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Critical Literature Review

(ANTA602)

Critical review on anthropogenic environmental changes and the effects that this may have had on Emperor penguin populations in Antarctica.

Wilma Faye Richards

Student ID: 91526932

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Abstract:

This literature review takes into consideration of different aspects of reporting, which include the use of; books, journals, online articles and published scientific articles, to get the overall feeling on people's attitudes on environmental change and its effect on Emperor penguin populations in Antarctica. Emperor penguins (*Aptenodytes forsteri)* are the largest of all penguins and it is thought that these ice-obligate species are particularly susceptible to environmental changes in the southern ocean conditions. The Emperor penguins due to specialised adaptations is able to survive the extreme weather conditions of Antarctica, and there are concerns that with a rise in atmospheric temperatures the sea-ice is melting and will cause extinction to many colonies reducing their total population. There has been a report of an Emperor penguin colony utilising floating ice shelves during years when sea-ice formed much later than usual. This new habit would appear to be the answer, excepting the rising atmospheric temperature combined with rising sea water temperatures has already claimed part of the Larsen Ice Shelf. Another oppressing factor is their food source mainly in the form of krill becoming subject to be seriously affected by rise in temperature, which is causing limitations of the available surface area of the underside of the sea-ice for algae. Commercial fisheries are now targeting the Emperor penguins food source the krill and squid, putting extra pressures on their survival.

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Introduction

Emperor penguins (*Aptenodytes forsteri)* are the largest of all penguins which have adapted to the extreme climatic condition of Antarctica making them an ice-obligate species and are particularly susceptible to environmental changes in the southern ocean conditions (Bajagai, 2013). These penguins can live up to 40 years, are the largest of all penguins with a body weight ranging between 22–40 kilograms and body length of 100–130 centimetres. They have a low annual reproductive output where each breeding pair produces only one chick per year and only the male incubates the single egg. It is this size of the penguin that increases its susceptibility to climate change with its morphology preventing them to forage up to greater depths and range (Bajagai, 2013).

1. Background

1.1 Distribution of Emperor Penguins in Antarctica

The Emperor penguin is the most ice-adapted of the penguin species, breeding generally on stable fast-ice within the Antarctic continent and adjacent islands with the large colonies in; Ross Sea region, Weddell Sea and East Antarctica (Figure 1) (De Roy, Jones & Cornethwaite, 2013). Emperor penguins although spending most of their lives at sea inhabit the sea ice at latitudes between 66^{o}S and 78^{o}S where a flat solid surface is essential for their breeding colonies and their long-term survival (De Roy, Jones & Cornethwaite, 2013; Scott & Scott, 2007).

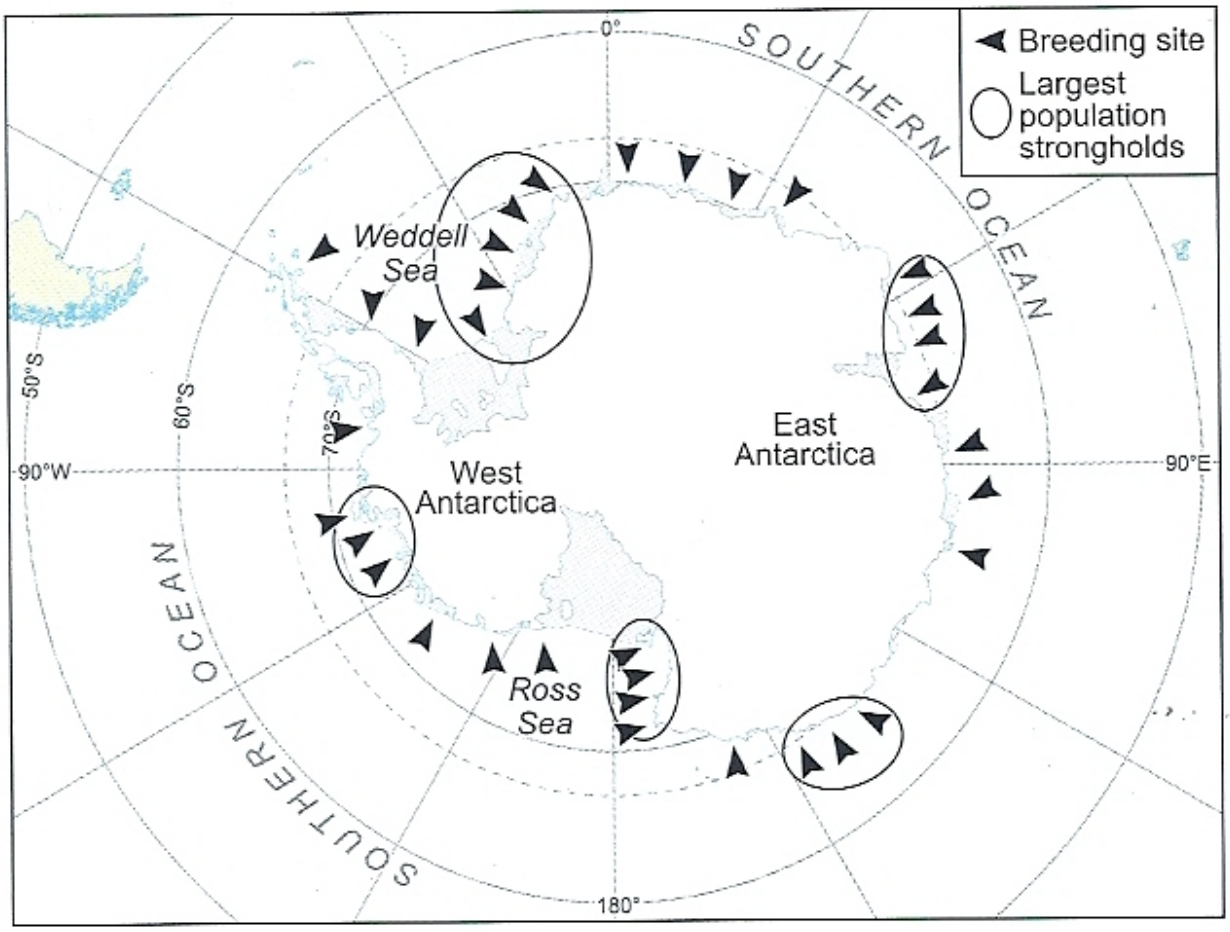

Figure 1: Emperor penguin colonies around the Antarctic continent (De Roy, T, Jones, M & Cornethwaite, J, 2013)

1.2 Adaptations of Emperor Penguins to Live in Antarctica

The Emperor penguin is able to survive the extreme weather conditions of Antarctica with their excellent insulation in the form of several layers of scale-like feathers that can cope very strong winds in some cases over 60 knots. Their bill and flippers, helps to conserve heat by having a very small surface open to the harsh environment. Another heat conservation adaptation is achieved by recovering much of the heat that is normally lost during exhalation through their nasal chambers (Australian Government, Department of the Environment, 2014). Emperor penguins have large reserves of energy-giving body fat combined with low level of activity during winter. They are also very social creatures, and one of their survival mechanisms is an urge to huddle together to keep warm (Australian Government, Department of the Environment, 2014). The Emperor penguin is the only species of penguin that is not territorial and allows the

extraordinary circulation pattern of a huddle ensuring that all the male Emperor penguins get some time in the warmth of the centre, enabling them to survive temperature drops often to minus 60^{o}C and winds up to 180 kilometres per hour (McGonigal & Woodworth, 2001).

1.3 Breeding cycle of Emperor Penguins

Due to the size of the Emperor penguin and their physiological constraints regarding incubation and chick rearing and not being able to fit breeding within the span of the summer months, they have resorted to their entire breeding cycle being advanced into winter (Hatherton, 1990). This has led to their breeding being at risk of the Antarctic winter conditions. Having breeding during the worst weather conditions on earth, where it can be so severe that ice forms too solidly over the open water, the penguins cannot feed and breeding is abandoned due to the fast-ice extending a long way which entails the Emperor penguins having a longer distance to travel across the ice, sometimes reaching 120 kilometres in distance before they reach the pack-ice where they can forage (Hatherton, 1990; Australian Government, Department of the Environment, 2014). Or conversely sea-ice melts within their colony, breaking up and resulting in the eggs, chicks and young adults being lost (Hatherton, 1990).

Ideal geological features for breeding colonies is that the sea-ice is level and is surrounded by any of the following; grounded icebergs, islands, capes or glacier tongues, these help to stabilise the sea-ice and provide shelter tor the penguins from adverse weather conditions (De Roy, Jones & Cornethwaite, 2013).

1.4 Timeline of Meteorology in Antarctica

With the Antarctic Treaty coming into force in 1961 its directive of science and peace being its driving force, many participating nations validated their presence in Antarctica by taking meteorological measurements as a means to be observed as ‘doing science’ (Hooper, 2007). In 1988 David Limbert, head of meteorology at British Antarctic Survey had noticed ‘some interesting variability’ through collating air temperature figures from various Antarctic stations looking at a climate change scenario and passed this information onto John King his successor (Hooper, 2007). This was in part due to computers becoming smaller, accessible, affordable and increasingly powerful allowing researchers to process large quantities of figures and this data

was later scrutinize by King (2007: 74) to be “patchy, of questionable quality”, leading to the exclusion of data creating gaps of observations, some of this due to inexperience when collecting measurements, lack of motivation or commitments and with some countries not passing over their records citing for military use (Hooper, 2007).

Trevor Hatherton editor of “Antarctica the Ross Sea region” (1990: 274) commented on the potential of a fourth phase in Antarctic history. After the initial exploration phase ‘The Heroic Age’, came the second phase of international science and construction of bases in the 1950s. This was followed by what he deemed as the third phase of permanent bases with the expansion of scientific activities period leading to the fourth phase ‘Antarctic science in the satellite age’ (Hatherton, 1990). This has certainly come of age with the analysis of satellite observations by British Antarctic Survey of four Antarctic Emperor penguin colonies when the sea-ice Analysis of satellite observations revealed that penguin colonies moved from their traditional breeding grounds of sea-ice during the years 2011 and 2012 when this formed later than usual to the much thicker floating ice shelves that surround the continent (British Antarctic Survey, 2014). This neighbouring floating ice shelf, consists of frozen freshwater as opposed to sea-ice containing saltwater and presents an additional challenge in that it requires the climbing up the sides of a floating ice shelf for the penguin, which at this site can be up to 30 metres high (Figure 2).

Figure 2: Emperor penguin colony taken from satellite on floating ice shelf, Photo: Ian Potten (British Antarctic Survey, 2014)

1.5 Climate Change and Melting Ice

With the increase in human populations worldwide post industrial revolution and their subsequent dependency on demanding energy in the form of wood, coal, oil and natural gas has seen a significant rise in carbon dioxide levels of 30 per cent higher than they were 200 years ago, although this greenhouse gas occurs naturally and without it, earth would be too cold for human habitation (McGonigal, 2008). This combined with methane another greenhouse gas which has 140 per cent higher levels compared to 200 years ago and the addition of chlorofluorocarbons, have all added to the extra greenhouse effect, warming the lower atmosphere and changing the Earth's climate (McGonigal, 2008). Evidence in average surface temperatures of the Earth over the past 100 years has shown a rise between $0.3^{o}C$ – $0.6^{o}C$, with a predicted rise to be between $1.4^{o}C$ – $5.8^{o}C$ by the end of this century, making the anticipated warming greater than any recent natural fluctuations (McGonigal, 2008).

Another consequence of the greenhouse effect is that of recent losses from ice sheets in both the Antarctic and Greenland, seeing a mean global rise in sea levels, Figure 3 shows the collapse of the northern most segment of the Larsen Ice Shelf which took only 35 days to disintegrate and disperse into the Weddell Sea (McGonigal, 2008). This occurred after the other separate embayed segments of the Larsen Ice Shelf A and C had already undergone retreat and disintegration, and the theory is these unexpectedly rapid collapses is due to the strong climate warming observed in the region since the late 1940s (McGonigal, 2008)

Figure 3: Collapse of Larsen B in January 2002 (McGonigal, 2008)

1.6 Climate Change and its Impacts on Habitat

Yadav Bajagai (2013), suggested that some scientists argue that melting of sea ice due to global warming is in fact beneficial for Emperor penguins as it reduces the distance to be travelled by them in search of food but with this melting of fast-ice, other scientists have pointed out that the disadvantages to their mortality such as flooding of colonies with sea water sweeping the chicks and young moulting adults into the sea. This mortality is due to the chicks and young adult feathers lacking the waterproofing required for life at sea (Richardson, 2009). Australian Government, Department of the Environment (2014) also stating; Emperor penguins depend on this fast-ice for their long-term survival and without this breeding platform they have nowhere to go, but it is also highlighting the importance that this platform is available for the duration of the chick rearing period and further adding the question regarding, if global warming alters the patterns of ice break-out or stability, it may be that the sea-ice disappears before the chicks are ready to go to sea. This opinion is also shared with Shaye Wolf (2009), noting that the Antarctic continent is warming as a whole, with the Antarctic Peninsula warming faster causing the sea-ice to shrink in size, and the sea-ice season becoming shorter causing harm to the Emperor penguin chicks and adults.

As stated in Veronika Meduna's book; "Science on the Ice: Discovering the Secrets of Antarctica" (2012:119), that; the Emperor penguins will be affected by future climate change through loss of critical habitats for both its breeding and feeding areas with the thawing of the ice in Antarctica; where it is expected to lose up to half of their breeding colonies.

It is known that the sea-ice surrounding Antarctica undergoes regular seasonal melting subject to changes that vary from season to season and even from year to year, dependent on factors such as the number and intensity of storms and blizzards and the time at which the sea-ice forms in autumn or breaks out in summer (Australian Government, Department of the Environment, 2014). It is now the rapid temperature increases which have been witnessed along the Antarctic Peninsula seeing this melting occurring much sooner than that has been experienced previously causing many colonies of Emperor penguins that breed in this area, suffering from greater declines in population, which is increasing the Emperor penguin's risk of extinction in the near future (Richardson, 2009).

It is also the average temperature of ocean surface being the next most important factor determining survivability of penguins following the integrity of sea ice (Bajagai, 2013).

1.7 Impacts on Distribution and Geographical Range of Emperor Penguins

Bajagai (2013) states that: "Alteration in integrity and extension of sea ice due to global warming has resulted in pole ward contraction of range of Emperor penguins". In the study of demographic and climate models for the Terre Adelie Emperor penguin colonies by Jenouvrier et al, found that seasonal sea-ice concentration anomalies affecting both the adult survival and breeding success. Their prediction from this modeling sees a decline in the Adelie Emperor penguin population of 81 per cent by the year 2100 with a further 43 per cent chance of an even greater decline of 90 per cent or more, concluding that climate change is a significant risk to its population (Jenouvrier et al 2012). Declines in Emperor penguin current populations, is seeing them at risk of extinction in the near future (Richardson, 2009). This sentiment has been echoed by the Australian Antarctic Division (2014) who is concerned with the future survival of Emperor penguins at risk along with many others due to publicity in news papers, radio and television and the IUCN having declared that the Conservation status of the Emperor penguin as: near threatened.

In 1948, a small colony of emperor penguins of approximately 150 breeding pairs was discovered breeding on Emperor Island (67° 51' 52" S, 68° 42' 20" W), in the Dion Islands, close to the West Antarctic Peninsula reported by Stonehouse in 1952, with their numbers being maintained until 1970 then showing a continuous decline to only 20 pairs by 1999. In 2009 with the use of high-resolution aerial photography revealed there was no remaining trace of the colony. This has been related to the decline and loss of the Emperor Island colony to a well-documented rise in local mean annual air temperature and coincident decline in seasonal sea ice duration. The loss of this colony provides some evidence to support recent studies made by Jenouvrier et al, on the vulnerability of emperor penguins to changes in sea-ice duration and distribution (Trathan, Fretwell & Stonehouse, 2011).

The findings which were reported in the journal Nature Climate Change in the week of article by Stewart, Dominion Post was based on forecasts of negative shifts in Antarctic sea-ice concentration under climate change, obtained from the study by Woods Hole Oceanographic Institution, warns that at least three-quarters of penguin colonies are vulnerable to future sea ice change, predicting a 20 per cent chance of extinction by the turn of the century (Stewart, 2014). Landcare Research Ecologist Phil Lyver, said this backed up his findings in 2010 of predictions that if troposphere temperatures reach 2^{o}C above preindustrial levels, this will decrease Emperor penguin breeding populations north of 70^{o}S, or even disappear by 2050 (Stewart, 2014).

1.8 Reduced Food Supply

This climate change has also brought about the amount of krill found in the southern oceans being decreased significantly in recent years (Richardson, 2009), given that the krill which the penguin eats has been severely limited by the available surface area of the underside of the sea-ice for their chosen food; algae. Richardson links the reduction in sea-ice resulting from climate change has meant that there has been much less food for penguins to eat. Similarly it was noted in Kooyman & Lynch book; “Penguins; the animal answer guide” suggested that recent hypothesis of this drop in penguin numbers is related to a drop in their food base krill (Kooyman & Lynch, 2013).

Another factor causing the decline in krill populations and also squid in the penguins foraging areas is the expansion of commercial fisheries overfishing and reducing their availability (Kooyman & Lynch, 2013).

1.9 Global Climate Change

Now days it has been a general consensus if climate change is allowed to get worse then it is likely that many species of penguin will disappear altogether (Richardson, 2009). Richardson states: "ensuring the reduction of global anthropogenic carbon dioxide emissions is an important step in ensuring the survival of these beautiful birds for generations to come." This statement was mirrored by Shaye Wolf, stating: "Rapidly reducing global greenhouse gas emissions is the single most important action needed to protect penguins from global climate change."

Conclusions

With the changes associated with 'Climate change', through this literature review it has been determined that there is a real threat to Emperor penguin populations in terms of reduction in their critical breeding habitats through climate change. This has been highlighted by the small colony of Emperor penguin discovered breeding on Emperor Island in 1948, with their numbers being maintained until 1970 then subsequent survey's showed a decline in numbers to only 20 pairs by 1999 and in 2009 found there was no remaining trace of the colony.

Evidence from the British Antarctic Survey of Emperor penguins adapting to low amounts of sea-ice for breeding purposes by favouring that of floating ice shelves is encouraging but there is no mistake that the ice shelves surrounding Antarctic is also at risk of retreating as shown by the collapse of Larsen B Ice Shelf due to the rise in sea temperatures, leaving the Emperor penguin in the distant future hopefully being able to adapt to another set of challenges aside from that of the exploits of commercial fisheries targeting their food source.

Recommendations

- Reduction of global anthropogenic carbon dioxide emissions into the atmosphere.

- Reduction of catch size to commercial fisheries targeting the food source of Emperor penguins; Krill and squid and providing protection to agreed areas also.

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