

Scientific Report

Exploration of Animal Science in Extreme Environment: An Indian Experience At Antarctica

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Abstract: Antarctica, the seventh continent of the earth is known for its extreme environmental conditions. It is the coldest, driest, windiest continent having highest average elevation of all the continents. Antarctica is considered as a desert, with annual precipitation of only 200 mm (8 inches), along the coast and far less inland. The minimum temperature recorded in Antarctica is “89°C (“129°F). The history of this icy continent is not more than two centuries. Hence very little is known about the flora and fauna of this landmass, though about 1150 species of fungi have been recorded from Antarctica, (about 750 are non-lichen-forming and 400 are lichen-forming). Regarding higher plants, there are about 100 species of mosses and 25 species of liverworts and only two species of flowering plants. Invertebrate life includes microscopic mites like the *Alaskozetes antarcticus*, lice, nematodes, tardigrades, rotifers, krill and springtails. The flightless midge *Belgica antarctica*, up to 6mm in size, is the largest purely terrestrial animal. Few terrestrial vertebrates live in Antarctica. Antarctic waters harbor only 100 fish species, out of known about 20,000 species. The bird species like Skuas, Penguin, Albatross, Antarctic shag etc., are found. Snow Petrel is one of only three bird species, that breed exclusively in Antarctica. Interestingly large animals like Weddel seal, Orcas, leopard seal, Antarctic fur seal, southern elephant seal, Ross seal, blue whale, baleen whale are also seen. Several works on diversity, physiology, anatomy of Antarctic animals has been carried out. But, works on genetics, molecular biology of animals of Antarctica has not been carried out extensively.

Key words: Antarctica, animal, Indian expedition.

Introduction

Antarctica is the southernmost and fifth in size, among the world's continents, with a size of 14.2 million square km. It is also known as 'white continent'. 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). It would be essentially circular except for the out flaring Antarctic Peninsula, which reaches toward the southern tip of South America (some 600 miles [970 km] away), and for two principal embayment, the Ross Sea and the Weddell Sea. It

is an amazing place. It is the coldest, driest and windiest continent on Earth and has the highest average elevation (~30MSL) of all other continents. About 98% of Antarctica is covered by ice that averages 1.9 km (1.2 mi; 6,200 ft) in thickness (Fretwell *et al.*, 2013) which extends to all but the northernmost reaches of the Antarctic Peninsula, while the McMurdo Dry Valleys is the driest place in the world, and has not seen rain for nearly 2 million years (Cain, 2008). Today, during summer 97% of Antarctica is covered with snow; while during winter it is covered 100%. Antarctica is

also known as cold desert covered in ice. Annual precipitation levels are around 200 mm (7.9 in) along the coast, but far less inland. In fact, researchers believe that there has been no rain on Antarctica for at least 2 million years. But, nearly eighty per cent of our planet's freshwater reserves are located there. Looking back at the geological history of our planet, we see a world much different than today. Things were pretty different in the past roughly some 3 million years ago, a much warmer and 'tropical' land and was harbouring with massive green forests, flowering plants, a verdant landscape home to ancient animals of all sorts. But today, it has miles of frozen water, nearly inhospitable landscape.

Some of the staggering observations at Antarctica are like 'Impossible' Cosmic Rays are being spotted shooting out of Antarctica. For example, The Advanced Thin Ionization Calorimeter (ATIC) is a balloon-borne instrument flying in the stratosphere over Antarctica to measure the energy and composition of cosmic rays. ATIC was launched from McMurdo Station for the first time in December 2000 (Overbey, 2008). In the latter half of the 20th century, the Antarctic Peninsula was the fastest-warming place on Earth, closely followed by West Antarctica, but these trends weakened in the early 21st-century (Stammerjohn *et al.*, 2020). Conversely, the South Pole in East Antarctica barely warmed last century, but temperatures shall have three times the global average in the last three decades (Clem *et al.*, 2020), the continent recorded its highest temperature of 18.3 °C (64.9 °F), which was a degree higher than the previous record of 17.5 °C (63.5 °F) in March 2015 (Larsen 2020). A 2018 systematic review study estimated that, ice loss across the entire continent was 43 gigatonnes per year on average during the period from 1992 to 2000, but accelerated to an average of 220 gigatonnes per year during the five years from 2012 to 2017 (Shepherd and Evins, 2018). An Iceberg the size of Malta has broken off of Antarctica in 2020, due to global warming. The planet's largest Ice shelf is melting 10 times faster than expected and quarter of Antarctica is unstable.

With effects ranging from influencing ocean currents to raising sea level, Antarctica plays a large role in the global

climate system. Further it is estimated that in case Antarctica melts it would contain enough liquid water to raise global sea levels by as much as 60 meters (200 ft). Researchers are using a variety of methods to understand how Antarctica will react to a changing climate.

The native terrestrial fauna is wholly invertebrate. The Antarctic microfauna includes heliozoans, rotifers, tardigrades, nematodes, and ciliate protozoans. The protozoans dominate soil and freshwater communities. The terrestrial macrofauna consists entirely of arthropods, many species being parasitic on birds and seals. The principal arthropod groups represented include Acarina (mites), Mallophaga (biting lice), Collembola (springtails), Anoplura (sucking lice), Diptera (midges), and Siphonaptera (fleas).

About 45 species of birds live south of the Antarctic Convergence, but only three viz., the emperor penguin, Antarctic petrel, and South Polar (McCormick's) skua breed exclusively on the continent or on nearby islands. As there are no mammalian terrestrial predators, make Antarctic coasts a haven for immense seabird rookeries. Of the 18 living species, only the Adélie and emperor live along the Antarctic coastline, while king, chinstrap, gentoo, rockhopper and macaroni penguins live in south as the northern Antarctic Peninsula and sub-antarctic islands. Other birds of the region include species of cormorants, pintails, gulls, terns, sheathbills, and pipits.

The zooplankton of antarctic water feed on the phytoplankton and in turn, form the basic diet of whales, seals, fish, squid, and seabirds. Due to upwelled nutrients, are more than seven times as productive as sub-antarctic waters. Important one is krill, *Euphausia superba*, which are present in large number. Though they are small, due to their higher density and built-in nets of baleen and hair like fibres, can strain out meals of a ton or more in a few minutes.

On the sea bottom one can get sessile hydrozoans, corals, sponges, and bryozoans, pycnogonids and isopods, polychaeta, echinoids, sea stars (starfish), and a variety of crustaceans and molluscs. Not more than 100 species of fishes of which a large number of them are seen at sea bottom, that too from seas south of the Antarctic Convergence.

Native mammals of antarctica are all marine and include seals (pinnipeds), porpoises, dolphins, and whales (cetaceans). Only one otariid, or fur seal, breeds south of the Antarctic Convergence; four species of phocids, or true seals—the gregarious Weddell seal, the ubiquitous crab eater seal, the solitary and aggressively carnivorous leopard seal, and the rarely seen Ross seal—breed almost exclusively in the Antarctic zone, and another, the southern elephant seal, breeds near the Convergence at South Georgia, Kerguelen, and Macquarie islands. The leopard seal, armed with powerful jaws and huge canines, is one of the few predators of adult penguins.

Whales and their cetacean relatives, porpoises and dolphins, range widely from Arctic to Antarctic waters and are found in all oceans and seas. More typical of Antarctic waters are the killer whale, sperm whale, and rare bottle-nosed, or beaked, whale. Seven species of baleen, or whalebone, whales also inhabit Antarctic waters.

Historical

It was in 530 BC, Aristotle said that, “...there should be some land mass in the south to balance northern hemisphere”. Later in 150 AD, Egyptians drew land continent linking Asia and Africa. In 650 AD, Ui Te Rangiora (a polynesian sailor) sailed up to sea, where it was frozen. In 1487, Bartholomeau (Portuguese) sailed around southern tip of Africa. It was James Hooker, a botanist sighted Antarctica in 1820. Waddell on 20-2-1823 discovered Saddle Island. It was HMS Challenger, in 1874, had the privilege to be considered as first ship to cross Antarctic circle. It was British Army Major Robert Scott made first journey on Antarctic ice cap. History was written by Roald Amundsen, a Norwegian explorer to reach South Pole on 14-12-1911, followed by Maj. Robert Scott on 18-1-1912. From 1950, International expeditions started. It was Edmond Hilary, who accompanied Tensing Norge in his Mt. Everest expedition, reaches South Pole on tractor (First overland journey) in 1958. After this several countries undertake expedition to Antarctica for scientific research work.

As the world came to know the importance of Antarctica, including waste land, resources, countries started misusing the continent for ulterior and selfish motto. To put an end to this, as 1957-58 was observed as an International geophysical year, on 1-12-1959, Antarctic treaty system was signed originally by 12 nations active in antarctica. This treaty came in force from 23-6-1961. Subsequently, in 1983, India became a member of the Antarctic treaty system and was granted a consultative member in the same year. The treaty applies to south of 60deg. south including ice shelves and islands. It mainly emphasizes on regulations of usage of Antarctic continent and saving its pristine environment.

Some of the important aspects of treaty were like the provisions of the treaty, applies south of 60 deg. S. Antarctic shall be used for peaceful purposes only. Bans any kind of military activity. Freedom of scientific investigations and cooperation. Free exchange of scientific results. All national claims are held static. Nuclear activity/ disposals of nuclear waste is prohibited. Disputes if any will be settled by International court. Free access for signatories to stations. Regular consultative meetings. No activity contrary to the treaty shall be carried out by any signatory country. Treaty came into existence from 23-06-1961. Treaty shall remain in force for a minimum of 30 years. Later in 1991 the treaty was extended for further 30 more years.

It was in 1982, first Indian Antarctic Scientific expedition under the leadership of Dr S. Z. Qasim was undertaken. The National Centre for Antarctic and Ocean Research (NCAOR), a premier institute exclusively dedicated to conduct research on Antarctica and oceans was established, as an autonomous Research and Development Institution of the Ministry of Earth Sciences (formerly Department of Ocean Development), Government of India on the 25th May 1998. With a mission mandate that is quite challenging, the Centre is designated as the nodal organization for the co-ordination and implementation of the Indian Antarctic Programme, including the maintenance of India's permanent station in Antarctica. Subsequently, as the research activities were

extended to Arctic region too, the NCAOR has been re-named as National Centre for Polar and Ocean Research (NCPOR).

From 1982, till date more than 30 Indian expeditions to Antarctica, Weddel sea, Southern Ocean etc., were undertaken and from a simple off shore First Indian station 'Dakshin Gangotri' to second more spacious station 'Maitri' (in 1989) and lastly a ultra-modern with best of the best facilities third Indian station 'Bharati' (in 2011) was established to do research on various aspects. Later, India also established its Arctic Research station 'Himadri'



Second Indian Antarctic Station 'Maitri' (Source: Personal photo, author)



Second Indian Antarctic Station " Maitri" (Source: Personal photo, author)

Important contribution from Indian Scientists

So far, over 30 institutions from all over India participated in Indian Antarctic Expeditions. If some of the projects are long



'Summer huts' at Second Indian Antarctic Station 'Maitri' (Source: Personal photo, author)

term and continuous one, some of them are of short period nature. By and large Indian Antarctic expedition program are broadly categorized into Atmospheric sciences, Biological sciences, earth and glaciology, Environmental sciences and Human physiology and medicine with "climate change" being broader theme.

Under Biological sciences, Molecular ecology of Antarctic cryospace, Adaptation strategies in aquatic and terrestrial habitats, Sea-ice ecosystem, terrestrial flora and fauna, Physiology and population dynamics, food web dynamics, search for novel bioactive molecules and processes, genomics etc.,

In this communications, major biological investigations and their outcome has been discussed. Under microbial research 8 new genera and 80 species of bacteria from terrestrial and aquatic environment of Antarctica. Discovery of new fatty acid desaturase gene from Antarctic bacterium. Established two genes aspartae aminotransferase gene and t RNA modification GTPase gene, required for survival at low temperature. Several bacterial isolates from the Cryosphere produce cols active proteases and lipases with application in biotechnology such as detergent, baking and brewery were isolated. Diversity of psychrohilic bacteria was recognized. Genome sequencing of about 20 bacteria to identify genes involved in growth and survival at freezing temperature was also completed. 7 species of bryophytes, 54 species of lichens were discovered from Schirmacher oasis area.

A greater diversity of invertebrate species such as nematodes, rotifers, tardigrades, acarina, collembola were studied with respect to their ecology and population fluctuation. 49 species of sea birds and 12 species of marine mammals were recorded. Reported range extension of Cory's Shearwater, Antarctic Skua, Cape Petrel, White Caped Albatross, Blue Petrel, Sooty Albatross, Kergulean Petrel, Great winged Petrel.

Expedition wise details of faunal research conducted by Indian Antarctic Expeditions

In first few Indian Antarctic expeditions, Polar vessels like 'M. V. Polar Circle' from Norway, 'M/ V. Magdalene Oldendorff' from Germany were hired by government of India, used to sail all the way from their home port, to Goa passing through western part of Europe and through Suez canal, entering into Arabian sea. From Goa, the expedition used to start and move to Mauritius, from where necessary stores and groceries were used to be loaded then move on to Antarctica. It used to take about a month by sea to reach Antarctica from Goa. As this mode used to take nearly two months (to and fro), administrators found it too time consuming. So, later the ships were to some to Cape Town South Africa and personnel used to fly from Goa to Cape Town, which reduced the travelling time drastically and was cost effective too.

On 6-12-1981, a team of 21 personnel including scientists and logistics, from seven institutions, under the leadership of Dr S.Z. Qasim, the then Director of National Institute of Oceanography, Goa, under the expedition code name 'Operation Gangotri' travelled 21,000 km to Antarctica and returned to Goa 21-2-1982, making the expedition of 77 days.

In First Indian Antarctic Expedition, Parulekar reported thirteen species of sea birds and five species of marine mammals observed in the Antarctic and the sub-Antarctic region are reported. Verlekar *et al.*, studied Biochemical Components such as carbon, nitrogen, phosphates of the Benthic Regions in Antarctic Waters

Benthic Fauna of the Antarctic Ocean-Quantitative Aspects macro and macrobenthos were studied by Parulekar *et al.* Further, Goswami studied distribution, biomass, abundance and diel variation in zooplankton in Antarctic waters. Apart from the above, From the same expedition, Goes and Devassy reported 28 species phytoplankton belonging to 23 genera along with Diatoms were represented by 27 species belonging to 20 genera and were distinctly the abundant forms at stations near the ice edge. Dinoflagellates and silicoflagellates were poorly represented.

In Second Indian Antarctic Expedition (IAE) expect observing Krill, nothing much biological work was carried out. Third IAE, a team with 69 members, under the leadership of Dr Harsh Gupta, undertook scientific research. There was also a wintering team, which would spend 16 months on icy continent. Aerobiological investigations, latitudinal distribution of zooplankton with special reference to Euphausiids in Southern Ocean, Spatial distribution of krill and other zooplankton off Queen Maud land, Microbial studies on Schirmacher oasis, effect of temperature on bacteria etc., were studied.

IV IAE under the leadership of Prof. BB Bhattacharya along with 69 other summer and 13 wintering members was carried out. During the expedition under Biology / oceanology section, Nutrients and phytoplankton production in southern ocean, preliminary studies on bacteria and yeast, water moss and other microfauna in Schirmacher oasis and Priyadarshini lake area were conducted.

Dr. M. K. Kaul from GSI lead V IAE with 88 members including 14 wintering members. By the time earlier wintering team had already completed the establishing Dakshin Gangotri station. During the expedition, saprophytic fungi seasonal studies on particulate organic matter, primary and extra cellular productivity during austral summer etc., were studied (Anonymous 2006e). A report of VI, VII and VIII was not published.

Dr Rasik Ravindra, who later became Director of NCAOR, was the leader of IX IAE, lead a team of 81 members including wintering members, left Goa on 30-11-1989. Members

were from Baba Atomic Research Centre, National Physical Labs, Indian Meteorology Department, Geological Survey of India, National Geomagnetism Research Institute etc., Primary Productivity, Phytoplankton Standing Crop and Physico-Chemical Characteristics of the Antarctic and Adjacent Central Indian Ocean Waters, Production of certain hydrolytic enzymes from bacteria from Krill; heterotrophic activity, bacterial types and abundance in different ecosystem in Queen Maud land, population ecology of soil nematodes in relation to some edaphic factors at Schirmacher oasis etc., were studied

Dr A. K. Hanjura was the leader of X IAE, who sailed off the Indian coast on 27th November 1990. The 100-member team had representatives from 13 research organisations and three defence services. Survey of India, All India Institute of Medical Sciences, Defence Institute of Fire Research and Indo-Tibetan Border Police participated in the Antarctic Program for the first time. Scientists from National Physical Laboratory and Defence Agricultural Research Laboratory and a doctor from Indo-Tibetan Border Police wintered in the icy continent for the first time. The Biological Sciences Research included growth and collection of cyanobacteria for physiological, biochemical and genetic studies, optimising Antarctic greenhouse environment and growing plants in hydroponics, phytoplankton count in Antarctic waters and trace element and organic carbon distribution in Antarctic lake waters.

Eleventh Indian Expedition to Antarctica was led by Dr S. Mukherji. The team left on 27-11-1991 with 98 members on board. Of these, 29 were scientists including 7 member who were to winter over the Indian station Maitri, drawn from various government organizations, universities and national laboratories. Out of the rest, 65 members formed the logistic support team with 28 personnel drawn from Indian Army, 18 from Indian Navy and 19 from Indian Air Force. This expedition studies soil bacteria of Schirmacher oasis area, investigated on invertebrate faunal aspects and also investigated on circadian rhythm changes on human beings in Antarctic environment. Report on 12th IAE was not published.

Dr G Sudkahar Rao led Thirteenth Indian Expedition to Antarctica, was formally flagged off on 7-12-1993. The 58

members team drawn from 13 scientific organizations viz., IMD, IIG, NPL, PRL, GSI, NGRI, OU, SOI, NEERI, NIO, AIIMS, R&DE(E) and DEAL, and defence services viz., Army, Navy and Armed Forces Medical Services. In this expedition the team studied role of UV radiation on primary productivity in Antarctic waters.

XIV Indian Expedition to Antarctica, led by Dr S. D. Sharma with 63 members belonging to various institutions and defence services, left Marmugoa port on 15-12-1994. During the expedition, studies on Tardigrads and associated fauna, south polar Skua, bird and mammal logging was undertaken. Long term studies on birds and mammals, using GPS and GIS was also initiated in the expedition. Apart from the above isolation and characterization of psychotrophic bacteria from antarctica was also carried out.

Dr Arun Chaturvedi led XV IAE with the participation of 30 scientists from 21 organizations of our country established another milestone on the path of polar scientific exploration. The team left Goa on 6-12-1995. As a part of faunal research, developed a long-term monitoring programme for Birds and 131 Mammals in the Indian Ocean and Antarctica. During the expedition the scientists not only did daily monitoring and aerial census of Penguins and Seals and nesting sites birds but also developed a long term monitoring program for birds and mammals.

Sixteenth Indian Expedition to Antarctica, sailed off from Marmugao port on 12-12-1996 in a chartered Norwegian vessel-POLAR BIRD. Under the leadership of Dr A.L. Koppar, a team comprised of 61 members. Out of these 26 were for winter and 35 were for summer period. Twenty scientific organisations viz. IMD, IIG, NPL, IITM GSI, JU, SASE, SOI, IITK, NGRI, BSI, WII, AIIMS, DIPAS, NAL, DIFR, NHO, DARL, DEAL, R & DE and the Indian Army and AFMS participated in the expedition. Five organizations viz. IITM, IITK, BSI, NAL and DIFR participated for the first time and SASE commenced their wintering programme. During the expedition, studies on Human Physiology with reference to co-relate Circadian Rhythmicity and metabolic status of personnel exposed to the severe Antarctic conditions in order

to understand the adaptive processes. The study included monitoring of heart (pulse) rate, body temperature, body composition, liver tests, food intake and related physioemotional studies. In addition, the following experiments will be undertaken (a) Interaction of opioids and altered photoperiod in immunomodulation during Antarctic winter. (b) Geomagnetic effects on neuro-behavioural measures and reproductive system. (c) Melatonin and body temperature coupling. 2. Biochemical Evaluation of Nutritional Requirements: Defence Institute of Physiology and Allied Sciences will mount a new initiative to study the nutritional aspects in order to evaluate the effects of physiological stress and resultant metabolic requirements to which a subject is exposed to in cold conditions. The primary objectives of this study was: (a) To rationalise the nutritional requirement of the members of Antarctic Expedition (both summer and winter) (b) To evaluate the effects of supplementation of specific antioxidants vitamins and minerals with regard to the physiological acclimatisation and performance of the expedition members was undertaken. Further a s part of biological sciences research long Term Monitoring of Mammals and Birds was done by Wildlife Institute of India, Dehradun to devise a monitoring system for population dynamics for mammals (only seals) and avian taxa.

On 8-12-1997, under the leadership of Dr A. Sivan and 48 members on board 'MV Polar Bird' flagged off XVII Indian Expedition to Antarctica, from Murmugoa The composition of the team consists of Scientists from 17 Organizations / Academic Institution, 13 members Logistic Team from Indian Army, DOD Observer and cooks from ITBP. Later the strength became 53 when the Medical Officer of the expedition and three German Scientists joined at Mauritius. It was the first time that the launching ceremony was held at the newly constructed Antarctic Study Centre (now NCAOR), Goa and ASC/ DOD made it a grand occasion. Studies on moss inhabiting invertebrate fauna, was undertaken during this expedition.

It was the privilege of Dr. Ajay Dhar to lead XVIII IAE, which flagged off on 14-12-1998 from Murmugoa port,

Goa. The team comprising of 56 members, included 39 scientist, 2 doctors from Indian Railways and 15 members from Indian Army and Indo-Tibetan Border Police. Twenty-six members of this team stayed for Polar winters to conduct various scientific experiments and maintain the Station and its life support equipment. The Pawan Hans Helicopters were chartered for the first time to operate with the Indian Antarctic Expedition. The scientists were drawn from 17 Institutions across the country and a participating scientist from Iran, and each organization had a specific program. Three lady scientists were also participated in this expedition, the highest number in any expedition till that expedition Limnological studies of Lakes, studies on accumulation of heavy metals on lake sediments, studies on marine mammals, faunal diversity, morpho-taxonomic survey of diatoms at Schirmacher oasis area, marine ambient acoustic noise in relation to marine life in Antarctic waters etc., was carried out during the expedition.

Once again Dr Arun Chaturvedi, a veteran in Antarctic expeditions led XIX Indian Expedition to Antarctica. The expedition team comprised 47 members representing 15 scientific departments and 4 logistic organizations. The scientific units were GSI, IIG, NGRI, IMD, BSI, ZSI, BSIP, NEERI, SASE, SOI, NAL, DIPAS, INMAS, RDEE and Bhopal University. Logistic teams were drawn from Indian Army, DEAL, ITBP and Central Health Services. One geoscientist from Lima University of Peru joined the team on board ship, taking the team strength to 48 members. Expedition was flagged off on 6-12-1999, from Goa. Till the previous year, all the expeditions were launched from the shores of Goa. This was to be the first expedition to sail off from the ports of a foreign land, i.e. from Cape Town in South Africa. The shifting of the launching site promised to cut down the sailing time to almost one-third, from 27 days to 9 days to reach the Antarctic coast; and thus the resultant financial savings. A six-member team of Pawan Hans, with two Bell Helicopters, joined the team on board ship, 'MV Magdalena Oldendorff'. An official sendoff from Cape Town, South Africa function was arranged on board ship was held on 9-12-1999. During this expedition, investigations on invertebrate fauna and bryophytes was carried-out.

Twentieth Indian Expedition to Antarctica was led by Dr. Mervin J D'Souza. The team was consisting of 51 members. The team from Goa boarded 'M V Magdalena Oldendorff', which departed from Capetown on 30-12-2000. Studies on stress, anxiety and loneliness among the expedition members, changes in Leptin and neuropeptide Y was undertaken.

XXI Indian Expedition to Antarctica, under the leadership of Dr. R. P. Lal, comprised 49 members (25 Winter Member and 24 Summer Member) drawn from 20 scientific institutions / organizations was set to achieve yet another goal, left Goa on 5-2-2002 and the team members boarded 'M. V. Magdalena Oldendorf' on 7-1-2002. As a part of biological sciences work, observation of sea birds during the voyage and isolation and molecular characterization of microbial community was accomplished.

Dr Arun Hanchinal led XXII Indian Expedition to Antarctica, with 48 members team consisting of 28 scientists drawn from 13 scientific institutes, two Doctors from Central Government Health Scheme (CGHS), 13 member logistic team from Indian Army, 2 cooks from Indo Tibet Border Police and 3 members communication team from Defense Electronics Application Laboratory (DEAL) left Goa on 5-1-2003 and boarded the Ship "Magdalena Olendorf". The team studied environmental status of Indian Antarctic station 'Maitri' and also conducted study on distribution and diversity of lichen in Schirmacher Oasis area.

On 9-12-2003, XXIII Indian Antarctic Expedition team comprising of 55 members under the leadership of Dr. Srinivasan Jayaram left Goa to board 'M. V. Emerald Sea' docked at Cape town of South Africa, left the port and entered the cold waters of South Indian Ocean and Antarctica on 24-12-2003. The team studied role of biomarkers and their application in Palaeontological studies of lake ecosystem at Schirmacher oasis. Environmental monitoring and enhancing of EIA lab at 'Maitri', apart from analyses of diatom flora at Schirmacher oasis area.

Twenty Fourth Indian Antarctic Expedition team under the leadership of Dr. Rajesh Asthana departed from Goa on 9-12-2004 and boarded the expedition vessel, 'M. V.

Emerald Sea' on 10-12-2004. Studies on anthropogenic pressure on lake system, diversity and ecology of mosses, bacterial diversity, effect of UV-B radiation of pigments in plants etc. in Schirmacher oasis was conducted.

Veteran Antarctic Dr L. Prem Kishore led Silver jubilee (XXV) IAE on 20-12-2005 left from Goa on way to Mumbai - Johannesburg - Cape Town. On 28-12-2005 "M.V. Paardeberg" was taken over for the 25th ISEA. The team sailed off on 29-12-2005. The team comprised of 52 members, 27 members for the summer and 25 for the winter. The team comprised of 34 Scientists from 18 Organizations/ Academic Institutes, 14 members Logistic Team from Indian Army and two cooks from Indo Tibetan Border Police. Two Medical Officers also joined the expedition as winter members. Microbial diversity in Schirmacher oasis area with special emphasis on biotechnological potential, ecological studies on Skua and Penguins, freshwater diatom communities etc., was explored.

XXVI Indian Antarctic Expedition members boarded the ship, which set sail on 10-1-2007, from Mormugao Port, Goa. The team was led by a veteran of Antarctic expeditions Dr D. Jaypaul, Geological Survey of India. The team had 29 summer and 24 wintering members. Multi-proxi studies on late quaternary lake sediment from lakes from Schirmacher oasis area, functional diversity of microbes, environmental monitoring of Indian Scientific station 'Maitri', water quality assessment etc., were explored during the expedition.

27th Indian Antarctic Expedition, once again under the leadership Arun Chaturvedi was flagged off on board MV Emerald Sea, As a part of biological / Environmental studies, physico-chemical analyses of waste materials produced at 'Maitri' station, recording of aerobic culturable microbial load, observation of birds and mammals, exploration of moss inhabiting invertebrate fauna was undertaken.

Dr Pradip Malhotra was leader and station Commander of XXVIII Indian Antarctic Expedition. The team had 25 wintering and 40 summer members. In first batch of 15 members left from Goa on 31-10-2008 to move towards Antarctica via Mumbai, Dubai and Cape Town. On the midnight of 5-11-2008, the team took the IL-76 flight to Maitri

and landed at Novolazarevskaya Runway near 'Maitri' in the very early hours of 6-11-2008. Subsequently other members too joined the team. As a part of Biological, environmental and human studies, effect of Antarctic weather on immune response in human beings, effect of temperature variability on metabolic rate in Antarctic krill, diversity and ecophysiology of lichens, status and distribution of birds in Southern Ocean and Antarctica with special reference to climate change.

Thus one can conclude that, Indian scientists have contributed significantly in research on fauna at Antarctica.

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