Namib Research: Its Development at Gobabeb and Implications for Namibia

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Zusammenfassung

Abstract

The aridity, variability and biodiversity of the Namib Desert have attracted researchers for over a century. The character of that research started as biophysical exploration, shifted towards biodiversity and economic geology, followed the emphasis of descriptive geomorphology and ecological systems. More recently, the focus is on long-term ecological research, biodiversity processes, restoration ecology, resource management and other applied topics. Since its establishment in 1962, the Gobabeb Training and Research Centre and its predecessors have generated over 1300 publications on the Namib while a similar number have emanated from other institutions world-wide.

Much of the Namib research reflects the unusual character of the desert, its longevity, shape and position, extreme aridity, prevalence of fog and wind, massive dunes and its ephemeral rivers forming linear oases. Approaches have ranged from observation, to natural and contrived experiments, and laboratory analyses of Namib-derived materials. One strength of Namib research has been the frequent use of a variety of approaches by collaborating investigators focusing efforts on specific questions. The collective results of this have ensured that the Namib is one of the best known deserts in the world.

While many research themes continue to be investigated a decade after Namibian Independence, there has been a major shift towards applied research in support of development. Fog collection as an alternative water source and the productivity of the !nara plant are just two examples. Application of existing results for land-use and regional planning, tourism development, combating desertification, monitoring global climate change and for environmental impact assessments is another recent development. A third direction is the use of research results for education and training. The Namib is particularly suited for this latter application because of the existing understanding of the environment as well as the stark clarity of its environmental systems that are reflected in other, less arid, regions of Namibia. Although more than a century of research has been focused on the Namib, there are many questions left and applications to be realised. Namib research can continue to make a major contribution to the development of Namibia.

Introduction

Environmental research has made the Namib one of the best known hyperarid deserts of the world. Situated at the central point of the Namib, the Gobabeb Training and Research Centre has contributed significantly towards this status in terms of conducting, coordinating, or collating research, as well as training young researchers. After Independence, this relatively good foundation of knowledge has facilitated the development of capacity, skills and knowledge to manage arid lands throughout Namibia and elsewhere in Southern Africa. By supporting development in this way, Namib research has gained local and regional significance in addition to its international reputation.

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28 January 2001, 11:00 Tea Room, Gobabeb

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1) Welcome

2) Attendance and apologies

3) Minutes of previous meeting/Matters arising

4) Review of GTRC status

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The Desert Research Foundation of Namibia (DRFN) that grew out of the Desert Ecological Research Unit (DERU) has been responsible for much of the above-mentioned activities. Appropriate for this 75-year Festschrift of the Namib Scientific Society, the DRFN is currently half as old as the society. This paper shows the course of the development of the DRFN, the research background from which it grew, and how it relates to Namib, Namibia, as well as Desert research in general. Today the DRFN is a leading Namibian NGO (non-government organisation) engaged in research, training and information exchange on the biophysical and the human environments. Its foundation for these national and regional roles rests on Namib research as outlined in this paper.

Early Explorations

The aridity, climatic variability and biodiversity of the Namib Desert have attracted researchers with varying interests for over a century. The character of that research started, before the turn of the century, as biophysical exploration. Often this early research was based on written comments from early traders with respect to the surrounding biophysical and socio-economic environment during the course of their activities (e.g., THOMPSON, 1786; ALEXANDER, 1838; WELWITSCH, 1861; BAINES, 1864, 1866; PEARSON, 1907). Although these very first observations can not be considered research as it is known today, they provide the basis for much investigative research that has followed. Moreover, these early accounts served to make information concerning the Namib Desert accessible to a limited reading public that would never visit Namibia.

The next group of people contributing to the foundations of research in the Namib emerged as Germany's colony 'Deutsch-Südwest-Afrika' became established. These included economic geologists looking for precious stones and metals as well as farmers, soldiers and others who found their new surroundings too interesting to ignore (VON FRANCOIS, 1893; GRIMME, 1910; TRENK, 1910; REUNING, 1913; KAISER and BEETZ, 1919; KAISER, 1920), as well as the first scientists (STAPFF, 1887a, b, 1888; GULLAND, 1907; MARLOTH, 1909). Following the First World War and the transfer of Namibia into South Africa's control, the basis for further fieldwork and good documentation broadened (e.g., KORN and MARTIN, 1937). One of the special features of the Namib, abundant and diverse tenebrionid beetles, was elucidated by GEBIEN (1937, 1939). With the broad ecological perspectives published by WALTER (1936a, b, c), the Namib Desert gained world renown.

Founding of Gobabeb as a research centre

The history of the Namib Desert Research Station, the first of many names for the centre at Gobabeb, dates back to 1948. In that year, the University of California made an expedition to the south-western coast of Africa and invited as their entomologist the world renowned tenebrionid beetle expert, Dr. Charles Koch (KOCH, 1950). Dr Koch was very familiar with other arid areas of the world and in particular their invertebrate fauna. When he encountered the diversity of species and forms and habitats of the Namib Desert, he gave up his museum work in Europe and dedicated the remainder of his life to their study (KOCH, 1960, 1961a, b, 1962a, b). After exploring the Namib throughout its length, from Angola south to South Africa, he selected a site on the Kuiseb River in the central Namib for establishing a research centre (KOCH, 1959; LAWRENCE, 1960). Although chosen for different reasons at the time, this site at Gobabeb has proved to be excellent for the research and training which has taken place

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over the years. It is located at a point of easy access to the d nes, the ephemeral K iseb River and the gravel plains and at a place where rainfall diminishes towards the west and where fog from the west ceases to be a reg lar phenomenon. What better place to st dy and learn abo t the effects of habitat and climatic variability, and res ltant pop lation dynamics and biodiversity, the Leitmotif of the Namib and most of Namibia.

To generate interest, and f nding for the research centre, many pop lar articles were written abo t the Namib and its biota. These articles ranged from an acco nt of the big K iseb River flood of 1963 (Koch, 1963) thro gh acco nts of the discovery of the el sive golden mole (Haacke, 1963) and overall descriptions of the n s al sand d ne fa na (Lawrence, 1959, 1965; Fitzsimons, 1963). Accompanying these pop lar articles were the basic taxonomic descriptions, written for the specialist, of the vario s tenebrionid beetles and other organisms discovered and described by Dr. Koch and his co-workers (e.g., in 1962 new species were described of tenebrionid beetles: Koch, 1962c; tenebrionid larvae Schulze, 1962a, b; grasshoppers Brown, 1962; spiders, scorpions, solif gids , and centipedes: Lawrence, 1962a, 1962b; pse doscorpions: Beier, 1962; geckos: Brain, 1962a; lizards: Fitzsimons, 1962). Both types of p blications were essential to provide the research base for f rther work, to inform the scientific comm nity abo t opport nities in the Namib and to share discoveries with the Namibian and international p blic.

Several years after the establishment of the Namib Desert Research Association at Gobabeb in 1962, as an independent research entity nder the a spices of the So thern African M se ms Association and the Transvaal M se m, research activities accelerated. The foc s was on making species inventories in different habitats, partic larly of tenebrionid beetles, b t also of all the other nexpected fa na. What has contin ed to fascinate many scientists ntil today (>180 p blications), is the high diversity of tenebrionid beetles in the Namib, despite the extremely low prod ctivity (Seely and Louw, 1980). Over 200 kinds of tenebrionids occ r in the Namib Desert (Koch *op cit.*, 1967; Penrith, 1975, 1977, 1979, 1986), with over 80 species near Gobabeb, and p to 42 sympatric species occ rring together in one habitat (Holm and Scholz, 1980; Wharton and Seely, 1982; Crawford and Seely, 1987; Henschel, Seely and Polis, 1998).

Why does the Namib have this rich fa nal assemblage when neither the Sahara nor any other sand massifs have comparable fa na? How does this wide variety of plants and animals live in s ch a seemingly hostile environment? These q estions capt red the attention of a n mber of scientists sing a variety of approaches thro gh the years (e.g., Brain, 1960, 1962b; Brain and Prozesky, 1962; Coetzee, 1969; Holm, 1970; Channing, 1976; Holm and Scholtz, 1980; Griffin, 1981; Haacke, 1982; Irish and Mendes, 1988; Griffin, 1990). The remarkable Welwitschia garnered a lot of this attention, then and now (e.g., Bornman, 1978; von Willert, 1985; von Willert and Wagner-Douglas, 1994; Henschel and Seely, in press), as 300 scientific papers indicate (Henschel *et al.*, in press).

Desert Ecological Research Unit (DERU)

By the 1970s, the Co ncil for Scientific and Ind strial Research of So th Africa (CSIR) was f nding a majority of the research of the Desert Ecological Research Unit (DERU) and the then Directorate of Nat re Conservation had taken over the infrastr ct re at Gobabeb. Nat re Conservation was responsible for iss ing all research permits for the

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Namib Park, where Gobabeb was situated, and conducted some own research in the Namib, or, more commonly, in collaboration with DERU. Emphasis of Namib research focused on descriptive geomorphology and ecological systems. It was during this period, when Dr. Mary Seely became Director of DERU, that the approach to research and training for which Gobabeb is widely known was established (SEELY, 1972, 1975, 1978a, b, 1979a, b; DERU, 1976-1990).

DERU has always been based on two main pillars of operation. First has been the research of the DERU 'staff', very limited in number and often in the process of undertaking post-graduate or post- doctoral studies. In addition to their own work, this nucleus of people supports the research of a variety of visiting scientists at Gobabeb who either work on their own topic or, more often, in collaboration with DERU staff. Since its establishment, DERU and its successor, DRFN, have generated over 1300 publications on the Namib (HENSCHEL *et al.*, 2000). Eighteen doctoral (cited in this paper) and 38 masters students have successfully completed their degrees under the auspices of DERU/DRFN.

A similar number of publications on the Namib has emanated from other institutions world-wide, including many Namibian institutions, for example the Ministry of Environment and Tourism, Department of Water Affairs, Geological Survey, National Museum of Namibia, Namibian National Botanical Research Institute, Society for Scientific Development, and the Namibia Scientific Society. Important among this research by other institutions are archaeological investigations that indicated that nomadic people were hunters and gatherers in the Namib Desert over the course of some ten millenia, becoming pastoralists during the past two millenia (e.g., SANDELOWSKY, 1976, 1977; JACOBSON, 1977, 1978, 1985; SHACKLEY, 1985; KINAHAN, 1991). With its high concentration of rock paintings, the Brandberg and nearby mountains attracted considerable international attention (e.g., PAGER, 1980; BREUNIG, 1989).

The responsibilities of the DERU staff, while focused on research, range more widely. The core staff, mainly degree students or post-docs, undertook their defined research projects. To enhance their research, however, most soon recognised that it was important to collaborate with and involve researchers from other institutions. Staff members were strongly encouraged to adopt this approach. In this way, Gobabeb-based researchers could undertake and support field investigations while relying on their collaborators in other institutions to provide the sophisticated instrumentation and perform sensitive analyses. Initiation of these collaborations was varied, from joining up with a visiting scientist while the researcher was in the Namib to seeking out persons and negotiating procedures for collaboration. In addition to enhancing research possibilities and their outputs, this approach served to multiply many-fold the always limited funding of the DERU.

The collaborative approach also served to enhance the publication output of the DERU and its associates. As researchers, the staff and visitors are dependent on publications in international peer-reviewed journals. In addition, however, publication in popular journals was encouraged and often pursued. This might be in the local journals for tourists as well as international conservation magazines. Another vehicle for popularisation of research is through films for a variety of audiences. DERU staff and visiting scientists often assisted with the story line and gathering actors for a variety of films, some of which have an intercontinental viewing audience. Yet another method of popularising research is the granting of interviews, often to overseas journalists

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gathering information about this, ever more famous, coastal desert. When necessary, the DERU staff could refer interested persons to their many collaborators scattered throughout the globe.

The collaborative approach extended to incorporate students on various levels from a variety of institutions into the overall research programme. Professors sent their students to carry out parts of their study programme in the Namib, and these people would be incorporated into the overall programme. Opportunities for summer vacation work were cultivated so that undergraduates could learn research techniques and, at the same time, contribute to ongoing research programmes. Soon the opportunities presented by Gobabeb were recognised in many institutions from which persons interested in field biology and geomorphology came to the Namib. Of note was that DERU maintained a high proportion of female students, who were generally excluded from fieldwork elsewhere in southern Africa. At the same time, collaborating colleagues identified Gobabeb as a suitable venue to hold field courses. University classes from southern Africa and overseas would spend several days or weeks taking advantage of the site, the information and the expertise provided by Gobabeb residents.

During this twenty year span, most of the current research directions were initiated (SEELY, 1990a). Climate is a prevailing theme for research in the long, narrow Namib desert with its steep west-east gradient of precipitation encompassing winter rainfall in the south and summer in the north. Since 1962, weather observations have been made at the First Order Weather Station at Gobabeb and reported thrice daily to the Namibian Meteorological Services (e.g., SEELY and STUART, 1976; LANCASTER, LANCASTER and SEELY, 1984). These long term records, augmented by shorter term records from elsewhere in the Namib document the episodic events and variability of climate that characterise all of arid Namibia. Analyses of the dynamics of the desert climate facilitated broader understanding in southern Africa (TYSON and SEELY, 1980; TYSON, 1986; LINDESAY and TYSON, 1990). Namib climate was also the key for elucidating geomorphological processes, and this connection allowed analyses of palaeoclimate to be made (SCHOLZ, 1963; BESLER, 1972; GOUDIE, 1972; BLÜMEL, 1976; HARMSE, 1980; VOGEL, 1981; WARD, SEELY and LANCASTER, 1983; WARD, 1984, 1988a, b; LIVINGSTONE, 1985; LANCASTER, 1989; EICHLER, 1990; HEINE, 1990, 1998; WARD and CORBETT, 1990; WALTER, 1994; ECKARDT, 1996).

Winds that shift surface material about blow for >50% of the time (LANCASTER, *et al.* 1984), shaping the landscape and the ecosystem. Wind continuously redistributes dead or dormant plant material and causes it to be buried and remobilised, thereby driving the slow, steady availability of detritus to detritivores (CRAWFORD and SEELY, 1994; HANRAHAN and KIRCHNER, 1997). It is therefore not surprising that detritivores, such as tenebrionid beetles, ants, termites, fish moths, and gerbils, are major consumers in the Namib (SEELY and LOUW, 1980; LOUW and SEELY, 1982; CURTIS, 1983; SEELY, 1983; CRAWFORD and TAYLOR, 1984; MARSH, 1985a; WEHNER, 1987; CRAWFORD and SEELY, 1987; WATSON, 1989; HANRAHAN and SEELY, 1990). Much of the research therefore concerned the functioning of these small animals and their consumers in such extremely arid conditions (e.g., WILLOUGHBY, 1967; COUTCHIÉ and CROWE, 1979; HADLEY and LOUW, 1980; WITHERS, LOUW and HENSCHEL, 1980; DE VILLIERS, 1984; MCCLAIN *et al.*, 1985; SEELY and GRIFFIN, 1986; DOWNS, 1989; FIELDEN, 1989; HENSCHEL, 1990; NICOLSON, 1990; ROBERTS, 1991; CLARKE, 1992; NAIDU, 1992; GRUBE, 1993). There is often little food, and tolerance of hunger is imporant (e.g., SEELY and LOUW, 1980; NAGY, SEELY and BUFFENSTEIN, 1993; HENSCHEL, 1994; LUBIN and HENSCHEL, 1996; SEYMOUR, WITHERS and WEATHERS, 1998). This is compounded by daily hot surface

Envelope-to: theresat@drfn.org.na
Date: Mon, 12 Feb 2001 09:42:25 +0200
From: Hilde Gevers <hbg@iafrica.com.na>
X-Mailer: Mozilla 4.61 [en] (Win95; I)
X-Accept-Language: en
To: Theresa Thatcher <theresat@drfn.org.na>
Subject: Your assistance please.

Good morning, Theresa!

Mary must be extremely busy, I know but I - unfortunately - have to confirm the following with her and ask you to please ask her when you get a chance and let me know.
She did answer once before but I just simply cannot find that specific e-mail again.

It concerns the files of the Scientists: My question to her was: would it not be better to file the Scientist from the earliest date up instead of down. e.g. a letter written in say 1960 will be the first, the 61, 62. 63 etc.

Admin files, CSIR, Tvl Museum, Nature Conservation could run the other way, so can Admin files, Library, Wind and Weather etc etc. I am only concerned about the Scientists and would like to have the feeling that once I am finished with the filing, all will be correct and I do not have to touch it again!!

Thanks a lot and please come back as soon as you.

With Love and Light.
Hilde

sbe@unep.ch

conditions and extreme daily temperature fluctuations (e.g., HENWOOD, 1974; HAMILTON, 1975; CURTIS, 1985; MARSH, 1985b, 1987; SEELY and MITCHELL, 1987; PIETRUSZKA, 1988; LOMBARD, 1989; CLOUDSLEY-THOMPSON, 1990; LUBIN and HENSCHEL, 1990; ROBINSON, 1990, 1993; WARD, 1990; ROBERTS, 1991). Studies of the ecophysiology of arthropods and small vertebrates in the Namib established world prominence in this field during the 1970s and 1980s (MALOIY, 1972; HADLEY, 1974; EDNEY, 1977; LOUW and SEELY, 1982; LOUW, 1990, 1993; SEELY, 1990a; CLOUDSLEY-THOMPSON, 1991; HEINRICH, 1993; LOVEGROVE, 1993; SOMME, 1995; HEATWOLE, 1996; BRADSHAW, 1997; DEGEN, 1997).

Studies of the spatial and temporal effects of variable climate on biotic communities of the desert contributed to understanding of functioning of natural and man-made ecosystems throughout Namibia and other arid regions of the world. A most important contribution of Namib research was the relationship that was established between productivity, biodiversity and climate. Fog has long been identified as a key component of the Namib (e.g., WALTER, 1936; BOSS, 1941; NAGEL, 1962) and is predictable (PIETRUSZKA and SEELY, 1985). Its precipitated water increases survival of plants and animals (HAMILTON and SEELY, 1976a, b; SEELY and HAMILTON, 1976; SEELY, DE VOS and LOUW, 1977; SEELY, 1979c; LOUW and SEELY, 1980; NOTT, 1985; LORIS, 1990; POLIS and SEELY, 1990; HENSCHEL, 1997a; HENSCHEL, SEELY and POLIS, 1998; SEELY, HENSCHEL and ROBERTSON, 1998). Fog explains the extraordinary growth and abundance of lichens in the Namib (SCHIEFERSTEIN and LORIS, 1992).

By contrast, rainfall is unpredictable to the degree that the occurrence of effective rain (affecting plant growth) cannot be predicted for any year (PIETRUSZKA and SEELY, 1985) and is rare. Nevertheless, temporal patterns of rainfall are of fundamental importance to the growth, abundance and diversity of Namib plants and animals. While fog enables many populations to sustain long periods without rain, effective rain is necessary for production (e.g., HOLM, 1970; SEELY, 1973, 1989, 1990b, 1991; SEELY and LOUW, 1980; NEL, 1983; HAMILTON, 1985, 1986; YEATON, 1988; BOYER, 1989; BERRY and SIEGFRIED, 1991; GÜNSTER, 1992, 1993; SOUTHGATE, MASTERS and SEELY, 1996; HENSCHEL, SEELY and POLIS, 1998; HENSCHEL and SEELY, in press). Distribution of rainfall affects spatial patterns within the ecosystem (ROBINSON, 1976; SEELY, 1978c, d; TILSON and HENSCHEL, 1986; GÜNSTER, 1992, 1995; BRAIN, 1993; KILIAN, 1995; KOK and NEL, 1996; BURKE, 1997). Although big rainfall events of >100 mm per annum have occurred only three times during the 20th century in the western Namib, they are believed to be of fundamental importance for the Namib ecosystem. Such rains elicit extremely strong, rapid increases in productivity of many plants and animals, effects that last for decades (WALTER, 1971; SEELY and LOUW, 1980; SOUTHGATE, MASTERS and SEELY, 1996; HENSCHEL, SEELY and POLIS, 1998).

In order to better understand the mechanisms, implications and applications of climatic variability, DERU initiated Long-term Ecological Research (LTER) at Gobabeb from its inception. Continuous monitoring grew partly out of short-term studies of microclimate, ecophysiology and behaviour (SEELY, 1975, 1979b, 1990a; SEELY and WARD, 1988), and continued to be an important activity after independence (SEELY and SGUAZZIN, 1992; SEELY *et al.*, 1999a; HENSCHEL, 1999). The Gobabeb LTER program now encompasses collaborative projects on climate, ephemeral and perennial plants, tenebrionids, spiders, dune movements, weathering, ephemeral river dynamics and natural resource use (HENSCHEL, SEELY and ZEIDLER, this volume).

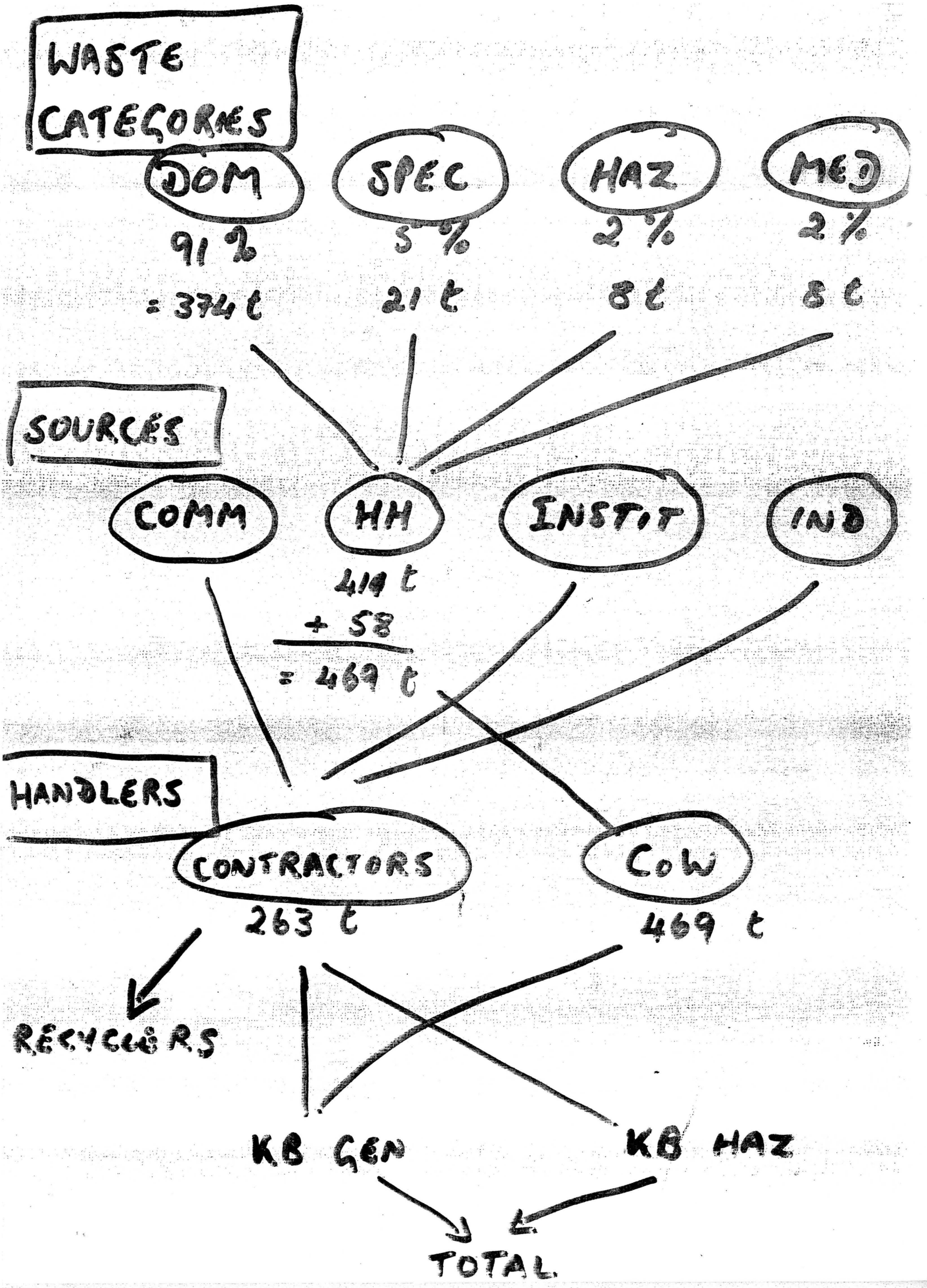
Desert Research Foundation of Namibia (DRFN) at Gobabeb

At Namibian Independence, the controlling and funding functions of the CSIR and Transvaal Museum over DERU ceased (SEELY, 1990c). The umbrella organisation that now incorporated DERU was named Desert Research Foundation of Namibia (DRFN). This non-government organisation (NGO) became an independent research and training institution. DRFN transformed the knowledge and understanding gained in the Namib in the previous thirty years and extended it country-wide, particularly focusing on ways of applying it to development involving the environment (SEELY, 1990d; SEELY *et al.*, 2000). In the meantime, training and research in the Namib continued, with DRFN continuing to be based at Gobabeb besides its new offices in Windhoek and Oshakati and a temporary office in Khorixas (DRFN, 1990-2000).

In the early 1990s, Gobabeb housed the rapidly expanding DRFN where new directions were formalised. The Enviroteach project, funded by the Swedish International Development Agency (Sida) developed an innovative approach to cross-curricular, activity-based, learner-centred environmental education in co-operation with the Ministry of Basic Education and Culture. The 'old lab' was transformed into a book production centre and titles ranging from energy, to water, population and environmental education methodologies were compiled (DU TOIT *et al.*, 1995a-j). These were tested in 25 pilot schools throughout the country and, when the project moved to Windhoek after four hectic years, emphasis shifted to the four Colleges of Education.

An income generating arm of the DRFN was established under the name of Environmental Evaluation Associates of Namibia (Pty) Ltd (EEAN) which used the knowledge and understanding gained at Gobabeb to undertake environmental assessments throughout Namibia. Previous research and current assessments were incorporated into books for decision makers and awareness materials for extension personnel, students and decision-makers (MARSH and SEELY, 1992; Update series, DRFN 1997-2000). The ephemeral rivers project epitomises the approach pioneered at Gobabeb where scientific research (e.g. HUNTLEY, 1985; JACOBSON *et al.*, 1999; SEELY *et al.*, 1999b) is applied to sustainable development in Namibia (book, video, map by JACOBSON, JACOBSON and SEELY, 1995a, b). This project, and its successor project that concentrated on the Hoanib catchment (LEGGETT, 2000), was funded by Sida and carried out in close collaboration with the Department of Water Affairs, with whom a number of other projects were also undertaken with funds from various sources. These projects include information on water sharing in southern Africa (PALLETT, 1997), the decision-maker's guide to water use in Namibia (HEYNS *et al.*, 1998), and regional water books (FORBES-IRVING and WARD, 1999; WARD and FORBES-IRVING, 1999).

As circumstances forced the move of most of the DRFN staff to Windhoek, the stage was set at Gobabeb for future directions. While continuing to incorporate the ongoing activities at Gobabeb, the DRFN formed partnerships with a variety of projects, institutions and Ministries. The DRFN's participation in Namibia's Programme to Combat Desertification originated at Gobabeb (SEELY and JACOBSON, 1994; SEELY, 1998; ZEIDLER, 2000) as did various projects taking place throughout Namibia. Gobabeb is now particularly known for the Summer Desertification Project (Sida funded) wherein young Namibians from the University and Polytechnic are taught skills of environmental problem solving, including planning, field and analytical methods, presenting and publishing (DEALIE *et al.*, 1993; DAUSAB *et al.*, 1994; JOBST *et al.*, 1995; GUIDAO-OAB *et al.*, 1996; JOBST *et al.*, 1997; HAININGA *et al.*, 1998; GAZZA *et al.*, 1999; AMOOMO *et al.*, 2000).



WASTE CATEGORIES
DOM
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91 %
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At Gobabeb, graduates from the University of Namibia and Polytechnicon can gain hands-on experience in the environmental field (HENSCHEL, 1997b). This facilitates the ability of such students to obtain higher degrees at foreign universities or relevant employment. The DRFN offers intensive week-long courses, intern courses of 6-12 months, and coaches postgraduate studies. Recently, the "Tropenökologisches Begleitprogramm" (TöB) of the "Gesellschaft für Technische Zusammenarbeit" (GTZ), has served as a good example of how students become integrated as in-service trainees (HAMUKWAYA, 1998), or post-graduates (PARENZEE, 2000), or staff (ZEIDLER, 2000). Where appropriate, the DRFN at Gobabeb also involves visiting scientists as trainees. The situation of Gobabeb with its "outdoor classroom" and relative isolation from urban distractions makes it an ideal training centre that can contribute substantially to the goal of a well-trained cadre of Namibians.

Besides continuing basic research (some recent activities have been described with previous activities in the above section on DERU), a shift in the approach to Namib research has been to provide immediate relevance to development in Namibia (SEELY, 1998; SEELY, ZEIDLER and PARENZEE, 2000; SEELY *et al.*, in press). Both quantitative analytical and qualitative approaches are used to assess environmental conditions and to monitor and evaluate resource use in the Namib. People become directly involved in the research process, rather than being research subjects only, as was the case previously. The resulting information is not only prepared for scientific audiences, but is fed back by appropriate means to the people concerned, and is transmitted to decision-makers. Examples are projects on the development of an Index of Biological Integrity (ZEIDLER *et al.*, 1998; ZEIDLER, 1999; PARENZEE, 2000; ZEIDLER, SEELY and PARENZEE, 2000; PARENZEE, ZEIDLER and SEELY, 2000), the connection between resource management and socio-politics (SULLIVAN, 1998), and environmental consequences of communal and commercial farming (WARD *et al.*, 1999). Similar approaches are used in the interaction with the Topnaar community living at and near Gobabeb, who have requested the DRFN to become involved in resource management, such as the use of water (DAUSAB, 1994; HENSCHEL *et al.*, 1998; MTULENI, HENSCHEL and SEELY, 1998; AMOOMO *et al.*, 2000) and !nara fruit (several separate studies on plant biology, GOLDBERG and IWANEK, 2000; information exchange concerning harvesting and marketing, SHILOMBOLENI, 1998; BÜTTENDORF, 2000). Other projects concern Gobabeb itself, such as using it as a model in developing and applying appropriate technology in arid lands (SHANYENGANA, 1997a, b). The latter project is partly based on the opportunities for research and testing of equipment at Gobabeb, and partly out of the need to change resource use at Gobabeb with its ageing infrastructure and currently limited water and energy resources.

The Ministry of Environment and Tourism (MET) also continues to conduct important research in the Namib, including research on mammals and reptiles (KILIAN, 1995; GRIFFIN, 1997; ongoing aerial censuses), coastal birds (BRABY, BRABY and SIMMONS, 1992; SIMMONS 1996; SIMMONS, CORDES and BRABY, 1998; ongoing wetland censuses), and the conservation of lichen fields (BRABY, 1990; ongoing monitoring). MET has been instrumental in bringing relevant information together to assist decision-making for development in the region (BARNARD, 1998; BENDER, 1999). Based on these and further internal studies, as well as interactions with other organisations and people of the Namib, the MET is adapting the management of its Namib parks to current conditions and needs. In this way, the Namib-Naukluft Park, the Skeleton Coast Park, and the new Walvis Bay Park incorporating the Walvis Bay lagoon and its surroundings, are benefiting from the current relatively good status of knowledge of the Namib.

Using the computer packages

General

All statistical packages will give summary statistics for sets of observations. However, generating exactly the set of statistics you are interested in may take several steps. The less frequently used statistics such as kurtosis may not be available.

SPSS

SPSS. In this package the data may appear in the same spreadsheet form as in a package such as Excel but the approach is rather different, as the statistics are displayed not on the spreadsheet but in a separate window. The data should be in a single column with an appropriate label. To change the column label simply double-click on the column name ('var0001' by default) and replace with something more suitable. The screen shot shows the various measures of dispersion that are available under the 'Descriptives...' options in the 'Summarize' submenu of the 'Statistics' menu. The default selections are shown which include the rarely useful minimum and maximum (Fig. 6.6). Once you have chosen the options you want the statistics are displayed in the '!Output' window. As you proceed through an SPSS session the nongraphic output accumulates in this window. This is very useful as you can go back and check results of previous tests very easily.

Further descriptive statistics can be accessed. From the 'Statistics' menu select 'Descriptives' then 'Frequencies...' selection. Select the 'Statistics...'

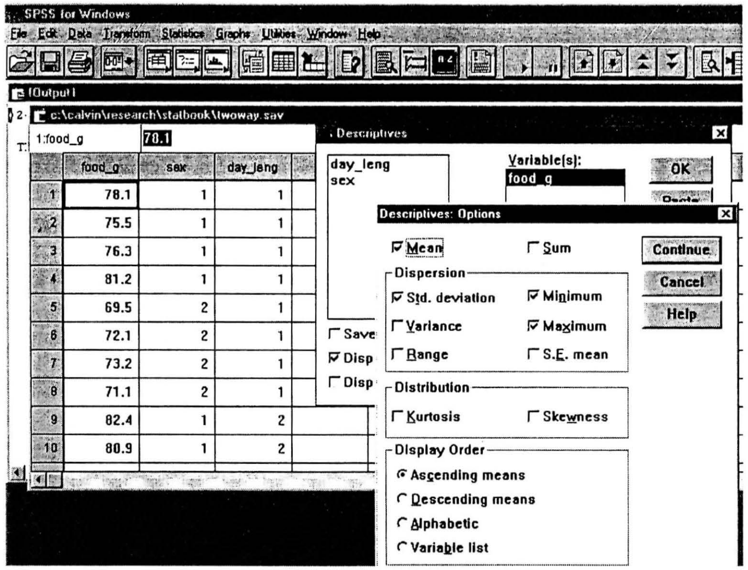

Fig. 6.6 A screenshot from SPSS. Selection of the various possible descriptive statistics.

button in the dialogue box and an array of options such as 'Skewness', 'Kurtosis', 'Mode' and 'Median' are available.

MINITAB

MINITAB. The data for a single variable should be in one column in the spreadsheet section of the package. The variable should be named appropriately in the cell under 'C1' although you are limited to eight characters. To get simple descriptive statistics go to the 'Stat' menu and select 'Basic statistics' and then 'Descriptive statistics...'. Move the name of the column with the data from the list on the left into the 'Variables:' box. Either leave the 'Display options' as tabular form or, if you want a more detailed output, change this to 'Graphical output'. Click 'OK'.

With 'tabular output' selected this is the sort of output that is generated:

```
Descriptive Statistics

Variable      N     Mean   Median   TrMean    StDev   SEMean
Height       24   11.338   11.335   11.337    0.088    0.018

Variable    Min      Max       Q1       Q3
Height   11.180   11.520   11.295   11.380
```

Data output 6.1

All the basics are reported here. The number of observations in the data set ('N'), the arithmetic mean ('Mean'), largest and smallest values ('Max' and 'Min'), standard deviation ('StDev') and standard error ('SEMean') as well as the 'nonparametric' versions of these statistics: median and the upper and lower quartiles ('Q3' and 'Q1'). Quartiles are explained further on page 48. If the 'Graphical output' is selected there is considerably more output to assess (shown in Fig. 6.7).

This output contains much of the same information as the 'Tabular' version but with some extras. In the mass of output on the right of the output the first thing is a test for normality. This is a test to determine whether the data in question is normally distributed. The 'A-squared' value is the output from a test and '*P*-value' is the probability that the data is normally distributed. If the '*P*-value' is less than 0.05 then this means it is unlikely to be normally distributed and therefore parametric statistics should not be used.

After this test comes the more usual descriptive statistics of arithmetic mean, standard deviation, variance and then the measures of the 'shape' of the distribution: skewness and kurtosis and the number of observations '*n* of data'. Next comes some information about the data arranged in rank order. The value of the smallest and largest observations and then observations one-quarter (1st quartile), half (median) and three-quarters (3rd quartile) of the way down a ranked data list.

The last section gives 95% confidence intervals for three of the descriptive statistics. 'Mu' is the arithmetic mean, 'Sigma' the standard deviation and the median.

In 1998, the MET and DRFN signed a Joint Venture Agreement forming a Board of Trustees for the Gobabeb Training and Research Centre (GTRC). The Board of Trustees leased the facilities of the GTRC for 20 years, assuring its continued operation. Part of DRFN continues to be based at the GTRC, and continues to play an active role through its ongoing training and research activities. The GTRC is a natural meeting place for students, scientists, community members, government institutions, and other decision makers, who contribute to and receive information and experiences of sustainable natural resource management from the ongoing programmes based at Gobabeb (SEELY, 2000). The DRFN at Gobabeb has developed an active rapport with indigenous people in Namibia. Positive interaction is ensured by active participation and ongoing consultation by all parties involved. This approach is proving to be a powerful means of transforming knowledge and understanding gained in research towards enhancing the capacity of Namibians towards sustainable management of their natural resources.

In the year 2000, the DRFN at Gobabeb focuses on long-term ecological research (LTER), biodiversity processes, restoration ecology, resource management and other applied topics. The Namibian capacity in environmental research is actively furthered through courses to students, intern programmes, learning opportunities for staff, as well as facilitating post-graduate studies by Namibians. Examples of novel or topical research directions that grew out of a wealth of previous knowledge generated at or near Gobabeb are:

- small-scale low-technology solar distillation experiments that incorporate findings dating back to the beginning of this century
- collecting of fog water by using a principle first identified for Namib animals and plants 25 years ago
- enhancing the ability of the Topnaars to manage utilisation of !nara products, based on extensive information exchange as well as participatory research in socio-economic and cultural fields, and ecological and ecophysiological research that focus on the plant's needs and its importance to its environment
- improving natural resource management along the ephemeral rivers of western Namibia, such as the Kuiseb, by forming partnerships with information networks, resource users and decision makers, and thereby increasing our collective ability to contribute to and use environmental knowledge
- monitoring and understanding extreme environmental variability of the hyperarid Namib with the Gobabeb Long Term Ecological Research Programme in synergy with related national and international research networks so as to facilitate the application of this understanding to other variable environments to reduce the latter's susceptibility to degradation and improve sustainable livelihoods (HENSCHEL, SEELY and ZEIDLER, this volume)
- interlinking Namib research of ecology, natural resource management and socio-economics in close collaboration with the Namibian Economic Policy Research Unit (Nepru) as a model for Namibia
- contributing actively towards networking between various government and non-government organisations, so as to improve information exchange, developing supportive partnerships, integration of research and information into decision making and policy formulation, as well as developing the appropriate methodologies for current research and related functions, for example via the internet-based Netwise (http://www.netwise.drfn.org.na/).

The shift of research emphasis has echoed not only the growing understanding of the Namib environment but also advances in international science as well as the needs of Namibia's development process. DRFN faces the future by building on its rich

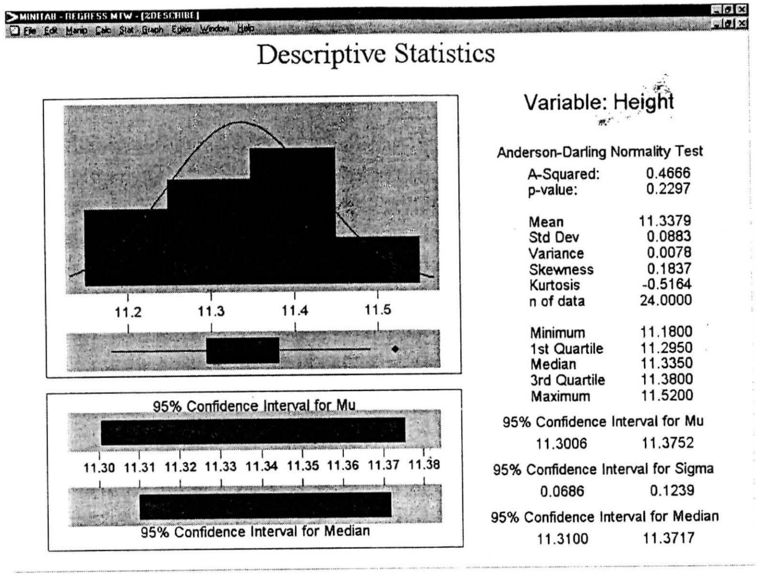

Fig. 6.7 A screenshot from MINITAB when the 'Graphical Output' version of descriptive statistics has been selected.

On the left of the output are four graphs. First is a histogram of the raw data with a normal distribution superimposed on it (the normal distribution shown has the same mean and standard deviation as the data). Then comes a box and whisker plot of the data (described earlier in this chapter) and finally graphical representations of the mean ('Mu') and median with their 95% confidence intervals.

Excel

Excel. In this package you have to assign a cell of the spreadsheet to contain the summary statistic you require. This is done by just clicking on an empty cell. Then you identify the cells that contain the variable (raw data) that you are interested in and the statistic appears. For example, your data, containing 100 observations, has been typed into the first column of the spreadsheet (column A). The first cell has the title of the variable and the actual observations are in rows 2 to 101. To calculate the arithmetic mean of this variable you go to any cell and declare its contents as '=AVERAGE(A2:A101)'. (As you can see Excel calls the arithmetic mean the 'average'.)

Other summary statistics are easily accessed using the 'function wizard' facility of the package. Or, once you have learned a few of the function codes you could just type them in. For instance '=STDEV(A2:A101)' to get the standard deviation reported in an empty cell.

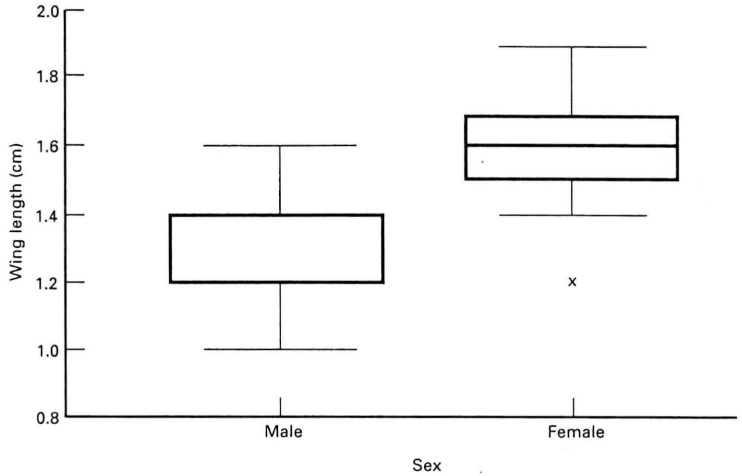

Fig. 6.8 In this SPSS-generated figure the sample of observations of wing lengths of a moth are divided into two groups by gender. As in most insects the females are considerably larger than the males and although there is some overlap in the 'whiskers' there is no overlap of the interquartile range of the two groups. Note that for the males the median and lower quartile are superimposed showing that 25% of the observations for males were almost of the same value.

Displaying data: summarizing two or more variables

Box and whisker (box plots). These are a good way of comparing two variables. They allow direct visual comparison of both the location and the dispersion of the data. An example of the use of two box plots is shown in Fig. 6.8.

Error bars and confidence intervals. A similar way of looking at the same data is to display the arithmetic mean and some measure of the dispersion of the data. An example of the use of mean and confidence interval is given in Fig. 6.9. Note that the interquartile range is not symmetrical about the median (Fig. 6.8), whereas the 95% confidence intervals (or standard deviation if you have chosen to display that instead) are symmetrical about the mean (Fig. 6.9).

You can display more than two groups using these methods. They provide a very powerful method of showing differences and similarities between many groups. In the example here there is almost no need for any further statistics — the difference between males and females is so striking!

Displaying data: comparing two variables

Associations

The best can be used if two observations are made for a single individual (e.g. the 'individual' is a stream and the water pH and stream flow have been foundation, by identifying opportunities for fruitful outreach, and addressing the challenges given by Namibia's need for environmental information and improved capacity to wisely manage natural resources in variable, arid environments.

Conclusion

Much of Namib research reflects the unusual character of the desert, its longevity, its shape and position, its extreme aridity, the prevalence of fog and wind, its ephemeral rivers forming linear oases and its massive dunes derived from sandstones across the continent. Approaches have ranged from simple observation, to experiments, and laboratory analyses of Namib-derived materials. One strength of Namib research has been the use of a variety of approaches by collaborating investigators focusing efforts on specific questions. The collective results of this extensive, frequently co-operative research have ensured that the Namib is one of the best known deserts in the world.

While many research themes continue to be investigated a decade after Namibian Independence, there has been a major shift toward applied research in support of development. Application of existing results for land-use and regional planning, for tourism development, for combating desertification, for monitoring global climate change and for environmental impact assessments is another recent development. A third fresh direction is the use of research results for education and training. The Namib is particularly suited for this latter application because of the existing understanding of the environment as well as the stark clarity of its environmental systems that are reflected in other, less arid, regions of Namibia. Although more than a century of research has been focused on the Namib, there are many questions to be asked and applications to be realised. The contribution of the Namib to the development of Namibia is a long way from being exhausted.

Acknowledgements
The Ministry of Environment and Tourism gave permission for research to be conducted in the Namib-Naukluft Park. We thank numerous donors for their generosity, which has enabled the Gobabeb Training and Research Centre to continue. In particular, Sida, GTZ, Norad, USAID, British Council and many other donors for their contribution toward the ongoing programmes of the DRFN. Over the years, many people have assisted diligently to ensure the functioning of the centre; currently these include ANNA BEES, DAWID DAMASEB, INGE HENSCHEL, ED HOGG, ALEX KHURIRAB, VILHO MTULENI, JAKOB MAKEMBE, SHARON MONTGOMERY, RAUNA NAWA, LESLEY PARENZEE, CHRIS PARK, DEON SHARURU and the current authors. SHARON MONTGOMMERY and MARK ROBERTSON kindly read previous drafts of this manuscript.

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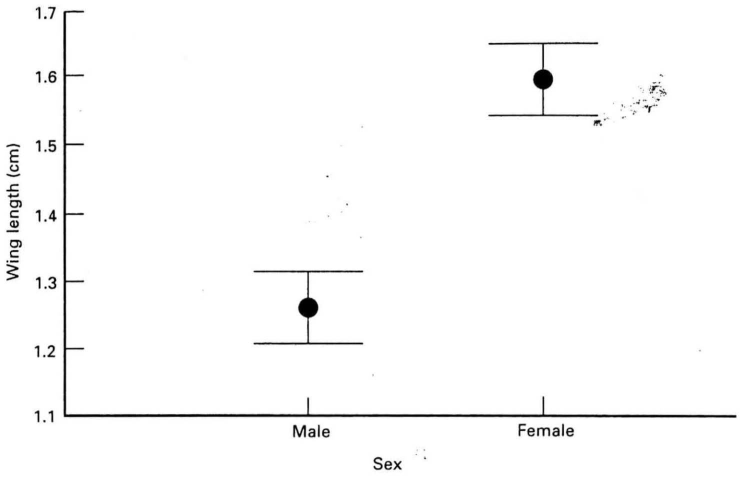

Fig. 6.9 This figure, also generated in SPSS, uses the same moth wing lengths as Fig. 6.8. The means for males and females are represented by filled circles and the 'whiskers' extend to cover the 95% confidence interval for the mean (i.e. there is a 95% chance that the true mean of the population lies between the extremes shown). There is no overlap of the 'whiskers' suggesting that the groups are likely to be highly significantly different.

recorded). Before any statistics are applied it is best to get a 'feel' for the observations by a graphical representation of the data.

Scatterplots. The simplest way to display a relationship between two variables is to use a plain scatterplot (Fig. 6.10). This assumes that two observations on the same row in the package are two measurements from the same 'individual'. An 'individual' can be almost anything: sampling station; greenhouse; pair or single bone.

It is important that all figures should have appropriate axis labels on them. They should also be accompanied by a figure legend that makes the plot interpretable without reading the relevant section of the text.

Do not add extra information that is not relevant or appropriate. For example many packages offer best-fit lines as a simple option. Do not use these unless: (1) you believe there is a 'cause' and 'effect' relationship between the variables; (2) you have used regression and you want a graphical accompaniment; (3) you intend to use regression; (4) you wish to use one variable to predict the other.

Multiple scatterplots. A good way to compare observations from two sites where the same variables have been recorded is to use a multiple scatterplot. The axes will be exactly the same as for the single scatterplot but each group will be displayed using a different symbol. This technique works particularly well for two or three groups and less well for more than that. Choose symbols carefully to make the groups easily distinguished and make sure that the figure caption makes it clear which symbol matches which group (Fig. 6.11).

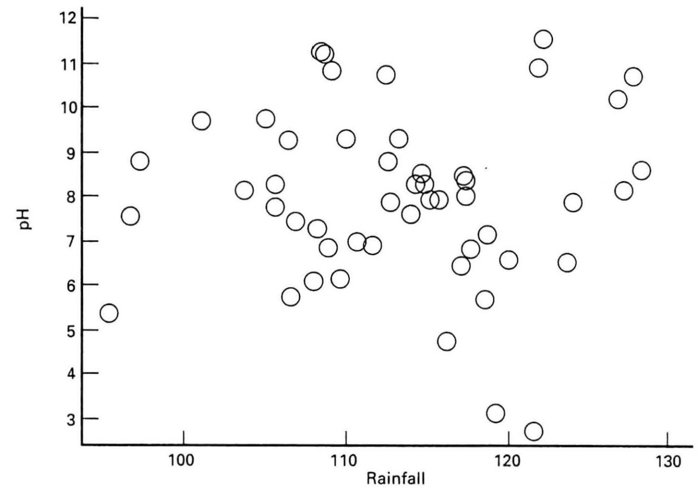

Fig. 6.10 The scatterplot of pH and rainfall from a range of sites shown here has been created in MINITAB using the default options. Clearly there is no obvious relationship between the two variables.

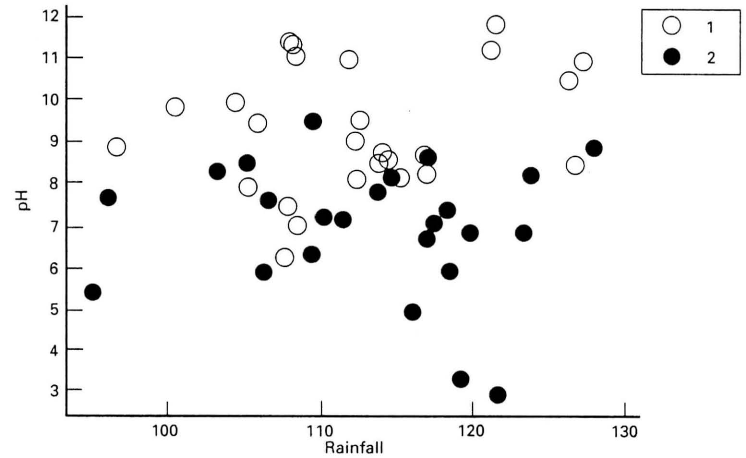

Fig. 6.11 In the example shown here two sets of observations from different study areas are identified with different symbols. A quick glance shows that group 1 is associated with a higher pH than group 2 but there is no obvious difference between the groups on the 'rainfall' axis. An analysis of variance or *t*-test could be used to determine the statistical probabilities but the results would only confirm what is obvious from the scatterplot.

More sophisticated use of symbols can convey a great deal of information about several factors on the same scatterplot. For example if the data for t·· morphological variables is collected and the individuals are di··' groups by sex and species then all this information can be ·