INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-6, Issue-1, Jan-Mar-2016 Coden: IJPAJX-CAS-USA, Copyrights@2016 ISSN-2231-4490

Received: 1st Oct-2015 *Revised: 27th Oct-2015* *Accepted: 1st Nov-2015*

Research article

SPATIAL DISTRIBUTION PATTERN AND ABUNDANCE OF *AGERATUM CONYZOIDES* (ASTERACEAE FAMILY) IN RIVERINE AND NON-RIVERINE HABITATS OF MWEKA

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ABSTRACT: The study of distribution of *Ageratum conyzoides* was conducted in Riverine and Non-riverine habitats of Mweka, focusing on the distribution pattern and abundance of the plant between the two sites. In each site 30 frame quadrats of 0.25 m^2 were randomly placed where each individual of *Ageratum conyzoides* rooted within the quadrat was counted to define the abundance of the plant. Variance to mean ratio (I) was used to determine the distribution pattern of the plant in both sites. The t-test was used to examine if variance to mean ratio (I) had a significant difference from 1 and for testing if there was a significant difference in abundance between these habitats. In both sites *Ageratum conyzoides* was clumpy distributed while its abundance was higher in non-riverine than in riverine habitats. This difference in abundance was statistically significant (t=3.070; df=58; P=0.0033). Clumped distribution of *Ageratum conyzoides* might be due to the higher concentration of soil nutrients in one area than in another. Abundance differences might be influenced by edaphic and anthropogenic factors.

Key words: *Ageratum conyzoides,* Distribution pattern, Variance to mean ratio, Vegetation quadrat sampling.

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INTRODUCTION

Different plant species exist in Mweka in both riverine and non-riverine areas. Some of these plant species are well known like *Lantana camara* but others are not common especially the non-woody plants. Most of these plants are native and some are exotic and sometimes invasive (weed) to native plants including crops. One of the weeds which exist in Mweka is *Ageratum conyzoides*. This is a vertical, straight annual plant [1,2] which exists in many countries, mainly in tropical and subtropical regions [2]. In other countries it occurs as an exotic plant since it originates from Central America and the Caribbean [3]. *Ageratum conyzoides*, commonly known as agerato (Portuguese-Brazil and Italy), ageratum or white weed (English), ageratum (Netherlands) and grows about 30 to 80 cm height in Shivalik Ranges of India, it has been reported to grow up to 2 m [4]. *Ageratum conyzoides* has white hairs covering its stems. The leaves of this species are oppositely arranged [5] and its inflorescence is corymb with purple or sometimes whitish [5]. The fruits of this herb are achene and seeds are dispersed by wind [5] and water [6]. This herb has been adaptable in many climatic conditions due to its abundant variation in morphology [3].

Ageratum conyzoides is distributed worldwide in Pantropical regions within the altitude of 700-1660 meters above sea level (m.a.s.l) [7], but it can also exist up to 2400 m.a.s.l [8]. This species can also appear in disturbed areas, forest areas, cultivated areas, grasslands, wetlands and shrub lands [3]. Different studies have been conducted worldwide reporting the plant invading natural and man-made habitats. In South East Asia, it was reported by Kato-Noguchi [9] that *Ageratum conyzoides* invaded upland crop areas; in India the plant is becoming the dominant weed in different agricultural lands and leads to the decrease in crop yields [10].

Ageratum conyzoides also has been reported to invade farming areas and ecosystems in Shivalik Ranges of India [11]; and, in Doon Valley the plant has harmful impacts in native biodiversity [3]. Although the plant is said to be harmful, in other ways it has some ecological, economic and social importance. In South Eastern parts of Nigeria the juice from *Ageratum conyzoides* is useful in healing of wounds [12]. In wastewater management, *Ageratum conyzoides* has been determined to be the cheap adsorbent in removing toxic pollutants. The use of *Ageratum conyzoides* leaf powder (ACLP) showed good results in removing methylene blue (MB) and hexavalent chromium Cr (VI) from wastewater. The powder has been determined to work more effectively in low pH levels [12, 13]. Ezech et al. [14] findings showed that the leaf powder of Ageratum can successfully remove effluent dye in optimum conditions (pH 4 and adsorbent concentration=0.06 g). Therefore understanding its spatial distribution pattern is necessary for the medical and wastewater scientists.

In Tanzania, the plant is considered invasive and has been reported by Kashina et al. [15] that it is the reservoir and host of tomato yellow leaf curl Tanzania virus (TYLCTZV), a disease that has been reported in Dodoma Region. This plant is invading farmlands in Tanzania and becoming the problem weed to the crops [15]. Scientists need to conduct more studies on different weeds, one being *Ageratum conyzoides* [4].

A variety of environmental factors affect distribution and abundance of plants [17], including soil [18, 19], rainfall and temperature [20,21]. There is a relationship between plant distribution and abundance as well as environmental variations and they need to be determined [22]. Environmental variations like nutrient status, soil texture and slope may affect the distribution and abundance of plants [22]. *Ageratum conyzoides* is an invader to Tanzanian farmlands and is now becoming problematic to crops [18]. In Tanzania especially at Mweka, There are insufficient studies on the ecology of *Ageratum conyzoides* and the gap still exists.

Therefore, this study was conducted to provide some vital information that can serve to control the weed. The main objective of this study was to find out the ecology of *Ageratum conyzoides* in riverine and non-riverine habitats of Mweka. Specific objectives were to determine spatial distribution pattern and abundance of *Ageratum conyzoides* in riverine and non-riverine habitats of Mweka and to make comparisons of the abundance of *Ageratum conyzoides* between the two sites (Riverine and non-riverine). We assumed that, *Ageratum conyzoides* is randomly distributed in riverine and non-riverine habitats of Mweka and the abundance between the two sites is similar.

STUDY AREA DESCRIPTION

Geographical Location

The study took place in riverine and non-riverine habitats of Mweka village which lies on the southern slopes of Mount Kilimanjaro [23]. The riverine habitat was the one from Kichau River while non-riverine habitat was chosen randomly from inland areas of Mweka Village. This village lies between lies between 37°15′ and 37°21′ E and 3°03′ to 3°20′ S with elevation of 800-2000 m.a.s.l. The rivers in Mweka Village have their origin from Mount Kilimanjaro.

Climate

Double rain seasons exist at Mweka, long rains start in March to June and the shorter ones start from November to January. The annual range of rainfall is 1000 to 1700 mm but it can rise up to 2500 mm depending on aspect and elevation. The temperature in Mweka varies between seasons but generally ranges between 17°C and 30°C throughout the year. The driest months are August to October and the coolest months are June to August.

Vegetation

Different types of vegetation exist at Mweka either naturally or by the influence of human being. These include tree-crop plantations, riverine vegetation, shrubs, and montane forest which are found along the slopes of Kilimanjaro National Park. The plantations are occurring between 700-2000 m.a.s.l and coffee and banana crops dominate the area although other food crops like maize, yams and beans are cultivated in the village [23]. Montane forest also forms part of the vegetation in this village located on the southern slopes of Mount Kilimanjaro. This forest lies between 1400-1800 m.a.s.l. whereby below 1800 m.a.s.l the dry montane forest exists and between 1400-1600 m.a.s.l. submontane riverine forest occurs [24]. Different species of shrubs are also found in the area such as *Lantana camara*, *Duranta arecta*, *Caesalpinia decapetala* and *Ricinus communis*. The grass species found in the area include *Pennisetum purpureum*, *Setaria splendida*, *Panicum maximum* and *Tripsacum andersonii* [25]. Herb species include *Argemone mexicana*, *Commelina bengalensis*, *Conyza floribunda*, *Euphorbia hirta*, *Tridax procumbens* and the studied one *Ageratum conyzoides*. The most common sedge in the area is *Kyilinga alba*. Both indigenous and exotic trees are found in Mweka Village including, *Albizia schimperiana*, *Croton macrostachyus*, *Dracaena usambarensis*, *Psidium guajava* [23]. Plant species most grown at the home gardens include, *Cupressus lusitanica*, *Erythrina abyssinica*, Ficus sp., *Grevillea robusta*, *Milicia excelsa*, *Persea americana* and *Rauvolfia caffra* [23].

Geology
Mweka village is mostly occupied by basic rocks which are rich in magnesium and calcium minerals [23]. These rocks are volcanic with shallow depth originated from the Archean Basement Complex [23]. According to Ngana [26], the Mawenzi lava exposes the oldest rocks which comprises of different types of rocks. All of the parent materials present in the area, which are shallow and rocky form the soil in Mweka [23].

Soil
Volcanic soil dominates Mweka Village and varies from one place to another [23], and thus classified into three types by Anderson [27] which include the upper (Umbwe Complex), the middle (Mrawi Series) and the lower part (Msinga Series). In all these parts the parental material found beneath them is either trachyte or Rhombporphyry, but Humic ferrisols is only present at the middle part (Mrawi series) while Ferruginous tropical ferrisols is present in the upper and lower parts (Umbwe Complex and Msinga Series respectively) [27].
The upper part (Umbwe Complex) has friable soil with very dark brown, gritty humic loam surface soil while its subsoil is brown colored with moderate prismatic texture [27]. The middle part (Mrawi Series) is friable with humic sandy loam texture, dark brown color surface soil while the subsoil is clay loam [27]. The lower part (Msinga Series) is also friable with slight tendency of cap; the surface soil is dark brown with sandy clay loam texture while the subsoil is dark red brown accompanied by silt clay loam texture [27].

MATERIALS AND METHODS

Data Collection
This process started with a reconnaissance survey to determine the areas for placing our vegetation quadrats.
In riverine and non-riverine sites, steel frame quadrat of 0.25 m^2 was randomly placed thirty times in 5 m × 15 m plot located by the Global Positioning System (GPS Garmin Extrex 20) and its boundaries marked by the sisal thread while its angles were marked by wooden pegs.

Procedure
The sampled area of 5 m × 15 m plot was randomly chosen in riverine and non-riverine habitats. As suggested by Elzinga et al. [28] rectangular plot was used to reduce zero and high counts as they cut across different micro habitats. In riverine area the sampled plot (5 m × 15 m) was chosen by randomizing at least 100 m from the flood plain while at non-riverine the sampled area was chosen by randomizing at least 50 m from the highest water mark. Randomization of the sampled area 5 m × 15 m plot in both sites was done by using the table of random numbers. In each of the sampled areas, thirty 0.25 m^2 frame quadrats were randomly placed as recommended by Johnson-Nistler et al. [29] and Critchley et al. [30] in their vegetation studies. For the allocation of 30 frame quadrats, sampled area (5 m × 15 m plot) was divided into three blocks of 5 m × 5 m and at each block ten 0.25 m^2 frame quadrats were randomly placed by using the table of random numbers. Each species of *Ageratum conyzoides* rooted within 0.25 m^2 frame quadrat was counted and recorded as suggested by Bullock [31].

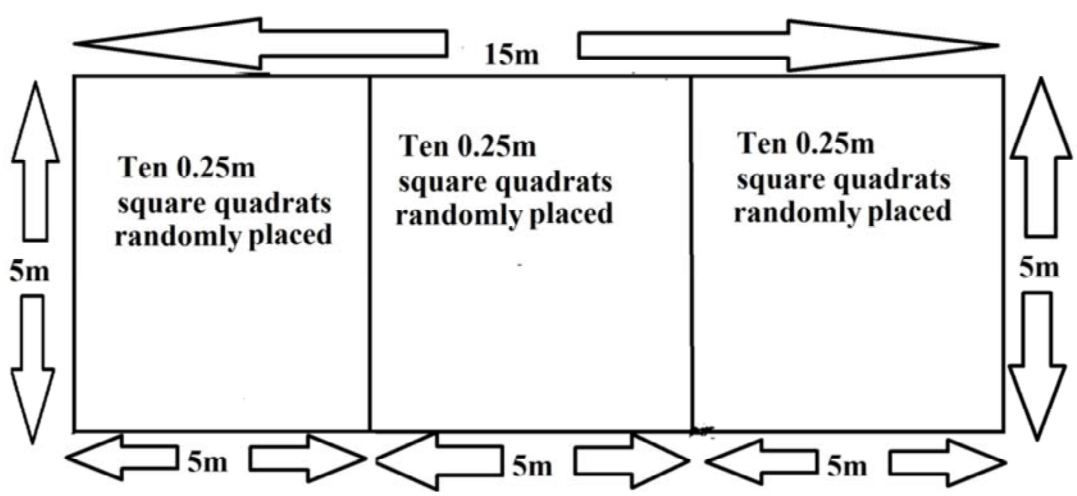

Figure 1: Illustration of the vegetation quadrat sampling technique where by thirty random 0.25 m^2 frame quadrats were placed in a sampled plot (5 m × 15 m) drawn randomly from riverine and non-riverine habitats.

Data Analysis

Both descriptive and inferential statistics were used to analyze data where mean abundance of *Ageratum conyzoides* was recorded in thirty frame quadrats, and variance of abundance per quadrat to the plot mean were calculated. Mean and variance were used to calculate the variance to mean ratio purposely to determine the distribution pattern of the species in the study area. The distribution is said to be random if variance to mean ratio is equal to 1, clumped when the variance to mean ratio is greater than 1 and regular if the variance to mean ratio is less than 1 [32]. We employed a two tailed t-test at 0.05 significance level to confirm if variance to mean ratio is significant different from 1. Plot abundance was determined by summing up the number of individual plants recorded in each frame quadrat. D'Agostino-Pearson test for normal distribution was also employed to test if the data fall under normal distribution.

R version 3.0.1, MedCalc version 12.5.0.0 and Microsoft Excel version 14.0.4760.1000 (32-bit) were also used.

RESULTS

The collected information did conform to normal distribution under D'Agostino-Pearson test for normal distribution (P=0.1172 in Riverine and P=0.1709 in Non-riverine). A total of 495 individuals of *Ageratum conyzoides* were recorded from both riverine (147) and non-riverine (348) sites. The difference in abundance between the two sites was statistically significant (t=3.070; df=58; P=0.0033). The plant density was relatively higher in non-riverine habitat (4.64 plant/m^2) than in riverine habitat (1.96 plant/m^2). The distribution pattern of the *Ageratum conyzoides* was clumped in both areas as determined by variance to mean ratio.

Distribution Pattern of *Ageratum conyzoides* in Riverine and Non-Riverine

Ageratum conyzoides was clumped in both riverine and non-riverine habitats of Mweka, with variance to mean ratio of 4.6 in riverine and 15.78 in non-riverine (Table 1). All the values varied significant from 1 (t 0.05 (2)29=21.97, P<0.05 in Riverine and t 0.05 (2)29=68.12, P<0.05 in Non-riverine) meaning that distribution pattern of *Ageratum conyzoides* is not random (Table 1). The distribution is said to be random if variance to mean ratio was equal to 1, clumped when the variance to mean ratio was greater than 1 and regular if the variance to mean ratio was less than 1.

Table 1: Variance to Mean Ratio for Riverine and Non-Riverine Habitats.

S/N	Computed population parameter	Riverine	Non-Riverine
1	Number of quadrats sampled (n)	30	30
2	Mean for the plot ($\bar{x}$)	4.9	8.47
3	Variance (S^2)=[$\sum(x-\bar{x})^2$/n-1]	22.51	133.63
4	Variance to Mean Ratio (I)=$S^2/\bar{x}$	4.6	15.78
5	$t_{calculated}$ (t)=$\lvert S^2/\bar{x} -1\rvert \div \sqrt{2/(n-1)}$	21.97	68.12
6	Degree of Freedom (df)=n-1	29	29
7	Level of significance (α)	0.05	0.05
8	$t_{tabulated}$ ($t_{0.05\ (2)\ 29}$)	2.045	2.045
9	Spatial Distribution Pattern	Clumped	Clumped

Abundance of *Ageratum conyzoides* in Riverine and Non-Riverine

Non-riverine habitat had higher abundance than riverine habitat (Figure 2) and the difference was statistically significant (t=3.070; df=58; P=0.0033).

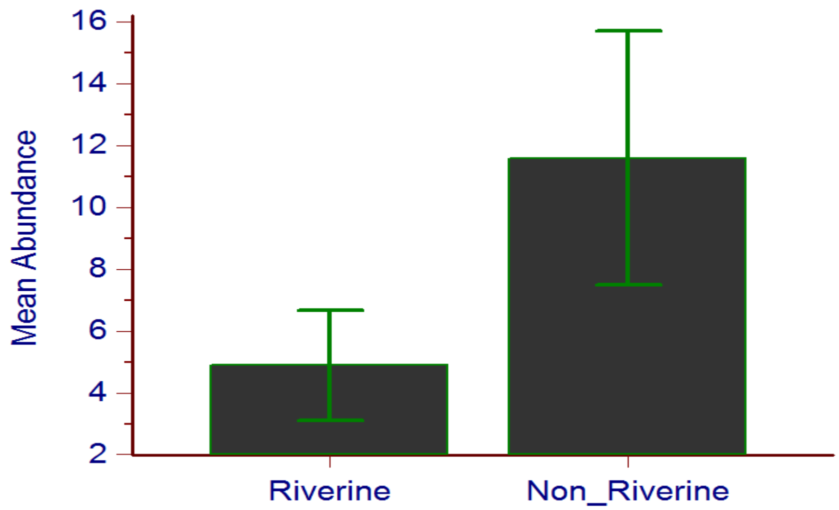

Figure 2: Mean abundance (number/quadrat) of *Ageratum conyzoides* in Riverine and Non-riverine Habitats (Riverine SD=4.74; Non-riverine SD=11.56).

DISCUSSION

Distribution of *Ageratum conyzoides* in Riverine and Non-Riverine

Three categories of distribution exist to any population, namely random, uniform and clump distribution patterns [33]. Naturally, clump distribution pattern is mostly occurring and at some observations random can also be observed [33]. But it is difficult to observe the uniform distribution pattern since environmental variables are not always similar [32,33]. Clumped distribution pattern for *Ageratum conyzoides* was observed in both areas (Riverine and Non-riverine) as per variance/mean ratio which was greater than 1. This clumped distribution pattern in both areas was inconsistent with the null hypothesis as it was predicted to be randomly distributed. The clumped distribution pattern of the plant in both sites might be influenced by patchy resource availability in the surveyed areas because the weed needs these resources for its survival [34]. Clumped distribution pattern is very common in plants both modular and unitary as *Ageratum conyzoides* is a modular plant. Clumping is regularly occurring when nutrients are concentrated in small parts within a bigger habitat [35]. The clumped distribution pattern is very common in most plants and it is influenced by availability of nutrients, specific preference of habitat and suitable environmental conditions [37,38].

Abundance of *Ageratum conyzoides* in Riverine and Non-Riverine

Species abundance in the universe is not uniform; some areas tend to have higher abundances while others have lower. This variability in abundance changes spatially and temporally and is among the main fundamental concerns of ecology [34]. Similarly, in Mweka the abundance of *Ageratum conyzoides* varies between habitats.

Non-riverine habitat had a higher number of *Ageratum conyzoides* than the riverine habitat. This difference between the two sites was statistically significant. This might be due to edaphic factors and human disturbances. The human disturbance mainly observed was crop cultivation and livestock keeping of which most were more conducted in the non-riverine habitats. Disturbances have influence on species abundance [39] and places with optimum disturbance were subjected to regeneration of vegetation hence more abundance [40]. Non-riverine area is rich in fertile soils (loam) added by human cultivation activities. The areas with good soils favour the growth and development of *Ageratum conyzoides* [41]. Plant species abundance is mostly affected by physical environmental variables which in turn affect soil chemistry [42].

CONCLUSION

Ageratum conyzoides in riverine and non-riverine habitats found to be clumped. This might have been influenced by heterogeneity of soil nutrients in the sampled area. Abundance of the species was relatively higher in non-riverine than in riverine habitat. The difference in abundances might have been associated with soil characteristics and anthropogenic factors such as agricultural activities which were more conducted in the non-riverine than in riverine sites. *Ageratum conyzoides* invaded crops such as maize as it was observed in non-riverine habitats. We suggest control measures should be developed to combat the impact of this weed and the campaign should focus much on non-riverine habitats to secure these important areas.

ACKNOWLEDGEMENTS

Thanks to Dr. Teresa J. Sylivina and Mr. Reginald T. Mwaya for their reviews and comments which has helped much in improving this work. We appreciate the support from College of African Wildlife Management, Mweka and two supportive reviewers for their valuable comments.

REFERENCES

[1] Akobundu, I.O. and Agyakwa, C.W., 1998. A Handbook of West African Weeds. Ibadan, Nigeria: International Institute of Tropical Agriculture, 162 p.

[2] Ekeleme, F., Forcella, F., Archer, D.W., Akobundu, I.O. and Chikoye, D., 2005. Seedling Emergence Model for Tropic Ageratum (Ageratum conyzoides): Weed Science, 53(1), pp. 55-61. Available from: http://www.jstor.org/stable/4046889 [Accessed: 28th March 2013].

[3] Global Invasive Species Database, 2009. Ageratum conyzoides (herb). Global Invasive Species Database. Available from: http://www.issg.org/database/species/ecology.asp?si=1493&fr=1&sts=&lang=EN [Accessed on 5th April 2013].

[4] Dogra, K.S., Kohli, R.K. and Sood. S.K., 2009. An assessment and impact of three invasive species in the Shivalik hills of Himachal Pradesh, India, International Journal of Biodiversity and Conservation, 1 (1), pp. 4-10. Available from: http://www.academicjournals.org/ijbc/pdf/pdf2009/ May/Dogra%20et%20al%20pdf.pdf [Accessed on 9th April 2013].

[5] Ming, L.C., 1999. Ageratum conyzoides: A tropical source of medicinal and agricultural products. In Janick, J. ed. Perspectives on new crops and new uses. ASHS Press, Alexandria, VA, pp. 469-473.

[6] Pacific Island Ecosystems at Risk (PIER), 2010.Ageratum conyzoides. PIER. Available from: http://www.hear.org/Pier/species/ageratum_conyzoides.htm [Accessed 9th April 2013].

[7] Hyde, M.A., Wursten, B.T. and Ballings, P., 2013. Ageratum conyzoides. L. Zimbabwe. Flora of Zimbabwe: Available from http://www.zimbabweflora.co.zw/speciesdata/species.php? species_id=15865 [Accessed on 9th April 2013].

[8] Singh, H.P., Kaur, S., Kohli, R.K. and Dogra, K.S., 2009. Ecological Impact of Invasive Weed Ageratum conyzoides on the Structure and Composition of the Native Communities in Northwestern Himalayas and Insight into the Mechanism of Invasion. In: Sim, H. C., ed. Asia and the Pacific forest health workshop: forest health in a changing world: extended abstracts from the workshop 1-3 December 2008, Kuala Lumpur, Malaysia. Vienna: IUFRO, International Union of Forest Research Organizations.

[9] Kato-Noguchi, H., 2001. Assessment of the allelopathic potential of Ageratum conyzoides. Biologia Plantarum, 44 (2), pp. 309-311.

[10] Kohli, R.K., Batish, D.R., Singh, H.P. and Dogra, K.S., 2006. Status, invasiveness and environmental threats of three tropical American invasive weeds (Parthenium hysterophorus L, Ageratum conyzoides L., Lantana camara L.) in India. Biological Invasions, 8(7), pp. 1501-1510.

[11] Kaur, S., Batish, D.R., Kohli, R.K. and Singh, H.P., 2012. Ageratum conyzoides: an Alien Weed in India. In Bahtt, J.R., Singh, J.S., Singh, S.R., Tripathi, R.S. and Kohli, R.K. eds. Invasive Alien Plants: An Ecological Appraisal for the Indian Subcontinent. CABI. Available from:www.cabi.org [Accessed on 9th April 2013].

[12] Ezechi, E.H., Kutty, S.R.M., Malakahmad, A., Isa, M.H., Aminu, N. and Salihi, I.U., 2015. Removal of Methylene Blue from Dye Effluent using Ageratum conyzoides Leaf Powder (ACLP). AIP Conference Proceedings 1669, 020013 - pp. 1-6 (2015); doi: 10.1063/1.4919151.

[13] Ezechi, E.H., Kutty, S.R.M., Malakahmad, A., Salihi, I.B. and Aminu, N., 2015. Determination of Optimum Range for Hexavalent Chromium Cr(VI) Removal using Ageratum conyzoides Leaf Powder (ACLP). AIP Conference Proceedings 1669, 020014- pp. 1-5, (2015); doi: 10.1063/1.4919152.

[14] Ezechi, E.H, Kutty, S.H.M., Malakahmad, A. and Isa, M.I., 2015. Characterization and optimization of effluent dyeremoval using a new low cost adsorbent: Equilibrium, kinetics and thermodynamic study. Process Safety and Environmental Protection, 98, pp.16–32.

[15] Kashina, B.D., Mabagala, R.B. and Mpunami, A.A., 2003. First report of Ageratum conyzoides L. and Sida acuta Burm F. as new weed hosts of tomato yellow leaf curl Tanzania virus. Plant Protection Science, 39(1), pp. 18-22.

[16] Lusweti, A., Wabuyele, E., Ssegawa, P., and Mauremootoo, J., 2011. Ageratum conyzoides (Billygoat Weed). BioNET- EAFRINET, Keys and Facts Sheet. Available from:http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Ageratum_conyzoides_%28Billygoat_Weed%29.htm [Accessed on 14th May 2013]
[17] Keddy, P.A., 2007. Plants and Vegetation: Origins, Processes, Consequences. Cambridge University Press.
[18] Medinski, T., 2007. Soil chemical and physical properties and their influence on the plant species richness of arid South-West Africa. Thesis (PhD), University of Stellenbosch.
[19] Hayati, A.A. and Al-shammary, S.H., 2011. Abiotic soil factors affecting plant distribution at Jubail Wildlife Sanctuary in the Eastern Region of Saudi Arabia. Sacha Journal of Environmental Studies, 1 (1), pp. 101-115.
[20] Woodward, F.I., 1987. Climate and Plant Distribution. Cambridge University Press.
[21] Maitima, J. M., Kariuki, P. C., Mugatha, S.M. and Mariene, L. W., 2009. Adapting East African Ecosystems and Productive Systems to Climate Change. Report for the Economics of Climate Change Adaptations in Africa.
[22] Tavili, A. and Jafari, M., 2009. Interrelations between plants and environmental variables.International Journal for Environmental Research, 3(2), pp. 239-246.
[23] William, C.M.P., 2003. The Implications of Land Use Change on Forests and Biodiversity: A Case of the"Half Mile Strip" on Mount Kilimanjaro, Tanzania. LUCID Project, International Livestock Research Institute.
[24] Ministry of Natural Resources and Tourism (MNRT) ed., 2001. Inventory Report of Kilimanjaro Forest Reserve in Tanzania.South Kilimanjaro Catchment Forest Project, Moshi.
[25] O'kting'ati, A. and Kessy, J.F., 1991. The farming systems of Mount Kilimanjaro. In Newmark, W.D. (ed), The Conservation of Mount Kilimanjaro. IUCN, Gland, Switzerland and Cambridge, UK, pp. 71-80.
[26] Ngana, J.O., 2001. Integrated water resources management: The case of the Pangani river basin. In Ngana, J.O. (Ed.), Water Resources Management in the Pangani River Basin: Challenges and Opportunities. Dar es Salaam University Press, Dar es Salaam.
[27] Anderson, G.D., 1993.The Soils and Land Use Potentials of the Southern and Eastern Slopes of Mount Kilimanjaro, Tanzania.Resource Management Paper No. 1. Institute of Resources Assessment, University of Dar es Salaam and International Development Program, Clark University, Worcester, Massachusetts, USA, pp. 22-30.
[28] Elzinga, C.L., Salzer, D.W. and Willoughby, J.W., 1998. Measuring and Monitoring Plant Populations. Bureau of Land Management. Denver, Colorado. USDI, BLM.
[29] Johnson- Nistler, C.M., Sowell, B. F., Sherwood, H. W. and Wambolt, C. L., 2004. Black tailed prairie dog effects on Montana's mixed-grass prairie. Journal of Range Management, 57(6), pp. 641 -648.
[30] Critchley, C., Allen, D., Fowbert, J., Mole, A. and Gundrey, A., 2004. Habitat establishment on arable land: assessment of an agri-environmental scheme in England, UK. Biological Conservation, 119, pp. 429-442.
[31] Bullock, J.M., 2006. Plants. In Sutherland, W.J. (Ed.), Ecological Census Techniques: A Handbook. Cambridge University Press, pp. 186-213.
[32] Greig-Smith, P., 1983. Quantitative Plant Ecology, 3rd Edition. Studies in Ecology Vol. 9. Blackwell Scientific Publication.
[33] Fangliang, H., Legendre, P., and LaFrankie, J. V., 1997. Distribution patterns of tree species in a Malaysian tropical rain forest. Journal of Vegetation Science, 8(1), pp. 105-114.
[34] Molles, M.C. and Cahill, J.F., 2008. Ecology: Concepts and Applications. McGraw-Hill Higher Education.
[35] Walker, S.E., 2011. Density and Dispersion. Nature Education Knowledge 3(10):3: Available from:http://www.nature.com/scitable/knowledge/library/density-and-dispersion-19688035 [Accessed on 9th November 2012].
[36] Krebs, C.J., 1994. Ecology: The Experimental Analysis of Distribution and Abundance, 4th Edition: Addison-Wesley Educational Publishers.
[37] Kohli, R.K., Batish, D.R. and Singh, H.P., 2005. Ecology: Population and Community Ecology. Available from:http://nsdl.niscair.res.in/bitstream/123456789/153/1/Population+and+community.pdf [Accessed on 20th August, 2013].
[38] Blackburn, T.M., Cassey, P., and Gaston, K.J., 2006. Variations on a theme: Sources of heterogeneity in the interspecific relationship between abundance and distribution. Journal of Animal Ecology, 75, pp. 1426–1439.

[39] Mollels, M.C., 2009. Ecology: Concepts and Applications, 5th Edition. McGraw-Hill Science/Engineering/Math.
[40] Thonicke, K., Venevsky, S., Sitch, S. and Cramer, W., 2001. The role of fire disturbance for global vegetation dynamics: Coupling fire into a dynamic global vegetation model. Glob. Ecol. and Biog., 10, pp. 661- 677.
[41] Khan, M. S., Tiwari, A. K., Ji, S. H. and Chun, S. C., 2012. Ageratum conyzoides and its role in begomoviral epidemics; Ageratum enation virus: An emerging threat in India. VEGETOS,25 (2),pp. 20-28.
[42] Enright, N.J., Miller, B.P. and R. Akhter, R., 2005. Desert vegetation and vegetation-environment relationships in Kirthar National Park, Sindh, Pakistan. Journal of Arid Environments, 61, pp. 397-418.

INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

ISSN 2231-4490

International Journal of Plant, Animal and Environmental Sciences