INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–2–202–214
http://www.fspublishers.org

Comparative Study on the Vegetation of Protected and Non-protected Areas, Sudera, Taif, Saudi Arabia

HOSENY A.M. MOSALLAM
Department of Biology, Collage of Science, Taif University, Hawyia, Taif, Kingdom of Saudi Arabia
E-mail: hosnymosallam@yahoo.com

ABSTRACT

This study was carried out at the National Wildlife Research Center (NWRC), located 45 km southern east of Taif governorate, Saudi Arabia. Three localities with different degrees of conservation were ecologically analyzed with respect to their vegetation cover, frequency, abundance and soil characteristics. Plant species were classified into three main communities dominated by *Arnebia hispidissima, Aizoon canariense* and *Argemone mexicana* communities depending on their degree of protection three life forms: therophytes, chamaephytes and phanerophytes constitute about 85.6% of the total flora of the reserves. Also, 40.8% of the recorded species are uni-regional. The application of CCA indicated that the plant species is controlled in their distribution by ten soil characteristics. 18 plants species were eaten by houbara, 10 species were eaten by ostrich and each of oryx and gazelle depended on 12 different species in the old and new protected areas. Overgrazing outside the reserves has bad effect not only on the plant life but also on the soil development. The vegetation in the reserves, in general, is relatively richer and the soil shows no symptoms of erosion. Productivity of the protected area was much higher than the adjacent un-protected ones.

Key Words: Vegetation; Overgrazing; Trampling; Oryx; Houbara

INTODUCTION

Proper knowledge of the resources will, no doubt, help in planning for the future extrapolation of more reserve area. Studies dealing with the evaluation of these natural resources and monitoring of the changes taking place are badly needed, especially ecological studies (El-Gazzar *et al*., 1995). The socioeconomic and the touristic industry development of the reserved areas are based on evaluation of its natural resources (El-Demerdash *et al*., 1996). Quite apart from aesthetic value of the area, it is well known that floristic frontiers are highly fragile habitats and should be high up on the list of priorities for conservation. In this context, the plant resources in NWRC (National Wildlife Research Center, Taif, Saudi Arabia) protected area acquire additional significance in view of the fact that the more livelihood of the local Bedouins is almost entirely dependent in these species for food, fire wood, grazing, medical treatment etc., We must control overall human activities, especially collecting of fire wood and safari tours, grazing, sever cutting of medicinal plants. Protection by fencing greatly increased both vegetation production and plant species diversity especially in the arid rangelands as in Saudi Arabia.

Pasture production depends on various factors such as climate, nature of soil, botanical composition, vegetation structure, type and intensity of management (Le Houerou & Hoste, 1977). There is no doubt that overgrazing, over cultivation and wood cutting are among the man-made factors, which lead to the deterioration of pasture production in arid regions. The improvement of the vegetation due to full or partial protection was depicted also by Halwagy (1962) near Oumdurman, Hammouda (as quoted by Kassas 1970) at Ras El-Hikma, 230 km west of Alexandria, Ayyad (1978), Ayyad and El-Kady (1982), Shaltout and El-Ghareeb (1985) in Omayed, 80 Km west of Alexandria.

Batanouny (1979) described the anthropogenic influences on the vegetation distribution between Jeddah and Mecca, Abd El-Ghani (1996) studied the vegetation along a transect in the Hijaz mountains, while El-Demerdash *et al.* (1994) discussed the impacts of these influences in the Red Sea coastal plains of Tihamah region, Saudi Arabia. Mosallam and Hassan (2001) studied also the range potentiality at Mahazat as-Sayed reserve area, Taif Governorate, Saudi Arabia. These studies concluded that some other factors e.g., heavy grazing, wood fuel cutting and termites play additional impacts.

Grazing by domestic livestock is commonly associated with changes in species composition in native grasslands throughout the world (Archer, 1989; Noy-Meir *et al*., 1989; Westoby *et al*., 1989; Milchunas & Lauenroth, 1993; Milton *et al*., 1994). Under long-term, intensive grazing the shift in species composition frequently involves the replacement of palatable grasses by un-palatable grasses (or) woody perennials (Noy-Meir *et al*., 1995).

This study includes the floristic and ecological account for three different levels of protection, two protected areas, namely NWRC protectorate, which is protected since 1986 (old protected) and the Extension protectorate since 1992 (new protected area) and one non-protected opened area at

Suddera, Taif Governorate, Saudi Arabia. The main objectives of this study are to report: (a) the ecology of the major plant species in each of the three regions under study, (b) analysis of the major edaphic variables related to the distribution of these species in the different habitats and (c) evaluate the response of vegetation to different levels of trampling.

The study area. The study was carried out during 2005 and 2006 at the National Wildlife Research Center (NWRC), located on the arid Najd plains of western Saudi Arabia, 45 km southern east of Taif Governorate. NWRC declared as a nature reserved scientific center of four km fenced since 1986, while extension area comprises 19 km adjacent to the NWRC and fenced since 1992 (ranging between 1440 – 1560 m.a.s.l.). The free grazing area is lying adjacent to both NWRC (old protected) and extension (new protected) areas. The NWRC boundaries is lying between latitudes 21°15'20", 21°15'56", 21°15'50" and 21°14'5" N and longitudes 40°40'53", 40°41'51", 40°42'36" and 40°41'36" E. Extension boundaries lying between latitudes 21°15'2", 21°16'43", 21°15'5", 21°13'57" and 21°13'21" N and longitudes 40°41'22.13", 40°43'45.19", 40°44'24", 40°44'8" and 40°41'22" E. (Fig. 1b). A perimeter fence erected has kept domestic livestock out, allowing the vegetation inside the protected area to recover from overgrazing and has discouraged illegal hunting and collection of litter.

According to Greth and Schwed (1993), Haque and Smith (1994 & 96), the reserved area has been established specifically to provide a save haven for reproduction and studying captive bred Arabian oryx (*Oryx leucoryx*), sand gazelles (*Gazelle subgutturosa marica*), Asian Houbara Bustard (*Chlamydotis macqueenii*) and Red-necked Ostrich (*Struthio camelus syriacus*).

The climate is tropical and arid, the mean monthly minimum and maximum ambient air temperatures, soil temperature, solar radiation and relative humidity are clearly shown in Fig. 2. The seasonal variations in rainfall vary greatly during the study period. Remarkably, the annual rainfall was 173.2 mm during 2006 and only 31.5 mm during 2005.

MATERIALS AND METHODS

A quantitative survey of the vegetation was carried out during 2005 - 06. Preliminary observations suggested that vegetation is correlated with the longevity of protection in the three different localities, for this reason stratified random sampling method is employed (Greig-Smith, 1957; Ludwig & Reynold, 1988) within each of the three studied sites. Vegetation was surveyed with ten permanent quadrates of 10 x 10 m along each of NWRC, extension protectorates and the free grazing area. Internal quadrates were spaced 2 m apart and away from the fence to avoid bias due to edge effects. External quadrates were placed at least 4 m from the fence to exclude the area disturbed during construction and a possible future zone of heavy grazing (should vegetation with the enclosure actively attract camels).

Vegetation parameters were measured included: species density, species frequency and species abundance. The sum of the relative values gave the importance value for the different plant species. Voucher specimens were deposited in the herbarium of NWRC, Taif, Saudi Arabia. Plant nomenclature follows: Collenette (1985 & 99), Chaudhary and Al-Jowaid (1999), Chaudhary (1989), Zohary (1987), Migahid (1978), Feinbrun-Dothan (1978 & 86), Vincett and Betty (1977).

Altitude was determined using a global positioning system (GPS) at various points in the study sites and then averaged. Climatic data was obtained from the weather station at the study area (NWRC). Observations of the animals were carried out early in the morning and at the mid-day to see, which plant species they ate. These data was confirmed from the NWRC data base.

The biomass of the species was sampled using 10 randomly located 1 m^2 quadrates. The % of total standing biomass of the above ground parts was determined for all species present. Excavated plants were carefully cleaned and oven-dried to constant weight at 105°C. A histogram was drawn to assess the relationship between total standing crop biomass of the above-ground parts of plant species inside both old and new protected areas on one hand and free grazing area on the other hand.

Species richness of the vegetation inside the old and new protected areas as well as the non-protected area was calculated as the average number of species per site and species turn-over as the ratio between the total number of species and the species richness. The relative change (increase or decrease) in richness, turn-over (RID) of the old and new protected areas compared with un-protected was calculated as follows: RID = [(protected un-protected)/protected] x 100 (Shaltout *et al*., 1996).

Soil samples were collected from each site as a profile (composite samples) at a depth of 0 - 25 cm. The soil samples were brought to the laboratory in plastic bags shortly after collection, spread over sheets of paper, air dried, passed through 2 mm sieve to remove gravel and debris and then packed in paper bags ready for analysis. Calcium carbonate was estimated using Bernard's calcimeter of the type described by Betremieux (1948). Soil water extracts at 1:5 were prepared for determination of soil salinity (EC), soil reaction (pH), chlorides and sulfphates. Soil reaction (pH) was estimated using a glass electrode pH-meter. Salinity was evaluated by a direct indicating conductivity bridge (dS/cm). Chlorides were estimated by direct titration against silver nitrate using 5% potassium chromate as indicator, carbonates and bicarbonates by titrating 5 mL of the 1:5 soil/distilled water extract against 0.01 N HCl using phenolphthalein and methyl orange indicators (Jackson, 1962). Sulphates were determined using the gravimetric with ignition of residue method. In this method sulphate were precipitated in 1% HCl solution as barium sulphate by adding of barium chloride (10%),

Fig. 1a. Kingdom of Saudi Arabia Protected Areas Including NWRC, Taif region, Saudi Arabia

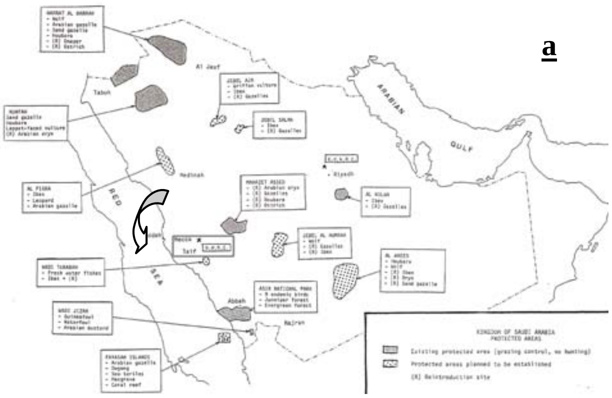
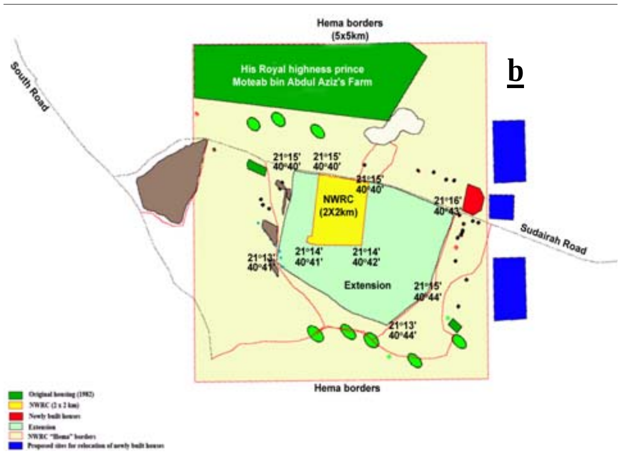


Fig. 1b. Borders of the old protected (NWRC) and newly protected (extension) areas



filtered, washed with hot distilled water, ignited at 800°C for two hours and then weighted as barium sulphate.

For the determination of soluble salts, soil extracts of Five gm air-dried soil samples were prepared using 2.5% v/v glacial acetic acid. The estimated nutrients in these extracts were Na^+, K^+, Ca^{2+} and Mg^{2+}. Flame photometer was used for determination of Na^+, K^+ and Ca^{2+}. Magnesium was determined using atomic absorption. All these procedures were outlined by Jackson (1967) and Allen *et al*. (1974) except that of calcium carbonates.

The Sorenson s quotient of similarity (Sørenson, 1948) was calculated to assess the degree of similarity between the species composition of the pairs of the three sites.

$$ISs = 2CA^{-1} + B \times 100$$

C = number of wild species common to both sites, A = number of weed species in the first site, B = number of wild species in the second site.

Canonical correspondence analysis (CCA, ver.2.1) was used to perform direct gradient analysis (Ter Braak, 1988). CCA is used to determine the relationships between vegetation data and environmental variables (Jean & Bouchard, 1993).

RESULTS

The plant species from the two reserved areas (NWRC & extension) were listed in Table I. A total of 234 plant species belonging to 57 families were recorded; of species 15.8, 9.4, 5.6, 5.1 and 4.3% belonging to the families Poaceae, Asteraceae, Fabaceae, Brassicaceae and Zygophyllaceae, respectively. It also reveals that 24 families were monotypic, eight families were represented by two species and five families had six species. Some of the listed species are edible by wild grazing birds and animals (Houbara, Ostrich, Oryx & Gazella).

The life form spectrum (Fig. 3b) exhibited a wide range of variation. Therophytes were the predominant life form and constituted 47.6% of the total flora of the studied reserves followed by chamaephytes (29.7%) and geophytes (cryptophytes, hemi-cryptophytes & helophytes) (12.7%). It is obvious that the three life forms: therophytes, chamaephytes and phanerophytes constitute about 85.6% of the total flora of the above recorded reserves (Table I). Results of the total chorological analysis of the surveyed flora (Table I & Fig. 3a) revealed that 40.8% of the studied species are mono-regional, of which 39% being native to the tropical chorotype. Typical Irano-Turanian chorotype

Fig. 2. Climatic records of the Meteorological Station of National Wildlife Research Center (NWRC) during 2005 and 2006

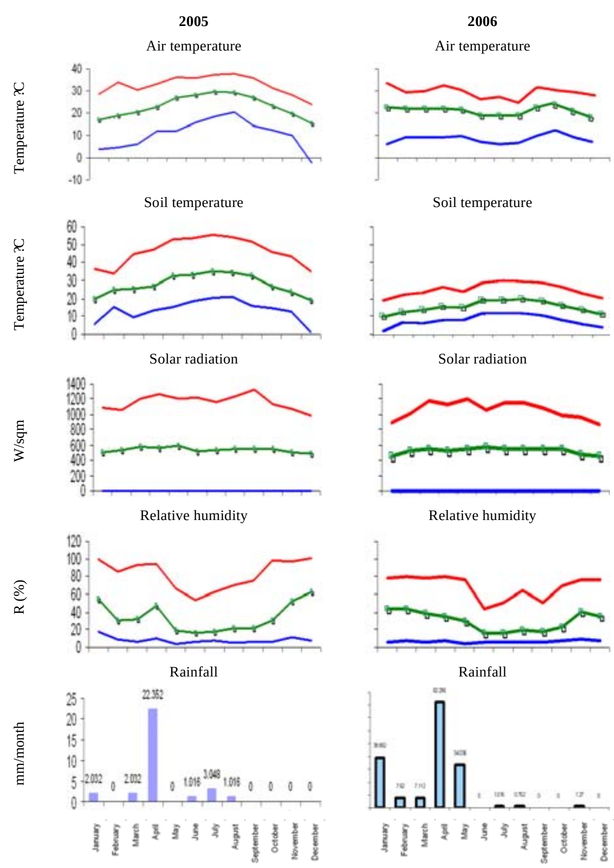


Table I. List of plant species recorded in the study area with their families, life forms, chorotypes and grazed plants eaten by wild grazing animals. The life forms are: Ph, phanerophytes; Ch, chamaephytes; G, geophytes (cryptophytes, hemi-cryptophytes and helophytes); Th, therophytes and P, parasites. The chorotypes are: COSM, cosmopolitan; ES, Euro-Siberian; EU, Europian; IT, Irano-Turanian; MA, Malysian; ME, Mediterranean; SA, Saharo-Arabian; SI, Sindian; SS, Saharo-Sindian; SU, Sudano-Zambezian and TR, Tropical

Family	Plant species	Wild grazing birds & animals	Life form	Chorotype
Acanthaceae	*Blepharis ciliaris* (L)Burtt		Ch	SA+SU
Aizoaceae	*Aizoon canariense* L		Th	IT+ME+SA+SU+TR
	Zaylea pentandra(L) Jeffrey		Th	COSM
Amaranthaceae	*Achyranthes aspera* L		Th	ME+TR
	Aerva javanica(Burm.f.) Juss.ex Schult.		Ch	TR
	Aerva lanata (L)Juss.ex Schult.		Ch	TR
	Amaranthus graecizans L		Th	TR
	Amaranthus viridis L		Th	COSM
	Pupalia lappacea L		Ch	TR
Amaryllidaceae	*Pancratium maximum* Forssk.		G	ME
Apiaceae	*Anethum graveolens* L		Th	SU
Apocynaceae	*Rhazya stricta* Decne.	Houbara	Ch	SA+SU
Asclepiadaceae	*Caralluma edulis* (Edgew) Benth.		Ch	SA+SU
	Calotropis procera (Ait) Ait.fil.		Ph	SA+SU
	Glossonema boveanum (Decne.)Decne.		Ch	SA+SU
	Gomphocarpus sinaicus Boiss.		Ch	SA
	Leptadenia pyrotechnica(Forssk.)Decne.		Ph	SA+SU
	Pentatropis nivalis (J.F.Gmel.)D.V. Field & J.R.I. Wood		Ph	IT+SA+ SU
	Pergularia tomentosa L		Ch	SA+SU
	Periploca aphylla Decne.		Ch	SA+SU
Asphodelaceae	*Asphodelus fistulosus* L		G	ME
Asteraceae	*Anvillea gracinii* (Burm.f) DC.		Ch	SA
	Atractylis carduus (Forssk.)C.Chr.		G	ME+SA
	Centaurea pseudosinaica Czerep.		Ch	SA
	Centaurea schimperi DC.		Ch	SA
	Echinops spinosissimus Turra, Farset.		Ch	ME
	Felicia abyssinica A.Rich.		Th	SA
	Filago desertorum Pomel		Th	IT+SA
	Flaveria trinerva (Spreng) Mohr.		Ch	
	Helichrysum glumaceum DC.		Ch	TR
	Ifloga spicata (Forssk.) Sch. Bip.		Th	ME+SA
	Launaea mucronata (Forssk.)Muschl.	Houbara	Ch	ME+SA
	Launaea sconchoides = (Launaea cassiniana)		Th	SA+SI
	Osteospermum vaillantii (Decne.) Norl.		Ch	SA+SU
	Phagnalon schweinfurthii Sch.-Bip.		Ch	IT+ME
	Picris cyanocarpa Boiss		Th	SA
	Psiadia punctulata DC.		Ch	
	Pulicaria undulata (Forssk.)Oliver.		Ch	SA+SU
	Reichardia tingitana (L) Roth		Th	IT+SA
	Scorzonera tortuosissima Boiss.		Ch	IT
	Senecio hoggariensis Batt. & Traub.		Th	
	Sonchus oleraceus L		Th	ES+IT+ME
	Verbesina encelioides (Cav.) Benth.&Hook.fil ex.A.Gray		Th	TR
Boraginaceae	*Arnebia hispidissima* (Lehm.) DC.	Houbara	Th	SA+SU
	Gastrocotyle hispida (Forssk.)Bunge		Th	IT+SA
	Heliotropium europaeum L		Ch	ES+IT+ME
	Heliotropium ramosissimum DC.	Houbara, Gazella, Oryx	Ch	ME+TR
Brassicaceae	*Brassica rapa* L		Th	COSM
	Brassica tournefortii Gouan.		Th	IT+ ME+SA
	Eremobium aegyptiacum (Spreng.)Asch.&Schweinf. ex Boiss.		Th	SA
	Eruca sativa Mill.		Th	ES+IT+ME+SA
	Farsetia longisiliqua Decne.		Ch	SU
	Farsetia stylosa R. Br.	Houbara	Ch	SU
	Morettia canescens Boiss.	Ostrich, Oryx	Th	SA+SU
	Morettia parviflora Boiss.		Th	SU
	Notoceras bicorne (Ait.)Amo		Th	SA
	Sisymbrium erysimoides Desf.		Th	ME+SA+SU
	Sisymbrium irio L		Th	ES+IT+ME
	Sisymbrium orientale L		Th	ES+IT+ME
Caesalpiniaceae	*Senna italica* Mill.		G	SU

Table I. Continue

Capparidaceae	Cadaba farinosa Forssk.		Ch	TR
	Capparis cartilaginea Decne.		Ch	SU
	*Capparis decidua (*Forssk.)Edgew.		Ph	SU+TR
	Capparis spinosa L	Houbara	Ch	IT+ME
	Maerua crassifolia Forssk.		Ph	SU
	Maerua oblongifolia (Forssk.)Rich.		Ph	TR
Caryophylaceae	*Paronychia arabica* (L.)DC.		Th	ME+SA+SU
	Paronychia chlorothyrsa Murb.		Th	SA
	Polycarpaea repens (Forssk.) Asch.& Schweinf.	Houbar*a*	Th	SA+SU
	Polycarpaea robbairea (Kuntze) Greuter & Burdet		Th	ME
	Silene hochstetteri Rohrb.		Th	IT+ME
	Vaccaria pyramidata Medik.		Th	ES+IT+ME
Celestraceae	*Maytenus parviflorus* (Vahl.)Sebsebe		Th	IT+ME
Chenopodiaceae	*Bassia eriphora* (Schrad.)Asch.		Th	IT+SA+SU
	Bassia muricata (L.)Asch.		Th	IT+SA
	Chenopodium album L.		Th	COSM
	Chenopodium murale L		Th	IT+ES+ME
	Chenopodium opulifolium Schrad.ex Koch&Ziz		Th	COSM
	Haloxylon salicornicum (Moq.)Bunge ex Boiss.		Ch	IT+SU
	Salsola kali L		Th	COSM
	Salsola imbricata Forssk.	Houbara	Ch	SA+SU
	Salsola villosa Schult.		Ch	IT+SA
Cleomaceae	*Cleome amblyocarpa* Barratte & Murb.		Ch	SA+SU
	Cleome droserifolia (Forssk.)Del.		G	SU
Commelinaceae	*Commelina albescens* Hassk.			
Convolvulaceae	*Convolvulus arvensis* L		G	TR
	Convolvulus asyrensis Kotschy		Th	ME
	Convolvulus glomeratus Choisy		TH	SU
	Convolvulus hystrix Vahl.		Ch	SA+SU
	Cuscuta planiflora Ten.		P	ME+SA
	Seddera arabica Forssk.			
	Seddera latifolia Hochst. & Steud.		Ch	
Crassulaceae	*Umbilicus horizontalis* (Guss.)DC		G	
Cucurbitaceae	*Citrullus colocynthis* (L)Schard.	Ostrich, Gazella, Oryx	Th	SA
	Cucumis prophetarum L		Th	SA+SU
Cyperaceae	*Cyperus conglomeratus* Rottb.		G	ME+SA+SU
	Cyperus rotundus L.		G	IT+ME+TR
	Cyperus rubicundus Vahl.		G	TR
Ephedraceae	*Ephedra foliata* Boiss. ex C.A. Mey		Ch	ME+SA
Euphorbiaceae	*Andrachne aspera* Spreng.		Ch	
	Chrozophora oblongifolia (Del.) Spreng.		Ch	SU
	Euphorbia granulata Forrsk.		Th	SA+SU
	Euphorbia scordifolia Jacq.		Th	
	Phyllanthus maderaspatensis L.		Ch	
	Securinega virosa (Roxb. ex Willd.) Baill.			
Fabaceae	*Astragalus eremophilus* Boiss.	Houbara	Th	IT+ME+SA
	Astragalus sieberi DC.	Houbara	Ch	SA
	Astragalus tribuloides Del.	Houbara	Th	IT+SA
	Astragalus vogelii (Webb) Bornm	Houbara	Th	SA+SU
	Hippocrepis ciliata Willd		Th	IT+SA
	Indigofera spinosa Forssk.	Houbara, Ostrich	Th	TR
	Lototonis platycarpa (Viv.)Pic.-Serm		Th	SA+SU
	Medicago laciniata (L)Mill.		Th	IT+SA
	Medicago minima L		Th	IT+ES+ME+SA
	Melilotus albus Medik		Th	ES+IT+ME
	Melilotus indica L		Th	IT+ME+SA
	Trigonella stellata Forssk.		Th	IT+SA
	Vermifrux abyssinica (A. Rich) Gill.			
Geraniaceae	*Erodium neuradifolium* Del.		Th	IT+SA
	Erodium pulverulentum (Gav.) Willd.		Th	IT+SA
	Monsonia nivea (Decne.)Webb		G	SA+SU
Hyacanthaceae	*Dipcadi viride* (L) Moench		G	SA+SU
Lamiaceae	*Ajuga arabica* P.Davis		Ch	IT
	Lavadula coronopifolia Poir.		Ch	SA+SU
	Micromeria biflora Benth.		Ch	ME
	Otostegia fruticosa Forssk.		Ch	SA
	Salvia aegyptiaca L		Ch	SA+SU
	Stachys sp. aff. *schimperi* Vatke		Ch	SA+ME

Table I. Continue

Loranthaceae	Plicosepalus curviflorus (Benth. ex Oliv.)Tiegh.		P	
Malvaceae	*Abutilon bidentatum* A.Rich.		Ch	SU
	Abutilon fruticosum Guill.&Perr.		Ch	SU
	Hibiscus micranthus L. f.		Th	TR
	Hibiscus vitifolius L		Ch	TR
	Malva parviflora L		Th	IT+ME
Menispermaceae	*Cocculus pendulus* (J.R&G. Forst.) Diels		Ph	SU
Mimosaceae	*Acacia asak* (Forssk.)Willd	Ostrich	Ph	TR
	Acacia ehrenbergiana Hayne	Gazella	Ph	TR
	Acacia iraquensis Rech. F.	Gazella	Ph	TR
	Acacia tortilis (Forssk.) Hayne	Houbara, Gazella, Oryx	Ph	SU
	Acacia tortilis ssp. *raddiana* (Savi) Brenan		Ph	SU
Molluginaceae	*Mollugo cerviana* (L)Ser.		Th	TR
	Gisekia pharnaceoides L		Th	COSM
Moraceae	*Ficus cordata* Thunb ssp. *salicifolia* (Vahl.) Berg		Ph	TR
	Ficus palmata Forssk.		Ph	IT+SU
Neuradaceae	*Neurada procumbens* L		Th	SA+SU
Nyctaginaceae	*Boerhavia diffusa* L	Gazella	Ch	SA +TR
	Commicarpus grandiflorus (A. Rich.) Standl.		Ch	TR
	Commicarpus sinuatus Meikle		Ch	TR
Ophioglossaceae	*Ophioglossum polyphyllum* R. Braun		G	TR
Orobanchaceae	*Cistanche phelypaea* (L) Cout.		P	ME+SA
	Orobanche cernua Loefl.		P	IT+ME+SA
Papaveraceae	*Argemone mexicana* L		Th	
Plantaginaceae	*Plantago afra* L		Th	IT+ME
	Plantago ciliata Desf.		Th	IT+SA
	Pantago cylindrica Forssk.		Th	SA
	Plantago ovata Forssk.		Th	IT+SA
Plumbaginaceae	*Limonium axillare* (Forssk.)Kuntze		Ch	SU
Poaceae	*Aristida adscensionis* L		Th	SA
	Brachiaria leersiodes Hochst. Stapf.		Th	TR
	Cenchrus ciliaris L		Th	ME+SA+SU+TR
	Cenchrus setigerus (L) Vahl.		Th	
	Centropodia forsskalii (Vahl.)Cope		G	
	Chloris gayana Kunth.		G	TR
	Chrysopogon plumulosus Hochst.		G	
	Cynodon dactylon (L) Pers.		G	COSM
	Dactyloctenium scindicum Boiss.		Th	TR
	Danthoniopsis barbata (Nees) Hubb.		G	
	Digitaria ciliaris (Retz.) Koel.		Th	COSM
	Digitaria nodosa Parl.		G	TR
	Echinochloa colonum (L) Link	Gazella, Oryx	Th	IT+ME+TR
	Enneapogon desvauxii P.Beauv.		Th	TR
	Enneapogon schimperianus (Hochst. ex A. Rich) Renvoize		Th	TR
	Eragrostis barrelieri Dav.		Th	ME+SA
	Eragrostis papposa (Roem. & Schult.) Steudel		Th	TR
	Hyparrhenia hirta (L) Stapf.		Th	IT+ME+SA+TR
	Lasiurus scindicus Henr.	Houbara, Gazella, Oryx	G	SA+SU
	Lolium multiflorum Lam.		Th	ES+IT+ME
	Opetium capese Stapf.		G	
	Panicum turgidum Forssk.	Gazella, Oryx	G	SA+SU
	Pennisetum divisum (Gmel.) Henr.		Ch	SA+TR
	Pennisetum orientale (L) C. Rich		Th	TR
	Polypogon monspeliensis (L)Desf.		Th	IT+ME+SA+TR
	Schismus arabicus Nees.		Th	IT+ME+SA
	Schismus barbatus (L) Thell.		Th	IT+ME+SA
	Setaria viridis (L) P. Beauv.		Th	IT+ME+ES
	Sorghum bicolor (L) Moench.		Th	TR
	Stipagrostis hirtigluma (Steud. ex Trin. & Rupr.) de Wint.	Ostrich, Gazella, Oryx	Th	SA+SU+TR
	Stipagrostis obtusa (Del.) Nees	Ostrich, Gazella, Oryx	Th	SA+SU+TR
	Stipagrostis plumosa (L) Munro ex T. Anders.	Ostrich, Gazella, Oryx	G	IT+SA+SU
	Stipagrostis uniplumis (Licht) de Wint.	Ostrich, Gazella, Oryx	Th	SA
	Tetrapogon villosus Desf.		G	SS+SU
	Tragus racemosus (L) All.		Th	
	Tricholaena teneriffae (L. f.) Link.		G	SA+SU
	Tripogon africanus (Coss. & Dur.) Schoz & Konig		G	
Polygalaceae	*Polygala erioptera* DC.		Th	
	Polygala schwartziana Piava		Ch	

Table I. Continue

Polygonaceae	Emex spinosa (L) Campd.		Th	IT+ME+SA
	Polgonum argyrocoleum Steud. ex Kunze		G	SA
	Rumex vesicarius L		Th	ME+SA+SU
Polypodiaceae	*Actiniopteris semiflabellata* Pic.-Ser.		G	
	Cheilanthes coriacea Decne.		G	ES+IT+ME
	Cosentina vellea (Ait.)Tod.			
Portulacaceae	*Portulaca oleracea* L		Th	COSM
Resedaceae	*Caylusea hexagyna* (Forssk.)Green		Th	SA+SU
	Ochradenus baccatus Del.		Ph	SA+SU
Rhamnaceae	*Ziziphus spina christi*(L)Desf		Ph	IT+ME+SA+SU
Rubiaceae	*Pyrostria phyllanthoidea* (Baill)Bridson		Ch	
Salvadoraceae	*Salvadora persica* L		Ph	SU
Scrophulariaceae	*Aptosimum pumilum* (Hachst.) Benth.		Th	
	Kichxia pseudoscoparia D. Sutton.		Ch	SA
	Scrophularia arguta Soland. ex Ait.		Th	
Solanaceae	*Lycium shawii* Roem. & Schult.	Houbara	Ch	IT+SA+SU
	Solanum glabratum Dunal var. *sepicula* (Dunal) Wood		Ch	
	Solanum forsskalii Kotschy ex Dunal.		Ch	
	Solanum incanum L		Ch	SU
	Solanum villosum (L) Lam		Th	ES+IT+ME
	Solanum schmperianum Hochst. ex A. Rich		Th	
	Withania somnifera (L) Dunal		Ch	IT+ME+TR
Tiliaceae	*Grewia tembensis* Fresen.		Ph	TR
	Grewia tenax (Forssk.) Fiori		Ph	TR
Umbelliferae	*Anethum graveolens* L		Th	
Urticaceae	*Forsskaolea tenacissima* L		Ch	SA+SU
	Parietaria alsinifolia Del.		Th	SA
Verbenaceae	*Lantana microphylla* Franch.		Ch	
Zygophyllaceae	*Fagonia bruguieri* DC.		Ch	IT+SA
	Fagonia indica Burm. f.	Houbara, Ostrich,Oryx	Ch	IT+SA
	Fagonia schweinfurthii Hadidi	Oryx	Ch	SA
	Peganum harmala L		Ch	ES+IT+ME+SA
	Seetzenia lanata (Wild) Bullock	Gazella, Oryx	Th	SU
	Tribulus macropterus Boiss.	Ostrich, Gazella, Oryx, Houbara	Th	SU
	Tribulus parvispinus Presl.		Th	SU
	Tribulus pentandrus Forssk.		Th	SU
	Tribulus terrestris L		Th	ES+IT+ME+SU
	Zygophyllum simples L		Th	SU

(2.4%) is the least representative followed by Mediterranean type (7.3%). About 34.3% of the recorded species are bi-regional, of which 44.9% being native to Saharo-Arabian and Sudano-Zambezian (the highest value). Each of Saharo-Arabian and Sindian, Irano-Turanian and Sudano-Zambezian, Sudano-Zambezian and Tropical and finally Saharo-Sindian and Sudano-Zambezian represented only by a single species. Cosmopolitan species constituted the lowest value (5%) from the total chorological analysis of the studied flora.

With regard to palatable plants eaten by the recorded birds and animals, Table I showed that 18 species were eaten by Houbara, 10 species were eaten by ostrich and each of oryx and gazelle depended on 12 different species. It was noticed that each of *Acacia ehrenbergiana*, *Acacia iraquensis* and *Boerhavia diffusa* were eaten only by gazelle, while *Polycarpaea repens*, *Rhayza stricta* and *Salsola imbricata* were eaten only by Houbara (Table I).

Base-line values for density, frequency, abundance and importance value index (I.V.I.) were demonstrated for NWRC (old protected), extension (new protected) and free grazing (un-protected) areas, as well as a listing of all species encountered in the quadrates (Table II). Three main communities were distinguished depending on their degree of protection as follows:

***Arnebia hispidissima* community (old protected area).** The characteristic species of this community are: *Indigofera spinosa* (I.V.I of 25.4), *Stipagrostis* sp. (I.V.I of 24.6), *Ifloga spicata* (I.V.I: 19.6), *Launae* sp. (I.V.I: 15.1) followed by *Fagonia* sp. (I.V.I: 14.4). All the above mentioned species having F. values of 100%. The other associate species were shown in (Table IIa) of old protected area but with lower values.

***Aizoon canariense* community (new protected area).** The characteristic species of this community were *Gisekia pharnaceoides* (I.V.I: 28.5), *Arnebia hispidissima* (I.V.I: 24.4), *Bassia muricata* (I.V.I: 18.9) and *Stipagrostis* sp. (I.V.I: 16.7). It can be noticed from these results that extension area, *Aizoon canariens*e dominates followed by *Gisekia pharnaceoides*, *Arnebia hispidissima*, *Bassia muricata* and *Stipagrostis* sp.

***Argemone mexicana* community (free grazing area).** The characteristic species of this community are *Indigofera spinosa* (I.V.I of 19.8 & F. value 60%), *Arnebia hispidissima* (I.V.I of 17.5 & F. value 100%), *Aizoon canariense* (I.V.I of 15.9 & F. value 80%) and *Ifloga*

Table II. Density (D), frequency (F), abundance (A) and importance value index (I.V.I) of plant species in a) old protected, b) new protected and c) free grazing areas in Taif Governorate, Saudi Arabia

(a) Old protected area (20 years ago)

Plant Species	No.	D	F	A	I.V.I
Acacia spp.	S1	2.8	100	2.8	5.3
Aizoon canariense	S2	18.4	100	18.4	14.0
Arnebia hispidissima	S3	57.6	100	57.6	36.1
Bassia muricata	S4	0.2	20	1.0	1.1
Boerhavia diffusa	S5	0.8	40	2.0	2.2
Cyperus conglomeratus	S6	2.6	100	2.6	5.1
Dipcadia viride	S7	2.4	100	2.4	5.0
Echinocloa colonum	S8	10.4	80	13.0	9.5
Echinops spinosissimus	S9	0.2	20	1.0	1.1
Eremobium aegyptiacum	S10	4.8	80	6.0	6.0
Erodium sp.	S11	7.2	100	7.2	7.7
Fagonia sp.	S12	19	100	19.0	14.4
Farsetia sp.	S13	0.8	20	4.0	2.1
Forsskaolea tenacissma	S14	0.4	20	2.0	1.4
Gisekia pharnaceoides	S15	8	100	8.0	8.2
Ifloga spicata	S16	28.4	100	28.4	19.6
Indigofera spinosa	S17	38.6	100	38.6	25.4
Launaea sp.	S18	20.4	100	20.4	15.1
Lycium shawii	S19	9.8	100	9.8	9.2
Medicago laciniata	S20	4	100	4.0	5.9
Micromeria biflora	S21	0.2	20	1.0	1.1
Monsonia nivea	S22	5.6	100	5.6	6.8
Morettia sp.	S23	0.4	40	1.0	1.9
Ophioglossum polyphyllum	S24	1.6	40	4.0	3.0
Pancratium maximum	S25	4.4	100	4.4	6.2
Panicum turgidum	S26	1	80	1.3	3.6
Plantago sp.	S27	10.4	100	10.4	9.5
Polycarpaea sp.	S28	15.8	100	15.8	12.6
Portulaca oleracea	S29	0.6	40	1.5	2.1
Salsola sp	S30	8.4	100	8.4	8.4
Salvia aegyptiaca	S31	2.8	80	3.5	4.7
Scorzonera tortuosissima	S32	2.6	20	13.0	5.0
Senna italica	S33	0.2	20	1.0	1.1
Stipagrostis sp.	S34	37.2	100	37.2	24.6
Tribulus sp.	S35	10.8	100	10.8	9.8
Trigonella stellata	S36	3.4	100	3.4	5.6

(b) New protected area (14 years ago)

Plant Species	No.	D	F	A	I.V.I
Acacia spp.	S1	3.2	80	4.0	4.6
Aizoon canariense	S2	105.6	100	105.6	36.6
Argemone mexicana	S3	19.8	60	33.0	10.5
Arnebia hispidissima	S4	65.6	100	65.6	24.4
Bassia muricata	S5	47.6	100	47.6	18.9
Boerhavia sp.	S6	1.6	20	8.0	2.2
Calotropis procera	S7	0.4	40	1.0	1.9
Senna italica	S8	1	60	1.7	3.0
Chenopodium sp.	S9	5.2	20	26.0	5.3
Commicarpus sp.	S10	1.4	40	3.5	2.5
Cyperus conglomeratus	S11	9.4	80	11.8	6.7
Dipcadi viride	S12	0.2	20	1.0	1.0
Echinops spinosissimus	S13	11	40	27.5	7.4
Echinocloa colonum	S14	12.6	80	15.8	7.8
Eremobium aegyptiacum	S15	5.6	100	5.6	6.1
Erodium sp.	S16	0.6	20	3.0	1.4
Fagonia sp.	S17	31.8	100	31.8	14.1
Forsskaolea tenacissma	S18	12.8	60	21.3	7.7
Gisekia pharnaceoides	S19	79.2	100	79.2	28.5
Ifloga spicata	S20	12.8	100	12.8	8.3
Indigofera spinosa	S21	30.8	100	30.8	13.8
Launaea sp.	S22	40.2	100	40.2	16.6
Lycium shawii	S23	7	80	8.8	5.9
Malva parviflora	S24	0.2	20	1.0	1.0
Monsonia nivea	S25	1	40	2.5	2.3
Morettia sp.	S26	0.6	20	3.0	1.4
Pancratium maximum	S27	2.6	80	3.3	4.4
Plantago sp.	S28	2.4	40	6.0	3.0
Polycarpaea sp.	S29	5.2	40	13.0	4.4
Portulaca oleracea	S30	0.2	20	1.0	1.0
Reichardia tingitana	S31	0.6	40	1.5	2.1
Salsola sp.	S32	4.2	100	4.2	5.6
Salvia aegyptiaca	S33	1.6	60	2.7	3.2
Scorzonera tortuosissima	S34	2.8	60	4.7	3.7
Stipagrostis sp.	S35	40.4	100	40.4	16.7
Tribulus sp.	S36	32	60	53.3	15.3
Withania somnifera	S37	0.2	20	1.0	1.0

(c) Free grazing area

Plant Species	No.	D	F	A	I.V.I
Aizoon canariense	S1	22.6	80	344.0	15.9
Argemone mexicana	S2	84.4	100	275.2	39.3
Arnebia hispidissima	S3	24.4	100	275.2	17.5
Bassia muricata	S4	7	60	458.7	9.6
Cyperus conglomeratus	S5	2.6	40	688.0	8.2
Emex spinosa	S6	3.6	40	688.0	8.6
Eremobium aegyptiacum	S7	0.2	20	1376.0	10.6
Erodium sp.	S8	3.2	20	1376.0	11.7
Fagonia sp.	S9	3.6	40	688.0	8.6
Gisekia pharnaceoides	S10	15.2	100	275.2	14.1
Ifloga spicata	S11	15.4	100	275.2	14.2
Indigofera spinosa	S12	35	60	458.7	19.8
Launaea sp.	S13	5.4	80	344.0	9.7
Lycium shawii	S14	0.6	40	688.0	7.5
Malva parviflora	S15	1	20	1376.0	10.9
Monsonia nivea	S16	10.6	80	344.0	11.5
Pancratium maximum	S17	0.6	40	688.0	7.5
Plantago sp.	S18	9	80	344.0	11.0
Polycarpaea sp.	S19	10.8	60	458.7	11.0
Reichardia tingitana	S20	0.8	20	1376.0	10.8
Salvia aegyptiaca	S21	7.8	100	275.2	11.4
Scorzonera tortuosissima	S22	1.6	20	1376.0	11.1
Stipagrostis sp.	S23	4.2	100	275.2	10.1
Tribulus sp.	S24	5.6	80	344.0	9.7

Table III. Absolute density (number per 100 m^2) and relative denisty (%) of the common specis in old, new protected areas and free grazing area (un-protected) in Taif Governorate, Saudi Arabia

Species	Old protected area					New protected area					Old and new protected area		
	Absolute density			Relative density		Absolute density			Relative density		Absolute density		
	Inside	Outside	P	Inside	Outside	Inside	Outside	P	Inside	Outside	Old	New	P
Aizoon canariense	18.4	22.6	0.668	5.12	11.12	105.6	22.6	0.12	20.15	11.12	18.4	105.6	0.033
Arnebia hispidissima	115	24.4	0.013	32.02	12.00	65.6	24.4	0.06	12.52	12.00	115	65.6	0.381
Bassia muricata	0.2	7	0.079	0.06	3.44	47.4	7	0.038	9.05	3.44	0.2	47.4	0.385
Cyperus conglomeratous	2.6	2.6	NS	0.72	1.28	9.4	2.6	0.074	1.79	1.28	2.6	9.4	0.389
Eremobium aegyptiacum	4.8	0.2	0.206	1.34	0.10	5.6	0.2	0.084	1.07	0.10	4.8	5.6	0.725
Erodium sp.	7.2	3.2	0.378	2.00	1.57	0.6	3.2	0.448	0.11	1.57	7.2	0.6	0.001
Fagonia sp.	19	3.6	0.064	5.29	1.77	31.8	3.6	0.009	6.07	1.77	19	31.8	0.564
Gisekia pharnaceoides	8	15.2	0.094	2.23	7.48	79.2	15.2	0.035	15.11	7.48	8	79.2	0.003
Ifloga spicata	27.2	15.4	0.029	7.57	7.58	12.8	15.4	0.555	2.44	7.58	27.2	12.8	0.379
Indigofera spinosa	38.6	35	0.826	10.75	17.22	30.8	35	0.82	5.88	17.22	38.6	30.8	0.272
Launaea sp.	20.4	6.6	0.064	5.68	3.25	39.2	6.6	0.016	7.48	3.25	20.4	39.2	0.381
Lycium shawii	8.2	1.5	0.386	2.28	0.74	7	1.5	0.242	1.34	0.74	8.2	7	0.482
Monsonia nivea	5.6	13.25	0.06	1.56	6.52	1	13.25	0.003	0.19	6.52	5.6	1	0.011
Pancratium maximum	4.4	1.5	0.108	1.22	0.74	2.6	1.5	0.516	0.50	0.74	4.4	2.6	NS
Plantago sp.	10.4	11.25	0.894	2.90	5.53	2.4	11.25	0.061	0.46	5.53	10.4	2.4	0.203
Polycarpaea sp.	15.8	18	0.775	4.40	8.85	5.2	18	0.108	0.99	8.85	15.8	5.2	0.977
Salvia aegyptiaca	2.8	7.8	0.017	0.78	3.84	1.6	7.8	0.002	0.31	3.84	2.8	1.6	0.1
Scorozonera tortuosissima	2.6	3	0.361	0.72	1.48	2.8	3	0.107	0.53	1.48	2.6	2.8	0.278
Stipagrostis sp.	37.2	4.2	0.0001	10.36	2.07	41.4	4.2	0.001	7.90	2.07	37.2	41.4	0.131
Tiibulus sp.	10.8	7	0.514	3.01	3.44	32	7	0.174	6.11	3.44	10.8	32	0.045

spicata (I.V.I of 14.2 & F. value 100%). Table II revealed also that both of NWRC (old protected) and extension (new protected) had nearly the same number of species, while free grazing area attains a lower number of plant species (24 plant species).

The percentage of similarities in floristic composition among NWRC and extension on one hand and free grazing species on the other hand showed the influence of grazing pressure. NWRC and extension were the most similar (82.2%), while NWRC and free grazing area were the least similar (66.7%). Of 20 species of common occurrence in old and new and free grazing areas, 11 species attained higher species density inside the old protected, while 8 species had higher density outside free grazing area. 12 species had higher species density in the new protected area compared with 8 species only in free grazing area (Table III). *Stipagrostis* sp. dominated in both old and new protected areas. Table III showed also that the absolute densities of five out of 20 overlapping species differed significantly between old and new protected areas. Three species (*Tribulus* sp., *Gisekia pharnaceoides* & *Aizoon canariense*) attained higher density in the new compared with the old protected area, while the reverse was true for the other two species (*Monsonia nivea* & *Erodium* sp.).

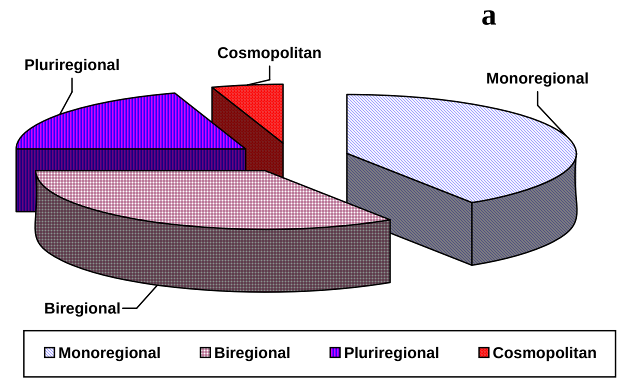
On comparing the old and new protected areas, the vegetation inside the new protected area had higher species richness, number of total species and species turn-over. On the other hand, the old and new protected areas had higher number of total species and species turn-over on comparing with outside of those areas (Table IV).

Fig. 4 revealed that the maximum total standing crop biomass was recorded inside new protected area (71.2%). This was about 1.8 times as high as that recorded in free grazing area (40%), while in old protected area attained a value of 59% (1.5 times as high as that recorded in free grazing area).

The application of CCA to the plant species and their edaphic variables in the three different localities indicated that the plant species is controlled in their distribution by ten soil parameters. Fig. 5 showed that each soil variable is represented by a vector, the longest showing the highest variation within the dataset. The correlation between variables is revealed by the angle between vectors, an acute angle: positive correlation; an obtuse angle: negative correlation. The soil variables are Ca^{2+}: calcium; Mg^{+}: magnesium; K^{+}: potassium; Na^{+}: sodium; HCO_3^-: bicarbonate; $CaCO_3$: calcium carbonate; Cl^-: chloride; $SO4^{2-}$: sulphate; O.M: organic matter; pH: soil pH and EC: soil electrical conductivity. The plant species are shown as triangular; a subset is listed in Table II.

Soil variables with the longest arrow relative to an axis have the greatest effect in constraining that axis. If the arrows of two variables subtend a small angle they are closely correlated; if they subtend an angle of > 90 they are negatively correlated. Thus, correlation between any two vectors is judged from the angle between them.

Fig. 3. Proportional percentage of phytochorological criteria (a) and life forms (b) of the vegetation of the study area



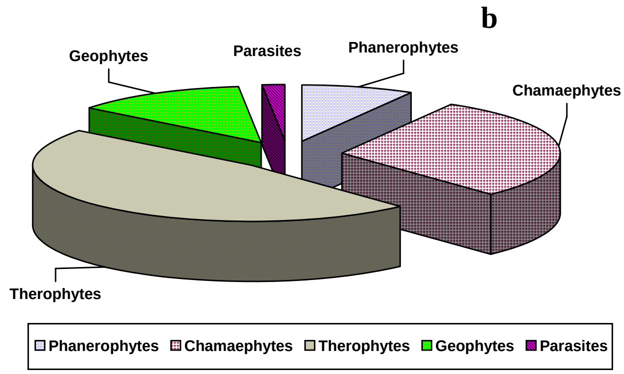


Fig. 4. Means (with ± SE) of above ground standing crop phytomass percentage of old, new protected areas and free grazing area (unprotected) in Taif Governorate, Saudi Arabia

Fig. 5a reveals that the effect of Na^+ was relatively dependent on Cl^- and of opposite effect to O.M, pH, HCO_3^-. Also, $CaCO_3$ having an opposite effect to SO_4^{2-}. Species clearly responsive to EC, Mg^{2+} and HCO_3^- are *Ifloga spicata* (S16), *Medicago laciniata* (S20), *Lycium shawii* (S19) and *Eremobium aegyptiacum* (S10), while *Fagonia* sp. (S12),

Table IV. Values of vegetation attributes of the common species in old, new protected and free grazing (unprotected) areas in Taif Governorate, Saudia Arabia. RID = The relative change (increase or decrease) in richness, turn-over

Vegetation variables	Old protected area			New protected area			Old and new protected areas		
	Inside	Outside	RID	Inside	Outside	RID	Old	New	RID
Total Species	36	24	0.5	37	24	0.54	36	37	0.03
Species richness (species per stand)	9.5	11.5	-0.17	16.2	11.5	0.41	9.5	16.2	0.71
Species turn-over	35.8	23.9	0.5	37	23.9	0.55	35.8	37	0.03

Trigonella stellata (S36), *Salvia aegyptiaca* (S31), *Tribulus* sp. (S35) and *Dipcadia viride* (S7) responded mainly to Na^+ and Ca^{2+}.

On the other hand, in the new protected area (Fig. 5b), the effect of HCO_3^-, SO_4^{2-}, EC, Mg^{++} and to a lesser extent for Na^+, Ca^{2+} and Cl^- were relatively dependent on each other. *Argemone mexicana* (S3), *Pancratium maximum* (S27), *Plantago* sp. (S28) and *Malva parviflora* (S24) are strictly responsive to $CaCO_3$, while *Stipagrostis* sp. (S35) and *Reichardia tingitana* (S31) responded to O.M and pH.

In free grazing area (Fig. 5c), the effect of pH was nearly orthogonal, while relatively independent on EC and Na^+ and to a lesser extent on SO_4^{2-}, Ca^{2+} and Mg^{2+}. On the same context, K^+ gives an opposite effect to Cl^-. *Tribulus* sp. (S24), *Bassia muricata* (S4) and *Argemone mexicana* (S2) responsive to K^+ and O.M, which are closely dependent.

Comparing the three different habitats, the vegetation inside the newly protected area had the highest number of total species, species richness and species turn-over. Species richness in old protected area, however, was higher outside the area compared with its inside (Table IV).

DISCUSION

Vegetation had been destroyed due to advancing and combating desertification, which are among causes of starvation or food medicinal depletion in many countries, has become one of the major challenges for securing food production for the hungry people of the world, especially in arid and semi-arid regions.

The sandy soils of the study reserves support a xerophytic vegetation formed of nearly forty percent of woody species (chaemophytes & phanerophytes constitute 38%). The results presented here suggest that the distribution of different life forms chiefly depends on soil properties and on the climatic factors of the study area. These results were in accordance with those of Yair *et al*. (1980) and Olsvig-Whittaker *et al*. (1983) in the Negev Desert, which demonstrated that surface properties of rock and soil are the main factors controlling the spatial distribution of soil moisture. Ayyad *et al*. (2000) also suggested a significant relation between species richness and the proportion of gravel in Saint Catherine area of Southern Sinai. In this context, the behavior of plant species (flora) belonging to different life forms and bio-diversity of the vegetation especially in reserve area deserves more attention in future studies.

The decrease of diversity of plant species in the free grazing area may be due to heavy grazing, wood fuel cutting and/or trample by 4 x 4 cars of Bedouins incessantly over the young twigs of plant species. This is undoubtedly irreplaceable and is being subjected daily to rapid deterioration. On the contrary, the relatively high diversity in the extension may be due to semi grazing effect. In this context, many authors reported that there is a highly curvilinear relationship between trampling intensity and vegetation response till a certain limit (Bell & Bliss, 1973; Hylgaard & Liddle, 1981; Kuss & Hall, 1991). Once trampling intensities exceed the thresholds, damage occurs and increases as trampling increases.

Vegetation can tolerate a certain amount of trampling, as long as trampling intensities do not exceed threshold level. Managers could maintain trampling impacts at negligible levels by keeping the trampling intensities below these thresholds. The dominance of *Stipagrostis* sp. in both old and new protected areas compared with the free grazing area coincided with the results obtained by El-Keblawy (2003), who studied the effects of protection from grazing in two regions of Abu Dhabi (UAE).

Table I showed that leaves and soft branches of *Acacia* spp. (Mimosaceae) are eaten (browsed) mainly by Gazella. These plants provide high quality animal feed, fuel wood, charcoal, gums and other products as well as contributing to soil stabilization and improvement through nitrogen fixation. These results in contrary with Mosallam and Hassan (2001) that found *Acacia* is eaten by other animals and Houbara at Mahazat as-sayed reserve. In this respect, Carlisle and Ghobrial (1968) found that pods and leaves of *A. tortilis* were sufficiently nutritious to satisfy all the water and food requirements for the Dorcas Gazelle in the Sudan throughout the dry season and for the Dama gazelle in northern Niger (Grettenberger & Newby, 1986). Mwalyosi (1987) stated that *Acacia tortilis* provides browse for many mammals.

According to Barkham and Rainy (1976), *Acacia* spp. have a dense mat of roots close to the soil surface, which rapidly utilizes any precipitation and hence rapidly "greens up" in response to even small amounts of rain. In seasons of low rainfall following those of relatively high rainfall, *Acacia* is able to draw on residual subsoil moisture efficiently than the grasses and produce abundant leaves, whereas grass growth may be poor (Brady *et al*., 1989).

Thorns do not prevent giraffe browsing in the Serengeti plains, but they slow down feeding so that below a critical level it becomes un-economic to seek the shoots between the spines of species such as *A. tortilis*. When thorns had been removed, increased herb ivory was noticed among free-ranging giraffe (Milewski *et al*., 1991). In spite of this, impala (*Aepyceros melampus* Lichlenstein) and rhinoceros (*Diceros bicornis* L.) browse on young *Acacia* of less than 1 m in height, but damage due to these animals is usually light and replaceable by growth (Vesey-Fitzgerald, 1973). In the present study, the dependence of gazelle on *Acacia* may be due to the adaptive anatomical and morphological feature of gazelle mouth.

The increase in numbers of plant species in both NWRC and extension may be referred to fertility of soil. These results coincided with that obtained by Chaneton and Lavado (1996), who concluded that total nutrient transfers to soil from decomposing dead roots and litter were larger in protected than in grazed grassland.

The vegetational composition of the studied area changed continuously since 1986 to 1992 as new plant species emerged that had better chances of survival under partial protection in extension (Table II). However, Benjamin *et al*. (1995) find that *Atriplex* species and *Cassia sturtii* recovered better after browsing. Also Zahran and Younes (1990) observed that the vegetation inside the reserves in general, is relatively richer than outside in Hijaz mountainous region of Saudi Arabia.

It is noticed from Table I and Fig. 3 that the flora of the opened area comprises 71% therophytes, 13% geophytes and 17% chaemophytes. The high percentage of therophytes indicated that there is no opportunity to flush and set phanerophytes and to a lesser extent chaemophyte due to overgrazing. These findings correspond with Floret (1981), who found that seven years of protection of steppic vegetation in the Mediterranean arid zone of southern Tunisia have caused an increase in cover of perennial species. Grazing also caused changes in species composition in southwestern Arizona (Smith & Schmutz, 1975), decreased cover of perennials in the Mohave Desert and lowered productivity in the semi-arid regions of Afghanistan (Hassanyar & Amir, 1977).

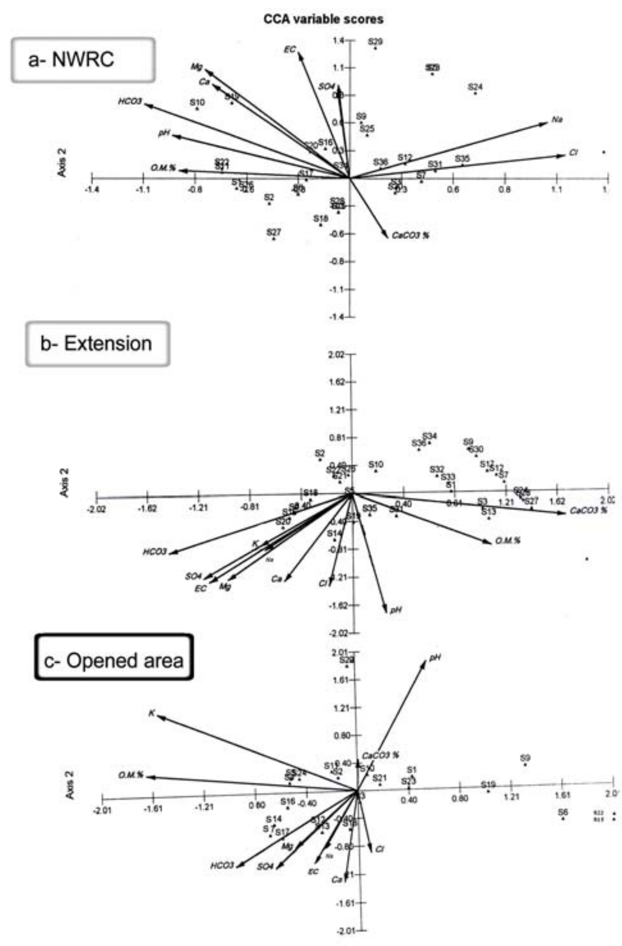
Chorological analysis of the floristic data revealed that tropical chorotype (16% & 39% mono-regional) forms the major component of the floristic structure in the two reserves. Mono-regional tropical chorotype was highly represented than the inter-regional chorotypes (bi- & pluri-regionals) in the present study, which is in accordance with the fact that plants of Saharo-Arabian species are good indicators for desert environmental conditions (Abd El-Ghani & Amer, 2003). Irano-Turanian chorotype was the least representative followed by Mediterranean type. These un-expected results may be due to the elevation and/or the longevity in protection of the study area.

The index of similarity between NWRC and opened area is lower (66.7%) when compared with that between extension and opened area (75.4%). This may be due to the fact that NWRC reserved since 1986 (long period), while extension reserved since 1992 (slightly short period).

The organic matter was relatively higher in the soils of the grazed flats when compared with that in the soils of the protected flats (Fig. 5). These conclusions agree with those of Ayyad and El-Kadi (1982) in the Mediterranean desert of Egypt. The improvement of soil nitrogen content of the grazed habitats can be attributed to the fact that the passage of herbage through the guts and out as feces speeds the nitrogen cycle. Moreover, the amount of organic matter in these habitats might be increased as a result of trampling and lying of standing dead materials by grazing animals.

Continuous observations of the animals by rangers inside NWRC to see, which plant species they ate were in accordance with the results obtained by Mosallam and Hassan (2001) at Mahazat as-Sayed protectorate, Taif, Saudi Arabia. The production of the protected areas in NWRC and extension was much higher than the adjacent un-protected area and these results coincided with that

Fig. 5. Canonical correspondence analysis (CCA) plot with environmental variables represented by arrows and species, for (a) Old protected; (b) New protected and (c) Free grazing area. For full species names, see Table 1. (S = refers to species)



obtained by Abu-Irmaileh, (1994).

Floristic changes induced by grazing frequently involve the replacement of palatable plants by un-palatable plants in the opened area. This conclusion coincided clearly with the dominance of *Argemone mexicana* (indicator of extensive grazing) in the opened area. It is hypothesized that selective defoliation of palatable species allows un-palatable species to realize a competitive advantage. In this respect, Noy-Meir *et al*. (1995) reveals that, under long-term intensive grazing the shift in species composition frequently involves the replacement of palatable plants by un-palatable plants (or) woody perennials.

The maximum yield was attained in the present study, in new protected area (semi-grazed) followed by old protected one and the least yield attained in free grazing area. This indicates that continuous overgrazing and continuous protection both have deleterious effects on vegetation. Protection leads to an initial increase in the density of vegetation and deprives the ecosystem from the deposition of dung and urine of grazing animals. Light nibbling and removal of standing dead shoots by grazing animals usually promotes vigor and growth of defoliated plants (Pearson, 1965). The passage of herbage through the guts and out as faeces speeds the nitrogen cycle and consequently grazed pastures are richer in nitrogen than un-grazed ones. A similar results obtained by Shaltout and El-Ghareeb (1985) of the Western Mediterranean desert of Egypt.

Due to the obvious overstocking of animals within the reserve, important consideration should be given to one or more of the following: (a) limiting animal numbers absolutely, to levels determined by the estimated carrying capacity of the reserve: (b) limiting their numbers/access seasonally during sensitive periods e.g., during the spring flush, flowering and seeding of plants.

Acknowledgement. All the materials and the experiments are the properties of the National Wildlife Research Center (NWRC) in Taif and of the National Commission for Wildlife Conservation and Development (NCWCD), Ryadh, Kingdom of Saudi Arabia, which are deeply acknowledge. The author is grateful to Sheila Collenette (author of Wildflowers of Saudi Arabia) for her confirming the identification of plant species. He thanks Prof. K. Shaltout (Prof. of Plant Ecology) for useful comments and suggestions on an earlier draft.

REFERENCES

Abd El-Ghani, M.M., 1996. Vegetation along a transect in the Hijaz mountains (Saudi Arabia). *J. Arid Environ*., 32: 289–304

Abd El-Ghani, M.M. and W.M. Amer, 2003. Soil-vegetation relationships in a coastal desert plain of Southern Sinai, Egypt. *J. Arid Environ*., 55: 607–28

Abu-Irmaileh, B.E., 1994. Al-Mowaqqar, a model for arid rangelands in Jordan: botanical composition and productivity. *J. Arid Environ*., 28: 155–62

Allen, S.E., H.M. Grimshaw, J.A. Parkinson, C. Quarmby and J.D. Roberts, 1974. *Chemical Analysis of Ecological Materials,* P: 565. Blackwell Science Publication Osney, Oxford, London

Archer, S., 1989. Have southern Texas savannas been converted to woodlands in recent history? *American Nat*., 134: 545–61

Ayyad, M.A.,1978. A preliminary assessment of the effect of protection on the vegetation of the Mediterranean desert ecosystem. *Taeckholmia,* 9: 85–101

Ayyad, M.A. and H.F. El-Kadi, 1982. Effect of protection on the vegetation of a Mediterranean desert ecosystem in northern Egypt. *Vegetatio*, 49: 129–39

Ayyad, M., A. Fakhry and A. Moustafa, 2000. Plant biodiversity in the Saint Catherine area of the Sinai Peninsula, Egypt. *Biodiv. Conserv*., 9: 265–81

Barkham, J.P. and M.E. Rainy, 1976. The vegetation of the Samburu – Isiolo Game Reserve. *East African Wild J*., 14: 297–329

Batanouny, K.H., 1979. Vegetation along the Jeddah- Mecca road: Pattern and process as affected by human impact. *J. Arid Environ*., 2: 21–30

Bell, K.L. and L.C. Bliss, 1973. Alpine disturbance studies: Olympic National Park, USA. *Biol. Conserv*., 5: 25–32

Benjamin, R.W., Y. Lavie, M. Forti, D. Barkai, R. Yonatan and Y. Hefetez, 1995. Annual re-growth and edible biomass of two species of *Atriplex* and *Cassia sturtii* after browsing. *J. Arid Environ.*, 29: 63–84

Brady, W.W., M.R. Stromberg, E.F. Aldon, C.D. Bonham and S.H. Henry, 1989. Response of semi-desert grassland to 16 years of rest from grazing. *J. Range Manage*., 42: 284–8

Carlisle, D.B. and L.I. Ghobrial, 1968. Food and water requirements of *Dorcas gazelle* in the Sudan. *Mammalia,* 23: 570–6

Chaneton, E.J. and R.S. Lavado, 1996. Soil nutrients and salinity after long-term grazing exclusion in a Flooding Pampa grassland. *J. Range Manage*., 49: 182–7

Chaudhary, S.A., 1989. ''*Grasses of Saudi Arabia*'', P: 465. National Agriculture and Water Research Center, Riyadh

Chaudhary, S.A. and A.A. Al-Jowaid, 1999. *In* "*Vegetation of the Kingdom of Saudi Arabia*" (NAWRC), Ministry of Agriculture and water, Riyadh, Saudi Arabia

Collenette, S., 1985. *An Illustrated Guide to the Flowers of Saudi Arabia*. Scorpion Publication LTD. London

Collentette, S., 1999. *In* ''*Wild Flowers of Saudi Arabia*''. NCWCD (National commission for Wildlife Conservation and Development, Publication), Saudi Arabia

El-Demerdash, M.A., S.Z. Henidy and H.F. El-Kady, 1996. Vegetation and conservation measures in Ras Mohammed sector of the protected areas in Southern Sinai, Egypt. *J. Union Arab Biology 3rd International Conference (b)*

El-Demerdash, M.A., A.K. Hegazy and A.M. Zilay, 1994. Distribution of plant communities in Tihamah coastal plains of Jazan region, Saudi Arabia. *Vegetatio,* 112: 141–51

El-Gazzar, A., M.A. El-Demerdash, H.F. El-Kady and S. Henidey, 1995. *Plant Life in the Gulf of Aqaba Area (S. Sinai, Egypt)*. Final report submitted to the Department of Protectorates of the Egypt. Egypt Environ. Affairs Agency (EEAA), Cairo

El-Kelbawy, A.A., 2003. *Effects of Protection from Grazing on Species Diversity, Abundance and Productivity in Two Regions of Abu Dhabi*. 3rd Millennium, U.A.E

Feinbrun-Dothan, N.A., 1978. *Flora Palaestina (Part III).* Jerusalem. Isr. Acad. Sci. Human

Feinbrun-Dothan, N.A., 1986. *Flora Palaestina (Part IV)*. Jerusalem. Isr. Acad. Sci. Human

Floret, C., 1981. The effects of protection on steppic vegetation in the Mediterranean arid zone of Southern Tunisia. *Vegetatio,* 46: 117–29

Greig-Smith, P., 1957. *Quantitative Plant Ecology*. Butter worth, London

Greth, A. and G. Schwed, 1993. A brief history of the reintroduction of the Arabian oryx, *Oryx leucoryx* in Saudi Arabia. *Int. Zool Yb*., 32: 73–81

Grettenberger, J.F. and J.E. Newby, 1986. The status and ecology of the dama gazelle in the air and Tenere National Nature Reserve, Niger. *Biol. Conserve*., 38: 207–16

Halwagy, R., 1962. The incidence of biotic factors in northern Sudan. *Oikos*, 13: 97–117

Haque, M.N. and T.R. Smith, 1994. Re-introduction of red-necked ostriches in Saudi Arabia. *Re-introduction News*, 9: 5

Haque, M.N. and T.R. Smith, 1996. Re-introduction of Arabian sand gazelle, *Gazella subgutturosa marica* in Saudi Arabia. *Biol. Conserve*., 76: 203–6

Hassanyar and S. Amir, 1977. Restoration of arid and semiarid ecosystems in Afghanistan. *Environ. Conserve*., 4: 279–301

Hylgaard, T. and M.J. Liddle, 1981. The effect of human trampling on a sand dune ecosystem dominated by *Empetrum nigrum*. *J. Appl. Ecol*., 18: 559–69

Jackson, M.L., 1962. *Soil Chemical Analysis*, P: 498. Prentice-Hall of India Private Limited, New Delhi

Jackson, M.L., 1967. *Soil Chemical Analysis – Advanced Course*, P: 498. Washington Department of Soil Sciences

Jean, M. and A. Bouchard, 1993. Riverine wetland vegetation: importance of small-scale and large-scale environmental variation. *J. Veg. Sci*., 4: 609–20

Kassas, M., 1970. Desertification versus potential for recovery in circum-saharan territories, *In*: Dregyne, H. (ed.), *Arid Lands in Transition*, 13: 123–42. American Association for Advancement of Science, Washington D.C

Kuss, F.R. and C.N. Hall., 1991. Ground flora trampling studies: Five years after closure. *Environ. Manage*., 15: 715–27

Le Houerou, H.N. and C.H. Hoste, 1977. Rangeland production and annual rainfall relations in the Mediterranean Basin and in the African Sahelo-Sudanian zone. *J. Range Manage*., 30: 181–9

Ludwing, J.A. and J.F. Reynolds, 1988. *Statistical Ecology*, P: 337. A Primer on Methods and Computing. John Wiley and Sons, New York

Migahid, A.M., 1978. *In:* ‘‘*Flora of Saudi Arabia*’’, 2nd ed. Riyadh, Saudi Arabia

Milchunas, D.G. and W.K. Lauenroth, 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. *Ecological Monographs*, 63: 327–66

Milewski, A.V., T.P. Young and D. Madden, 1991. Thorns as induced defenses: experimental evidence. *Oecologia*, 86: 70–5

Milton, S.J., W.R.J. Dean, M.A. Du Plessis and W.R. Siegfried, 1994. A conceptual model of arid rangeland degradation. *Bio-Sci*., 44: 70–6

Mosallam, H.A. and S.A. Hassan, 2001. On the ecology and range potential of plants growing at Mahazat as-Sayed reserve area, Taif, Saudi Arabia. *Desert Inst. Bull. (Egypt)*, 51: 395–422

Mwalyosi, R.B.B., 1987. Decline of *Acacia tortilis* in Lake Manyara National Park. *African Wild Life J.*, 14: 285–95

Noy-Meir, I., 1995. Interactive effects of fire and grazing on structure and diversity of Mediterranean grasslands. *J. Veg. Sci*., 6: 701–10

Noy-Meir, I.M. Gutman and Y. Kaplan, 1989. Responses of Mediterranean grassland plants to grazing and protection. *Ecol*., 77: 290–310

Olsvig-Whittaker, L., M. Shachak and A. Yair, 1983. Vegetation patterns related to environmental factors in Negev Desert watershed. *Vegetatio*, 54: 153–65

Pearson, L.C., 1965. Primary production in grazed and un-grazed desert communities of Eastern Idaho. *Ecol*., 46: 278–86

Shatout, K.H., E.F. El-Halawany and H.F. El-Kady, 1996. Consequences of protection from grazing on diversity and abundance of the coastal lowland vegetation in Eastern Saudi Arabia. *Biodivers. Conserv*., 5: 27–36

Shaltout, K.H. and R. El-Ghareeb, 1985. Effect of protection on the phytomass and primary production of ecosystems of the western Mediterranean desert of Egypt. I. Ecosystem of non-saline depressions. *Bull. Fac. Sci. Alexandria University*, 25: 109–31

Smith, A. David, and E.M. Schmutz, 1975. Vegetative changes on protected versus grazed desert grassland ranges in Arizona. *J. Range Manage*., 28: 453–8

Sørenson, T., 1948. A method of establishing groups of equal amplititude in plant sociology based on similarity of species content. *Det. Kong. Danske Vidensk. Biol. Skr. (Copenhagen)*, 5: 1–34

Ter Braak, C.J.F., 1988. *CANOCO-A FORTRAN Program for Canonical Community Ordination by [Partial] [Detrended] [Canonical] Correspondence Analysis and Redundancy Analysis (Ver.2.1)*. TNO Institute of Applied Computer Science, Wageningen

Vesey-Fitzgerald, D., 1973. *East African Grasslands*. East African Publishing House. Nairobi, Kenya

Vincett and Betty A. Lipscombe, 1977. *Wild Flowers of Middle Area, Saudi Arabia*. Tipostile S.R.L, COMPOS-Milan, 1977

Westoby, M., B. Walker and I. Noy-Meir, 1989. Opportunistic management for rangelands not at equilibrium. *J. Range Manage*., 42: 206–74

Yair, A., D. Sharon and H. Lavee, 1980. Trends in runoff and erosion processes over an arid limestone hillside, North Negev, Israel. *Hydrological Sci. Bull.*, 25: 243–55

Zahran, M.A. and H.A. Younes, 1990. Hema system: traditional conservation of plant life in Saudi Arabia. *J. King Abdulaziz University Sci*., 2: 19–41

Zohary, M., 1987. *Flora Palaestina (Part II)*. Jerusalem. Isr. Acad. Sci. Human

(Received 08 November 2006; Accepted 20 January 2007)