Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print), 2222-3045 (Online)
http://www.innspub.net
Vol. 6, No. 2, p. 8-15, 2015

INNSPUB

RESEARCH PAPER OPEN ACCESS

Temporal trends in phenology and demographic status of *Acacia modesta* population in Malakand Division, Pakistan

Zahid Muhammad*, Nasrullah Khan[1], Atta Ullah[1]

Laboratory of plant Ecology, Department of Botany University of Malakand Dir Lower, Pakistan

Key words: Malakand division, *Acacia modesta* population, Demography, Phenology.

Article published on February 01, 2015

Abstract

Population of *Acacia modesta* was monitored for demographic and phenology purposes in Malakand division Pakistan during 2013. The study sites were located on hills slopes and open graveyards from 593 to 1185 meter elevation. Density, height and diameter were noted for each tree in all stands and their population dynamics like static life table, diameter/height verses density curve were calculated. Density diameter curve was reverse J shaped representing sustainable regeneration status of the population. Mortality of seedling was 71% while life expectancy was higher for saplings among all other stages. The life table represent that seedling stage is the shortest life stage and only 21% of seedling population develop into saplings stage. Phenological study revealed that leaves formation starts in March while flower sprouting in June. Leaves and pods senesces starts in November and December. The aim of the study was to draw attention towards population structure, present and future status of *Acacia modesta* population on conservation and management perspective.

***Corresponding Author:** Zahid Muhammad ✉ Zasa1989@gmail.com

Introduction

The word *Acacia* is derived from Greek word 'akis' meant sharp point, majority of which are trees and shrubs but rarely herbs. They can grow in any type of extreme conditions including xerophytic and water logged soils majority of which are distributed in Africa and Australia (Ibrar, 2011). The genus *Acacia* is dominated by woody species in tropical, subtropical and semi arid areas throughout the world (Ross 1981). They provide timber wood, fruits, fodder, secondary plant products and many others for the welfare of human beings (Turnbull, 1987). Wiegand *et al* (1999) studied *Acacia* trees in arid region with high death rate and limited recruitment. According to Ward and Roher (1997) that death rate for *Acacia* trees are different at variety of life stages and only 61% of the whole population reach to mature stage due effects of anthropogenic, climatic and various biotic factors. Jusaitis (2009) reported from Tumby Bay on the Eyre Peninsula in South Australia a coastal region and observed that marked absence of juvenile resulted in low natural recruitment for *Acacia whibleyana*. Xerophytes are modified in the arid environment with various morphological, anatomical and physiological features to avoid xeric conditions. Among these life saving features are reduce foliar area, shedding of leaves and branches are common phenomenon (Oppenheimer, 1960).

Acacia modesta (Linn) Wall, is distributed in Pakistan, Afghanistan and India having deciduous nature, moderate size tree is distributed in the foothills ranges of Himalayas below 1200 meter elevation, Salt Range, Sulaiman Hills, Balochistan, Kirthar Range and plains areas adjacent to these mountains ranges in Pakistan. As a multipurpose tree it used as Fodder, fuel, agricultural implements, hedge, apiculture, and gum (Sheikh, 1993).

Nowadays the specie *Acacia modesta* is not endanger, but improper, uncontrolled harvesting and lack of conservation measures, can lead this specie into susceptible type due to continuous decline of its population.

Most studies are conducted on natality and mortality on early growth stages of plant life due to their critical nature not only, but also these stages enhance the effectiveness of controlled experiments and their performances. In majority of plant populations, population characteristic changes with diverse generations having Varity of structural and life stages (Turner *et al.,* 1966 and Hegazy, 1990). In the present research temporal trends in phenology, demographic status and population dynamics of *Acacia modesta* forests in Malakand division, Pakistan was studied. The aim of the study was to quantify the population characteristics for knowing of basic information for biodiversity conservation measures and assessment of the respective specie.

Materials and methods

Study area

Malakand division is geographically distributed within varying ranges of altitudinal, latitudinal and altitudinal coordinates. The area fall under 34° to 36° N latitude and 71° to 73° E longitude within elevation range of 500 meter to 3000 meter at Malakand and Chitral respectively (Bangash and Alam, 2003). The basic origin of rocks are igneous and Meta sediments rocks from Precambrian and lower Paleozoic era (Hussain, 2002). The study area belonged to Sino Japanese and some areas to Saharo-sindian climatic region (Shinwari and Shinwari, 2010). December, January and February are the coldest months while June, July and August are the hottest months of the year mean monthly rainfall is 112 mm (wunder ground 2013).

Field methods

Table 1 represent the GPS data of the major distribution zones of the Malakand division occupied by four districts and 32 study sites. Thirty two natural forests dominated by *Acacia modesta* distributed in open graveyards and foothills of Malakand division with at least 0.5 ha and least disturbing history were selected. 10 quadrates of $100m^2$ were laid along with a line transect in a specific direction followed by Curtis and Mclntosh (1950). In each quadrate Trees number was counted while height was determined by stick method and diameter by forestry tapes at 1.37 cm height. Individuals were divided into three growth stages, with Diameter 0-3cm were considered seedlings, from 4-5 cm were saplings and above trees which. For observing general appearance throughout the year (phenology) of the population a site dominated by *Acacia modesta* was selected and monthly visited from January 2013-december 2013) was arranged for determining and observing monthly events and changes (growth, developing fresh leaves, flowering, fruiting, senescence). The trees were selected for phenological observations and photographs were taken of each observation in each month to determine foliar and flowering stages of the specie.

Table 1. Geographical distribution of the study sites in Malakand division, Pakistan.

site No	Major distribution zone	No of stands studied	Longitudinal (E) range	Latitudinal (N) range	Altitudinal range(m)
1	District Dir lower	14	71°47-72°04	34°38-34°46	593-842
2	District Malakand	14	71°44-71°59	34°31-34°37	598-992
3	District Swat	2	72°14	34°41	831-856
4	District Buner	2	72°17	34°36	1182-1185

Data treatment

The number of individuals of *Acacia modesta* in different life stages was classified into various DBH size classes. For seedlings the criteria was 0-3cm, saplings 4-5cm and trees on wards with 10cm intervals. DBH Diameter and height classes were made on regular intervals on per hectare basis in Excel worksheet following Dombios and Ellenberg (1974). The polynomial curve was fit to disclose the pattern of distribution and regeneration status of *Acacia modesta* in the study area. Life table was calculated from the observations of stem diameter size density/ha after Tiwari (2010).

Results

Population demographic status

Diameter/height

Height and diameter at breast height classes were constructed on hectare basis for whole sampled area at given intervals in feet for height and centimeter for diameter sizes given in graph (1). From the diameter at breast height graph it is clear that 57% of the whole population was belonged to lower diameter size classes (6-15 cm, 16-26 cm) followed by seedlings stage which constitute 22% of the total population. Highest number of trees in lower DBH size classes represents stable nature and regeneration status of those particular sizes. The polynomial curve represent that the population size gradually decreases with increasing diameter size, showing a decline status of population toward maturity. The reason is either tree dropping by storm due to high size or cutting for various purposes. Also from the graph it is clear that largest number of population comprised of lower height size classes including seedling and saplings of varied height. The polynomial curve for height is inverse j shape or L shape representing high density of lower height classes steadily followed by lower density of higher height size indicating stable population and distribution pattern.

Population life static table

Table 2 represents demographic status of various life stages. First column represent life stages of the life cycle of *Acacia modesta*. The columns represented by ax and lx represent the actual density and proportional density at beginning of life cycle, Similarly column 4 and 5 show density of dead individuals and mortality rate. Lx and Tx representing survived individuals while ex is the expected life at each stage. Fig. 3(a) illustrate survivorship curve (lx) for *Acacia modesta* representing a gradual decline from seedling stage to sapling stage which sharply increased with juvenile stage (6-15cm) and then gradually decreases with increasing age (Table 2). Mortality (qx) curve is represented by graph 3(b), showing high mortality in seedling stage and old stages of Life with some intermediate variability in different age groups. The population of *Acacia modesta* is represented by 22.30% seedlings, 6.38% saplings and 71.37% trees. Therefore the population is highly constituted by trees stages following by seedling stages. Mortality rate of seedling population was 71%, a first death peak during population development of *Acacia modesta* and only 29% of the whole seedlings population developed into saplings stage of life. The life expectancy (ex) value was high for saplings stage (11.66) followed by seedlings stage (3.98). The life expectancy values show no marked variations in majority of tree ages (graph 3c).

Table 2. Static life table for *Acacia modesta* population in Malakand division, Pakistan.

(DBH) size classes	ax	lx	Dx	Qx	Lx	Tx	ex
Seedlings	311	1000	713.83	0.71	643.08	3982.26	3.98
Saplings	89	286.17	-1559.48	-5.5	1065.91	3339.18	11.66
6—15	574	1845.65	1093.24	0.59	1299.03	2273.27	1.23
16—25	234	752.41	456.59	0.6	524.11	974.24	1.29
26—35	92	295.82	118.98	0.4	236.33	450.13	1.52
36—45	55	176.84	112.54	0.63	120.57	213.8	1.21
46—55	20	64.3	28.93	0.45	49.83	93.23	1.45
56—65	11	35.37	16.08	0.45	27.33	43.4	1.22
66—75	6	19.29	12.86	0.67	12.86	16.07	0.83
76—85	2	6.43	6.43	1	3.21	3.21	0.5

ax=survival individuals, lx=proportion of survival of individuals from beginning to age x, $lx=ax/x^o\times1000$, dx=number of dead individuals from age x to x+1, dx=lx-lx+1,qx show mortality from x to x+1,qx=dx/lx, Lx show mean number of survival individuals from age x to x+1, Lx=(lx+lx+1)/2, Tx=total number of survival individuals from age x, Tx=∑Lx, ex is the life expectancy at age x, ex=Tx/lx.

Trends in phenology

The present study stress upon phenological behavior of *Acacia modesta* in the form of young foliar branches development, senescence, fruit formation and maturation at different seasons of the year. From the study it is clear that young foliar formation is started at March on old branches followed by young shoot tips formation in April. Maximum foliar area is covered by leaves in May and June later of which mature in July. Mature foliage senescence start in August increasing in September while minimum leaf cover takes place in October and November and maximum branches appear naked due to leaves shedding and senescence. Flowering formation and development in *Acacia modesta* consist of several periods of the year, continue till maximum seed productivity. Flower formation start at the beginning of May on old branches majority of which cannot develop into fruiting stage due to drooping by high storms or heavy rainfall. Flowering formation is varied in different locations depending on geographical distribution and climatic conditions of the area. The second flowering period is highly productive due to flower formation on freshly developed shoots and old branches, about 80% pods produced by the second flowering stage.

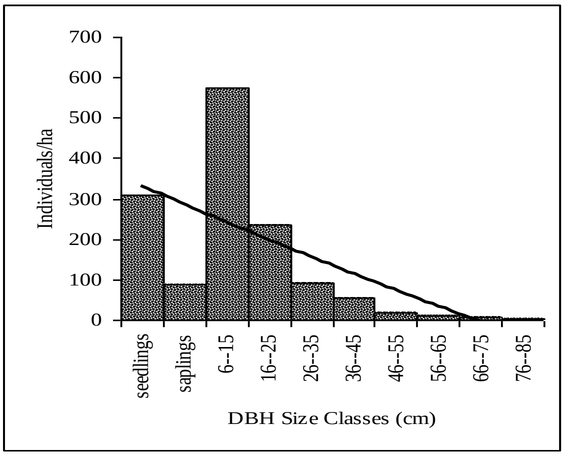
Seeds and pods formation is continue with flower formation with passage of time and maximum seed output is observed in pods developed in later stages as compared to pre flowering stages. Pods are varied in size and ranged from 5 to 8 cm in length and ripening begun in November.

Discussion

Population demographic status

Diameter/height

Distribution of *Acacia modesta* natural forests in Malakand division, Pakistan is varying according to varied topographic, Climatic and edhapic factors of the sites. Distribution of different Height and diameter sizes depends on the human and other biotic and a biotic factor. According to Chaghtai *et al* (1978) the Muslims graveyards are the least disturbed will protect sites of variety of vegetation. Due to some religious attitudes some forests are protected from various declining and destruction factors by local inhabitants by declaring them revered jungles in various semi-tribal areas of Pakistan since British era (Shah *et al.,* 2012). The declining of large size classes is due to the results of forceful anthropogenic and factors with other climatic factors like drought (Hegazy and Elhag, 2006). From the Size distribution of *Acacia modesta* it is clear that population is greatly depends on site and its disturbing factors. Majority of lower size trees were observed in foothills while large size volumes in graveyards, however ordinary variation in size, intra-specific competitions in high density stands, soil factors, grazing effects and pathogen activities all donate a combined pressure on plant size (Jusaitis *et al.,* 2009). Density diameter curve for *Acacia modesta* population combined for all the stands was L shape or inverse J shape representing regeneration stability. Inverse J shape curve for diameter verses density indicate highly sustainability of regeneration status and young stage (Vetaas, 2000). There was observed very fewer numbers of trees with high diameter size classes followed by seedlings and saplings stages (Fig. 2). It was found that majority of higher girth size trees was lower due to less covered areas occupied. The results show that density for lower size classes was high as compared to higher size classes. Seedlings and saplings density was 311 and 89 individuals per hectare representing high seedling mortality (71%) due to grazing human and intense climatic conditions indicated in Fig. 2.Maximum number (38%) of individuals observed in lower height size class (1-10 feet) while only 3% individuals of the whole population was found in higher height size classes (41-50 and 51-60), stated that lower size classes are more favor than high size classes (Fig. 2). The lower height size classes may be due to trees dropping by high storm or cutting (Ahmed *et al,* 2009). Mortality of the seedlings was highest and only 29% of the total seedlings population develops to saplings stage. In the present study high life expectancy was observed for individuals of *Acacia modesta* having diameter size of 4-5 cm and reduces with increasing diameter size which may be possibly due to anthropogenic and climatic conditions. Survivorship curves show irregular peaks for each individual life stage (graph 2).



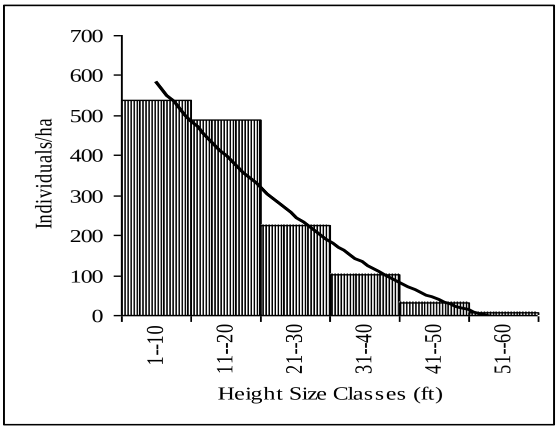
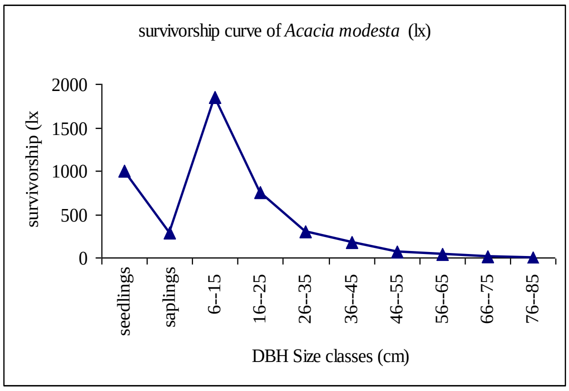
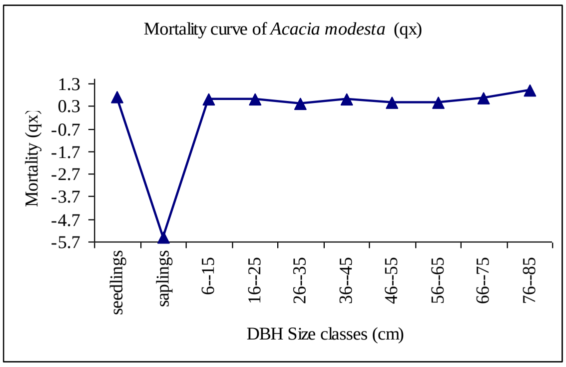


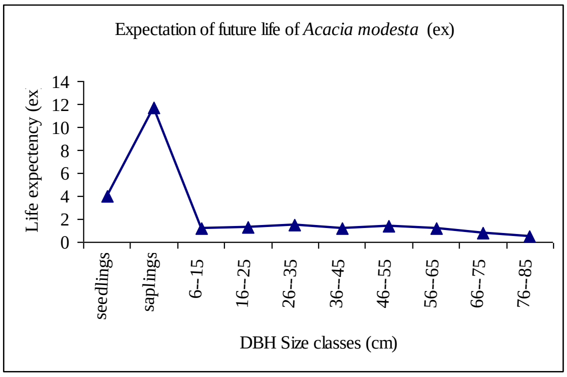
Fig. 1. Diameter and Height size classes for *Acacia modesta* population verses density/ha.



(a)



(b)



(c)

Fig. 2. a) changes in survival of individuals of *Acacia modesta* b) Mortality rate of *Acacia modesta* individuals in different life stage c) Life expectancy of different life stages of *Acacia modesta*.

Trends in phenology

Trends in phenology are the annual presentation of life stages like flowering, fruiting, senescence and growth of shoot apices through changes in various spatial and temporal conditions. Defoliation on old branches during hot summer and scarcity of water is considered as an adaptation to severe and adverse conditions (Hegazy and Elhag, 2006). In areas with heavy rainfall and storm partial defoliation is resulted. Formation of new leaves is favored in rainy and hot season particularly in moon soon. Leaves formation does not affect seed and pod formation; however flowering stage is affected by defoliation and formation of new shoot tips. Leaves shedding are Maximum in October-November due to winter changes in climate and pods appear on semi barren branches. The phenological stages are mainly concerned with flowering stage (Moustafa *et al.,* 1996). The phenological events of *Acacias* are the results of internal body rhythms which remnant its unique phenology behavior adapting to its locality of occurrence (Springuel *et al.,* 1996). On productivity base *Acacia modesta* start flowering during May and continue till July depending on geographical distribution, increasing seed output. Fruit formation starts in June and July and mature at end of October, Senescence of ripen pods and leaves occur In November and December, trees show brown red coloration at this stage.

Conclusion and recommendations

Density diameter curve was inverse J or L shape representing will regeneration status. In *Acacia modesta* population of Malakand division Pakistan the trees density was decreases with increase in Diameter size. Seedling mortality was high as compared to other stages due to over grazing uncontrolled cutting and lack of proper management. Saplings stage has highest life expectancy. Minimum number of higher diameter and height size classes show disturbances in these forests. Summer season is the productive stage of new generations and climatic conditions during this stage greatly effects productivity of the seeds output.

The population structure and dynamics can be improved 1) Through regular estimation and monitoring of the respective population stages 2) prevention, protection and proper nursing of seedling, sapling and juvenile stages 3) regulation, check and control on local human impacts e.g. Grazing, cutting 4) understanding proper knowledge of conservation and population biology.

References

Ahmed M, Khan N, Wahab M, Hamza S, Siddiqui MF, Nazim K, Khan, MU. 2009. Vegetation structure of *Olea ferruginea* Royle forests of lower Dir district of Pakistan. Pakistan journal of Botany **41,** 2683-2695.

Bangash FK, Alam S. 2003. Assessments of pollutants and its impacts on drinking water quality of Malakand division. Pakistan Journal of chemical Society of Pakistan **25,** 1-8.

Curtis JT, Mclntosh RP. 1950. The interrelations of certain analytic and synthetic phtosociological characters. Ecology **31,** 434-455.

Dombios M, Ellenberg H. 1974. Aims and methods of vegetation ecology. John Wiley and sons Inc New York.

Hussain M. 2002. The Impacts of Eucalyptus Plantations on The Environment Under the Social Forestry Project Malakand Dir. environmental audit report. Environment and governance series.

Hegazy AK. 1990. Population ecology and implications for conservation of Cleome droserifolia: a threatened xerophyte. Journal of Arid Environment **19,** 269-282.

Hegazy AK, Elhag M. 2006. Considerations of demography and life static table analysis for conservation of *Acacia tortilis* in south Sinai. World applied science Journal **1,** 097-106.

Ibrar K. 2011. Phytochemical evaluation, bioassay screening and Standardization of *Zizyphus jujuba* and *Acacia modesta*. PhD thesis University of Peshawar Peshawar.

Jusaitis M, Sorensen B, Polomka L. 2009. Population Structure, Flowering and Seed Production in the Endangered Whibley Wattle, *Acacia whibleyana* (Leguminosae: Mimosoideae). The Open Conservation Biology Journal **3,** 4-13.

Moustafa AA, El Wahab RHA, Helmy MA, Batanouny KH. 1996. Phenology, germination and propagation of some wild trees and shrubs in South Sinai, Egypt. Egypt Journal of Botany **36,** 91-107.

Oppenheimer HR. 1960. Adaptation to drought: xerophytism. Arid zonesres., UNESCO, Paris **15,**105-138.

Ross JH. 1981. An analysis of African acacia species, their distribution, possible origion and relationship. Bothalia **13,** 389-413.

Sheikh MI. 1993. Trees of Pakistan. Pictorial Printing (Pvt) Ltd, Islamabad.

Shinwari MI, Shinwari MI. 2010. Botanical Diversity in Pakistan; Past Present and Future. World environment day.

Shah A, Hussain S, Din N, Bhatti KH, Khan A, Marwat SK, Zafar M, Ahmad M. 2012. Sacred Jungles: A Traditional Way of Conserving Endangered Ecosystems and Biodiversity in Semi-Tribal Area, Kurd Sharif & Sho (District Karak, Khyber Pakhtunkhwa), Pakistan. Science Technology and Development **31,** 312-326.

Springuel I, Shaheen AS, Murphy KJ, West NE. 1996. Effect of grazing, water supply and other environmental factors on the natural regeneration of *Acacia raddiana* in an Egyptian desert wadi system. Rangelands in a sustainable biosphere. Proceeding of the Fifth International Rangeland Congress Salt Lake City, Utah, USA **1,** 529-530.

Tiwary RM. 2010. Community Structure and Regeneration of Sub-alpine *Abies spectabilis* (D.Don) Mirb. Forest in Langtang National Park, Central Nepal. M.sc thesis. Central Department of Botany Tribhuvan University Kirtipur Kathmandu Nepal.

Turnbull JW. 1987. Australian Acacias in developing countries. Australian centre for international agricultural research proceedings 16(ACIAR, Canberra).

Turner RM, Alcorn SM, Oting G, Booth JA. 1966. The influence of shade, soil and water on saguaro seedling establishment. Botany Gazettes **127,** 95-102.

Vetaas OR. 2000. The effect of environmental factors on the regeneration of *Quercus semecarpifolia* Sm. in Central Himalaya, Nepal. Plant Ecology **146,** 137-144.

Wiegand K, Jeltsch F, Ward D. 1999. Analysis of the population dynamics of acacia trees in the Negev desert, Israel with a specially-explict computer stimulation model. Ecological Modeling **117,** 203-224.

Ward D, Roher C. 1997. Anthropogenic causes of high mortality and low recruitment in three acacia tree taxa in the Negeve desert Israel. Biodiversity conservation **6,** 877-893.