The Desert Ecological Research Unit of Namibia: Current Status of Ecological Research in the Namib

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The Namib Desert, with its unusual geomorphology and climatology and its associated unique fauna and flora, has been a focus for biological research since the turn of the century. Today, much of this research takes place within the ambit of the Desert Ecological Research Unit of Namibia, which is currently working in the central Namib Desert at Gobabeb. The Unit's research has been supported by the Foundation for Research Development of the Council for Scientific and Industrial Research, the Transvaal Museum and the Directorate of Nature Conservation of Namibia. DERU activities are the result of cooperative efforts by a number of staff, visiting scientists and technical assistants. Here I outline the general research approach of DERU as well as current and future research emphases.

GENERAL APPROACH

All research carried out under the auspices of the Desert Ecological Research Unit addresses aspects of the what, how and why of desert ecology. Particularly encouraged are in-depth studies leading to predictive capabilities and comprehensive syntheses. In addition, descriptive studies are not discouraged for these constitute the first steps towards the overall objectives. Thus the research of DERU includes general observations on natural history as well as more refined studies incorporating development and testing of current ecological theory. The research projects may be specific to the Namib or lead to amplification of basic biological principles. Any organisms that lend themselves to answering the questions at hand may be considered by DERU staff and visitors. Many studies of specific organisms or systems are designed to serve as models of a class of biological or environmental interactions rather than for elucidation of specific facts about the organisms.

Why the Namib? Could this work not be done elsewhere? Gobabeb is located in about the driest part of the most arid desert in southern Africa, where physical conditions impose severe constraints on the biotic component of the environment. As a result, the biotic community is 'relatively simple' and processes are more readily identified than in more moderate areas. Moreover, the Namib also experiences frequent fogs which provide a small but relatively regular source of water for those organisms able to take advantage of it. The combined result is a relatively rich fauna and flora living in an extreme environment providing great potential for biological research.

Opportunistic perhaps might be the best single word to describe the research approach. Major irregular and unpredictable events, particularly rainfall but also very strong winds and extreme high and low temperatures, may have pronounced and prolonged effects on desert ecosystems. Any desert research programme must be flexible enough to take advantage of such events and also provide at least a basic background against which these events can be evaluated. In addition, because of its limited staff structure, DERU must also take opportunistic advantage of available scientists, only a very small number of whom are able to spend any length of time in the field. Collaborative research is thus strongly encouraged between the few longer-term resident staff of DERU and numerous visitors from all over the world.

DERU research is essentially field oriented with laboratory experimentation carried out to augment field observations and manipulations. Related laboratory research on Namib organisms by other institutions is supported. In the central Namib, advantage is taken of the natural laboratory provided by 1) the juxtaposition of three diverse habitats: dunes, river and plains, and 2) the steep east-west environmental gradient. The comparative approach is further emphasized by incorporating differing species or groups of organisms into the experimental design when possible. For DERU scientists, Namib oriented research, firmly grounded on basic biological theory, is encouraged. In particular, they carry out research projects that 1) take advantage of unusual or unique characteristics of the Namib, 2) deal with relatively important components of the community, 3) are facilitated by local conditions, 4) are likely to maximize predictive capabilities.

Long-term studies form the backbone of the research programme. Because a desert is an event-driven system with stochastic inputs, the direction and degree of induced changes are unpredictable. Nevertheless, undisturbed deserts are highly resilient ecosystems even though the changes with time may be extensive. These changes may be very rapid or extremely slow, often with a long recovery time between events. Unpredictable bottlenecks, genetic drift and other factors affecting the biotic communities will only be observed during the course of long-term studies. Moreover, these long-term studies usually include climatology and geomorphology as the major causative and controlling agents.

The patterns and processes that underlie desert biology are

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revealed by the research programme, and allow for comparisons with other ecosystems. In particular, emphasis has been placed on ecophysiological studies of the fauna and flora which have addressed questions of water and temperature relations, the use of fog, rain, wind and desert substrata and the behaviours associated with these processes. Other areas of biological study include reproductive, developmental, population and community ecology. An evolutionary perspective is applied in an attempt to understand why a natural desert works as it does. It is this evolutionary approach that necessitates integration with studies of the climatic and geomorphic history of the desert and their influence on the biota.

A variety of scientists carrying out a diversity of projects produce material that is of value to the research programme. Synthesis of this disparate material at different levels remains an important objective, particularly of the longer-term staff members. Each is also encouraged to synthesize his own work and integrate it into the fabric of existing knowledge about the Namib as well as into a general biological framework. In these attempts at an holistic overview, collaborative work between DERU staff and regular visitors is often particularly effective.

Conservation of the Namib environment is an important consideration in all DERU research. In particular, DERU research has contributed extensively towards public awareness of the unique environmental conditions that have evolved in this desert through time. Moreover, most of the research results have important implications for management of arid and semi-arid areas dedicated to conservation as well as other forms of land use. Staff and visitors are encouraged to interpret their research for the public and conservation authorities as well as the scientific community.

The research approach of DERU is expected to evolve as our knowledge of desert ecosystems expands and the research climate continues to change.

CURRENT RESEARCH

Research takes place on various levels. Visiting scientists tend to work at the ecophysiological level as these studies can be carried out during relatively short periods in the field. Other projects of longer duration, many based at the level of population biology, are carried out by DERU staff alone or on a collaborative basis.

What are the characteristics of the Namib Desert? This was the first question to be asked by scientists working in the Namib and is still the object of consideration. From a geological point of view, the question currently receiving direct attention addresses the history of the area that is now the Namib. Although the great age of the Namib has been the subject of controversy for the last 25 years, until very recently the amount of time spent on speculation had exceeded greatly that spent on actual research. Geomorphologists working in the Namib have concentrated on the origin and particularly the dynamics of maintenance of the various extant dune forms. Comparison of their observations with what has been found in the sandstone record contributes to elucidating the history of the Namib. This history and its effects on the evolution of the biota still generates much heated discussion. However, with geologists and biologists now working more closely together, at least a partial consensus of opinion appears to be developing.

Characteristics of the regional weather and climate are studied in their own right as well as in relation to various components of the desert biota. Fog as a relatively predictable although meagre source of water, wind as an important agent in shaping the dunes and transporting detritus, temperature as it affects surface activity of animals, and rain as an unpredictable driving force of many communities, all receive attention during the course of various investigations. Since the subsurface environment appears to be very important, the microclimate of this habitat, particularly temperature and moisture, is being investigated.

What animals and plants live in the Namib is a question that has been asked since biologists first encountered this desert. Although DERU staff do not usually examine this question directly, they do contribute material and information to systematists and biogeographers. In particular, staff of the Transvaal Museum, the State Museum, Windhoek, and the National Collection of Insects, Pretoria, facilitate such investigations.

How do animals and plants live in the Namib Desert? This is the type of question most often approached by ecophysiologists and behavioural ecologists. During the past, many have applied themselves to understanding how animals and plants cope with high temperatures, low water vapour pressures, strong winds, apparent scarcity of water and food and unpredictability of resource availability. Organisms living in the sand dunes have received most attention as it was postulated that these had to tolerate the most extreme conditions. However, reconsideration of this assumption has led to the tentative conclusion that sand dunes may provide a less extreme environment, for those adapted to these conditions, than the environment presented by the more compact substrate of the gravel plains. For the full explanation of how components of the biota live in the desert, however, other aspects in addition to physiology must be considered. For example, morphology appears to be important in the suites of adaptations used by plants, whereas behaviour is very important for animals. For many animals, behaviour may be more important than physiology or morphology in the use of fog-water, avoidance of high temperatures and various other adaptations that explain how animals exist in the Namib.

Why has such a wide variety of reproductive patterns in plants and animals evolved, particularly within the fog zone? It has been postulated that reproduction will be synchronized with rainfall in a desert. Annual grasses, other annual plants, and a number of invertebrate species do, indeed, respond to rainfall by rapidly growing and reproducing within a short space of time. There are, however, varied groups of plants and animals that reproduce continually or seasonally and are not entrained to rainfall. Many of these organisms live within the coastal Namib fog zone and appear to use fog as a source of moisture. Reproductive patterns of annual and perennial plants in relation to seed longevity and seed predation are of current interest. In addition, the variety of mating behaviours among closely related tenebrionid beetles that reproduce throughout the year lend themselves to examination of questions concerning mate guarding and sperm competition and are currently under investigation. Most of the studies of life history patterns can be integrated into a view of the Namib either as a high energy system operating in response to unpredictable rain with a rapid but short-term period of activity,

or as a low energy system operating mainly over longer periods in response to fog as a relatively predictable source of water available regularly but in small amounts.

Have community interactions developed under these extreme desert conditions? Several species of scorpions and spiders are particularly numerous and conspicuous in the sand dune or riverine habitats, lending themselves to examination of this question. Organisms with differing methods of predation show different population responses, behaviour and energetics when faced with environmental extremes. Interactions among various classes of predators may influence their populations, but the importance of predation on herbivore and detritivore communities has rarely been demonstrated.

Plant and animal interactions, in particular pollination, herbivory and seed predation, are important in even the most extreme desert community. Some of these interactions are perhaps quantitatively more important in the less extreme areas; comparisons between fog- and rain-influenced parts of the Namib are currently being made.

Detritus, a conspicuous aspect of the dune ecosystem, was first pointed out by Dr Charles Koch to be an important food source for macro-detritivores. Relative importance of macro- and micro-detritivores in arid environments, decomposition and mineralization of detritus, and dynamics of detritus production, redistribution by wind and consumption have attracted the interest of many Namib scientists. Comparisons with other arid and less arid environments are helping to elucidate the role of detritus and detritivores in arid environments.

On an ecosystem level, the dynamics of the three major habitats in the Namib remain the subject of investigation. Efforts are beginning to focus on the Kuiseb, as the most energy-rich system, and its influence on the dunes and plains. As a system driven by unpredictable stream-flow and unpredictable rainfall, it provides an excellent model for desert linear oases throughout the Namib and other arid environments.

FUTURE PROGRAMME

In the foreseeable future, the research directions of DERU will vary somewhat from those taken in the past. In particular, two areas of endeavour will be addressed. Results from a variety of research will be used towards enhancement and maintenance of a long-term data base against which environmental changes can be measured. Research design and interpretation will include a strong orientation towards gathering data and other information applicable to the conservation of biotic diversity in arid and semi-arid areas. Within this overall framework there are, however, several areas where particular emphasis will be placed.

One such area will be the subsurface environment. Nutrient cycling is an important factor which takes place almost entirely beneath the surface of the desert environment. Why do many desert animals spend more than half of their time beneath the surface, some coming on to the surface for only a few hours or less each day? Beneath the sand surface, particularly beneath certain perennial plants, there is a concentration of animals. Are predation and other community level processes more important beneath the surface than they are above? Is this perhaps the location where density dependent interactions take place in the desert?

Throughout the period of Namib research initiated by Dr Charles Koch, one emphasis has been on the unique aspects of the Namib. To ascertain whether something is unusual or different from something else, the characteristics of both objects of comparison must be known. During the past 25 years a great deal of information concerning the Namib has been assembled. However, we still know little about how the apparently unusual fauna and flora of the Namib differ from those of the remainder of the South West Arid Region or how they differ from other deserts or other environments. Future research will have to place even greater emphasis on comparisons between the Namib and other areas in an effort to determine 'what, if anything, is special about the Namib?'. This question will have to be approached on levels extending from the biogeographical to the ecosystem level and cover such areas as taxonomy, ecophysiology, behaviour, reproduction and life history patterns. Obviously this will involve extensive collaboration with a number of colleagues working at many institutions.

The importance to the Namib of the cold-water upwelling of the Benguela system has frequently been pointed out. The inversion layer which reduces rainfall over the desert, the dry winds, the moderate temperatures, the fog, and the gypsum soils of the western Namib plains all are attributable at least in part to the Benguela. The mechanisms of these interactions require extensive study. The effects of this multiplicity of factors on the fauna and flora are thought to influence aspects of the ecophysiology, behaviour, reproductive patterns, life histories and ecological patterns of the Namib biota. Future research will be giving even more consideration to ascertaining these interactions and attempting to extricate these factors from others operating on the Namib Desert. The Benguela is thought to have developed only about 10 to 7 million years ago, well after at least a proto-Namib Desert existed. How did this change the course of evolution of the Namib biota? To answer questions such as this, collaboration with many scientists in a number of disciplines will be necessary.

The research approach of DERU will continue to emphasize wide collaboration on many levels. It will remain the responsibility of the longer-term DERU staff to integrate material as it becomes available from a variety of sources and to attempt to fill in the gaps as they are identified. It is clear that exciting areas of research are not in short supply and investigations on many interesting topics will keep DERU active for many years to come.

In addition to research, however, the future of DERU will include expansion of its environmental education programme. Communication of research results on a variety of levels will be the major objective of this endeavour. As in the past, school children and university students will be introduced to the basic concepts of arid and semi-arid environments using specific examples from the central Namib. Focus will shift, however, to the training of teachers in the area of ecological principles, using local examples as a means by which they will be able to communicate effectively with their pupils. Wider dissemination of basic ecological concepts and how these apply in arid and semi-arid environments, especially the Namib, will also be attempted using a variety of popular media. In these ways, the results of DERU research will be available not only to the scientific community but also to the local inhabitants of the Namib and its surrounding arid regions.

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