Deploying student power to monitor India's lifescape

Madhav Gadgil

Along with his many scientific contributions, Sálim Ali will be remembered for a whole series of superbly written and illustrated books on Indian birds, books that played a key role in stimulating popular interest in India's rich living heritage. In honour of this great naturalist the Indian Academy of Sciences will launch on the occasion of his birth centenary a project called 'Lifescape' as a part of its initiative to enhance the quality of science education. This project aims to publish illustrated accounts of 2500 to 5000 Indian species of microorganisms, plants and animals. These accounts would help high school, college and postgraduate students and teachers of biology to reliably identify these species, and thereby constitute a basis for field exercises and projects focusing on first hand observations of living organisms. The information thus generated could feed into a countrywide system of monitoring ongoing changes in India's lifescape to support efforts at conservation of biological diversity, as well as control of weeds, pests, vectors and diseases. These accounts would also help create popular interest in the broader spectrum of India's biological wealth, much as Sálim Ali's books have done for birdlife over the last fifty years.

INDIA is a land of great natural diversity, diversity that embraces mangrove swamps of Sunderbans and rain forests of Western Ghats, coral reefs of Lakshadweep and wetlands of Bharatpur, hot deserts of Rajasthan and cold ones of Ladakh. Thanks to this diversity of environmental regimes and its position at the trijunction of African, Eurasian and Oriental biotas, India is one of the world's 12 megadiversity countries. Over 125,000 species of living organisms have been described from our subcontinent; it probably harbours another 400,000 awaiting to be described. India is also one of the global centres of diversity of crops and livestocks[1–5].

This biodiversity and its knowledge is now assuming great significance, for the second half of twentieth century belongs to sciences and technologies of life. Beginning with the elucidation of the chemical nature of heredity, life sciences have made rapid strides in understanding of the working of the machinery of life. Knowledge is power; and this understanding has been translated into an ever growing sophistication in manipulating living organisms. This has opened up many novel possibilities of application, and it is expected that the resulting biotechnologies may account for as much as 40% of the world economy in the coming decades. The stupendous diversity of life is the raw material for these applications and an understanding of this diversity must go hand in hand with a deepening understanding of the working of life to reap fully the fruits of modern advances in biological sciences[6,7].

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Our weaknesses

Unfortunately, India's scientific base of knowledge of this diversity of life and ways of adding value to it is very weak. Only some 20% of the species we harbour are likely to have been scientifically described; but even of these a large proportion has been described by British and other Western scientists[8]. Their specimens are located in the Museum of Natural History or Kew Herbarium in London; but are often absent from Indian collections. Thus A. K. Ghosh (pers. comm.), formerly Director of Zoological Survey of India reports that of 82,000 described species of animals, specimens of only 51,000 species are located in the Indian Museum in Calcutta. Specimens of an additional 1000 animal species may be available with Universities or institutions like the Bombay Natural History Society; that still leaves 30,000 species for which the specimens are available only abroad. For some groups like birds we have in India specimens of all the species; but, even in this case there are likely to be 10 times as many specimens abroad as in India (J. C. Daniel, pers. comm.). On the other hand, with animal groups like aphids, India holds specimens of only about 10% of the described species (A. K. Ghosh, pers. comm.). Aphids are important crop pests and now foreign agencies holding Indian material are charging thousands of rupees for help in identifying a single specimen. We are also very unfavourably placed with respect to crop genetic resources the rice germplasm collection of the International Rice Research Institute is, for instance, richer, even in terms of Indian material, than any of our own collections. We do not have a single properly organized and internationally recognized repository of microbial cultures either.

We are equally unfavourably placed in terms of scientific capabilities of identifying, working with, adding value to biodiversity resources. India boasts of the third largest scientific manpower in the world. Our Botanical and Zoological Surveys have very long history, and together employ over 1000 trained biologists. Our more than 6000 colleges and University departments employ another 20,000 or so. Every year more than 100,000 students get a bachelor's degree in one of the branches of Life Sciences. But only a very small fraction of these get an exposure to India's living wealth. Practically none of our master's degree holders in zoology is able to name more than 5 to 10 species of birds, lizards, fish or butterflies put together. This is because they are never encouraged to look at living creatures abounding around them, their training being confined to identifying a few dead specimens, or dissecting a still living cockroach or a dead pigeon. Given such a training programme few teachers of biology know much of the living wealth of India either.

Monitoring biological populations

Identification of the great diversity of living organisms around us, a majority of whom, especially smaller animals like mites and marine animals like bottom dwelling worms are yet to be described is a challenging task. This would call for a high level of professional training and infrastructure. But equally significant is a task which can be undertaken without sophisticated technical inputs – this is the task of monitoring the ongoing changes in the populations of living organisms through the length and breadth of the country, a task we are committed to undertake as a party to the Convention on Biological Diversity[8,9]. It is very much in our interest to do so for a variety of reasons – to appreciate if populations of medicinal herbs are on decline through overharvests, or if wild relatives of cultivated plants are being eroded through habitat transformations; to appreciate if populations of weedy species such as water hyacinth are exploding and choking our wetlands, or whether new species of insects are assuming pest status for our crops; and to keep track of populations of vectors of human diseases such as mosquitoes. This is a task which does not call for a capability to identify all of our known 125,000 species – or unknown 400,000; but a task which can be effectively discharged by developing the capability to reliably identify a few hundreds, or a few thousands of species. The Foundation for Revitalization of Local Health Traditions has identified a set of 300 species of medicinal plants of particular significance from Karnataka, Tamil Nadu and Kerala. To this we may add a couple of hundred species of edible fishes, a few hundred species of butterflies, frogs, turtles, birds, mammals of conservation significance, a few hundred species of insect pests of crops, a few hundred species of bacteria, fungi, intestinal worms and other human and livestock parasites and their vectors and so on. The list may come to a few thousand species of considerable significance that ought to be monitored throughout the entire stretch of our country's landscape, waterscape and seascape. Only a few hundred out of this set of a few thousand may be present in any given locality. To develop the capability of reliably identifying such a subset is not a difficult task at all; it is a task that could be mastered by any interested lay person. After all many enthusiastic bird watchers can readily identify two hundred to three hundred species of birds; and every practising fisherman and woman easily identifies a few hundred species of fish and other marine animals. It is therefore quite possible for students and teachers of biology to acquire such a capability, each for their own locality, given adequate support in terms of literature, and given that there is adequate motivation to acquire this knowledge.

Two facets of biology

To assess this proposition, we must take a second look at the teaching of biology. Teaching and research in biology are addressed to two facets of life:

(a) Functioning of life based on a machinery largely held in common by organisms as different as bacilli, moulds, trees and birds,

(b) The resulting diversity of living organisms and their associations.

The functioning of life is the subject matter of the disciplines of biochemistry and molecular biology, physiology, developmental biology and genetics. The diversity of life is the subject matter of disciplines of morphology, taxonomy, evolution, ecology, ethology and biogeography. The former set of disciplines may be termed functional biology, the latter organismic biology. The teaching of these two branches, functional biology and organismic biology poses different challenges. In teaching functional biology the emphasis has to be on the underlying commonalties; genetic code is genetic code, and Kreb's cycle or transmission of nervous impulses across synapses are the same whether taught in Madurai or Madrid, Malawi or Massachusetts. In teaching of organismic biology, however, the focus can, with profit, be very different. The variety of birds or butterflies is very different and much greater in Madurai than in Madrid, in Malawi than in Massachusetts. To teach functional biology in Madurai on the basis of textbooks and laboratory experiments designed in

Massachusetts can be very sensible, to teach organismic biology in a similar fashion does little justice to the wealth of life in and around Madurai.

There is yet another significant difference. Our understanding of functional biology is rapidly advancing. But this calls for probing into the machinery of life with sophisticated instruments, with expensive chemicals. Given our limited financial resources, Indian universities and colleges are at a disadvantage in arranging laboratory exercises for teaching many aspects of functional biology. Our understanding of organismic biology is also advancing, though not at the same rate as our understanding of functional biology. Twentyfive years ago, it was estimated that there were around 3 million different species of living organisms, of which some 1.6 million had been described. Subsequent studies have led to an upward revision of this estimate to somewhere between ten and thirty million. This implies that most of the diversity of life has not even been documented in terms of a simple description and naming of species, let alone taken further in understanding of the ecological role, geographic distribution, evolutionary relationships of that species. Most of these unknown species are believed to occur in tropical forest and coastal habitats. They must be identified, their distribution, their ecological role investigated where they occur in their natural setting; that means a tremendous opportunity for us in India in adding to the store of biological knowledge.

Untapped opportunities

Of course, some of these investigations require considerable support in terms of literature and museum or herbarium specimens[8,10]. Tragically little of such support is available within our country. But description of new taxa is only one part of research in organismic biology; information on the distribution and abundance of many species of known significance is also of considerable relevance. As stressed above, much of this is of applied value – we need to know whether populations of medicinal plants like sarpagandhi, *Rauwolfia serpentina* or wild relatives of cultivated plants like wild rice, *Oryza nivara*, are threatened with extinction, where and when populations of crop pests like brown leaf hopper or vectors like anopheline mosquitoes are undergoing rapid increase. Such information is vital to efforts at conservation of our rich biodiversity resources, and attempts at control of pests, diseases, vectors.

This kind of information, information for monitoring populations of thousands of species of human significance needs to be continually collected from all over the country. There are of course centralized agencies entrusted with the task of doing so, but they are unable to do full justice to this responsibility. Thus we do have a Botanical Survey, a Forest Survey, a Central Institute of Medicinal and Aromatic Plants; yet we have essentially zero information on the status of hundreds of species of medicinal plants of the country. We do have a Central Institute of Communicable Diseases, but its machinery could not monitor the outbreak of rat and flea populations preceding the plague outbreak of 1994.

Obviously these centralized organizations must be supported by a much more widespread network of centers for monitoring the populations of a number of species of living organisms across the country. Undergraduate science colleges along with high schools and centres of post-graduate studies are clearly the answer. These span every one of country's 500 districts, a vast source of scientific competence that has been made little use of. The botany, zoology, microbiology teachers and students of these colleges could easily study and document the distribution, abundance and seasonal and annual changes in populations of a few hundred species of organisms in their own localities. Indeed, there have already been several interesting experiments along these lines. Around the Palamau Tiger Reserve in Bihar, biology teachers from some undergraduate colleges have formed a network for monitoring the Tiger Reserve ecosystem working in collaboration with the Wildlife Wing of the State Forest Department (D. S. Srivastava, pers. comm.). The Ahmedabad based Center for Environmental Education has extensive programmes of involving high school and college teachers in monitoring a variety of environmental parameters[11]. The Western Ghats Biodiversity Network coordinated through the Centre for Ecological Sciences at the Indian Institute of Science involves botany and zoology teachers from about 15 colleges working with teams of 5–15 students to map local landscapes and investigate the occurrence of species of a number of groups of plants and animals including mosses, flowering plants, aquatic insects, fishes and birds[12]. Such studies not only would constitute a valuable learning experience, they would also generate considerable information of potentially applied value which could feed into a properly organized bioresource monitoring system of the country.

Fresh approach

It is thus entirely possible to take up this challenge. But to do so successfully calls for a fresh and different approach to the teaching of organismic, in contrast to functional biology. Functional biology has to be taught on the basis of a largely uniform curriculum, and a curriculum focused on laboratory experiments. Organismic biology could be taught much more meaningfully on the basis of a flexible curriculum focusing on locally occurring plants, animals and microbes, and should supplement laboratory exercises by extensive field observations. These requirements of flexibility, of scheduling field observations, and of assessing field based studies do pose difficulties, but these are challenges that can surely be surmounted with some effort.

Such an approach need not however involve additional burden of course work for students and teachers. Our high school curricula already include environmental studies. Our B Sc and M Sc biology courses provide for teaching of morphology, classification, evolution, ecology, biogeography. What needs to be done is that part of this material be substituted by other material – more flexible, and emphasizing first hand observations. Thus in zoology courses we have a paper on chordates. As a part of this paper students learn of platyrrhines, the primitive monkeys found in South America, but they do not learn that Jodhpur has troops of hanuman langur, *Presbytis entellus* which has been the subject of fascinating ecological and behavioural studies in Rajasthan, Gujarath, Uttar Pradesh and Himachal Pradesh. They are not encouraged to estimate these monkey populations or observe their social behaviour. At the same time, the Government of India has spent huge sums of money to sponsor through Zoological Survey of India a survey of primate populations of India, a project that was abandoned half way through, a project whose results have never been published. If all zoology students in India had been taught of the identity of the macaques, langurs, gibbons in their respective localities and encouraged to yearly maintain records of the monkey troops in their own area, we could have accomplished not only a one time primate survey, but an ongoing monitoring of primate populations in a most cost effective fashion. It would be no serious loss if in the process, we teach the zoology students a little less of squirrel monkeys in South America.

Such broadbased programmes of monitoring populations of some selected set of species have been successfully conducted in many parts of the world, primarily drawing on the resources of amateur bird watchers. The best known of these is the Christmas bird count of the National Audobon Society in the United States of America. Started in 1900, the programme now involves over 45,000 volunteers. The counts are conducted in over 1500 designated areas, each 12 km in radius. Within a week or two of Christmas, each designated count area is censused for one day, with participants seeking out and counting all birds in the area[13]. Parallel exercises have been conducted in India, such as the wintering waterfowl count sponsored by the Asian Wetland Bureau. Project Lifescape visualizes similar countrywide monitoring, drawing on biology teachers and students and covering the entire spectrum of living diversity.

Lifescape of India

An interesting approach to teaching organismic biology in this way would be to do what was proposed above, i.e. to come up with an overall list of plant, animal, microbial species of India whose first hand observations might form an important component of teaching of environmental sciences or biology – not all species everywhere, but in some part of India or other. For instance, this list may include a few of primate species – (1) bonnet macaque, (2) rhesus macaque, (3) Assamese macaque, (4) hanuman langur, (5) Nilgiri langur, (6) hoolock gibbon. Only one of these species may be selected for study in any given locality – for instance, bonnet macaque in Madurai, hanuman langur in Jodhpur, hoolock gibbon in Shillong and so on. This is not to suggest that students should close their eyes to species outside this list; the listed focal species should instead serve to build a foundation for getting students involved in observing other living organisms as well. Employing the study species as an example, the students would then observe its members under natural conditions and in the process become familiar with the morphological characteristics of primates, the place in classificatory scheme and evolutionary relationships of macaques as a part of the Chordate paper. They could observe their habitat use, food preferences and estimate their numbers as a part of the ecology or environmental biology paper, observe their social behaviour as a part of the behaviour paper, look at their geographical distribution as a part of the biogeography paper, and so on. Some of their observations could also feed into a country-wide project of monitoring primate populations.

The six primate species noted above would be part of an overall national list of microorganisms, plants and animals. This list has to be a subset of the estimated 500,000 and the described 125,000 or so species of India. We therefore need some criteria for inclusion in the total list. Possible candidates for such criteria include:

- Economic significance, for instance, medicinal plants, wild food plants, plants producing minor forest products such as tendu leaves, genetic resources such as wild relatives of cultivated plants or domesticated animals, animals which may be bred under domestication with profit, such as in butterfly farming, crop pests, weeds, crop pollinators, vectors of human diseases, fresh water fishes.
- Striking appearance and therefore ease of and attraction to observation: larger mammals, commoner species of birds, crocodiles, fireflies, dragonflies, plants with attractive flowers, large trees.
- Cultural significance: Monkeys, peafowl, *Ficus* species such as peepal.
- Conservation significance, for instance, endemic or threatened species.
- Desirability of having representatives available in all parts of the country, from Port Blair in Andamans to

Leh in Ladakh, and from rainforests of Mizoram to concrete jungles of Mumbai.

• Desirability of having representation of all groups of living organisms. Thus we should include seaweeds, lichens, mushrooms, ferns along with higher plants amongst wild food plants.

How big should such a national list be? It has to be a subset of the 125,000 described species of living organisms. Any given educational institutions could readily include an area within a radius of 3 km; say a total area of 32 km^2 for the field studies. The total area of our country is 32 lakh km^2, larger by a factor of 10 to the power of 5. Ecological theory tells us that depending on the group of organisms concerned the total number of species encountered increases at a power of 0.2 to 0.4 with the area. This implies that a study area of 32 km^2 may harbour between 1% and 10% of the total; i.e. between 1250 and 12,500 species of microbes, plants and animals, all put together. These are likely to be overestimates, for the habitats readily accessible to educational institutions would surely be poorer in living diversity than the more natural habitats for which these estimates should hold. But even then students at any educational institution should easily have access to several hundred species of living organisms in their close vicinity. Anthropological studies in Amazonian forest have shown that indigeneous people have distinct names for as many as 1500 species of local plants and animals. Trained biology students could then also learn to know several hundreds, say 250 to 500 species without much difficulty. Following the rule of thumb of 1% to 10% of total set being present in the vicinity of any given school or college in the country, the national list has to lie in the range of 2,500 to 50,000. For reasons of practicality it is best to aim the lower part of this range; so we may aim for a national list of 2500 to 5000 species. Such a national list may be viewed as the list of indicator species for assessment of the status of biodiversity in the country for the purpose of Indian national reporting to the Convention of Biological Diversity[9,14].

It is our proposal then that the locally available subset of a few hundred out of this national list of 2500 to 5000 species be employed as subjects for first hand observation as a part of teaching of environmental science, or of branches of biology such as morphology, classification, evolution, ecology, biogeography, behaviour over the three years of high school, 2 years of junior college, 3 years of undergraduate and 2 years of M Sc curriculum. Again not every student may end up observing all the locally available species, many may be subject to special observation as an individual or group project by one or few of the more interested students. Table 1 suggests a possible taxonomic breakup of a set of 2500 species and Box 1 a possible way of apportioning these species at different stages of high school and college education. The Appendix provides a possible model account of one of these species including a set of possible student projects.

Table 1. Possible taxonomic break up of a set of 2500 species

Viruses	50
Bacteria	90
Algae	90
Fungi	200
Lichens	10
Bryophytes	10
Pteridophytes	10
Gymnosperms	10
Angiopsperms	700
Protozoa	25
Sponges	5
Coelenterata	20
Platyhelminthes	10
Nematodes	20
Annelids	10
Minor phyla	10
Insects	700
Spiders	20
Millipedes, centipedes	10
Crustacea	25
Mites	25
Molluscs	40
Echinoderms	25
Fishes	120
Frogs	10
Reptiles	30
Birds	200
Mammals	25
	2500

Environmental setting

This subset of focal species of any particular locality would occur in a specific environmental setting. It would be desirable that the curriculum include a first hand study of this setting which could become a part of the environmental sciences, biology, geography or geology paper. Indeed study of this setting is the subject of a newly emerging discipline known as landscape ecology. Landscape ecology views any region as a mosaic of repeated occurrences of a set of landscape element types which may occur as patches, for example, paddy field, grassland, pond, evergreen forest, scrub savanna, human habitation or as linear or branching elements such as watercourses, roads, electric lines. It would be desirable to select one particular area, say of ten to thirty square kilometers near the high school, college or University and to prepare a good map of the area in terms of occurrence of different types of landscape elements. Satellite imagery could be a very useful aid in the preparation of this map, and such a study programme could be linked to a programme of remote sensing literacy. This landscape map could then be the basis for organizing the

Box 1
The students of environmental science and of biology in any given locality may become acquainted with the subset of the total 2500 species present in their locality in a graded fashion beginning with the commonest, most striking, easily identifiable, most significant species and adding on the less common, less significant, more difficult species at higher standards. Consider as an example, 95 species of birds (out of a total country wide set of 200 species) present in any given locality. In the 8th standard the students may begin with Jungle Crow, Indian Myna, House Sparrow, Roseringed Parakeet and Pariah Kite, adding species like the Ashy Wren-Warbler, Blyth's Reed Warbler, or Sparrow Hawk at the 2nd or 3rd year B Sc level. The 95 species may be covered in the following sequence. VIII (5), IX (5), X (5), XI (10), XII (10), I BSc (20), II B Sc (20), III B Sc (20). There would of course be no expectation that the students would not explore and get to know bird species outside this list. In fact, the account for the Indian Myna would mention how to discriminate it from very similar bird species such as Jungle Myna drawing attention to this additional species. In a locality where Hill Mynas are present, the students would naturally notice them as well, once they begin observing Mynas even if the Hill Myna may not figure amongst the list of 200 species of India selected for the purpose of this programme.

study of distribution, abundance, behaviour of the focal subset of species. It could, for instance, be used to organize information on distribution of habitats where mynas or mosquitoes breed, or a certain species of medicinal plant occurs. Ancillary information, such as older satellite imagery, official documents or oral accounts by local people could be used to reconstruct the dynamics of change in the study locality and to use it to infer changes in availability of habitats preferred by species under investigation.

Economic significance

A study of the economic significance as well as the folk knowledge and usage of the focal subset of species could form a part of a paper such as environmental science/economic botany/economic zoology/applied biology/sociology/economics. The economic significance may range from a variety of services such as food or medicine or disservices such as crop pests or vectors of human diseases. Such studies could be linked to other parts of the curriculum as well. For instance, a local medicinal plant may be the source of a specific alkaloid which could be studied as a part of the biochemistry course. The local uses of the medicinal plant could be studied as a part of the social studies, sociology or economics courses. In any event, linking the study of biology to species with specific known significance would greatly enhance the understanding of the subject by students, as well as motivate them to contribute to programmes of management of the species, whether of conservation or control.

Management regimes

A first hand study of ongoing attempts either at conservation or control of the focal subset of species, as well as of the land-use management of the entire study area at the landscape level could also be usefully incorporated in environmental science/biology curricula. Focusing on species level, there may be relevant local traditions such as protection to peafowl or peepal trees, or official measures such as a ban on hunting of all birds, or of cutting of any tree from a reserved forest. There may be programmes of propagation of medicinal plants, or control of rat or mosquito populations. It would be worthwhile studying the intentions behind such measures, as well as the efficacy of their actual operation in the field. It would also be worthwhile undertaking field studies and documentation of phenomena such as harvest, trade, marketing of medicinal plants or poaching of quails and partridges.

At the landscape level there would be a variety of regulatory measures, as well as developmental activities, both of which should be investigated and documented. These may include prohibition of encroachment on reserve forest land, or in the city prescription of the ratio of open to built up land. It would be worthwhile to monitor the efficacy of the regulatory measures, the ongoing changes and their impact on populations of the focal subset of species under study. Such investigations would not only be a useful device of teaching environmental science/biology but of generating an environmentally literate citizenry.

Organizing information

The exercises proposed above would be valuable to teaching of all aspects of environmental science/organismic biology. Additionally they could generate information of applied value in at least four different contexts.

(1) Conservation of valued species, such as wild relatives of cultivated plants, crop pollinators or threatened species of wildlife. Currently State Forest Departments, Forest Survey of India, Wildlife Institute of India, Botanical and Zoological Surveys of India are engaged in

some monitoring with this end in view.

(2) Utilization of economically valued species such as medicinal plants. Currently some drug companies have limited monitoring of their resource species.

(3) Surveillance of crop pests or livestock diseases. Currently state departments of Agriculture, Horticulture, Animal Husbandry and Veterinary Services have monitoring programmes of this nature.

(4) Surveillance of vectors of human diseases. Currently the National Institute of Communicable Diseases has limited programmes of such monitoring.

Potentially the teaching programme sketched above could generate much information of value in all these contexts. While all environmental science/biology students from 8th standard onward may be involved in the broader programme, a limited set of motivated students may participate in generating more reliable data to feed into an information system for applied purposes of conservation, economic utilization or control. Such students may be those who opt to undertake special projects as an optional part of the regular curriculum, or those who participate in some special activity such as a National Earthwatch Corps on the model of the National Cadet Corps or National Service Scheme.

This information should feed into new well-designed, vigorous programmes of monitoring all aspects of country's environment, including of course the lifescape. Such a system should take full advantage of the modern informatics technologies and be organized as an interlinked network of computerized data bases[1,7,15]. Educational institutions should be part of such a network involving a number of other agencies such as Forest, Botanical and Zoological Surveys, National Remote Sensing Agency, National Centre for Communicable Diseases, Forest, Agriculture, Animal Husbandry and Health Departments of State Governments, etc. The overall effort may be co-ordinated by a programme such as the Natural Resources Data Management System of the Department of Science and Technology[16]. Educational institutions should not only feed information into such a network, but should have access to information supplied by other agencies to facilitate students in taking projects using more synoptic information such as studies on geographical distribution patterns of their focal species.

Public awareness

Apart from becoming an integral part of the educational system, such an effort, based on the availability of good illustrated accounts of some 2500–5000 significant species of living organisms of the country could trigger off popular interest in the broader spectrum of the country's living diversity. At the time of independence there were hardly any amateur bird watchers of Indian origin in our country; today there are hundreds of bird watchers' clubs scattered throughout the country. An important cause behind this transformation is the availability of good pictorial guides beginning with Sálim Ali's Book of Indian Birds first published in 1941. This has been followed by a series of other field guides often of excellent quality. To cite a few examples, these include Pascal and Ramesh[17] on trees and lianas of Western Ghats, Tadulingam[18] on Indian weeds, Mathur[19] on coelomycetes, Daniel[20] on amphibians and reptiles, Whittaker[21] on snakes, Gay, Kihimkar and Punetha[22] on butterflies, Vijayalakshmi and Ahimaz[23] on spiders and Chhapgar[24] on seashore animals. In addition, there are the volumes of fauna of India and a number of excellent floras. But much of this latter material is too technical and of little practical use to non-specialists, even to Biology M Sc's. For instance, there is no ready aid for us to identify such striking groups of plants as lichens or of animals as dragonflies. None of this material also tells us how to go about assessing the populations of the species, or the many interesting questions that may be posed about their ecology, behaviour, distribution. The proposed material on the 2500–5000 species should fill these manifold gaps and make it possible for the citizens of India not only to become familiar with but ask intelligent questions about our living companions – not just birds, but butterflies and wasps, earthworms and orchids, starfishes and toads, lichens and lizards. If many of us can easily get to know them, their fate would become much more meaningful to us, contributing to a broader public concern for the health of India's environment. To serve this purpose, we must of course keep in mind what Sálim Ali was so notable for, namely, that 'besides providing factual scientific information to the reader it is just as important to make the account a pleasurable reading'[25].

Laying the foundation

Such an effort percolating the educational programmes at high school, college and university level, as well as promoting public awareness cannot of course substitute for the need to develop higher level skills and facilities to investigate the total range of country's biodiversity, at least two orders of magnitude higher than the proposed set of 2500–5000 species[4,10,26,27]. But this effort would surely help attract more talented scholars and generate further public support for that effort. It would thus be an important foundation for this more advanced effort. At the same time it could in itself help create a very efficient system of monitoring the status of country's biodiversity, as well as programmes to control pests and vectors.

Organizing the effort

The Indian Academy of Sciences proposes to co-ordinate such a countrywide effort as a part of its initiatives to enhance the quality of science education, as well as publish scientific literature. It would work with a range of actors in this effort. These would include:

a) Systematic biologists with Botanical and Zoological Surveys of India, research institutions such as National Institute of Oceanography and with the Universities and Colleges.

b) Interested teachers at the High School, College and Post-graduate levels.

c) Institutions active in conservation and nature education such as Bombay Natural History Society, World Wide Fund for Nature – India, Centre for Ecnvironmental Education and C.P. Ramaswamy Foundation.

d) People's Science Movement groups such as Kerala Sastra Sahitya Parishat.

e) Knowledgeable practical ecologists, such as the tribal field guide Natarajan of the Annamalai Wildlife Sanctuary who brought the presence of Peninsular Bay Owl to the notice of scientists.

Interested people drawn from such groups should then be organized to decide upon and work towards the following objectives:

a) Deciding on the criteria to select the set of 2500–5000 species – or any other number agreed upon. These criteria should reflect adequate coverage in terms of: (i) taxonomic groups, (ii) geographical distribution, (iii) habitat preference, (iv) human significance in relation to economic, aesthetic, conservation or other considerations.

(b) Arriving at the actual list of species by applying these criteria.

(c) Deciding on what sort of descriptive/illustrative material should go into the account of each species. This could relate to morphology, habitat preference, seasonal changes, notable behaviour patterns, geographical distribution, relationship to humans, ways of discriminating from other related species, names in Indian languages, techniques for assessing population status, suggestions for student projects (see Appendix for a possible example).

(d) Commissioning the actual writing up of the accounts with the help of a panel of experts, which may include practical ecologists like Natarajan mentioned above.

(e) Peer review, revisions and editing of the prepared accounts.

(f) Translation of the accounts in Indian languages.

(g) Deciding on the form/s in which the material should be published and distributed. For instance, the material could be in several volumes on the model of Ali and Ripley's *Handbook of Birds of India and Pakistan*. It could be supplied as loose-leaf material in ring files so that a high school, for instance in Shillong may only order the accounts of species present in Meghalaya prescribed for study by the State Department of Education. It could also be published electronically, as CD ROMS or on the internet.

(h) Actual production and distribution, hopefully so that at least some of the species accounts reach every high school, college or university, as well as homes of interested citizens throughout the country.

(i) Raising the funds for such a programme. This would especially involve honorarium for writing the accounts, preparation of illustrations and finally publication. At Rs 200 per species the writing and illustration would come to Rs 5 to 10 lakhs. If each account averages 3 pages, this would entail publishing 7500 to 15,000 pages. At Rs 300 per page this amounts to Rs 22.5 to 45 lakh. Another Rs 5 lakh may be required for co-ordination of the whole project, resulting in a budget of Rs 32.5 to 57.5 lakhs. Translation and publication in Indian languages would entail further expenses. It may be noted that these estimates are a small fraction of the three billion dollar budget projected for the grandiose systematics 2000 project, currently proposed as the basis of the effort at taxonomic capacity building for worldwide implementation of the Convention on Biological Diversity[28].

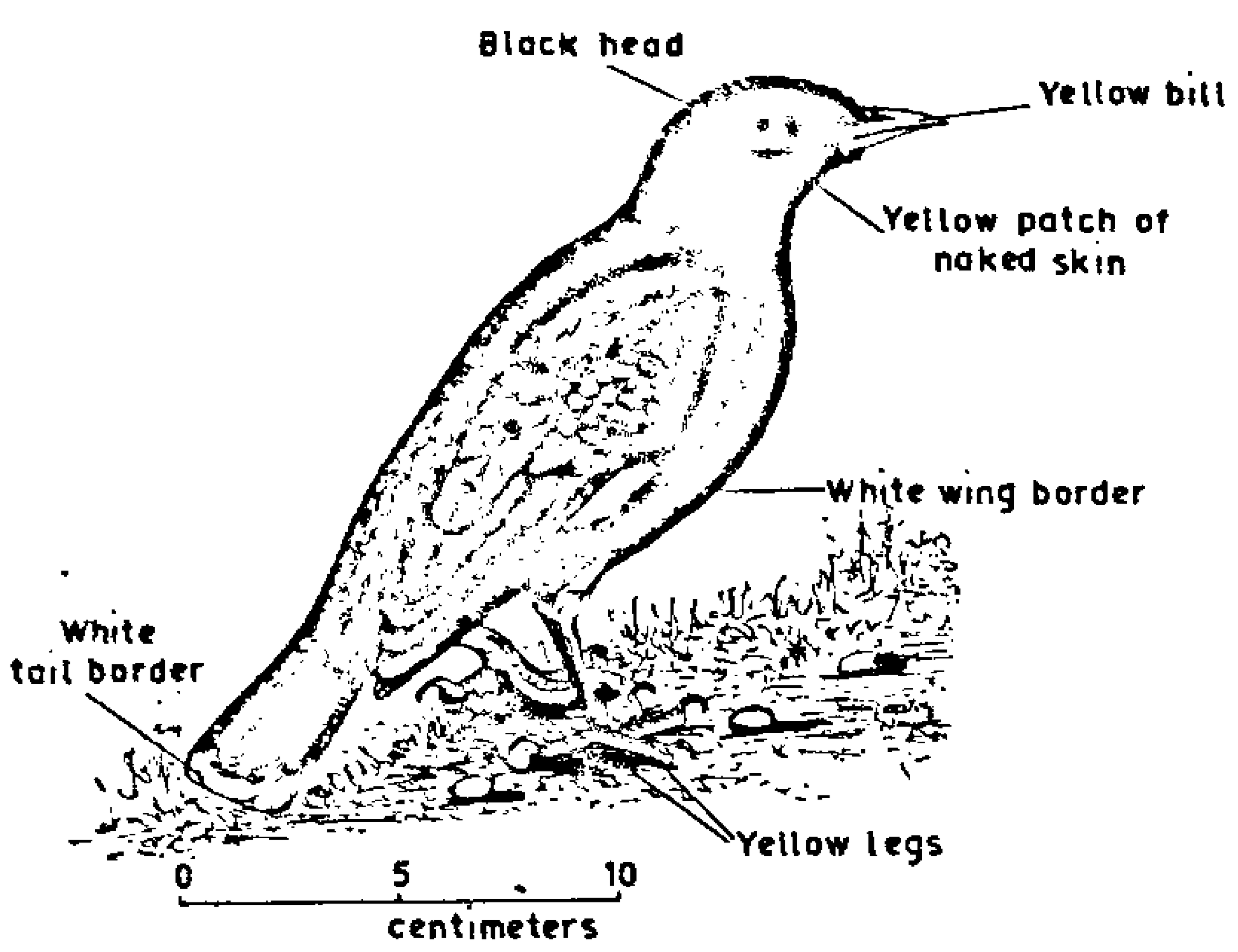
The Indian Academy of Sciences will be launching this programme in November 1996 to commemorate the birth centenary of Sálim Ali, one of the Academy's most distinguished fellows. With this objective, the Academy is joining hands with the Indian Institute of Science and the Jawaharlal Nehru Center for Advanced Scientific Research to organize a discussion meeting that would bring together a group of over 100 people representing the many different sets of actors mentioned above. This meeting would debate on the specific content and time schedule for the project. But apart from this meeting suggestions, including offers of help and participation from all interested citizens of India; biologists, educationists, nature lovers would be most welcome. These should be addressed to the convener of the project, Madhav Gadgil at the Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012; Fax: 80-3341683; e-mail: madhav@ces.iisc.ernet.in.

APPENDIX 1

Indian Myna

Acridotheres tristis (Class Aves, Order Passeriformes, Family *Sturnidae*).

Size: 23 cm in length, about 110 gm in weight, a little smaller than a dove, bigger than a bulbul.



Field character: With its plump body, short tail and straight, sharp bill, the Indian Myna is a characteristic feature of Indian life. It is dark brown in colour with a glossy black head and bright yellow legs, bill and a naked patch below and behind eye. When in flight a white bar opens out on the wing; its tail is also bordered with white. Males and females are indistinguishable, the young are a little duller in colour with the heads ashy brown rather than black.

Related species. Indian Myna most resembles the Jungle Myna (*Acridotheres fuscus*) which lacks the yellow patch of skin behind the eye, is greyer in colour and has a little tuft of black feathers at the base of its bill on the forehead. The Bank Myna (*Acridotheres ginginianus*) is slightly smaller and pale bluish grey in colour, with a brick red patch of naked skin below and behind the eye.

Habits. Indian Myna follows people everywhere in the country, quick to colonize even far out in the desert. It is to be seen in town and villages, fields and gardens, sometimes walking after cattle, other times hunting insects on its own. It has a direct, business like flight in the air and a parade step on the ground. Mynas go in pairs or small parties, chattering a great deal. They sleep in large aggregations at communal roosts in large leafy trees, coconut groves, sugarcane fields, or in warehouses or railway stations. Such communal roosts are often mixed with those of crows, sparrows, parakeets or rosy pastors.

Nesting. The breeding season is primarily between April and July, but may commence as early as mid-January in Kerala and extend to September in parts of the country. Mynas nest in holes in trees or in walls and roofs of buildings. Usually there is considerable competition for nesting sites with violent fights between members of prospective pairs. Each partner grapples with its opposite number in a noisy rough and tumble, often dropping to ground. Mynas generally raise two successive broods over the breeding season laying clutches of 4 or 5 blue eggs.

Food. Indian Mynas have a broad range of diet, chiefly fruit, grain, insect and grubs but also small animals like baby mice, lizards and crabs and kitchen scraps form garbage dumps. They are also fond of nectar from bird flowers like silk cotton.

Distribution. Indian Mynas are resident, staying in a given locality year after year, probably coming to the same communal roost evening after evening. They occur throughout the subcontinent including Pakistan, Bangladesh, Nepal, Bhutan and Sri Lanka, going up to 3000 m in Himalayas. They have also been introduced to Andaman, Nicobars and Lakshadweep, as well as other parts of the world such as New Zealand.

Human significance. Indian Mynas are a companion of man all over the country amusing people with their chirpy chatter. To an extent they damage crops and orchards, but also help by destroying insects.

Population assessment. Indian Mynas are quite conspicuous and may be easily recorded on bird counts along straight transects. Their large noisy communal roosts with several hundred to thousands of birds may also be located and mapped, and birds counted fairly accurately as they gather at the roosts just before the sunset in the evenings. It is also possible to locate their nests and estimate their breeding populations in a given area.

Suggestions for student projects

(1) Mapping of communal roosts of mynas, crows, parakeets and populations censuses; (2) Role of mynas in pollination of trees like silk cotton and coral trees; (3) Role of mynas as pests of crops like jowar; (4) Biological clock of Mynas in terms of time at which they return to the roosts in the evening; (5) Nesting success of Mynas; (6) Variety of calls used by Mynas in different situations.

Local names: Desi myna (Hindi); Hor (Kashmiri); Salik, Bhat salik (Bengali); Salik sorai, Salika, Ghor salika (Assamese); Dao myna (Cachari); Bemni, Saloo (Chota Nagpur); Gulgul (Madhya Pradesh); Shale, Salonki (Marathi); Kabar (Gujarati); Gorwantera (Kannada); Nahanavai (Tamil); Goranka (Telugu); Kavalamkili, Matatta (Malayalam).

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