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Ecological Characteristics of Plants of Harboi Rangeland, Kalat, Pakistan

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Abstract: The floristic composition, ecological characteristics and ethnoecology of plants of Harboi rangeland (Kalat, Pakistan) were done during 1997 to 1999. There were 202 species that belonged to 45 plant families. Asteraceae, Papilionaceae, Poaceae, Brassicaceae and Lamiaceae were the leading families. *Juniperus macropoda* was the only tree species while *Artemesia maritima*, *Sophora griffithii*, *Hertia intermedia*, *Nepeta juncea*, *Perovskia abrotanoides*, *Convolvulus leiocalycinus* and *Astragalus* spp. were the most common shrubs. The dominant life forms were therophyte and hemicryptophyte while nanophylls, microphylls and leptophylls were dominant leaf sizes. The growing season lasts from March to November with two flowering periods. Most, i.e. 83.6% plants flowered during April to June while 63.3% plants bloomed during July to September. Some 145 species had various local uses. They included 129 fodder species, 50 medicinal species, 12 vegetable/fruits species, 7 fuel wood species, 3 species each were used for roof thatching and making herbal tea. Deforestation, over grazing and over collection of medicinal and fuel wood species have led to the degradation of this rangeland. There is need to conserve these resources with the participation of local communities.

Key words: Pakistan; Harboi Rangeland; Ecological characteristics
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The Harboi rangeland, Kalat, Pakistan, covers an area of 22 351 hectares and it lies between 29°N and 66°45' to 67°E. It was declared as Protected Forest since January 1967 (Fig.1). The study area has rugged mountainous limestone and conglomerates with many small valleys and dry ravines. The altitude varies from 2 900 to 3 300 m. The area is under heavy grazing and human pressure due to lopping and uprooting of plants for fuel, forage and medicinal purposes.

The climate is of dry temperate type. The nearest meteorological station locates at Kalat which is 30 km away from the research site. Short summer lasts from May to September. The mean temperature of the hottest months, June and July, rises to over 30℃ with maximum temperature up to 35℃ at Kalat. Winter is long and cold lasting from October to April. The coldest month, January, has a mean monthly temperature of -4℃ that may drop to as low as -16℃. The cold spell is quite severe with chilling winds. Wind speed varies from 1.88 to 3 m s^{-1}. The mean annual air pressure is 1 516 MPa that varies from low during May (1 443 MPa) to high (1 564 Mpa) in September. The mean annual relative humidity is 44% with lowest (33%) during July and highest (60%) in January. The mean value of clouds is 1.87 OKTS. The highest cloud (28 OKTS) occur in March and least in September (0.62 OKTS). The mean dew point temperature varies from -5℃ (January) to 9℃ (July). The mean annual rainfall is 28.5 mm that varies from 2.4 mm (September) to 125 mm (December). Evapo-transpiration is higher than rainfall that causes aridity. The precipitation is mostly received during winter from western depression. The area receives regular snowfall during winter.

Various workers did sporadic collections of plants from different parts of Balochistan including Harboi range[1-3]. Khattak[4], Kazmi[5] and Zaman et al.[6,7] worked on various species of *Ephedra* and *Juniperus* found in these hills. Rafi[8] and Durrani et al.[9] stated

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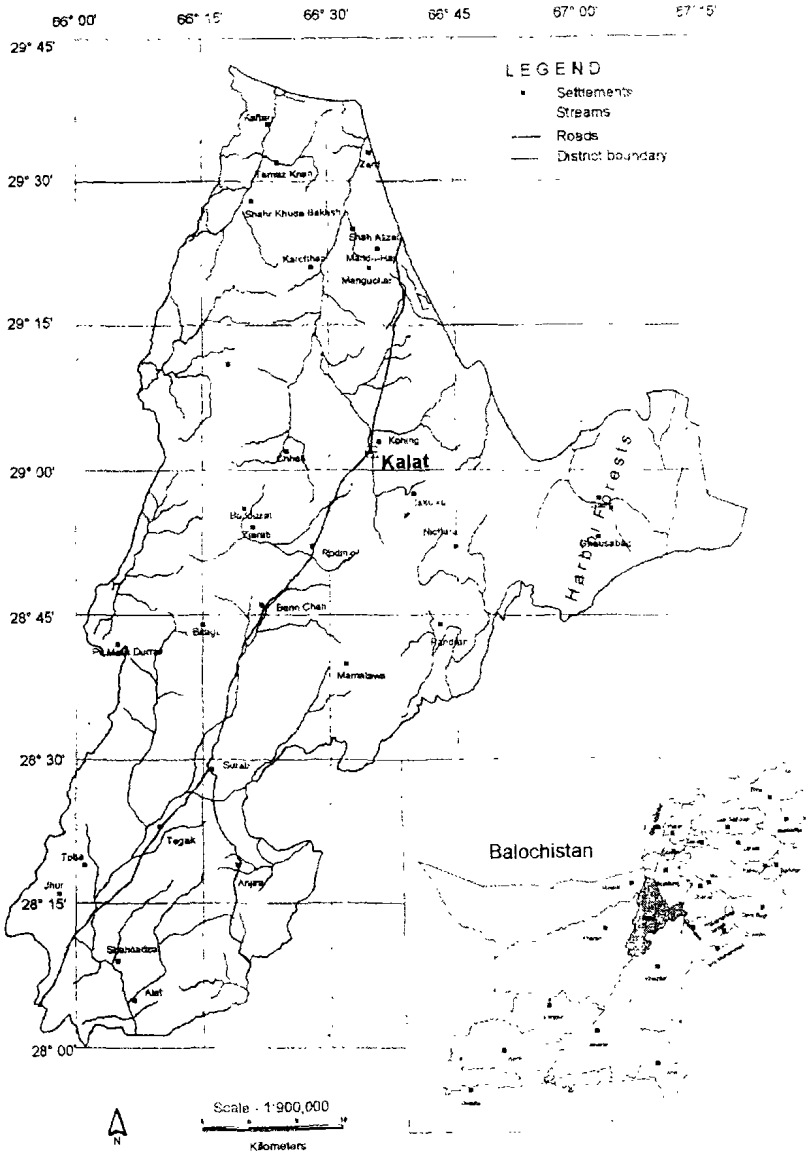

Fig. 1 Map of Kalat showing research area

that deforestation, overgrazing and over collection of plants by local peoples has deteriorated the vegetation of this area. No other reference on the flora and vegetation of this area is available. The present paper, therefore, reports the floristic composition, its ecological characteristics and local uses of plants from this rangeland.

1 Materials and Methods

1.1 Floristic composition

Plant collection was done every month for 3 consecutive years from 1996 to 1998. They were identified with the help of available literature[10,11]. The identification was later on confirmed at various herbaria of Pakistan. Thus, a complete floristic list along with families was compiled.

1.2 Life form and leaf size spectra

Plants were classified according to different life forms and leaf size classes following Raunkiaer[12].

1.3 Phenological behaviour

The phenological observations were recorded every month from 1996 to 1998 and plants were classified into following phenological stages: 1. V1= Pre-flowering stage (Vegetative or seedling stage), 2. RP= Reproductive stage (Flowering/fruiting stage), 3. V2= Post reproductive stage (Seeds or fruits matured/ dispersed), and 4. V3= Dormant stage (Annuals complete their life cycle and shed their seeds and die; deciduous perennials shed their leaves and perennate either by

leafless shoots or by underground parts, while evergreens cease their growth).

1.4 Classification of plants by their local uses

Plants were classified according to their known local uses on the basis of information gathered primarily from the inhabitants within the area and supplemented with field observations.

2 Results and Discussion

2.1 Floristic composition

There were 202 species that belonged to 35 dicot., 8 monocot. and 2 gymnosperm families (Table 1). Asteraceae (29 spp.), Poaceae (24 spp.), Brassicaceae, Papilionaceae (each with 17 spp.), Lamiaceae (15 spp.), and Boraginaceae (11 spp.) were the leading families. These families were followed by Chenopodiaceae (7 spp.), Euphorbiaceae, Ranunculaceae, Scrophulariaceae and Apiaceae (each with 6 spp.), Caryophyllaceae and Liliaceae (5 spp. each), Rosaceae (4 spp.) and Juncaceae (3 spp.). Each of the remaining 30 families had either one or two species. *Juniperus excelsa* (*J. macropoda*) was the only tree species in the area. Burkill[1] reported 42 species from this area but half of them remained uncollected during the present study. This might possibly be due to either the extermination of species owing to deforestation and over collection by the local people or Burkill might have also listed plants from other parts of Harboi range as the present study was confined to the Kalat portion (Sarawan) only. The present study showed that there were only 27 species (6 shrubs, 16 herbs, 5 grasses) common to the floristic list of Bolan as reported by Jafri[13]; while 25% floristic similarity was achieved with the flora of Quetta and Harnai as reported by Tareen & Qadir[14,15]. The poor floristic similarity of plants of this area with those of other parts of Balochistan probably was due to differences in climate and altitude[9,13-15]. The present flora had 12% similarity with those of nearby Iskalku range[9], which is open and highly degraded. Our findings agree with other workers[1,2,10,11,13-16] who also reported Asteraceae, Papilionaceae, Poaceae, Brassicaceae and Lamiaceae to be well represented in the Flora of Pakistan including Balochistan. *Pennisetum oreintale*, *Bromus tectorum* and *Bromus sericeus* were the most commonly distributed grasses. While *Poa bulbosa*, *Piptatherum vicarium*, *Stipa pinnata*, *Tetrapogon villsus*, *Cymbopogon jwarancusa*, *Melica persica*, *Aristida* spp., *Schismus arabicus* and *Phacelurus speciosus* had limited distribution in this area. However, they have been reported as common grasses from other regions with similar climate[14-17]. The study area is an extension of Iranian flora and vegetation as many plants were common to Flora Iranica. Cushion plants such as *Acantholimon munuroanum*, *Acantholimon polystachyum* and *Gaillonia eriatntha* were common due to adaptation to harsh habitat conditions including cold winters, hot summers with high evaporation, strong winds and intense grazing pressure. *Acantholimon* species are component of the cushion plant formation through out dry temperate and alpine vegetation of Pakistan and elsewhere[18]. Although, floristic composition is a qualitative character, yet a rich flora might mean high species diversity, gene pool and preliminary indicator of range productivity of the area.

The largest pure *Juniperus excelsa* forest spreads over Ziarat, Kalat and Loralai districts of Balochistan[19]. At present, the investigated part of Harboi range harbours pure *Juniperus excelsa* forest. However, Rafi[8] reported a mixed *Juniperus macropoda* - *Fraxinus xanthoxyloides* forest in the past. It was interesting to report that *Fraxinus xanthoxyloides* was not even recorded during the present study. Deforestation might have eliminated it from this habitat. The findings agree with Ahmed et al.[16,18] who also reported that deforestation has decreased many species including *Fraxinus xanthoxyloides* from similar pure Juniper forests from different parts of Balochistan. In protected areas of Ziarat, Ciesla et al.[19] reported mixed forest of *Juniperus polycarpos* - *Fraxinus xanthoxyloides*, whereas *Pinus gerardiana* associates with *Juniperus polycarpos* in the Babusar Valley, Diamer[20]. *Juniperus polycarpos* is associated with scattered individuals of *Pinus roxburghii* at lower altitude in similar climatic regions of Astore. In the past the rangeland was protected by the State rulers till its merger into settled districts of Pakistan in 1971. The area, therefore, became open to

Table 1 Floristic list of plants of hHarboi rangeland, Kalat

1. Amaranthaceae
   1 *Aerua javanica* (Burm.f) Juss.
2. Alliaceae
   2 *Allium dolichostylum* Vved.
   3 *Asparagus capitatus* Baker.
3. Apiaceae
   4 *Bupleurum exaltatum* Bieb.
   5 *Bupleurum linearifolium* DC.
   6 *Cuminum cyminum* L.
   7 *Ferula foetida* Regal.
   8 *Psammogeton* sp.
   9 *Seseli libanotis* (L.) Koch.
4. Asteraceae
   10 *Achillea santolina* L.
   11 *Artemisia maritima* L.
   12 *Artemisia tournefortiana* Reich.
   13 *Asteriscus pygmaeus* (DC.) Coss & Dur.
   14 *Conyza bonariensis* (L.) Cronguist.
   15 *Cousinia heterophyla* Boiss.
   16 *Cousinia onopordioides* Ledeb.
   17 *Cousinia* sp.
   18 *Crepis sancta* (L.) Babc.
   19 *Echinops echinatus* Roxb.
   20 *Gnaphalium luteoalbum* L.
   21 *Hertia intermedia* (Boiss.) O. Ktze.
   22 *Hetderoderis stocksiana* Boiss.
   23 *Lactuca auriculata* Wall. ex DC.
   24 *Lactuca orientalis* (Boiss.) Boiss.
   25 *Lactuca persica* Boiss.
   26 *Filago hurdwarica* (DC.) Wagenitz.
   27 *Pulicaria gnaphalodes* (Vent.) Boiss.
   28 *Sonchus maritimus* L.
   29 *Scorzonera laciniata* L.
   30 *Scorzonera tortuosissima* Boiss.
   31 *Scorzonera* sp.
   32 *Scrozonera mollis* M. Bieb.
   33 *Senico* sp.
   34 *Taraxacum officinale* Wigg.
   35 *Tragopogon gracilis* D. Don.
5. Berberidaceae
   36 *Berberis balochistanica* Ahrendt.
   37 *Berberis callibotrys* Aitch ex Koenne.
6. Boraginaceae
   38 *Heliotropium brahuicum* Stocks.
   39 *Lappula microcarpa* (Ledeb) Gurke.
   40 *Lappula sessiliflora* (Boiss.) Gurke.
   41 *Lappula spinocarpos* (Forssk.) Ascherson.
   42 *Lithospermum arvense* L.
   43 *Onasma dichroanhum* Boiss.
   44 *Onasma limitaneum* I. M. Johnton.
   45 *Mattiastrum asperum* (Stocks) Brand.
   46 *Nonnea caspica* (Willd) G. Don.
   47 *Nonnea kandaharensis* H. Riedl.
   48 *Trichodesma stocksii* Boiss.
7. Brassicaceae
   49 *Alyssum linifolium* Stapf ex Willd.
   50 *Alyssum marginatum* Steud ex Willd.
   51 *Alyssum szovitzianum* F & M.
   52 *Alyssum desertorum* Stafp.
   53 *Arabis saxicola* Edgew.
   54 *Conringia planisiliqua* Fiseh & Mey.
   55 *Coronopus didymus* (L.) Sm.
   56 *Descurainea sophia* (L.) Webb & Berth.
   57 *Drabopsis verna* C. Koch.
   58 *Farsetia heliophila* Bunge ex Coss.
   59 *Isatis emarginata* Kar & Kir.
   60 *Leptaleum filifolium* (Willd.) DC.
   61 *Malcolmia africana* (Linn.) R. Br.
   62 *Malcolmia* sp.
   63 *Malcolmia strigosa* Boiss.
   64 *Neslia apiculata* Fisch & Mey & Avelal.
   65 *Robeschia schimperi* (Boiss) O. E. S.
8. Capparifoliaceae
   66 *Lonicera hypaleuca* Dcne.
9. Caryophyllaceae
   67 *Holosteum umbellatum* L.
   68 *Gypsophila lignosa* Hemsl & Lace.
   69 *Minuartia meyeri* (Boiss.) Bornm.
   70 *Silene brahuica* Boiss.
   71 *Stellaria alsinoides* Boiss & Buhse.
   72 Unidentified 97-83
10. Chenopodiaceae
   73 *Chenopodium album* L.
   74 *Chenopodium botrys* L.
   75 *Chenopodium foliosum* (Moench) Ashers.
   76 *Chenopodium hybridum* L.
   77 *Haloxylon griffithii* (Moq.) Bunge ex Boiss.
   78 *Kochia stellaris* Moq.
   79 *Salsola kali* L.
11. Convolvulaceae
   80 *Convolvulus arvensis* L.
   81 *Convolvulus leiocalycinus* Boiss.
12. Cupressaceae
   82 *Juniperus excelsa* M. Bieb.
13. Cyperaceae
   83 *Carex* sp.1
   84 *Carex* sp.2
   85 *Cyperus* sp.
14. Dipsicaceae
   86 *Scabiosa oliveri* Coult.
15. Ebenaceae
   87 *Ebenus stellata* Boiss.
16. Ephedraceae
   88 *Ephedra intermedia* var *glauca* Schren K. Regel, Stapf.
17. Euphorbiaceae
   89 *Euphorbia caeladenia* Boiss.
   90 *Euphorbia falcata* L.
   91 *Euphorbia graulata* Forssk.
   92 *Euphorbia maddenii* Boiss.
   93 *Euphorbia multifurcata* Rech.
   94 *Euphorbia prostrata* Ait.
18. Fumariaceae
   95 *Fumaria indica* (Hausskn.) H. N.
19. Geraniaceae
   96 *Erodium cicutarium* (L.) L' Herit ex Ait.
20. Iridaceae
   97 *Iris* sp.
   98 *Iris tenuifolia* Pall.
21. Juncaceae
   99 *Juncus* sp.
   100 *Juncus articulatus* L.
   101 *Juncus infexus* L.
22. Juncaginaceae
   102 *Triglochin palustris* L.

23. Lamiaceae
- 103 *Eremostachys vicarys* Benth.
- 104 *Isodon rugosus* (Wall ex Bth) Codd.
- 105 *Lallementia royleana* (Bth.) Bth.
- 106 *Marrubium vulgare* L.
- 107 *Mentha longifolia* (L.) Huds.
- 108 *Nepta* sp.
- 109 *Nepeta juncea* Bth.
- 110 *Perovskia abrotanoides* Karel.
- 111 *Perovskia atriplicifolia* Bth.
- 112 *Salvia cabulica* Bth.
- 113 *Scutellaria stocksii* Boiss.
- 114 *Scutellaria* sp.
- 115 *Teucrium stocksianum* Boiss.
- 116 *Zizyphora clinopodioides* Lam.
- 117 *Zizyphora tenuior* L.

24. Leonticaceae
- 118 *Bongardia chrysogonum* (Linn) Spach.

25. Liliaceae
- 119 *Eremerus persicus* (Jaub & Spach) Boiss.
- 120 *Gagea pseudo-reticulata* Vved.
- 121 *Gagea* sp.
- 122 *Rhinapetalum karelinii* Fisch.
- 123 *Tulipa polychroma* Stapf.

26. Malvaceae
- 124 *Malva neglecta* Wallr.

27. Onagraceae
- 125 *Epilobium minutiflorum* Hausskn.

28. Orobanchaceae
- 126 *Orobanche cernua* Loeffl.

29. Papaveraceae
- 127 *Hypecoum pendulum* L.
- 128 *Papaver macrostomum* Boiss & Huet ex Boiss.

30. Papilionaceae
- 129 *Astragalus gompholobium* Bth. ex Bunge.
- 130 *Astragalus* 97 – 151
- 131 *Astragalus* 97 – 53
- 132 *Astragalus* 97 – 8
- 133 *Astragalus afghanus* Boiss.
- 134 *Astragalus anisacanthus* Boiss.
- 135 *Astragalus orthocarpus* Boiss.
- 136 *Astragalus psilocentros* Fisch.
- 137 *Astragalus purpurascens* Bunge.
- 138 *Astragalus subliformis* DC.
- 139 *Caragana ambigua* Stock
- 140 *Colutea armata* Hemsl. & Lace.
- 141 *Medicago lupulina* L.
- 142 *Medicago polymorpha* L.
- 143 *Onobrychis cornuta* (L.) Desv.
- 144 *Onobrychis dealbata* Stocks.
- 145 *Sophora griffithii* Stocks.

31. Plantaginaceae
- 146 *Plantago lanceolata* L.
- 147 *Plantago major* Aitch.

32. Plumbaginaceae
- 148 *Acantholimon munroanum* Aitch & Hemsl.
- 149 *Acantholimon polystachyum* Boiss.

33. Poaceae
- 150 *Aristida* sp.
- 151 *Aristida adscensionsis* L.
- 152 *Boissera squarrosa* (Soland) Nevski.
- 153 *Bothriochloa ischaemum* (L.) Keng.
- 154 *Bromus sericeus* Drobov.
- 155 *Bromus tectorum* L.
- 156 *Cymbopogon jwarancusa* (Jones) Schult.
- 157 *Phacelurus speciosus* (Steud.) C. E. Hubb.
- 158 *Eragrostis minor* Host.
- 159 *Festuca arundinacea* Schreb.
- 160 *Hordeum bogdannii* Wilensky.
- 161 *Melica persica* Kunth.
- 162 *Pennisetum orientale* L.
- 163 *Phalaris* sp.
- 164 *Piptatherum vicarium* Boiss.
- 165 *Poa bulbosa* Lu.
- 166 *Poa sinaica* Steud.
- 167 *Polypogon fugas* Nees ex Steud.
- 168 *Schismus arabicus* Nees.
- 169 *Stipa pinnata* L.
- 170 *Tetrapogon villosis* Desf.
- 171 *Vulpia ciliata* (Lam K. & DC) Link.
- 172 Unidentified grass # 97 – 108
- 173 Unidentified grass # 97 – 150

34. Polygalaceae
- 174 *Polygala hohenackeriana* Fisch & Meiy.
- 175 *Polygala sibirica* Linn.

35. Polygonaceae
- 176 *Polygonum aviculare* L.
- 177 *Polygonum paronychioides* C. A. Mey.

36. Primulaceae
- 178 *Androsace* sp.

37. Ranunculaceae
- 179 *Adonis aestivalis* L.
- 180 *Anemone tschernfaewii* Regal.
- 181 *Ceratocephalla falcatus* (L.) Pers.
- 182 *Ceratocephalla testiculata* (Crantz) Roth.
- 183 *Clematis graveolens* Lindll.
- 184 *Clematis orientalis* L.

38. Rosaceae
- 185 *Prunus* sp.
- 186 *Prunus eburnean* Aitch.
- 187 *Rosa lacerans* Boiss & Buhse.
- 188 *Spirea boissieri* Schneider.

39. Rubiaceae
- 189 *Gaillonia eriantha* Jaub & Spach.
- 190 *Galium asparine* L.

40. Scrophulariaceae
- 191 *Leptorhabdos parviflora* (Bth) Bth.
- 192 *Scrophularia* sp.
- 193 *Verbascum erianthum* Bth.
- 194 *Vernoica didyma* Tenore.
- 195 *Veronica anagalusaquatica* L.
- 196 *Veronica biloba* L.

41. Solanaceae
- 197 *Solanum nigrum* L.
- 198 *Hyoscyamus pusillum* L.

42. Tamariaceae
- 199 *Reaumaria* sp.

43. Thymeleaceae
- 200 *Daphne mucronata* Royle.

44. Valerianaceae
- 201 *Valerianella oxyrrhyncha* Fisch & Mey.

45. Zygophyllaceae
- 202 *Peganum harmala* L.

plant and wild life exploiters that resulted in ruthless cutting of forest trees and poaching for animals. The shrubby species including *Artemisia maritima*, *Sophora griffithii*, *Hertia intermedia*, *Nepeta juncea*, *Astragalus* and *Convolvulus leiocalycinus* were most common through out the *Juniperus* and *Artemesia* range. *Perovskia abrotanoides* and *Verbascum erianthum* were well distributed in dry watercourses.

The perennial and seasonal water springs have localized vegetation consisting of *Mentha longifolia*, *Juncus articulata*, *Juncus influxus*, *Carex* spp., *Taraxacum officinale* and *Veronica anagalus-aquatica*. They are bordered by *Convolvulus arvensis*, *Plantago lanceolata*, *Plantago major*, *Scutelaria* spp., *Gnaphalium luteoalbum*, *Trichlochin palustris*, *Epilobium minutiflorum*, *Cyperus* spp., *Phalaris* spp., *Hordeum bogdanii*, *Polypogon fugux* and *Juncus* spp. These plants survive longer and better due to moist soil.

2.2 Life form and leaf size spectra

Therophytes (48%), followed by hemicryptophytes (21%) dominated the area; while there were 10% chamaephytes, 8% nanophanerophytes, 7% geophytes and 5% hydrophytes. *Orobanche cernua* was the only root parasite. Climbers such as *Clematis* were rare. The leaf size spectra showed that there were 49% nanophylls, 30% microphylls, 16% leptophylls and 5% mesophylls.

The dominance of therophytes and hemicryptophytes reflect unfavourable dry habitat conditions, overgrazing and deforestation[21,22]. Annual species dominated during spring. The investigated area experiences a long dry spell from end of May to November. Plants therefore, adapt by reducing their body size, height, foliage and life cycle as a response to aridity, strong winds, poor soil development and short growing season. The present studies suggest that the adaptation in life form and leaf size spectra of plants agree with the prevailing unfavourable climate and habitat conditions. The dominance of plants with small body and leaf size has also been reported for other dry temperate regions[12,14,15,23,24]. Thero-hemicryptophytic life forms coupled with small leaf sizes are a good strategy of plants to cope with dry environment, overgrazed and deteriorated habitat. Most perennial plants become stunted owing to grazing, high transpiration of water and windy habitat.

2.3 Phenological behaviour

Phenological studies are important for planning regeneration, afforestation and conservation programs in rangeland ecosystem. The vegetation in Harboi range had seasonal physiognomic contrast due to replacement and blooming of plants. There were two flowering seasons in the area. The first flowering spell extended from April to May/June, which was followed by the second blooming period from July to October. In the first flowering spell, 83.6% of the species flowered. Of them, 61% were shrubs, 65.2% herbs and 63% grasses. In the second spell over all 60.3% species bloomed. Of them, 30.5% were shrubs, 29.7% herbs and 31% grasses. However, some plants including 8.3% shrubs, 5.9% herbs and 3.7% grasses flowered throughout the growing season (Fig. 2).

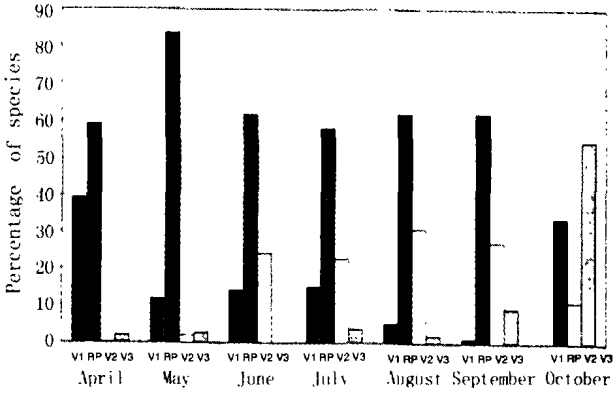

Fig. 2 The overall phenological pattern of vegetation of Harboi rangeland

The month of May was the peak flowering season as 83.3% species bloomed. The percentage of flowering plants was 59, 60.4, 58.2, 61.8, 61.9 and 33.9 respectively during April, June, July, August, September and October (Fig. 2). There were only 9.7% plants in dormant stage from June to September while 54.8% became dormant during October (Fig. 2). *Juniperus excelsa* flowered from April to May and its berries remained intact on parent trees for up to two years. Shrubby species had maximum (72.4%) flowering around May (Fig. 3) that decreased to 43.7% towards September. Some 68.7% of the shrubs remained dormant from October through March.

The major bulk of herbaceous species (85.3%) bloomed during May (Fig. 4). There were 76.5% species in flowering stage in April, 80.8% in June, 70.6% in July, 75% in August, 80% in September and 38.1% in October (Fig. 4). Among the grasses, 90% blossomed during first week of May (Fig. 5). The percentage of flowering grasses gradually declined from June (71.4%) through July (76.2%), August (70.6%), September (50%) and October (44.4%). *Pennisetum oreintale* bloomed throughout the growing season. The present findings agree with those of Shrestha and Shrestha [25] who reported that majority of plants flowered during April/May in Riyale, Nepal. Similarly,

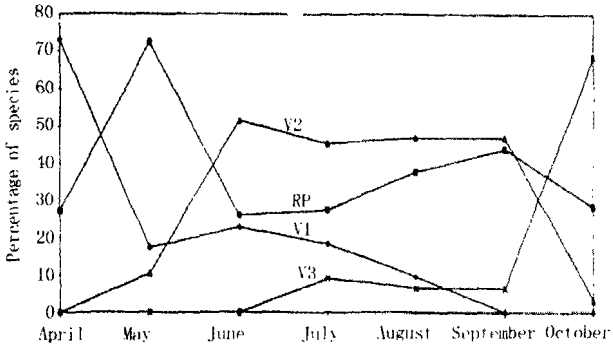

Fig. 3 Phenological behaviour of shrubs

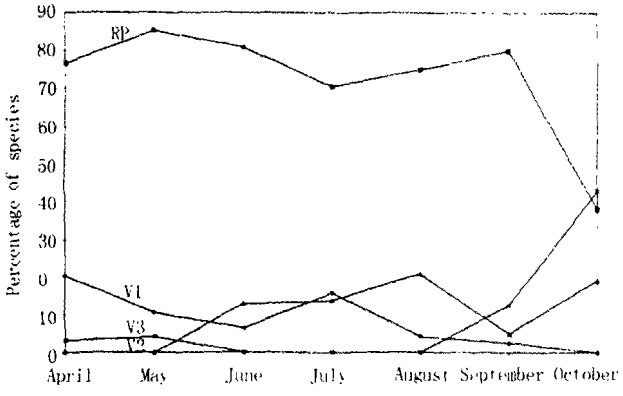

Fig. 4 Phenological behaviour of herbs

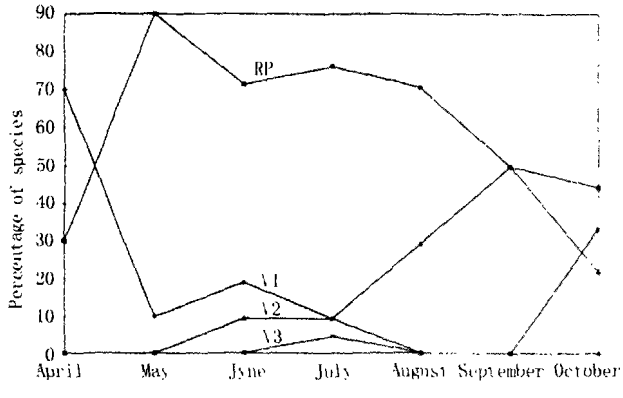

Fig. 5 Phenological behaviour of grasses

Chen et al. [26] also reported that peak of flowering occurred during May in various parts of China. Shranghetti and Ranga[27] and Morellato et al.[28] reported two flowering periods in their study area where shrubs had continuous flowering almost through the growing season and this agrees with the present findings.

The amount and time of rainfall drastically affects the phenological activity of plants in any area. During 1998, the rainfall was much less (only 60 mm from April to September) than the rainfall received in 1997 and this caused aridity. This aridity stimulated the flowering one month earlier than that observed during 1997. The plants completed their life cycle in early September and the vegetation almost became dormant from late September onwards. The correlation analysis revealed that there was a weak (r = -0.227) correlation between temperature and flowering; while it was strongly correlated with rainfall during 1997 and it was slightly weak for 1998 both for temperature (r = 0.056) and rainfall (r = 0.083). The post flowering stage, i.e. maturation of seeds/fruits was strongly (r = 0.796) correlated with temperature and weakly (r = 0.276) correlated with rainfall in 1997. During 1998 a strong correlation was observed for temperature (r = 0.864) and rainfall (r = 0.443). The dormant phase was negatively correlated with temperature (r = 0.796) for both the years. While in 1998 negative correlation was observed for temperature (r = -0.406) and rainfall (r = -0.323). The vegetative phase was negatively correlated with temperature (r = -0.492) and weak correlation with rainfall (r = 0.345) in 1997. The correlation was negative for temperature (r = - 0.344) and rainfall (r = -0.113) during 1998. The phenological cycle of flora of Harboi range is in agreement with the climatic cycle. Generally, plants disperse seeds/fruits before the appearance of cold weather. The seeds germinate and plants sprout from the below- and/or above ground parts during early spring after winter. Grazing might be allowed when the critical flowering and fruiting season is over. Seed collection can be done before summer and then before winter. It is to be noted that rainfall was uncertain in the area; therefore the amount of seeds production and emergence of seedlings might

be variable in different years. The plants of the Harboi range had limited distribution, short life cycle with xeromorphic characters. This is reflected by small leaf size, spiny habit, bushy life form, stunted growth, cushion-like habit, sparse and isolated distribution; all characterizing xerophytic flora.

2.4 Classification of plants by their local uses

It was observed that of the total 202 recorded species, 145 (72%) species had varied local uses. It included 65% fodder species, 25% medicinal species, 6% wild vegetable/ edible fruit species, 4% fuel wood species, 1% or less than 1% species were used as roof thatching, source of nectar for honey bee, herbal tea, tanning/dying, resin collection, washing utensils/clothes, fencing, making pencils and used for repelling evils (locally called Nazarbund). Some 6% species were poisonous to livestock and human beings. Among the poisonous plants, *Daphne mucronata*, *Euphorbia* sp., *Hyoscymus pusillum* and *Melica persica*, etc., were notable. Many species used in Harboi range had almost similar uses in other regions of Balochistan[29-32] due to the common traditions. It was obvious that the major resources of this rangeland were fodder and medicinal plants. Thus, ecological management is required for improving both these rangeland resources for its sustainable use and conservation of biodiversity. Most of the plants recorded in the present study have also been reported as fodder and medicinal species by other workers[1,3,6-8,13,29,33]. However, with the increasing exploitation useful plants have decreased in the area. The traditional trade of medicinal plants is sizable in Balochistan, but it lacks scientific and sustainable management. Many plants have multiple uses; therefore, such plants suffer the most under the existing dry climate prevailing in the area. Palatable species, such as *Juniperus*, *Artemesia*, *Prunis*, *Hertia*, and some grasses, which are also used for fuel and medicinal purposes, are the most threatened plants. People living around the rangeland depend on herding of sheep, goat and fuel wood for domestic and livelihood earnings. Juniper wood is sold commercially, while shrubby species are uprooted for domestic fuels only. Overgrazing and deforestation has caused the deterioration of habitats for many useful plants. It is, therefore, important to manage the grazing system to encourage the regeneration of such plants. There is a need to conserve these resources with the participation of the local communities.

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