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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

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Full Length Research Paper

Restoration of spent oil degraded soil with bio and inorganic fertilizers using *Manihot esculenta* Crantz as a test crop

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This study was carried out on spent oil degraded soil using bio and inorganic fertilizers to attempt its restoration using *Manihot esculenta* Crantz., as test crop under Screen House conditions. Nine (9) kg of spent oil contaminated and uncontaminated soils were each crushed and weighed into 10 L plastic pots with Camry Premium Scale (Model J100/2839). All pots were perforated at the base to drain excess water. The pots were arranged in completely randomized block design and replicated three times. Cow dung, Human effluent and NPK fertilizer were applied to the soil at the rates of 50, 100 and 150 g two weeks after planting cassava stems. The following morphological parameters were used to assess plant growth: plant height, leaf length, leaf width, stem diameter, number of nodes, leaf fall were taken for 20 weeks and fresh and dry weights of tubers immediately after harvest and drying, respectively. The highest growth was recorded in uncontaminated soil (control) which had the highest mean plant height (52.77±17.22 cm); followed by soil treated with 150 g NPK with a mean plant height of 42.47±24.70 cm. Soils treated with human effluent at 50 g had the least plant height of 17.08±5.05cm. The best performance of the cassava test species was recorded in the spent oil contaminated soil amended with NPK and closely followed by contaminated soil remediated with cow dung treatment. The findings of this study revealed that addition of bio and inorganic fertilizer was useful in remediating spent oil polluted soil.

Key words: Soil amendment, degraded soil, bio- and inorganic fertilizers, *Manihot esculenta*.

INTRODUCTION

Soil provides the essential nutrients required for plant growth and development. The presence of pollutants in soils affects normal soil chemistry in that nutrient release and uptake as well as amount of water is reduced in polluted soils as compared to unpolluted soils. Spent oil is a toxic soil contaminant not naturally found in the environment (Dominguez-Rosado and Pichtel, 2004). It gets to the environment through discharge and activities of motor

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vehicle and generator mechanics (Odjegba and Sadiq, 2002) and from the exhaust system of automobile engines due to engine leakages (Anoliefo and Edegai, 2000; Osubor and Anoliefo, 2003). In Nigeria, about 20 million gallons of spent engine oil are generated annually from mechanic workshops and discharged carelessly into the environment (Faboya, 1997; Adegoroye, 1997). Oil contaminated soils are therefore of environmental concern because they are unsuitable for agricultural and recreational use and are potential sources for surface and ground water contamination (Schwab and Banks, 1999). Reports have shown that oil contamination affect plants adversely by creating conditions which make essential nutrients like nitrogen and oxygen needed for plant growth unavailable to them (Agbogidi et al., 2007). According to Henner et al. (1999), some volatile organic fractions with less than 3 rings are found in spent oil. These compounds are known to have severe inhibitory impact on germination of several plant species. Another group of chemical compounds which are found abundantly in spent oil are polycyclic aromatic hydrocarbons, and they are known to have indirect secondary effects in plants including disruption of plant-water-air relations (Renault et al., 2000).

Remediation of contaminated soils using bio-fertilizer is a natural process of oil clean-up and it is cost effective, although microbial seeding is inevitable as it converts the hydrocarbons into harmless by-products (Li et al., 2009). An uncommon way of soil remediation is by the use of bio-fertilizers such as cow dung and human effluent popularly regarded as waste and inorganic fertilizer [nitrogen-phosphorus-potassium (NPK) fertilizer]. The effectiveness of bio-fertilizers and inorganic fertilizers (cow dung, human effluent and NPK) in soil remediation are becoming acceptable technology in the clean-up of petroleum contaminated soils. Many researchers have considered the concept of using bio fertilizer to improve oil contaminated soils (Krishan et al., 2005). Molindo (2008) found that irrespective of the enormous organic wastes potential in Nigeria, very small amount is utilized to increase soil fertility and crop productivity. Therefore, it may be inferred that there is under utilization of this natural resources by farmers. This study is an attempt to establish the use of bio fertilizers as viable means of soil restoration in an environmentally benign and sustainable way in order to maximize the use of local resources and also save local farmers cost of remediating such soils through more expensive means. This study therefore examines the potential of bio-fertilizers and inorganic fertilizers (cow dung, human effluent and NPK) in the amendment of spent oil contaminated soils.

MATERIALS AND METHODS

The experiment was carried out in a Screen House at the Department of Botany, Faculty of Science, University of Ibadan, Ibadan, Nigeria. The University of Ibadan lies between latitude 3° 53´ E and 26´ N, the altitude of 185 m above sea level (Akin-Oriola, 2003) with a mean daily temperature of 24.6°C (Uka and Chukwuka, 2007). Samples of spent oil contaminated soils were collected and transported from Mechanic Village, Samonda, Ibadan to the Screen House of the Department of Botany, University of Ibadan, Ibadan. Samples of uncontaminated soils were also collected from the same location. For this study, two control experiments were set up-spent oil contaminated soil without any treatment (Control 1) and uncontaminated soil (Control 2). The soils were crushed to break down soil aggregates and sieved through a 1 cm metal sieve mesh. Fresh stem cuttings of *Manihot esculenta* (TMS- 581) sourced from International Institute for Tropical Agriculture (IITA), Ibadan, were used as test plant species for the study. The treatments used for the study include: cow dung, human effluent and NPK fertilizer. These were obtained from the Animal Research Farm of the Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria. The cow dung and human effluent were sun dried, crushed and sieved with a 1 cm metal sieve mesh. Nine kilograms of soil was placed into 10 L buckets perforated at the base to allow excess water to drain out. The fresh cassava stem cuttings were buried at a slant angle of about 45°C into the soils. Spent oil contaminated soil was amended with NPK, human effluent and cow dung individually at different concentrations and replicated three times, two weeks after sprouting of the cassava plants. The treatment details are given in the Table I below.

The performance indices of cassava were taken weekly. Data on the following parameters were noted and recorded: sprouting rate, plant height (cm), leaf length (cm), leaf width, (cm), stem diameter (mm), number of nodes, leaf fall, tuber fresh and dry weights (g). Determination of total hydrocarbons was carried out according to Song et al. (2002). Dry matter and moisture determination by the method of AOAC (2003) was adopted for the study. Phosphorus determination was done using the spectrophotometric method. Determination of Mg, Pb, Cd, Mn, Fe and Zn were carried using Atomic Absorption Spectrophotometer (AAS). pH was determined with the help of a digital pH meter. Data obtained were analyzed using analysis of variance with SAS PROC GLM. Means were separated using Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

The physicochemical properties of contaminated and uncontaminated soil samples are as shown in Table 2. The two soil types were different in pH and chemical composition. The contaminated soil was slightly alkaline (7.22) while the uncontaminated soil was slightly acidic (6.36). Organic carbon was higher in contaminated soil than in uncontaminated soil. The total hydrocarbon content in spent oil contaminated soil was 13.12% with some traces in the uncontaminated soil. The soil physicochemical properties showed an increase in the organic content of contaminated soil when compared with uncontaminated soil. This is in agreement with previous work reported by Roscoe and Russell (1980) that soils contaminated with crude oil show large increase in total organic carbon when compared with normal soils. Moisture is a crucial environmental variable. Moisture level affects soil respiration, and as such, the environment must contain sufficient water for maximum microbiological action (Sims, 1990). According to Vidali (2001), 25-28% of water holding capacity is required for microbial activity. The low moisture content of contaminated soils could be attributed to the effect of hydrocarbons in the soil according to Rowell (1977) who reported that in heavily polluted soils, water droplets

Table 1. Treatment detail of organic and inorganic fertilizers in the contaminated and control soils.

Treatment details (in triplicates)	Controls (in triplicates)
50 g NPK + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
100 g NPK + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
150 g NPK + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
50 g Human effluent+ Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
100 g Human effluent + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
150 g Human effluent + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
50 g Cow dung + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
100 g Cow dung + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil
150 g Cow dung + Spent oil contaminated soil	Control 1: Spent oil contaminated soil, Control 2: Uncontaminated soil

Table 2. Physico-chemical properties of spent oil contaminated soil and uncontaminated soil.

Parameter	Values	
	Spent oil contaminated soil	Uncontaminated soil
Total petroleum hydrocarbon (%)	13.12	0.11
Total organic carbon (%)	0.15	0.09
Available phosphorus (mg/kg)	458.86	1815.67
pH	7.22	6.36
Percentage moisture	2.46	3.14
Fe (mg/kg)	3685.75	274.28
Cd (mg/kg)	2.47	0.49
Pb (mg/kg)	71.70	26.8

adhere to the hydrophobic layer formed, and this prevent wetting of the inner parts of soil aggregates.

Table 3 shows the effects of NPK, human effluent and cow dung on the growth of *M. esculenta*. The highest growth was recorded in uncontaminated soil (control) which had the highest mean plant height (52.77±17.22 cm); followed by soil treated with 150 g NPK with a mean plant height of 42.47±24.70 cm. Soils treated with human effluent at 50 g had the least plant height of 17.08± 5. 05cm. In all parameters measured, soils treated with NPK gave the highest performance which is in line with the work of Lee et al. (1995) who reported greater effect of NPK fertilizer than poultry dung in stimulating crude oil degraded soils by increasing total heterotrophic microbial growth activity. Also, Parr et al. (1986) reported that composted animal manure and sewage sludge can be more resistant to microbial attack and release their nutrients at a relatively slow rate. This is also in line with the findings of Cornell University Nutrient Guide cited by Samantha (2009) who stated that synthetic fertilizers (NPK) produce quick results while natural fertilizers work slowly over time to improve soil. Leaf fall was highest for 100 g of NPK with a mean leaf fall of 2.02±1.82, while the least leaf fall was recorded in NPK 150 g and spent oil contaminated soil with mean values of 1.19±1.76, respectively.

The fresh yield of cassava (six months after planting and establishment) is presented in Figure 1. The highest yield was recorded in uncontaminated soils (Control 2)

Table 3. Effects of NPK, human effluent and cow dung on the growth parameters of cassava studied.

Treatment (g)	Sprout rate	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Stem diameter (mm)	Number of nodes	Leaf fall
NPK 50 + CONT.	2.09±0.88^{ab}	40.71±18.91^{b}	27.63±8.18^{c}	16.57±4.93^{b}	6.10±2.74^{c}	15.85±6.15^{c}	1.86±2.36^{a}
NPK100 + CONT.	2.01±0.86^{ab}	37.24±16.78^{b}	28.33±8.12^{c}	16.70±4.17^{b}	6.72±3.08^{c}	17.80±5.09^{b}	2.02±1.82^{a}
NPK 150 + CONT.	1.18±0.45^{d}	42.47±24.70^{b}	31.10±10.14^{b}	17.68±4.52^{b}	7.88±4.31^{b}	18.04±8.18^{b}	1.19±1.47^{a}
HE 50 + CONT.	1.88 ±1.20^{ab}	17.08± 5.50^{d}	18.78±6.95^{e}	10.66±2.29^{c}	3.65±1.86^{e}	7.98±2.50^{f}	1.44±1.91^{a}
HE100 + CONT.	1.17±0.710^{d}	22.55± 8.08^{dc}	19.36±5.11^{ed}	11.69±2.63^{c}	5.08±2.26^{d}	10.50±3.23^{ed}	1.30±2.41^{a}
HE 150 + CONT.	1.74±1.72^{bc}	20.49±7.67^{dc}	20.05±4.94^{ed}	11.71±2.20^{c}	4.68±2.12^{ed}	8.92±2.50^{ef}	1.27±1.70^{a}
CD 50 + CONT.	1.82±0.65^{b}	22.05±7.99^{d}	18.82±4.25^{e}	1.61±2.23^{c}	4.46±1.88^{ed}	10.21±2.29^{ed}	1.63±2.33^{a}
CD 100 + CONT.	1.30±0.57^{d}	23.88±9.50^{dc}	20.23±3.83^{ed}	11.63±2.20^{c}	4.81±2.12^{d}	11.94±3.25^{d}	1.33±1.62^{a}
CD 150 + CONT.	2.23±1.08^{a}	22.09±7.53^{dc}	19.98±3.42^{ed}	10.70±1.49^{c}	4.65±2.20^{ed}	9.78±2.39^{ef}	1.58±1.88^{a}
SPENT OIL CONT. SOIL (Control 1)	1.24±0.54^{d}	23.52±9.25^{c}	21.96±9.20^{d}	11.77±2.22^{c}	4.640±2.20^{ed}	9.91±4.85^{e}	1.19±1.76^{a}
UNCONT. SOIL (Control 2)	1.39±0.62^{dc}	52.77±17.22^{a}	40.23±9.76^{a}	21.88±3.64^{a}	9.50±3.96^{a}	24.67±6.43^{a}	1.45±1.78^{a}

Each value is the mean plus standard error for three replicates at p≤0.05. Same letters under the same column are not significantly different using DMRT. Key: CD = cow dung; HE = human effluent; CONT=contaminated soil; UNCONT=uncontaminated soil.

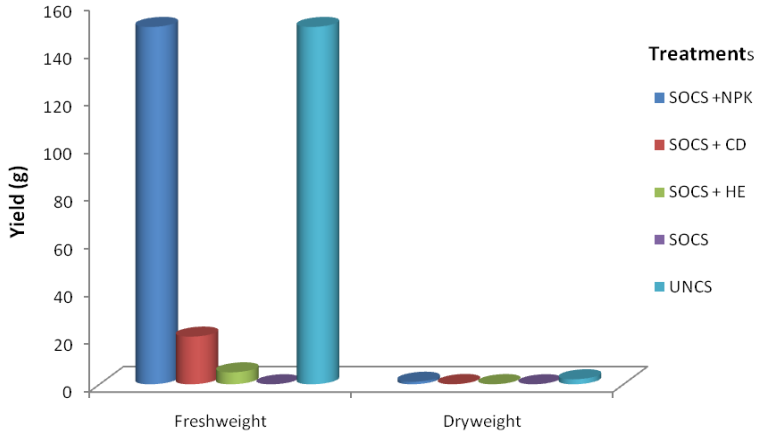

Figure 1. Fresh and dry weight (g) of cassava yield at 6 months after planting. SOCS + NPK = Spent oil contaminated soil + NPK; SOCS + CD = spent oil contaminated soil + cow dung; SOCS + HE = spent oil contaminated soil + human effluent; SOCS = spent oil contaminated soil (control 1) and UNCS = uncontaminated soil (Control 2).

which had a fresh weight of 150 g and dry weight of 2.09 g followed by NPK treated contaminated soil with fresh weight of 150 g and dry weight of 1.04 g. Cow dung treated contaminated soil had fresh weight of 20 g and dry weight of 0.1 g, while human effluent treated soil had fresh weight of 5 g and dry weight of 0.05 g. No yield was recorded in spent oil contaminated soils (Control 1). This is consistent with the works of previous authors (Kinghorn, 1983; Odiegba and Sadiq, 2002) who noted poor growth of *Capsicum annum* L. and *Lycopersicon esculentum* Mill., when treated with 4 and 5% of spent oil. This could also be due to depletion of nutrients according to Schwab and Bank (1999) who reported that oil contaminated soils are of environmental concern because they are unsuitable for agricultural production.

The influence of cow dung, human effluent and NPK on cassava yield in the contaminated (spent oil) soil is shown in Figure 1. The yield of cassava in the contaminated soil amended with NPK (50 and 1.04 g for both fresh and dry weight, respectively) was higher than those amended with cow dung (20 and 0.1 g for both fresh and dry weight, respecttively). The plants grown in the uncontaminated soil grew better than those from the contaminated soil even though no treatment was added. This shows that spent oil contamination inhibited plant growth. Various workers (Akinola et al., 2004; Merkl et al., 2004; Agbogidi et al., 2007) reported similar findings in their works on the effects of crude oil on growth performances of crops. The addition of NPK did not produce any significant difference on the sprouting of cassava. However, early sprouting of stem cuttings were more pronounced in contaminated soil treated with cow dung (150 g) as compared to the sprouting of the plants in the uncontaminated soil. The addition of cow dung and NPK fertilizer to spent oil contaminated soils led to increase in the dry matter content of the cassava (Figure 1). Thus, the dry weights of the cassava from soils that were contaminated with spent oil and received cow dung and NPK treatments were greater than those from spent oil contaminated soils that had no treatments. The addition of cow dung and NPK to the contaminated soil had much influence on the dry matter content of the cassava plant grown in the soils. The increase in the dry matter content observed in this study could be attributed to continuous growth and physiological activities of the plants as reported earlier.

Conclusion

Spent oil significantly affected the growth and performance of cassava test species negatively in this study. At the end of the experiment, there was a higher yield of cassava in soils treated with NPK fertilizer relative to soils treated with cow dung and human effluent. This remediation of spent oil contaminated soil through the use of organic and inorganic fertilizer therefore showed that bio fertilizers can be used to remediate spent oil contaminated soil.

REFERENCES

Adegoroye G (1997). Environmental Considerations in Property Design, Urban Development and Renewal. In Akinjide, O (Ed.), Dimensions of Environmental Problems in Nigeria. Washington: Friedrich Ebert Foundation. pp. 12-25.

Agbogidi OM, Eruotor PG, Akparabi SO (2007). Effects of time of application of crude oil to soil on the growth of maize (*Zea mays* L.). Res. J. Environ. Toxicol. 1(3):116123

Akinola MO, Udo AS, Okwok N (2004). Effect of crude oil (Bonny Light) on germination, early seedling growth and Pigment Content in maize (*Zea mays* L.). J. Sci. Technol. Environ. 4(1&2):6-9.

Akin-Oriola GA (2003). On the phytoplankton of Awba Reservoir, Ibadan, Nigeria. Rev. Bio Trop. 51(1):99-106.

Anoliefo GO, Edegai BO (2000): Effects of Spent oil as Oil Contaminant on the Growth of two Egg plant species *Solanum melongena* and *S. incanum*. J. Agric. For. Fish. 1:21-25.

AOAC International (2003). Official methods of analysis of AOAC International. 17th edition, 2nd revision. Gaithersburg, MD, USA, Association of Analytical Communities.

Dominguez-Rosado RE, Pichtel J (2004). Phytoremediation of soil contaminated with used motor oil, 1. Enhanced microbial activities from laboratory and growth chamber studies. Environ. Eng. Sci. 2:157-168.

Faboya OOP (1997). Industrial Pollution and Waste Management. In Akinjide, O. (Ed.) Dimensions of Environmental Problems in Nigeria. Washington: Friedrich Ebert Foundation. pp. 12-25.

Henner P, Schiavon M, Druelle V, Lichtfouse E (1999). Phytotoxicity of Ancient Gas Work soils. Effects of Polycylic Aromatic Hydrocarbons on Plant Germination. Org. Geochem. 30:963-966.

Kinghorn RRF (1983). An Introduction to the Physics and Chemistry of Petroleum. John Wiley and sons NY. p. 420.

Krishan C, Greep S, Ravindranath P, Srivathsa RSH (2005): Regional Centre Of Organic Farming Coimbatore, Tamil Nadu. India

Lee K, Tremblay GH, Cobanli SE (1995). Bioremediation of oil beach sediments: Assessment of inorganic and organic fertilizers. Proceedings of 1995 Oil Spill Conference, American Petroleum Institute, Washington DC

Li X, Lin X, Li P, Liu W, Wang L, Ma F, Chukwuka KS (2009). Biodegradation of the low concentration of polycyclic aromatic hydrocarbons in soil by microbial consortium during incubation. J. Hazard. Mater. 172:601-605.

Merkl N, Schutze-Kraft R, Infante C (2004). Phytoremediation in the tropics the effect of crude oil on the growth of tropical plants. Bioremediat. J. 8 (3-4):177-184

Molindo WA (2008). Determination of the Nutrient Status of a Soil after Incubation with Organic Residues for Different Days in Benin City. World J. Agric. Sci. 4 (6):731-736.

Odjegba VJ, Sadiq AO (2002). Effect of spent engine oil on the growth parameters, chlorophyll and protein levels of *Amaranthus hybridus* L. Environmentalist 22:23-28.

Osubor CC, Anoliefo GO (2003). Inhibitory effects of spent lubricating oil on the growth and respiratory functions of *Arachis hypogea* L Benin Sci. Dig. 1:73-79.

Parr JF, Papendick RI, Colacicco D (1986). Recycling of organic wastes for a sustainable agriculture. Biol. Agric. Hortic. 3:115-130.

Renault S, Zwlazek JJ, Fung M, Tuttle S (2000). Growth Response of Germination, growth and gas exchange of selected boreal *Ricinus communis* L (Castor oil) in Spent Lubricating Oil. J. Appl. Sci. Environ. Manage. 2:73-79.

Roscoe E Jr., Russell SA Jr. (1980). Contamination of Soils by Petroleum Hydrocarbons. Advanced Agronomy 13, 197-216. Department of Agronomy, Kansas State University, Manhattan.

Rowell MJ (1977). The Effect of Crude Oil Spills on Soil. A review of literatures in: The Reclamation of Agricultural Soils after Oil Spills, Toogood, J.A. (Ed.). University of Alberta, Edmonton. pp. 1-33.

Samantha W (2009). Effluent Fertilizer Guide. Bio-Response Solutions 317.987.9099

Schwab, P., and Banks, K., (1999). Phytoremediation of petroleum-contaminated soils. In: Adriano, D. C., Bollag, J. M., Frankenberger, W. T. (Jr.) and Sims, R. C. (Eds.), Bioremediation of Contaminated Soil, Agronomy 37, pp. 783-795, American Society of Agronomy, Inc.,

Crop Science Society of America, Inc., Soil Sci. Society of America, Wisconin.
Sims GK (1990). Biological degradation of soil. Adv. Soil Sci. 11:289-330
Song YF, Jing X, Fleischmann S, Wilke BM (2002). Comparative study of extraction methods for the determination of PAHs from contaminated soils and sediments.Chemosphere 48:993-1001.
Uka UN, Chukwuka KS (2007). Effect of water hyacinth infestation on physio-chemical characteristics of AWBA reservoir, Ibadan, South-West, Nigeria. J. Biol. Sci. 7(2):282-287
Vidali M (2001). Bioremediation. An overview. Pure Appl. Chem. 73(7):1163-1172.

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Full Length Research Paper

Comparison of the trees regeneration at different distances from Alang Dareh forest roads considering tourist pressure

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Natural regeneration is the most important factor in survival and sustaining forest parks. This study was conducted to compare the regeneration frequency of trees species at distances of 15, 40 and 80 mfrom roads considering tourist pressure in Alang Dareh forest park. Results show that number of high seedling in low tourist pressure area was more than that of area with severe tourist pressure. Moreover, total number of seedlings in low tourist pressure area was more than that of area with severe tourist pressure. Lowest number of seedlings was recorded at distance of 80 m from road edge because of the tourist density and consequently soil compaction.

Key words: Tourist pressure, regeneration, forest road, Alang Dareh park.

INTRODUCTION

Changes to regeneration conditions are considered by forest park managers to be an important impact of tourism use and consequences of soil compaction (Good, 1995). Reduction of regeneration is a well-documented negative effects of tourism use (Good and Grenier, 1994). Decompaction using subsurface tilling, grazing and blocking compacted area after regeneration or plantation are preferred site-preparation treatments by many public and private park managers (Shestak and Busse, 2005). Beside, ground cover by slash and plant residuals is said to decrease soil compaction by providing a pressure absorbing layer, lowering the net ground pressure of passing equipment.

Siikamäki (2009) in a study in Paanajärvi National Park, Republic of Karelia, Russia indicated that high compaction of the soil mineral horizons lead to critical status for normal growth and development of the root system. Beside it was concluded that the most important factors in soil resistance to trampling are moisture and type of the plant community. Natural regeneration is the most important factor in survival and sustaining forest parks. Therefore, study of the regeneration condition in a forest park can be useful to predict ecosystem future and apply forestry programs for improving forest stands. Despite Alang Dareh Forest Park's size and status, it has not been closely studied, and thus little information is available about floristic condition of forest to develop ecology-based management tools. The objective of this study was to compare the regeneration frequency of trees species at different distances from roads considering population

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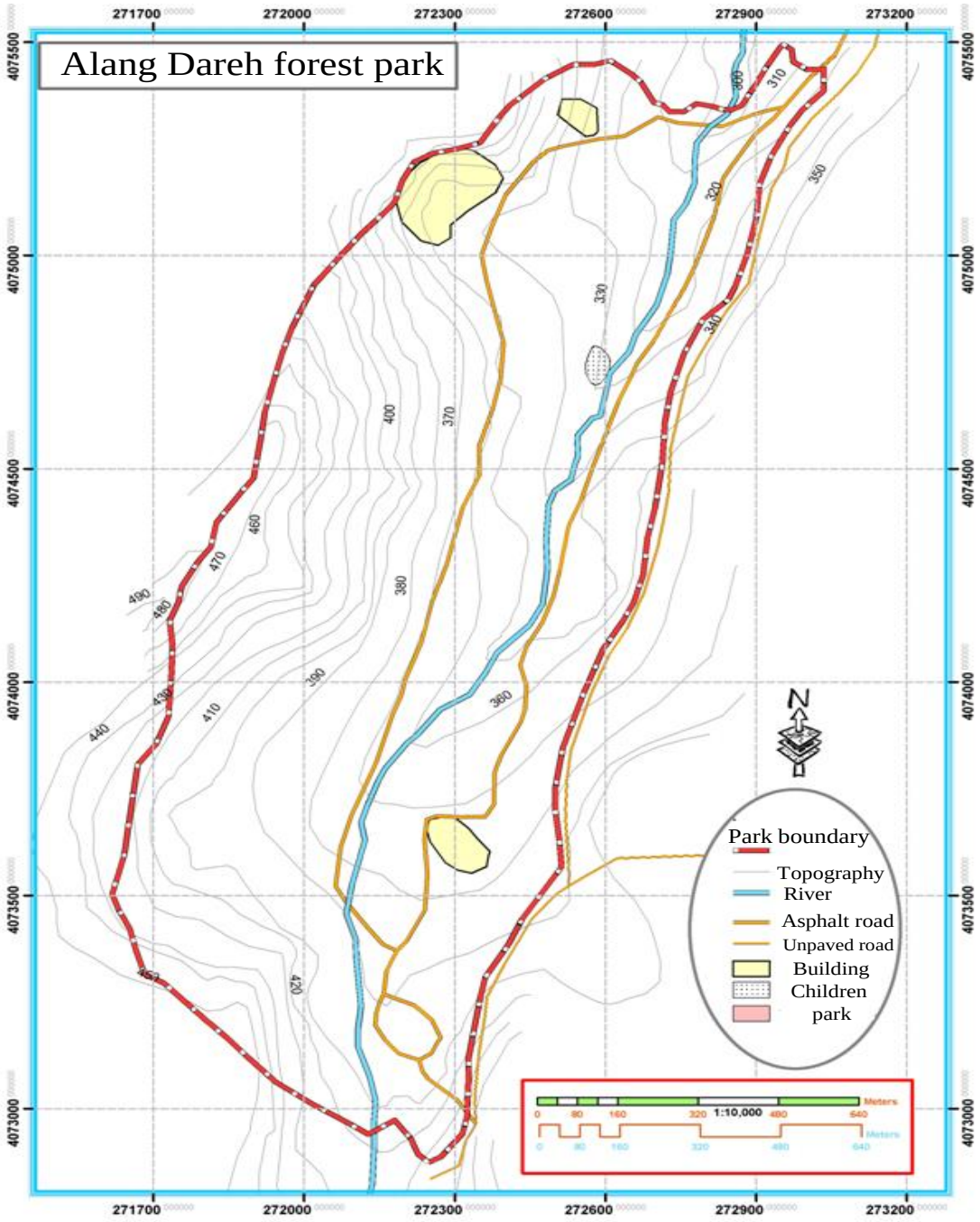

Figure 1. The geographical position of the study area.

density in Alang Dareh forest park.

MATERIALS AND METHODS

Study site

Alang Dareh forest with an area of 185 hectares Alang Dareh is a forest 5 km away from Gorgan city in the south west on the way to Naharkhoran (36°47′43″ N and 54°26′44″ E). The climate of the region is moderate, moist and mid-moist. The bedrock of this forest is green schist and sedimentary loess stone with altitude ranging from 300 to more than 400 m above sea level. The forest is mixed deciduous which has been established on brown forest soil. The mean annual precipitation is 837 mm which the highest is occurred in autumn (Figure 1). The Ambrotermic curve of the study area can be shown as Figure 2. Floristic composition of the park are *Oplismenus undulatifolia*, *Oplismenus* sp., *Carex silvatica*, *Viola spp.*, *Juncus* sp., *Euphorbia* spp., *Agropyrum* sp., *Convolvulus* sp., *Parrotia persica*, *Carpinus betulus* and *Quercus castaneifolia*.

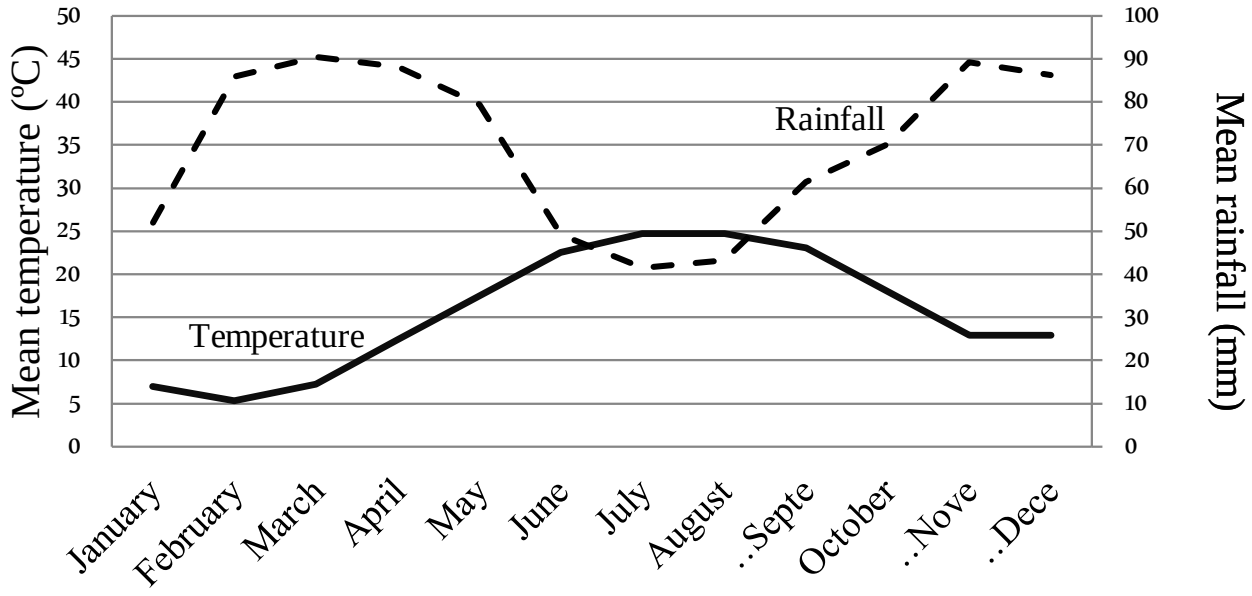

Figure 2. Ambrotermic curve of the Alang Dareh forest park.

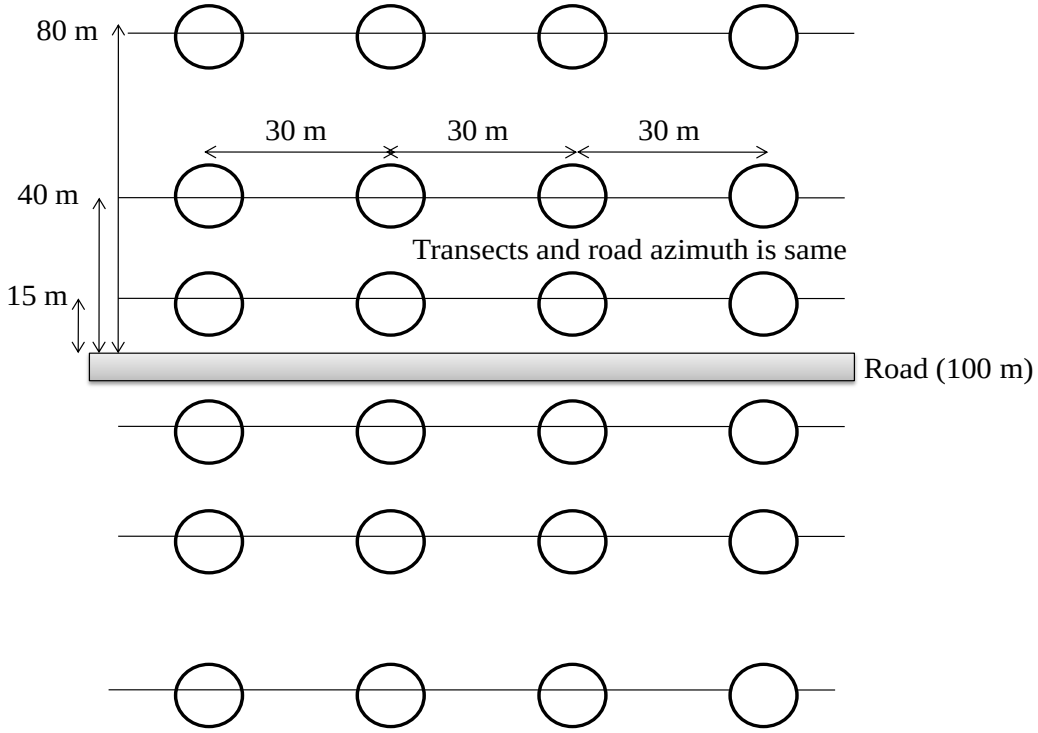

Figure 3. Sampling design in study area.

Sampling design and field survey

In this study two road segment each of with a length of 100 m was selected in Alang Dareh forest park. It was attempted to select roads with similar condition considering altitude, slope gradient, slope direction, vegetation type and soil. Road segment one is located in a region with high population density in park and another is located in a region with low population density. Three transects were established at each sides of the road and at distances of 15, 40 and 80 m. On each transect, four plots with an area of 100 m^2 and radius of 5.7 m was systematic randomly selected. The distance of plots to each other was 30 m (Figure 3). Trees regeneration with

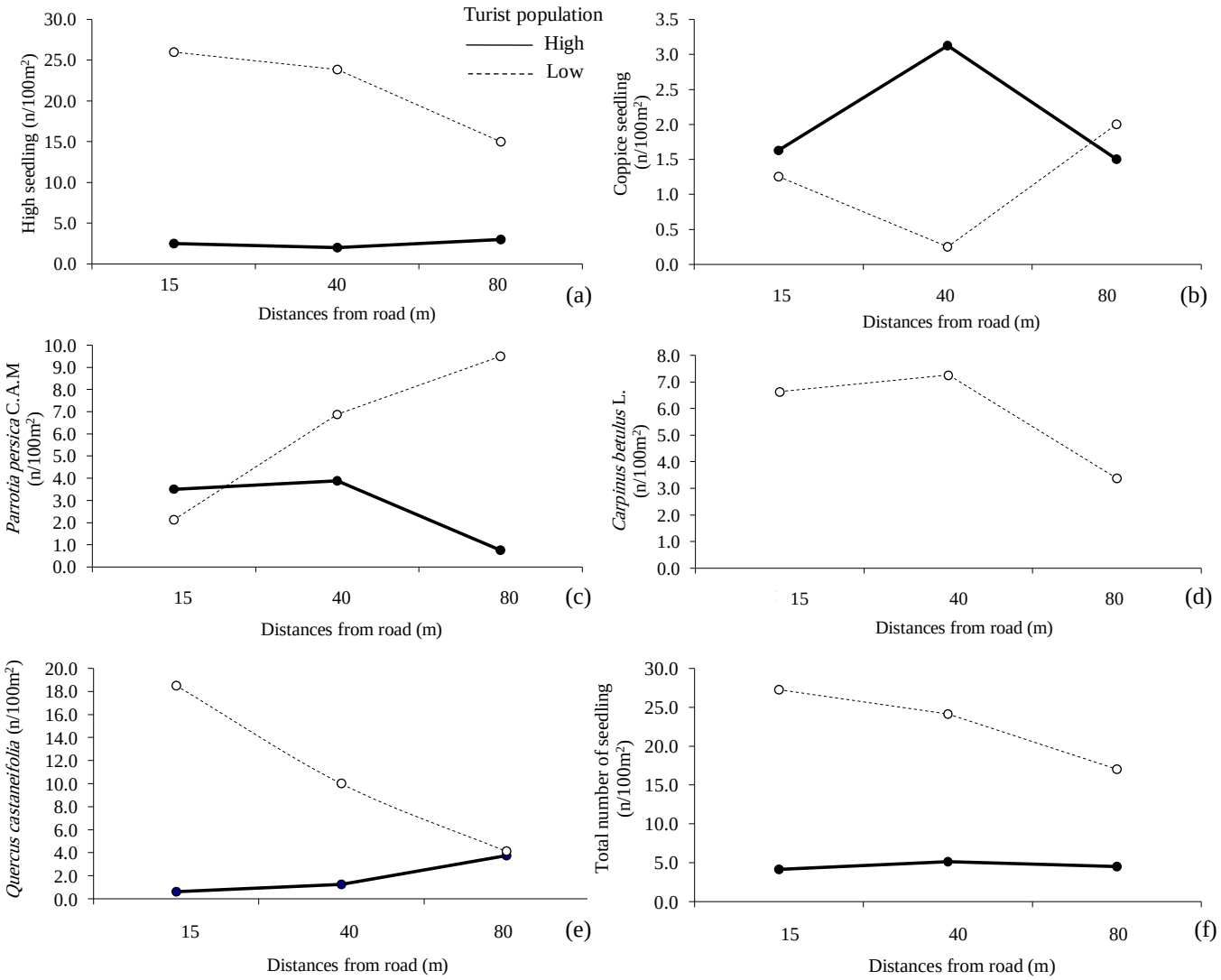

Figure 4. Regeneration trend at different distances from road edge considering population density.

diameter at breast height (DBH) less than 7.5 cm and height of less and more than 1.30 m were counted separately for each species within the plots. Graphs were designed in Excel software.

RESULTS AND DISCUSSION

Results of the study in high density population area indicates stationary trend at different distances from road concerning high seedling frequency (Figure 4a). Low and high tourist population showed that there was no obvious trend in coppice seedling frequency at the different distances from road edge due to the human interference (Figure 4b). The frequency of different species including *Parrotia persica* (Figure 4c), *Carpinus betulus* (Figure 4d) and *Quercus castaneifolia* (Figure 4e) are shown. Lowest number of seedlings grew at the distance of 80 m from road edge, because tourist density and consequently soil compaction was high in this zone. Indeed number of seedling decreased with increasing distances from road edge in low tourist pressure area. In severe tourist pressure area there was no significant differences among distances in term of seedlings frequency (Figure 3f). Glaeser (2006) conducted a research within a Forest Park, in Queens County, New York, to document the current floristic composition and structure of the woodland community. His findings about the disturbance patterns, the decline in traditional dominant tree species, the abundance of pioneer tree species and the continued colonization by *Phellodendron amurense* may be the signs of structural change throughout the park.

Number of high seedling in low density population area was more than that of high density population area (Figure 5a), while number of coppice seedling in low density population area was less than that of high density population area (Figure 5b). Low density population area has been dominated by *P. persica* (Figure 5c), *C. betulus* (Figure 5d)

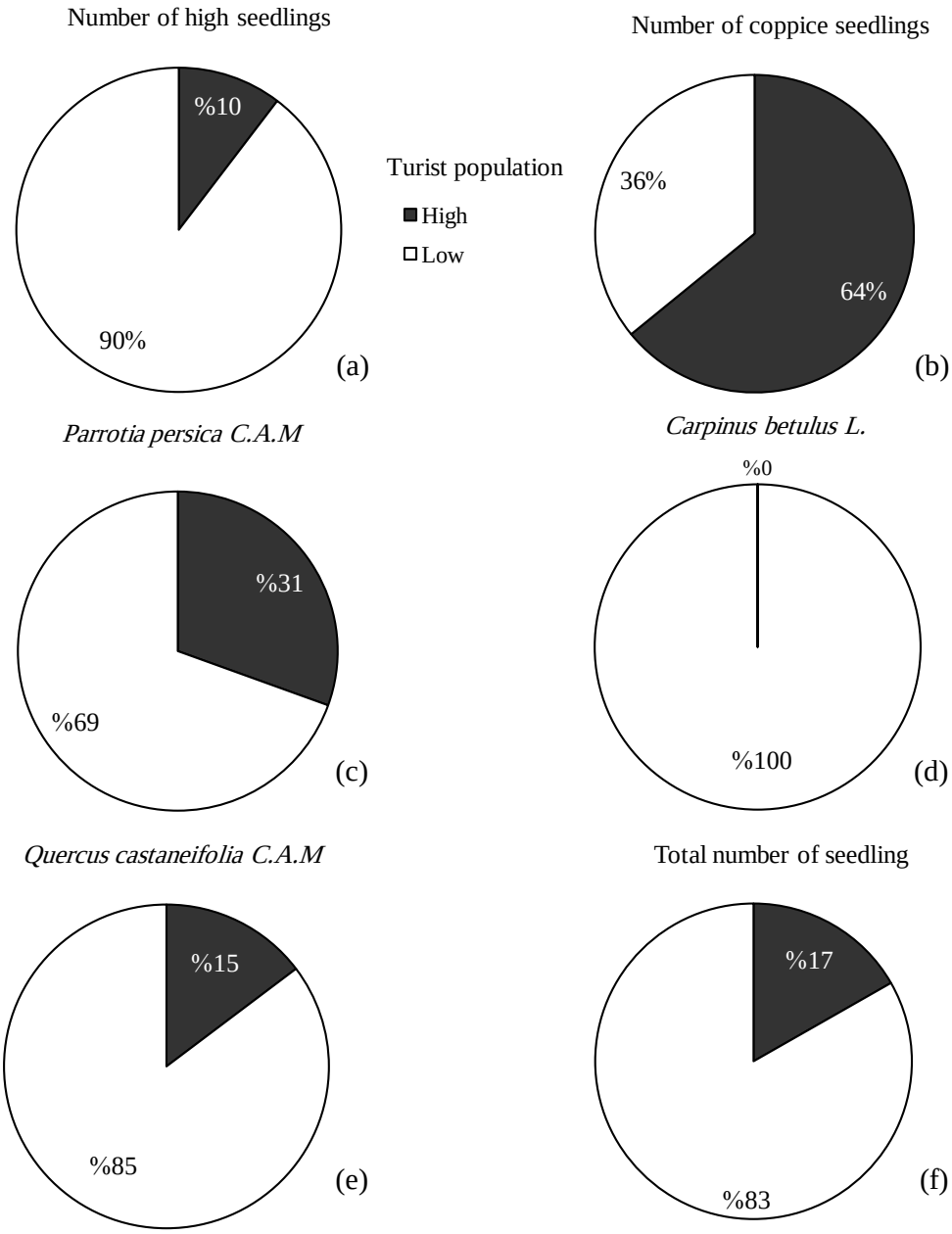

Figure 5. Regeneration in low and high density population area.

and *Q. castaneifolia* (Figure 5e). Total number of seedlings in low density population area was more than that of high density population area (Figure 5f). The loss of regeneration cover and severe compaction and erosion of soil due to human activities resulted in a forest park without restoration (Trn et al., 2006). In forest park, the diversity of ecosystems species and wild gene should be maintained. Native species and populations are highly sensitive to human and domestic animal disturbance (Bhandari, 1999). Increasing the amount of tourism use within an area usually results in increased disturbance to vegetation (Whinam et al., 1994; Cooper et al., 2007).

Conclusions

Study about regeneration, and how it is affected by trampling, etc., considering a conservation area is necessary to develop management recommendations. It was concluded that the number of high seedling in low density population area was more than that of high density population area. Moreover, total number of seedlings in low density population area was more than that of high density population area. Lowest number of seedlings was recorded at distance of 80 m from road edge because of the tourist density and consequently soil compaction. It is necessary

to carry out much more research studies in completion of the study.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Bhandari M (1999). Tourism Raised Problems in Masai Mara National Park Narok, Kenya APEC, Nepal. 14p.

Cooper C, De Lacy T, Jago L (2007). Impacts of recreation and tourism on plants in protected areas in Australia. Catherine Pickering and Wendy Hill Technical Reports, University of Queensland, ISBN 9781920965099; 30p.

Glaeser CW (2006). The Floristic Composition and Community Structure of the Forest Park Woodland, Queens County, New York. Urban Habitats. Urban Habitats 4:102-126.

Good RB (1995). Ecologically sustainable development in the Australian Alps. Mountain Res. Dev. 15:251-258.

Good RB, Grenier P (1994). Some environmental impacts of recreation in the Australian Alps. Australian Parks & Recreation (Summer). pp. 20-26.

Shestak CJ, Busse MD (2005). Compaction Alters Physical but Not Biological Indices of Soil Health. Soil Sci. Soc. Am. J. 69:236-246.

Siikamaki P (2009). Research and monitoring of sustainability of nature-based tourism and recreational use of nature in Oulanka and Paanajarvi National Parks. Oulanka Research Station University of Oulu, ISBN 978-951-42-9089-3; ISSN 0358-3651, 52p.

Trn A, Rautio J, Norokorpi Y, Tolvanen A (2006). Revegetation after short-term trampling at subalpine heath vegetation. Ann. Bot. Fenn. 43:129-138.

Whinam J, Cannel E, Kirkpatrick J, Comfort JB (1994). Studies on the potential impact of recreational horseriding on some alpine environments of the central plateau, Tasmania. J. Environ. Manage. 40:103-117.

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Length-weight relationship and Fulton's condition factor of *Carasobarbus luteus* (Heckel, 1843) in Hoor Al-azim wetland

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Length-weight relationship and Fulton's condition factor of Hemeri (*Carasobarbus luteus*) in Hoor Al-azim wetland (Khuzestan provinces, Iran) were investigated. During this study, from 2012 to 2013 more than 460 specimens' *of C. lutus* were measured. Mean±S.D length values for this species were 228±15 respectively and maximum and minimum total length were 118 and 362 mm respectively. Mean ±S.D weight values for this species were 190±91 g and maximum and minimum weight were 86 - 416 g respectively. The length-weight relation were calculated as $W=0.0096\ L^{3.11}$ ($n=138, R^2=0.97$) for males, $W=0.0079\ L^{3.18}$ ($n=271, R^2= 0.94$) for females, $Y=0.0018L^{3.18}$ ($n=466$, R2 =0.96) for total fishes; verifying calculated b with 3 using Students t-test, there was no significant difference between calculated b and 3 ($P>0.05$) and the growth pattern was isometric. The b value in the length-weight relationship did not differ significantly between males and females (t-test, $P>0.05$). Fulton's condition factor (K) for male and female and total fish was 1.38±0.12, 1.44±0.20, and 1.40±0.18 respectively and Students t-test showed no significant difference between Fulton's condition factor of males and females ($P>0.05$). This study reports and provides basic information for fishery biologists in Iran.

Key words: *Carasobarbus luteus*, length-weight relationship, Fulton's condition factor.

INTRODUCTION

The relationship between body weight and length is simple but essential in fishery management (Chien-Chung, 1999). Length-weight relationships of fish are useful in fisheries ecology and stock assessment for converting growth-in-length to growth-in-weight, for estimating condition factor, and for geographic comparisons of life histories (Pauly, 1983; Froese and Pauly, 2010). Length-Weight Relationship (LWR) has the important role in fishery resource

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management and also useful for comparing life history and morphological aspects of populations inhabiting different regions. In fish studies, the length of a fish is often more rapidly and easily measured than is its mass, therefore it is opportune to be able to determine mass where only the length is known (Harrison, 2001).

Hoor Al- AzimWetland in Khuzestan province is one of the 18 international wetlands registered on UNESCO's Natural Heritage List. Hoor Al-Azim is parts of a single hydrological system and forms one of the largest permanent freshwater wetlands in Lower Mesopotamia, being located between N 30° 58´- 31° 50´ and E 47° 55´- 47° 20´ (Ghadiri, 2005). This wetland is situated in the North Azadegan Plain, 80 km south-west of Ahvaz city, near the border between Iran and Iraq. The marshes have experienced significant changes during the last two decades and are expected to face further modifications in the next years; formerly they extended 85 km from north to south and 40 km from east to west, covering about 254000 ha. The system was fed by two tributaries of the Tigris and by the River Karkheh, which rises on the Zagross Mountains in western Iran. The northern and central parts of the marshes were permanent, while in the south they were largely seasonal (UNEP, 2001).

Order Cypriniformes with six families, 321 genera and some 3268 species (Nelson, 2006) is one of the most widespread and large (specious) orders of fishes all over the world. The barbels, genus *Barbus*, are found in Europe, Southwest Asia and Africa and comprise about 800 species (Coad, 2006). According to Coad (1995) and Abdoli (2000) more than 17 species of Barbus have been reported from different basins of Iran. Hemeri *(Carasobarbus (=Barbus)luteus*) belong to the order Cypriniformes, the family Cyprinidae, and the genus Barbus. This species widely distributed in the rivers Tigris and Euphrates and adjacent drainage basins (Berg, 1949; Marammazi, 1995; Abdoli, 2000).

Different aspects of biological work of *C. luteus* have been done by different authors (Szypula et al., 2001; AL Hazzaa, 2005; Gokcek and Akyurt, 2008; Hashemi et al., 2010; Eydizadeh et al., 2013; Hashemi et al., 2014), but no work has been done on relationship between body weight and length and Fulton's condition factor of this species in Hoor Al-azimwetland. The present study describes the Length-Weight Relationships and Fulton's condition factor of *C .luteus* from Hoor Al-azim wetland in Khuzestan Province (Iran).

MATERIALS AND METHODS

Study area

Length-frequency data of *C. luteus* were collected monthly from the catches from landing At three stations: Rofaie(47˚,53´ E, 31˚,35´ N), Tabor(47˚,51´ E, 31˚,29´ N) and Shatali (47˚,42´ E, 31˚,23´ N) from April 2012to March 2013 (Figure 1). Fish sampling was carried out by using 12.5m long gill nets, with meshes of 45 mm (stretched) and then transported to lab with dry ice. Nets were anchored at each of the sampling stations at sunset and they were removed at sunrise on the following day, remaining 12 h in water. Total length with ± 1 mm and total weight with ±0.01 g were measured for this species.

Methods

A total of 466 fresh specimens of *C.luteus* were collected from Hoor Al-azim wetland in Khuzestan Province (Iran). Fishes were collected by fishermen using cast net or gill nets with 45 mm mesh and then transported to laboratory with dry ice. In the laboratory, for each specimen, total length (TL), whole body wet weight (g) and sex was recorded. The length-weight relationship was estimated by using following equation:

$W = a L^b$

Where W is the whole body weight (g), L is the total length (mm), a is the intercept of the regression and b is the regression coefficient (slope) (Ricker , 1975).

A t-test was used for comparison b value in the power regression of male and female fishes (Zar, 1999). The growth pattern (t) was determined using the following Equation (Pauly and Munro, 1984):

$$t = \frac{sd\ln L}{sd\ln W} * \frac{|b-3|}{\sqrt{1-r^2}} * \sqrt{n-2}$$

Where Sdlnx is Standard deviation of the Length natural logarithm (cm), Sdlnw is Standard deviation of the natural logarithm weight (g), b is Curve slope of the relationship between length and weight, r2 is Regression coefficient between length and weight and n is number of samples. When the b value in length-weight relationship was statistically equal to or did not show significant deviation from 3, the growth was considered isometric, whereas the positive or negative allometric growth occurred when the b value was significantly different from 3. In order to verify if calculated b was significantly different from 3, the Students t-test was employed (Zar, 1996).

Fulton's condition factor (K) was calculated by the formula (Htun-Han, 1978): $K=W/L^3 \times 100$, Where, W is the whole body wet weight in grams and L is the total length in cm (Froese, 2006). Data were transferred to Microsoft Excel spreadsheet for analysis. SPSS 21.0 statistical software was used Student's t-test analysis; differences were considered significant at values of $p<0.05$.

RESULTS AND DISCUSSION

The total lengths of 466 fish in the size range 118 to 362 mm for *C. luteus* using a meter scale (1±mm) were measured. Length frequency percentage groups of *C. luteus* are presented in Figure 2. Mean±S.D length values for this species were 228±15 respectively and maximum and minimum total length were 118 and 362 mm respectively. Size sexual dimorphism was observed in Hemeri species since females dominated in the longer length classes and the males in the shorter.

Mean ±S.D weight values for this species were 174±87 g and maximum and minimum weight were 154-202 g respectively. The mean value of length for the male and female were calculated as 216±37 and 233±38 mm and mean value of weight for the male and female was as

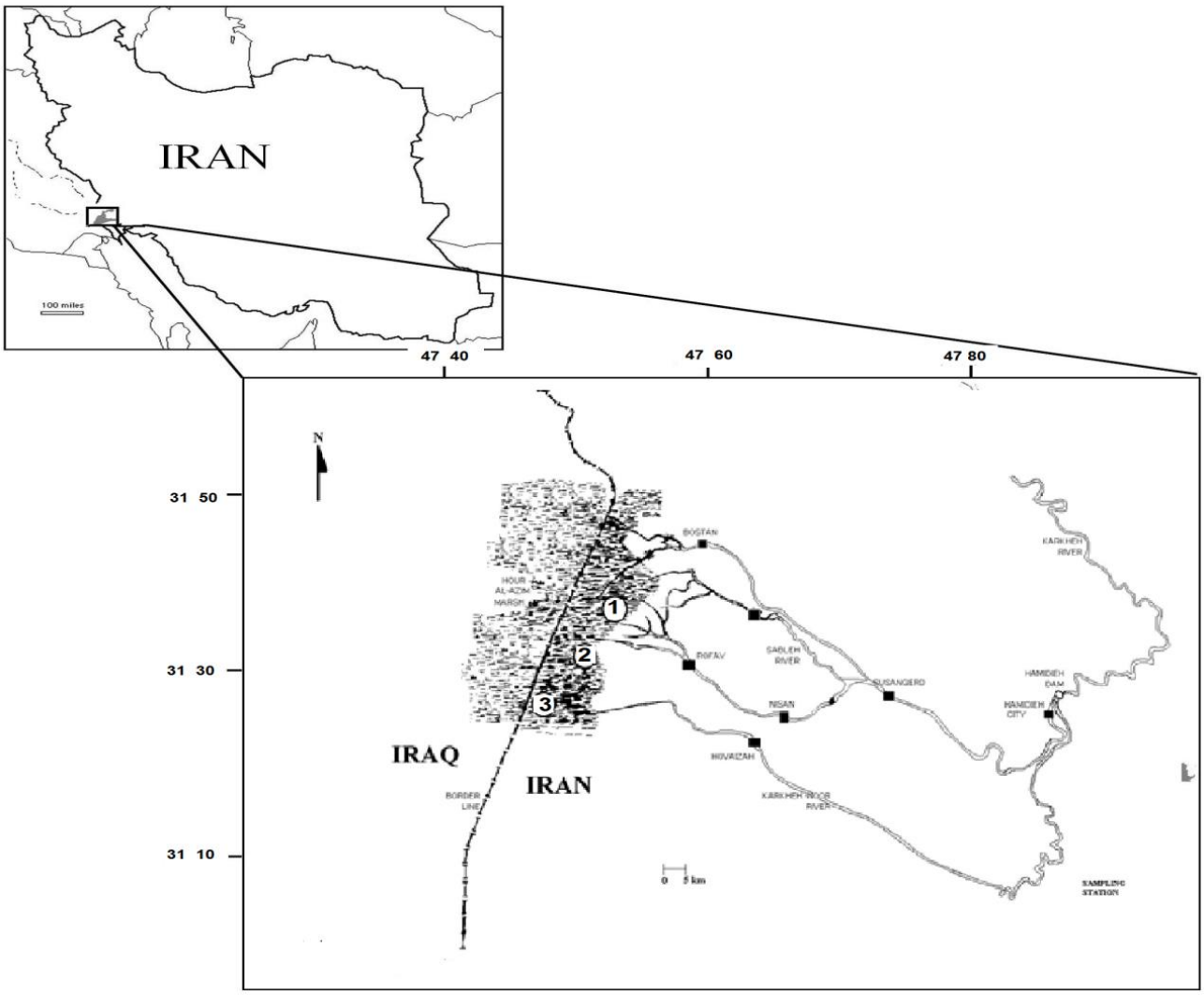

Figure 1. The map of Situation on Hoor al-azimwetland (1: Rofaye , 2: Tabar, 3: Shatali) in Khuzestan province (South West of Iran).

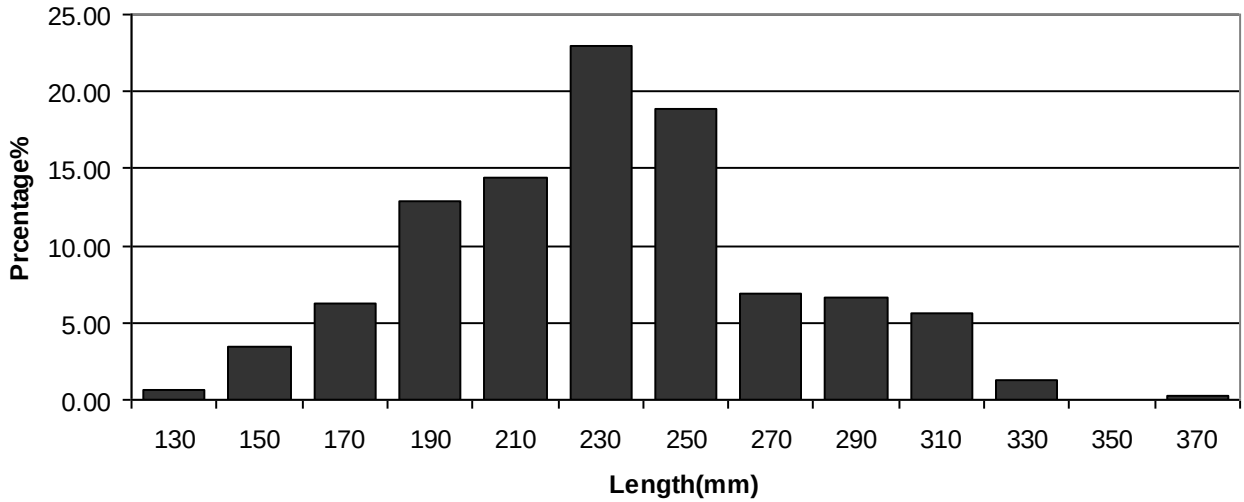

Figure 2. Percentage frequency of length *C. luteus* on HoorAl-azim wetland in Khuzestan province during 2012-2013.

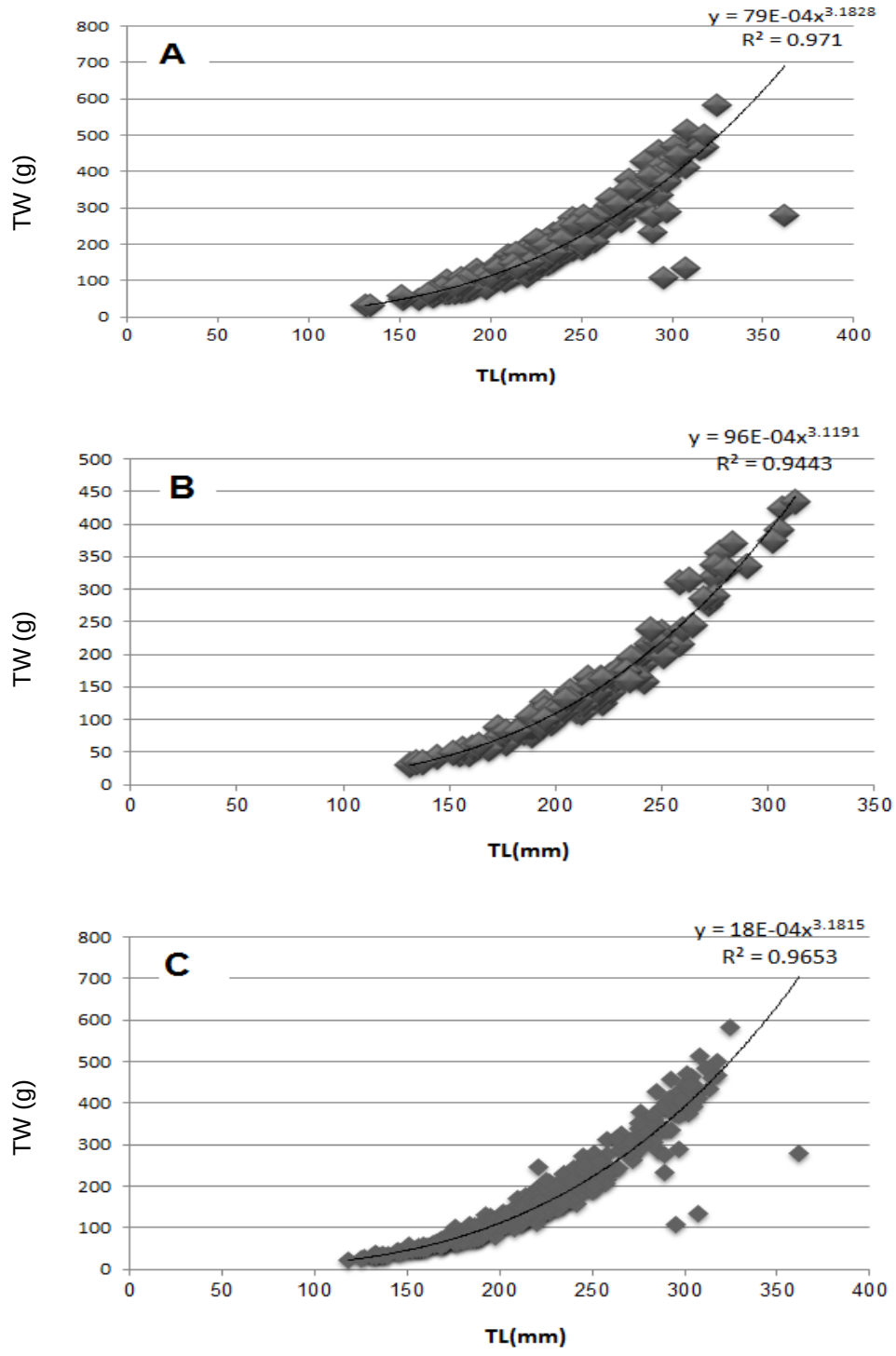

Figure 3. Length-weight relationship of *C. luteus* (A=Female, B=Male, C=Total) on Hoor Al-azim wetland in Khuzestan province during 2012-2013.

170±91 and 211±88 g respectively which means that length-weight of the female was heavier than males in the same length group. The length-weight relation were calculated as $W=0.0096\ L^{3.11}$ (n=138, R^2=0.97) for males, $W=0.0079\ L^{3.18}$ (n=271,R^2= 0.94) for females and $Y=0.0018L^{3.18}$ (n=466, R2 =0.96) for total fishes (Figure 3); verifying calculated b with 3, using Students t-test there was no significant difference between calculated b

Table 1. Length-weight relationships of some species from the HoorAl-azim wetland (2012-2013).

Family	Species	N	a	Min (mm)	Max (mm)	b	S.E (b)	R2	P=0.05	Growth type
Cyprinidae	*C. luteus* (male)	138	0.0096	131	313	3.11	0.15	0.97	P> 0.05	I
	C. luteus (female)	271	0.0019	131	362	3.18	0.4	0.94	P> 0.05	I
	C. luteus (All fish)	466	0.0018	131	362	3.18	0.23	0.96	P> 0.05	I

N, the sample size; min; max; mean total length; a, the intercept of relationship b, the slope of relationship; r, coefficient of correlation; P value (difference of b from 3) and Growth type (isometric=I and allometric negative= A- and allometric positive= A+).

Table 2. Fulton's condition factor (K) of C. luteus species from the HoorAl-azim wetland (2012-2013).

Family	Species	N	Mean ±S.D	Minimum	Maximun	CL (%95)
Cyprinidae	*C. luteus* (male)	138	1.38±0.12	1.1	1.81	0.02
	C. luteus (female)	271	1.44±0.20	0.96	1.87	0.024
	C. luteus (All fish)	466	1.40±0.18	0.96	1.87	0.016

and 3 (P>0.05), growth pattern was isometric (Table 1).The b value in the length-weight relationship did not differ significantly between males and females (t-test, P>0.05). The b parameter values in the weight-length model, W= a L^b are close to 3 for *C. luteus*, indicating isometric growth.

The value of b from other studies for *C. luteus* were b=2.98 and b=3.00 (male and female) in Orontes river of Turkey (Gokcek and Akyurt, 2008), b=3.05 and b=2.98 (male and female) in Euphrates River, Syria (Szypula et al., 2001) and b= 3.06 in Shadegan wetland of Iran (Hashemi et al., 2010) were estimated. The value of b from other studies for this species were b=3.09 in Habbaniya lake, b= 2.97 in Tharthar lake estimated in the Iraq country (Szypula et al., 2001). Length–weight relationship is a practical index of the condition of fish, and may vary over the year according to several exogenous and endogenous factors such as food availability, feeding rate, health, sex, gonad development, spawning period and preservation techniques (Froese, 2006).The length-weight relationship in fish is of great importance in fishery assessments (Haimovic and Velasco, 2000). The variation of b in the different regions could be by seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection, sex, gonad development and nutritive conditions in the environment of fish (Biswas, 1993; Eydizadeh et al., 2013). According to Martin (1994), the range of "b" could be from 2.5 to 4 and Tesch (1968) believed "b=3 in fish with isometric growth". These results are suitable for the estimation of length-weight relationship since; the values of bare within the range of values of this parameter usually estimated in fishes, which according to Froese (2006) lies between 2.5 and 3.5.

In the present study, (a) were 0.0096 and 0.0019 (male and female). In length- weight a value is related to fish condition. The value of (a) for *C. luteus* were a = 0.0001 in Shadegan wetland of Iran (Hashemi et al., 2014) and a=0.013 and a=0.019 (male and female) in Euphrates river (Syria) (Szypula et al., 2001). The value of (a) from other studies for this species: a =0.0071 in Habbaniya lake, a = 0.0097 in Tharthar lake were estimated in the Iraq country (Szypula et al., 2001). Also (a) depends on weight and it can be used as status value (King, 2007) and may vary over the year according fish condition.

Fulton's condition factor (K) for male and female and total fish was 1.38±0.12, 1.44±0.20, and 1.40±0.18 respectively and Students t-test showed no significant difference between this parameter for males and females (Table 2). The K values for males and females of these species of fishes are presented in Table 2.The mean values of condition factor (K) in the female was heavier than for male's specimens. The K value did not differ significantly between males and females (t-test, P>0.05). Unfortunately, no references from other studies for K value are available regarding these species in this local. The relative robustness or degree of well-being of a fish expressed as the coefficient of condition (condition factor) is an important tool for the study of fish biology, mainly when the species lies at the base of the higher food web (Diaz et al., 2000; Lizama and Ambrósio, 2002). Fulton's condition factor is widely used in fisheries and fish biology studies (Froese, 2006). Condition factor is a well-being value and it increasing coincides with fish weight increasing (King, 2007). Seasonal growth amount can be measured by status factor and growth changes may be related to fish food or reproduction stage (King, 2007).This study reported the length-weight relationship and K value of this species and the results of the study are useful inputs for fisheries scientists stock assessment models and useful spatial- temporal comparison in the future.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Abdoli A, (2000). The Inland Water Fishes of Iran. Iranian Museum of Nature and Wildlife, Tehran. 378 pp. In Farsi.

AL Hazzaa R (2005). Some Biological Aspects of the HimriBarbel, *Barbusluteus*, in the Intermediate Reaches of the Euphrates River. Turk J. Zool. 29:311-315.

Berg LS (1949). PresnovodnyerybyIrana i sopredel'nykhstran (Freshwater fishes of Iran and adjacent countries). Trudy Zoologicheskogo Instituta Akademii Nauk SSSR. 8:783-858.

Biswas SP (1993). Manuel of methods in fish biology, fish biology and Ecology laboratory, Dibruyarh university, Dibrugarh. p157.

Chien-Chung H (1999). The length-weight relationship of Albacore.Thunnusalalunga, from the Indian Ocean. Fish. Res. 14:87-9.

Coad BW (2006). Endemicity in the freshwater fishes of Iran. Iranian J. Animal Biosyst. 1(1)(2005):1-13.

Coad BW (1995).Fresh Water Fishes of Iran.Acta Sci. Nat. Acad. Sci. Bohemicae. 29:1-164.

Diaz LS, Roa A, Garcia CB, Acero A, Navas G (2000). Length-weight relationship of demersal fishes from the upper continental slope off Columbia. NAGA, 23(3):23-25.

Eydizadeh A, Eskandary Gh, Mohammadi Gh, Hashemi SAR (2013). Population Dynamics and Assessment of *Carasobarbusluteus* (Heckel, 1843) in hooral-Azim Wetland (Khuzestan provinces, Iran). World J. Fish Marine Sci. 5(4):430-436.

Froese R, Pauly D (2012). FishBase World Wide Web electronic publication http://www.fishbase.org.

Froese R (2006). Length-weight relationships for 18 less-studied Fish species. 14:117-118.

Ghadiri H, Ghadiri M (2005). Marsh lands of Mesopotamia and the rivers that feed them. 8th International River Symposium 2005, 5-9 September, Brisbane, Australia.

Gökçek CK, Akyurt I (2008). Age and growth characteristics of himribarbel (*Barbusluteus*Heckel, 1843) in Orontes River, Turkey. Turk. J. Zool. 32(4):461-467.

Haimovici M, Velasco G (2000). LengthWeight relationship of marine from southern Brazil. NAGA 23(1):14-16.

Harrison TD (2001). Length-weight relationships of fishes from South African estuaries. 17:46-48.

Hashemi SAR, Ghorbani R, Kaymaram F, Hossini SA,Eskandari G, hedayati A (2014). Length-Weight Relationships for some fish Species from Shadegan wetland. Global Adv. Res. J. Food Sci. Technol. 3(2):076-083.

Hashemi SAR (2010). Survey growth parameters of fish species in the Shadegan wetland. National Wildlife Conference, Azad University, Ahvaz, March 2010. 14 pp. In Farsi.

Htun-Han M (1978). The reproductive bio.of the dab Limandalimanada)L.) in the north Sea: gonadosomatic index, hepatosomatic index and condition factor. J. Fish Biol. 13(1):351-377.

King M (2007). Fisheries biology and assessment and management .Fishing news press,p 340.

Krupp F (1985). Systematik und Zoogeographie der Süßwasserfische des levantinischen Grabenbruchsystems und der Ostküste des Mittelmeeres. Dissertation zur Erlangung des Grades "Doktor der Naturwissenschaften" am Fachbereich Biologie der Johannes Gutenberg Universität in Mainz. 215 pp., Anhang: Abbildungen, Karten, Tabellen, 169 pp.

Lizama M, de Los AP, Ambrósio (2002). Condition factor in nine species of fish of the Characidae family in the Upper Parana River floodplain, Brazil. Braz. J. Biol. 62(1):113-124.

Maramazi Gh, (1995). Ichthology report of marshShadegan, South of Iran aquaculture fishery research center,Ahwaz.Iran.63 p.In Farsi.

Martine WR (1949). The Mechanics of environmental control of body form in fishes. Univ. Toronto stud. BioI. 58:1-91.

Nelson JS, (2006). Fishes of the World.3rd Edition. John Wiley and Sons, New York. xix + 601pp.

Pauly D, Munro JI (1984). Once more on the comparison of growth in fish and invertebrates, ICLARM. Fish byte, 2 (1):106p.

Ricker WE (1975). Computation and interpretation of biological statistics of fish populations. Bull. Fish Res. Board Can., 191:382.

Sokal RR, Rohlf FJ (1995). Biometry. The Principles and Practice of Statistics in Biological Research, third ed., W.H. Freeman and Co., New York, 887pp.

Szypula J, Epler P, Bartel R, Szczerbowksi J (2001). Age and growth of fish in lakes Tharthar, Razzazah and Habbaniya. Arch. Pol. Fish. 9 (Suppl. 1):185-197.

Tesch FW (1968). Age and growth in methods for assessment of fish production in fresh water. Ed. WE Ricker. IBP Handbook No.3.

UNEP (2001). The Mesopotamian Marsh-lands: Demise of an Ecosystem, Early Warning and Assessment Technical Report. United Nations EnvironmentProgramme. UNEP/DEWA/TR.01-3.

Zar JH (1996). Biostatistical analysis.3rd edition. Prentice-Hall Inc. New Jersey,USA. 662p.

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Ethnic-based diversity and distribution of enset (*Ensete ventricosum*) clones in southern Ethiopia

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Enset cultivation in southern and south-western Ethiopia is practiced mainly in densely populated areas. A survey covering 280 farm households and seven districts was conducted in seven zones of southern Ethiopia with the main objective of assessing the diversity and distribution of enset clones. Interviews using structured and semi-structured questionnaires were conducted to generate data. A total of 218 enset clones were recorded in the surveyed areas. The number of clones cultivated on individual farms ranged from two to 26 (mean of 8.9 ± 0.9). The highest richness of enset was recorded in Hadiya (59 clones) whereas the lowest was in Sidama zone (30); the mean richness being 39.7 ± 3.8 clones per zone. Exchange of clones among farmers in different ethnic groups in enset growing regions revealed that strong cultural and linguistic similarities exist between zones. Farmers reported that clones such as Gena and Mazia are replacing previously grown clones due to their resistance to *Xanthomonas* wilt. Several enset clones previously known by farmers have disappeared in recent years due to disease, extended drought and wild animals, pointing to genetic erosion and the necessity of genetic conservation.

Key words: Abundance, Gurage, Kembata, Mazia, richness, Wolaita.

INTRODUCTION

The genus *Ensete* belongs to the order Schistaminae and Musaceae family and comprises several species that grow in Africa and Asia (Bezuneh, 1984). Wild *Ensete ventricosum* can be found in Africa from the Ethiopian highlands to Malawi. However, domesticated enset (*E. ventricosum*) Welw. (Cheesman) is only cultivated in Ethiopia

The Ethiopian highlands are a center of genetic diversity for enset, tef, sorghum, barley and finger millet (Engels and Hawkes, 1991). The enset farming system supports over 15 million people with food, fiber, medicine and animal feed (Brandt et al., 1997).

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The major food types obtained from enset are *kocho*, *bulla* and *amicho*. *Kocho* is fermented starch obtained from decorticated (scraped) leaf sheaths and grated corms. *Bulla* is a liquid which is obtained when leaf sheaths and corms are pulverized; the liquid containing starch is squeezed out from scraped leaf sheathes and grated corm and the resultant starch allowed to concentrate into white powder. *Amicho* is boiled enset corm/rhizome pieces that are prepared and consumed in a similar manner to other root and tuber crops (Brandt et al*.,* 1997).

Reports of landrace diversity in enset are numerous. Alemu and Sandford (1991) reported names of 99 enset clones in the North Omo area, while Shigeta (1990) listed 78 vernacular names of cultivated enset clones in the Ari region of southern Ethiopia. Negash (2001) reported that farmers maintain and enrich the diversity of enset, and select or classify clones for various uses. Tesfaye (2002) indicated that enset landraces are not evenly distributed across the region mainly due to altitude variations. Tsegaye (2002) reported that numerous enset clones were identified in each region and the variations in the number of clones were attributed to a combination of socio-cultural and agro-ecological factors. Furthermore, Birmeta (2004) reported that the observed genetic diversity in cultivated enset in a particular area appears to be related to the extent of enset cultivation and the culture and distribution pattern of the different ethnic groups.

Some limited work has been done to evaluate, analyze and document clonal identity. Clonal names reported in the literature are associated with only limited phenotypic data provided by farmers (Shigeta, 1990). In enset, molecular characterization of clones has been done using amplified fragment length polymorphism (Negash, 2001; Negash et al*.*, 2002; Tsegaye, 2002) and random amplified polymerphic DNA (RAPD) techniques (Birmeta, 2004). These earlier studies of enset diversity were limited to one or a few ethnic groups or a specific and limited growing region. However, a study encompassing many enset growing regions and ethnic groups has previously not been carried out, although knowledge on the level of morphological diversity of enset across a large number of ethnic groups or a large geographical area is important to assess the number of enset clones in the country and in the same time to develop a strategy for better genetic diversity conservation. Therefore, the objective of this study was to investigate farm level diversity and distribution of enset clones in seven (out of 16) major enset production areas in southern Ethiopia.

MATERIALS AND METHODS

The study area

The Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) has a total area of 117,506 km², with altitudes ranging from 378 to 4,207 m above sea level (masl) (Abebe, 2005). The study was conducted in seven administrative zones: Wolaita, Kembata, Hadiya, Sidama, Gamo Gofa, Gurage and Dawro. One district was selected in each zone. The selection was based on the prominence of enset cultivation and information about enset distribution obtained from the Departments of Agriculture of the respecttive zones.

Sampling and data collection

A household-level survey covering the seven zones was conducted from August 2008 to February 2009. In each zone, two peasant associations (PAs) (PA; this is the lowest tier of civil administration, equivalent to a village) were selected. Twenty households were randomly selected from each PA, giving a total of 280 households across the seven zones. Farmers were asked to name and describe each enset clone present on their farm.

In order to quantify on-farm genetic diversity, in all the directly monitored farms, a participatory zigzag sampling in diagonal direction of the plot was made in all 280 enset farms. All encountered clones were counted and discussions were made with farmers. For further verification of the clones, sample plants were taken from each clone to Areka research center for further on station assessment of selected quantitative and qualitative traits (Yematawet al., 201)

Data analysis

Simpson (1949) and Shannon and Weaver (1949) diversity indices are the two most widely used measures of heterogeneity (Magurran, 1988). Both of them were calculated for all the zones. Simpson's index (D) measures the probability that two individuals, randomly selected from a sample, belong to the same category (Simpson, 1949) and hence, as D increases, diversity decreases. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give Simpson's Index of Diversity (1 – D). The value of this index ranges between 0 and 1; the greater the value, the greater the sample diversity. The index was computed for all the zones and all the clones using the function:

Simpson's Index of Diversity (1-D) = $1-\sum (n/N)^2$

$$D = \sum_{i-1}^{n} \frac{(n_i\,(n_i - 1)}{(N(N-1)}$$

Where, n_i= the frequency of the i^{th} clone, frequency being the number of farms in which the clone is found in the district, and N = the total number of farms surveyed in the district.

The Shannon–Weaver diversity index (Shannon and Weaver, 1949) and Evenness measure (E) are commonly used tools that incorporate both richness and the evenness of abundance (Magurran, 1988). The Shannon diversity index (*H'*) is high when the relative abundance of the different species in the sample is even, and is low when few species are more abundant than the others. Shannon–Weaver diversity index takes into account both number and evenness of categories considered and can be increased either by greater evenness or more unique species or clones in this case.

It was calculated using the formula, $H' = -\Sigma\, pi\, ln\, pi$ (Magurran, 1988).

Where pi, the proportional abundance of the i^{th} clone = $(\frac{ni}{N})$.

Although Shannon's index takes into account evenness of the abundance of clones, evenness can be calculated separately as a measure of the observed diversity to the maximum diversity. It is defined by the function E = H'/lnS, where H' is the Shannon index and S refers to the number of clones described in each zone. A high

Table 1. Distribution of households by number of enset plants.

Number of enset plants/household	Number of households	Percent
≤500	59	21
501-1000	80	29
>1000	141	50
Total	280	100

N	Minimum	Maximum	Mean	Standard error
280	60	15000	2018	147

Table 2. Variation in the number of enset clones planted per farm in the seven zones.

Number of enset clones per farm	Number of farms								Mean number (%) of farms
	S*	W	GG	K	H	D	G	Total	
≤ 5 clones	6	2	9	1	2	3	6	27	4.1(10.3)
6-10 clones	19	22	24	39	31	26	23	184	26.3 (65.8)
11-15 clones	12	14	6	0	2	11	9	54	7.7 (19.3)
≥15 clones	3	2	1	0	5	0	2	10	1.9 (4.8)
Total	40	40	40	40	40	40	40	280	

*S = Sidama; W = Wolaita; GG = Gamo Gofa; K = Kembata; H = Hadiya; D = Dawro; G = Gurage.

evenness, resulting from all clones having equal abundance, is normally equivalent to high diversity (Magurran, 1988).

Measures of similarity/variation are almost as numerous as measures of species diversity. The purpose of these functions is to quantify the similarity between two or more sampling sites. The expected variation in clone composition that exists between sites was analyzed using Sorenson's similarity coefficient (Cs) (Sorenson, 1948):

$$Cs = \frac{2J}{a+b}$$

Where, *a* is the number of clones at site A, *b* is the number of clones at site B, and *J* is the number of clones common to both locations.

Sorenson's similarity coefficient ranges in value from zero (no similarity) to one (complete similarity).

Clone diversities (Simpson's and Shannon-Weaver diversity indices) were measured separately for each zone. Pearson's correlation coefficient was used to compare diversity and distribution values at different sites. A tree diagram was constructed based on Euclidean distances developed by an unweighted pair-group method based on arithmetic averages (Nei, 1987). The SAS computer program (SAS, 2002) was employed for data analysis.

RESULTS AND DISCUSSION

Enset clone richness

The number of enset plants per farm household ranged from 60 to 15,000 and depended on farm size and availability of labor. The mean number of enset plants per household was 2,018 ± 147 (Table 1). Half (50-4%) of farm households have more than 1,000 enset plants on their farm. A farmer with a large number of enset plants and a wide diversity of clones is considered food secure and a model farmer in the locality. This study agrees with the study of Brandt et al. (1997) and Negash (2001) who observed large number of enset plants and clones in wealthy farmers' fields. Majority of the farms surveyed (65.8%) constitute 6-10 enset clones per farm (Table 2).

Based on the total number of different clones recorded (richness of the zone) and the number of enset clones per farm, Hadiya was the richest zone with a total of 59 clones, followed by Kembata (43), Dawro (41) Wolaita (39), Gamo Gofa (34) and Gurage (31) (Table 3). The lowest richness was found in Sidama zone with 30 clones. In previous studies, comparable results were reported by Tsegaye (2002), who described 146 different enset clones from three zones (52 clones from Sidama, 55 clones from Wolaita and 59 clones from Hadiya). Negash (2001) recorded 146 different enset clones from four zones (65 clones from Kefa-Sheka, 30 clones from Sidama, 45 clones from Hadiya and six clones from Wolaita). Moreover, Birmeta (2004) described 111 enset clones from nine growing areas of Ethiopia and Tesfaye (2002) studied 79 clones from the Sidama zone of the southern region. Although two zones (Dawro and Kembata) of our geographical study region were different from previous studies, 23 of the Sidama clones reported in our study were also listed by Tesfaye (2002). Out of the 59 enset clones of the Hadiya zone reported in this study, 36 were also reported by Tsegaye (2002). Of the clones in Wolaita studied by Tsegaye (2002), 18 clones were different from those included in

Table 3. Enset clone diversity in the seven zones, Southern Ethiopia, expressed as richness, Simpson (1-D) and Shannon (H') diversity indices, and Evenness.

Districts	Richness (%)	Mean richness/farm	Minimum richness	Maximum richness	Number of unique landraces	1-D	H'	Evenness
Sidama	30 (10.8*)	9.47	3	18	24	0.97	3.58	0.97
Wolaita	39 (14.02)	10.25	4	19	22	0.98	3.67	0.10
GamoGoffa	34 (12.23)	7.95	3	17	23	0.97	3.59	0.97
Kembata	43 (15.5)	7.53	4	10	24	0.98	3.64	0.99
Hadiya	59 (21.2)	9.3	2	26	33	0.97	3.61	0.98
Dawro	42 (15.1)	8.95	3	15	29	0.97	3.61	0.98
Gurage	31 (11.15)	8.95	2	24	23	0.98	3.63	0.98
Mean±SE	39.7 ± 3.8	8.94 ± 0.94						

*Calculated on the basis of the 278 clones described throughout the study area.

our study.

This indicated that the number of clones in any zone is not fully established and is underestimated by the survey methods used in independent studies. Further study including many enset growing area within the same time is very important. Many studies have been conducted to assess the patterns of genetic diversity in landraces of different crops using different methods and identifying promising accessions for different traits that could be utilized in breeding programmes. Examples include studies on tef (Bekele, 1996); wheat (Negassa, 1985), barley (Demissie and Bjørnstad, 1996), and sorghum (Ayana and Bekele, 1998).

The number of clones cultivated on individual farms ranged from two to 26 (mean of 8.94 ± 0.94) (Table 3). Average number of clones per farm ranged between 10.25 for Woalita to 7.53 for Kembata Sidama (9.47) and Hadiya (9.3) had high farm level diversity, followed by Dawro and Gurage with 8.95 clones per farm. This is because they have many farms with 11-15 clones, while other zones such as Kembata have few such clones, although the total number of clones in the zone was the highest (Table 3).

Diversity indices for the seven zones studied were computed from the numbers of clones present on the 40 farms within the zone (Table 2). Although zones differed in richness, they were similar in diversity. The Simpson's 1-D ranged between 0.971 (Sidama) to 0.977 (Wolaita), H′ ranged between 3.58 for Sidama to 3.67 for Wolaita, while evenness also had a very narrow range: 0.97 for Gamo Gofa to 0.99 for Wolaita (Table 3). All these values indicate the high enset diversity in these seven zones.

In the seven zones, a total of 218 clones with distinct names were recorded. During the survey, we were able to confirm that each farmer is determined to maintain as much enset diversity as possible as long as he/she has enough land. It was possible to verify the existence of up to 26 different enset clones maintained by one household. During discussion with the farmers it was also observed that there were more than 100 enset clones grown in each locality a few years back, however, farmers reported that most of the clones were lost due to disease and wild animals such as mole rat, porcupine and wild pigs. Tesfaye (2002) also found out that in Sidama, farmers reported names of 20 enset clones which were not encountered in any of the farms that were visited. Some enset landraces might have been totally lost from farmers' fields.

Hadiya and Kembata zones shared 17 clones (Table 4), while Wolaita and Gamo Gofa, and Wolaita and Dawro had 11 clones in common. These zones are adjacent to each other and the Kembata and Hadiya, and Wolaita and Dawro zones were until recently one administrative area.

Strong cultural and linguistic similarities exist between Kembata and Hadiya, and between Wolaita, Dawro and Gamo Gofa. This justification was noticeably confirmed by Fleming (1975), who stated that Dawro, Gamo Gofa and Wolaita peoples of the Southern Ethiopia belong to Omotic people who have a dialect of the central Omotic languages.

This may be reflected in the observed high similarity in cultivated clones. Clustering of the seven zones using the Sorenson's similarity index grouped the seven zones into four clusters (Figure 1) as follows: i) Kembata and Hadiya, ii) Wolaita, Dawro and Gamo Gofa, iii) Sidama and iv) Gurage. It is interesting to note that Sidama and Gurage do not share many clones with neighboring zones

These findings, however, noticeably differ from those of Tesfaye (2002), who reported that 52% of enset clones in Sidama zone were shared among farmers of the study area suggesting that informal exchanges among farmers are limited within narrowly defined ethnic groups. The informal exchange of planting material among farmers mainly occurs within the geographical zone occupied by an ethnic group and it is hence difficult, to compare values with results of previous surveys due to differences in the number of locations and ethnic considerations.

In agreement with Tabogie (1997), duplication of clone names was observed. The same enset clone was given different names in different areas and vice versa (different enset clones were given the same name in different localities) (Tabogie, 1997). Tsegaye (2002) also showed that duplication of clone names was related to different

Table 4. Number of shared clones (above diagonal) and Sorenson similarity indices (below diagonal) between pairs of zones.

Zones	Sidama	Wolaita	Gamo Gofa	Kembata	Hadiya	Dawro	Gurage
Sidama	--	3	1	2	2	3	1
Wolaita	*0.06	--	11	1	4	11	1
Gamo Gofa	0.06	0.27	--	0	1	6	0
Kembata	0.03	0.02	0.026	--	17	0	2
Hadiya	0.07	0.08	0.02	0.35	--	2	8
Dawro	0.06	0.3	0.16	0	0.04	--	0
Gurage	0.03	0.03	0	0.05	0.18	0	--

*=Sorenson's similarity index.

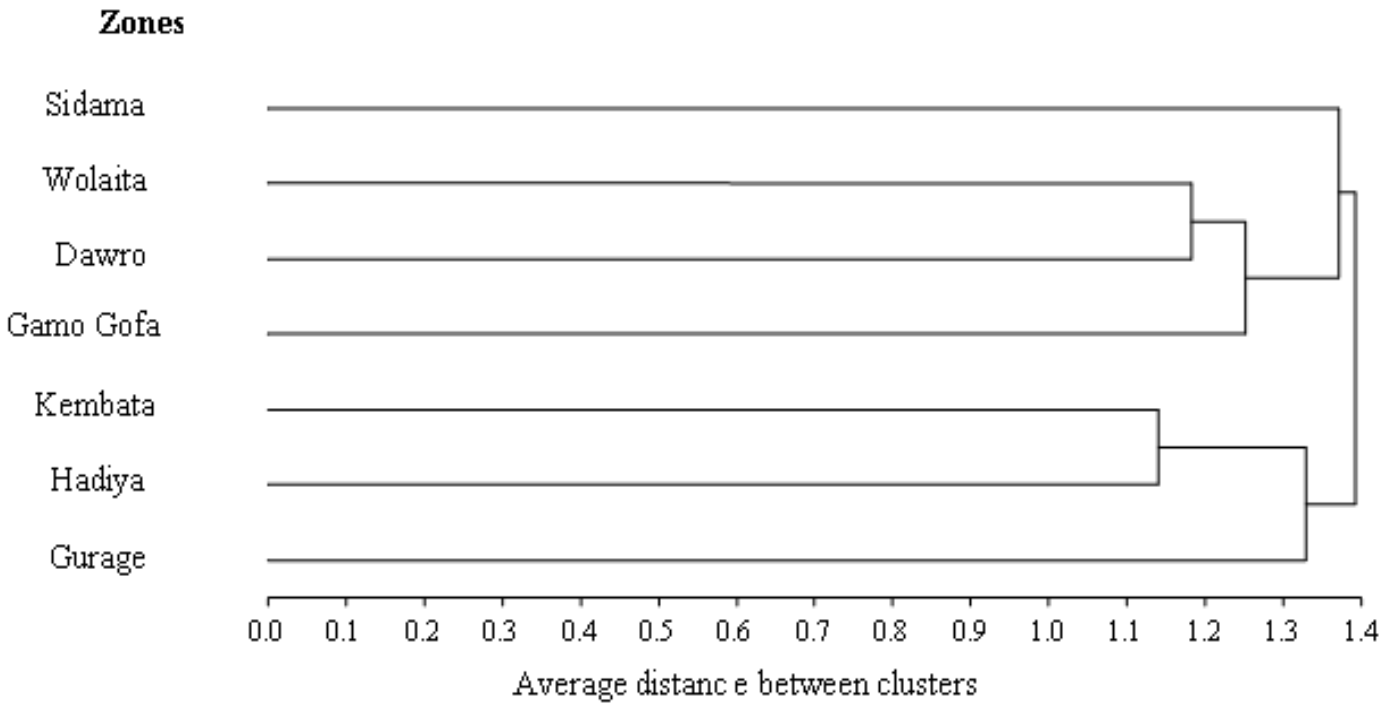

Figure 1. Dendrogram of the seven zones based on Sorenson's similarity index.

utilization purposes of clones and the changing of vernacular names after exchange of clones between different ethnic groups.

Distribution and abundance of clones

Large differences were evident between clones in their abundance and distribution. Some clones had a rather patchy distribution, that is they had a very high local abundance at one or two locations and were absent from the rest. For example, 'Shodedenia' was encountered on all the 40 (100%) of the farms visited in Dawro (Table 5). It was not found in any other zones surveyed. This is an abundant clone with a narrow distribution. The same was true for 'Amerate' in Gurage and Genticha in Sidama which were recorded on 33 and 27 of the 40 farms, respectively (Table 5). On the other hand a relatively small number of clones played a dominant role in more than one zone. These were 'Mazia', 'Gena', 'Astara' and 'Badedea' (Table 5). Mazia was the most abundant clone as it was recorded on 89 (32%) of all the farms surveyed, and also in a much higher proportion of the 40 farms surveyed in the three zones where it was found: Wolayita, Gamo Gofa and Dawro zones 17 (7%), 35 (12%) and 37 (13%) respectively) (Table 5). However, there was overall a significant correlation between distribution and abundance of the clones ($r = 0.66$, $p \leq 0.0001$). Clones that are used by many famers in any zone tend to be found in other zones and have wider distribution.

There was also a considerable difference among the clones with respect to their distribution across the zones

Table 5. Numbers of farmers growing widely distributed and the most abundant enset clones in each zone.

Clone	H†	K	G	W	GG	S	D	TOT	Zones
Astara	13	22	14			10		59	4
Sabara	16	8	16					40	3
Mochea	13	2		5				20	3
Badadea	10		3	8			2	23	4
Gena	1			14	14	20	10	55	5
Katania				11	5		3	19	3
Agena				7		10	9	26	3
Switia				8	4		4	16	3
Kekerwa				7	9		6	22	3
Mazia				17	35		37	89	3
Banga				9	2		7	18	3
Shodedenia							40	40	1
Amerate			33					33	1
Genticha						27		27	1

†= H = Hadiya, K = Kembata, G = Gurage, W = Wolaita, GG = Gamo Gofa, S = Sidama, D = Dawro, TOT = Total number of farmers.

Table 6. Distribution of enset clones across the seven zones

Number of zones	Number of enset clones (%)
One	178 (82)
Two	29 (13)
Three	8 (4)
Four	2 (1)
Five	1 (<1)
Six	0
Seven	0
Total	218

covered by this study. Out of the 218 clones, 178 (82%) were observed in only one zone. Twenty nine (13%) of the clones were present in two zones. Eight clones (4%) were present in three zones. Two clones (1%) were present in four of the seven zones and only one clone (Gena) was present in five of the seven zones (Tables 5 and 6). Household characteristics, distance from one location to another and ethnic preferences in few locations for few number of clones bring high clonal diversity, while for more number of clones that do not fulfill the selection criteria of each ethnic group brings clonal paucity.

To classify the total abundance and distribution of the whole clone into four quadrant plane, a clone having an equal abundance x distribution point was selected. Based on that, if we designate a clone that is present in at least 15 of the 40 farms in a given zone having an average abundance of 0.38, then all the 218 clones can be categorized into four groups on the abundance x distribution plane (Table 7 and Figure 2). The first category (widely distributed and abundant clones) applies only to 'Mazia'. The second category (localized but abundant clones) included 23 enset clones. The highest numbers of enset clones (183) were grouped in the third category which is the localized and rare clones. The fourth group (widely distributed but rare clones) included 11 clones.

The abundance of clones across sites within a zone and the distribution of clones across the seven zones were generally uneven, because of a limited number of widespread and dominant clones. The hierarchical nature of the spatial distribution of enset clones with a small number of highly abundant clones which are also grown throughout the region and a much larger number of moderately common and rare ones has been documented for enset (Tesfaye, 2002), and several other crops including cassava (Boster, 1985) and yam (Tamiru, 2006).

Conclusion

A large number of enset clones was recorded in the southern region. However, the diversity of enset clones is not spread evenly across the region. A small number of highly abundant clones are grown throughout the region, while a much larger number of moderately common and rare clones characterize the distribution-abundance pattern. The widespread distribution of some clones challenges the view that traditional farming systems are isolated and closed, with limited exchange of germplasm. The findings of this study and similar studies depict a system that is rather open and dynamic, where local knowledge exists for exchange of planting materials across wider areas and heterogeneous environments. The unequal distribution and abundance of clones reflect

Table 7. Classification of the 218 clones into four groups based on their abundance and distribution.

Quadrant	Category	Number of clones in the category
I	Widely distributed and abundant clones	1
II	Localized but abundant clones	23
III	Localized and rare clones	183
IV	Widely distributed but rare clones	11

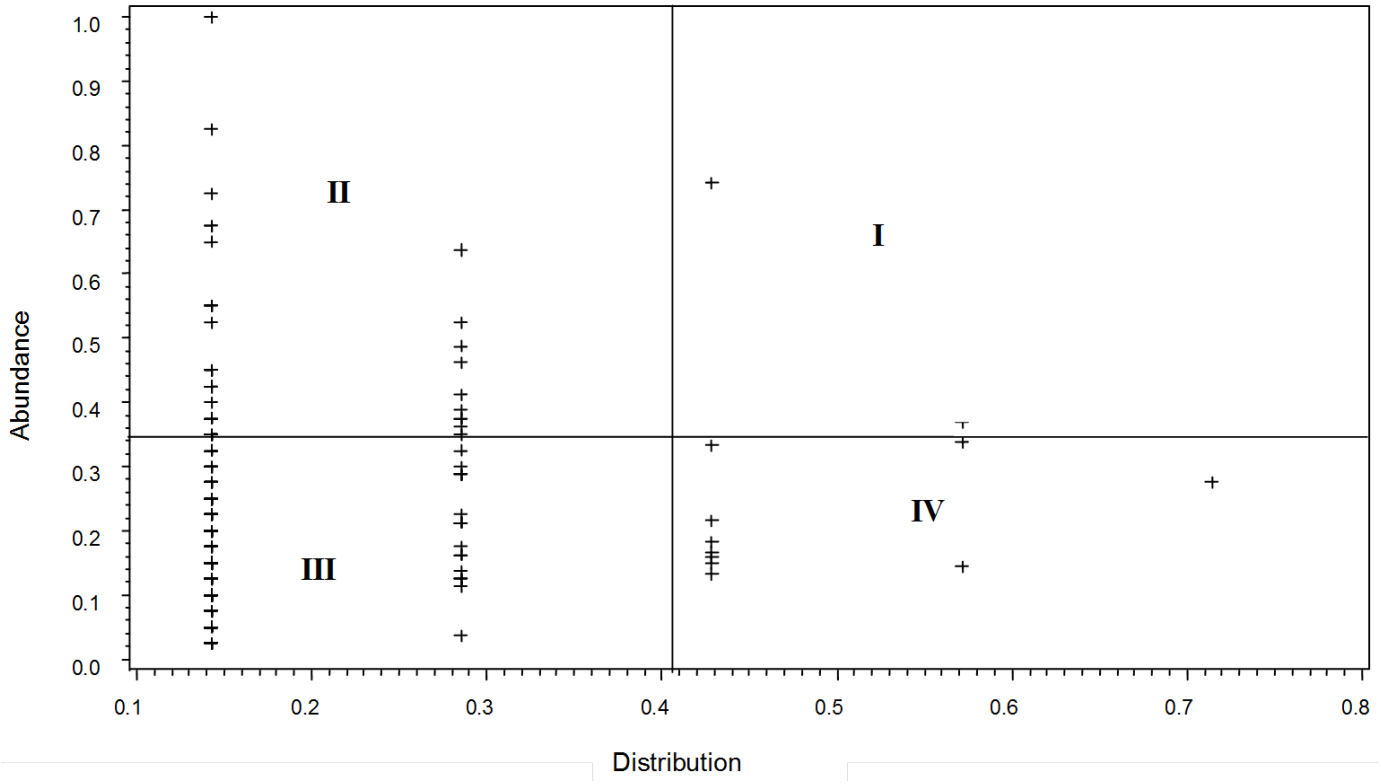

Figure 2. Classification of the 218 enset clones into 4 groups using their scatter in abundance X distribution plane. (a lot of clones are hidden).

their relative importance to farmers and provide strong evidence for selection. Highland regions have a high concentration of diverse and unique enset landraces and should be given priority in efforts aimed at collection and *in situ* germplasm conservation.

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REFERENCES

Abebe T (2005). Diversity in homegarden agro-forestry systems of southern Ethiopia. PhD dissertation, Wageningen University, The Netherlands. 143 pp.

Alemu K, Sandford S (1991). Enset in North Omo Region. Farmer's Res. Project Technical Pamphlet No. 1. Farm Africa, Addis Abeba. 49 pp.

Ayana A, Bekele E (1998). Geographical patterns of morphological variation in sorghum (*Sorghum bicolor* (L.) Moench) germplasm from Ethiopia and Eritrea: qualitative characters. Hereditas 129:195-205.

Bekele E (1996). Morphological analysis of *Eragrostis teff*: Detection for regional variation. *Sinet*: Ethiopian J. Sci. 19:117-140.

Bezuneh T (1984). Evaluation of some *Ensete ventricosum* clones for food yield with emphasis on the effect of length of fermentation on carbohydrate and calcium content. Trop. Agr. 61:111-116.

Birmeta G (2004). Genetic variability and biotechnological studies for the conservation and improvement of *Ensete ventricosum*. Doctoral thesis, Swedish University of Agricultural Sciences, Alnarp. 91 pp.

Boster J (1985). Selection for perceptual distinctiveness: evidence from Aguarina cultivars of *Manihot esculenta*. Econ Bot. 39:310-325.

Brandt SA, Spring A, Hiebsch C, McCabe ST, Tabogie E, Diro M, Welde-Michael G, Yentiso G, Shigeta M, Tesfaye S (1997). The 'Tree Against Hunger'. Enset-based Agricultural Systems in Ethiopia. American Association for the Advancement of Science. 56 pp.

Demissie A, Bjørnstad A (1996). Phenotypic diversity of Ethiopian barley in relation to geographical region, altitudinal range, and agro-ecological zones: As an aid to germplasm collection and conservation strategy. Hereditas 124:17-29.

Engels J, Hawkes J (1991) .The Ethiopian gene centre and its genetic diversity. In: Engels J, Hawkes J, Worede M (eds). Plant Genetic Resources of Ethiopia. Cambridge University Press, Cambridge

Fleming H (1975). Recent Research in Omotic-Speaking Areas. In: Marcus H.G (ed.). Proceedings of the First United states Conference on Ethiopian Studies, 1973. East Lansing: Michigan State University. pp. 261-278.

Magurran A (1988). Ecological diversity and its measurement. Croom Helm, London. 125 p.

Negash A (2001). Diversity and conservation of enset (*Ensete ventricosum* Welw. Cheesman) and its relation to household food and livelihood security in South-western Ethiopia. PhD dissertation, Wageningen University, The Netherlands. 247pp.

Negash A, Tsegaye A, Van Treuren R, Visser B (2002). AFLP analysis of Ensete clonal diversity in south and southwestern Ethiopia for conservation. Crop Sci. 42:1105-1111.

Negassa M (1985). Patterns of phenotypic diversity in an Ethiopian barley collection and the Arsi-Bale high land as a center of origin of barley. Hereditas 102:139-150.

Nei M (1987). *Molecular evolutionary genetics*. Colombia University Press, New York.

SAS (2002). Statistical Analysis Systems SAS/STAT user's guide Version 9 Cary NC: SAS Institute Inc. USA.

Shannon C, Weaver W (1949). The mathematical theory of communication. University of Illinois, Urbana, IL 117pp.

Shigeta M (1990). Folk *in situ* conservation of enset (*Enset ventricosum* (Welw.) Cheesman): Towards the interpretation of indigenous agricultural science of the Ari, south western Ethiopia. Afr Stud Monogr 10:93-107.

Simpson E (1949). Measurement of diversity. Nature 163:688.

Sorenson T (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analysis of the vegetation on Danish commons. K dan Vidensk Selsk Biol. Skr. 5:1-34.

Tabogie E (1997). Morphological Characterization of enset (Ensete ventricosum (Welw.) Cheesman) clones and the association of yield with different traits. M.Sc. Thesis. Alemaya University of Agriculture, Alemaya, Ethiopia. 89 pp.

Tamiru M (2006). Assessing diversity in yam (*Dioscorea spp.)* from Ethiopia based onmorphology, AFLP marker and tuber quality, and farmers' management of landraces. Ph.D. thesis, George -August University. Germany. 155pp.

Tesfaye B (2002). Studies on landrace diversity, *in vivo* and *in vitro* regeneration of enset (*Enset ventricosum* Welw.). PhD dissertation, Humboldt University, Berlin, Germany, 129 pp.

Tsegaye A (2002). On indigenous production, genetic diversity and crop ecology of enset (Enset ventricosum (W elw.) Cheesman) . PhD dissertation, W ageningen University, The Netherlands. 197pp.

Yematawz, Mohamed H, Diro M, Addis T, Blomme G (2014). Enset (*Ensete ventricosum*) clone selection by farmers and their cultural practices in southern Ethiopia. Genet Resour Crop Ev. 61(3): DOI 10.1007/s10722-014-0093-6.

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