

*Published in: Atharva. 8(3); 2013*

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## **The Neglected Natural Resources of Goa**

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( Authors' note:- From May 8, 2011 to August 28, 2011, I published a series of 16 weekly articles in the local English daily The Navhind Times on various aspects of neglected biodiversity of Goa. Many self styled and fake nature lovers, tiger, snake, turtle, frog and bird lovers and foreign funded NGOs have suddenly proliferated in Goa and have managed to keep themselves in media limelight. Their philosophy is as per old Goan proverb- "kashti suki davrun thighur dharap" . Unfortunately the full environmental discourse has been hijacked by these brigades and government is dancing to their tunes. When it comes to knowledge, research, facts and figures there is no substitute for truth-ecological and biological and in that direction this series was aimed to popularize science of Goa's natural resources and biodiversity treasure. It was original and the longest in the journalistic history of Goa on this subject. These articles are now compiled in the form of this monograph to reach larger audience of users, students and teachers. )

### **1. The neglected Stromatolite and plant megafossils**

What are "stromatolites" ?. These are internally-laminated, macroscopic sedimentary structures, commonly of biological origin which form the dominant part of Earth's early fossil record and so provide a potentially important source of information about early life. This article reports the new discovery of Archean (more than 2500 million years old) stromatolites-vast fossilized algal mats on border of Goa, inside Mahadayi river basin among metasedimentary rocks. Time is running out for fossil researchers because the strong currents of Mahadayi have eroded the stromatolites. These mats are not the routine major or minor folds found in metasedimentary rocks. There are stromatolitic carbonates as well. A group of trekkers had visited the source of Mahadayi river. In the bed of the river and on the banks they came across strange rocks. The students of Geology amongst them could not identify these strange formations. One of the leader of the trekkers, Prakash Parienkar who teaches at Konkani department of Goa University showed me the photographs. One of these is published alongwith this article. After minute examination of the images and based on geology and lithostratigraphy of the Mahadayi basin which is full of detrital Archean metasediments and after consulting other published sources on stromatolitic deposits in India and outside, I arrived at the conclusion that upper Mahadayi basin is a vast, unexplored, neglected treasure trove for archean fossil hunters with stromatolite fossils being relatively abundant. But the currents are eroding these fossils. It is virtually a Archean paleontological museum. Only fools would ignore its' monumental scientific, academic , intellectual potential. The Mahadayi river basin is part of Western Dharwar Craton (WDC) of Meso-archaeon age. WDC shows greenstone

belts, tonalite-trondhjemite gneisses, high-Mg basalts, komatites with metavolcanics and meta-sedimentary rocks. Among these mafic and ultramafic volcanic rocks, arenites, phylites, polymictic and oligomictic conglomerates, greywackes, banded iron formations and carbonates are dominant. What's practical importance of discovery of stromatolite fossils in Goa?. My attention was drawn to Geologist Hofmann's 1973 paper on stromatolites from which I take liberty to quote the relevant part- " Stromatolites are remarkable structures. They are so primitive and simple, and yet so complex and versatile. Not so long ago still regarded by some as curious objects, these laminated biosedimentary structures are now intensively studied. They provide information whose importance spans more than 2.9 billion years of time and three of the major fields of science: geology, biology and astronomy. Within geology, they have contributed information of use in sedimentology, paleontology, stratigraphy, paleogeography, geophysics, and even tectonics. They have been called upon: (1) to identify places of past biotic activity; (2) to interpret ancient depositional environments and paleosalinities; (3) to make correlations and age determinations; (4) to place limits of the time of origin of cyanophytes, oxygen-producing photosynthesis, filamentous habit of algae, and integrated biological communities; (5) to determine paleocurrent directions; (6) to map ancient shorelines; (7) to measure past tidal ranges; (8) to time the closest approach or the capture of our moon; (9) to determine ancient astronomical rhythms such as the length of the synodic month and the number of days per year; (10) to determine rates of sediment accumulation; (11) to determine paleolatitudes; (12) to prospect for base metal deposits; (13) to prospect for microfossils; (14) to make top-determinations in deformed sequences; (15) to serve as tourist attractions." A huge amount of work has been done after Hoffman's well delivered paper at the 46th Annual Meeting of the Society of Economic Paleontologists and Mineralogists, April 18, 1972, Denver, Colorado. Extraordinary claims need extraordinary evidence. Late Anant Dhume who wrote "cultural history of Goa" as surveyor had toured the whole state in his field based career of more than half a century. He could read geomorphology of Goa like a book. While editing his book I gained a lot of new knowledge about paleontology of Goa. He had mentioned about discovery of a marine conch at Rive, Thana, Sattari at a depth of half metre. I had asked him in 1984- "how is it possible to get marine fossils in Sattari, that too at an altitude of few hundred metres and more than 50 kms. from the sea?". He attributed it to paleotectonic activity. The detrital metasediment in Mahadayi basin points to the possibility of violent tectonic activity before the formation of Deccan flood basalt and orogeny of western ghats. Before publication of this article people would not have believed that the upper basin of Mahadayi river in Sattari was once ( at least 2.5-3 billion years ago) below the sea or was a shallow paleoseashore/ paleointertidal zone or may be even a paleoreef. And this sea or seashore was teeming with life as shown by the extraordinarily rich stromatolitic fossil rocks. Why stromatolite fossils were not previously reported?. Firstly there is poor emphasis on paleontology in education and research. The biogenic factors are often forgotten. Then these rocks are not located in a single place. Most of the time the currents mask or hide them. The exposed ones get mixed and easily camouflaged within the surrounding metasedimentary rocks. Not every folded rock is a stromatolite. A discovery can be made only if focussed, consistent, rational sampling efforts are done. This is a region of upper Mahadayi basin which no scientist from NIO, Goa University, GSI or any other educational or research institutions

has ever dared to enter. The terrain and the route is treacherous. The route is known only to the local people. Visit is possible only during late winter. According to experts, Stromatolites are shaped by a complex interaction of physical, chemical, and biological processes, and identifying unambiguous signatures of life from the preserved morphology of the structures can be extremely difficult. There is also need to identify the activities of benthic microbial communities. But such attempts face problems due to the process of diagenetic alteration, particularly recrystallization: a diagenetic process that commonly affects the chemical (precipitated) sediments with which stromatolites are often associated. Goa is teeming with such macro and microfossils. But palaeontology of Goa is a totally neglected subject. I have a piece of fossilized or silicized wood which was found during 1966-67 while building an approach road on Borim's Siddanath hill. How fossilized wood can be found at such an altitude?. Except NIO's Dr. Rajiv Nigam no scientist has paid any consistent attention to research on Goa's marine fossils which are still being mined for making mortar. The criminal neglect of fossils in Goa shows how little we care for challenging research. We should feel ashamed that after 1876 neither the government -Portuguese or Indian, nor the scientists and academicians followed this interesting lead which would have put Goa on world map of plant megafossils and could have boosted tourism in western ghats. Isabel, Lady Burton (1831 -1896) — née Isabel Arundell — was the wife and partner of explorer, adventurer, and writer Sir Richard Francis Burton (1821-1890). Sir Richard Burton had visited Goa and had written an account-Goa and the blue mountains in 1851. But the great adventurer missed what his wife later found. Lady Burton's visit took place somewhere in 1875-6. This is how she described her experience of visiting a site of petrified forest in Goa -“We made two boat expeditions together -- one to see a coffee plantation, in which is a petrified forest. Each expedition occupied two or three days. We embarked for the first in a filthy boat, full of unmentionable vermin, and started down the river in the evening, with storms of thunder and lightning and wind precluding the monsoon. On arrival we toiled up two miles of steep, rocky paths through cocoa groves. At the bottom of the hill was a little rivulet, and pieces of petrified wood were sticking to the bank. As we ascended the hill again we found the petrification scattered all over the ground; they were composed chiefly of palms and pines; and most interesting they were. “ (Source: Burton, Lady Isabel (1831-1896). Wilkins, W. H. (1860-1905). *The Romance of Isabel Lady Burton Volume II, The Story of Her Life, Told In Part by Herself and In Part by W. H. Wilkins.* Chapter 22). After 136 years I was probably following her trail blindly on an unusually warm November afternoon. This is a short report on my discovery of a new and exciting location of petrified forest-meaning plant/tree megafossils in Goa. This is not the same location reported by some fossil hunters in May 2012. They were actually confirming another 1876 report. I have inspected that location also and obtained samples for studies. Goa is land of micro, macro and megafossils. Marine fossils are plundered from Camurlim, Tuem, Agapur for making lime. Marine fossils are also located near Mapusa river. Sancoale or Shankhawali derives its' name from fossilized marine conches and windowpane oyster shells found in the soil there. There is belt of marine fossils from Cortalim to Chikhalim and Bambolim to Siridao on both the banks of Marmagoa bay. Since the trained scientists, except NIO's Dr. Nigam and his student have not cared to study these and such sites I was compelled to undertake the field and lab investigations. Work done by Dr. Nigam's students on marine fossils of Konkan showed relict presence

of *T. squamosa*. They explained it by the fact that it resided in this area and got encrusted on foraminiferal tests when the sea level was lower at ca. 10,000 yrs BP, thus indicating that at ca. 10,000 yrs BP, the Konkan shoreline was 80 m lower than that at present. No historian in Goa has understood the implications of such lower sea level for human migrations. The finding was published in January 2013 issue of GOA TODAY because there is an unhealthy and unethical competition to take false credit. I experienced it when rock art gallery was discovered in May 1993 at Usgali/Panasaimal, Kolamb, Rivona (Goa Today, June 1993). Hoards of fossil hunters may descend in Goa after publication of this article. Goa has violent tectonic past which resulted in rocks being folded and faulted, rivers changing their courses and entire forests becoming petrified. The legend of Parashurama abstracted these events. Portuguese suspected it. Lopes Mendes mentioned it. German geologist Oertel believed it. Anant Dhume was first historian to point to marine fossils in Sattari. He found a marine conch at Thane, Sattari and hinted at fossils at Ivrem khurd and budruk villages. He had even donated a petrified root specimen to Goa museum where it is not now traceable. During 1966-8, a road construction was undertaken on Bori hill. Mr. Percival Noronha, the then director of tourism, found fossilized tree trunks and petrified logs by the roadside and managed to retrieve a sample which he later gifted me. It was identified by Goa University geologists as silicized wood. However, no expert on geology of Goa could explain to me how plant megafossils could be found at an altitude of several hundred metres from present sea level. Then in upper reaches of Mhadei river basin I could detect rare fossilized stromatolites, the most ancient photosynthetic marine bacteria on earth, in photographs taken by Mr. Prakash Poreinkar during a three day trek to the source of river. This was first report of such ancient microfossils (<http://www.navhindtimes.in/panorama/neglected-stromatolite-fossils-go>) anywhere on west coast and western ghats of India. During my field trip in November 2012 for specific investigations of petrified forests reported by British geological adventurers in Sattari (Marchesetti, C. D. On a Pre-historic Monument of the Western Coast of India. Journ. Bombay Branch B. As. Soc. vol. xii. pp. 215-218. 8th April 1876) guided by Prakash Poreinkar, I discovered on the banks of Mhadei river and in the semi dry channel as well at a location called – JAGHDHA (location name changed) thousands of sq. mts of petrified forest comprising huge horizontally piled up petrified trees possibly monocots. The local rock formation is Vageri meta-greywacke/metabasalt in a banded Iron formation zone. The dating is difficult and would be shortly done by Birbal Sahani institute experts. B massive and deeply layered, richly textured, very hard but brittle plant megafossils are different than 20 million years old petrified trees found at the National Fossil Wood Park in Thiruvakkarai, located about 35 km from Puducherry. These belong to what is called the 'Mio-Pliocene' age. GSI experts say that these fossil woods were the result of a huge flood that occurred millions of years ago and destroyed large parts of forests in the adjoining area. The flood story for Goa is unknown. However going by the hard metabasaltic nature of the JAGHDHA, Sattari fossils may be as old as fossils of Akal Fossil Wood Park, Jaisalmer. These petrified wood carries signature of the luxuriant forests in a warm and humid climate, bordering the sea some 180 m.y. ago. The fossils are of petrophyllum, ptylophyllum, equisetitis species and dicotyledonous wood and gastropod shells of Lower Jurassic period. The JHADHA Sattari megafossils also differ from the petrified specimens in National Fossil Wood Park in Sattanur, Perambalur District which contains large trunks

of petrified trees of Upper Cretaceous age (100 m.y). The trees belong to conifers (non-flowering) that dominated the land vegetation during the period. The fossilised tree trunk at Sattanur measures over 18 m in length. The JHAGHDA petrified trees are horizontally piled up, and extend several metres in the river channel. The petrification event may be associated with the violent tectonic event of change in the course of Mhadei river. Experts have opined that this area was a geological high ( at least above 800 metres) when volcanism in Deccan, 63-66 million years ago formed the flood basaltic plateau. Fossil specimens which I have examined in laboratory clearly showed intact petrified vascular bundles, a lot of pyrite ( Iron sulphide) , black sulphides of Gold, silica grains and auriferous quartz. On basis of ecological, hydrological, local geological evidence and mineralogical basis, I wish to tentatively date these megafossils to 100-180 my may be more but dating is tricky and expert confirmation is awaited. My attempts since November 24 to contact the Chief Minister and arrange his visit to this sensational fossil site failed. I would try again. Only he can issue proper orders. The easily accessible and unprotected area needs surveillance otherwise within no time it would be plundered. A more detailed report would be published in this magazine later. The local village panchayat, the forest, the water resources department and collector, north Goa should take steps to protect this site immediately. It is actually a continuous belt of massive petrified forest extending from Bhironda to Khotodem and exposed only by the channel of river of Mhadei. The part which is buried is difficult to trace but may be exposed in trial trenches. We need to be grateful to Lady Burton for awakening us. Here is the nucleus for Goa's new geological park.

## **2. The neglected microbial wealth**

The world of microbes is vast and diverse, but so little is known about them in Goa despite their local diversity and economic usefulness. Microbes are microscopic organisms, not visible to naked eyes. They began life on earth some four billion years ago. They made plant and animal evolution possible by giving up their independent existence and getting incorporated as mitochondria and chloroplasts. It is a common man's and even trained scientists' superstition that rainwater directly falling from the clouds is pure and sterile. That explains why no microbiologist has ever studied it. But for past three years, inspired by the microbiological work of Brent Christner of Louisiana State University, I have been training students to identify the 'microbial life in monsoon clouds over Goa'. All that they do is collect samples of rainwater from different locations directly in sterile containers and examine these raindrops for presence of microorganisms- bacterial cells, algal cells and fungi. Results of past three years have indicated that Goa receives a mini shower of microorganisms. The full ecological, biological dimension and significance of this phenomena is yet to be investigated. But we are sure that within a few years "microbiology of monsoon clouds' would be a specialized area of study. Goa has lost the headstart given by microbiologist Froilano de Mello (1887-1955). He has left behind a rich legacy of original work on tropical microbial parasites. He is credited as finest and one of the pioneer protozoologist of India. Goa is actually sitting on a very valuable microbial wealth. There are hundreds of biotechnologically useful microbial species. The unprecedented top soil erosion is leaching out millions of tones of sediments to the sea. In this process Goa is

rapidly losing beneficial soil microbial diversity. Antibiotics are heavily prescribed in Goa but patients rarely complete the course. This leads to evolution of antibiotic resistant bacteria. For past sixty years the terrestrial and aquatic environments have been receiving antibiotic residues and antibiotic resistant mutating microorganisms which could pose a threat to humans. There is no count of what we have actually lost because the local soils are teeming with microorganisms which produce powerful antibiotics. Microbes do create problems as human, animal or plant pathogens or spoiling agents but many species also provide solution to pollution. Without microbes composting is not possible. Sewage treatment depends on microbes. People who prepare and consume fermented foods and beverages owe it to microorganisms. These tiny organisms are found in most unlikely places, even inside nuclear reactors. Microbes have perfected the art of survival. Scientists have been successful in reviving 225 million years old bacteria entombed in crystals of salt. Microbiologists and ecologists hesitate to make any guess about the actual number of the species on this planet. The age of biotechnology dawned with use of microorganisms and not any animals and plants. Even today students who learn the fundamentals of biotechnology have to begin and end with microorganisms. In other words most of the classical biotechnology is microbial biotechnology. Microbial diversity is ill understood and neglected in Goa. It would take several generations of research efforts to survey, map, catalogue, identify and bring into culture the microbial diversity of Goa. An ordinary crumb of soil would show the presence of hundreds of species. A spoonful of sediment from a stream, river or mangrove area would reveal amazing microbial diversity. Besides there are endophytic (within the plants) and endolithic (within the rocks), parasitic, symbiotic and mutualistic species. Research on microbes in Goa actually began with the introduction of Portuguese medicine. Froilano de Mello worked at bacteriological institute, Campal, Panaji from 1914-1945. His classical papers on hemoparasitology of Indian birds are still referred. He identified several new species. The first leprosanarium and TB sanitarium in Asia was founded in Goa. The old Goa medical college contributed immensely in understanding pathogenic microorganisms which cause various tropical diseases. Establishment of NIO in 1973 gave a boost to new dimension of marine microbiology. NIO microbiologists began surveying the microbial diversity of estuaries, mangroves, sediments, Off shore waters, beaches, sand dunes and the Arabian sea. Opening of post graduate department of Microbiology at CPIR under University of Bombay in 1973 also saw a new era in understanding microbial diversity in Goa. The ICAR at Old Goa also began working on agricultural microbiology in the 80s. Subsequently, establishment of new departments at Goa University-Marine science, biotechnology, Botany and Zoology also gave a tremendous boost to microbiological research. Establishment of a specialized polar research facility –the NCAOR at Vasco made it possible to study microbes under extremely cold conditions. A few years back the Goa campus of BITS, Pilani also added to the capacity in microbiological research. But despite the combined and cumulative efforts of microbiologists in Goa for past half a century, only a tip of the microbial iceberg has been scrapped. Considering different landforms in Goa, thousands of microhabitats are yet to be explored. There is poor knowledge of geomicrobiology and the presence of microbiota of deep bygone biospheres. Novel taxa can not be found unless hard field work is attempted. The Soil survey bureau of Nagpur prepared the soil atlas of Goa in 1995. It showed 25 distinct soil types. Each type is expected to have a different microbial diversity. But there is no

knowledge of soil microbial diversity of Goa. Some work on algae and cyanobacteria from lakes and streams have been attempted but the knowledge of freshwater microbes is very poor. Several lakes in south Goa have become sewage ponds harboring dangerous pathogens like leptospirillum. Almost nothing is known about the microbiology of waterfalls and stream sediments. Research at Goa university has shown the biotechnological potential of salt loving bacteria which belong to Archaea- the first group to appear on earth. It has proved that locally produced salt has medicinal properties due to beneficial halobacteria. The solution to beach pollution lies in the sands-microorganisms which utilize the tar ball residues for growth. The solution to mining pollution also lies within the mining area if we search for chemolithotrophic or rock eating and metal tolerating microorganisms. Soils of Goa have nitrogen fixing bacteria but there is poor research on these species. From marine environment to the western ghat ecosystem, Goa is endowed with a rich but underexplored and neglected microbial diversity. Soil erosion, habitat loss would further erode this wealth. Therefore, neglected microbes of Goa need much more attention than frogs, turtles and tigers because novel microbial products can serve the humanity and save the planet and help to revive even extinct animals.

### **3. Goa's most unique cyanobacterial wealth- Nostoc spherules**

World largest living organism by area occupied is a fungus *Armillaria* found in Oregon, USA spread over nine sq. kms. Goa's largest living organism by area could be the massive colony of the alga *Nostoc pruniforme* found at Bambolim-Taleigao-Dona Paula plateau spread over more than ten sq. kms. This species can be declared as "official cyanobacterial species of Goa". The millions of *Nostoc* spherules are Goa's own, least discussed "mother's eggs". Such sites like the one found at Harriman Springs Resort, near Rocky Point, Oregon are preserved in USA for their ecological and scientific value. But who cares for microbial heritage in Goa when there are rich rewards to be reaped by harping on more familiar and popular species?. It is amazing that in our own university campus such sites are systematically being destroyed under the pretext of biodiversity enrichment. We lost several locations where my students used to do ecological studies on *Nostoc* spherules. Here no biological impact assessment is ever conducted when earth moving equipments move in to blindly destroy entire habitats and communities. The *Nostoc* empire on this plateau could also be one of the oldest coastal prokaryotic colony. It is an ancient photosynthetic prokaryote, a cyanobacteria which has the capacity to fix atmospheric nitrogen. Such a useful natural species is completely neglected by landscape managers, agriculturists, photobiologists and biotechnologists due to their ignorance and indifference. The main monsoon vegetation on this lateritic plateau and similar coastal plateaus in Goa are the grasses. This property had compelled communities of Goa to reserve such areas as "gavthans" or community pastures. A rare species of Gondwana wild rice is also found on such plateaus. How these grasses can grow so fast and dense in just three months without any external nutrient subsidies in a nutrient poor soil?. I found the answer by closely looking at the root zones of the grasses. It is the processing of dry crust of dead *Nostoc* biomass which returns nitrogen rich nutrients to soil which are taken up by the roots of grasses. There are large patches of grass roots entwined by the *Nostoc* colonies. During the dry months if one pulls out a patch of these dry grass

roots then a large dry Nostoc mat gets easily separated exposing the surface of the laterite. The plateau experiences a drying and wetting cycle with a five months wet spell and seven months dry spell. Nostoc colonization is maximum between June to middle of August. Once intensity and duration of rains decrease Nostoc colonies also become dry and almost unrecognizable. Like desert varnish the dry crust of these colonies create continuous greenish black carpets which outwardly look as cakes of cowdung but once intensive showers take place and sunshine is cut off these crustose mats suddenly revive and the action of movement of rainwater over the carpets creates something not found documented by anyone. Yellowish green to dark green, semi transparent cerebroid gelatinous or jelly like spherules appear. These are often found in groups of 10 to hundreds. It is a joy to stand on the wind swept plateau with the rain beating on the umbrella and the rainwater washing your feet. And right in front of you is the magic of nature-a phenomenon totally neglected by all those blinded by only precision laboratory science. The Nostoc spherules get dislodged with flowing turbulent sheets of water and begin rolling on the plateau, while getting entangled by the grass roots, natural depressions and cavities and crevices in the spongelike lateritic rock surface. I have seen translocation of some spherules for a distance of several metres before their final entanglement. Generally the rolling speed is high on an incline or gradient and slow on a flat surface. The force of the current also disperses these spherules over large distances. So colonies of same species get dispersed year after year and then come to establish a giant clonal colony. The Nostoc pruniforme spherules collected and examined by my students showed uniquely buoyant property when dropped in water indicating their low density and probable presence of air cavities in the gelatinous matrix. The gelatinous nature also showed presence of an unidentified compound with exceptional swelling properties- similar to Jalshakti water absorbing synthetic polymer foam produced by National Chemical laboratory, Pune. We did not try using powdered dry and old biomass of Nostoc to check whether it can be revived as spherules after absorbing water. The unique wetting, swelling, expanding and then drying, contracting, collapsing feature of spherule forming ecotype, genotype and biotype of Nostoc pruniforme makes it a special case in algal biotechnology. This form is sensitive to humidity, temperature and light and prefers high to very high humidity, moderate temperature and only diffused light. Direct sunlight causes the spherules to shrink. This species is Goa's natural factory of nitrogenous biofertilizers. If its' wild habitat is conserved and studied scientifically then intelligent scientific clues can be obtained to control its' production. The relative ease of drying the spherules after water loss makes it an excellent candidate for mass propagation and biofertilizer formulation. Nostoc spherules could be easily mistaken as heaps of herbivores dung. Their colour merges with the ground vegetation. During the dry spell the spherules simply vanish and one finds a thin greenish mat on their original location. Such morphological mode switching from two dimensional stationary mats to three dimensional rolling, dynamic spherules and vice versa remains relatively under investigated in the area of phycology- the science of study of algae. This property also makes the species another excellent model in developmental biology and molecular morphogenesis. A time lapse series of photographs of the filamentous mat transforming into rolling spherules would be so interesting that it would open a new line of research in ecological genetics. The "mare's eggs" of Goa, is a living fossil, a primary producer, with high photosynthetic and Nitrogen fixing capacity



and deserves its' due place among the list of important species to be protected. Compared to known species there is more danger of extinction of relatively less known or unknown species like *Nostoc pruniforme* which may simply vanish after land use change, habitat modification and ecological simplification. The spherules have evolved in tune with the rocky plateau. The rare spherule forming *Nostoc pruniforme*, the unsung cyanobacterial species of Goa is as important as tigers and turtles, frogs and fish. But who cares?. Even the agriculture department has not heard of this species.

#### **4. The Neglected Forests of Goa**

Forests in Goa are of two types-government and private. Most of the government forests are confined to foothills of the western ghats and are drained by Mandovi, Zuari, Talpona and Galjibaga rivers. These forests have grown on soils formed by some of the world's most ancient rocks-more than two billion years old. In terms of valuation of ecosystem services the forests of Goa contribute Rs. 10000 crores per year. Latest satellite images show heavy fragmentation of forests of Goa. The supreme court has directed protection of both-government and private forests but Goa forest department develops cold feet over private forest conservation. "we can't stop burning of forests in private lands" the department told me when I had brought incidents of deliberate burning of forests at Bambolim, Kadamba plateau, Curca and Odxel, Taleigao to their notice. Forests of Goa have a bleak future if forest department is so helpless. The current year has been declared as International year of the forests by the UN. Goa's forest department dreads to celebrate this theme because it is actively encouraging illegal mining in government forest lands and permitting diversion of forest lands for dumping of ore rejects. The Goa assembly has taken a very serious note of failure of forest department to conserve and preserve the invaluable biotic assets. Several laterite stone quarries operate in Cotigao wildlife sanctuary. All the streams within sanctuaries are used for washing trucks transporting Iron ore. Rivers passing through sanctuaries are used for 'blast fisheries'. 'White rafting' is the new adventure sports illegally permitted by this department in Sattari. It is clueless about biodiversity of wild species and turns a blind eye to rampant daylight biopiracy – from bacteria to rare butterfly species from wildlife sanctuaries. The theme of world environment day, in 2011 was "Forest: Nature at your service". But once we enter the forests of Goa we find proof of mismanagement. Forest department of Goa never observes world environment day. Forests, wildlife and biodiversity in Goa have no saviours in the government. Only two percent of forests of Goa can be classified as 'dense forests'. Rest is just land under tree cover. A forest is a living, complex ecosystem. Nobody fences such ecosystems. But our forest department hands in gloves with contractors has decided to erect compound walls around wildlife sanctuaries- a thoughtless exercise and waste of public funds. The neglect of Goa's forests began in 1962. The MGP government created a forest contractors lobby. More than 25 thousand hectares of forests were cleared till 1979. Goa foundations' source book on Goa explains the tragedy of these years. Under the policy of 'regeneration'- endemic timber trees were auctioned and cut down mercilessly. A network of forest roads was opened for transport of the timber and other forest products. Species alien to Goa's forest such as Eucalyptus, Rubber, Acacia were planted. Monocultures of teak, Eucalyptus and cashew destroyed the wild biodiversity. Government under Mr. Pratapsingh Rane attempted to counter the

forest contractor's lobby by enacting "tree conservation act". But the deforestation continued. Forest department silently watched the elimination of green belts near urban areas, the clean shaving of densely vegetated hills, the denudation of green hills for mining. When I showed photographs of basalt quarries and blasting operations damaging the thickly forested Morlegarh mountain, in Sattari, the then chief forest conservator had remained silent. After a few years an uprising took place in Saleli village to close down the stone crushers- a tragedy which the forest department could have avoided by banning stone quarries in forested areas. To expedite unsustainable urbanization, the forest department cooperated with Planning and development authorities (PDAs) and town and country planning department by giving quick clearances to clear trees and forested areas. Removal of precious life support system in coastal areas of Goa has now endangered the ecological security. There is more soil erosion, high day time temperatures, aquifer depletion, biodiversity loss-thanks to indifference by forest department. The Kadamba plateau near Old Goa was thickly forested. Today it is turning into a concrete jungle. By neglecting the upkeep of dense forests, favourable conditions for entry of elephants from surrounding state were created. Forest department has no map of traditional corridors of animal migration or routes or sites of bird migration. Forest department has virtually no inventory of ancient human trails and archeologically important sites within its' property. Forest department silently watched the destruction of wild habitats of panthers, gaur and the migration of wild primates in settlement areas. Forests need natural regeneration with native, endemic species. The watersheds in the forests, the small springs, streams, rivulets need to be maintained in pristine conditions. But once you enter Bondla and Mahavir sanctuaries you are welcomed by plastic waste and heaps of empty liquor bottles. Quality of forests can be seen from the thick layers of mining dust coating the trees and the leaves. Forest department has no rules to regulate ecotourism or camping and trekking within the wildlife sanctuaries. This has encouraged picknickers, poachers and hunters. Even during afternoon loud explosions are heard within Mahavir sanctuary. For past 20 years a lot of discussion has taken place on arming the forest guards, providing wireless communications but in practice the forest department doesn't wish to improve field vigilance. The fear is that it would increase the load of litigations. Even inaccessible routes inside the deep, dense forests have been opened by private forest/ tourist guides who are minting money without any registration, licenses or authorization. Forests in Goa are not yet zoned into -"open" and "no entry core areas". So any amateur/tourist can roam freely anywhere. Forests with thin or open canopies are now invaded by Eupatorium-a dangerous weed. The invasive species are now marching interiors in wildlife sanctuaries. But the forest department has not taken any preventive or curative measures. The dreaded Kyasanur forest disease is a reality in Cotigao sanctuary. By neglect and mismanagement of forests of Goa the department is opening the quarantines of new vectorborne diseases. These would now reach the urban areas and create havoc. On world environment day, people may have to conclude that the real enemy of forests, wildlife, biodiversity and natural resources of Goa is the forest department itself. The proof is there in Goa assembly records.

## **5. The Neglected mushrooms of Goa**

Goa has a minimum five thousand years old tradition of ethnomycology and

ethnomycophagy. Worship of mushrooms is older than worship of tigers and serpents. The shamans of Kushavati culture consumed a psychedelic mushroom-*Psilocybe* found engraved on the rocky platform at Pansaimol. The land which worships the goddess of anthill-Santeri is systematically destroying her sacred mushrooms. The sacred processional umbrellas or ceremonial tarangas of goddess Santeri are based on the shape of mushrooms of *Termitomyces heimii*-the major edible species in Goa found in markets these days. After 25 years of research work on mushrooms, as I look back, I am horrified to see the trail of destruction of the wild habitats of ecologically and economically useful mushrooms. Edible species are vanishing due to overexploitation and habitat destruction. Non edible species are vanishing due to habitat modification and biopiracy by private companies and their paid local agents. Some of these species are endemic only to western ghats and Goa. More than 50 species of mushrooms, including 10-15 endemic to Goa are endangered and these include those which people prize the most- Roen olami or the termite hill species. For past five to ten years I could not spot species like *T. striatus*, *T. albuminosus*, *T. globulus*, *T. aurantiacus*, *T. medius*, *T. dudhsagarensis*, *T. mammiformis* in the market samples. In the wild habitats, the termite mounds appear barren because the mushroom gatherers pick up everything. The crops which come to market are from newer areas and mounds. Termite hill mushrooms are imported from Anmod, Dandeli, Khanapur and Banda, Sawantwadi area sensing opportunities to get high prices in Goa. This unrestricted trade would also deplete the diversity of the species in those states. But the mushroom pickers have no knowledge of the complex life cycle and biodiversity of these species. I have catalogued more than 100 species of edible mushrooms in Goa but traditionally local people collect only 40 species. Among these the highly valued species of *Termitomyces* cultivated in the wild by three different species of fungus grower termites capture the full market share. Due to political opposition and pressures from urban consumers the state government has also relaxed the ban on collection of the species from wild life sanctuaries. If the tribals or forest dwellers collect mushrooms for their own consumption then the forest guards should not harass them. The velips of Canacona even preserve several species of edible mushrooms. Somehow the new culture of tasting 'wild gourmet food' has hiked the demand for wild edible mushrooms. During July and August wild mushrooms worth Rs. 10 lakhs are sold in Panaji. A school going child selling small packets of mushrooms near syngenta factory, Dhulapi earns Rs. two thousand per day. By the time the same child reaches our university for higher education the species would be gone from her backyard habitat and neither she or her parents won't feel anything for the loss. During 1990, I had reported the smallest edible species of *Termitomyces* in world from termite hills near Old Goa. It was named *Termitomyces gomantakiensis*. After a gap of 20 years, with

difficulty I found just 10 specimens in a market sample, for which I had to pay Rs. 100. There was no alternative but to purchase these for study. Among the other threatened edible mushrooms of Goa we can include several species of *Boletus* ( *Boletus* species) and rare *Russula*, *Calocybe*, *Pluteus* species. Among the non edible species the most threatened is the living fossil- *Podaxis pistillaris* a gasteromycetes which is found on sand dunes. There is a close relationship of this fungus with the beech creeper *Ipomoea*. Between Baga to Benaulim with difficulty only a handful of specimens can be located. In our own campus, in front of my eyes wild habitat of a rare basidiolichen –*Omphalina* was destroyed in a frenzy of excavating pits. Fortunately I had recovered most of the details about habit, habitat, ecology and biology of this mushroom before the interference in its' habitat reduced its' population. Goans need to know that wild species of mushrooms which can not be cultivated should be left alone in their natural habitats and only if surplus crops appear then under scientific guidelines a small portion can be harvested. European countries have imposed a strict 'mushroom pickers' code'. Britain is leading in sensitizing its' citizens about the impact of mushroom forays on their natural populations. Mycologists have been warning People republic of China as it is destroying its' wild mushroom resources for foreign exchange. In Himachal Pradesh the wild crops of 'Gucchi' ( *Morchella esculenta*) a macroascomycetous mushroom began depleting due to overexploitation. This species is highly prized for its' flavour and gets a good price in western markets. Goa has no code for mushroom pickers. This has created a cartel of wild mushroom collectors who have been consistently defying the ban on the collection of wild *Termitomyces* mushrooms. What are the losses to humanity?. Scientists from Indian Institute of Chemical biology, Kolkota have worked since 1977 on a single species *Termitomyces clypeatus*, known in Goa as *khut olame*, *chochyale* or *toshale olame*, very common in Sanguem and Canacona. They have published more than 70 papers on this species and have identified several industrially useful enzymes. I was pleased to see nice growth of 'shit/shitol olami' or *Termitomyces microcarpus*, last year on August 21 at Bondla wild life sanctuary. For the meeting of wildlife advisory board I took some specimens with me to show to the chairman-the then CM of Goa Mr. Kamat. Whereas I was discussing the importance of systematic conservation of the wild species there was more interest in harvesting them. The CM even remarked that he couldn't see any crops in the markets. It is easy to convince common people on conservation of large carnivores or cute animals, beautiful birds and butterflies. But the neglected endangered mushrooms of Goa have no such support. Actually a living fossil like *Podaxis pistillaris* is in same category as *Oliver ridley* turtles. But the mushrooms appear for just a week. So who would worry about their rarity?. Recently the finding of

‘Clathrus ruber’, red cage mushroom, at Carmona, Salcete has shown the importance of guarding the village habitats which people take for granted. One rare species of mushroom can put a village on global map. It is our duty to protect what has survived, what exists for posterity

## **6. The neglected wildflowers**

Let us meet a botanist, phytosociologist Professor Stefan Porembski. To understand the knowledge value and existence value of wildflowers of Goa, we may have to travel 7000 kms. to visit him at the Institute of biosciences, University of Rostock, Germany. He specializes in ecology and biology of terrestrial habitat islands or Inselbergs. He has studied several rock outcrops, granitic and gneissic inselbergs and ferricretes. These are distinguished by extreme environmental conditions such as very thin layers of nutrient poor soil, high temperatures, limited water availability or wet spells followed by dry spells. If he sees a wildflower bloom then he would call that phenomenon- ephemeral flush vegetation (EFV). It represents a highly seasonal community characterized by the prevalence of specialized annual species. Stephen found that throughout the tropics EFV is constituted by taxa that are indicative for nutrient poor and seasonally wet localities. Wildflower species of Eriocaulaceae, Xyridaceae and carnivorous Lentibulariaceae and Droseraceae are mostly found in wet localities with good representation of wildflower species of the Poaceae, Cyperaceae and Commelinaceae. Phytosociologically Stephan found that rocky outcrops support EFV which belongs to the class Drosero-Xyridetea. *Eriocaulon sedwickii* and the insect trapping *Utricularia reticulata* species are very common in wet localities on plateaus in Goa. Thanks to my senior colleague in Botany department, angiosperm taxonomist, M. K. Janarthanam, I was introduced to Professor Porembski when he visited Goa. He may not find EFV in some of the locations which he had visited a decade ago. But phytosociologists like him know what it means to conserve and protect pristine landscapes which actually belong to the whole humanity. Wildflowers have no friends in Goa. One by one the best locations, the most secluded and pristine habitats of wildflowers are vanishing. A heavy toll has been taken by the land covered by 18 industrial estates. The landscaped Verna industrial estate and continuation of the same plateau in direction of Sancoale-Dabolim was once the largest habitat of these species. Goa sports about 200 species which can truly qualify as ‘wildflowers’ if we use the key given by Ingallahlikar. Among these at least 60-80 are threatened and 4-15 have become rare. Many of these are keystone species on plateaus essential for guilds of pollinating insects. If you carefully watch the tiny spiderflowers-*Justicia* species- a large number of wild honeybees would be seen visiting them before sunset. The later half of

July to middle of September is the best season for wildflower aficionados. This is the season of colorful wildflowers- these blooms are known as ephemeral flush vegetation (EFV). The best locations in Goa to view and appreciate are the plateaus. It is easy to identify all the species with pictorial keys given in Issac Kihimkars, "Common wild flowers" and Shrikant Ingalhallikar's, "Flowers of Sahyadri" which lists 500 species and 'Further flowers of Sahyadri' which lists an additional 900 species. Both the books cover 1700 species along the northern and central Sahyadris. Ingalhallikar's both colour monographs are indispensable field guides. The first species to appear in June are the species of Cleomaceae-the spiderflowers. There are three neglected species-Whiskered spider flower-Cleome gynandra, Common spider flower-cleome rutidosperma, and Yellow spider flower- Cleome viscosa. All three are ecologically and medicinally important. Anti inflammatory and anti cancer compounds have been detected in these species. Analgesic and antipyretic chemicals have also been found in these tiny species. Common small justicia- Justicia procumbens appear in big flushes. How many know that powerful anti tumour and anti viral compounds have been isolated from these species?. The wild relative of cultivated turmeric –Curcuma pseudomontana is first to be seen after the rains. Its' rhizomes yield essential oils with anti inflammatory and anti fungal properties. Blue fountain bush-Clerodendrum serratum has almost vanished from island of Tiswadi. A few stands are still seen near Bambolim bypass. Neeta Shrivastava and Tejas Patel B. V. Patel Pharmaceutical Education and Research Development (PERD) Centre, Ahmedabad have written an interesting review- "Clerodendrum and healthcare". The authors says that the genus is being used as medicines specifically in Indian, Chinese, Thai, Korean, Japanese systems of medicine for the treatment of various life threatening diseases such as syphilis, typhoid, cancer, jaundice and hypertension. But Clerodendrum wildflowers are totally neglected in Goa. How many Goans stop to appreciate the carpets of Graham's groundsel-Selecio grahami, decorating the hillslopes?. But even these flowers are under pressure due to dumping of mining rejects, solid waste and tourism activity. The Sirsaim hillsides once wore thick carpets of this species. Today mining reject covers this area. Trichosanthes curcumerina- wild fagalam produce lovely white flowers. Scientific interest has now made this species important because it yields Cucurbitacin B a chemical which kills the proliferating cells in breast cancer. What we lose when we lose wild relatives of cultivated plants? We would lose the gene pool. It is only from wild gene pool that scientists extract desirable genes to impart a particular trait in crop breeding. Among the wildflowers we have several relatives of cultivated crops. These include the members of Malvaceae family represented by wild ladies finger-jungli bhendi and ran bhendi, or Abelmoschus manihot ssp Tetraphyllus. This plant produces anti viral

chemicals. Country mallow-*abutilon indicum*, locally known as petari produces a chemical which kills mosquito larvae and another one which protects the liver. Besides closely related to cultivated species are wild musk melon-*Curcumis melo*, Spiny melon-*Curcumis prophetarum*, Bristle gourd-*Momordica dioica*, Madras pea pumpkin-*Mukia maderaspatana* and plants of bean family like common swordbean- *Canavalia gladiata*, Bombay bean-*Clitoria annua* and Butterfly bean-*Clitoria ternatea*. Climate change seems to be favourable to proliferation of flowering tubers like the Dragon stalk yalm-*Amorphophyllus commutatus*, taro-*Colocasia esculenta*. However their seed/tuber banks would be destroyed due to land use changes. Among all the wildflowers on Taleigao-Dona Paula plateau, I singled out two neglected photosensitive species-*Rhamphicarpa longiflora* or 'Tutari' and *Crotalaria retusa*- the rattleweed. *Rhamphicarpa* are also known as "five o'clock" flowers. *Crotalaria retusa* seems to have an intricate electrophysiological system which makes it open its petals in response to the angle of the sun in the sky and the light intensity. Both these wildflowers offer superb ecophysiological models to study the effect of climate change. Wildflowers need to be experienced, appreciated and systematically conserved to stop the neglect of their habitat and diversity. The 200 species in Goa host more than 1000 medicinally useful molecules and it would be a mistake to lose the 'pharmacy of nature'.

## 7. The neglected fruits of Goa

Three colourful varieties of cultivated Zamb (*Syzigium jambos*, pale green, coral red and pinkish), five different varieties of Jamun/Jambul (*Syzigium cumuni*), two rare annona (custard apple family) species -*Annona reticulosa* (bullock's heart) and *Annona muricata* (palpanas), three related species of cultivated jackfruit (*Artocarpus heterophyllus*), acidic bilimbi (*Averrhoa bilimbi*), carambolam or starfruit (*Averrhoa carambola*), raj aawla (*Phyllanthus acidus*), Adam's apple or adanva (*Mimusops/Manilkara kauki*), zagama and chafera belonging to *Flocurtia* species-this is not a complete list of neglected fruits of Goa. For past 50 years the agriculture department has done virtually nothing to promote these species. Clubbed under "minor fruit crops" there is only a limited academic interest in these fruits-many of which can be found only in Goa and Konkan. The Goa state horticulture corporation which is promoting cultivation of hybrid crops has also turned its back on these fruits and same is the story of Goa forest development corporation and the plantation wing of Forest department. So who would then encourage the cultivation of these fruit species?. These fruits attract premium price in the market. Zamb-*Syzigium jambos* is a nice, tasty, soft, fleshy fruit. The pale green variety is seen in market more frequently than the attractive small coral red and the very delicious and spongelike pinkish one. The last two varieties have become very rare now. A few families in Bardez and Salcete may have these trees. The pale green Zamb fruits are sold for Rs. 20 a dozen. These are semi ever green trees and provide nice shade in garden. Very few people engage in commercial plantation of Jamun or Jambul. Most of the stock which comes to

market is from collection from wild jambul trees. There are at least five varieties-the small pink, the small black, the medium pinkish black, the large purplish black and the large black. A large number of old jambul trees from Tiswadi, Bardez and Ponda have been cut. So now most of the supply of Jambul comes from Sawantwadi area. The prices have escalated to Rs. 80 per hundred. The Portuguese are credited with introduction of *Annona* species in India. But the government did not promote cultivation of bullock's heart and palpanas species. It is very rare to see these fruits in local markets despite their taste and value. Those who bring a few bullock's heart fruits to market demand premium price-Rs. 60-80 per fruit. Palpanas reminds one of Durian. It grows very well in soils of Bardez but there is negligible production. Goa is endowed with a rich diversity of *Artocarpus* fruits. Panas or the jackfruit is a major fruit of Goa. There is surplus production but no market. The crisp kapo variety and the juicy, rasal variety-both are popular. At least 50 products can be made from local jackfruits. Nothing goes to waste. Even the seeds can be roasted and consumed. Compared to jackfruit the story of breadfruit- *Artocarpus altilis*, is different. There is more demand and less supply. Breadfruit trees are well adapted to soils of Goa. A breadfruit promotion mission is required. A single large breadfruit is sold for Rs. 60 which shows how wealth can be generated from breadfruit plantations. Stress has to be given on diseases of breadfruit trees which cause fruit drop. For landscaping also breadfruits are excellent species. Being evergreen with wide canopy, breadfruit trees can add to the quality of local environment. Another rare but neglected variety is *Artocarpus integer*-it looks like jackfruit but is not the same species. However the agriculture department has no information on distribution of *Artocarpus heterophyllus* and *Artocarpus integer* species. It may wake up only after a multinational seed company makes them an offer to source germplasm of these species. Nothing has been done to promote otamb fruits produced by another *Artocarpus* species- *Artocarpus lakoocha*. The rind is a good source of organic acids. Although bilimbi and carambolam trees are common in Goa's rural areas. There is not much emphasis on improving the cultivar and promoting their value added products like –sliced, salted and dried bilimbi, bilimbi pickles, production of oxalic acid from bilimbi etc. Ripe bilimbis can be used for wine production. Carambolam make excellent pickles and jams. Both these fruits are not recommended for people with kidney problems as the oxalate content is high. Carambolam wine is popular in south east asia. A form of gooseberry-raj aawala- *Phyllanthus acidus* is an excellent source of Vitamin C. But people plant this species more for ornamental purposes and waste the abundant fruits. The fruits make tasty sweet and sour pickles and jams. Zagama and Chaferam are now rarely seen in the markets. These fruits of *Flocurtia* species have good nutritional value. At least Goa's major educational institutions could have raised gardens of these fruits. Portuguese planted Adanva trees near the churches and chapels. Then these beautiful evergreen trees spread to interiors of villages. But during the harvesting period (December-March) very small crops are now seen in the markets. Six years ago I had paid Rs. 300 for 100 fruits. There needs to be a systematic attempt to use these luxuriant trees for landscaping of church and temple premises. So far no thought has been given to use these species for roadside arboriculture. Goans patronised these fruits for several centuries because they love to experiment with novel plant species. It is the duty of the village panchayats to catalogue the wealth of the fruit trees in their jurisdiction and provide incentives to cultivators. Most of these fruit species are garden crops and don't require very large tracts of land for



cultivation. If villages in Tiswadi, Bardez, Ponda, Salcete and Marmagoa keep a target of planting just 10-20 trees of each of the above species every year then these areas would turn into a tropical fruit garden. National horticulture mission needs to be converted into State fruits promotion mission. Coloured fruits, fruits with phenolics and anti-oxidants, fruits with beneficial pigments have been highly recommended as probiotics to keep away various forms of diseases and cancers. Goans are compelled to eat temperate fruits imported from China, Australia, New Zealand, Chile only because there is inadequate supply of traditional seasonal fruits. The neglected fruits of Goa need focus of the civil society before their diversity is completely lost. Poor crops of Cashew and Mangoes indicate that local fruits have no real local champions. For the next generation photographs of Zams, bhedsa, palpanas, zagama, adanvas, chaferas may be the sole consolation.

## **8. Goa's neglected tuber ( kanaga) diversity**

What was the carbohydrate supply of our ancestors besides rice?. Wherever humans have migrated and settled during prehistory the starchy tuber crops have saved them. The monsoon has been favourable to tuber crops. Climate change may be actually beneficial to these starch storing species. This is exciting news because places like Goa which have a large tuber species diversity would benefit in Carbon marketing. A look around the campus since June told me that the unusual distribution of rainfall has favoured wide and luxuriant sprouting of all types of underground tubers and overground bulbils. It first began with a large number of Amorphophallus tuberous herbaceous plants which sprouted after the first showers in places where we never saw them for two decades. Amorphophallous flowering was followed by various edible aroids-taro, yams and then the aroid bat flower or Tacca species which reminds you of our high mast lamps. I found that tubers and bulbils have been well adapted to our lateritic grassland ecosystem, probably because these are fire resistant. I had earlier counted more than 300 spiny bulbils, a biomass of 25 - 40 kg. produced by a single Dioscorea liana. Till the rains appear these bulbils lie on the bare ground, dormant. Summer wildfires don't roast them. These species are efficient starch producing machines of the south west monsoon. So why are we looking elsewhere for tree species which can remove and store atmospheric Carbon dioxide when the bulbils show what they are capable of?. Their unusual density and wide distribution this season reminded me that tuber diversity of Goa has been totally neglected. If a little more attention is paid to their diversity, priceless traditional local cultivars, culinary or medicinal use by local people then some of these species could prove biotechnologically beneficial and their organized cultivation on large commercial scale can solve the problem of high energy carbohydrate rich foods. Besides the surplus crops can be used for fermentation and

value added food production. We have successfully utilized locally grown sweet potatoes or kongyo, to produce bioethanol on small scale. Tubers and bulbils are plant storage organs. Plants modify their organs-stems or roots to store carbohydrate and nutrients. The tuberlore of Goa tells us something about food security of our ancestors. The discovery of edible tubers and bulbils was made by the women food gatherers. They learnt to domesticate wild varieties of tubers and bulbils. Encounter with Portuguese also saw introduction of Sweet potatoes and Cassava. But the later is not as popular as in Kerala. Biodiversity of local tuber crops is reflected in their Konkani terms- Chirake, Kuka, bhut kanagam, madyo and alavamadi, (Alocasia), allavachyo mudlyo (Colocasia) , nagarkone, , kurpane, favring, kon, kond, teryakande, luti komb, suran ( Amorphophallous) , mhan, chinni, kanare, nangarchinni, natkondo etc. Each of this species forms important nutritional component of traditional Goan diet and especially the tribal food menu. Their edible leafy biomass is a rich source of fibre, proteins, vitamins and minerals. Some tubers are roasted and consumed. Some are sliced and cooked. Some are cut into large chunks and boiled with salt. Many end up in mixed vegetable preparations. When we explore the tuber crops offered for sale near highways in Goa we must realize that the agriculture department has not made any contribution to their cultivation in the past 50 years. It is more interested in wiping out local agrobiodiversity and pushing only the hybrid varieties. It has no checklist of tuber crops of Goa and no dedicated scheme to promote cultivation of Goan edible tubers and bulbils. Such a neglect is unprecedented when one considers that tuber crops are well suited to Goa and there is a growing market for value added products like wafers, chips. Farmers are taking these crops for past three thousand years by maintaining the wild germplasm. In any fertile area there are seed banks of wild tubers and bulbils. It is only during the monsoon one can see their sprouting. Peoples' knowledge of tuber diversity of Goa is astounding. Common name for tubers is "kanaga" and "karande" for bulbils. But sweet potatoes –kongyo, are distinguished from the spiny ones- kate kongyo. If the sandy, soft fields of Siridao and Agacaim are famous for sweet potatoes then the best crops of spiny tubers are produced at Keri, Sattari. These " kate kanagas", a post monsoon, early winter crop is highly prized for texture and flavour. Ponda taluka produces a wide range of Alocasia, Colocasia and yams or surans. These are marketed at Banastarim and Ponda. Traditionally Goans have used a variety of plant storage organs of different colors, shapes, sizes, textures, tastes and starch content. Some species contain cyanogenic glycosides. But Goans learnt the art of removing this toxic principle following their experience with tender bamboo shoots. That's how the traditional Goan wafers- the deep fried white, crunchy Mhanam which one sees being sold during zattras and feasts were prepared from a bitter species of

bulbils-Dioscorea species. Worldwide there are 600 species of Dioscorea. The liana like habit of these bulbils creates nuisance by covering trees, lamp posts, overhead cables. In our university campus there are at least 5-6 species of Dioscorea. But what we know about more than 40 species of tuber crops of Goa?. Their geographical races are not well documented. Only 15 to 20 are found sold in urban markets. These include yams, edible aroids and sweet potatoes. About 5-10 species of mostly various types of yams would be seen in roadside stalls in small quantities. Tiny tubers or kunka are being sold in south Goa. In some arecanut orchards people take intercrops of edible aroids. It is not known when the first cultivation of sweet potatoes began in Goa. But the farmers could have experimented with the crops. The local cultivars show a peculiar mixture of various strains. There are white, creamish, yellowish, orange red, reddish, pinkish red and purplish sweet potatoes. Besides there are some bland or low sugar and some sweeter varieties. Even within the “kate kanagas” different stains can be easily spotted. These vary in size, shape, thickness of the skin and the texture of the starch. Experts have expressed danger of agricultural simplification-the aggressive promotion of a few hybrid food crops by the consortium of government departments and the MNC seed companies. What then happens to Goa’s tuber diversity?. The exodus of local tuber cultivators to hybrid cash crops may spell an end to tuber agrobiodiversity in a few years

## **9. Neglected Capsicum (mirsang) diversity**

What these local names of various cultivars of local chillies of Genus Capsicum mean to us?. How many varieties of Chillies are cultivated in Goa?. The estimate ranges from 23 to 45 with verifiable samples of 30 varieties seen by this author. Each cultivar has its’ own history, biology and story to tell. Each of the cultivar is a repository of useful genes. Some of these genes code for the colourful pigments-mostly carotenoids. Some code for the pungent principle Capsaicin. This chemical is highly sought in pharmaceutical industry as an anti-inflammatory agent. A tentative survey reveals that at least 15 generations of farmers have worked on selection of these local varieties. More important is their sense of preservation of this precious germplasm without any practical government support. In biomass, colour, size, shape, taste, flavour and pungency/hotness all these cultivars differ. We are talking about Goa’s traditional capsicum cultivars like- the neglected Moidechi moti mirsang ( the large Capsicum variety only produced at Moira village in Bardez) , Aldonechi moti kali mirsang, Aldonechi kali gaunti kashmiri mirsang ( both varieties are grown only at Aldona by a few families), Morjechi mirsang ( the rare variety cultivated at Morajim, Pernem) , lambat mirsang, motvi kamtanchi mirsang, Chandelche barik butao ( a variety

specific to village Chandel in Pernem) , Datt salichi massoori mirsang, Mandrechi mirsang ( the famous Mandrem variety) , Sataritli gaunti mirsang, dhangari pavsali mirsang ( a variety adapted to western gahts of Goa and specially cultivated by the Gouly agropastoralists) , bugdi mirsang, dhangari unhali mirsang, patal salichi masoori mirsang, Harmalche butao ( the small variety from Arambol, Pernem) , Talgaonche battoo, Cuncolechi mirsang, Portugali mirsang (seven varieties, the smallest is called piment malaget), Pandhri jalgi mirsang, tambdi jalgi mirsang, dhavi lavngi mirsang, tambdi moti portugali mirsang, and lamb taroti mirsang. Goan cuisine would lose its' soul without the local chillies. Food cooked by replacing local chillies with imported varieties would never be authentic Goan cuisine. The species in Genus Capsicum, chillies of Goa are now in real danger. The origin of Capsicum annum and C. frutescens is South America. The government would be pleased if all the chilli farmers in Goa switch over to just one single hybrid variety. This is effect of globalization. The first, last and the only official report on production and marketing of local chillies was published by the state marketing officer some thirty years ago. It laid emphasis on the popular "Harmal" and "kholachi" varieties. The local cultivar diversity of chillies has been consistently neglected during past 30 years. All these varieties genuinely deserve registration under GIP act. The most serious form of corruption is to eliminate a country's biodiversity and especially the precious agrobiodiversity and permit the profit and market driven seed companies to introduce genetically identical cash crops everywhere. Post WTO the major aim of first world seed companies is to systematically engineer ecological and genetic simplification in third world agriculture. Whereas only monetary forms of corruption are discussed the biological modes are ignored. Similar o more than 100 local varieties of mangoes , Goa also has a large and precious gene pool of genus Capsicum-commonly known as chillies, chilli pepper, mirchi, myrsang etc. Indian cuisine used black pepper (miri) for pungency before the Portuguese introduced Capsicum species in Goa as a novel, exotic crop. The biopirates are interested in stealing the 30 precious local varieties of chillies. After some improvement the same varieties could be sold to Indian farmers. I have no doubts that any systematic molecular breeding programme to produce transgenic Capsicum species suitable to India's hot and humid climate would need to access the Goan chilli varieties. Completely orphaned by the state government and dismissed by the agriculture department, the Goan Capsicum agrobiodiversity has no supporters. The shameless sale of local varieties of Brinjals to greedy biopirates of Seed MNCs and the mental slavery of some spineless Indian scientists has come under scanner in Karnataka and Kerala which are up in arms against transgenic brinjals. The Goa government has admitted in the assembly that its' statutory biodiversity board was not aware of transgenic

research using local varieties of Brinjals- the much sought after Agacaim and Taleigao varieties. But to everyone's horror the field trials of transgenic brinjals took place at government farm , Margao, blessed by Goa's agriculture department which admittedly knows nothing about plant genetic engineering. Countries signatory to biodiversity convention have laid down strong measures to safeguard their agrobiodiversity. The local Capsicum varieties are genetic time capsules. Once lost it is difficult to revive them. Goa's food security depends on conservation, protection and promotion of this local germplasm. Besides their specific culinary applications, the local cultivars also have medicinal uses. Many local cultivars are adapted to stressful conditions and microbial plant pathogens. Fungal diseases is a major problem in chilli cultivation. Local varieties which show resistance to fungal diseases would be targeted by the biopirates. Who owns these neglected varieties?. The ownership rightfully belongs to farmers in those villages famous for one or more Capsicum varieties. Naturally without their informed consent, permission and equitable profit sharing based on written statutory agreement mandated by community biodiversity committees and endorsed by the Gramsabhas it would be an offense to steal these seeds and pass these to transgenic Capsicum researchers. Major Capsicum cultivator villages like Moira, Chandel, Aldona, Taleigao, Morajim, Arambol, Mandrem, Cuncolim, Khola, Gaudongri, Cotigao, Morpirala, Keri need to be given special incentives to conserve the traditional germplasm. As compared to past, smaller crops of many local varieties of abovementioned chillies appear in village markets and during Zatras and feasts. Some varieties have become rare and expensive. Aggressive promotion of green chillies by the government has also tempted many farmers to switch over from cultivation of traditional varieties. Just as hybrid rice varieties slowly began to replace the salt resistant and flood resistant local rice varieties, the local Capsicum varieties are likely to meet a similar fate despite attracting a premium price in the market from gourmet customers. Goan cuisine is inseparable from local chillies. Gradual extinction of biodiversity of local Capsicum species would also change the idiom of Goan cuisine. Such cultural loss has been anticipated by biodiversity experts. Village panchayats in Goa are actually sitting over a goldmine of precious agrobiodiversity. If Capsicum cultivator villages draw an action plan for conservation, protection, GIP registration, promotion, marketing and value addition of their famous cultivars of chillies then purpose of this monograph would have been served.

## **10. Neglected Rice Diversity**

Rice is staple food of Goa with curry (humon) and fish. Food security of Goa like rest of India is intimately linked to

rice production. Genetic and ecological security of Goa is linked to conservation of local rice genetic diversity. The mysterious names of traditional rice varieties of Goa hide the story of their origin and domestication. These are unique names which throw a challenge to linguists and anthropologists. Damgo, Kalo damgo, Babri, Dodig, Kochri or Khochri, Patni, Corgut or Korgut, Kalo korgut, Asago, Kendal, Kenal, Vadlo Kenal, Sotti, Giresal, Xitto, Nermar, Mudgo, Shirdi, Belo, Noxvan, Dongri, Valai or Valay, Chagar, Kusago, Runga, Odusko, Panyo, Mutalgo, Barik kudi, Dhawe, Ek Kadi, Ghansal, Girga, Kalo novan, Kalo Mungo, Karz, Kolyo, Kotmirsal, Masuri, Muno, Ner, Sal, Taysu, Shiedi and Tamde Jyoti. Among these at least 20 varieties tolerate saline or salty soils like the Khazans. Kendal and Kochri are cultivated in sandy soils. Patni is upland rice. Panyo tolerates flooding. Names like sal and Giresal indicate Mauryan influence. Villages like Sal in Bicholim and Saligao in Bardez could have been granaries of these rice varieties. Rice has an astounding diversity. Strains differ in colour ranging from white to red, brown and black. One can distinguish different rice varieties by studying their habitat; plant height; leaf shape, size and colour; ligule and auricle; grain shape, size and colour; features of the panicle; sterile/fertile lemma; and the awn. Such a variation was engineered by generation of rice farmers and natural evolutionary processes. Rice of different types can be differentiated one from another on the basis of various characters. For instance, there is the yield and duration of the crop. Rice varieties also vary in terms of their ability to withstand excess or shortage of water, their ability to grow in acid, alkaline or saline conditions, and their resistance to pests and diseases. Indian rice researchers, Richharia and Govindasamy in their 1990 publication “Rices of India” claimed that India is endowed with 200 thousand rice varieties. In Chhatisgarh region itself Richharia had identified 20000 rice varieties. It is known that about 50 thousand varieties are being cultivated across the country. But this number has rapidly fallen during the “green revolution”. Deb (2005) in his “Seeds of Tradition, Seeds of Future” provided detailed morphological descriptions of 416 Indian folk (traditional) rice varieties, which are on the verge of extinction from farmers’ fields. The picture is not different in Goa. Despite consistent and critical scientific attention to studies on rice diversity of Goa at Botany department at Goa University, there is little hope for the existing traditional rice diversity unless the farmers find it attractive to cultivate the traditional varieties. In all the villages known for traditional rice varieties the government has to provide attractive incentives to establish community seed banks and cultivate rice strains only for germplasm conservation. Just as there is growing demand for elite varieties of mangoes of Goa-there would be demand for rare and nutritious rice varieties. But Government of Goa is

silently watching the annihilation of precious rice varieties –the crop genetic heritage which once lost would be lost forever from this planet. All these varieties are not less than 3000 years old. These varieties can withstand water stress, are resistant to pests and diseases, adapted to local soils and their cultivation is economical. Their yield is 10 percent more than high yielding varieties (HYV). As we had seen in the previous article on Capsicum diversity, it is difficult to arrive at a correct estimate of local, traditional rice diversity of Goa. I could count 42 traditional rice varieties but my colleague, Rice biologist Dr. Sellappan Krishnan informed me that despite three years of survey work his team could locate only 29 local varieties. His survey may not have adequately covered Sanguem, Sattari and Quepem talukas. Varieties cultivated and directly consumed by tribals of Goa may never appear in market. Rice cultivation first began in Yangtze valley in China about ten thousand years ago. The sino Tibetans introduced it in northern India about six thousand years ago. In western India, Konkan and Goa, domestication of rice took place about 3500 years ago. Rice was not brought by Negritoes or the Austriacs. There is interesting correlation between megalithic culture and the domestication of rice in Goa. The first rice cultivators settled in western ghats. Then they reached the coastal plains. The Khazans were designed only for domesticating salt tolerant rice. The success led to proliferation of salt tolerant varieties in Mandovi and Zuari estuarine zone. Bhonsle and Krishnan (2011) in their paper on traditional salt varieties grown in Khazan lands of Goa collected Assgo, Bello, Korgut, Kalo Korgut, Damgo, Kalo damgo, Kalo Novan, Khochro, Muno and Shiedi. Their aim was to evaluate the local varieties for systematic breeding programme. Since high yielding varieties introduced in Goa with innumerable subsidies have failed the future breeding programme in rice research may be confined to improvement in grain quality instead of focus on high yields. The micronutrient content of Goan rice varieties has not been analysed. The red rices are expected to have high carotene content. ‘Ukdya tandalchi pez’, the starchy, thick gruel prepared from red variety of local rice is still a favourite of local people. But the red rices are now getting imported from Kerala. Bhonsle and Krishnan (2010) also compared 22 traditionally cultivated and three HYV. In terms of best cooking quality (appearance, cohesiveness, tenderness on touching, tenderness on chewing, taste, aroma, elongation) they identified Korgut, Tamde Jyoti, Dhava, Kenal, Kendal, Vadlo Kenal as the best varieties. This is certification of their genetic potential. Unfortunately farmers are neglecting cultivation of highly ranked varieties like Korgut identified by the researchers as most promising for its’ salt tolerance and cooking quality. Neglect by farmers and neglect by government would not only harm the future conservation of these precious varieties but it would deprive the legal owners of the

seeds –the farmers themselves if they lose what their forefathers had conserved over centuries. It is duty of hibernating state biodiversity board, village panchayats and NGOs to promote the knowledge of Goa's rice diversity, stop biopiracy and help to conserve what remains. The festival of Worship of Lord Ganesh is linked to domestication of rice in western India. Therefore it was thought appropriate to end the series on biodiversity on the eve of the rice worshipping festival.

## 11. The Neglected insects

Insects belong to Phylum arthropoda, class insecta which includes 31 orders. They appeared on earth 400 million years ago. The official list of insect diversity of Goa includes only 349 species. There is more emphasis on dragonflies and damselflies, butterflies, scorpions and spiders. This is just a tip of iceberg because insect diversity of Goa cataloguing all 31 orders is completely neglected. The number is not consistent with 60 thousand insect species so far reported in India. The knowledge of insects like aphids is very poor. There are more than 1000 species of insects in our university campus itself in less than two sq. kms. area. Last year between June to November I had photographed 60 different species of nocturnal phototropic moths sitting on the wall of a single room in our faculty building. The number of moth species in world is estimated to be about quarter millions. But we don't even have a checklist of moth species of Goa. About one third of all the species surveyed and catalogued in the world are insects. The present number of known insect species is about one million. It is estimated that their actual number may be of the order of two to 30 millions. As compared to any other higher faunal taxa, insects are least surveyed considering their vast numbers. It is said that if one fumigates canopy of a large tree in Amazonian forests then hundreds of species of beetles would be found raining down. They say that insect diversity in a hectare of Amazon rainforest is higher than the whole of France. In our campus a single bush of *Ziziphus oenoplia* (jackal' jujube) which I studied from flowering to fruiting showed 300 different species of associated insects. A quick estimate of number of insects entering and leaving or adapted to domestic environment in a typical grassland ecosystem showed more than 300 species. Among these ants, beetles, flies, wasps and moths predominated. My intellectual association with the world of insects began during my doctoral research work on fungi cultivated by termites-the termitophilic mushrooms of Goa. It showed me the complex ecological and biological dimension of the world of termites. Work done by French entomologists Grasse, Noirot, American entomologists Lakh and Susan Batra and the wonderful work done on termites and their habitats by J. Scott Turner (visit <http://www.esf.edu/efb/turner/Turner.htm>) was awe inspiring. Myrmecology is the study of ants. Founder of Socio-biology and the great champion of biodiversity conservation, Pulitzer award winner Dr. Edward O. Wilson devoted his life to the study of ants. His tome "The Ants" co-authored with Dr. Holldobler is a model study for world's entomologists. Goa is a land of prodigious insect diversity. But there are very few dedicated entomologists who would be able to survey and tell us the actual biodiversity of insects. Dr. Ganihar from Biology department of Dhempe college had catalogued more than 600 insect species from mining areas of Goa. This work remains unpublished. The Malaria research centre had catalogued 60 species of mosquitoes in Goa. But we have



little information about other arthropods like ticks. Every year more than 50 people die in Goa due to Arthropod borne haemorrhagic fever (ABHF). To know more about ABHF we need more information on vectors like ticks. Ticks are not useful insects but climate change may breed and spread them in human settlements. There are three aspects of neglected insect diversity of Goa. The first is the carelessness about the species diversity, habitat and life cycle of ecologically and economically beneficial insects, second is the lack of detail data about insect pests, invasive insect species and emerging insect pests, third is the lack of data about insects threatening humans and animals. Ants and termites could be seen as either beneficial or pests. Both play a very important role in biogeochemical cycling. Among the beneficial insects we need to include the wild honeybees and the bumblebees which are expert pollinators. Wild honeybees are neglected and misunderstood because sometimes if their hives get disturbed then they may chase the attacker. The small wild honeybees possibly *Apis florea* is dominant on plateaus of Goa during the monsoon. These small honeybees pollinate the vast carpets of wildflowers. They build small hives known locally as “mhovancho shiso” (a cask of honey). Among the beneficial ants we need to include the red weaver ant-*Oecophylla smaragdina* which builds arboreal nests and attacks any invasive faunal species. Slowly this species is emerging as a dominant arboreal species in Goa. If the trees are densely planted then this species colonizes all the canopies and builds a network of arboreal routes. Spiders are very beneficial. Spiders in garden and on windows trap mosquitoes. Spider diversity is essential to control the menace of unwanted flying insects. *Photinus* and *Photuris* are the two genera of fireflies which I located in Goa. These appear with pre-monsoon showers and then hibernate at the end of November. Burning of ground and litter, spray of pesticides, strong illumination at night and deforestation is affecting the firefly diversity, distribution and density everywhere in Goa. To create awareness on firefly conservation I have launched “Save firefly campaign”. The blog of the campaign can be seen at <http://www.kazule.blogspot.com>. It includes a list of 18 videolinks based on my studies of fireflies in Goa University campus. The real beneficiaries of climate change are the termites. *Macrotermes*, *Odontotermes* and *Microtermes* are the three major genera of termites in Goa. These build different types of mounds. Termite control and elimination from human settlements would be a major enterprise in this century. The knowledge on dampwood termites of Goa is also poor but these are now entering the houses through small cracks in flooring and walls. The paper wasps attract attention only when they sting some humans. But we can't permit these dangerous species anywhere close to human settlements. The stinging wasps, yellowjackets are best protected in their original wild habitats. Being predatory these social insects help to control insect population. There is more interest in Goa in butterflies but the rest of the insect species are waiting for attention. The neglect of insect diversity in Goa is a serious issue for ecosystem maintenance, crop production, human welfare, public health and sustainable development. Climate change would boost insect population-but we're ill prepared to cope with a world dominated with insects which we don't know.

## **12. The Neglected and vanishing Fireflies**

Fireflies are least discussed neglected luminescent beetles of Goa of the family Lampyridae. The jobs which experts in Goa and India are supposed to do is done by

common firefly watchers in USA where the museum of science , Boston has created world's largest citizen movement for firefly sightings (try <https://www.mos.org/fireflywatch/>). When she came across my efforts in Goa to create awareness on conservation of fireflies and watched my You Tube videoclips on fireflies of Goa- Miss Hess Morgan, a high school student from Washington, DC, USA fully involved in firefly surveys wrote to me on May 15. " I am writing from the Washington , D.C. area, and have been on the fireflywatch site for 2 years. I agree with you about the fact that everyone makes a big deal about all the big carnivores, but not much about insects and not our beloved fireflies. Great for you for starting the program in Goa. Unlike most of the people on the Watch site, I really had to know all I could about fireflies. I read all the papers I could lay my hands on, and since I have a science background, it was not too hard to understand what was being said. I got to visit with the premier firefly researcher in the US, Dr. James Lloyd. He has collections of all the fireflies in the US. I loved getting all the information, and we went out fireflying. I am interested in identifying our local fireflies, because I want to see if they are still around. We had 2 local firefly observers, Herbert Barber, and Frank McDermott. They are no longer alive, but they sorted out what was around the local area, and I want to see if they are still here. It has not been easy. " I was further impressed by this school student's research aptitude- she wrote-" Last October, I took a couple of Photuris larvae , and put them into a fish tank with worms and other succulent larvae, and ignored them for the winter. They were kept in a cold room. Couple of weeks ago, I put the tank in the living room, and tonight, as I was walking by, there was an adult firefly flashing ! ( I really did not think anything would hatch) I think its a she, but I will check tomorrow. I love Photuris! They will flash for a person until about 4 am in the darkness. I was interested in your videos, and wondered if the fireflies are warmer than their environment, because in the IR video, they are brighter than their background. " At the end of her mail was this encouraging sentence-" Just wanted to be supportive of your work, even though I am a half a world away. " This is the spirit which we completely lack in Goa about our neglected species. The life cycle of a firefly typical of a coleopteran begins with the egg stage, followed by an overwintering larval stage of a number of instars, then by pupation in the summer, and eventual eclosion as an adult, usually before the monsoon. Photinus larvae are only rarely found on the surface, as they spend most of their lives under the leaf litter or in the soil. Photuris larvae, in contrast, are found in large numbers at night on the surface. This larval life stage is carnivorous. The larvae feed on other insect larvae, worms, and molluscs, which they immobilize by injecting poison into them through their curved mandibles. Occasionally in our campus I have seen these larvae crossing the road and also illuminating a small area like a microtorchlight. Fireflies in Goa would be confined soon to the interior regions, wildlife sanctuaries unless their normal habitat is protected in coastal and midland talukas. As a backyard natural historian I have been studying fireflies for the past 15 years. Intensive observations have been made since 2001 and these help to prove that firefly diversity, density and distribution is diminishing all over Goa and especially in urban, suburban and developed areas. There is a craze to burn the garden litter and all types of biodegradable waste. Burning litter and damage to the soil disturbs the life cycle of these species. How serious is the status of this neglected species?. I have seen the population of both Photinus and Photuris diminishing every year. Photinus prefers large fern covered areas where I could see their larvae almost at the

end of the monsoon. Without special equipment it is difficult to measure the type and duration of firefly flashes. But why they flash?. The flash of a firefly, a brilliant burst of light lasting fractions of a second, is a signal in a courtship and mating communication system in which species and sexual identity are conferred by flash timing parameters. Experts have found that they communicate by one of two basic flash codes. The simplest code is typified by *Photinus pyralis*, the most widespread firefly common in both USA and India. It involves a series of consecutive flashes emitted by the male at intervals of about 6 seconds at 23 deg. C and a single flash answer by the female approximately 2 seconds after each male flash. A few years ago, my house was flooded with fireflies since the windows were open at night. It was a eerie experience. This year very few sightings have been made. Ms. Hess in response to sharing of my firefly observations wrote back- "Last year in our " season" , we had the TV on ,and I noticed that there were fireflies trying to get through the glass because they thought that the TV was a female! What's more, these males were flashing their mating pattern. It was so cool to see them so close in action. Those are called *Photuris versicolor*, and around here, have a pattern of a fast triple flash. Someone has studied them, and the males, at least, can copy at least 12 patterns of other fireflies, to flush out the females, who , of course, are copying female response patterns of other females to eat other male fireflies. Do you have *Photuris* over there that also do that?. Do you have any fireflies that make an orange or yellow color?." " To this inquisitive student I sent some research papers on fireflies in India. World and Goa too need an army of inquisitive and involved students like Ms. Hess.

### **13. The Neglected Birds**

Goa is not only a tourist paradise but also a paradise of birds representing an awesome 37 percent of country's avian diversity. Unfortunately this diversity is taken for granted and almost nothing is being done to identify, conserve and protect the pristine habitats of birds. Birds face twin challenges-coping with climate change and the human interference in their habitats. More than 100 species of birds in Goa are neglected. These include familiar species like sparrows, bee eaters, larks, woodpeckers, thrushes, warblers. Appreciation of birds is different than transparent, uncompromising, sustained concern for conservation of their wild, natural habitats. I remember the enriching hours spent in the company of prolific wildlife writer Sahitya Akademi award winner, Maruti Chitampalli. All his books in Marathi are soaked in heartfelt compassion for the wild species. He compiled the *Pakshikosha*-encyclopedia on birds in Marathi. It includes several bird names from Goa and Konkan. During one of his Goa visits, he expressed the desire to visit the nesting sites of white bellied sea eagle -*Haliaeetus leucogaster*. I advised him to explore Kadamba plateau. But this bird is normal visitor to fishing hamlets of Odxel ward of Taleigao village. It has some nests on a giant banyan tree which towers above the small houses under its' canopy. After the eyesore commercial cum residential project comes up behind this habitat, the birds would vanish. Those who love birds have automatic duty to do everything to protect their habitats. Academic studies often end up in aesthetic narcissism. Many times outside the very seminar halls the bird habitats may be endangered but the experts don't pay any attention. Besides official state level apathy, the cultivated and institutionalised disconnect between publication oriented academism and conservation oriented activism is basic cause of the

demise of bird diversity in Goa, except for a few pockets like our university campus where Professor Shanbhag and his research students have documented 114 species of birds in less than two sq.km. area. Do you miss in your neighbourhood, the chimani, the house sparrow (*Passer domesticus*), the chiutai of local lullabies and rhymes?. In our university canteen we used to have several of them. But one by one they vanished. There are disturbing reports from urban areas of Goa about the disappearance of the sparrows. This raises a serious question about our concern regarding the familiar and not so familiar birds of Goa. Where are the long billed vultures of Goa-the *Gyps indicus* species?. During my visits to the Vaishnavite monastery of Partagal, decades ago, I used to be scared of these large, ugly looking birds feeding on dead animals deposited on the banks of Talpona river. About a decade back we spotted long billed vulture above Calapur's Bondval lake. I remember large flocks of vultures near Goa Meat complex, Usgao several years back and big white rumped vultures on the banks of Assolna rivulet near Chinchinim. Vultures are critically endangered species. But the poor birds have no support like Project Tiger. Goa has a rich avian diversity. Foreign tourists flock to Goa to capture snapshots of their favourite winged friends. Bird watching related ecotourism has benefitted many self educated local guides and amateur bird watchers. Ornithologists like Parag Ranganekar , Ajay Gramopadhye and well known wildlife artist and BNHS specialists like Carl De Silva have dedicated themselves to spread awareness about the avian diversity. But there is no organised, sustained movement to identify, conserve and protect the habitats of birds which are slowly disappearing. British birder Steve Blain visits Goa to capture the beauty and magic of birds. His blog <http://steveblain.blogspot.com/2008/02/kingfishers-of-go.html> has beautiful images of seven species of kingfishers found in Goa. In this paradise of birds we have the right to be woken up early morning by a cacophony of ornithological melodies. The coels and cuckoos regale us during summer. Without flowerpeckers and sunbirds our gardens would not look lively and lovely. Goan countryside misses the woodpeckers with their peculiar knocking sounds. In several villages, farmers consider the national bird-Indian peafowl as a pest, a nuisance. But the problem of bird nutrition is often manmade. Traditionally, till end of the past century in most of the villages owners used to leave behind some fruits or pods on the trees without harvesting. In villages of 'new conquests' there were taboos against plucking the fruits from trees reserved exclusively for birds and animals. After breakdown of these ethical practices- the birds are finding it difficult to get their normal, natural food. This tropical aspect is not much discussed in Goa. Now solid waste is attracting many bird species. The toxins in such waste affect the birds. The house sparrows are no doubt declining even in western countries but their rapid decline from towns and local settlement areas should cause a grave concern. The rodent menace in our campus increased suddenly with the decline of population of the nocturnal hunter-spotted owl. The birds are so shy that a small human movement alerts them. There is no status report on owls of Goa popularised in local folklore as "ghughum". In countryside, the cute little Jungle Bush-Quail are still hunted, roasted and consumed. They blend so well in dry litter and cross the road so swiftly that their behaviour is a lesson in camouflage and speed. We may believe that egrets and herons are safe. But these are still being hunted in countryside for cooking Xacoti. Bird trappers from outside Goa catch parakeets illegally during the harvest season. Souvenir hunters and collectors often take the arboreal leaf nests of common tailorbird. Everyone loves the intricately designed nests of

baya weaver birds hanging on coconut tree branches. This species may not be threatened. But owners of coconut plantations need to leave the nest bearing parts of the trees. Otherwise there could be damage to the eggs of these birds. One finds these nests displayed with the eggs removed in many school exhibitions and also used as decorative hangings. Only discarded or fallen nests could be collected. But Goa scores low on conservation ethics. This is affecting the neglected species of birds. Birds need their privacy. Birds have right to exist with us. During summer we need to arrange water for them. During times of food crisis, we need to offer them cereal grains, fruits and nuts. By involving school children, it would be possible to care for Goa's neglected bird species. Members of Goa's eco clubs, nature clubs, green corps could do this in their own areas.

#### **14. The Neglected Reptiles**

Among the 100 species of reptiles of Goa we find crocodiles, turtles, tortoises, lizards and snakes. Among these tortoises and lizards have received scanty public attention. Crocodiles receive some attention on account of boating trips in their habitats, English horror movies like Lake Placid 3, tourist interest and their migration or ingress in human settlement areas. Global publicity to Oliver Ridley turtles has made Goa's turtle conservation projects well known. Snakes and pythons always catch public fancy. Killing, catching or playing and posing with snakes is a popular activity in Goa. It is not unusual to see some youth modelling bare chested with a rock python around their nake. Many snake enthusiasts have made it a profession to catch and parade live snakes in the name of community education. They don't realize the trauma which they cause to these species. Although snakes are reptiles, all reptiles are not snakes. Class reptilian in Goa is represented by loricata ( crocodiles, Gharials, Alligators etc.), testudines ( turtles, tortoises and terrapins) and squamata (lizards, snakes). Loricata species of Goa include Indian or Marsh crocodile, also called Mugger closely related to the extinct dinosaurs. Although attempts have not been made there is a high possibility of recovering dinosaur fossils from upper parts of Mahadayi river basin. Crocodiles have found an ideal habitat in the Cumbarjua canal and mangrove swamps. Their population needs to be confined to the wild habitats because they could create nuisance near settlement areas. The turtles of Goa include- loggerhead sea turtle, green sea turtle, hawksbill sea turtle or tortoise shell turtle, Olivder ridley sea turtle, leatherback sea turtle. All these are marine turtle species. More information on these species can be found at <http://www.seaturtlesofindia.org>. Since state government has not made it mandatory for fishing vessels to fit turtle exclusion devices (TED) , there is no check on fate of turtles accidentally caught in fishing nets. Those which prefer interior, terrestrial aquatic habitats include Indian-snail eating turtle, Star tortoise or Indian starred tortoise, southern flap-shelled turtle and peninsular soft shelled or Leith's Softshelled turtle. Foreign tourists like star tortoises of Goa as pets and illegal sale takes place in coastal areas. The flap shelled turtle is very common in Goa and often found in village wells and tanks. Some people keep it in aquarium tanks as pet. People poach the eggs and catch Leithi's softshelled turtle from rivers for cooking a "xacuti". Sometimes these turtles get killed when explosives are thrown in river to kill fish. The Hindus revere turtles as the second reincarnation of Lord Vishnu-the Kurmavatar. But still freshwater turtles are being sold in markets. No attention has been paid to the ecological role of the freshwater turtles of Goa. During

monsoon when paddy fields get flooded and village tanks overflow the freshwater turtles migrate by crossing roads at night. People lie in wait to catch them. This practice needs to be stopped by launching "Save freshwater turtles of Goa" movement. About 199 species of lizards have been known in India. In Goa we find 30 species. These have received poor attention despite identification of a novel species of gecko in forests of Canacona named as Goa forest Palli (*Cnemaspis goaensis*). The geckos of Goa include- south Indian rock gecko, north Malabar rock gecko, south Malabar rock gecko, north kanara hill palli, Goa forest palli, dark spotted giant gecko, blotched gecko, spotted house gecko, Prashad brown gecko, reticulated gecko, Ticticky house gecko, common bark gecko and yellow bellied house gecko. The geckos play a very important role in controlling insect population. Over a period of 12 hours at night a gecko may consume hundreds of insects. They are essential to control the mosquitoes in domestic environment. Goa has five lizard and a single chameleon (shedde) species. These include-south Indian flying dragon or flying lizard, Indian Fan-throated lizard, Indian garden lizard, Matheran olive brown calotes, olive brown rock lizard and Indian chameleon. The chameleons appear during monsoon and are seen to enjoy a feast of grasshoppers and beetles crawling on the vegetation. They hide themselves so well that one can not spot them in the green vegetation without a movement. You can see the flying lizard in Molem wildlife sanctuary and also in some thick plantations. Skinks, locally known as shilli are different types of lizards. Goa has eight species of skinks- Allapalli forest skink, Bornzy grass skink, common Indian skink, Beddom's south Indian skink, five striped skink, dotted garden skink, Malabar dotted skink, golden brown four toed skink and Goanese bronze skink. The last species name is not correct. It should have been Goan bronze skink-*Riopa goensis*. However it is a species so far found only in Goa in Molem forest sanctuary. That shows the richness of our forest ecosystem. These quiet, shy reptiles are interesting to watch. They can climb easily along any rough surface. They are also masters of camouflage. One of the rarest skink species is Beddom's snake-eyed lacerta. It is found only in forests of Goa. Goa's most ancient membranophone-the Ghumot exploits the skin of the common Indian monitor or monitor lizard locally known as ghorpad. The producers say that there is no match for this material obtained by killing the monitor lizard. Although the monitor lizard is widespread its' catching and killing is banned under wildlife protection act. IUCN has classified it as vulnerable species. Unless a substitute material with same acoustical properties is found for covering the mouth of Ghumot, the hunting of monitor lizards may continue. If hunting is stopped in Goa then people may smuggle the skins from neighbouring states. Goa has 60 species of snakes. But there is a possibility that a few more species could still be found in unexplored habitats. In our small campus 15 species of snakes have been reported. The menace of rodents has increased after decrease in number of the snakes. The reptiles of Goa may not be cute and attractive. Lesser known reptiles may even look ugly. But the ugliest of geckos, skinks and chameleons are ecologically very important members of the local food webs. More attention needs to be paid to chameleons which are hunted due to superstitions. Trade in freshwater turtles, tortoises need to be stopped. These creatures can be released to clean the village tanks and wells. Reptile research has a great future in Goa if high schools begin to document the local diversity and distribution and pressures on habitat.

## **15. The Neglected Mammals of Goa**

This is to focus public attention on neglected faunal creatures of Goa. Goans get carried away by the hype created over a few species of animals which get good press. But in the process the rest of the fauna gets neglected. Understanding animals is a serious biological science which has been diluted by amateur busybodies in Goa. It is awful to see hundreds of large earthworms crushed under speeding vehicles during the monsoon. It is shocking to see freshwater tortoises being sold in village markets. These unfortunate creatures end up as 'Xacuti' in some houses. It is sad to hear gunshots wounding fruit bats (pakhe). Every beat of Goa's ghumat echoes the death throes of monitor lizards. Every local dish of sharks like 'mori ambot tikh' reminds one of the ban imposed on their catching. But our fish markets are full of banned elasmobranch fishes. People love to talk about elephants, tigers, panthers, turtles and frogs- animals which have global support. But there are hundreds of other species which also need our attention. The present knowledge of faunal diversity of Goa is based on surveys conducted by Zoological survey of India (ZSI). They identified 1326 species of 17 groups. Among these birds dominate with 458 species. Goa could be called a paradise of birds because 37 percent of country's bird diversity is found here. In our small university campus spread over less than two sq. kms. area, Prof. Shanbhag and his students have catalogued 110 species of birds or 25 percent of state avian diversity. Whereas 456 species of reptiles are found in whole country-Goa scores well with 100 species. The most advanced group of animals-mammals is well presented here with 83 species (21 percent) out of total 390 for the whole country. Mammals of Goa also comprise six marine species-Indopacific Humpback dolphin, common dolphin, spinner dolphin, back finless porpoise, fin whale and dugong. There are reports of killing of dolphins. Dugongs were sighted at Chapora and Anjuna some times back. These are extremely shy and rare marine mammals. There are many reports of whale carcasses washed ashore in coastal Goa. But the forest department doesn't monitor such events and report these to IUCN or whale and Dolphin conservation society. The other 77 mammal species are listed here. Shrews (chichundri) are represented by Madras tree shrew, common house shrew, Savi's pigmy shrew. Bats are very important in seed dispersal and pollination. These flying mammals have the gift of echolocation. We need a better knowledge of bats and the viruses which they carry in Goa. I would not advise anyone to consume fruits damaged or punctured by bats because there is a chance of viral transmission of diseases. Some of these viruses are fatal to humans. The bats of Goa include 26 species-Indian fulvus fruit bat, Indian flying fox, short-nosed fruit bat, lesser Dog-faced fruit bat, Pouch-bearing tomb bat, Long winged tomb bat, Black bearded tomb bat, Theobald's tomb bat, lesser false vampire bat, Greater false vampire bat, Blyth's Horse-shoe bat, Rufous Horse shoe bat, fulvus leaf nosed bat, Kelaart's leaf-nosed bat, Schneider's leaf-nosed bat, painted bat, Tickell's bat, Horsfields' bat, Kellart's Pipistrelle, Indian Pipistrelle (three subspecies), Asiatic greater yellow house bat, Asiatic lesser yellow house bat, Long-winged bat or Schreibers' bat and Egyptian Free tailed bat. The tiny and cute pipistrelle bats routinely visit the corridors of my faculty building during the monsoon. At night sightings of Indian flying foxes is common. They just love to hang on our fruit trees. When I used to keep ripe fruits as baits on my roof they used to descend and smartly pick them. I suspect that a colony of these giant bats may be present on the 'Bat island' in the Marmagoa bay. The primates have smaller population in Goa-slender loris (vanmanus), Bonnet Macaque (makod/khete) and Hanuman Langur (vandar)

-just three out of 25 primate species in the country. There is just a single species of pangolin-Indian pangolin. The canine family is represented by Indian jackal, Indian wild dog (dhole/kolsun) and Bengal fox. Among these we need to pay special attention to small surviving population of highly social Indian wild dog found in western ghats. A single species of sloth bear is what is left of ursidae family. The smooth-coated Indian otter (ud) is a wonderful and rare species of Goa. Other wonderful and cute species include- small Indian civet, Palm civet or Toddy cat (catandor), Indian gray Mongoose, Ruddy Mongoose, Striped Hyena, Jungle cat, Leopard Cat, Rusty spotted cat, Leopard/panther, striped tiger, Indian elephant, Indian wild boar, Indian mouse deer, Indian spotted deer or chital, Sambar, Barking deer, Gaur, chosuinga or four Horned antelope. Squirrels are well represented. The Bondla sanctuary is best place to watch Indian Giant Squirrel and common giant flying squirrel. There are two species of Indian giant squirrel. Other local species include three striped jungle squirrel and Indian five striped northern palm squirrel. The later is very common in Goa and abounds in our gardens. Why Goa should host so many species of rats?. The family of wild rats and mice, muridae family is represented by Indian Gerbil or Antelope Rat, Long tailed tree mouse, Metad rat, House rat or Roof rat, white bellied rat, Norvey rat, Indian bush rat, common house mouse, little Indian field mouse, lesser bandicoot rat and Large bandicoot rat (three subspecies). The Indian crested porcupine can be seen at the Bondla zoo. The Indian black napped hare (soso) has been hunted down in Goa for centuries. Occasionally it is spotted after the first monsoon rains in grasslands. During my childhood, attempts to domesticate this species rescued from hunters had failed as our space was not sufficient for this mini kangaroo like creature. It used to jump so high that each leap used to take our breath away. How much we know and care for habitat of these 83 mammal species?. The wildlife census of forest department lists only a few species. They don't care about the other life forms. What about the species outside the forest areas?. The peculiar call of Indian jackal is missed in villages of Goa. Farmers now hate the monkeys destroying their plantation crops. The nocturnal and shy todody cat now finds it difficult to hide itself, feed and reproduce as constructions have come up close to coconut plantations.

## **16. The Neglected fish of Goa**

Goa contributes 3 percent of national fish production. The marine fisheries in Goa would be over in next 20 years due to overfishing, heavy pollution, global warming and acidification of the Arabian sea. Our only hope would be community based sustainable inland fisheries-in estuaries and rivers, ponds and lakes using careful scientific studies of local species. More species of fishes are endangered as compared to animals, birds, butterflies or frogs. For thousands of years the first settlers in Goa lived on fish which were plentiful. The local names for fishes of Goa have interesting origins-based on their habitat, colour, shape, ornamentation etc. People's knowledge of biodiversity of fishes comprises of names like- Tambso, Gobro, Karkaro, Burbudo, Rane, combo, Palu, Unkir, Ranwas, Ghol, Bale, Arro, Sheluk, Khapi, Saundale, Halwa, Hamp, Bangade, Visvan, Morso, Chonak, Luski, Bhuyari, Bokado, Tonki, Dinas, lep, Sangat, Kodem, ped, Velli, Pedave, Karli, Mori, Sunare, Phadke, Waghole etc. Those who consume a lot of fish from childhood become intelligent. Fish in diet explains why Goans are born creative and shine everywhere. Goa's poet laureate B.B. Borkar dedicated more than a dozen poems



and few essays to sing glories of fish. Goa's fish, curry and rice is ranked among top 25 recipes in world. With drastic reduction in other marine catch, Goans are compelled to eat mackerels and sardines. The demand-supply gap is met by imports from other states. Very few cultures take discussion on fish so seriously as the Goans do. Nature endowed Goa with marine and inland fish diversity. About 200 species of marine and estuarine fish, 60 species of crabs and a dozen species of oysters, clams, bivalves and mussels make Goa a resourceful location. The actual diversity of fish and shellfish is neglected. Konkani writer Prakash Porienkar has shown me undocumented species of fish from the Mahadayi river basin and forest officer Paresh Porob and folklorist from Canacona, Mahendra Phaldessai talk about large and strange species of fish in the granite rock pools in Cotigao sanctuary. Upper reaches of most of our rivers have not been surveyed for fish diversity. The fisheries department has converted itself into a "marine fisheries department" and has no idea about inland fish habitats, diversity, distribution and pressures on population. It has not worked to preserve the traditional fish catching technique and the fish catching gears. It is the only fisheries department in India which considers public funded reports as academic documents- scientific studies to be commissioned and then forgotten. Fisheries department has refused to implement the report "Assessment and re-validation of demersal fishery resources with particular reference to Penaeid prawns of Goa coast" submitted by NIO in March 2008. The report which cost more than Rs. One million is being treated by the department like a nuclear secret. Nobody knows the actual recommendations and the fate of Solar prawns which fuel the politics of Goa when their breeding season approaches. The fisheries department has not paid any attention to the potential of fisheries during the monsoon in the creeks, backwaters and ponds. After first rains people in villages rush to catch "kharchanyo" a tasty fish which likes muddy waters. Near estuaries dhodiario and sangta (catfish) are monitored. The natural habitat and breeding ground of Kharchanyo are neglected. People still catch female Kharchanyo with roe intact. The largest density of sports fishermen and anglers in India would be found in state of Goa. As kids we used to prepare a fishing rod and enter the creeks, ponds and rivulets. During July and August we used to catch a lot of fish in Khazan rivulets and ponds. Now pollution has taken a heavy toll of these fish habitats. At Miramar and Caranzalem the local fishermen used to harvest 23 different species of fish. Now they catch plastic waste and bottles in their beach nets. At Chorao and Ribander more than 48 different species were found in baskets. Now the nets show floating solid waste. Goa's famous small prawn-'Galmo' is a variety of *Acetes indicus*. It is abundant in Mandovi estuary. In harvesting Galmo, Goans show same taste as Japanese. But *Acetes* species of Goa are completely neglected. A whole industry can be built if this species can be mass produced. It is wonderful source of proteins and minerals. Goans just love any preparation of "muddhoshi" (scientific name *Sillaginodes sihama*). Muddhoshi are captured using hook and line, stake net, Gill net and shore seines. Best catches are available during the monsoon. Most of production comes from inland waters. However the delicious "muddhoshi" is one of the most neglected species of fish in Goa. Its' production fluctuates between 40-200 metric tonnes. But with proper attention to its' breeding ground, biology, feeding habits it should be possible to identify and conserve the best areas and also attempt to enrich those which produce the heavy catches. Another highly prized fish is "Ranwas" (*Polynemus spp.*). Anglers have taken specimens weighing more than 30 kg from sites near Zuari bridge. But we know next to

nothing about this fish. Similarly-Chanak ( *Lates calcarifer*) is very popular in hotels and among tourists. But there is short supply of these freshwater fish. The sweet tasting Saundale –*Lactarius lactarius* are now rarely seen in the market. There is need to have a careful look at how Goa is rapidly losing the biodiversity of fish. Lack of knowledge about local diversity of fish and shellfish is basic cause of neglect of these food resources in estuarine and freshwater interior areas of Goa. Goa has only a single private aquarium in Verna. The fisheries department is disinterested in conservation and propagation of the species of fish which are disappearing rapidly. The village panchayats need to be encouraged to form local fisheries resource management committees and take the help of experts to catalogue local fish and shellfish diversity. Siolim was famous for large oysters. But we know nothing about these neglected species. Khazan lands are habitats of spiny lobsters (*Shivads-Panulirus*) and large crab species. In fact the vast Khazans of Bhoma-Kundaim and Cortalim-Agacaim produce some of the largest edible crab specimens in Asia. These “khadapi kullyo’ are sold at Rs. 50-100 each. But the production is falling because no studies are available about their ecology and biology. Goa’s food security stands threatened today because of such criminal neglect of useful species of fish and shellfish. Unless all stakeholders act, by end of A.D. 2025-30, Goa would lose 75 percent of inland fish diversity

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