

Draft Report of the Task Forces constituted to make Recommendations to the Government for Strengthening of Botanical and Zoological Surveys of India

1) Terms of reference

The terms of reference for the Task Forces are as follows:

- (i) Review the existing mandate, objectives, organizational structure, manpower and infrastructure in order to strengthen their scientific and technical capacities;
- (ii) Render suggestions for formulation of a strategic Action Plan;
- (iii) Provide recommendations for conceptualization of Vision Document, 2020;
- (iv) Redefine priorities and programme of BSI/ZSI; and
- (v) Suggest measures for strengthening of BSI/ZSI for effective utilization of special grants of Rs. 15 crores each allocated to BSI/ZSI during CFY, 2009-10.

2) Approach

A few years ago, John Maynard Smith, one of the most distinguished evolutionary biologists of twentieth century wrote an important book called the 'Major Transitions in Evolution'. He proposed that the saga of life on earth may be visualized as involving nine major transitions, beginning with: i] Replicating molecules –to- Populations of molecules in protocells, followed by ii] Independent replicators –to- Chromosomes, and so on. This evolutionary process has given rise to two other forms of replicating entities besides genes, namely, memes or behaviour patterns propagated through replication, and artifacts. The development of memes has led to the ninth major transition: ix] Primate societies –to- Human societies with an elaborate symbolic language. Finally, the culmination of evolution of artifacts to the present day Information and Communication Technology has brought us to the threshold of a tenth major transition: x] Language based human societies –to- Human societies with global access to the entire stock of human knowledge, and engaged in an endeavour of collaborative knowledge generation.

It is imperative that Indian science look to the future and imbibe this inclusive spirit of sharing and generating knowledge in a collaborative fashion. Hence, a major focus of our Task Force recommendations will be on promoting institutional mechanisms and creating infrastructure to facilitate collaboration. The collaboration should be across scientific disciplinary boundaries, amongst institutions, and amongst individuals. In particular, the endeavour should embrace the more inclusive discipline, that of Systematics.

Systematics is the study of biological diversity and its origins, focusing on understanding evolutionary relationships among organisms, species, higher taxa, or other biological entities, such as genes, and the evolution of the properties of taxa including intrinsic traits, ecological interactions, and geographic distributions. Systematics is also concerned with the development of methods, including numerical methods, for various aspects of phylogenetic inference and biological nomenclature/ classification.

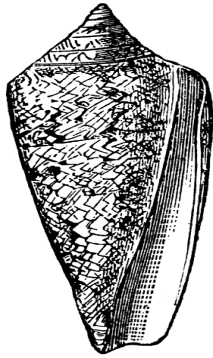
In other words, along with taxonomy, the Task Forces have kept in view cognate disciplines including evolutionary biology, biogeography, ecology, conservation biology, and behavioural biology, employing traditional as well as modern molecular and quantitative - computational techniques. Indeed, we recommend that Botanical and Zoological Surveys of India should not work in isolation, but instead become the hubs of a network of taxonomists and scientists working in related disciplines within India at two levels, that of scientists and of 'barefoot taxonomists'. We may refer to this as the Biodiversity Network. Apart from the Surveys, the scientific institutions in the Biodiversity Network may include some Min of En & F institutions like WII and CES, IISc, National Museum Natural History and Regional Museums of Natural History, University Departments like Departments of Botany and Zoology at AMU, BHU, Calcutta, Calicut, Delhi, NEHU and Shivaji, laboratories like CCMB, NBRI and NCBS, state govt institutions like KFRRI, NGOs like ATREE etc. The Biodiversity Network should also bring in individuals who may not necessarily have an institutional affiliation, like Dr T N Ananthakrishnan. This Biodiversity Network should play a key role in capacity building with a two-way interaction, of experts in allied disciplines, e.g. in molecular taxonomy from NCCS training BSI/ZSI taxonomists, and the BSI/ZSI taxonomists training fellow scientists like ecologists at CES, IISc.

At the level of 'barefoot taxonomists' the Biodiversity Network may link to existing institutions like National Innovation Foundation and associated networks like the Honeybee network, and to

the network of District, Taluk and Gram Panchayat level Biodiversity Management Committees, that are expected to be established as a part of implementation of the Biological Diversity Act 2002. Furthermore, this Biodiversity Network may attempt to proactively promote, throughout the country, district level centers of taxonomic expertise in selected Colleges/ Universities in collaboration with Zilla Panchayat level Biodiversity Management Committees. In this context, the Biodiversity Network should play a key role in capacity building with a two-way interaction, with the BSI/ZSI taxonomists training barefoot taxonomists, as well College and School teachers dispersed throughout the country, and the barefoot taxonomists building the capacity of BSI/ZSI taxonomists and College and School teachers in indigenous knowledge systems. In order to facilitate this, the University Grants Commission should be asked to provide a special thrust to training and research in Systematics – Taxonomy in at least one College/ University identified for this purpose in each district of the country.

The Information Management Systems of the two Surveys should also be linked to national networks like DBT's India Biodiversity Information Network (IBIN) and NBA's India Biodiversity Information System (IBIS).

Cone Collaboration



Cone snails are marine gastropods that are amongst the most venomous organisms on earth. Their venom has immense medical importance. Our Indian coast is rich in cone snails with 81 known species. A team of scientists from IISc, NCBS (Bangalore), TIFR and Centre for Fisheries Education and Research (Mumbai), Andhra University, Marine Biology Laboratory (Porto Novo), St. Stephen's College (Kollam), Marine Research Institute (Tuticorin), Metavom Bioinformatics Pvt. Ltd., University of Barcelona, University of Utah and Dublin University are working on taxonomy, venom characterization, protein chemistry, molecular biology, pharmacology, genomics and molecular phylogeny cone snails. This team of scientists has

published 18 internationally peer reviewed papers (including papers on taxonomy and morphology) on Indian cone snails and acquired two international patents since 2004. Many students have worked for their Ph.D. or post doctoral fellowships through this multi-institutional and multi-disciplinary collaboration.

Coordinating Group on Systematic Biology

To support such an inclusive approach, the Min of En & F should consider setting up a permanent, open, inclusive *Coordinating Group on Systematic Biology*, charged with building bridges amongst all institutions and individuals interested and active in different facets of Systematic Biology, as also pertinent international efforts such as GBIF. Botanical and Zoological Surveys would, of course, be key players in the functioning of such a Coordinating Group promoting collaborative efforts towards survey, collection, documentation (including the practical, folk knowledge associated with plants and animals) and *ex situ* conservation of wild plant and animal diversity of the country.

3) Mandate

The current BSI/ZSI mandate is: "Survey, collection, documentation (including the traditional knowledge associated with plants and animals) and *ex situ* conservation of wild plant and animal diversity of the country." It may be better to talk of practical or folk level rather than merely traditional knowledge, since people continually update their understanding of the natural world in course of their day-to-day attempts to obtain a livelihood.

The Botanical and Zoological Surveys should undoubtedly focus on this existing mandate of survey, collection, and documentation of wild plant and animal diversity of the country, and to a limited extent on *ex situ* conservation of wild plant diversity of the country through Botanical Gardens. However, this should not be interpreted to mean that survey, collection, and documentation of wild plant and animal diversity of the country is their sole prerogative. Many institutions, e.g. Bombay Natural History Society, as well as individuals like Father Cecil J Saldanha have made significant contributions in this field, and the two Surveys should be viewed as nodal, but not exclusive, agencies for the survey, collection, and documentation of wild plant and animal diversity of the country. Science progresses not by avoiding duplication,

but by open scrutiny of any phenomenon under investigation by several independent investigators, exchanging the results of their investigations. So the Surveys should develop a culture of collaborative surveys, joint collections, welcoming others to work on the BSI/ZSI collections, collaborative investigations in related fields such as molecular taxonomy and conservation biology, and collaborative publications. This should be done both at the level of institutions of advanced scientific education and research, as well as grass-roots level Biodiversity Management Committees.

4) Objectives

The objectives of BSI/ZSI may be classified under two heads, namely as high priority activities that are their main focus, and as activities to be undertaken primarily through collaboration. Of course, activities that are the main focus should also be undertaken while welcoming collaboration.

High priority

- Exploration, inventorying and documentation of biodiversity in general and protected areas, hotspots, fragile ecosystems and sacred groves in particular
- Publication of National, State and District Floras/ Faunas
- Taxonomic studies, revisionary/ monographic studies on selected plant/animal groups
- Identification of Red list species and species rich areas needing conservation
- Development of a National database of Indian plants/ animals, including herbarium/ museum specimens, live specimens, paintings, illustrations etc.
- Repatriation of information on Indian plants/ animals held by herbarium/ museum collections abroad
- Developing and maintaining Botanical Gardens, Museums and Herbaria.
- Preparation of Seed, Pollen and Spore Atlas of Indian Plants
- *Ex situ* conservation of critically threatened taxa in botanical gardens
- Capacity building in taxonomy through training programmes

Activities to be pursued through extensive collaboration

- Capacity building in broader discipline of Systematic Biology through training programmes
- Survey and documentation of practical, folk knowledge (ethno-biology) associated with plants/ animals.
- Biogeographical and ecological studies
- Chromosomal mapping- DNA fingerprinting- molecular taxonomy. In fact, both BSI and ZSI should join the Barcode of Life Consortium.
- Numerical taxonomy and phyletics
- Qualitative analysis of nutritive value of ethno-food plants/animals and other economically useful species.
- Environment Impact Assessment of specific localities
- Ex situ conservation of critically threatened animal taxa through techniques like cell culture

5) Programmes

Surveys

As a high priority, BSI/ZSI should prepare a comprehensive **State of Art Report** to help identify gaps in knowledge of different taxonomic groups, in knowledge of different geographical regions and habitats and in the availability of expertise relating to different taxa and geographical regions. Based on such an exercise, further work should be specially directed towards under-explored/understudied groups of organisms such as soil and aquatic invertebrates, helminthes, fungi, and marine microorganisms and plankton communities, and towards under-explored regions such as greater parts of the North-Eastern Region of the country, or offshore marine realms.

It is now abundantly clear that teamwork yields far greater dividends in the world of science. A team of an ecologist, an algologist, and an ichthyologist surveying freshwaters of Nilgiris or Manipur river system can undoubtedly yield far more in terms of scientific insights than the three of them working independently. They can also save a great deal in terms of financial resources

required. Therefore, the Surveys should now gear themselves to proactively seeking partnerships and collaborative activities. The Coordinating Groups on Systematic Biology should play a key role in facilitating such partnerships.

World over research in systematic has undergone a paradigm shift, to take advantage of technological advances, as also in recognition of the fact that there has been a serious depletion of biological diversity over much of the world. Such a shift involves a move from wet and dry collections to digital libraries, minimizing unwarranted collections, especially of common species; instead documenting their existence digitally using photographs, sound recordings, and collection of supporting evidence/voucher material, like feathers, quills, fecal matter, shells (mollusks), sloughs (snakes), etc. This should be coupled to digital photography of landscapes, habitats and microhabitats, and careful recording of the study locations with help of GPS instruments. BSI/ZSI should also follow such an approach, and ensure that all scientists are equipped with digital cameras, portable tape recorders and hand held GPS instruments, and trained in relevant techniques, recognizing that the older tradition of relying on a single 'staff photographer' is now outdated.

To reiterate, a great value of the information collected by ZSI and BSI is to help in conservation - which means that this data should be of use for monitoring changes in biodiversity over time. At present, this is only partially possible, because the reports and outputs are not completely spatial, nor are they explicitly temporal. There is a need to revise future collection strategies so each collection record has an explicit spatial location and time of collection attached to it. Consider some instances of when this may be important. For instance, if a study in Arunachal Pradesh has catalogued a list of species - and a new study comes along 5 years later and fails to record these. Unless we know the time, date and exact location - we don't know if these species have become locally extinct, or if we have just missed the breeding/migratory seasons, or it is a microhabitat specific species. Similarly, there is a critical need for new specimens to be collected with lat/long information using a GPS. Following this, in the collaborative research activities, it would of course be good to work with labs working on landscape ecology, biogeography, GIS and remote sensing so that these activities can be used to add value to the current data.

Flora and Fauna of India

The primary mandate of the BSI/ZSI is to document the plant/ animal resources of the country. Hence an important focus of their activity would be to complete the Flora/ Fauna of India. India has produced a large number of fine taxonomists, many of whom work outside BSI/ZSI, e.g., universities, research organizations and as emeritus scientists. Therefore, it is important that BSI/ZSI now take on the role of coordinating and pooling the expertise of all the taxonomists including those working outside this organization to consolidate the **Flora and Fauna of India volumes**. This is particularly important because the local field biologists and experts who have spent a considerable amount of time in a particular geographical area can add tremendous information on habitat, associations, biogeography and population status. Floras/ Faunas written by the individuals having limited field knowledge, merely based on the museum/ herbarium specimens lack in such information. Coordinated work on Flora/ Fauna of India should also include all the works on various taxonomic groups done through AICOPTAX Project of MoEF. Such coordination would of course require a strong editorial board and a few full time dedicated executive secretaries. This should be achievable in 10 years and should figure out as **Priority I** in BSI/ZSI's Vision 2020 document. This could be achieved in the following phases:

- i. Establish a panel of experienced and active taxonomists for each state and take their consent on participation in Flora / Fauna Project,
- ii. Prepare an annotated checklist of vascular plants and other taxa under consideration for each state / UTs based on all published documents and herbaria, giving local names, if any, locality and habitat,
- iii. Circulate the electronic version of checklists among the panel of botanists/ zoologists who would, in turn, check for omissions, ambiguities, localities and habitat through active consultation with other local botanists/ zoologists,
- iv. To begin with, state floras/ faunas should be published electronically giving correct names, basionyms, localities, habitat, sketches and photographs of important species preferably on an interactive '**Flora/ Fauna of India Blog**'. On this page all naturalists, photographers and biological artists should be encouraged to contribute information on taxonomy, distribution, natural history, biology, ethnobiology, etc. This will also act as an outreach programme for all the biologists. The ethnobiological surveys should be done

mainly by the local biologists, college and university teachers, working with local Biodiversity Management Committees under technical guidance by BSI/ZSI.

- v. An editorial board may be constituted at the national level to decide the format of the flora/ fauna and also assign plant/ animal families for compilation which should include nomenclature, description, ecology, natural history, distribution, sketches and photographs.

Permanent Biodiversity Monitoring Plots (BMP's)

It is notable that many recent conceptual advances in Systematic Biology such as the Theory of Island Biogeography can be directly or indirectly traced to permanent plot studies initiated in Panama and Costa Rica by a consortium of international organizations beginning in 1960's. Moreover these permanent plots have served as on field training centers for a whole new generation of ecologists, systematists and conservation biologists from many parts of the world. In addition, this model of a multi-disciplinary and-multi institutional consortium has encouraged the establishment of permanent vegetation plots across the globe including in India. Such studies have made a major contribution to our understanding of biodiversity.

Moreover, in the present day context of anticipated climate change and its immediate and long term impact on biodiversity, it is essential to monitor the components of biodiversity across regions and ecosystems. The BSI and ZSI with their extensive experience in biosystematics and presence of regional centers in all the biogeographic zones of India should therefore take a lead in the establishment and operation of a system of permanent landscape level Biodiversity Monitoring Plots (BMP's). These BMPs can function as an on site training facility for students, amateurs and professionals in current techniques in systematics, ecology and conservation biology. Moreover, such plots should attract researchers from allied sciences streams such as climate science, sociology, anthropology etc., to address various questions pertinent to biodiversity conservation. The data generated through BMP's will have immense academic and management value.

Information management

1. All the regional centers and headquarters of BSI/ZSI should be interlinked through a computer network.

2. All the identified species records should be computerized and geo-referenced, with a high priority assigned to the oldest collections.
3. Collection inventory and management should be computerized using open source softwares such as Specify 6.0 (www.specifysoftware.org).
4. BSI/ZSI should develop one omnibus periodical/journal (doing away with all others) to publish short and long papers/communications in taxonomy of both plants and animals.
5. The journals and other occasional publications should go online and could be part of Public Library of Science (PLoS). This will save a lot of time and financial resources.
6. Heritage publications and drawings should be digitized and could be part of Biodiversity Heritage Library project.
7. BSI/ZSI must give a thrust to preparing an inventory of collections at Colleges, Universities, and other institutions, as also with private individuals and organizing a computerized and geo-referenced database pertaining to these. Wherever appropriate arrangements should be made for acquiring these collections and funds should be earmarked for this purpose.
8. BSI/ZSI must also give a thrust to repatriation of Indian biodiversity information held in Herbaria and Museums abroad.
9. Finally, BSI/ZSI must concentrate on developing a “Cybertaxonomy” base for Indian biota.
10. There are several significant on-going initiatives in India on developing Biodiversity Information Systems. CSIR has developed a database called INDFAUNA that can serve as a starting point for ZSI’s database activities. The Department of Biotechnology, Govt has established an Indian Biodiversity Information Network (IBIN) and the National Biodiversity Authority is initiating the development of an Indian Biodiversity Information System (IBIS). The BSI/ZSI database activities should be closely linked to and developed in collaboration with these initiatives.

Survey Manuals

BSI/ ZSI should develop standardized survey manuals dealing with different taxa and ecosystems incorporating current quantitative and qualitative survey techniques through wide expert consultations. These standardized survey techniques should be implemented across regional centers and programmes for uniform data collection. Such a manual may have the following sections/contents:

- The continuity of life: from genes to ecosystems; the fragility of the lines drawn while classifying life into its components
- The importance of species; definitions; scope and limits
- The magnitude of biodiversity; a review of status of knowledge of species richness in each class/taxonomic category/geographical unit
- Introduction to diversity indices.
- Quantitative floral/ faunal diversity assessment techniques. Introduction to softwares for quantitative faunal diversity assessment. Stratified sampling techniques.
- Biogeography; focus on Indian subcontinent; major regions/provinces; history & endemism; adaptive radiation and vicariance
- Landscape ecology; the significance of geographic scale; basics of cartography and remote sensing; Using and interpreting toposheets and other maps.
- Introduction to Geographic Information System (GIS). Use of GIS in designing biodiversity surveys.
- Collection/survey; designing a field study; choosing sites; the importance of species-area/effort in deciding the area and intensity of surveys
- Sample size selection.
- Survey protocol selection.
- Surveying techniques for different groups of organisms
- Preservation techniques; dry collections, wet collections, taxidermy, hair samples, fecal samples, etc
- Field identification techniques; digital collections; secondary evidence of species presence
- Classical taxonomic procedures; codes of biological nomenclature; systematics
- Assessing rarity; simple ways of ranking species by their commonness or rarity
- Folk systems of classification; trade names

- Environmental Impact Assessment: biodiversity attributes; Invasive species and bio-indicators; species with high conservation value
- Processing and storing of data
- Data organization
- Data analysis tools-softwares.
- Use of GIS techniques.
- Interpreting results and data presentation

Field guides

The Surveys have so far not been actively involved in production of field guides and field identification keys to groups of organisms of interest to general public; the many excellent field guides available today have all been written by outsiders, often amateurs, as in case of 'Trees of Delhi'. A new thrust will have to be on production of such field guides and keys, in printed as well as electronic versions, not just in English, but in all local languages to support the work of Biodiversity Management Committees at district, taluk and Municipality/ gram panchayat levels.

Other activities

Surveys should organize revisiting the **Type Localities** of threatened or unique plants/ animals, revalidation of ambiguous taxa and population estimation of species listed in Red Data Books, and drawing in-situ conservation plans in collaboration with the State Forest Departments, Botany Departments, Regional Institutions, NGOs and NGIs. This would require a dedicated team within BSI/ZSI, who should be encouraged to collaborate with the state and local institutions, as well as grass roots taxonomists for long term monitoring of rare plant populations.

Ex-situ conservation programme of rare species would require revamping. All the Botanical gardens maintained by BSI as well as other agencies in the country need to be brought under a **National Network of Botanical Gardens and Arborata** for exchange of germplasm, rehabilitation of rare and threatened taxa within the gardens located closest to the natural habitat. Several volunteers, horticulturists, private land owners and biotechnologists in the country may like to join this venture, and should be welcomed.

6) Organizational structure

Science flourishes in a free atmosphere. Hence it would be appropriate to confer autonomy on the Botanical and Zoological Surveys of India. These Surveys may eventually be merged into a single Biological Survey of India. World over, the trend has been towards such a unification of all life related sciences. In our educational system, the University Grants Commission attempted without success to merge the teaching of botany and zoology everywhere into a single subject of Life Sciences in early 1970's. Unfortunately, this did not make progress. As a result, a less desirable option of Biotechnology as a subject at B Sc and M Sc levels is now eroding into Botany and Zoology, and many colleges are closing the Botany and Zoology departments. As a result there may be a real dearth of graduates in Botany and Zoology proper for recruitment to the Surveys in future. It is also notable that fungi turn out to be biochemically closer to animals than plants and are now placed in an entirely separate kingdom. So, in view of all of this, and in view of the ever greater integration of life sciences, and emergence of disciplines like molecular taxonomy, it might be advisable to work towards unification of the two Surveys.

Science flourishes in an atmosphere of working together. A study published in the journal 'Science' last year showed that collaborative publications have far more impact than single author works. Hence, the other set of organizational changes needed would be directed towards promoting collaboration, both at the level of advanced science and the grassroots. As suggested above, the Min of En & F, GoI may set up a national level Coordinating Group on Systematic Biology that will work closely with Heads of Botanical and Zoological Surveys to promote and support interaction with a network of taxonomists and scientists working in related disciplines within India at the levels of scientists as well as that of 'barefoot taxonomists'. At the same time, each Regional Station should set up its own Regional Coordinating Group on Systematic Biology, co-opting appropriately qualified members from within the region. These Regional Coordinating Groups should promote and support interaction, both in terms of research and capacity building, with a network of taxonomists and scientists working in related disciplines within their own regions at the levels of scientists as well as that of 'barefoot taxonomists'.

7) Human resources

The level of expertise needed for Taxonomic Identifications currently stands at a very low point. During last 15 years a large number of Senior Scientists had retired, and in many branches we do not have a single, trained scientist, even outside the Survey network. The Directors of ZSI and BSI should prepare a quick report to help identify the gap areas of expertise, and concerted attempts be made to plug these gaps. In this connection, it may be noted that the current policy of Govt. of India not to fill up sanctioned positions has already inflicted considerable damage to the Surveys. It is therefore necessary to ensure that scientific departments like ZSI and BSI are exempted from the routine ban.

A relook into the recruitment criteria at the entry point of Taxonomist scientists is very much required. Unfortunately, while we are quite aware of the dearth of trained scientists in Taxonomy, while selecting them, the basic essential qualifications are often ignored. The MoE&F has been running a prestigious programme- AICOPTAX, with a view to build capacity in Taxonomy. However, the trained manpower coming out of such a programme does not receive any recognition when it comes to joining a position in BSI/ ZSI. Therefore, the current process of recruitment of scientists should be reexamined. The entry qualifications must reflect that the persons recruited at scientist's level (C) should have adequate background knowledge about the group of Taxa that he or she will have to work on both in the field and in the laboratory. The categories of Technical Supporting Staff and their entry point qualifications also need to be reviewed, so that with progress of time and experience one can go up the ladder.

Taxonomic training in the Universities is sadly falling behind and as a result both the surveys find it hard to get the suitable person for recruitment. The UGC may be asked by the appropriate authorities to declare Taxonomy as a Thurst Area, with adequate funding support so as to facilitate the process of future recruitment.

Capacity building: scientists

The Botanical and Zoological Surveys have recently recruited a substantial number of young scientists, and it is appropriate to immediately address the challenge of capacity building of this vigorous group of up and coming workers. As of today there is no in-service system of training them in relevant disciplines. Of course, training focusing on particular groups of organisms is vital and a good system of in-service training needs to be developed. The Survey scientists should also acquire adequate grounding in digital photography- of organisms, along with

landscapes, habitats and microhabitats, recording of calls, and careful recording of the study locations with help of GPS instruments. The Survey Manuals discussed above would be an important resource in this context.

The training should also focus on biogeographical zones e.g. Western Ghats, Deccan Plateau, as well as biomes such as islands, high altitude, deserts, rainforests, coral reefs etc., bringing together regional stations of BSI/ZSI and local experts including NGOs. In this context, the country-wide network of Biodiversity Monitoring Plots can function as an on site training facility for the Survey scientists as well as other students, amateurs and professionals in current techniques in systematics, ecology and conservation biology.

It is also important that the training should extend beyond taxonomy to the cognate disciplines including evolutionary biology, biogeography, ecology, conservation biology, and behavioural biology, employing traditional as well as modern molecular and quantitative - computational techniques. It is therefore suggested that a system should be set up for providing such training in a collaborative fashion. It so happens that Bengaluru has a number of institutions including CES, IISc, UAS, NCBS, JNCASR, ATREE with very significant expertise in all these cognate areas. There are of course other important centers that should also be involved such as AMU and Delhi Universities, CCMB, Hyderabad, WII, Dehra Dun and French Institute, Pondichery. An excellent possibility would be to rent a set of apartments in a suitable locality in Bengaluru to house all the younger BSI/ZSI scientists for 4 months each year for an initial period of 3 years, and arrange two kinds of special courses, courses on topics like evolutionary biology taught by experts who may be outside the Surveys to the younger BSI/ZSI scientists, and courses in taxonomy taught by BSI/ZSI experts to scientists outside the Surveys. Over a total of three such 4- month period trainings it would be possible to provide the younger BSI/ZSI scientists a sound grounding in all cognate disciplines that would greatly strengthen their future work, as also put them in touch with all the leading workers in the related disciplines in the country. Simultaneously, this will build up taxonomic capacity of scientists outside the Surveys. Beyond the first three years the system may be transformed into a system of regular short term courses.

Furthermore, the BSI/ZSI should organize short term courses in identification of specific taxa (common ones like trees, birds and butterflies as well as rare taxa) aimed at undergraduate and M Sc students, as well as practicing scientists in other disciplines such as ecology. NRSA conducts many such short courses, and they are very well subscribed to. A similar model can

be followed by BSI/ZSI.

Capacity building: district level scientific community and barefoot taxonomists

All the Regional stations of the Surveys would have to gear up to conduct capacity building programmes for the district level centers of taxonomic expertise in selected Colleges/ Universities established in collaboration with Zilla Panchayat level Biodiversity Management Committees. In turn these district level experts would have to engage in building capacity of the grassroots taxonomists in their own districts. The Surveys should also support these district level capacity building programmes.

The National Museum Natural History and Regional Museums of Natural History under the of MoEn&F may play a very productive role in this context. Specializing in the regional ecosystems including fauna and flora; they are developing into good repositories and have rare collections.

8) Infrastructure

Currently Kolkata is the focus of the activities of Botanical and Zoological Surveys. However, its warm, humid atmosphere is not conducive to maintenance of collections. For this purpose, Hyderabad, which has a drier climate, and has Regional Stations of both Botanical and Zoological Surveys, as also a vibrant scientific culture would be a better choice. The Surveys have recently been assigned a good piece of land on the campus of the Hyderabad Central University. Hyderabad may therefore be made the focus of further major development of infrastructure for the Surveys. Hyderabad would also be a very good place for developing a joint BSI/ZSI DNA lab in collaboration with CCMB. This should serve as a National Facility with provision for scientists for sending samples for molecular identification. A fee may be charged for this service. For instance, the RMNH (Bhubaneswar) has a good collection of the rare (dead) specimens which are washed ashore. A few years back a dead whale was washed ashore and although the skeleton could be salvaged, proper identification was not possible because of the

state of decay and lack of common facilities for DNA fingerprinting. A common facility will be of great help in building up a database on such fauna on a regional basis.

9) Strategic action plan

This would follow the contours sketched above, visualizing BSI/ZSI activities as an integral component of the overall programme for Systematic Biology for India, both at scientific research level and at the grassroots level. At the same time, BSI/ZSI should proactively promote collaboration and partnerships. We recommend that the plan include the following components:

- 1) Min of En & F should set up a permanent, open, inclusive *Coordinating Group on Systematic Biology* so that BSI/ZSI come to constitute the hub of a vibrant network of activities in all fields of systematics
- 2) Surveys should gear themselves to proactively seeking partnerships, welcoming others to work on the BSI/ZSI collections, and undertake collaborative surveys, joint collections, and collaborative investigations in related fields such as molecular taxonomy and conservation biology, and collaborative publications. This should be done both at the level of institutions of advanced scientific education and research, as well as grass-roots level Biodiversity Management Committees.
- 3) BSI/ ZSI should prepare a State of Art Report to help identify gaps in knowledge of different taxonomic groups, in knowledge of different geographical regions and habitats and in the availability of expertise relating to different taxa and geographical regions.
- 4) BSI/ ZSI should establish a panel of experienced and active taxonomists for each state and take their consent on participation in Flora / Fauna Project
- 5) BSI/ ZSI should prepare an annotated checklist of vascular plants and other taxa under consideration for each state / UTs based on all published documents, museums and herbaria, giving local names, if any, locality and habitat
- 6) BSI/ ZSI should circulate the electronic version of checklists among the panel of botanists/ zoologists
- 7) BSI/ ZSI should set up an interactive 'Flora/ Fauna of India Blog'
- 8) An editorial board may be constituted at the national level to decide the format of the flora/ fauna and also assign plant/ animal families for compilation
- 9) BSI/ ZSI should organize revisiting the Type Localities of threatened or unique plants/ animals

- 10) BSI/ ZSI should organize revalidation of ambiguous taxa and population estimation of species listed in Red Data Books, and drawing in-situ conservation plans
- 11) BSI/ ZSI should organize a National Network of Botanical Gardens and Arboreta
- 12) BSI/ ZSI should develop one omnibus periodical/journal (doing away with all others) to publish short and long papers/communications in taxonomy of both plants and animals
- 13) Min of En & F should set up a system of permanent landscape level Biodiversity Monitoring Plots (BMP's) in all the biogeographic zones of India
- 14) All the regional centers and headquarters of BSI/ZSI should be interlinked through a computer network.
- 15) All the identified species records should be computerized and geo-referenced, with a high priority assigned to the oldest collections.
- 16) Collection inventory and management should be computerized using open source softwares such as Specify 6.0 (www.specifysoftware.org).
- 17) The BSI/ ZSI journals and other occasional publications should go online and could be part of Public Library of Science (PLoS). This will save a lot of time and financial resources.
- 18) BSI/ ZSI Heritage publications and drawings should be digitized and could be part of Biodiversity Heritage Library project.
- 19) BSI/ZSI should prepare an inventory of collections at Colleges, Universities, and other institutions, as also with private individuals and organizing a computerized and geo-referenced database pertaining to these. Wherever appropriate arrangements should be made for acquiring these collections, and funds should be earmarked for this purpose.
- 20) BSI/ZSI must give a thrust to repatriation of Indian biodiversity information held in Herbaria and Museums abroad.
- 21) BSI/ZSI must develop a "Cybertaxonomy" base for Indian biota.
- 22) BSI/ZSI must link their database activities with DBT's Indian Biodiversity Information Network (IBIN) and the National Biodiversity Authority's Indian Biodiversity Information System (IBIS) initiatives.
- 23) BSI/ ZSI should develop standardized survey manuals for different taxa and ecosystems
- 24) BSI/ ZSI should develop field guides and keys, in printed as well as electronic versions, not just in English, but in all local languages to support the work of Biodiversity Management Committees at district, taluk and Municipality/ gram panchayat levels.
- 25) BSI/ ZSI should identify the gap areas of taxonomic expertise, and make concerted attempts to plug these gaps

- 26) Min of En & F should ensure that scientific departments like ZSI and BSI are exempted from the routine bans on recruitment
- 27) BSI/ ZSI should reexamine the recruitment criteria at the entry point of Taxonomist scientists so as to encourage people who have already developed taxonomic expertise
- 28) UGC may be asked by the appropriate authorities to declare Taxonomy as a Thurst Area, with adequate funding support so as to facilitate the process of future recruitment.
- 29) BSI/ ZSI should develop an effective in-service system of training
- 30) BSI/ ZSI's in-service training should extend beyond taxonomy to the cognate disciplines including evolutionary biology, biogeography, ecology, conservation biology, and behavioural biology, employing traditional as well as modern molecular and quantitative - computational techniques.
- 31) BSI/ZSI should organize short term courses in identification of specific taxa (common ones like trees, birds and butterflies as well as rare taxa) aimed at undergraduate and MSc students, as well as practicing scientists in other disciplines such as ecology on the model of NRSA
- 32) All the Regional stations of the Surveys would have to gear up to conduct capacity building programmes for the district level centers of taxonomic expertise in selected Colleges/ Universities established in collaboration with Zilla Panchayat level Biodiversity Management Committees. In turn these district level experts would have to engage in building capacity of the grassroots taxonomists in their own districts.
- 33) Hyderabad should be made the focus of further major development of infrastructure for the Surveys.
- 34) BSI/ ZSI should develop a joint DNA lab in collaboration with CCMB at Hyderabad.
- 35) Botanical and Zoological Surveys should eventually be merged into a single Biological Survey of India

10) Vision

The Vision document may be most appropriately developed as a component of an integrated vision for Systematic Biology for India, with the Surveys being a key component. This might be best organized as a collaborative effort of several institutions such as:

1. Aligarh Muslim University Zoology Department
2. ATREE

3. Calicut University Zoology and Botany Departments
4. Center for Cellular and Molecular Biology
5. Center for Conservation Biology, UAS, Bengaluru
6. Centre for Ecological Sciences, IISc
7. Delhi University Zoology Department
8. National Bureau of Animal Genetic Resources
9. National Bureau of Fish Genetic Resources
10. National Bureau of Plant Genetic Resources
11. National Institute of Oceanography
12. National Museum of Natural History
13. North-eastern Hill University
14. Regional Museums of Natural History
15. Shivaji University Botany Department
16. Tropical Botanical Garden and Research Institute
17. Wild Life Institute of India

We need to draw up a comprehensive list and organize a well designed exercise.

11) Special grants

To be discussed at Jodhpur