and 64% of female respondents) and picnicking (n=84; 46% of both male and female respondents) the most frequent (Fig. 2).

Almost all of the respondents (98%; n=178) indicated they observed signs within Royal NP. While 87% (n=156) of respondents indicated that they stayed on formal walking tracks, 23 wandered off tracks. Male respondents were no more likely to wander off tracks than females (χ^2 =0.2, df=1, P=0.66) (Fig. 3). The frequencies in the answer categories to other questions were also independent of gender (P>0.05) so pooled values are given.

Only 25 respondents (14%), of which 17 were male, knew that the broad-headed snake existed within Royal NP. There was only one certain sighting of the broad-headed snake by a respondent. Eight respondents may have seen the snake, while another 11 were uncertain.

There were 6% of respondents who had observed rock disturbance within Royal NP (Fig. 4). Overall, 27% of respondents did not know it was illegal to interfere with rock habitat (Fig. 4).

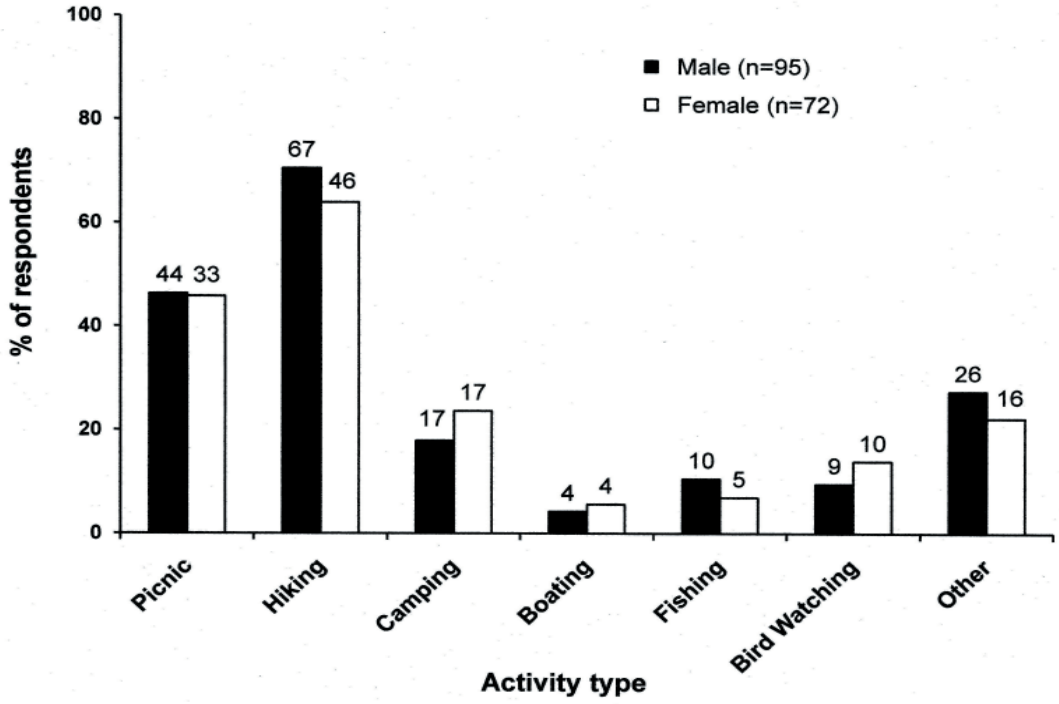

Figure 2. Activities conducted in Royal National Park by male and female respondents. The number of respondents is shown above bars. Those who did not indicate their gender (n=14) are omitted.

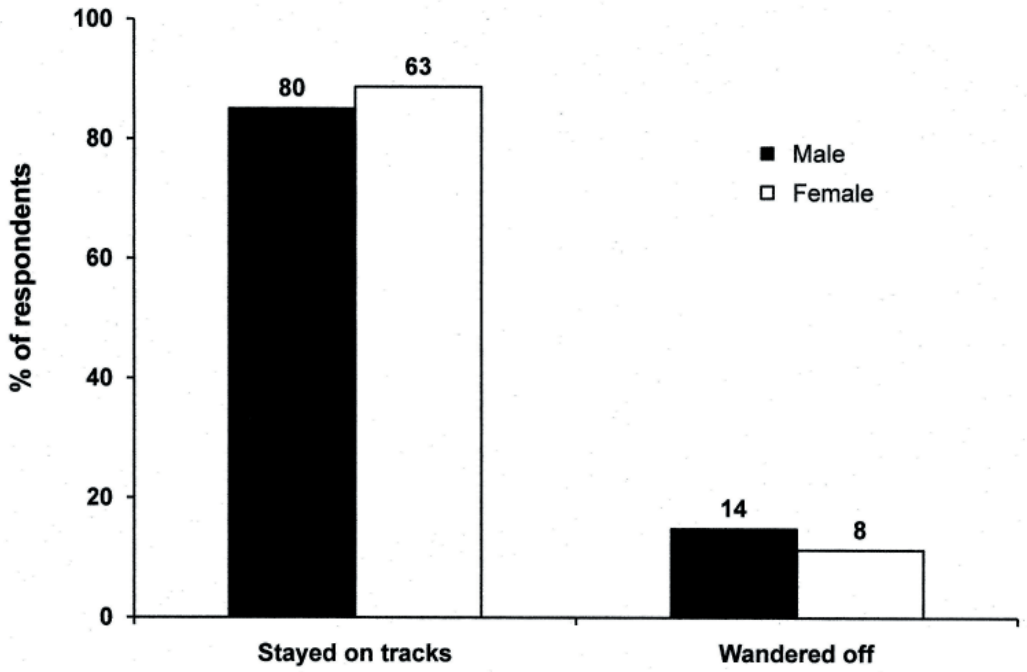

Figure 3. Percentage of male and female respondents that stayed on or wandered off walking tracks. The number of respondents is shown above bars. The gender was not given for a further 13 who stayed on tracks and one who wandered off tracks.

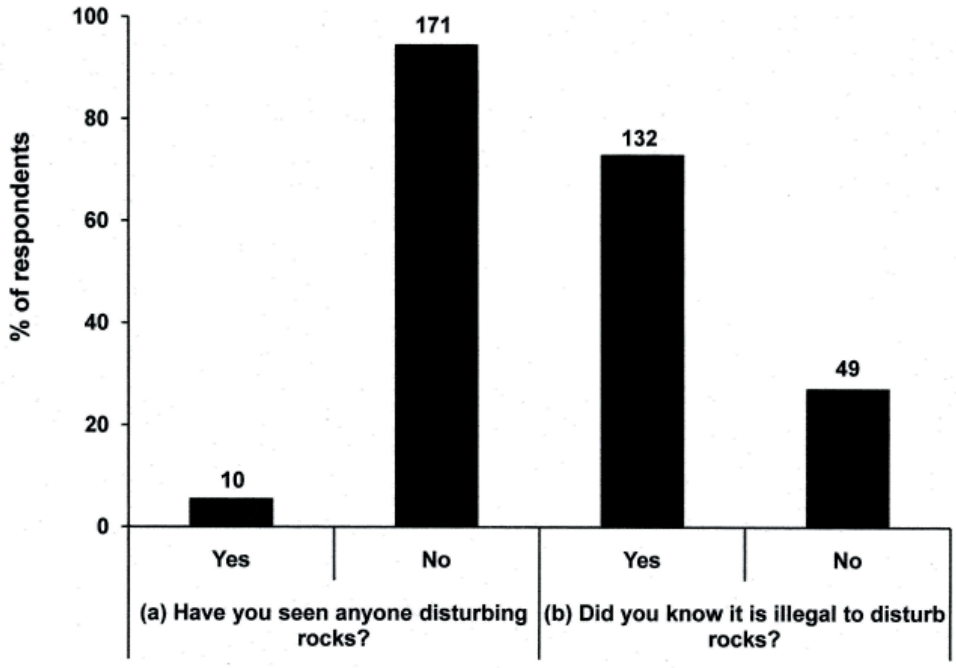

Figure 4. The percentage of respondents who stated (a) whether or not they had seen somebody disturbing loose rocks, and (b) whether they knew it was illegal to do so. The number of respondents is shown above bars.

After being informed about the dependence of the endangered broad-headed snake on sandstone habitat, 85% of respondents thought that people would be more likely to report acts of disturbance to rock habitat (Fig. 5). There were 53% of respondents who believed that rock disturbance would not continue if

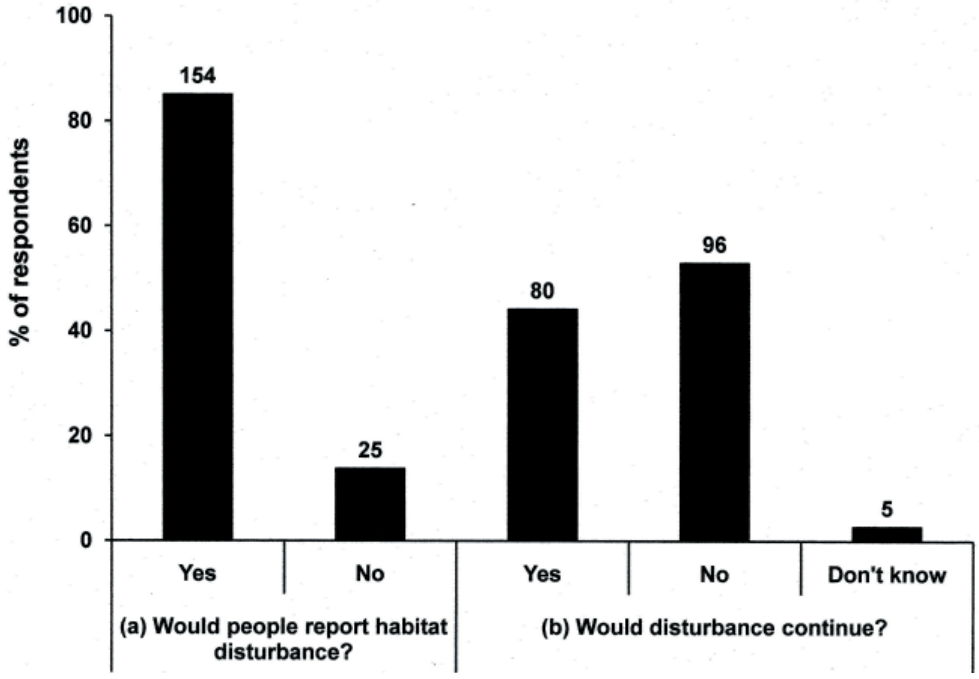

Figure 5. The percentage of respondents who stated (a) whether people would report observations of activities disturbing rock habitat, and (b) whether they thought disturbance would continue if people were better informed. The number of respondents is shown above bars.

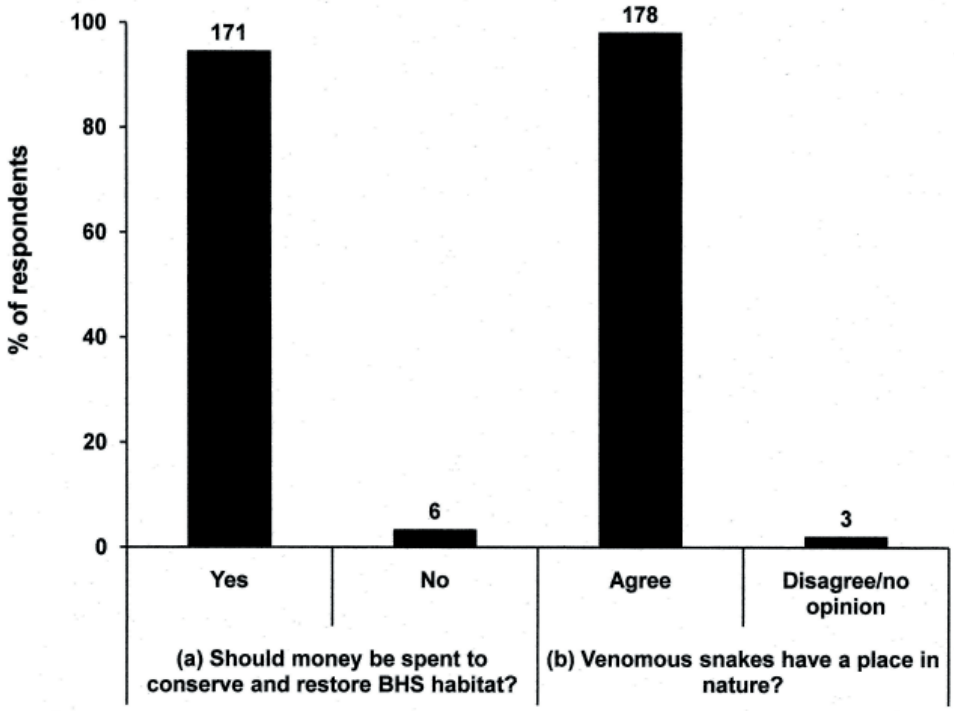

Figure 6. The percentage of respondents who stated whether or not (a) money should be spent to conserve and restore the habitat of the broad-headed snake, and (b) venomous snakes have a place in nature. The number of respondents is shown above bars.

people were better informed about its impact on the broad-headed snake (Fig 5).

A majority of respondents (95%) agreed that restoring and conserving broad-headed snake habitat should be funded (Fig. 6). A majority (98%) also indicated they 'strongly agree' or 'agree' with the statement, 'venomous snakes have a place in nature' (Fig. 6).

DISCUSSION

The endangered broad-headed snake is highly dependent on loose rocks for shelter (Fig. 7) and, as a consequence, it is vulnerable to degradation of its rock habitat (see Shine et al. 1998; Webb et al. 2002). The activities of Park users have been identified as one of the main causes of habitat degradation and this disturbance is ongoing (Goldingay 1998; Goldingay and Newell 2000; Newell and Goldingay 2005; Goldingay and Newell 2006). The present study sought to describe the level of knowledge that Park users had of the snake and its habitat, and from this identify some approaches that may reduce impacts to rock habitat.

Ignorance of the broad-headed snake and its habitat dependence may be partly responsible for the on-going incidence of disturbance to its rock habitat. Only 14% of visitors knew that this species occurred within Royal NP, while 27% did not know it was illegal to interfere with rock habitat. This suggests that there is considerable scope to educate visitors about the snake and its habitat. Indeed, 53% of respondents believed that rock disturbance would cease if people were informed about its impact on the broad-headed snake.

The walking track system attracts many visitors to Royal NP, with over 150 km of tracks (NPWS 2000; DECCW 2009). In 1988, 38% of visitors surveyed identified hiking as their main activity (NPWS 2000). In our study, hiking was the most frequent activity (67%) undertaken by respondents. Hikers are potentially one of the biggest threats to the rock habitat of the broad-headed snake because some hikers move or damage rocks and create rock cairns (Goldingay and Newell 2000; Newell and Goldingay 2005; Figs 8, 9). Many of the walking tracks in the Park extend along rocky ridges and other areas of rock habitat that are used by the snake, which brings hikers directly into contact with the snake's habitat (Fig. 10). This has been highlighted for many years (Goldingay 1998) but so far has not led to any rationalisation of the walking track network within the Park.

Figure 7. Typical loose rock habitat used by the broad-headed snake in Royal National Park (photo: Hayes 2010).

Figure 8. Rocks illegally broken by hikers in Royal National Park (photo: Hayes 2009).

Figure 9. Rock cairn created illegally by hikers in Royal National Park (photo: Hayes 2009).

Figure 10. Aerial view of Mt Bass walking track in Royal National Park. Note that the light shaded areas indicate rock habitat (photo: Google Earth 2009).

Thirteen percent of respondents reported that they wandered off tracks. Buckley and Littlefair (2007) warn that results based on self-reported behaviour should be treated with caution as this may deviate from actual behaviour. Thus, this value should be treated as a conservative percentage of people who wandered off tracks. Such behaviour is of concern because it may lead to inadvertent disturbance to rock habitat, in addition to direct interference. There is likely to be a benefit in educating Park users about potential impacts to habitat. There is no mention of staying on tracks in the Royal NP brochure/map (DECCW 2009), though the NSW Department of Environment, Climate Change and Water (now NSW Office of Environment & Heritage) website does include this, with information on hiking behaviour under 'Visiting a Park – be a considerate park visitor' (DECCW 2008). Information could be more conspicuous within the Park, to advise that treading on or disturbing loose rocks may degrade important habitat for many species.

Signs and information boards may help to reduce disturbance by informing visitors of the sensitivity of the broad-headed snake to rock disturbance and to stay on walking tracks. This may be effective because 98% of respondents claimed they read and observed signs. Jacobi (2003) found that signs significantly decreased the addition of rocks to cairns, which are used to mark trails, though it was acknowledged that signs alone were insufficient in resolving the problem of disturbing rock habitat. Kim et al. (2011) also found that environmental interpretation can be effective in influencing visitor behaviour. It is recommended that changes be made to the signage and literature within Royal NP, with an emphasis on improving visitors' awareness in an attempt to reduce impacts on habitat, particularly rock habitat. The location of signs is critical and it is suggested that key areas, such as the beginning of walking tracks and other high use areas (e.g. lookouts) that overlap potential snake habitat be targeted.

A review by Marion and Read (2007) found that most efforts to educate visitors did improve knowledge, behaviour and resource conditions. Royal NP actively encourages education/interpretation through various programs and literature (NPWS 2000). Clearly, more can be done to raise the awareness of the broad-headed snake and its habitat, and to manage visitors' activities. Currently, the only broad-headed snake signage present in the Park is an enforcement sign, located on the western edge of the Park at Heathcote Oval, to restrict entry into that area. An information sign on protecting rock habitat and the broad-headed snake had been erected near the kiosk at Audley, but has since been removed due to renovations. It is anticipated that a computer-based interpretive display in the Visitor Information Centre will replace this in the near future (M. Treanor, Parks and Wildlife Group, pers. comm.). Kerbiriou et al. (2009) found that disturbance from humans can have severe impacts on wildlife and possibly disrupt population viability. They recommended an education program to increase awareness of the negative consequences of human disturbance.

Goldingay (1998) suggested that a program of public education "could be used to encourage reporting of people who may interfere with the snake's habitat". In the present study, 85% of respondents thought people would report acts of disturbance to rock habitat once they knew of the dependence on this habitat by the broad-headed snake. This could be effective because 6% of respondents reported they had observed people interfering with rock habitat. It may also help to reduce the incidence of reptile poaching, which is prevalent in the Park and significantly disturbs rock habitat (Newell and Goldingay 2005).

The overwhelming support for the funding of projects to restore broad-headed snake habitat and the agreement that 'venomous snakes have a place in nature' (95% and 98% of respondents, respectively), reflect the current interest in environmental issues and conservation. However, the results may not reflect the same level of support across the broader community. The results may be biased in that all respondents were Park users, and therefore, may be more sympathetic towards conservation. Knight (2008) claims that "those who engage in outdoor naturalistic or recreational activities will have higher levels of support for protecting species than those who do not". Nevertheless, Park management needs to be aware of the strong support shown by Park users in this study for the conservation of the broad-headed snake.

Monitoring visitors and their activities is an important component of management because this information can be used to assess the state of natural resources, identify potential threats and indicate whether management actions have been successful (Buckley 2002; Buckley et al. 2008). In Australia, there is a paucity of detailed monitoring data within National Parks, particularly on visitor activities, which is probably due to a lack of resources (see Hadwen et al. 2007; Buckley et al. 2008). The effectiveness of an education program to induce behavioural change of Park visitors could be evaluated in this case by periodic monitoring of specially constructed rock outcrops (see Goldingay and Newell 2000). Additional questionnaire surveys could be conducted

to assess specific elements of the education program, such as determining whether interpretive signs lead to more visitors knowing that the broad-headed snake occurs within Royal NP. Buckley et al. (2008) highlighted the need for increased monitoring data on both visitors and endangered species populations within Australian NPs. This applies to Royal NP due to its very high number of visitors and the potential impact they can have on native species and habitat.

CONCLUSION

Protected areas are one of the primary mechanisms for conserving threatened species. Increasing use by Park visitors will increase the threat to population viability of these species (e.g. Kerbiriou et al. 2009). This will require novel approaches to how species and people within Parks are managed. The broad-headed snake within Royal NP offers something of a model system because the impacts of visitors can be readily quantified, allowing measurement of the effectiveness of programs to induce behavioural change amongst visitors. Developments within this system could be used to inform other cases where the activities of visitors disrupt the life cycle of threatened or other significant species. Adequate funding will be essential for such a project involving the broad-headed snake in Royal NP.

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APPENDIX A - Questionnaire

Please circle which category you belong to:

Male Female

Age: <20 yrs 20-30 yrs 30-40 yrs >40 yrs

1. Please tick the boxes that best represent the activities you undertake most often in Royal National Park?
☐ Picnicking
☐ Hiking
☐ Camping
☐ Boating
☐ Fishing
☐ Bird watching
☐ Other (please specify)
……..

2. How often do you visit this park?
☐ Weekly
☐ Monthly
☐ Yearly
☐ Rarely

3. How often do you visit other National Parks?
☐ Weekly
☐ Monthly
☐ Yearly
☐ Rarely

4. Do you read and observe information signs that are provided in Royal National Park?
☐ Yes
☐ No

5. If you go on a hike would you ...
☐ Stay on formal walking tracks
☐ Wander off the track to go exploring

6. Were you aware that a species of endangered snake known as the broad-headed snake exists within Royal National Park?
☐ Yes
☐ No

7. Have you ever seen a broad-headed snake in Royal National Park?
☐ No
☐ Maybe
☐ Uncertain

8. Have you ever observed anybody tampering with or removing sandstone bush-rock from Royal National Park?
☐ Yes
☐ No

9. Did you know it's illegal to interfere with rock habitats within a National Park?
☐ Yes
☐ No

10. After being informed about the dependence of the endangered broad-headed snake on sandstone habitat, do you think people would be more likely to report activities that disturb this habitat to the Parks and Wildlife Service?
☐ Yes
☐ No

11. People may inadvertently disturb rock habitats. Do you think this would continue if people were better informed about its impact on an endangered species?
☐ Yes
☐ No

12. Should money be spent to restore and conserve the habitat of the broad-headed snake?
☐ Yes
☐ No

13. Please indicate how you feel about the following statement:
Venomous snakes have a place in nature.

Strongly agree Agree No opinion

Disagree Strongly disagree