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INFLUENCE OF DISTURBANCE ON THE DEMOGRAPHIC PATTERNS OF *GYNANDROPSIS GYNANDRA* (L.) BRIQ. – A COMPARATIVE STUDY

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ABSTRACT

Demographic studies of *Gynandropsis gynandra* (L.) Briq. was carried out for two consecutive years 2012 and 2013. Site was totally undisturbed in 2012 but found to be highly disturbed in 2013. Therefore, the present study evaluates the impact of anthropogenic and grazing disturbance on *Gynandropsis gynandra* (L.) Briq. during these years. Plants in both the years exhibited Deevey Type I survivorship curve showing increased mortality towards the end of their life. However, species richness declined in year 2013 for towards the adverse impact of disturbance. Disturbance also attributed for low plant height and decline in the overall reproductive output in year 2013. Trends of biomass allocation in *G. gynandra* revealed maximum expenditure towards vegetative growth which stayed consistent throughout their life cycle and just a small part of resources to reproductive growth in the initial weeks, constituting for fitness strategy under harsh environment.

Key words: Disturbance, Survivorship curves, Demography, Growth patterns, Biomass allocation.

INTRODUCTION

Ecological disturbances occur over numerous temporal and spatial scales. According to Pickett and White (1985) disturbance is defined as an event that disrupts ecosystem by creating changes in resource availability or the physical environment. The biotic and abiotic components of environment impact the growth and development of plants in all phases of life. Increased urbanization, anthropogenic disturbances along with livestock grazing are known to cause decline in biodiversity (Zhang *et al.*, 2010) by altering the natural environments of different species. Disturbed grounds cannot support viable populations, eventually becoming a key issue in the conversation of biodiversity (Klein, 1989). On the contrary, the intermediate disturbance hypothesis postulates that that moderate levels of disturbance trend towards improved biodiversity and ecosystem functionality (Connell, 1978). Since disturbance limits some plants from acquiring resources for a short term, it creates resource availability for other species (Craine, 2009). Annual species are diversified in nature and may grow in a broad range of climatic conditions. Thus, we may not be able to draw concrete conclusions to confirm whether a general rule governs their life history strategies particularly accounting for different disturbance gradients.

The present study is designed to provide a comprehensive analysis on the survivorship patterns, growth, biomass allocation and reproductive output of *Gynandropsis gynandra* for two consecutive years, 2012 and 2013.

MATERIALS AND METHODS

Study Site

The site chosen for the study is located in the Karachi university Campus, Sindh (Lat. 24˚ 48' N., Long. 65˚ 55' E.). The summer temperature varies from 32 – 35˚C. Due to high temperature, the rate of evapotranspiration is also high. Disturbances like, grazing, mowing, trampling and to a lesser extent garbage dumping along with other anthropogenic disturbances were more common in 2013. The site is located in a semi-shady area where huge trees are present at random distances

Demography

Demographic data was collected using systematic sampling technique by placing ten permanent quadrats (10×10 m^2). Quadrats were counted every week throughout the growing season. The number of plants surviving in each quadrat were counted. This data was used to construct conventional life table and survivorship curve.

Vegetative Growth

At every sampling date two plants were randomly collected from outside of each quadrat. These plants were brought to the laboratory. Root and shoot length of each plant was recorded immediately. The plants were then wrapped in an aluminum foil and were allowed to dry in the oven at 80˚C for 48 hours. For each plant the dry weight of component organs was recorded.

Reproductive Growth

Reproductive growth was estimated at every sampling date by counting the number of flowers, fruits per plant and number of seeds per fruit. They were then dried to a constant dry weight (80˚ C for 48 hours) and weighed.

RESULTS

The life tables of *Gynandropsis gynandra* were constructed for year '2012' and '2013' and presented in the Tables 1a and 1b. Plants were observed to complete their entire life cycle in 10 weeks. Survivorship curves for both the years followed Deevey type-I survivorship curve, reflecting a low death rate in early and drops steeply as death rates increase among older age groups (Fig. 1). It was observed that plant density was significantly higher (P < 0.001) in 2012 as compared to 2013 and the mortality rates were higher (P < 0.01) in 2013. Overall, mortality increased as plants approached later stages of life.

Table 1a. Life table of *Gynandropsis gynandra* (L.) Briq. (2012).

Age (Weeks)	Number of Individuals Alive (lx)	Number of Individuals Dying (dx)	Stationary Population (Lx)	Residual Life (Tx)	Age Specific Mortality (qx)	Life Expectancy (ex)
1	1000	-76.9	103.85	8730.9	-0.08	8.4
2	1076.9	-692.3	1423.1	7692.4	-0.64	-5.4
3	1769.2	384.6	1692.3	6269.3	0.28	3.7
4	1615.4	384.6	1423.1	4577	0.24	3.2
5	1230.8	153.9	1153.9	3153.9	0.13	2.7
6	1076.9	307.7	923.1	2000	0.29	2.2
7	769.2	307.7	615.4	1076.9	0.4	1.7
8	461.5	153.8	384.6	461.5	0.33	1.2
9	307.7	307.7	76.9	76.9	1.0	1.0
10	0	0	0	0	0	0.0

Table 1(b). Life table of *Gynandropsis gynandra* (L.) Briq. (2013).

Age (Weeks)	Number of Individuals Alive (lx)	Number of Individuals Dying (dx)	Stationary Population (Lx)	Residual Life (Tx)	Age Specific Mortality (qx)	Life Expectancy (ex)
1	1000	-136.36	1068.18	6045.4	-0.13	6.0
2	1136.36	90.91	1090.95	4977.2	0.08	4.4
3	1045.45	-136.36	1113.63	3886.2	-0.13	3.7
4	1181.81	500	931.81	2772.6	0.4	2.3
5	681.81	136.37	613.62	1840.8	0.2	2.6
6	545.44	90.91	499.98	1227.2	0.16	2.2
7	454.53	136.36	386.35	727.2	0.3	1.6
8	318.17	136.36	249.99	340.8	0.42	1.0
9	181.8	181.8	90.9	90.9	1.0	0.4
10	0	0	0	0	0	0

Table 2a. Reproductive phase of *Gynandropsis gynandra* (2012).

Weeks	Number of flowers/plant	Number of fruits/Plant	Number of seeds/ fruit	Number of seeds/ plant
1	0 ± 0	0±0	0 ± 0	0 ± 0
2	0 ± 0	0±0	0 ± 0	0 ± 0
3	0.4 ± 0.1	0±0	0 ± 0	0 ± 0
4	6.6 ± 1.1	2.7 ± 0.7	32.45 ± 6.4	100.85 ± 2.1
5	5.3 ± 1.1	5.8 ± 0.9	39.62 ± 3.3	218.1 ± 2.9
6	0.8 ± 0.5	7 ± 1.0	38.52 ± 4.2	250.35 ± 3.1
7	0.25 ± 0.2	10.7 ± 0.8	44.45 ± 1.7	476.4 ± 3.8
8	0.05 ± 0.05	14.15 ± 1.2	37.48 ± 1.1	514.95 ± 3.5
9	0 ± 0	17.7 ± 1.4	36.86 ± 2.1	606.15 ± 4.9

Table 2b. Reproductive phase of *Gynandropsis gynandra* (2013).

Weeks	Number of flowers/plant	Number of fruits/Plant	Number of seeds/ fruit	Number of seeds/ plant
1	0 ± 0	0±0	0 ± 0	0 ± 0
2	0 ± 0	0±0	0 ± 0	0 ± 0
3	0.5 ± 0.1	0±0	0 ± 0	0 ± 0
4	5 ± 0.7	1.55 ± 0.4	13.74 ± 3.6	34.95 ± 10.6
5	4.6 ± 0.9	3.35 ± 0.4	32.57 ± 3.21	74.6 ± 13.8
6	0.65 ± 0.2	6.85 ± 0.8	35.5 ± 5.4	236.2 ± 29.76
7	0.25 ± 0.2	11 ± 0.71	30.35 ± 1.1	333.35 ± 25.0
8	0.05 ± 0.05	7.25 ± 0.7	41.36 ± 3.0	289.9 ± 27.8
9	0 ± 0	3.15 ± 0.5	33.48 ± 2.29	113.8 ± 17.2

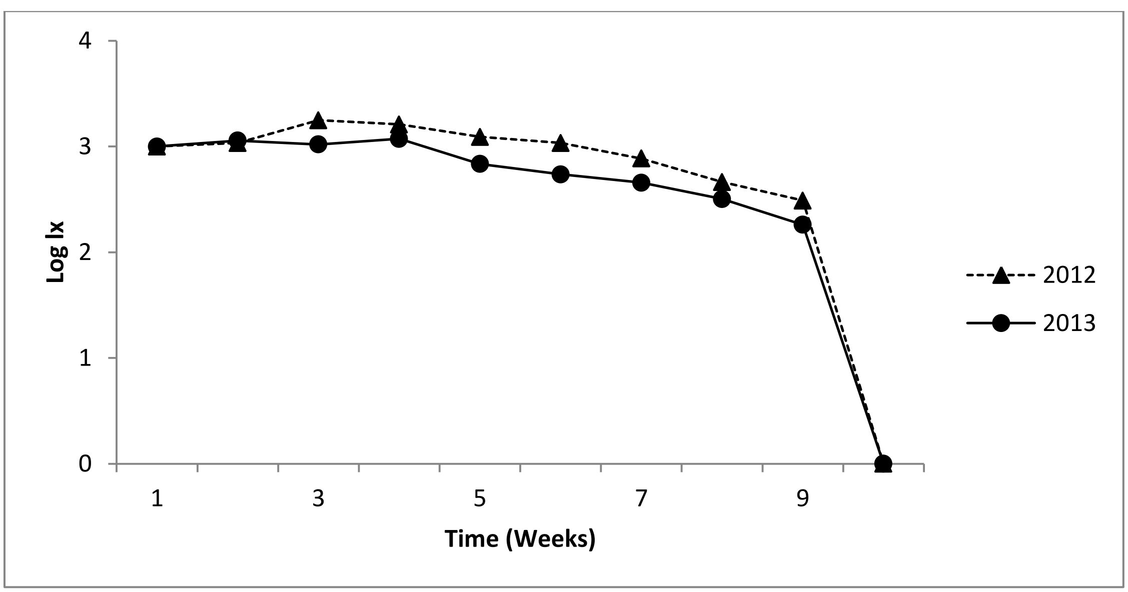


Fig. 1 Survivorship curves of *Gynandropsis gynandra* individuals in the year 2012 and 2013.

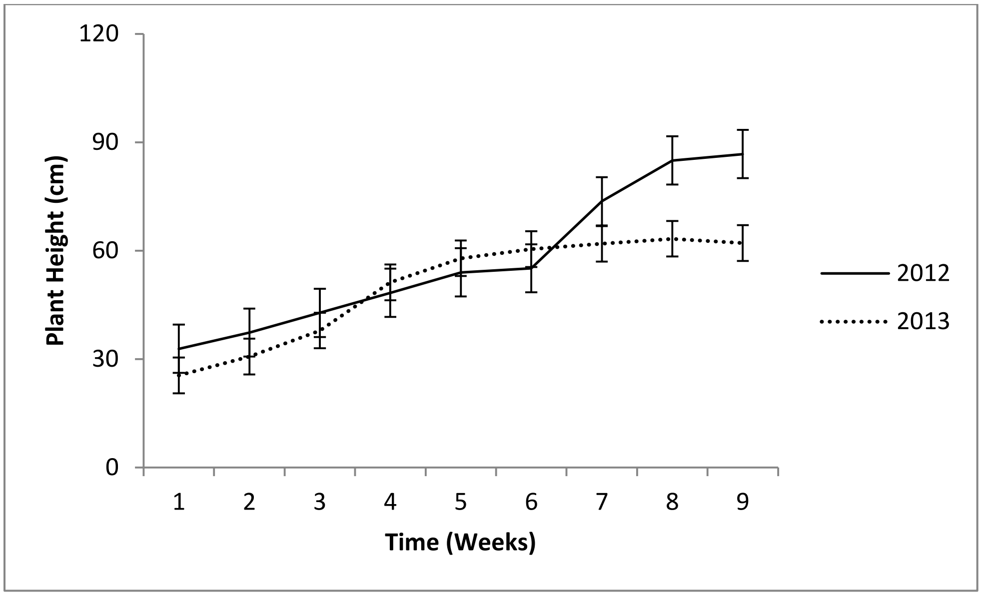
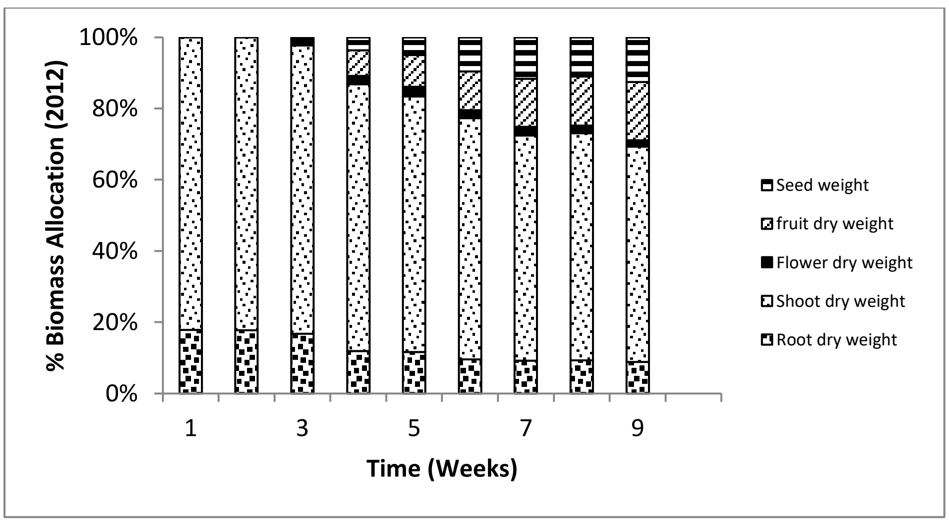


Fig. 2 Plant height (cm) of *Gynandropsis gynandra* individuals in the year 2012 and 2013.



Considerable differences in Plant height was observed in both the years (Fig. 2). It was significantly higher in 2012 (P < 0.001.) In both years, *Gynandropsis gynandra* plants showed a typical sigmoidal curve indicating an initially increasing in growth pattern but then a decline, characteristic feature of annual plant species.

Week three marks the beginning of flowering in both year 2012 and 2013. Significantly greater (P < 0.001) number of fruits per plant and seeds per fruit were observed in the year 2012. Reproductive output, however, was low in 2013 (Table 2a and 2b).

Biomass allocation to component organs is presented in (Fig. 3). In both years, plants allocated most of their resources towards vegetative organs throughout their life and just a part of resources were assigned for establishment. Significantly, higher biomass to reproductive organs were allocated in 2012 (P < 0.001).

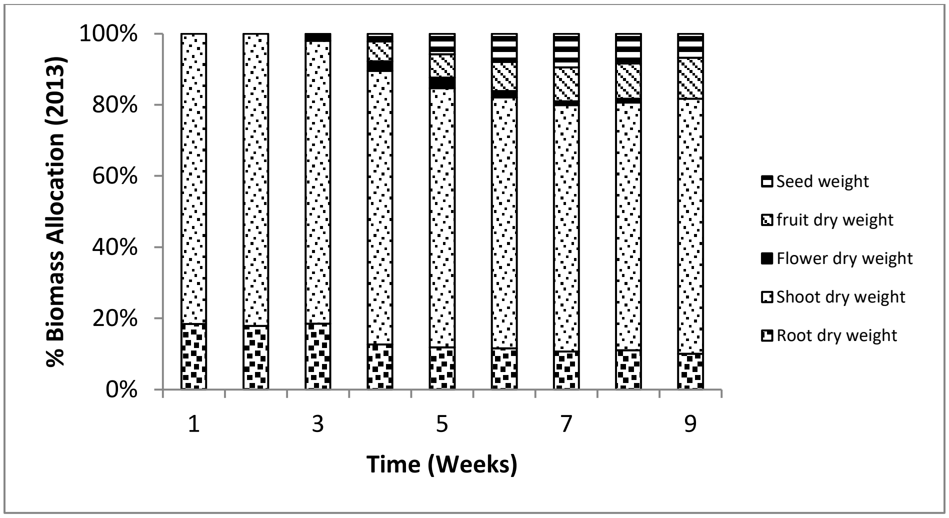


Fig. 3 Biomass allocation to component organs of *Gynandropsis gynandra* individuals in the year 2012 and 2013.

DISCUSSION

Demography

The demographic analysis of *Gynandropsis gynandra*, conducted for two consecutive years 2012 (undisturbed) and 2013 (disturbed) revealed an initial increase in the number of individuals in the early phase of life and decrease in the later phase. However, plant density was greater in year 2012 (undisturbed) compared to that in 2013 (disturbed). The influence of environmental disturbance at both the sites greatly affects plant density and seems to be highly variable on biodiversity (Putz *et al.* 2000). Our results are in accordance with a study conducted to evaluate the effects of anthropogenic disturbance on a grove in Meghalaya, North East India where increase in the levels of disturbance caused a marked decline in species richness (Mishra *et al.*, 2004). It was noted that at our study site human activities not only degraded useful plant populations but also had an adverse effects on adjacent plant localities. The extent of disturbance on our study site is not only restricted to human activities but also to mild grazing, trampling and garbage dumping. Heavy grazing pressure has been reported to reduce the diversity of herbs and shrubs in the range land (Zhao *et al.*, 2006). Whereas, Oba *et al.*, (2001), considered grazing as a potential factor leading to alterations in biodiversity. Defoliation via grazing might leads to low photosynthetic activity and consequently shrinkage of root system which results in low plant diversity. A study conducted in the Al – Fara'a area to understand grazing impacts revealed that species diversity, evenness, above ground biomass and density were significantly higher in the recently no-grazing grassland and natural reserved grassland than under grazing grassland Ali-Shtayeh and Salahat (2010). According to Cole (1995), human trampling and vehicle parking have a huge role in causing mechanical damage to plants tissue causing loss in vegetation cover, plants height, living biomass, species composition, reproductive capacity.

Growth

Our results show that plant height was significantly higher in 2012 i.e. in low disturbed area, thus pointing towards disturbance as potential regulators of plant height. It is well known that water is the limiting factor in arid regions and in many cases precipitation may serve to be the only source of sustaining the desert ecosystem. Disturbance impacts ecosystems resulting in fluctuations in plant height and species composition (Barros *et al.* 2013). Trampling along with disturbances leads to soil compaction which deteriorates plant roots (Watkins and Clements 1978; Dormaar and Willms 1998). This prevents plants from acquiring adequate resources for dynamic growth (Belsky and Gelbard 2000). Grazing can influence the structure and organization of plant communities in different ways (Noy-Meir *et al*., 1989). A study conducted in the alpine meadow showed decrease in vegetation height, coverage and above-ground biomass significantly with increased grazing intensity (Li *et al.*, 2011). Grazing animals decrease flower and seed production directly by consuming reproductive structures, or indirectly by stressing the plant and reducing energy available to develop seeds. Grazing animals eat the leaves, flowers and stems above ground. The direct effect of herbivory on vegetation includes modifications to plant growth, reproduction and architecture. The main effect of grazing on plant growth is the reduction of photosynthetic capacity associated with the loss of leaf area. This reduces the supply of assimilated compounds to roots, seeds, developing fruits and growing shoots (Willard and McKell, 1973; Donaghy and Fulkerson, 1997).

Fecundity and Biomass Allocation

Progressive decrease in the reproductive output of *G. gynandra* was observed in response to increased disturbance in the year 2013. Due to the fact that annuals have short life cycles, even minor disturbances in the environment may produce pronounced effects on their reproductive output (Symonides, 1988). *G. gynandra* shows remarkable phenotypic plasiticity in response to environmental changes (Khan and Shaukat, 2000). The activity of soil organisms is largely influenced by disturbance (Curry and Good, 1992) resulting in the reduction of biomass and biotic diversity. Grazing has been reported as a major factor leading to alterations in dry biomass (Lamprey, 1979) as it causes selective removal of plant tissues or species. Grazing on dominant species reduces their vigor. A study conducted to identify the species responses to disturbance showed that fruit set was reduced in response to livestock disturbance while anthropogenic intervention showed a similar trend with less intensity (Mckenchnie & Sargent, 2013). In general, annuals from disturbed environments are known to produce high numbers of fruits but the number of seed/fruit decreases (Delph 1986) which may be termed as a fitness strategy in fluctuating environments. With that said, patterns of biomass allocation are great indicators of the adaptation strategies of plants in disturbed environments (Zhang *et al.,* 2013; Ning *et al.,* 2014). It has been reported that root/shoot ratio is comparatively higher in desert plants (Barbour, 1973). Theoretically, high allocation of biomass to roots allows greater access to moisture and nutrients (Zhou *et al.,* 2014). Annual plants do possess optimum strategies to withstand arid environments, one of which is a shift from vegetative to reproductive growth. The greater resource allocation to the storage organ (tuber) reflects a conservative strategy to avoid damage and to maintain the potential for re-colonization in a frequently disturbed habitat (Ning *et al.,* 2014). However, G. gynandra individuals growing in disturbance revealed different results. During our study, it was observed that *G. gynandra* showed almost similar pattern of biomass allocation in both years. Flowering initiated in the third week which shows that annuals may show early flowering in response to disturbance to further shorten their life cycle and may dedicate part of their resources to reproductive organs in the early phase of life while continuing their vegetative growth (Symonides, 1988). Thus, plants tend to strike the correct balance between growth, reproduction and biomass allocation to enhance their fitness. Moreover, the second year of study i.e., 2013 exhibited higher levels of intrusion. Through this it was evaluated that how biotic disturbance accounts for the overall change in growth, fecundity and biomass allocation of *G. gynandra.*

REFERENCES

Ali-Shtayeh, M. S. and A.G.M. Salahat (2010). The impact of grazing on natural plant biodiversity in Al-Fara'a area. *Biodivers. & Environ. Sci. Studies Series,* 5(1): 1 – 17.

Barbour, M.G. (1973). Desert dogma reexamined: root–shoot productivity and plant spacing. *Am. Midl. Nat.,* 89:41–57.

Barros, A., J. Gonnet and C. Pickering (2013). Impacts of informal trails on vegetation and soils in the highest protected areas in the Southern Hemisphere. *J. Environ. Manage.* 127, 50-60.

Belsky A.J. and J.L. Gelbard (2000). Livestock grazing and weed invasions in the arid west. Oregon Natural Desert Association.

Cole, D. (1995). Experimental trampling of vegetation. I. Relationship between trampling intensity and vegetation response. *J. App. Ecol.,* 32: 203-214.

Connell, J.H. (1978). Diversity in tropical rain forests and coral reefs. *Sci.,* 199: 1302- 1310.

Craine, J. (2009). The History of Plant Strategies. In: *Resource Strategies of Wild Plants*. Princeton University Press, pp. 15-44.

Curry, J.P and J.A. Good **(**1992). Soil faunal degradation and restoration. *Adv. Soil Sci.,* 17: 171-215.

Delph, L.F. (1986). Factors regulating fruit and seed production in the desert annual *Lesquerella gordonii*. *Oceol.* 69:471-476

Dormaar, J.M. and W. Willms (1998). Effect of forty-four years of grazing on fescue grassland soils. *J. Range Manage.* 51(1): 122-126.

Donaghy, D.J. and W.J. Fulkerson (1997). The importance of water soluble carbohydrate reserves on regrowth and root growth of *Lolium perenne* (L.).*Grass Forage Sci.,* 52: 401-407.

Khan, D. and S.S. Shaukat (2000). Site and density regulated phenotypic plasticity and size heiranrchies in field populations of *Gynandropsis gynandra* (L.) Briq. *Hamdard Medicus,* 93: 103-126.

Klein, B.C. (1989). Effects of forest fragmentation on dung and carrion beetle communities in Central Amazonia. *Ecol.*, 70: 1715–1725.

Lamprey, B.H. (1979). Structure and function of semi-arid grazing land ecosystem of Serengeti region, Tanzania, UNESCO

Li, W., H. Zhou, Z. Zhang and G. Lin (2011). Effects of grazing on the soil properties and C and N storage in relation to biomass allocation in an alpine meadow. *J. Soil Sci. Plant Nutr.* 11 (4): 27-39

McKechnie, I.M. and R.D. Sargent (2013). Do plant traits influence a species' response to habitat disturbance? A meta-analysis. *Biol. Cons.*, 168: 69–77.

Mishra B.P., R.S. Tripathi, O.P. Tripathi and H.N. Pandey (2004). Effects of anthropogenic disturbance on plant diversity and community structure of a sacred groove in Meghalaya, Northeast India. *Biodiv. Conserv.* 13: 421–436.

Ning, Y., Z.X. Zhang, L.J. Cui and C.L. Zou (2014). Adaptive significance of and factors affecting plasticity of biomass allocation and rhizome morphology: A case study of the clonal plant *Scirpus planiculmis* (Cyperaceae). *Pol. J. Ecol.*, 62: 77–88.

Noy-Meir, I., M. Gutman and Y. Kaplan (1989). Response of Mediterranean grassland plants to grazing and perotection. *J. Ecol.*, 77: 290-310.

Oba, G., E. Post, P.O. Syvertsen and N.C. Stenseth (2001). Bush cover and range condition assessments in relation to landscape and grazing in southern Ethiopia. *Landscape Ecol.*, 15: 535-546.

Pickett, S.T.A. and P.S. White (1985). The ecology of natural disturbance and patch dynamics. Academic Press, New York.

Putz, F.E., K.H. Redford, J.G. Robinson, R. Fimbel and G.M. Blate (2000). *Biodiversity Conservation in the Context of Tropical Forest Management*. The World Bank Environmental Department, Washington DC.

Symonides, E. (1988). On the ecology and evolution of annual plants in disturbed environments. *Vegetatio,* 77: 21-31.

Watkins, B. and R. Clements (1978). In: Wilson, J.R. (Editor), *Plant relations in pastures*, pp. 273-289. CSIRO, Canberra.

Willard, E.E. and C.M. Mckell (1973). Simulated grazing management systems in relation to shrub growth responses. *J. Rangeland Manage.* 26: 171-174.

Zhang, Y., X. Shao, C. Chen, Y. J. Zhang and K. Wang (2013). Morphological characteristics and biomass allocation of *Leymus Chinensis* (Poaceae) (Trin.) responses to long-term overgrazing in agro-pastoral ecotone of Northern China. *J. Anim. Plant Sci.*, 23(3): 934-939.

Zhao, W. Y., J.L. Li and J.G. Qi (2006). Changes in vegetation diversity and structure in response to heavy grazing pressure in the. Northern Tianshan Mountains, China. *J. Arid Environ.* 68: 337-508.

Zhou, X., Y. Zhang and K.J. Niklas (2014). Sensitivity of growth and biomass allocation patterns to increasing nitrogen: a comparison between ephemerals and annuals in the Gurbantunggut Desert, North-western China. *Ann Bot.,* 113(3): 501–511.

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