Online: ISSN 2771-5868
Print: ISSN 2771-585X

Scientific Report

Significance of Faunal Biodiversity in having Sustainable Development of Polar Region with Special Reference to Antarctica

***I. K. Pai**
Department of Zoology, Goa University, Goa-403 206, INDIA
***Corresponding author:** ikpai@unigoa.ac.in
Received: June 10, 2023; revised: August 13, 2023; accepted: August 20, 2023
Available Online: September, 2023
https://doi.org/10.56716/4/6328

Abstract: The planet Earth is hospitable and fit for human habitation, mainly because of its average temperature of 15^{0}C which is due to the presence of Polar Regions. Though, technically both poles are 'similar', due to the geographical position of Arctic, where northern sea is surrounded by land mass, human habitation, industries, usage fossil fuel for various activities etc., compared to Antarctica, the temperature of Arctic region is increasing significantly at a faster rate than ever before resulting in melting of polar ice. While, at Antarctica due to geographic position, where the icy continent is surrounded by marine water, non-human habitation, no vehicular traffic, industries etc., melting of ice is much slower. However, Albedo effect is becoming dangerously alarming. This also contributes to rise in global temperature and thus leading to climate change. Added to the above, anthropogenic activities like uncontrolled fishing including whale in both northern sea and southern sea causes serious concerns.
Keywords: Antarctica, faunal diversity, sustainable development.

The faunal diversity existing on Antarctica land and also in the southern ocean, surrounding the continent plays pivotal role is maintaining the atmospheric temperature in particular and environment in general. Preservation and development of the diversity in this region, helps in having sustainable development of the area.

The variety of animals, plants, fungi and even microorganisms like bacteria, that make up our natural world is known as biodiversity and each of these species and organisms work together in ecosystems like an intricate web to maintain balance and support life. As each species, no matter how small plays an important role to enhance ecosystem productivity. On the contrary, if biodiversity is lost, there is a risk that some thresholds will be passed, undermining the functioning of the earth system. For example, a larger number of plant species means a greater variety of crops. Greater species diversity ensures natural sustainability for all life forms. Biodiversity is essential for the processes that support all life on Earth, including humans. We cannot have the healthy ecosystems that we rely on to provide us with the air we breathe and the food we eat without a wide range of animals, plants and microorganisms. People also value the Nature itself. There is no other life on earth including human beings, without diversity. This diversity provides clean water, oxygen and all other things, that we end up being part of our diet, including clothing and shelter. Further, it provides psychological benefit too. Habitat destruction and fragmentation, direct harvest, innumerable forms of pollution and of late, the climate change are the threats for biodiversity. As biological diversity encompasses all environmental factors,

so there are direct threats such as habitat fragmentation as well indirect threats such as distortion of nitrogen cycle, proliferation of dead zones in estuaries and coastal waters around the world. Further, conservation and sustainable use of biodiversity contributes to sustainable development and mitigation and adaptation to climate change. Hence, one can't solve the biodiversity problems, if we don't solve all these problems too.

As humans, using and consuming more resources than ever before and hence, put increasing pressure on the planet and so we risk upsetting the balance of ecosystems and losing biodiversity. The 2019 landmark Global Assessment Report by the Intergovernmental Platform on Biodiversity and Ecosystem Services reported one million animal and plant species are now threatened with extinction – the highest number in human history. WWF's 2020 Living Planet Report found an average 68% decline in global populations of mammals, fish, birds, reptiles, and amphibians since 1970.

In the recent past, not only three-quarters of the land-based environment but also roughly 66% of the ocean environment have been significantly altered. Crop and livestock production consumes more than a third of the world's land surface and nearly 75% of freshwater resources. To worsen the situation, the climate change has its impact of other stressors on nature and our wellbeing. Selfish humans have overfished the oceans, cleared forests, polluted our water sources and created a climate crisis. These actions are having cascading impact on biodiversity around the world, from the most remote locales to our own backyards. All these pressures add up to a landscape that is quickly changing, with nature struggling to keep up. We're destroying threads from the biodiversity web and it has already started to collapse.

To save our lonely and lively planet and to protect biodiversity, there need to be a major shift in perception from thinking nature as something with a fence around it in the middle of an expensive, man dominated landscape as opposed to thinking about embedding our aspirations in Nature. There is a need to restore vegetation along watercourse and putting natural connections back into the landscape, which will make the species, begin to move and respond to climate change. One of the best ways to mitigate climate change is by protecting biodiversity. As we know that, the amount of carbon dioxide in the atmosphere destroyed and degraded the ecosystem over the last ~8000 years and today, its quantum is 450-500 gigatonnes, which is more than the total amount of carbon dioxide emitted from fossil fuel combustion so far. Ecosystem restoration is also important to reduce carbon load in the atmosphere, which is the root cause of global climate change. It is estimated that, restored ecosystem could provide up to one third of the mitigation needed by sequestering carbon from the atmosphere. This has made thinking of planet as not purely physical system but as a linked biological and physical system

As ecosystem is the interaction between biotic and abiotic factors, there is a direct relation between diversity and regions of the world. Darlington in 1957 defined zoogeography is the branch of the science of biogeography that is concerned with present and past geographic distribution of animal species. Further, modern-day zoogeography also places a reliance on GIS to integrate a more precise understanding and predictive model of the past, present and future population dynamics of animal species both on land and in the ocean. Understanding inter-relationship between habitat formation and the migration patterns of organisms at an ecological level allows for explanations of speciation events that may have arisen due to physical geographic isolation events or the incorporation of new refugia to survive unfavorable environmental conditions (Taylor and McPhail, 1998). Based on Zoogeographic studies, one can predict what kind of fauna one can expect in any given geographic area and Vice Versa. This clearly indicates geography an area determines type of fauna and in turn, the fauna has an equal role to determine the geography of an area.

Darlington (1957) proposed two schemes of zoogeography of the world. First scheme classifies the world into three realms viz., Megagea (Arctogea), Neogea and Notogea and six regions namely Ethiopean, Oriental, Paleartic, Neartic, Neotropical and Australian regions. In the second

scheme, he named them as Climate limited regions, main regions of the old world tropics and barrier limited regions.

The polar regions, also called the frigid zones or polar zones of Earth are the regions of the planet, that surround its geographical poles (the North and South Poles), lying within the polar circles. These high latitudes are dominated by floating sea ice covering much of the Arctic Ocean in the north, and by the Antarctic ice sheet on the continent of Antarctica and the Southern Ocean in the south.

Antarctica, the world's southernmost and fifth largest continent and site of the South Pole, is a virtually uninhabited, ice-covered landmass. Its landmass, which is nearly 14.2million Km^2, is almost wholly (98%) covered by a vast ice sheet also the world's highest, driest, windiest, coldestand iciest continent. Geologically, the continent is divided into East Antarctica (which is largely composed of a high ice-covered plateau) and West Antarctica (which is largely an ice sheet covering an archipelago of mountainous islands). Ecologically and climatologically they behave differently.

The Antarctica, southern polar region has no permanent human habitation as of now (Mathew, 2014). McMurdo Station is the largest research station in Antarctica, run by the United States. Other notable stations include Palmer Station and Amundsen–Scott South Pole Station (United States), Esperanza Base and Marambio Base (Argentina), Scott Base (New Zealand), Maitri and Bharathi stations (India) and Vostok Station (Russia) located at magnetic south pole.

Most cruises to the continent visit the Antarctic Peninsula, which stretches toward South America. It's known for the Lemaire Channel and Paradise Harbor, striking, iceberg-flanked passageways, and Port Lockroy, a former British research station turned museum.

As records tell us that, the Antarctica was sighted in 1820, the history of this icy continent is just about two centuries. Hence, very little is known about the flora and fauna of this landmass. Due to low Net Primary Productivity to start with, Antarctic ecosystems cannot develop long food chains or support large vertebrate consumers; and biodiversity is low. Still, about 1150 species of fungi, 100 species of mosses and 25 species of liverworts and only two species of flowering plants apart from invertebrate like lice, tardigrades, rotifers, krill, springtails have been reported. Further, Antarctic waters harbour only 100 fish species, birds like Skuas, Penguin, Albatross, Antarctic shag etc., are found. Snow Petrel is one of only three bird species that breed exclusively in Antarctica. Large mammals such as Weddel seal, Orcas, leopard seal, Antarctic fur seal, southern elephant seal, Ross seal, blue whale, baleen whale are also seen.

The peninsula's isolated terrain also shelters rich wildlife including many penguins. While there are no indigenous human habitations, there is a complex ecosystem, especially along Antarctica's coastal zones. Krills are basic and major nutritious food for most of the large animals, ranging from penguins to whales. Upwelling at coasts, due to various reasons cause large scale mixing, which in turn brings nutrients for these krills. Coastal upwelling provides abundant nutrients which feed krills, a type of marine crustacea, which in turn feeds a complex of living creatures from penguins to blue whales.

Most species in Antarctica seem to be the descendants of species that lived there millions of years ago. As such, they must have survived multiple glacial cycles. The species survived the periods of extremely cold climate in isolated warmer areas, such as those with geothermal heat or areas that remained ice-free throughout the colder climate (Convey *et al.*, 2020)

Invertebrate life of Antarctica includes species of microscopic mites such as *as Alaskozetes antarcticus,* lice, nematode, tardigrades, rotifer, krill and springtails. The few terrestrial vertebrates are limited to the sub-Antarctic islands (Anonymous, 2008). The flightless midge *Belgica antarctica*, the largest purely terrestrial animal in Antarctica, reaches 6 mm ($^1D_4$ in) in size (Sandro *et al.*, 2011). Antarctic krill, which congregates in large schools, is the keystone species of the ecosystem of the Southern Ocean, being an important food organism for whales, seals, leopard seals, fur seals, squid, icefish, and many bird species, such as penguins and albatrosses. Some species of marine animals exist and rely, directly or indirectly, on phytoplankton. Antarctic sea

life includes penguins, blue whales, orcas, colossal squids and fur seals (Ancel *et al.*, 2013). The Antarctic fur seal was very heavily hunted in the 18th and 19th centuries for its pelt by seal hunters from the United States and the United Kingdom. Leopard seals are apex predators in the Antarctic ecosystem, and migrate across the Southern Ocean in search of food (Steinland *et al.*, 2018)

There are approximately 40 bird species that breed on or close to Antarctica, including species of petrels, penguins, cormorants and gulls. The ocean around Antarctica is visited by various other bird species, including some that normally reside in the Arctic (Woods *et al.*, 2009). The emperor penguin is the only penguin that breeds during the winter in Antarctica and the Adélie penguin breed farther south than any other penguin (Ancel *et al.*, 2020).

At the same time, in Antarctica, despite almost zero human interference, Sei whale, Blue whale, Fin whale, Amsterdam Albatross, Tristan Albatross, Sooty Albatross, Indian yellow nosed Albatross, Gray headed Albatross, Northern Island Albatross, Abbott's Booby etc., have reached a level of endangered status indicate that, the climate change is slowly but certainly taking toll in this cold desert too.

Climate change is said to be a long-term shifts in temperatures and weather patterns, which may be natural. But, since the beginning of industrial revolution, human activities have been the main driver of climate change, primarily due to the burning of more and more fossil fuels (like coal, oil, and gas) by human beings, which produces heat-trapping gases resulted in changing a vast forest lands to farmland. Climate change or global climate change is generally considered a "more scientifically accurate term," than global warming, as NASA explained in 2008, in part because "Changes in precipitation, temperature, wind patterns and sea level are likely to have much greater human impact than the higher temperatures alone".

Effects that scientists had predicted in the past would result from global climate change are now occurring: loss of sea ice, accelerated sea level rise and longer, more intense heat waves. Climate change impacts our society by disrupting the natural, economic and social systems we depend on. This disruption will affect food supplies, industry supply chains and financial markets, damage infrastructure and cities and harm human health and global development. The impacts of climate change are already here. Climate Change is the defining issue of our time and we are at a defining moment. From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale.

The climate change affects not only air temperature and sea levels, but soil as well. The frozen desert valleys of Antarctica are among the world's most inhospitable environments. The landscape is so barren that just 30 years ago, experts did not think it could support life. But beneath the surface, microscopic worms called nematodes thrive in a unique ecosystem - and they are helping researchers understand the effects of climate change. All life is hidden in the soil, under frozen lakes or in melt water streams that run just for a few weeks a year. The world has begun to understand that, climate changes results in changes in temperature, plant activity, rainfall, all of which affects the soil's carbon reservoir. The way we manage soils can either mobilize that carbon back into the atmosphere and contribute to greenhouse gasses or work the other way.

A study by Jasmine *et al.,* (2017), which is among the first to investigate how ice-free areas in Antarctica may be affected by climate change, predicted Ice-free areas of Antarctica — home to more than 99 percent of the continent's terrestrial plants and animals — could expand by more than 17,000 km^2 by the end of this century.

The overall rise in atmospheric temperature due to climate change results in having the albedo effect on land. Albedo is a simple concept that plays complicated roles in climate and astronomy. Albedo is an expression of the ability of surfaces to reflect sunlight (heat from the sun). Light-colored surfaces return a large part of the sunrays back to the atmosphere (high Albedo). Dark surfaces absorb the rays from the sun (low Albedo). An increase in global temperature causes snow and ice to melt,

which decreases the extent to which they cover the surface, which then decreases Earth's albedo. This decrease in albedo means more energy is absorbed, which causes further warming and in turn causes more melting. Snow albedo is highly variable, ranging from as high as 0.9 for freshly fallen snow, to about 0.4 for melting snow, and as low as 0.2 for dirty snow (Hall, 1985). Thus, the albedo effect will have devastating effect on flora and fauna of Antarctica.

The biodiversity of the main land of the world is suffering the results of climate change due to its own 'sins' such as geographic location, over population, unabated usage of fossil fuels, enormous rise in automobiles, unchecked growth, reduction in forest cover, fragmentation, expansion of urban areas, fossil fuel based industrial outburst, usage of millions of tons of chemical fertilizers and pesticides etc.,

As arctic is basically northern ocean surrounded by land mass exposed to outer side is melting faster due to climate change and thus causing devastating effect on fauna like polar bears, decrease in marine fauna in general and ichthyofauna in particular, due to reduced salinity due to melt water from hundreds of gigatonnes of polar ice into northern sea. On the contrary, the Antarctica, for no 'sin' of its own, is also melting at a slower pace, than arctic, due to climate change, leading to cascading effect on Antarctic fauna, as a result of 'sins' caused on the main land.

Environmental impacts in Antarctica occur at a range of scales. Global warming, ozone depletion and global contamination have planet-wide impacts. These affect Antarctica at the largest scale. Fishing and hunting at other islands of polar region surrounding Antarctica, have more localized impacts, but still have the potential to cause region-wide effects. Consequently, Antarctic ecosystems are changing, some at a rapid pace while others are relatively stable. A cascade of responses from molecular through organismic to the community level are expected.

To have sustainable development and to minimize its effect on flora and fauna, one has to follow the principles of retain, recharge, reduce, refuse, reuse, recycle and reawaken. A rich biodiversity will help to mitigate climate change.

The first international agreement to protect Antarctica's biodiversity was adopted in 1964 (Wauchope *et al.*, 2019). The overfishing of krill (an animal that plays a large role in the Antarctic ecosystem) led officials to enact regulations on fishing. In 1980, The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), an international treaty that came into force, which regulates fisheries aiming to preserve ecological relationships (Anonymous, 2022a). Despite these regulations, illegal fishing, particularly of the highly prized Patagonian toothfish, is marketed as Chilean Sea Bass in the U.S. remains a problem (Anonymous, 2021).

In analogy to the 1980 treaty on sustainable fishing, countries led by New Zealand and the United States negotiated a treaty on mining. This Convention on the Regulation of Antarctic Mineral Resources was adopted in 1988. After a strong campaign from environmental organizations, first Australia and then France decided not to ratify the treaty (Day, 2019). Instead, countries adopted the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol), which entered into force in 1998 (Anonymous, 2022b). The Madrid Protocol bans all mining, designating the continent as a "natural reserve devoted to peace and science" (Anonymous, 2019).

The pressure group Greenpeace established a base on Ross Island from 1987 to 1992, as part of its attempt to establish the continent as a World Park (Anonymous, 1992). The Southern Ocean Whale Sanctuary was established in 1994 by the International Whaling Commission. It covers 50 million km^2 (19 million sq mi), and completely surrounds the Antarctic continent. All commercial whaling is banned in the zone, though Japan has continued to hunt whales in the area, ostensibly for research purposes (Anonymous, 2022c)

Despite these protections, the biodiversity in islands near Antarctica is still at risk from human activities. Specially protected areas cover less than 2% of the area, and provide better protection for animals with popular appeal than for less visible animals(Wauchope, *et al.,* 2019). There are more terrestrial protected areas than marine protected areas

(Coetzee *et al.*, 2017). Ecosystems are impacted by local and global threats, notably pollution, the invasion of non-native species, and the various effects of climate change (Wauchope *et al.*, 2019).

Today, we have reached to 'Now or never' state to save our mother earth. This can be achieved only if all civilized society and nations come together and take drastic steps like reducing carbon foot print, reducing excessive consumption, Go green policy, usage of green, non-conventional energy sources, add a minimum of 3-6% organic content in agricultural soil to save them from their death, reduce rampant ground water extraction, have more and more rain water harvesting and implement in Toto United Nation's Sustainable Development Goals, for survival, sustenance and progress of the our lonely and lively planet.

Acknowledgement:

It's my pleasure to sincerely thank Government of India for selecting the author for XX Indian Antarctic Expedition and conduct biological research.

References:

Ancel, André., Beaulieu., Michaël, Gilbert and Caroline. 2013. "The different breeding strategies of penguins: a review". Comptes rendus de l'Académie des Sciences. Wauchope, 336 (1):112. doi: 10.1016 / j. crvi. 2013.02.002.ISSN 0001-4036. PMID 23537764.Retrieved 12 October 2020 – via Elsevier Science Direct.

Anonymous. 1992. Now you see it now you don't! (PDF). ECO. Vol. 82, no. 3. November 1992. Pp:5. Archived from the original (PDF) on 20 February 2022. Retrieved 20 February 2022.

Anonymous. 2008. Land Animals of Antarctica. British Antarctic Survey. Natural Environment Research Council. Archived from the original on 7 October 2008. Retrieved 25 April 2017.

Anonymous. 2019. Protocol on Environmental Protection to The Antarctic Treaty (The Madrid Protocol). Australian Antarctic Programme. 17 May 2019. Retrieved 8 February 2021.

Anonymous. 2021. Toothfish fisheries. Convention for the Conservation of Antarctic Marine Living Resources. 2 July 2021. Retrieved 13 January 2021.

Anonymous. 2022a. Antarctica. The World Factbook. Central Intelligence Agency. 3 May 2022. Archived from the original on 9 May 2022. Retrieved 9 May 2022

Anonymous. 2022b. The Madrid Protocol. Australian Antarctic Division. Retrieved 20 February 2022.

Anonymous. 2022c. Southern Ocean Whale Sanctuary. Antarctic and Southern Coalition. Archived from the original on 13 January 2022. Retrieved 13 January 2022.

Coetzee, Bernard W. T., Convey, Peter and Chown, Steven L. 2017. Expanding the Protected Area Network in Antarctica is Urgent and Readily Achievable: Expanding Antarctica's protected areas. Conservation Letters. 10 (6): 670–680. doi:10.1111/conl.12342. S2CID 89943276.

Convey, Peter., Biersma, Elisabeth., Casanova-Katny, Angelica. and Maturana, Claudia S. 2020. Refuges of Antarctic diversity. In Oliva, Marc and Ruiz Fernandez, Jesus (eds.). Past Antarctica : paleoclimatology and climate change. London. p. 182, 187–188. ISBN 978-0-12-817925-3.

Darlington, P. J., Jr. 1957. Zoogeography: The Geographical Distribution of Animals. New York, Archived 2018-08-13 at the Wayback Machine.

Day. 2019. The Antarctic Treaty of 1959.

Hall, Dorothy K. 1985. Remote Sensing of Ice and Snow. Dordrecht: Springer Netherlands. ISBN978 -94-009-4842-6.

Jasmine R. Lee, Ben Raymond, Thomas J. Bracegirdle, Iadine Chadès, Richard A. Fuller, Justine D. Shaw and Aleks Terauds. 2017. Climate change drives expansion of Antarctic ice-free habitat. Nature, 2017 DOI: 10.1038 / nature 22996

Matthew, Teller. 2014. Why do so many nations want a piece of Antarctica? BBC. Retrieved 22 March, 2019.

Sandro, Luke. and Constible, Juanita. 2011. Antarctic Bestiary – Terrestrial Animals. Laboratory for Ecophysiological Cryobiology. Miami University. Retrieved 22 October 2011.

Staniland, Iain J., Ratcliffe, Norman., Trathan, Philip N. and Forcada, Jaume. 2018. Long term movements and activity patterns of an Antarctic marine apex predator: The leopard seal. PLOS ONE. 13(6) e0197767. Bibcode: 2018 PLoSO. 1397767S. doi: 10.1371 / journal. pone. 0197767. PMC 5988266. PMID 29870541.

Taylor, E. B. and McPhail, J. D. 1998. Evolutionary history of an adaptive radiation species in pairs of three spine sticklebacks (Gasterosterus): insights from mitochondrial DNA. Biological Journal of the Linnean Society. 66: 271-291.

Wauchope, Hannah, S., Shaw, Justine D. and Terauds, Aleks. 2019. A snapshot of biodiversity protection in Antarctica. Nature Communications. 10 (1): 946. Bibcode:2019 NatCo..10..946W. doi: 10.1038 / s41467-019-08915-6. ISSN 20411723. PMC 6391489. PMID 30808907.

Woods, R., Jones, H. I., Watts, J., Miller, G. D. and Shellam, G. R. 2009. Diseases of Antarctic Seabirds. Health of Antarctic Wildlife: A Challenge for Science and Policy. Springer. pp. 35–55. doi:10.1007/978-3-540-93923-8_3. ISBN 978-3-540-93922-1.