PREFACE

The present work is an investigation on some desert plants in north-west of Sinai. Sinai was chosen for this investigation because of the scarcity of ecological studies on that important part of Egypt. Since liberation of Sinai it has become the focs of many projects for its development.

The course of the study included phytosociological analysis of the main plant communities in the main habitat types of north-west of Sinai. Ecophysiological studies were carried out on the dominant species of glycophytes and halophytes to elucidate their means of adaptation to their arid and frequently saline environment. Anatomy of stem and/or leaves was studied to find out the role of anatomical structures as a means of plant adaptation.

The sociological studies included analytical and synthetic characters of the vegetation units (plant communities). Analysis of the soils associated with the plant communities was investigated to elucidate their physical and chemical characteristics.

Ecophysiological studies included determination of plant moisture content, degree of succulence, ash content and composition in both winter and summer. Study of metabolic features of plants comprised determination of total carbohydrates, reducing sugars and polysaccharides in addition to total nitrogen, total amino acids and fatty acids.

The Sinai peninsula is a triangular plateau in northeastern Egypt with its head in the south at Ras Mohamed. It covers an area of 61,000 sq. km. The peninsula is bordered from the north by the Mediterranean, from the west by the Gulf of Suez and Red Sea and from the east by the Gulf of Aqaba. In Sinai, three physiographic provinces can be distinguished (1) the narrow coastal strip, (2) the table-land of Tih desert and (3) the rough mountain area, which occupies the southern third of the peninsula.

The northern part has an area of about 40,700 sq. km and is formed of a great plateau (El-Tih desert) bounded from the north by the coastal Mediterranean land. The southern part of the peninsula forms Sinai proper. It has an area of about 20,300 sq. km.

Sinai embodies the characteristics of both the **Eastern and Western Deserts, Said (1962)** and **Abu Al-Izz (1971)**. Thus there are cuestas like those of the western desert, a remnant of Arabo-Nubian block in the south (analogous to the Red Sea mountains), and the wadis cutting the peninsula.

Said (1962) stated that the Eastern desert and Sinai form one unit whose geomorphology is closely connected with its geological structure. The Arabo-Nubian massif in the south is made of igneous and metamorphic rocks of the pre-carboniferous basement complex and also occupies the eastern part of the Eastern desert. This massif consists of many fault blocks which were formed in conjunction with the great African rift valley, a movement that had its inception most probably during the Tertiary and which continued through the Pleistocene.

The Sinai horst because of its high altitude receive ample rainfall which has produced wadis and water courses. Most of the water courses run in gorges, and the wadis appear as hanging valleys. Some wadis flowing to the Gulf of Aqaba are Ghayib, Nasb and Watir, all of which are steep valleys. Running to the west, Feiran, Sidri, Sudr and Gharandal, all of which are wide and have a relatively rich vegetation cover.

REVIEW OF LITERATURE

Desert plants have received a great attention during recent years as a possible economic biological system. Many of these plants may be used as a diet for animal feeding as well as for man consumption. Most of these plants can be used as a source or crude matter for several chemical products. Some of desert plants may be used as indicators for habitat types, presence of underground water, soil salinity, etc.....

Migahid et al. (1959) described the vegetation of south-west Sinai into communities of plains, wadis, mountains and rocky ridges, oases and springs, salt marshes and sand dunes.

Zahran (1967), reported on the vegetation of the littoral salt marsh of the east coast of the Gulf of Suez. The supralittoral fringe is the habitat of the mangrove Avicennia marina while the supralittoral zone is dominated by ten salt marsh communities. He also stated that the vegetation of the littoral salt marsh of Suez Gulf is influnced by (a) inundation during the high tides, (b) lateral extension of the sea water underground and (c) Sea water spray.

The vegetation of the waids of south-west Sinai was described by **Girgis and Ahmed (1985).** The wadis were classified into a northern group draining Eocene and Cretaceous formations and a southern group dissecting the basement complex formations. **Ahmed (1983)** described the habitats and plant communities in El-Qaa plain, south-west Sinai.

Ferrar (1914) and Zahran (1967) gave notes on the mangrove vegetation at Ras Mohamed in south Sinai. **Hassib (1951)** classified the vegetation of Sinai into (a) xerophytic plant community, (b) marsh plant community, (c) aquatic plant community and (d) halopytic plant community. He stated that this vegetation is open, climatic and climax, but the flora is comparitively rich including 527 species (134 species restricted to Sinai).

Sherve (1951) stated that the outstanding characteristics of most desert communities are the low but unequal stature of plants, the openness of stands, and the mixture of dissimilar life forms.

The review on adaptation of plants to aridity and salinity is very extensive. Adaptation of the plants to arid or otherwise dry environments and salinity takes place not only through anatomical and morphological adaptation but also by the accumulation of certain metabolites and minerals.

The principal means by which plants may increase their rate of water uptake during prolonged periods of drought is by extension of the roots into previously unexplored areas of the soil, **Osmond** <u>et al.</u> **(1980)**. To some extent continued exploration of the soil within the rooted zones may also increase the capacity to extract water from the drying soil. Most workers agree that in most desert perennials the root/shoot ratio is very large. In general the depth and breadth of the roots are several times as great as the height and lateral extension of shoot, **Migahid and Abdel Rahman (1954)**.

Fitter and Hay (1981) stated that the tactics adpated by xerophytes and mesophytes to ensure survival under conditions of water shortage can be grouped into three classes: (a) adaptation leading to acquisition of maximum amount of water (principally the amelioration of water stress), (b) adaptation to ensure the conservation and efficient use of acquired water (involving the amelioration and tolerance of water stress), (c) avoidance in certain species that restrict their activities to periods of water availability and (d) adaptation (mainly biochemical and ultrastructural), protecting cells and tissues from damage and death during severe desiccation (tolerance of water stress).

Physiological and anatomical mechanisms of resistance to drought have been dealt with by many workers.

Migahid and Shafei (1956) recorded high values of bound water in xerophytes and low values in mesophytes.

Abd El-Rahman and Batanouny (1964a) reported that Zygophyllum coccineum survives the dry period in active state, owing to its succulence. In general, this plant is furnished with several morphological, anatomical and physiological peculiarities that help for successful drought resistance and for withstanding several dry conditions.

Many authors reported on the role of succulence as a means of drought and salt tolerance.

Ahmed and Girgis (1979) reported that succulence of Zygophyllum coccineum and Nitraria retusa increased with increase of soil drought, while that of Hammada elegans and Z. album showed an increase with increased water availability in their habitats. Chlorides seem to be the most effective parameter affecting succulence in these plants.

Osmond et al. (1980) reported that succulent plants, capable of crassulacean acid metabolism, resist drought by maintaining high tissue water potential and almost completely eliminate the exchange of external Co_2 and water.

Malik and Srivastava (1982) stated that plants have several mechanisms to tolerate drought conditions. One of these is the presence of hydrophilic substances in the protoplasm like high molecular weight proteins and some carbohydrates (e.g. alginic acid). Low-molecular weight compounds like polyhydric alcohols act as hydrophilic compounds. Sugars are usually increased in drought conditions in such plants since their presence in solution directly lowers the water potential of cell sap. This device helps the plant to conserve water and save the protoplasm from desiccation. In general, drought tolerant plants have small cells, high nucleic acid contents, less starch and very high amount of sugars.

Marie (1988) reported that the accumulation of electrolytes and nonelectrolytes together with the development of succulence seem to be essential adaptive responses in the adjustment of succulent xerophytic species, namely Z. coccineum, Anabasis setifera and A. articulata. The succulent xerophyte Hammada elegans depends on the accumulation of electrolytes besides nitrogen, succulence and xeromorphic characters towards the increase in drought stress.

Regarding to anatomical adaptation **Abu-Sitta (1981)** mentioned that the anatomical characteristics which are involved in reducing water loss, in Lygos raetam, Anabasis articulata and other species, include : (a) small volume of intercellular spaces helping in suppression of the internal evaporation, (b) presence of dense cover of hairs, (c) presence of thick cuticle, (d) disappearance of spongy large cells and increased development of palisade tissue in some cases, (e) occurrence of stomata in protected furrows, (f) shedding of the green fleshy cortex in chenopods, (g) presence of multiple epidermis in some cases, (h) presence of great proportion of lignified elements and (i) high ratio of volume to surface.

Weaver and Clements (1938) stated that cuticular transpiration is greatly decreased or completely prevented by heavy cuticularization and extreme cutinization of the epidermis. Cells of the epidermis are sometimes protected against water loss by the secretion of a coating of wax, resin, or other materials.

The stomata number is reduced, become narrowing sinking below the general level of the epidermis, either singly or in numbers, in special flask-shaped depressions on the underside of the leaf, or the over arching of the stomata by adjoining cells so that they come to be situated in cavities protected from the wind. Many xerophytes with small leaves have branches crowded together to form a dense cushion for checking transpiration **(Weaver and Clements, 1938)**.

The literature about the tolerance of plants to salinity is rather bulky. **Walter (1961)** stated that the roots of the halophytes absorb the soil solution in a diluted form. As water is transpired accumulation of salts in the leaves may take place on the long run. The halophytes overcome this in different ways, viz. with or without regulating mechanism (cumulatives, excretives and succulents).

Tolerance of saline conditions is currently viewed as the interaction of ion uptake and transportation, selectivity and excretion processes which permit effective osmotic adjustment **(Flowers,1975 and Flowers et al.,1977).**

Following **Osmond et al. (1980)** leaves of some halophytes have oftently additional controls over leaf ion concentration. These include salt glands which effectively unload the salt to the exterior of the leaf, and the capacity of many halopytes to become succulent, which effectively dilute salts within the leaf.

The salt glands would allow a halophyte to maintain low extracellular ion concentration by excreting salt which could not be absorbed to the vacuole of the leaf cells, **Oertli (1968).**

Ahmed and Girgis (1979) stated that salt excretion mechanisms of Cressa cretica was selective to either Na^+ and/or Cl^- under conditions of water-logging or high salinity.

Danin (1983) stated that Tamarix trees absorb deep saline water and excrete the excess salts through glands on their green stems and small leaves. The salt falling from the tree accumulates at the soil surface and creates favourable environment for other halophytes.

Succulence is considered as a mechanism through which certain halophytes are adapated to their saline environment, for the hypertrophy of leaves and shoots causes a dilution of intercellular solution of salt. It has an effect on ion dilution by increasing the volume to surface-area **(Shakhov, 1959 and Bieble and Kinzel, 1965 and Rozema et al., 1983).**

METHODS OF ANALYSIS

I- Vegetation analysis :

Vegetation analysis was caried out according to the methods described by **Braun-Blanquet (1932), Weaver and Clements (1938), Hanson and Churchill (1955) and Kershaw (1973).**

A- Quadrats :

The quadrat is a sample patch of vegetation of any desirable size used for purposes of analysis. Ten juxtaposed quadrats were laid in a representative stand of the community type. The species present in each quadrat were listed, the cover of each individual was measured and the species cover was calculated.

1- Frequency index is calculated as a percentage of number of quadrats that contained a given species to all quadrats analysed.

2- Frequency histograms :

Frequency percentage has been estimated according to **Raunkiaer (1934)** which classified the occurrence of species in an area into five classes as follows :

Frequency class I :

Species occurring with frequency of 1-20%.

Frequency class II :

Species occurring with frequency of 21-40%.

Frequency class III :

Species occurring with frequency of 41-60%.

Frequency class IV :

Species occurring with frequency of 61-80%.

Frequency class V :

Species occurring with frequency of 81-100%.

The number of species in different frequency classes gave a frequency polygon. This is compared to Rankiaer's law of frequency which states that :

Class I > II > III >∠< IV < V

3- Relative abundance is calculated as the percentage ratio of the number of individuals of species in all the quadrats as follows :

$$Ab\% = \frac{\text{No. of individual of species}}{\text{total No. of individual of all species}} \times 100$$

4- Total coverage = percentage of ground area covered by plant growth.

5- The species : area relationship is used to deduce the minimal area. The minimal area may be defined as the least size representing the species composition and structure of a community. This relationship shows the usual pattern of an initial increase in the number of species as the area increases, followed by lesser or almost negligible increase in the number of species as the area increases.

B- Stands :

The synthetic characters of any community can be derived from the comparative study of a number of stands of the community. A representative stand is a sample plot fulfilling the requirements of the minimal area. A list of species is made including :

1- Species composition.

2- A note on phenological aspect,
g = in foliage, d = dry, fl = flowering, fr = fruiting

3- Total-estimate according to the following modified Domin scale :-

+ = very rare
1 = occaisonal
2 = common
3 = very common
4 = abundant
5 = dominant, covering at least 5-25%.
6 = cover 25-33%
7 = cover 33-50%
8 = cover 50-75%
9 = cover 75-90%
10 = cover 90-100%

Presence histograms :

- Presence was classified into the following classes :

Presence class I :

Species occurring in 1-20% of stands.

Presence class II :

Species occurring in 21-40% of stands.

Presence class III :

Species occurring in 41-60% of stands.

Presence class IV :

Species occurring in 61-80% of stands.

Presence class V:

Species occurring in 81-100% of stands.

The presence percentage was calculated according to the following equation.

$$\text{Presence (P\%)} = \frac{\text{No. of stands in which species occurred}}{\text{Total No. of stands examined}} \times 100$$

II- Plant analysis :

The material used in this investigation was obtained from the aerial parts of the dominant species in the studied area. The plant material was subjected to the following analyses.

1- Plant moisture content :

Samples of about 100 gm were taken from the tips of the branches of dominant species and handly cleaned, weighed and then dried in an oven at 105°C to constant weight. The moisture content of the plant was expressed as a percentage of the oven dried plant material.

2- Succulence :

The degree of succulence was calculated as a ratio of fresh weight/dry weight as followed by **Dehan and Tal (1978).**

3- Ash content :

After determination of plant moisture the crucible containing the plant material was placed in an electric muffle furnace at 550 ± 25°C for six hours. The crucible was then transferred to a vacuum desiccator and cooled for 12 hours. The residue remained in the crucible was calculated as percent of ash **(Ward and Johnson, 1962).**

4- Elemental analysis of ash :

Analysis of the cations (Na, K, Ca, Mg and P) present in the ash was carried out using flame photometer, Corning Model 400.The chloride content was estimated following the AgNo3 method according to **Jackson and Thomas (1960)** after extraction from the ashed powedered samples.

5- Carbohydrate contents :

a- Estimation of total carbohdyrates :

A known weight of the air dried plant material was placed in a sealed test tube with a known volume of 6NHCl and put in a hot oven at 110°C for twenty four hours. The test tube was centrifugated and the total carbohydrate was determined from the supernatant layer according to **Dubois** **<u>et al.</u> (1951) and Naguib (1964).**

Extraction of total and reducing sugars :

A known weight of air dried plant material of the shoot was extracted by means of 80% ethyl alcohol for six hours using soxhlet apparatus. After filtration, the solvent was evaporated to small volume, the extract was neutralized by using phenol red **(Naguib, 1964)**, then cleared using basic lead acetate solution (137 gm/L), deleaded using NaH2 Po4 and made up to known volume. The residue was dried at 60°C to a constant weight and used for estimation of polysaccharides.

b- Estimation of direct reducing value (D.R.V.) :

This includes all reducing sugars. One ml of the cleared solution was mixed with 1ml of 5% phenol solution and 5 ml of 98.08% $H2So_4$ was added to each tube. After 10 minutes the tubes were reshaken and placed in a water bath at 25-30°C for 20 minutes **(Dubois *et al.*,1951)**.Absorbance was measured at 490 mu using spectocolourimeter (VEB carl zeiss).

c- Estimation of total reducing value (T.R.V) :

Two ml of 1.5 $N.H2So_4$ were added to two ml of cleared solution in a test tube, after which it was kept in a boiling water bath for half an hour. The test tube was cooled, neutralized by using phenol red, cleared using basic lead acetate (137 gm/L), deleaded using NaH2Po4 and made up to known volume **(Naguib, 1964)**. The process was proceeded as in case of direct reducing value.

d- Estimation of polysaccharides :

A known weight of the plant residue, which remained after the extraction of soluble sugars was refluxed in 1.5 N H_2SO_4 for four hours at 100°C. The solution was neutralized (phenol red), cleared with basic lead acetate (137 gm/L), deleaded with NaH_2PO_4 (119 gm/L) and made up to a known volume **(Naguib, 1964)**. The reducing value was then determined colourimetrically as described in the estimation of direct reducing value.

6- Nitrogen contents :

a- Total nitrogen :

The total nitrogen content was determined by micro-Kjeldahl method **(Peach and Tracey, 1956, Allen, 1953 and Cole and Parker, 1946)**. The results obtained were expressed as gram nitrogen per 100 g dry weight.

b- Soluble nitrogen :

The soluble nitrogen was extracted using 30% trichloro-acetic acid as follows : a known weight of the air-dried plant material was treated with 5 ml of 2% phenol in water and 10 ml of 30% trichloro-acetic acid. The mixture was shaken, left overnight and filtered. The residue was washed with another volume of trichloro-acetic acid and filtered. The filtrate was made up to known volume, ready for the estimation of the various soluble nitrogen fractions. The residue was dried at 60°C till a constant weight, Peach **and Tracy (1956).**

A known volume of the trichloro-acetic acid filtrate was subjected to digestion and distillation. The soluble nitrogen was determined by the micro-kjeldahl method and the results were expressed in g/100 gm dry weight.

c- Insoluble nitrogen :

This fraction was obtained mathematically : Insoluble nitrogen = total nitrogen - soluble nitrogen.

7- Investigation of amino acids :

A known weight of dried clean plant material was hydrolysed in 6 N HCl for 24 hours at 110°C in a sealed tube according to **Block (1950)** and the total amino acids content was determined following the ninhydrin method of **Lee and Takahshi (1966)** by using L-leucine as standard.

8- Investigation of fatty acids :

a- Extraction of lipids :

Known weights of the air dried plant material were extracted separately with petroleum other (b.P. 60-80°C) for 24 hours using soxchlet apparatus, then distilled and evaporated.

b- Fatty acid composition :

Analysis of the constituting fatty acids was carried out through their methyl esters adopting the GLC technique.

Preparation of the fatty acids methyl ester :

Following **Balba** **et al.** **(1981)** the lipid fractions were methylated by refluxing their solution in absolute methanol with 5% sulphuric acid on a boiling water bath for three hours. After cooling, the mixture was transferred to a separating funnel,then diluted with water and the ester was extracted with petroleum ether (b.p. 60-80°C). The petroleum ether extract was washed with water, then dried and concentrated to a small volume. Complete methylation was checked by means of thin layer chromatography.

c- Analysis of methyl ester of fatty acids :

The prepared methyl ester of each lipid fraction of the shoot system collected from different species under investigation was separately analysed by using HP. 5840 Gas chromatography adopting the following conditions :

Column : Mixed column composed of equal ratio of 3% of SE 30 CV 17 and OV 101

Injection temperature 270°C

FID. 270°C

Column temperature : Programing temperature starting from 150°C to 250°C with rate of 5°C/minute

carrier gas : Nitrogen

Identification of the fatty acids was achieved by comparing in each case, the relative retention time of their corresponding peaks with those of the pure available authentic samples.

III- Soil analysis :

A- Sampling :

The soil samples associated with each community type were collected at successive depths up to 60 cm (0-20, 20-40 and 40-60 cm). Each sample was dried in air, mixed thoroughly, passed through a 2 mm sieve to remove gravels and debris and then kept in nylon bags for further analysis.

B- Physical properties :

1- Soil moisture content :

Fresh samples were taken at the successive depths and were rapidly transferred to previously weighed aluminium tins, then weighed and dried to a constant weight at 105°C. The soil moisture content was calculated as percentage of oven-dry weight.

2- Soil texture :

The sieve method was used in the granulometric analysis in order to determine the soil texture. The size of the meshes of the sieves used was 2,1, 0.5, 0.25, 0.2, 0.125, 0.08 and 0.006 mm.

C- Chemical properties :

Preparation of 1:5 soil water extract :

The 1:5 soil water extract was prepared by addition of 1000 ml distilled water to 200 gm of air dried soil.