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Biodiversity: gaps in knowledge

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Summary. The Convention on Biological Diversity set conservation of biodiversity on the world agenda. Gaps in knowledge need to be addressed for actions to be effective and sustainable. Gaps include: species diversity, micro-organisms and their ecological roles, ecological and geographical status of species, human capacity to assess and forecast bio-ecological degradation. Requirements for global inventories call for worldwide collaboration. Criteria for setting priorities need to be formulated and agreed.

Biodiversity in an eco-geographical region, the southern Mediterranean, is discussed as a case study. Outlines of national actions to contribute to world endeavor are outlined.

Keywords: biodiversity, priorities, bio-indicators, biomonitors, southern Mediterranean

Introduction

Concern for the protection of biodiversity, under the designation of natural heritage, goes back in history; for example, the *Hema* system of the Arabian Peninsula (Draz, 1969; Kassas, 1972), the national parks system in North America (Yellowstone National Park established in 1872), the history of the World Conservation Union (IUCN) since its birth in 1948, etc. The year 1980 marked a significant landmark with the world-wide launching of the World Conservation Strategy (IUCN-UNEP-WWF,† 1980). The general acceptance of this seminal document was due to the support of a consortium of IUCN, WWF, UNEP, FAO and UNESCO,† and the subsequent development, of national conservation strategies in several countries in all continents. This was further supported by United Nations World Charter for Nature (UN, 1982), Caring for the Earth (IUCN-UNEP-WWF, 1991) and the Global Biodiversity Strategy (WRI†-IUCN-UNEP, 1992).

Chapter 15 of Agenda 21 (UN, 1992) addresses the issue of conservation of biological diversity. Aspects of this broad issue are dealt with in chapter 16 (environmentally sound management of biotechnology) and in chapters dealing with various ecosystems including forests; conservation of biota is inseparable from conservation of ecosystems of which biotic elements are integral parts. Biodiversity is now perceived as comprising three facets: habitat diversity, species richness and genetic materials within species. Conservation programmes need to address these facets. *In situ* conservation entails protection of ecosystems. *Ex situ* conservation entails protection of species (botanical and zoological gardens, sanctuaries, breeding stations, etc.) and the genetic resources (germplasm banks).

Programmes of action envisaged in Agenda 21 (chapter 15) aim at ensuring that national policies and strategies supportive to the cause of conservation of biodiversity are adopted, that national plans of action are developed and integrated into national development plans and strategies, and that national mechanisms are set to manage the implementation of national programmes of action.

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†International Union for Conservation of Nature and Natural Resources (IUCN), now World Conservation Union, World Wildlife Fund (WWF), now Worldwide Fund for Nature, United Nations Environment Programme (UNEP), United Nations Food and Agriculture Organization (FAO), United Nations Education, Scientific and Cultural Organization (UNESCO), World Resources Institute (WRI).

The Convention on Biological Diversity (UN, 1992) was endorsed at the United Nations Conference on Environment and Development (UNCED): Earth Summit in June 1992 and since December 1993 it has become international law. The Convention addresses a number of issues: conservation of world biological resources, balance between intellectual property (ownership of patent rights of biotechnology) and ownership rights of germplasm material and of indigenous knowledge, and provision of technical and financial resources to developing countries so as to enable them to play their indispensable roles in conservation of biological diversity. The Convention includes a preamble that outlines the issues that need to be addressed and the commitments that need to be upheld. The first five articles set an introductory background: objectives, principles, scope, cooperation and use of terms. Articles 6–10 outline the actions that need to be undertaken by Parties (national strategies and programmes for monitoring and assessment, *in-situ* conservation measures, *ex-situ* conservation measures, sustainable use of biological resources). Articles 11–18 address elements of supporting measures and capacity building: incentives, research and training, education and awareness, impact assessment of development projects and monitoring such impacts, access to genetic resources and to technology, technical and scientific cooperation. Article 19 addresses the sore issue of biotechnology and distribution of its benefits. Articles 20 and 21 deal with financial resources (explicit commitment of developed countries to provide new additional resources to assist developing countries towards meeting incremental costs of implementing measures which fulfil the obligations of the Convention), and financial mechanisms for providing the resources to developing countries. Articles 23–25 established the conference of parties and outlined its functions and its subsidiary bodies. The rest, Articles 26–41, set the legal frame of the Convention and procedures of its operation.

This Convention provides an institution that can deliver, if supported by the unequivocal political commitment of all countries, developed and developing; and it can otherwise remain a forum for exchange of information and of blame. The key to success is not only the words of the Convention but also the deeds of all partners. Here is the cardinal role of the Conference of Parties. Parties can make it the beating heart of a worldwide operation that is effective and sustainable. The point to be made here is that countries should prepare themselves for the effective participation (not just presence) in the Conference of Parties.

Gaps in knowledge

The first gap in biodiversity knowledge relates to the inventory of the global species diversity, that is, the number of species on Planet Earth. The gap is remarkable. The Global Biodiversity Strategy (WRI-IUCN-UNEP, 1992, p. 9), states "Estimates of global species diversity have varied from 2 million to 100 million species, with a best estimate of somewhere near 10 million, and only 1.4 million have actually been named." If the 10 millions is accepted as the best-guess estimate, the situation is of 14 percent known and 86 percent unknown species. This is perhaps the most serious gap, although the number known may now be 1.7 million species.

The second gap relates to the biodiversity of the less conspicuous organisms. These include fungi, bacteria, algae, protozoa, etc., and to their role in world ecology. Here, again, "The number of formally named and accepted micro-organisms is currently around 157,000 species, the fungi comprising almost half of these. However, current conservative estimates of probable world species totals as high as 1.8 million," Hawksworth (1992a). Certain roles of micro-organisms in the functioning of various ecosystems and particularly in the decomposition of organic remains and hence in nutrient cycling are known. It is also recognized that micro-organisms are principal pathogens to plants and animals (including humans), and may thus have seriously negative impacts on crops and livestock, etc., but may also have positive impacts in maintaining the balance of populations in natural ecosystems. Micro-organisms have their roles in certain global processes: methane production and build-up of greenhouse gases in the atmosphere, production of dimethyl sulphide and its derivatives by oceanic algae and its role in rainfall patterns (Lovelock, 1991, pp. 123–6), etc. Furthermore, reference to the role of micro-organisms in the fields of bio-technology may be added. What is known of the taxonomic inventory, ecological roles and economic potentials of micro-organisms leaves considerable gaps in human knowledge.

The third gap relates to the role played by each species among biotic elements of ecosystems. Several authors (e.g. Walker, 1992) raise the question of "ecological redundancy," and its natural sequel "what to protect?" (Vane-Wright *et al.*, 1991). In other words: are all species equal ecologically and taxonomically? There is insufficient information to enable judgement on the functional roles of all species or to evaluate the taxonomic weights of all species. The debate that relates to what to protect cannot be settled without measurement of weights of species and without policy decision as regards the purpose of protection.

The fourth gap relates to human ability to assess and forecast bio-ecological degradation. Comprehensive assessment of all components of an ecosystem is a laborious task, even if carried out on limited scale. This has led to ideas related to bio-indicators, e.g. Hawksworth (1992b); identification of certain species whose change in density, ecological behaviour or physiological performance should provide indicators to the status of the ecosystem as a whole.

To these four broad gaps in present knowledge may be added those gaps related to specific geographical areas including country-level issues, and gaps related to specific taxonomic units including inventories of genetic materials. Such gaps could be covered in national biodiversity research programmes that would provide for intensive studies.

Available estimates of: (1) number of species on Earth, (2) rate of man-induced loss of species, (3) natural rate of speciation and (4) rate of natural extinction of species, are currently best intelligent guess-work. There is need for a step towards a 'much firmer scientific basis' for such estimates. The UNESCO-SCOPE-IUBS[‡] proposal for inventorying and monitoring biodiversity (Di-Castri *et al.*, 1992) aims at establishing a world-wide network of sites and a world programme of systematic monitoring. But because "resources are limited and time is short, a full inventory of biodiversity is considered impossible. The task of inventorying the complete fauna and flora of the world seems impossible at this time. . . ". The UNESCO-SCOPE-IUBS programme suggests focus on selected sites that form a world-wide network. This network would take advantage of existing Biosphere Reserves and will cover terrestrial, coastal and marine habitats. Selected sites would provide for ecological analyses that address other gaps outlined above.

But global inventorying needs a collaborative international effort, perhaps under the aegis of the Convention on Biological Diversity. The recently formulated Global Taxonomy Initiative is a step in the right direction. It will require the active participation of all countries of the world. In most countries, especially in the third world, national programmes need to include:

— training of scientists and technicians who would form national teams for field surveys and monitoring and for curation and maintenance of referral collections;
— establishment of field sites that represent (preferably all) habitat diversity in the country;
— establishment of national systematic reference collections as appropriate (herbarium materials, cultures of algae and micro-organisms, seed stores, etc.), these may be elements in national natural history museums;
— establishment of a national management unit for the national programme, this unit will need the support of data bank facilities and working links with the above three component elements.

Regional coordination is necessary and should form building blocks for a global programme. Regions should be conceived on eco-geographical bases and not on political grounds.

The UNESCO-SCOPE-IUBS proposed programme for an international network for inventorying and monitoring biodiversity (Diversitas) aims at filling the principal gaps in present knowledge. This is welcome. But an international programme that rests on selected sites will fall short of the comprehensive coverage of the world habitats. Country programmes, including country networks of sites, should be elaborated and become sources of basic information.

Taxonomic inventories of organisms need to be extensive in coverage and to be complemented

[‡]Scientific Committee on Problems of Environment. (SCOPE) and the International Union for Biological Sciences (IUBS), both of the International Council of Scientific Unions (ICSU).

by in-depth studies on rates of change in their diversity. Change includes loss (man-induced and natural extinction of species) and evolution (speciation). These studies depend on long-term monitoring and may be confined to selected sites where detailed studies have been carried out for years. Endemic species deserve special attention in these studies as an endemic species may represent (a) a relict of once widespread species that is now on the decline and may eventually become extinct, or (b) a newly evolved (young) species that may eventually become widespread. Human-induced loss of species is often related to changes in habitat that are adverse to its healthy growth and reproduction. Here ecological monitoring may be equally important as biotic monitoring. Sites of these studies may usefully be inter-related into regional networks with systems of effective exchange of information.

A group of plants and animals that are often referred to as micro-organisms include: algae, fungi, bacteria, viruses, protozoa, etc. Some of these (bracket fungi, seaweeds, etc.) are not small and do not qualify for the term micro-organism. Our taxonomic knowledge related to these organisms is limited: about 1700 species of fungi and 120 species of bacteria are described as new to science each year (Hawksworth, 1992a). Micro-organisms may have had a crucial role in the evolution of the global biosphere (Lovelock, 1991). It is known that they:

— are essential elements in the nutrition and digestion of foodstuffs of many animals (ranging from termites to herbivorous mammals), and plants (root nodules, mycorrhiza, etc.);
— have essential role in the functioning of natural ecosystems especially in process of food webs and material cycling;
— comprise pathogens that cause economic loss of agriculture but may have a valuable ecological role in maintaining balance among populations;
— are principal elements in fields of biotechnology and its industrial applications.

The taxonomy of micro-organisms is often difficult as the morphology and physiology of taxonomic units (species) may show wide ranges. Taxonomic research in this field needs to be enhanced so as to set solid bases for classification and identification; molecular biology gives promise. Survey work for inventory of micro-organisms in various habitats and conservation work are arduous and demanding. Resources may not be available everywhere, and there is potential for areas of international (regional or world-wide) collaboration.

Priorities

Resources available for conservation programmes are limited and hence the need to set priorities. Criteria for setting priorities for species conservation relate to their ecological and sociological roles and their status. Noss (1990) lists five categories "that may warrant special conservation effort; (1) ecological indicators, species that signal the effects of perturbations; (2) keystone, pivotal species upon which the diversity of a large part of a community depends; (3) umbrellas, species with large area requirements; (4) flagships, popular, charismatic species; (5) vulnerables. Walker (1992) suggests that analysis of ecosystem function would lead to "functional classification of biota" into guilds. Further analysis of interactions within each guild may show the functional redundancy of certain species. This category 'redundant' may be added to the above five and its proponents seem to suggest that its priority for conservation is low. These are interesting ideas that remain notions with little scientific backing. Walker (1992) suggests exclusion of moral or ethical arguments, a notion that is difficult to accept.

Priority should relate to the objective of the action of conservation and should be supported by research information. If the intention is to conserve habitat diversity, then conservation priority should be given to species, conspicuous and non-conspicuous, that have roles in the healthy functioning of the ecosystem including its ability to maintain its resilience. Here ecological knowledge is basic. If the intention is to conserve species diversity, then conservation action should cover all species. Here floristic and faunistic knowledge is basic. If conservation action aims at protecting genetic diversity, *ex-situ* in germplasm banks or *in-situ* in sanctuaries, then priority has already been decided: what elements to conserve.

Here conservation priority relates to the economic weight of the genetic resources or to the above-mentioned categories identified by Noss (1990).

Bio-indicators

Ecological studies earlier in the 20th century addressed issues related to use of plant growth (species-communities-formations) as indicators of the ecological conditions and associated environment. This depended on knowledge of the ecological requirements of these indicators. With the widespread interest in conservation of biodiversity (ecosystems-species-genetic materials) it became evident that it was necessary to discover indicators that are informative and that could be used in environmental monitoring and assessment. Hawksworth (1992b) enumerates six groups:

— bio-indicators
— biomonitors
— bio-accumulators
— biomarkers
— bioprobes
— bio-assays.

In conservation programmes the first two are more closely relevant.

Bio-indicators, if identified properly, could provide criteria for (a) selection of sites to be conserved, (b) identifying adverse ecological factors. Biomonitors could provide indicators for the success or failure of conservation measures, they could be valuable tools for evaluating management procedures set for conservation sites. There is a rich literature on the topic of bio-indicators but little of it relates to the conservation of tropical and subtropical regions. This is a gap that should be addressed in international research programmes.

Biodiversity in southern mediterranean

The Mediterranean, with its east-west stretch, lies in the transition between the temperate and humid regions of Europe in the north and the hot and arid territories of the African Sahara and the deserts of the Arabian Peninsula in the south. Biogeographical affinities of the two sides are different, the histories of their climate during recent geological times (Quaternary) are different. The Mediterranean basin has a long history of intense human occupation; it has been described as 'the cradle of western civilization' (Branigan and Jarret, 1975). There are limited relicts of its original natural vegetation and associated animal life remain (Thir-good, 1981), but sites of early (Neolithic) agricultural settlements are everywhere in the Mediterranean Basin and its eastern outskirts (Zohary, 1986).

North Africa, with its sea-front on the Mediterranean coast, covers the southern section of the basin. This section, with its eastward extensions in western Asia, comprises a series of bio-geographical belts: the Mediterranean, the Saharo-Arabian and the Sudano-Deccanian. The eastern limit is the Irano-Turanian highlands (Schmida, 1985).

The southern and south-eastern side of the Mediterranean basin embraces a number of biogeographic corridors that link the tropics in the south with the palaearctics in the north. The Gulf connects the Indian Ocean with the temperate region of the Iraqi-Iranian highlands and their northern territories. The Red Sea is a major corridor between the tropical seas in the south and the Mediterranean in the north. The man-made Suez Canal provided a route for active biotic exchange between the two seas. The Gulf of Aqaba, with its peculiarly warm environment due to the highland topography of its northern side, brings tropic formations (corals, mangroves, etc.) to the world's northernmost geographical limit. The River Nile links equatorial Africa with the Mediterranean and its basin provides ecological links amongst the territories of the ten countries that share this basin. These corridors are principal parts of the migratory routes of the palaearctic-tropic journeys of birds; the wetlands of Iraq (Ahwar marshes) and of Egypt (Delta lakes) are vital resting stations on these routes (Meininger and Atta, 1994).

Gene resources: plants

The eastern part of the Mediterranean basin is one of Vavilov's eight centres of origin of the world's cultivated plants. Vavilov (1949–50) enumerates 83 species (18 crops, 39 fodder, etc., and

26 fruits and spices) that have their origin in this region. Zohary and Hopf (1988) provide a detailed survey of the history of agriculture and hence history of plant domestication during the Neolithic. The sum of this extensive survey includes: (1) cultivation seems to have originated in a series of farming villages that form the "nuclear area" of the Near East arc from where it spread in all directions; (2) this origin dates back to 7500–7000 BC; (3) it was based on the domestication of a limited number of local plant species. Referring to these "founder crops," Zohary (1986) notes that wild progenitors of these crops are native to the Near East and that "some progenitors (wild emmer, wild chickpea, wild bitter vetch) are endemic to this region." These founder crops include:

— emmer wheat (*Triticum turgidum subsp. dicoccum*),
— eikorn wheat (*Triticum monococcum*),
— barley (*Hordeum vulgare*),
— lentil (*Lens culinaris*),
— pea (*Pisum sativum*),
— bitter vetch (*Vicia ervilia*),
— chickpea (*Cicer arietinum*),

Later (6000 BC) crops include:

— broad bean (*Vicia faba*),
— flax (*Linum usitatissimum*).

Additional crops include: *Papaver somniferum*, *Cyperus esculentus*, *Panicum miliaceum*, vegetables, oil crops, fruit trees, etc. (4000 BC).

To these may be added species that are fodder crops and range plants. Two leguminous genera (*Medicago* and *Trifolium*) and several grass genera (*Panicum*, *Pennisetum*, etc.) are of particular value. Wild relatives of these crop and fodder plants are elements of the flora of the region and retain genetic materials that are of special economic significance and hence deserve special conservation programmes.

The flora of the Mediterranean basin provided its peoples, all through their history, with a great variety of medicinal herbs, hundreds of these plant species are enumerated in lists by UNESCO (1960) and Boulos (1983). Some of these species may have been lost or are threatened, but most of them and their relatives are present. These species deserve special conservation measures and programmes of biodiversity prospecting.

For comparable notes on animal species, see Osborn and Helmy (1980), Houlihan (1988), Green and Drucker (1991), etc.

National actions

All the gaps of knowledge enumerated above are noted in all countries especially those with limited capacities in fields of taxonomy and inventories of biodiversity and its three principal elements. National capacities encompass:

— trained manpower,
— referral collections of biota and biodiversity data banks,
— national programme for biodiversity inventories,
— national programmes for conservation of biodiversity.

These four elements are mutually supportive and need to be developed as an integrated national effort.

A national programme for the development of manpower needs to aim at training of: taxonomists specialized in the principal groups of biota, field surveyors and collectors, curators of referral collections, and specialist for management of data banks. A national programme for conservation of biodiversity remains the umbrella that provides guidance and support to the other elements and that provides the basic institutions that include: a national network of nature reserves of various categories, a national natural history museum that provides home for the referral collections and biodiversity data banks, a national germplasm bank, institutions for manpower development (with support and participation of universities and institutes of higher education), legal, financial and institutional elements for managing the national programme.

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