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Full Length Research Paper

Micro-mineral contents in eight forage shrubs at three phenological stages in a Pakistan's rangeland

Zaman Sher[1]*, Farrukh Hussain[2] and Lal Badshah[2]

[1]Government Degree College, Lahor, District Swabi, Pakistan.
[2]Department of Botany, Phytoecology Laboratory, University of Peshawar, Pakistan.

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Livestock rearing is a common practice in Gadoon Hills by the locals to earn their livelihood. Low productivity due to poor health of livestock is major consideration in the study area. In order to know whether this low productivity and poor health might be due to poor quality of forage, eight shrubs, namely, *Berberis lycium, Debregeasia salicifolia, Dodonea viscosa, Gymnosporia royleana, Indigofera heterantha, Justicia adhatoda, Rosa moschata* and *Zizyphus nummularia* were analyzed for micro-mineral quantification at three phenological stages. The palatability of these species was recorded from the shepherds and after following the animals while grazing in the rangeland during this study. The samples were analyzed for Cd, Cr, Cu, Fe, Ni, Pb, Zn and Mn minerals. Cd contents ranged from 0.205 to 0.217, Cr: 0.006 to 0.967, Cu: 0.031 to 0.123, Fe: 1.819 to 12, Ni: 0.109 to 0.184, Pb: 0.08 to 0.8, Zn: 0.082 to 0.371 and Mn: 0.077 to 0.432 ppm in different investigated forage shrubs. ANOVA (P = 0.05) revealed significant difference in micro-mineral contents among the various phenological stages of the different shrubs while insignificant difference was observed for these micro-minerals among the different shrubs except Cu and Fe levels, which showed significant difference. It is concluded that micro-minerals concentrations available in these forage plants to the grazing livestock were very low, hence this may be, one of the causes responsible for the pitiable health and productivity of the grazing animals in Gadoon Hills, KPK, Pakistan.

Key words: Micro-mineral contents, forage shrubs, phenological stages, livestock health, Gadoon Hills.

INTRODUCTION

Livestock are potential source of food, which play a key role in Pakistan's annual export income (Finance Division, 2006). The growth and health of livestock are considerably governed by the concentration of trace minerals in feed/forage in rangelands. Mineral evaluation of plant forages is considered indispensable for nutritional concerns. The uptake of mineral elements can provide significant information on plant forage quality (Yusuf et al., 2003). Livestock grazing is one of the important components of land use of land management system (Jones and Martin, 1994). The main sources of these minerals are water and soil upon which the forages grow (McDowell, 2003). Hussain and Durrani (2008) relate different physiological disorders, pitiable health and diseases in the livestock of Harboi rangelands to poor nutrient availability. Mineral deficiencies are the main cause of growth and many reproductive problems in livestock even under satisfactory feed supply (Tiffany et al., 2000). Toxicity of heavy metal is another concern for livestock health (Tokalioglu et al., 2000). Underwood (1981) reported considerable variations in mineral levels of different plant species even growing on the same soil. The survival and physical condition of plants depend on the regular supply of mineral nutrients from the soil. Ganskopp and Bohnert (2003) and Khan et al. (2004, 2005a, 2006) reported that mineral composition of range plants is influenced by various environmental factors including geographic aspects, climate, soil minerals and grazing stress, seasonal changes, phenological stages, available palatable species and ability of plant to uptake minerals from soil and digest in its body. The deficiencies of trace elements (Co, Cu, I, Mn, Se, and Zn) are likely to affect production of grazing livestock at pasture in most of the regions of the world (Judson et al., 1987; Judson and

*Corresponding author. E-mail: zamanbotany@yahoo.com.

Table 1. Shrub species selected for micro-mineral analysis showing their palatability at three phenological stages.

Species	Palatability at		
	Vegetative stage	Reproductive stage	Post- reproductive stage
1*. Berberis lycium* Royle.	Highly palatable	Highly palatable	Highly palatable
2*. Debregeasia salicifolia* (D. Don) Rendle	Highly palatable	Highly palatable	Highly palatable
3. *Dodonea viscosa* (L.) Jacq.	Non palatable	Non palatable	Rarely palatable
4. *Gymnosporia royleana* Wall ex Lawson	Highly palatable	Highly palatable	Highly palatable
5*. Indigofera heterantha* L.	Highly palatable	Highly palatable	Highly palatable
6*. Justicia adhatoda* L.	Non palatable	Non palatable	Rarely palatable
7. *Rosa moschata* non J. Herrm.	Highly palatable	Highly palatable	Highly palatable
8 .*Zizyphus nummularia* Buem.f. Weight	Highly palatable	Highly palatable	Highly palatable

McFarlane, 1998).

The purpose of this study was to evaluate the variations in the concentrations of the micro-nutrients Cd, Cr, Cu, Fe, Ni, Pb, Zn and Mn at three phenological stages in eight forage shrubs from Gadoon Hills. This information will lead to a better understanding of the likely micro-nutrient needs of grazing ruminants during particular phenological stage. This is because Gadoon Hills is an important mountainous rangeland that supports a considerable number of livestock but with poor health and productivity.

MATERIALS AND METHODS

Study area

District Swabi occupies the south and south-west part of Peshawar valley, Khyber Pukhtunkhwa, with an average elevation varying from 360 to 2250 m. It lies between latitude 34-0' and 34-25' N and longitude 72-9' and 72-40' E. The north and north-eastern boundary is natural following for the most part the interfluves of Ambela (Buner). The Indus River borders the south and south east while the west is separated by Mardan and Nowshera Districts. Gadoon tract is hilly lying in the north-eastern part of Swabi District. Of the total 27441 ha area, 13921 and 8021 ha is occupied by forests and agriculture respectively while the remaining 5499 ha are rangelands. The altitude of the area varies from 410 m Gandaf to 2250 m at Shah Kot Sar (Mahaban forest). The climate of the tract is sub-tropical and it is semi-arid in the lower reaches and temperate of the upper parts. The area lies between monsoon and western disturbances, resulting in increased rainfall and humidity. Hot summers are the characteristics with June and July as the hottest months having mean maximum temperature of 40 to 42°C. There is a drop in temperature with rising altitude. Winters are cold. The mean monthly winter temperatures are 4 to 10°C. January is the coldest month. The annual rainfall varies from 60 to 145 cm increasing as one goes upward north and rises in height. Bulk of the rain is received during the monsoon. Snow fall in the winters is characteristic feature at high altitude (Said, 1978).

Collection of plant samples

Plant leaves of eight shrubs (Table 1) were collected at three phenological stages (vegetative, reproductive and post reproductive) from Gadoon Hills. They were oven dried at 65°C for 72 h. The dried powdered samples were stored in plastic bags for chemical analysis. Cd contents were measured at 228.8 nm, Cr at 357.9 nm, Cu at 324.8 nm, Fe at 248.3 nm, Ni at 232.0 nm, Pb at 283.3 nm, Zn at 213.9 nm and Mn at 279.5 nm using computerized atomic adsorption spectrophotometer following standard procedures (PARC, 1982; NRC, 1985; Galyean, 1985).

Statistical analysis

The data was statistically analyzed through ANOVA.

RESULTS

Cadmium

Cadmium concentration ranged from 0.205 ppm (*Gymnosporia, Justicia* and *Zizyphus*) to 0.217 ppm (post-reproductive stage of *Debregeasia*). Statistical analysis showed insignificant differences among the different shrubs and among the various phenological stages regarding cadmium concentration. In *Berberis,* the Cd contents were similar (0.212 ppm) in vegetative and reproductive stage but it decreased slightly to 0.211 ppm in post reproductive stage. A slight increase was observed among the three phenological stages of *Debregeasia* and *Justicia* with maturity. Cd contents in *Debregeasia* were 0.209, 0.215 and 0.217 ppm while *Justicia* had 0.205, 0.211 and 0.212 ppm for vegetative stage, reproductive stage and post-reproductive stage respectively. *Dodonea* had high Cd contents in vegetative stage (0.213 ppm) than reproductive (0.208 ppm) and post-reproductive (0.209 ppm) stages. *Gymnosporia* showed the reverse trend regarding Cd levels from that of *Debregeasia* towards maturity. Vegetative, reproductive and post-reproductive stages of *Gymnosporia* had 0.212, 0.207 and 0.205 ppm respectively. The Cd levels in the vegetative and post- reproductive stages of *Indigofera* were 0.214 and 0.211 ppm respectively, but it was higher in the reproductive stage (0.215 ppm). *Rosa* species had similar Cd contents (0.212 ppm) in vegetative and post-reproductive stages but it was higher in the reproductive stage (0.214 ppm). Cd level was higher in the reproductive stage (0.208 ppm) of *Zizyphus* than vegetative (0.206 ppm) and post-reproductive (0.205 ppm) stages.

Chromium

No significant differences were recorded in Cr levels among the different shrubs but significant differences were observed among various phenological stages. It ranged from 0.006 ppm (vegetative stage of *Dodonea*) to 0.967 ppm (reproductive stage of *Indigofera*) among the shrubs species. The concentration increased with maturity in *Dodonea, Gymnosporia* and *Zizyphus*. The recorded Cr concentration in *Dodonea* was 0.006, 0.067 and 0.234 ppm, in *Gymnosporia* 0.287, 0.312 and 0.447 ppm while in *Zizyphus* 0.485, 0.493 and 0.599 ppm for vegetative, reproductive and post-reproductive stages respectively. Inconsistent behavior regarding the Cr concentration was recorded in different phenological stages of the other species. *Berberis* had higher Cr contents in reproductive stage (0.914 ppm) than the vegetative (0.725 ppm) and post-reproductive (0.707 ppm) stages. *Debregeasia* showed similar trend for reproductive stage (0.663 ppm) while comparing with vegetative (0.512 ppm) and post-reproductive (0.62 ppm) stages. Cr contents were greater in reproductive stage (0.967 ppm) of *Indigofera* than vegetative stage (0.892 ppm) but it abruptly decreased in the post-reproductive stage (0.196 ppm). The reproductive stage (0.284 ppm) of *Justicia* had low Cr level than the vegetative (0.293 ppm) and post-reproductive (0.369 ppm) stages.

Copper

The concentration of copper ranged from 0.031 ppm (reproductive stage of *Berberis*) to 0.123 ppm (post-reproductive stage of *Berberis*). Copper contents significantly differed among the different shrubs and among different phenological stages. In *Debregeasia* the copper contents showed no significant differences between vegetative (0.058 ppm) and reproductive (0.059 ppm) stages but an increased to 0.073 ppm in post-reproductive stage was seen. A gradual decrease in Cu contents was observed in *Indigofera* while this decline was abrupt in *Rosa* towards maturity. The Cu contents in *Indigofera* were 0.068, 0.066 and 0.054 ppm while *Rosa* had 0.074, 0.055 and 0.05 ppm in vegetative, reproductive and post-reproductive stages respectively. The copper contents were 0.06 ppm in the vegetative stage of *Berberis*, which increased to 0.123 ppm in post-reproductive stage but it declined to extremely low level at reproductive stage (0.031 ppm). *Dodonea* had low Cu contents in the post-reproductive stage (0.05 ppm) compared with vegetative (0.076 ppm) and reproductive (0.079 ppm) stages. The reproductive and post-reproductive stages of *Gymnosporia* had similar (0.053 ppm) Cu levels but it was greater in the vegetative (0.062 ppm) stage. The reproductive stages of *Justicia* (0.079 ppm) and *Zizyphus* (0.069 ppm) had higher Cu contents than the other two stages.

Iron

Significant differences in Fe contents were recorded among the different shrubs and among the different phenological stages. Fe contents ranged from 1.819 ppm (reproductive stage of *Berberis*) to 12 ppm (reproductive stage of *Gymnosporia*). Fe contents decreased in *Dodonea* and *Indigofera* with maturity while the rest of the shrubs showed inconsistent Fe contents in their phenological stages. Fe contents in *Dodonea* were 10.41, 6.948 and 2.873 ppm while *Indigofera* had 6.579 , 2.883 and 2.124 ppm in vegetative, reproductive and post-reproductive stages respectively. The post-reproductive stage (6.747 ppm) of *Berberis* had higher Fe concentration than vegetative (2.989 ppm) and reproductive (1.819 ppm) stages. Insignificant difference in Fe contents was recorded among reproductive (3.549 ppm) and post-reproductive (3.852 ppm) stages of *Debregeasia* but it was significantly higher in vegetative stage (5.444 ppm). In *Gymnosporia* the highest level of Fe contents was observed for reproductive stage (12 ppm) however, it was extremely low in post-reproductive stage (2.442 ppm) than vegetative stage (6.12 ppm). In *Justicia* the Fe concentration was 2.503 ppm, 1.893 ppm and 5.408 ppm in vegetative, reproductive and post-reproductive stages, respectively. Fe levels were higher in vegetative stage (6.339 ppm) of *Rosa* but the reproductive (2.148 ppm) and post-reproductive (2.735 ppm) stages had no significant differences. Fe contents in the reproductive (7.849 ppm) stage of *Zizyphus* were higher than the vegetative (5.246 ppm) and post-reproductive (6.374 ppm) stages.

Nickel

Ni contents ranged from 0.109 ppm (vegetative stage of *Justicia*) to 0.184 ppm (vegetative stage of *Zizyphus*). Significant difference regarding Ni contents was found among the phenological stages while the difference among the various shrubs was insignificant. Ni contents increased in *Indigofera* and *Justicia* but decreased in *Gymnosporia* with maturity. In the *Indigofera* Ni contents were 0.146, 0.148 and 0.18 ppm while *Justicia* had 0.109, 0.117 and 0.138 ppm in vegetative, reproductive and post-reproductive stages respectively. The vegetative, reproductive and post-reproductive stages in *Gymnosporia* had 0.174, 0.171 and 0.157 ppm respectively. The reproductive stage (0.152 ppm) of *Berberis* had high Ni level than vegetative (0.129 ppm) and post-reproductive (0.13 ppm) stages. Similar trend regarding Ni level was observed in vegetative (0.121 ppm), reproductive (0.14 ppm) and post-reproductive (0.133 ppm) stages of *Debregeasia*. In *Dodonea,* the reproductive stage (0.159 ppm) had low Ni contents than vegetative (0.162 ppm) and post-reproductive (0.168 ppm) stages. Similar trend was also observed in the reproductive stage of *Rosa* and *Zizyphus* regarding Ni contents.

Lead

Pb contents ranged from 0.08 ppm (reproductive stage of *Justicia*) to 0.8 ppm (post-reproductive stage of *Zizyphus*). ANOVA revealed significant difference among the phenological stages but insignificant difference among the forage shrubs. Pb contents decreased in *Debregeasia* and *Rosa* while increased in *Zizyphus* with maturity. The Pb contents in *Debregeasia* were 0.489, 0.245 and 0.138 ppm while *Rosa* had 0.428, 0.409 and 0.313 ppm in vegetative, reproductive and post-reproductive stages respectively. The Pb levels recorded for vegetative, reproductive and post-reproductive stages were 0.452, 0.571 and 0.8 ppm respectively. In *Berberis*, the pb contents in vegetative (0.583 ppm), reproductive (0.595 ppm) and post-reproductive (0.557 ppm) stages was insignificant. In *Dodonea,* the reproductive stage (0.316 ppm) had low Pb concentration than vegetative (0.452 ppm) and reproductive (0.505 ppm) stages. The reproductive stages of *Gymnosporia* and *Indigofera* had significantly higher Pb levels than other two stages in both the forage shrubs. The vegetative and reproductive stages of *Justicia* had very low levels of Pb but it was significantly higher in the post-reproductive stage (0.3 ppm).

Zinc

Significant difference was found in Zn contents among the phenological stages while the difference among the various shrubs was insignificant. Zn contents ranged from 0.082 ppm (post-reproductive stage of *Berberis*) to 0.371 ppm (post-reproductive stage of *Justicia*). In *Berberis*, Zn contents showed insignificant difference among vegetative (0.232 ppm) and reproductive (0.231 ppm) stages but it reduced significantly in post-reproductive (0.082 ppm) stage. Reproductive (ppm) stage of *Debregeasia* had low Zn level than vegetative (0.24 ppm) and post-reproductive (0.232 ppm) stages. In *Dodonea,* no significant difference was recorded for vegetative (0.18 ppm) and reproductive (0.177 ppm) stages but it increased significantly in post-reproductive (0.274 ppm) stage. *Gymnosporia* had greater Zn contents in reproductive (0.336 ppm) stage than vegetative (0.302 ppm) and post-reproductive (0.263 ppm) stages. Zn contents reduced in *Indigofera* with maturity. *Justicia* had no significant difference among vegetative and reproductive stages but it increased in post-reproductive (0.371 ppm) stage. In *Rosa* and *Zizyphus*, the reproductive stages had low levels of Zn than vegetative and reproductive stages in both shrubs.

Manganese

Mn contents ranged from 0.077 ppm (post-reproductive stage of *Berberis*) to 0.432 ppm (post-reproductive stage of *Debregeasia* and vegetative stage of *Gymnosporia*). Mn contents had significant differences among the phenological stages but differences were insignificant among the different shrubs. In *Berberis* and *Gymnosporia,* Mn contents reduced but it increased in *Justicia* with maturity. Mn contents in *Berberis* were 0.13, 0.122 and 0.077 ppm while *Gymnosporia* had 0.432, 0.375 and 0.241 ppm in vegetative, reproductive and post-reproductive stages respectively. The vegetative, reproductive and post-reproductive stages of *Justicia* had 0.099, 0.141 and 0.148 ppm respectively. The reproductive stage (0.265 ppm) of *Debregeasia* had low Mn level than the vegetative (0.361 ppm) and post-reproductive (0.432 ppm) stages. Similar trend regarding Mn contents were recorded for *Dodonea* and *Rosa* species. In *Indigofera* post-reproductive (0.255 ppm) stage had significantly low Mn contents than vegetative (0.338 ppm) and reproductive (0.358 ppm) stages. *Zizyphus* showed no significant difference among vegetative (0.188 ppm) and reproductive (0.187 ppm) stages but it increased in post-reproductive (0.283 ppm) stage.

DISCUSSION

Trace elements though required in very minute quantities but their importance could not be considered the least in the growth and metabolism of human and animal bodies. Most of the trace elements have antagonizing effects for macro-minerals. The main sources of these minerals are water and soil upon which the forage plant species grow (McDowell, 2003). Mineral deficiencies can inhibit forage digestibility and herbage intake and ultimately decreases livestock production efficiency (Provenza, 1996; Khan et al., 2005b). At the same time if these minerals are in excess then they cause severe physiological disturbances. Heavy metals affect the nutritive values of agricultural products and also have deleterious effect on human beings. National and international regulations on food quality set the maximum permissible levels of toxic metals; hence heavy metals in food should be in safe limits (Radwan and Salama, 2006; Sobukola et al., 2008). Livestock rearing is a common practice in Gadoon hills by the locals to earn their daily commodities. Cadmium concentration ranged from 0.205 to 0.217 ppm showed insignificant difference among the different shrubs and among the various phenological stages. Fytianos et al. (2001) reported no significant differences in the concentration of metals in most of the vegetables analyzed. The present findings are in line with them. A slight increase was observed among the three phenological stages of *Debregeasia* and *Justicia* with maturity. The reproductive stages of *Indigofera, Rosa* and *Zizyphus* had higher Cd levels than the other two stages. The other shrubs showed inconsistent trend in Cd concentrations at various phenological stages. The Cd level in the present sustainability of shrubs was below the critical values. Low Cd concentration was observed in some fruits and vegetables in Nigeria (Sobukola et al., 2010). The present findings agree with them. However, our findings are not in line with those of Farooq et al. (2008) and Radwan and Salama (2006) who reported the highest levels of Cd, in strawberries, cucumber, dates spinach and other vegetables.

Chromium (Cr) plays important role in the synthesis of fatty acids and cholesterols, metabolism of carbohydrates, proteins, lipids and has also been proved that it facilitates the action of insulin. Oral administration of 50 ppm of Cr has been associated with growth depression and liver and kidney damages in experimental animals. In the present investigation Chromium concentration ranged from 0.006 to 0.967 ppm in the investigated shrubs species which is extremely low from toxic level. The concentrations of Cr observed in the pasture forage plants from salt range (Pakistan) are significantly higher than the critical levels. Thus, this forage may cause toxicosis problems in animals grazing the area (Ahmad et al., 2009). The present study did not support their results. Significant difference in Cr contents was recorded among various phenological stages but insignificant difference among the different shrubs. Chromium concentration increased with maturity in *Dodonea, Gymnosporia* and *Zizyphus*. Mineral ion concentration decreases with increase in age both in the case of legumes and grasses (Rahim et al., 2008). Our results are contradictory with them. Inconsistent behavior regarding the Cr concentration was recorded in different phenological stages of the other species. Sharma et al. (2006) studied the heavy metal contents in different vegetables and noted the concentration of Cr to be within the safe limits. Our results are in line with them.

Copper is necessary along with iron because it is required in red cell maturation. It is also important for normal bone formation. Symptoms of copper deficiency vary among species. Anemia is the general symptom along with depressed growth and bone abnormalities. Copper toxicity is very rare in animals when adequate supply of iron and Zn is present in diet. The concentration of copper ranged from 0.031 to 0.123 ppm in the present analysis of forage shrubs. Copper contents significantly differed among the different shrubs and among different phenological stages. In *Debregeasia* the copper contents showed no significant difference in vegetative and reproductive stages but increased in post- reproductive stage. A gradual decrease in Cu contents was observed in *Indigofera* while this decline was abrupt in *Rosa* with maturity. Gonzalez-V et al. (2006) also reported decrease in mineral ion concentration with maturity in the case of legumes and grasses. The reproductive stages of *Justicia* and *Zizyphus* had higher Cu contents than the other two stages. The overall concentration of Cu was very low than the safe limits. Sobukola et al. (2010) also recorded the lowest copper levels in some fruits and leafy vegetables from Nigeria.

Iron is a constituent of blood pigment, haemoglobin, muscle protein, myoglobbulin and various enzymes. The deficiency of iron may cause anemia and a decrease resistance to diseases. Very high levels of iron may cause nutritional problems by decreasing phosphate absorption. Significant differences in Fe contents were recorded among the different shrubs and among the different phenological stages. Fe contents ranged from 1.819 to 12 ppm in the analysis of shrubs commonly grazed by animals in the study area. Fe contents decreased in *Dodonea* and *Indigofera* with maturity. The results support the findings of Gonzalez-V et al. (2006). While the rest of the shrubs showed inconsistent Fe contents in their phenological stages. The post-reproductive stage of *Berberis* had higher Fe concentration than vegetative and reproductive stages. Insignificant difference in Fe contents was recorded among reproductive and post-reproductive stages of *Debregeasia* but it was significantly higher in vegetative stage. Espinoza et al. (1991) reported variations in Fe concentrations in their study in Florida. Their results support our findings. In *Gymnosporia* the highest level of Fe contents was observed for reproductive stage however, it was extremely low in post-reproductive stage than vegetative stage. The overall concentration of Fe in all the shrubs was very low.

Ni is present in RNA in rather high concentrations. It is also essential for urease activity in rumen microbes. Levels of Ni greater than 1000 ppm in the diet are toxic to most animals. Significant difference regarding Ni contents was found among the phenological stages while the difference among the various shrubs was insignificant (Table 2). In the present investigation the Ni contents ranged from 0.109 to 0.184 ppm in different shrubs analyzed. Ni contents increased in *Indigofera* and *Justicia* but decreased in *Gymnosporia* with maturity. The reproductive stage of *Berberis* had high Ni level than vegetative and post-reproductive stages. Similar trend regarding Ni level was observed in *Debregeasia*. In *Dodonea,* the reproductive stage had low Ni contents than vegetative and post-reproductive stages. Similar trend was also observed in the reproductive stage of *Rosa* and *Zizyphus* for Ni contents. High concentration of Ni has been reported in many studies (Tokalioglu and

Table 2. Micro-minerals composition of some shrubs of Gadoon Hills, District Swabi (at three penological stages).

Species	Phenological stage	Cd	Cr	Cu	Fe	Ni	Pb	Zn	Mn
1. *Berberis lycium* Royle.	Vegetative	0.212	0.725	0.06	2.989	0.129	0.583	0.232	0.13
	Reproductive	0.212	0.914	0.031	1.819	0.152	0.595	0.231	0.122
	Post-reproductive	0.211	0.707	0.123	6.747	0.13	0.557	0.082	0.077
2. *Debregeasia salicifolia* (D. Don) Rendle	Vegetative	0.209	0.512	0.058	5.444	0.121	0.489	0.24	0.361
	Reproductive	0.215	0.663	0.059	3.549	0.14	0.245	0.211	0.265
	Post-reproductive	0.217	0.62	0.073	3.852	0.133	0.138	0.232	0.432
3. *Dodonea viscosa* (L.) Jacq.	Vegetative	0.213	0.006	0.076	10.41	0.162	0.452	0.18	0.233
	Reproductive	0.208	0.067	0.079	6.948	0.159	0.316	0.177	0.18
	Post-reproductive	0.209	0.234	0.05	2.873	0.168	0.505	0.274	0.198
4. *Gymnosporia royleana* Wall ex Lawson	Vegetative	0.212	0.287	0.062	6.12	0.174	0.523	0.302	0.432
	Reproductive	0.207	0.312	0.053	12	0.171	0.761	0.336	0.375
	Post-reproductive	0.205	0.447	0.053	2.442	0.157	0.455	0.263	0.241
5. *Indigofera heterantha* L.	Vegetative	0.214	0.892	0.068	6.579	0.146	0.474	0.283	0.338
	Reproductive	0.215	0.967	0.066	2.883	0.148	0.784	0.219	0.358
	Post-reproductive	0.211	0.196	0.054	2.124	0.18	0.526	0.18	0.255
6. *Justicia adhatoda* L.	Vegetative	0.205	0.293	0.067	2.503	0.109	0.093	0.313	0.099
	Reproductive	0.211	0.284	0.079	1.893	0.117	0.08	0.316	0.141
	Post-reproductive	0.212	0.369	0.069	5.408	0.138	0.3	0.371	0.148
7. *Rosa moschata* non J. Herrm.	Vegetative	0.212	0.135	0.074	6.339	0.156	0.428	0.225	0.247
	Reproductive	0.214	0.135	0.055	2.148	0.153	0.409	0.159	0.17
	Post-reproductive	0.212	0.01	0.05	2.735	0.163	0.313	0.17	0.216
8. *Zizyphus nummularia* Buem.f. Weight	Vegetative	0.206	0.485	0.062	5.246	0.184	0.452	0.301	0.188
	Reproductive	0.208	0.493	0.069	7.849	0.176	0.571	0.182	0.187
	Post-reproductive	0.205	0.599	0.061	6.374	0.179	0.8	0.266	0.283

Kartal, 2005; Sobukola et al., 2010; Ahmad et al., 2009). The present investigation showed contradiction with them.

Lead is one of the most common causes of accidental poisoning in human and domestic animals. Lead concentration of 80 ppm in forages could be toxic to horses but cattle could tolerate 200 ppm or more. Pb contents ranged from 0.08 to 0.8 ppm. High concentration of lead was recorded in some vegetable and forages (Sobukola et al., 2010; Ahmad et al., 2009). The findings of the present investigation are not in line with them as these levels are within the safe limits. Results of the present study showed significant difference among the phenological stages but insignificant difference among the forage shrubs. Pb contents decreased in *Debregeasia* and *Rosa* while increased in *Zizyphus* with maturity. In *Berberis*, the Pb contents in vegetative, reproductive and post-reproductive stages were insignificant. In *Dodonea,* the reproductive stage had low Pb concentration. The reproductive stages of *Gymnosporia* and *Indigofera* had significantly higher Pb levels than other two stages in both the forage shrubs. The vegetative and reproductive stages of *Justicia* had very low levels of Pb but it was significantly higher in the post-reproductive stage. Malik et al. (2010) also observed variations in the lead contents in some studied plant species.

Zn is present in carbonic anhydrase (found in RBC) which play a key role in eliminating CO_2. Zn is also an activator of many other enzymes. Dwarfism and absence of sexual maturation are important symptoms in severe Zn deficiencies. Zn concentration was relatively higher in grasses than broad leaved (Malik et al., 2010). Our findings agree with them because low Zn levels were recorded for all shrubs in the present study. Significant difference was found in Zn contents among the phenological stages while the difference among the various shrubs was insignificant. Zn contents ranged from 0.082 to 0.371 ppm. In *Berberis*, Zn reduced significantly in post-reproductive stage, the other two stages showed insignificant difference. In *Debregeasia,* reproductive stage had low Zn level than the other stages. High Zn contents were recorded in post-reproductive stage of *Dodonea* and *Justicia,* while no significant difference was found among the other two stages. *Gymnosporia* had greater Zn contents in reproductive stage than vegetative and post-reproductive stages. Zn contents reduced in *Indigofera* with maturity. In *Rosa* and *Zizyphus*, the reproductive stages had low levels of Zn than vegetative and reproductive stages in both shrubs. Zinc concentration in grasses of northern rangelands of Pakistan was not affected by maturity or change in climate (Sultan et al., 2008). The present study agrees with their findings.

Mn is required to activate several enzymes such as arginase and thiaminase. A major symptom of manganese deficiency in most animals is bone abnormality. Manganese is considered to be the least toxic of the trace elements to birds and mammals. Manganese between 50 and 125 ppm affected haemoglobin formation in lambs and mature rabbits. Mn contents ranged from 0.077 to 0.432 ppm. In *Berberis* and *Gymnosporia,* Mn contents reduced but it increased in *Justicia* with maturity. The reproductive stage of *Debregeasia* had low Mn level than the vegetative and post-reproductive stages. Similar trend was recorded for *Dodonea* and *Rosa* species. In *Indigofera* post-reproductive stage but it was higher in *Zizyphus.* Mn contents had significant difference among the phenological stages but insignificant difference among the different shrubs. Similar levels of plant Mn have already been reported in Florida (Espinoza et al., 1991), and in Pakistan (Khan et al., 2006, 2007).

It is concluded that micro-minerals concentrations available in these forage plants to the grazing livestock were very low, hence this may be, one of the causes responsible for the pitiable health and productivity of the grazing animals in Gadoon hills. It is suggested that further investigation like proximate composition and digestibility of these forage plants is needed because micro-minerals deficiency in forage shrubs may not be the only cause of the said problem.

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