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1.0 Introduction

Since the discovery of Antarctica and the Sub-Antarctic regions, man has been fascinated with the nature and biology of the family Spheniscidae (Chester, 1996). It is this fascination that has led us to study the behaviours, reproduction and physical activities of the penguin. Although all of the 17 species of penguins are found in the southern hemisphere, only a handful of them actually occur on the continent of Antarctica itself (Sitwell & Ritchie, 2002). The four species that actually breed on the continent being the Adelie, Gentoo, Chinstrap, and Emperor penguins (Mcgonigal & Woodworth, 2002). Because of its relatively higher temperature than the rest of the Antarctic continent (Pyne, 2003), the Peninsula offers an exquisite breeding ground for these birds (McGonigal & Woodworth, 2002). However, the higher temperature also means that access to the peninsula is reasonably uncomplicated. This creates a situation ideal for tourists to view wildlife in it's natural habitat, and for scientific work to be carried out on the species.

This ideal environment for tourism and science however, creates a situation where certain stresses can be placed on the animals that take to the Peninsula for breeding and foraging (Micol & Jouventin, 2001). More disturbingly, recent studies (Enzenbacher, 1992) have shown that scientific and recreational activities are increasing. The effects of these increases in activity have been well documented in regard to the impact that human disturbance has towards animals, but there has been little research to highlight the potential habituation of individual penguins to human activity.

Nisbet (2000) defines human disturbance as “..any human activity that changes the contemporaneous behaviour or physiology of one or more individuals within a breeding colony of waterbirds.” Human activity then, can be classified into several categories according to what the activity involves, and the humans that undertaking the activity. Some of the potential disturbances to penguin colonies in the Antarctic can be placed in the following categories (after Nisbet, 2000);

1. Research procedures – activities of investigators applied to individuals of the species under study.

2. Visitor Intrusions – activities of humans other than researchers who may disturb animals deliberately to photograph individuals, or casual intrusions and disturbances by humans pursuing recreational activities etc.
3. Visitor approaches – activities of humans as they approach animals – i.e., they may not cause disturbance in the sense of movements away from the intruder, but they may cause alarm and vigilance distracting the animal away from its normal activity.
4. Positive Management – activities of managers to benefit natural populations of animals. These include erecting fences, eliminating predators, patrolling the protected area etc.
5. Negative management – Activities of managers specifically designed to reduce numbers and control activity of natural populations of animals. This could include killing animals, modifying habitat etc.
6. Persecution, harassment, and vandalism – Human activity intended to disturb and harm natural populations by indiscriminate hunting and killing, destruction of nests/dens, pursuing animals in vehicles or with dogs etc.

These categories make it easier to specify the disturbance, and perhaps give some indication as to the effect that the disturbance is having on the actual animal, with different activities having varied responses from individual birds and nesting colonies (Walker *et al.*, 2005). Human disturbance of penguins can lead to a number of situations, all of which can have negative influences on the bird, it's young, and the survival of the colony. Nisbet (2000) outlines effects that are a result of direct human activity, including physiological effects, moving away from a nest or territory, abandonment of individual nests or whole colonies, reduced breeding effort, and adult or chick mortality (Culik *et al.*, 1990; Holmes *et al.*, 2005; Giese, 1998). These responses may however, be lessened or increased depending on the situation, for example stage of breeding, and previous experiences of disturbance (Holmes *et al.*, 2005).

According to Holmes *et al.* (2005), the response of penguins subject to high levels of human activity on a regular basis may not necessarily be similar to those subject to low levels infrequently. The former perhaps owing to certain levels of habituation due to previous experience. Habituation is defined as ‘the diminishing of a physiological or emotional response to a frequently repeated stimulus’ (Nisbet, 2003).

In this report, I wish to outline the effects of and ways in which human disturbance is monitored throughout penguin colonies, and how disturbance can lead to habituation. I aim to also suggest possible means by which we can monitor the effects that habituation has on individual penguins and colonies.

2.0 Tourism in Antarctica

Penguin colonies are popular wildlife tourist destinations (IAATO, 2005; Stonehouse, 1992; Boersma, & Stokes, 1995), and human presence in Antarctica is more likely to expand than it is to contract (Giese, 1996). This places great importance on the establishment of strict universal guidelines to minimise disturbance of colonies and individual birds (Giese, 1996). Current visitor guidelines of Antarctica New Zealand (2005) insist a minimum approach distance of 10 metres, and encourages visitors to increase this distance if the bird appears disturbed or is on a nest. However, most visitors, irrespective of their purpose of being on the continent, seek close interactions with penguins, and a five metre minimum approach distance guideline (IAATO, 2003) is recommended by some organizations as providing a suitable buffer between breeding penguins and people. Ultimately it depends on the organization that is operating the tourist visit, and the co-operation of the tourists themselves, as to which of these distances are applied.

In previous years, it was thought that populations of penguins in the Antarctic and Sub-Antarctic islands were quite robust to visitation, however more recent studies have challenged this assumption (Culik & Wilson, 1991). There have now been several studies that have indicated that even though penguins may not be showing outward signs

of distress, they often experience significant heart rate and stress related hormone elevation, demonstrated behavioural and physiological effects (Holmes *et al.*, 2005; Culik *et al.*, 1990; Giese, 1998).

Fowler (1999) suggests that though tourist visitation is perhaps less invasive than research (e.g. tourists rarely capture and handle birds) it is generally more prolonged and involves many more people. When we consider tourist visitation in the Peninsula, which involves thousands of people each season (Cobley, & Shears, 1999), visiting the same few landing areas (Port Lockroy, Deception Island and Torgersen Island) (Mortimer, 2004), creates problems in regard to the amount of time that penguin colonies are exposed to the effects of disturbance. According to studies by Cobley & Shears (1999), tourism to Port Lockroy in the year 1999 increased from one ship per week, to one ship per day. Remembering the increased growth in Antarctic tourism since 1999, approximately 28000 people visited Antarctica as tourists in the year 2004, of which, 90% visited the Peninsula (Mortimer, 2004).

The recent introduction of ‘Ecotourism’ (an ecologically friendly and viable system for the conservation of resources) to wilderness destinations worldwide has sparked an increasing interest in how tourism affects these areas and the animals found within them (Walker *et al.* 2005). Studies examining other specific animals affected by ecotourism have noted that some species have been able to adapt to visitation (e.g. Galapagos marine iguanas (Romero & Wiklinski, 2001)), whereas others such as African rhinoceros (Lott & McCoy, 1995) and woodland caribou have displayed negative consequences of tourism (Duchense *et al.*, 2000). These studies indicate a real need to continually monitor the effect that high and frequent levels of tourist visitation has on penguins and colonies in Antarctica and the Sub-Antarctic Islands.

3.0 Science in Antarctica

Antarctica is a continent devoted to peace and science (Antarctic Treaty, 2005). And a large part of the science that is carried out in Antarctica is based on biological research and monitoring. Penguins have in no way been spared of the prying and invasive actions of the inquisitive human hand. In the past 15 years, the focus of science carried out among penguin populations has turned from physiological features and numbers, to responses to human impacts, and the importance of monitoring to reflect changes in populations due to climate and other environmental changes.

At the turn of the twenty first century, there were over 40 permanent stations in the Antarctic region (McGonigal & Woodworth, 2002). The land occupied by some of these stations has had a dramatic influence on some penguin colonies, especially in the Antarctic Peninsula, and along ice-free beaches. It is here along the beaches that several species of penguin nest, and ice-free space occupied by bases and equipment is likely to previously have been utilized by breeding penguins. A classic example of a negative effect situation is the French base Dumont d'Urville, where in constructing the airstrip, explosives were used on small islands that were inhabited by breeding petrels and penguins (Monteith, 1996). The effect of this type of disturbance is extremely negative, and events such as this are not often seen. However, there are also common scientific practices that are undoubtedly cause for some concern.

The practices of flipper banding, and G.P.S. tracking of penguins are seen to be quite stressful practices for penguins, and the even more common practice of nest checking (Giese, 1996), presents significant changes in behavioural and hormonal responses. Although nest checking probably produces that most accurate record of breeding success, in small colonies it has been found that this practice can significantly interfere with reproduction (Giese, 1996). A study by Martin *et al.*, (2004) also believed that the mere approaching of a human figure led to elevated heart rate, and hormonal changes regardless of whether it fled or not. This response imitates that which is displayed on the approach of a predator, such as a skua, indicating that the bird associate humans as predatory animals (Martin *et al.*, 2004). Studies have also shown that the height of

reaction is often associated with the speed of approach towards the individual bird (Yorio & Boersma, 1992).

4.0 Indicators and Effects of Disturbance

For many years, disturbance was only thought to be of impact if the animal moved away or fled from the source of disturbance. Disturbance is now regarded as something which changes the contemporaneous behaviour or physiology of one or more individuals (Nisbet, 2000). The early views that penguins were not affected by human interaction merely because they displayed no external signs of stress have been replaced with knowledge that internal responses are of great concern to the welfare of the animal.

Behavioural signs that indicate stress due to disturbance can include wing shivering, flipper raising, standing and exposure of eggs/chicks when nesting, and bill shaking. It is thought that wing shivering, bill shaking and flipper raising are a result of high levels of stress hormones including Glucocorticosteroids. These and other hypothalamic-pituitary-adrenal hormones allow birds to respond to stress by changing their behaviour and physiology to allow the animal to escape or endure the disturbance, otherwise known as the fight or flight response (Walker *et al.*, 2005). High levels of these hormones can also have seriously detrimental effects on the bird, leading to muscle wasting and in severe cases even death (Walker *et al.* 2005). The use of field endocrinology has allowed scientists to measure the levels of such hormones, as indicators of stresses placed on individual animals with fairly accurate results. However, some methods such as the collection of blood are intrusive, and may in fact induce a higher stress rate within the animal. There are some other methods that may be utilized when measuring endocrine levels, with studies increasingly using scat analysis to determine hormonal profiles (Walker *et al.*, 2005). Hormonal liters in scats however, represent an accumulated stress profile over an unspecified time period, and many hormones are metabolised extensively prior to excretion making analysis inaccurate.

One of the more recent developments in monitoring the effect of disturbance is measuring the heart rate of animals using artificial eggs, which monitor heart rate when placed under nesting penguins (Holmes *et al.*, 2005). In previous studies (Holmes *et al.*, 2005), it has been shown that the use of artificial eggs does not alter the behaviour of penguins, leading to the assumption that this method is accurate in recording data. This method of collecting data, although not as specific as hormonal indicators, is easy to perform and has virtually no negative effect on the animal. Other indicators of stress or disturbance include reduced breeding effort, which is determined by recording egg counts and fledging percentage (Fowler, 1999). This method has long been used to record changes to penguin colonies over long periods of time, not just to measure human disturbance, but also environmental influences such as climate change and natural disaster (Micol & Jouventin, 2001).

5.0 Habituation

According to Walker *et al.* (2005) disturbances caused by humans may force permanent changes in life history characteristics of organisms so they can survive such perturbations. Repeated exposure to human disturbance in small amounts, be it scientific prodding or tourist visitation, can lead to the habituation of some birds. Habituation is not to be confused with tolerance, defined by Nisbet (2003) as the intensity of disturbance that an individual tolerates without responding in a specified way (e.g. when a bird simply does not react to a human more than 30 metres away). Habituation occurs, when an individual learns not to respond to stimulus when no reinforcement follows (e.g. a bird has had repeated contact with humans approaching and observing from close distances, and does not respond in any manner to these activities) (Walker *et al.*, 2005). The use of field endocrinology has led us to be more confident in saying this behaviour does not happen in the situation where birds are habituated. Laboratory studies have also shown that the adrenocortical response to stress can be gradually reduced (i.e. habituated) as animals grow accustomed to low intensity stressors (Marti & Armario, 1998).

Studies in Antarctica have shown that penguins in areas visited by tourists have become habituated to having tourists around their nests at certain sites (Yorio & Boersma, 1992; Fowler 1999). These penguins were shown to exhibit reduced defensive behavioural responses and lower stress hormones in response to capture and restraint, as well as appearing calm and accepting of humans, often walking undisturbed amongst them (Walker *et al.*, 2005). However, for habitation to occur, there needs to be exposure to a consistent and frequent stimulus (Mazur, 1998), and this is only likely to occur at highly frequented colonies.

6.0 Conclusions

There has been a large amount of research into the effects that tourism and human disturbance has on penguin colonies of all species (Holmes *et al.*, 2005; Fowler, 1999; Walker *et al.*, 2005; Giese, 1996). And it is obvious that human activity in Antarctica and the Sub-Antarctic Islands has quite a significant effect on the stress levels, and reproductive success of these animals. Thanks to studies such as those carried out by Fowler (1999), Holmes *et al.* (2005), Walker *et al.* (2005) and Yorio & Boersma (1999), we can now accurately indicate whether or not certain activities are having a negative effect on different populations, and take measures to avoid all possible disturbance.

With the predicted increase of human visitation and scientific work in the Antarctic (Boersma & Stokes, 1995), it is essential that regardless of what activities are proposed to be carried out among penguin colonies, maximum precautions are taken to minimise disturbance. The use of buffer zones and wildlife approach distances are a positive influence when tourists are involved, and the limited number of colonies that are visited also has a certain degree of benefit. By only exposing certain colonies to the stresses of constant visitation, it can be expected that the birds exposed will in turn display certain degrees of habituation to this activity over time (Walker *et al.* 2005). The result of this habituation will ultimately provide a more engaging visit for the tourists, and a less stressful and potentially harmful experience for the penguins involved.

However, this scenario will only happen if tour operators work together to frequent the same colonies, which may not always be possible when considering the numbers of people and the environmental damage that could accumulate with such numbers.

The effect that science is having on penguin colonies is something that is likely to continue, although there are methods of collecting data that could be adopted to eliminate some undue stress. Field endocrinology for example is one area of scientific observation that has the potential to expand, and together with new technologies could create significant differences in effects of scientific study.

In order to accurately monitor the process and effects of habituation to human activity that penguins display, there needs to be more research into the ways in which we are able to collect and analyse data. Currently, the most accurate method of determining if animals are habituated to certain activities is endocrinology, which as previously mentioned is quite invasive. The monitoring of heart rate is also quite successful, but is limited in the period of time that this technology can be used throughout the year. There also needs to be constant monitoring of the breeding colonies that are exposed to high levels of tourism, as not only are the penguins subject to human disturbance, but the land and vegetation is also.

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