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Website: <http://www.ugcnepal.edu.np>

E-mail: ugc@ugcnepal.edu.np

Post Box: 10796, Kathmandu, Nepal

Phone: (977-1) 6638548, 6638549, 6638550

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Comparison of Microtensile Bond Strengths of a One-Step Self-Etch and a Two-Step Etch-and-Rinse Adhesive System to Primary and Permanent Dentin – An In Vitro Study

Nitin Kumar Agrawal, Ashwin P. Rao* and Samarika Dahal

Department of Dentistry, IOM, TUTH, Maharajgunj, Kathmandu, Nepal

*Department of Paediatric and Preventive Dentistry, Manipal College of Dental Sciences, Mangalore, Karnataka, India

Email: cdrnitin@gmail.com, dr.samarika@hotmail.com

Abstract: *Dentin bonding agents are the foundation for durable composite restorations. Traditionally, dentin bonding involved etching, priming and adhesive application, followed by the composite restoration. Recently one-step self-etch adhesives or popularly called as the seventh generation bonding agents have been introduced which simplify the bonding procedure by omitting of the post conditioning rinsing phase and thus completing the procedure in a single step. This can be a very attractive proposition in primary teeth bonding where time is a critical factor. Hence this study compared microtensile bond strengths of a one-step self-etching (G Bond) and a two-step etch-and-rinse (Adper Single Bond 2) adhesive in primary teeth dentin. Bond strengths of bonding agents to primary teeth dentin compared to permanent dentin have shown varied results in literature. Hence this study obtained microtensile bond strength values of a one-step self-etch and a two-step etch-and-rinse adhesive in primary teeth dentin and compared the results to those obtained with the same adhesive systems in permanent dentin. Reports have suggested that decreasing etching time in primary teeth dentin may result in thinner hybrid layers and higher bond strengths. But, results to this experiment have been varied. Hence, this study evaluated the effect of shortening the dentin etching time on microtensile bond strengths of two bonding agents in primary teeth dentin.*

Keywords: *Microtensile bond strength, bonding agent, primary teeth, etching.*

Introduction

Dentin bonding agents are the foundation for durable composite restorations. Composite restorations are now commonly used in Pediatric Dentistry in the form of strip crowns in class I restorations of young permanent teeth and in cases of restoration of traumatic injuries in anterior teeth and even in posterior primary teeth especially in the late mixed dentition.

Traditionally, bonding composites involved etching, priming and adhesive application, followed by restoration. The first step of simplification of the conventional three-step bonding was to combine the primer and the adhesive, resulting in a two-step etch-and-rinse adhesive (Summit *et al.*, 2002). The next simplification was the development of two-step self-etch approach, where the acid and the primer are combined into one solution to form an acidic monomer prior to the application of a subsequent bonding step. These are popularly known as the sixth

generation bonding agents. This was followed by the development of one-step self-etch adhesives or popularly called the seventh generation bonding agents. Here the acidic primer and adhesive are combined in one-bottle and applied in a single clinical step (Atash and van den Abbeele, 2005).

Although a number of articles have been published on the shortcomings of one-step self-etch adhesives, they may still have an important role in composite restorations of primary teeth. The choice of an adhesive in Pediatric Dentistry does not depend solely on tensile or shear force values. The choice also depends on the child's temperament and age. For children, who find it difficult to accept treatment and for toddlers, for whom speed is of the essence, adhesives which require only one application can be recommended (Atash and van den Abbeele, 2005).

This study compared microtensile bond strengths of a one-step self-etching adhesive to primary teeth dentin and compared the results to those obtained with a two-step etch-and-rinse adhesive, considering the latter as the control. This study also compared microtensile bond strength values of a one-step self-etch and a two-step etch-and-rinse adhesive to primary teeth dentin and compared the results to those obtained with the same adhesive systems in permanent dentin.

Manufacturer's instructions for using adhesives in primary teeth are not yet firmly established and currently manufacturers do not recommend a different protocol for their products when used for primary teeth dentin bonding (Kaaden *et al.*, 2003; Hosova, 2008). So this study evaluated the effect of shortening the dentin etching time on microtensile bond strengths of a one-step self-etch adhesive and a two-step etch-and-rinse adhesive in primary teeth dentin.

Materials and methods

The present study was conducted in the Department of Paedodontics and Preventive Dentistry, Manipal College of Dental Sciences, Mangalore, in coordination with the Department of Dental Materials, Manipal College Of Dental Sciences, Manipal. An ethical committee clearance was obtained prior to the study.

16 premolars, extracted for orthodontic reasons, and 32 primary molars, extracted for therapeutic reasons, were collected and stored in distilled water. It was ensured that the crown of the selected teeth were free from caries. All extracted teeth were used within three months. The 16 premolars were divided randomly into 2 groups, consisting 8 teeth in each group and the 32 deciduous molars were divided randomly into 4 groups of 8 each.

These groups were as follows:

Group I (E/Rperm) – Two-step etch-and-rinse adhesive system application on Premolar, with conventional timing of etchant application.

Group II (SEperm) – One-step self-etch adhesive system application on Premolar, with conventional timing of etchant application.

Group III (E/Rpri) – Two-step etch-and-rinse adhesive system application on primary molars, with conventional timing of etchant application.

Group IV (SEpri) – One-step self-etch adhesive system application on primary molars with manufacturer's recommended timing.

Group V (E/RpriR) – Two-step etch-and-rinse adhesive system application on primary molars, with reduced timing of etchant application.

Group VI (SEpriR) – One-step self-etch adhesive system application on primary molars, with reduced timing of adhesive application.

Preparation of test specimen: Each tooth was mounted on a self cure acrylic resin block in such a way that only the roots were embedded in the block and the coronal part of the crown was exposed.

One third of each occlusal tooth was sliced with a diamond disc under copious irrigation. Then the flat occlusal surface was rubbed with sand paper to create the smear layer.

Method of bonding agent application

Etch and rinse adhesive system for Group I and Group III: The etchant (Scotchbond Multi-Purpose) was applied with the applicator over the exposed dentin surface and left for 15 seconds. After that, the etchant was washed with water for at least 10 seconds. Then the area was blot dried with a cotton pellet. Then two layers of bonding agent (Adper Single Bond 2) were applied with the applicator and then cured according to the manufacturer's instructions.

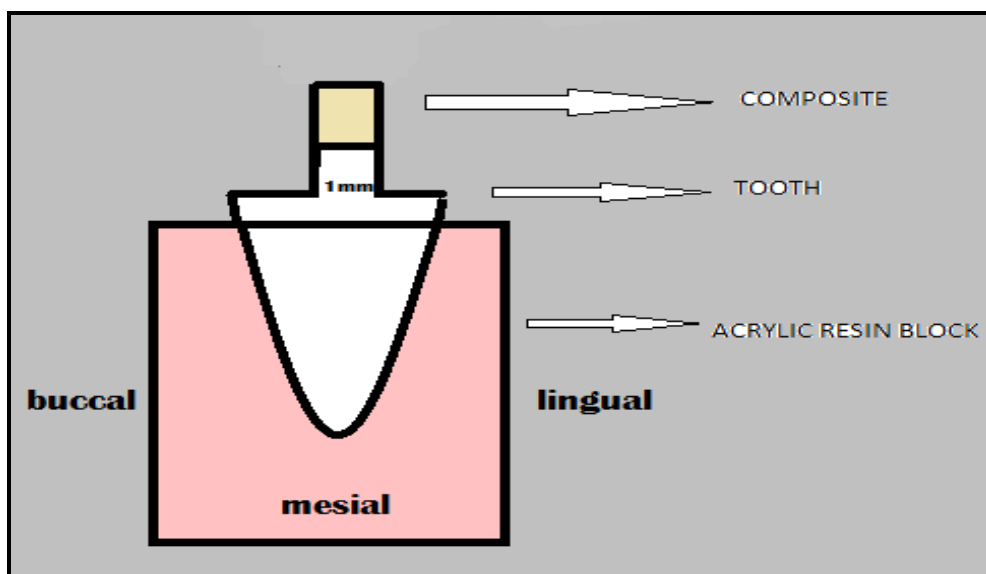
Etch and rinse adhesive system for Group V: The etchant (Scotchbond Multi-Purpose) was applied with the applicator over the exposed dentin surface and left for 8 seconds. After that, the etchant was washed with water for at least 10 seconds. Then the area was blot dried with a cotton pellet. Then two layers of bonding agent were applied with the applicator and then cured according to the manufacturer's instructions.

Self etch adhesive system for Group II and Group IV: After washing the surface with water and blot-drying it with a cotton pellet, a layer of self-etch adhesive (G-Bond) was applied with the applicator and was air-dried. Then the second layer of same adhesive was applied and left for 10 seconds, and was then cured according to the manufacturer's instructions.

Self-etch adhesive system for Group VI: After washing the surface with water and blot-drying it with a cotton pellet, a layer of self-etch adhesive (G-Bond) was applied with the applicator and was air-dried. Then the second layer of same adhesive was applied and left for 5 seconds, and was then cured according to the manufacturer's instructions.

Method of composite build up: After the adhesive was applied and cured, a Teflon mould, 5 mm in diameter and 2 mm in height, was placed over the occlusal aspect and a composite of around 2 mm was packed and was light cured according to the manufacturer's instructions. Once the composite build up was done, the crown of the tooth along with the composite was sectioned in a buccolingual direction, on either side of the tooth, leaving 1 mm of tooth and composite in the middle as shown in the (Fig. 1).

Fig. 1. Diagrammatic representation of after-composite buildup

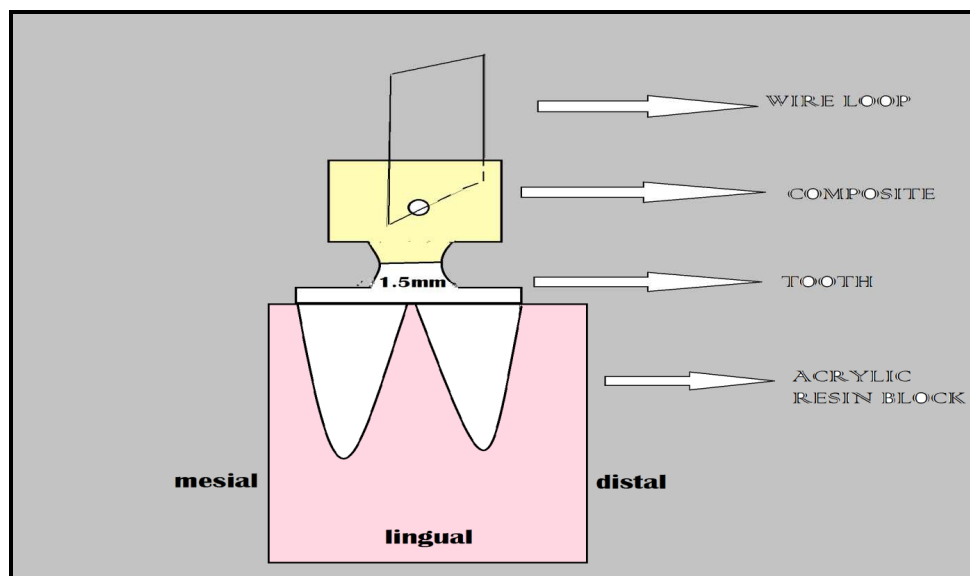


A second layer of composite buildup was done in the following manner. 2 mm of composite was placed again with a 22 gauge wire placed in a bucco-lingual direction over the cured composite. Slowly, this wire was removed and the remaining composite was cured for 40 seconds. The idea behind placing the wire is to obtain a hole in the composite block without subjecting it to undue stress. This hole would be utilized by passing a loop of wire through it which would help in engaging the specimen during the bond strength measurement.

Then the third layer of composite buildup was done over the second layer. The third layer was placed to reinforce the second layer of composite to prevent its breakdown while subjecting it to microtensile loading.

Then the composite tooth interface was reduced with a straight fissure bur mounted on an airtor hand piece. This reduction was carried out mesiodistally so that 1.5 mm of composite-tooth interface was left in a mesio-distal direction. The dimensions were measured with a digital vernier caliper. A 22 gauge stainless steel wire of 10 cm in length, was passed through the hole and bent into a loop (Fig. 2).

Fig. 2. Diagrammatic representation, after placing wire loop in hour glass specimen



A hook was separately made with a 19 gauge stainless steel wire to be held in the upper unit of the Universal Testing Machine.

Evaluation of microtensile bond strength: This part of the study was done at the Department of Dental Materials, Manipal College Of Dental Sciences, Manipal. A Universal Testing Machine (Instron 3366) was utilized in this study for the measurement of microtensile bond strength (MTBS) of the two adhesive systems used. The prepared specimens were subjected to microtensile bond strength measurement. The Instron machine has two jaws, one of which held the resin block, and the other held the hook made from stainless steel wire (19 gauge) tightly. Once the specimen was secured properly in place, the loop of wire in the composite was passed passively into the hook. After this, it was subjected to tensile loading at a crosshead speed of 1 mm/min until the debonding took place. The load at which the composite debonded from the tooth was noted in Newton (N). This reading was divided by the surface area of the specimen i.e. 1.5 mm² to obtain the microtensile bond strength (in MPa).

Statistical analysis: The data obtained were analyzed using SPSS for Windows release 11.5 (SPSS, Chicago, IL, USA) and subjected to Kruskal Wallis and Mann Whitney U test at a significance level of 0.05.

Results and observations

The results were studied under the following headings: 1) Mean and Standard deviation values, 2) Inter group comparisons

1) Mean and Standard deviation values

The mean and standard deviations of microtensile bond strength values obtained for the six groups are shown in Table 2.

Table 1. MTBS values of different groups (in MPa)

Group I (E/Rperm)	Group II (SEperm)	Group III (E/Rpri)	Group IV (SEpri)	Group V (E/RpriR)	Group VI (SEpriR)
15.11	9.50	16.67	11.16	12.16	10.31
16.10	12.23	22.21	10.26	14.21	9.45
21.39	16.15	14.67	12.21	14.25	9.07
13.25	13.21	13.32	13.72	15.21	12.23
18.44	15.21	19.56	15.83	17.21	13.31
16.08	12.67	10.12	17.67	18.36	12.76
19.66	15.21	11.25	18.34	20.51	10.21
17.11	16.22	15.11	15.56	17.97	14.10

Table 2. Mean MTBS and Standard deviation values of six groups

	N	Mean	Std. Deviation	Minimum	Maximum
Group I	8	17.14	2.61	13.25	21.39
Group II	8	13.80	2.33	9.50	16.22
Group III	8	14.34	2.99	10.26	18.34
Group IV	8	16.24	2.74	12.16	20.51
Group V	8	15.36	4.06	10.12	22.21
Group VI	8	11.41	1.87	9.07	14.10
Total	48	14.72	3.28	9.07	22.21

H=15.569 p=.008 hs (H= Kruskal -Wallis test)

Kruskal-Wallis test was used to compare the mean values of MTBS obtained in each group. The test showed that the difference in the mean values of MTBS was statistically significant (p=0.008).

2) Intergroup comparisons

The Mann-Whitney U test was used for intergroup comparisons when significant differences were detected by the Kruskal Wallis test. All statistical analysis were conducted at the significance level of 0.05.

The following observations were recorded under the intergroup comparisons based on the aims and objectives of the study.

- I. Comparison of microtensile bond strengths of a one-step self-etching and a two-step etch and-rinse adhesive in primary teeth dentin. This was obtained by comparing Group III (E/Rpri) with Group IV (SEpri)
- II. Comparison of bond strengths of the adhesives in primary and permanent dentin. This was obtained by comparing:
 - i) Group I (E/Rperm) with Group III (E/Rpri)
 - ii) Group II (SEperm) with Group IV (SEpri)

- III. Comparison of the effect of reduced dentin etching times of the two adhesives used on MTBS values of primary teeth dentin. This was obtained by comparing:
- i) Group III (E/Rpri) with Group V (E/RpriR)
 - ii) Group IV (SEpri) with Groups VI (SEpri R)

On comparing microtensile bond strengths of Group III (E/Rpri) with Group IV (SEpri) in primary teeth dentin (Table 3), no significant statistical difference between the groups was found, suggesting that MTBS values of primary teeth dentin, when treated with the two-step etch-and-rinse adhesive and the one-step self-etch adhesive, were comparable.

On comparing bond strengths of the adhesives in primary and permanent dentin, Group I (E/Rperm) with Group III (E/Rpri), as shown in Table 3, it was noted that there was a significant statistical difference found between both the groups ($p=0.036$), suggesting that, when bonded with the two-step etch-and-rinse adhesive, MTBS values in permanent dentin were higher than primary teeth dentin.

There was no significant statistical difference found between Group II (SEperm) and Group IV (SEpri), as shown in Table 3, suggesting that MTBS values of both the groups were comparable.

On comparing the effect of reduced etching times of the two adhesives used on MTBS values of primary teeth dentin, there was no significant statistical difference found between both the groups, Group III (E/Rpri) and Groups V (E/RpriR), as shown in the Table 3, suggesting that MTBS values of both the groups were comparable.

There was significant statistical difference found between both the groups ($p=0.003$), suggesting that MTBS values of Group IV (SEpri) was higher than that of Group VI (SEpriR), as shown in Table 3.

Table 3. Inter group comparisons among various groups

Inter group comparison	Z	P
Group III vs Group IV	1.475	0.140
Group I vs Group III	2.102	0.036 sig
Group II vs Group IV	1.155	0.248
Group III vs Group V	0.631	0.528
Group IV vs Group VI	2.941	0.003 hs

Z= Mann- Whitney U test

Discussion

Composite restorations are now commonly being used in paediatric dentistry. The clinical success of a composite restoration depends on an adhesive system that provides durable bonding of the composite material and dentin (Yaseen *et al.*, 2007). A successful adhesive should fulfill the minimal acceptable level of bond strength that help to resist both polymerization and thermal stresses at the bonding interface.

Bond strength was reported as the initial mechanical load to the fracture divided by the defined cross-sectional area of the bond. Almost all bond strengths were categorized as tensile or shear bond strength until recently when Sano *et al.* (1994) developed the microtensile bond strength-testing methodology. The microtensile method carries several advantages over the traditional method because it: a) permits the use of only one tooth to fabricate several bonded dentin-resin slabs, b) allows for testing substrates of clinical significance such as carious dentin, cervical sclerotic dentin or enamel, c) results in fewer defects occurring in the small area (0.5 to 1.5 mm²) specimens, as reflected in higher bond strengths, d) allows for testing of regional differences in bond strengths within the same tooth.

Self-etching adhesives are classified, depending on their etching aggressiveness, as strong, intermediary strong and mild self-etch adhesives (Summit *et al.*, 2002). Kaaden *et al.* (2003) suggested that mild self-etching adhesives demineralize dentin only to a depth of 1 µm. Moreover, this superficial demineralization occurs only partially, keeping the residual hydroxyapatite still attached to the collagen. Nevertheless, sufficient surface porosity is created to obtain micromechanical interlocking through hybridization. The preservation of hydroxyapatite within the submicron hybrid layer may serve as a receptor for additional chemical bonding. G-Bond is a mild self-etch adhesive. Furthermore, G-Bond contains MDP (methacryloxydecyl dihydrogen phosphate), which has a chemical bonding potential to the calcium in the residual hydroxyapatite. The present study used a one-step mild self-etch adhesive (G-Bond) and a two-step etch-and-rinse adhesive (Adper Single Bond 2), to test bond strengths.

The micro tensile test provides a purely tensile load on a very small cross-section of the bonding interface regardless of the specimens' design (Betamar *et al.*, 2007). Studies indicate that a small size of the specimen will lead to a more favorable stress distribution and also to a failure of bonds which are closer to the ultimate strength (van Meerbeek *et al.*, 2010). The present study used a hour-glass specimen proposed by Sano *et al.* (1994) with the bonded interface being rectangular in cross-section, with an area of 1.5 mm².

- I. Interpretation of data comparing the microtensile bond strengths of a one-step self-etching and a two-step etch and -rinse adhesive in primary teeth dentin: *Group III (E/Rpri) vs. Groups IV (SEpri)*:
- II. Interpretation of data evaluating microtensile bond strength values of a one-step self-etch and a two-step etch-and rinse adhesive in primary teeth dentin and comparing the results to those obtained with the same adhesive systems in permanent teeth dentin: *i) Group I (E/Rperm) vs Group III (E/Rpri), ii) Group II (SEperm) vs. Groups IV (SEpri)*:

The present study showed no significant statistical difference between Group III (E/Rpri) and Groups IV (SEpri), suggesting that MTBS values of both the groups were

comparable. This study also showed a statistically significant difference between Group I (E/Rperm) and Group III (E/Rpri) ($p = 0.036$), suggesting that MTBS values of Group I (E/Rperm) were higher than that of Group III (E/Rpri). The study also did not find a statistically significant difference between Group II (SEperm) and Groups IV (SEpri), suggesting that MTBS values of both the groups were comparable.

Drawing an inference of the above three results in a nutshell, it suggests an overall lower bond strength of the two step etch and rinse adhesive (Adper Single Bond 2) to dentin in primary teeth. The results also suggest that G- Bond provides comparable bond strengths to dentin, in both primary as well as in permanent teeth though lesser than the two step etch and rinse adhesive in permanent teeth dentin.

Soares *et al.* (2005) showed that there was no significant difference between the bond strengths in both primary and permanent teeth dentin when an etch-and-rinse adhesive was used. But other literature suggests that the peritubular dentin, which is more mineralized but less crystalline than intertubular dentin, is two to five times thicker for primary teeth compared with permanent teeth. The dentin conditioning with the etchant tends to remove the peritubular dentin, resulting in wider, less retentive tubules and decreasing the area for bonding, thereby decreasing the bond strengths of etch-and-rinse adhesive (Adper Single Bond 2) to primary teeth dentin in this study.

Uekusa *et al.* (2006) in their study showed that bond strengths of primary dentin were significantly lower than that of permanent dentin for self-etch adhesive systems and attributed this to the differences in chemical composition and structural components between primary and permanent dentin. But, according to Kaaden *et al.* (2002) mild self-etching adhesives show higher bond strengths compared to other contemporary self etching adhesives. Inoue *et al.* (2001) in their evaluation of eleven contemporary adhesives to dentin described the mild self etching systems as having a pH of around 2 and demineralizing dentin no deeper than 1 μm . This superficial demineralization is incomplete, leaving residual hydroxyapatite still attached to collagen. Nevertheless the authors felt that sufficient surface porosity is created to obtain micromechanical interlocking through hybridization. The thickness of the hybrid layer is much less than that of the strong self-etch or etch-and-rinse approach, but this has not proven to be important with regard to the effectiveness of the bond.

Yoshida *et al.* (2004) also supported this in their comparative study on the performance of functional monomers, suggesting that the preservation of hydroxyapatite within the submicron hybrid layer may serve as a receptor for additional chemical bonding. They explained the potential of functional monomers in adhesives to chemically interact with residual hydroxyapatite within submicron hybrid layers as part of a so-called mild self-etch approach. They also stated that MDP has been reported to have high chemical bonding potential to hydroxyapatite within a clinically reasonable application time. Furthermore, MDP adhesive monomer

molecular structure allows for decalcification and penetration into tooth structure, “creating a chemical bond to calcium” whereby, MDP chemically bonds to hydroxyapatite, as opposed to a micro mechanical retention bond created using total-etch systems.

G-Bond being a mild self-etching adhesive containing MDP could perhaps thus obtain comparable microtensile bond strengths to dentin in both primary and permanent teeth.

III) Interpretation of data comparing the effect of shortening the dentin etching time on microtensile bond strengths between a one-step self-etch and a two-step etch-and-rinse adhesive in primary teeth dentin:

i) *Group III (E/Rpri) vs. Groups V (E/RpriR):*

Sanabe *et al.* (2009) and Osorio *et al.* (2010) suggested for shortening the etching time for primary dentin. They opined that the concentration of calcium and phosphate in peritubular and intertubular dentin is lower in primary than in permanent teeth, making the primary dentin more reactive to acidic conditioners. This results in deeper decalcification of the intertubular dentin, forming an increased thickness of hybrid layers and a subsequent lack of penetration of the adhesive resin in primary teeth, thus contributing to the lower bond strengths. Van Meerbeek *et al.* (1994) reported that most adhesive systems use conventional phosphoric acid etchants in concentrations above 30% to etch both enamel and dentin in one application. They suggested that these etchants be applied first to enamel so that enamel is etched for at least 15 seconds. But other studies (Nor *et al.*, 1997; Shashikaran *et al.*, 2002) have shown that it is the quality of hybrid layer which matters and not the quantity and hence did not recommend the reduced etching times to obtain thinner hybrid layers for primary teeth dentin. This study also found no significant difference between Group III (E/Rpri) and Groups V (E/RpriR), suggesting that MTBS values of both the groups were comparable. Also, practically the concept of selectively etching enamel and dentin separately in primary teeth for different etching times can be very challenging for even an experienced clinician. This is especially true in a young child with difficult isolation needs, where time is the essence.

ii) *Group IV (SEpri) vs. Group VI (SEpriR)*

The results of this study showed that there was a significant statistical difference found between the two groups ($p=0.003$), suggesting that MTBS values of Group IV (SEpri) was higher than that of Group VI (SEpriR). When the application time of G Bond is decreased by 50% from that recommended by the manufacturer i.e. 10 seconds, the mild pH of G-Bond does not successfully penetrate and demineralize and infiltrate the subsurface dentin in 5 seconds, thereby explaining the decrease in MTBS values.

Summary and conclusion

The present study was done to compare the microtensile bond strengths of a one-step self-etch (G-Bond) and a two-step etch-and-rinse (Adper Single Bond 2) adhesive in primary teeth dentin. The study also aimed to compare any differences present between bond strengths of the two bonding agents to dentin in primary teeth as compared to permanent teeth. It also evaluated the effects of shortening the etching time on microtensile bond strengths in a two-step etch-and-rinse (Adper Single Bond 2) and a one-step self-etch (G-Bond) adhesive in primary teeth dentin.

The following is a summary of observations recorded from the study:

- I. No significant statistical difference was found between primary dentin treated with G-Bond and Adper Single Bond2, suggesting that MTBS values of both the groups were comparable.
- II. i) Permanent dentin treated with Adper Single Bond 2 showed higher MTBS values than primary dentin treated with the same adhesive. This result was statistically significant ($p=0.036$).
ii) MTBS values obtained in both primary and permanent dentin treated with G-Bond was comparable and there was no significant statistical difference.
- III. i) The MTBS values obtained for primary teeth dentin treated with Adper Single Bond 2 with conventional dentin etching time and with reduced times were comparable.
ii) There was a significant statistical difference found in the primary teeth dentin treated with G-Bond compared to the specimens treated with half the recommended time ($p=0.003$), suggesting that MTBS values for conventional time of bonding application were higher.

Based on the results, the study concluded that:

- I. The one-step self-etch adhesive (G-Bond) used in this study provided comparable MTBS to the two-step etch-and-rinse adhesive (Adper Single Bond 2) in primary teeth dentin.
- II. Bond strengths obtained for primary teeth were lesser compared to permanent teeth in the case of the two-step etch-and-rinse adhesive (Adper Single Bond 2), and comparable in the case of the one-step self-etch adhesive (G-Bond).
- III. A reduced etching time cannot be recommended as a method of improving bond strengths of the two-step etch-and-rinse (Adper Single Bond 2) and the one- step self-etch adhesive (G Bond) for dentin bonding in primary teeth.

Though it is tempting to recommend the one step self etching adhesive as an alternative to the two step etch and rinse adhesive for primary teeth considering its ease of use, it is important to note that this study evaluated MTBS only to dentin. The

bonding potential of the seventh generation bonding agent to primary teeth enamel and its long term clinical performance should be evaluated before one ventures into early conclusions.

As van Meerbeek *et al.* (1992) rightly said that the objective of universal enamel-dentin conditioning agents is to find the best compromise between etching enamel sufficiently to create a microretentive etch pattern and etching dentin mildly enough to avoid exposure to collagen to a depth that is inaccessible for complete infiltration by resin. But, on the other hand Atash *et al.* (2005) makes a valid point when he writes that the choice of an adhesive in Pediatric Dentistry does not depend solely on tensile or shear force values. The choice also depends on the child's temperament and age. For children who find it difficult to accept treatment and for toddlers, for whom speed is of essence, a one step self etching adhesive like G-Bond could still play an important role.

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The Effect of Local Analgesics for Postoperative Pain Control after Ovariohysterectomy (OVH) in Dogs

Manoj Kumar Shah¹ and Yum Bahadur Gurung²

¹Department of Pharmacology and Surgery, Institute of Agriculture and Animal Science, Rampur, Chitwan, Tribhuvan University, Nepal ²Department of Pathology and Clinics, Institute of Agriculture and Animal Science, Rampur, Chitwan, Tribhuvan University, Nepal

Abstract: The purpose of this study was to evaluate the efficacy and to compare the effect of different incisional local analgesics following ovariohysterectomy in dogs. The study was designed as prospective randomized, placebo-controlled and double blinded clinical trial. Eighty female dogs aged 2.74 ± 1.92 yrs (range 0.58 to 9) and weighing 16.0 ± 5.6 kg (mean \pm SD) were used in this study. All the dogs were premedicated with 0.05 mg kg⁻¹ acepromazine intramuscularly (IM) plus 0.5 mg kg⁻¹ subcutaneous (SC) meloxicam and induced with thiopentone @ 10 mg kg⁻¹ intravenously (IV) to effect and maintained with 1.5-2% isoflurane. A series of 80 ovariohysterectomies were performed and just before closing the skin 20 dogs received 2% lignocaine @ 7.0 mg kg⁻¹ (LIG), 20 dogs received of 2% lignocaine plus adrenaline @ 7.0 mg kg⁻¹ (LIG+A), 20 dogs received 0.5% bupivacaine @ 2.5 mg kg⁻¹ (BUP) by incision infiltration and in the 4th group the surgical wound was flushed with 5 ml of 0.9% saline (SAL). The level of analgesia were assessed before premedication, 0.5 h after premedication plus 0.5 h, 1 h, 1.5, 2, 3, 4 and 21 h by dynamic interactive visual analogue scale (DIVAS) scoring for pain and wound tenderness. Finally, parametric variables were analyzed using student t-test, paired samples t-tests and one way ANOVA in the appropriate cases. Overall, postoperative pain and wound tenderness scores increased ($P < 0.01$) irrespective of groups. There were significant differences between DIVAS pain scores at each assessment time from the baseline with low values for pain occurring at 0.5 h and gradually increasing through other observation periods and reached the peak at 21 h postoperatively in all the groups. The DIVAS pain scores decreased ($P < 0.01$) in LIG group at 0.5 h, LIG+A and BUP groups at 1 and 1.5 h of operation compared to SAL group. Similarly, DIVAS wound tenderness scores increased ($P < 0.01$) at each assessment time from the baseline measured lowest at 0.5 h then after gradually increased through other observation periods and reached the peak at 21 h postoperatively in all the groups. DIVAS wound tenderness decreased ($P < 0.01$) in LIG group at 0.5 and 1 h, LIG+A and BUP groups at 1.5, 2, 3 and 4 h postoperatively compared to SAL group. It was demonstrated that incision administration of lignocaine provided excellent analgesia for a short period, whereas lignocaine plus adrenaline and bupivacaine provided analgesia for a longer period of time. A multimodal analgesic approach with incision application of local analgesics is suggested for postoperative pain control.

Keywords: Local analgesics, postoperative, pain, wound tenderness, ovariohysterectomy and dogs.

Introduction

Pain can be defined as the perception of an unpleasant sensory and emotional experience associated with actual or potential tissue damage (Bell, 1994; Wall, 1992). Reaction to pain can be communicated to others through behaviour, vocalization, and in human beings, through speech (Flecknell, 1999). Perception of pain in animals may not be the same as in humans, but that they perceive it as something to be avoided is

beyond reasonable doubt (Flecknell, 1999). This perception is based not only on neuronal input, but also includes the interpretation of this input based on the past experience and the present state of mind. Although often considered bad, pain normally occurs only when there is actual or potential for tissue injury. It most frequently serves as a warning device so that the individual experiencing pain will avoid the potentially harmful stimulus (Johnston, 2000).

Pain management has become widely recognized as an essential component of veterinary care (Taylor & Vierck, 2003). Practitioners are becoming more aware of the need of control of pain in animals especially during surgical procedures (Troncy *et al.*, 2004). Despite this acceptance of the desirability of relieving pain, in many instances it is either not treated or treated ineffectively (Flecknell, 1988) and analgesics are still underused in general veterinary practice (Lascelles *et al.*, 1999). In human patients, it has been found that 12% reported unbearable pain in the hospital of the United Kingdom where the pain score was found to be greater than or equal to six (Dix *et al.*, 2004).

Traditionally, pain has been considered as merely a protective mechanism designed to guard against further tissue damage; however, recent research has shown that pain syndromes incorporate pathophysiologic response that are themselves damaging to the body (Sinatra, 1992). Emphasis must be placed on the fact that pain is a perception, a phenomenon of the mind and thus has no physical dimensions therefore can not be quantified using physiochemical terms such as grams per unit area or concentration of chemical substances (Kitchell, 1987). It is difficult to assess pain in human beings because the experience of pain is unique to each individual (Fordyce, 1983). In animals, these difficulties are magnified because of a lack of effective means of communication between the animal and the caretaker (Holton *et al.*, 1998^a) and due to the fact that veterinarian must rely on the interpretation of behavior to detect pain (Carpenter *et al.*, 2004). Assessment of animal pain is highly species-specific and is of necessity a value judgment, relying on the interpretation of behavioral and physiological indices to provide indirect evidence of pain (Price *et al.*, 2003).

An effective pain management can only be achieved and maintained when signs of pain can be assessed reliably and accurately (Holton *et al.*, 1998^b). There is also a corresponding increased demand among animal caretakers so that their animals must receive appropriate and available pain relieving treatment. New methods have been developed and implemented as well. New drugs have been introduced and used with the aim of reducing pain (Pettersson, 2001).

The use of wound infiltration with local anaesthesia for postoperative pain relief may be an attractive method because of its simplicity, safety and low cost. Local analgesics inhibit the propagation of the nerve impulses by blocking the sodium channels of the nerve fiber prohibiting the generation of action potentials (Dejong,

1994). However, despite widespread use, wound infiltration is still inconsistently and randomly used by many surgeons and anaesthetists in human beings and small animals. Considering the fact, the job of postoperative pain relief treatment has to be done by a surgeon when the wound is closed. The present work was initiated in ovariohysterectomized dogs to develop the multimodal therapeutic protocol for postoperative pain management and to train and develop confidence in the veterinary graduates with the ovariohysterectomy surgery. Specifically, this study aimed to evaluate the efficacy and to compare the effect of different incision application of local analgesics following an ovariohysterectomy in dogs.

Methodology

Experimental animals

Eighty stray and owned dogs aged 2.74 ± 1.92 yrs (range 0.58 to 9) admitted to the IAAS Spay Clinic, Veterinary Teaching Hospital, Rampur for ovariohysterectomy (OVH) were used in this study. The dogs were maintained without medication, considered apparently healthy and were free from any painful conditions. Their weight (in Kg) was recorded before premedication which ranged from 6 to 13 kg with a mean of 8.50 ± 1.70 kg.

Study design

The order of treatments was determined by a random number generator prior to the start of the study. Dogs were assigned to 4 groups of 20 on the day of surgery with lignocaine (LIG), lignocaine plus adrenaline (LIG+A), bupivacaine (BUP) or saline (SAL) as the control.

Pre and post-operative pain scoring was performed by using the dynamic interactive visual analogue scale (DIVAS) by one observer (MKS), who was blinded (observer ignorant of the drug used) to the treatment status of the dogs. All the dogs were scored for signs of pain, wound tenderness before premedication, 0.5 h after premedication and at 0.5, 1, 2, 3, 4 and 21 h after the surgery. DIVASs were recorded by placing a cross mark on a 100- mm scale between 'no pain' and 'worst imaginable pain' for pain scores (DIVAS-pain). Similar methods were applied for wound tenderness (DIVAS- wound tenderness) using the same time intervals. The measured mean length of incision upon completion of surgery was 3.15 ± 0.40 cm.

The experiment was performed as a prospective randomized, placebo-controlled and blinded clinical trial study.

Premedication, anaesthesia and surgery

All the ovariohysterectomies (OVH) were performed on early hours of the day. Food, but not water, was withheld for 12 h prior to premedication. All dogs were clinically examined prior to premedication. Baseline values for heart rates (HR), respiratory rates (RR) and rectal temperatures (RT) were recorded as 94.46 ± 11.70 per minute, 30.21 ± 4.45 per minute and 101.67 ± 0.79 °F respectively.

Acepromazine (0.05 mg kg^{-1}) in the lumbar epaxial muscles intramuscularly (IM) and meloxicam (0.5 mg kg^{-1}) subcutaneously (SC) into the scruff and prophylactic, benzathine penicillin ($40,000 \text{ IU kg}^{-1}$) intramuscularly (IM) at once was administered 30 minutes before the induction of anaesthesia. After intravenous placement of catheter into the right cephalic vein, thiopentone-Na 2.5% (10 mg kg^{-1}) was given. Endotracheal (ET) intubation was performed and for the maintenance of anaesthesia, isoflurane (1.5-2%) in 100% oxygen was delivered. During anaesthesia, all the animals were monitored for the depth of anaesthesia, heart rates (HR), respiratory rates (RR) and rectal temperatures (RT) at an interval of 15 minutes. After anaesthetization, the operation site was prepared and the key-hole right flank ovariohysterectomy was performed in all dogs following the standard aseptic surgical procedures. On the abdominal closure, each muscle layer was sutured using chromic catgut (No. 2) individually, i.e. 3 separate layer (the peritoneum is incorporated with the closure of transverse abdominis muscle) but in puppies, the peritoneum, transverse abdominis and internal abdominal oblique were sutured together using chromic catgut (No. 1) with one suture and the external abdominal oblique separately with another suture. The dead space remaining underneath the skin was properly obliterated.

Just prior to the closure of the skin, the trial drug was incisionally infiltrated. Finally, the skin incision was closed by a subcutaneous suture using vicryl and its end edges were buried appropriately. An insect repellent cream was topically painted around the wound site to repel flies. Upon the completion of the surgery, the delivery of isoflurane (1.5 -2%) in 100% oxygen was switched off and the endotracheal tube (ET) was taken out. The dogs were placed in sternal recumbency for 10 minutes. Finally, just before placing the dogs in the kennel, all the dogs received an anti-rabies vaccine.

Dogs that were operated on were checked by veterinary surgeons through a physical examination of the wound and ear notches at least once a day for 3 days and during the entire postoperative period, food and water were provided *ad libitum*.

Trial drug administration

Once the completion of muscles suture, 2% lignocaine hydrochloride or 2% lignocaine plus adrenaline both @ 7 mg kg^{-1} or 0.5% bupivacaine @ 2.5 mg kg^{-1} were infiltrated at the wound. In the 4th, i.e. control group, the area was just flushed with 5 ml of 0.9% normal saline.

Dynamic interactive visual analogue scale (DIVAS) acoring for pain and wound tenderness

In all trials, DIVAS were used to quantify the scoring. All the dogs were scored for pain and wound tenderness before premedication, 0.5 h after premedication plus 0.5, 1, 1.5, 2, 3, 4 and 21 h after surgery. A scale of 100 mm was used, in which '0' represented no pain and '100 mm' the worst imaginable pain. Similar methods were applied for wound tenderness.

Statistical analysis

Data were obtained by measuring the distance on the DIVAS from '0' to the cross marked point in mm and the mean \pm standard deviation (SD) was calculated for pain and wound tenderness at each observational time point. Finally, parametric variables were analyzed using student t-test, paired samples t-test and one way ANOVA in completely randomized design (CRD) in the appropriate cases. Non-parametric variables were analyzed using chi-square (χ^2) test. Difference between mean (\pm SD) were considered significant at $P < 0.01$. The data were presented as mean \pm SD. All the statistical analyses were conducted by using recent version of SPSS (SPSS Inc.USA) and MSTATC.

Results and discussion

Recently, local anaesthetics like lignocaine, lignocaine plus adrenaline and bupivacaine are gaining popularity in veterinary medicine. Local and regional anesthesia can be performed to prevent pain in many animals. These agents are unlike other analgesics in that they actually produce complete blockage of sensory nerve fibers and prevent the development of central sensitization to pain (Lemke & Dawson, 2000). Local analgesics are available worldwide, they are safe and cheap and the techniques of local analgesia application are not difficult to learn and do not involve the use of expensive or complicated equipment. So this study was important to look at their effects on the wound in providing analgesia in ovariohysterectomized dogs.

The ability to quantify the degree of pain experienced by animals is an important component in the assessment of the animal welfare (Barnett, 1997). The visual analogue scale has been proved to be sensitive, reliable and easy to use by an experienced observer (Mathews, 2000) so it is widely used in both human and veterinary practices to quantify the degree of pain, wound tenderness and sedation (Bianconi *et al.*, 2004; Carpenter *et al.*, 2004; Dix *et al.*, 2004). In the present study, a DIVAS which was developed after the incorporation of interactive animal behaviour with VAS (Lascelles *et al.*, 1998) by Hashim (2004) was used to quantify the degree of pain, wound tenderness and sedation each at different time intervals. However, no alternative methods were used to compare the result obtained in this study. Firth & Haldane (1999) stated that there could be a wide observer variation in measuring VAS; in this study a single observer (MKS) did the measurement so there was little risk of observer variation.

Demographic data

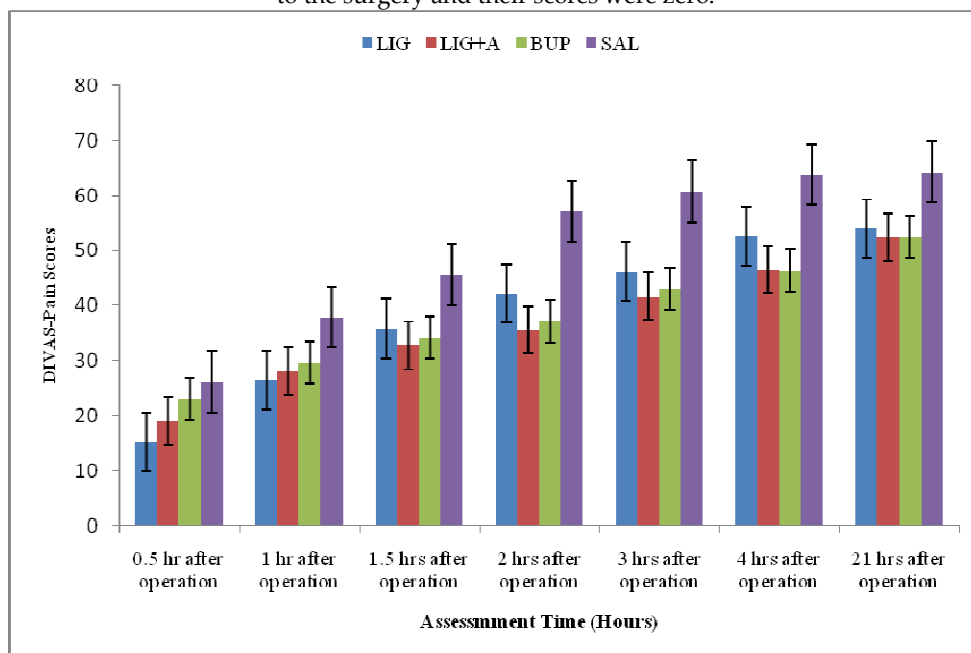
There were no significant differences between groups regarding age, body weight and incision length. The mean age was 2.74 ± 1.92 yrs (range 0.58 to 9). Similarly, the mean values of body weight, incision length, heart rate (HR), respiration rate (RR), rectal temperature (RT) and incision length were 16.01 ± 5.67 kg, 3.15 ± 0.40 cm, 94.46 ± 11.70 per minute, 30.21 ± 4.45 per minute and $101.67 \pm 0.79^\circ\text{F}$ respectively. There were

no significant differences between groups regarding the total amount of anaesthetics given. No adverse event or reaction to the treatments was observed throughout the course of the study. No dog was given any supplemental analgesics.

DIVAS-pain scores

There were significant differences between DIVAS pain scores (Figure 1) at each assessment time from the baseline with low values for pain occurring at 0.5 h and gradually increasing through other observation periods and reached the peak at 21 h postoperatively in all the groups.

Fig. 1. Postoperative (mean \pm SD) DIVAS-pain scores (mm) in different treatment groups at each assessment time. Basal DIVAS scores are not shown in because the dogs were not in pain prior to the surgery and their scores were zero.



There was a significant increase in pain scores at each of the assessment time among all the groups as observed in the present study which is in agreement with the observation made in dogs and cats by Hashim (2004), who indicated that the postoperative time is vulnerable for nociceptive pain if not properly managed. On the contrary, the results of the present study contradicts with that of Carpenter *et al.* (2004) who observed that the peak values for pain occurred at 0.5 h and gradually declined through the other observation periods. The probable cause behind it may be due to the combined use of acepromazine as premedicant and butorphanol as preemptive analgesics. However, in this study, only acepromzaine has been used as a premedicant. This is in accordance with Flecknell (1999) whose results showed that

such an approach was more likely to provide optimum analgesia than the use of single analgesic agents. The component of balanced regimens should act by different mechanisms in order to maximize their beneficial analgesic effect and minimize any harmful side effects (Slingsby and Waterman-Pearson, 2001).

The result of this study demonstrated that the LIG group had significantly lower pain scores followed by the LIG+A, BUP and SAL groups at 0.5 h of postoperative assessment time. This could be due to relatively rapid onset (5 to 10 minutes) and intermediate duration of action (1 to 2 h) of lignocaine (Carpenter *et al.*, 2004; Lumb & Jones, 1996). The result of the present study indicated the postoperative use of lignocaine provided excellent analgesia for a short period (0.5 to 1 h) of time, and is consistent with the hypothesis of Hashim (2004) that the postoperative incisional use of lignocaine after ovariohysterectomy (4 mg kg⁻¹) had marked beneficial effects in dogs and cats for a short period time.

Similarly, at 1 h and 1.5 h postoperatively, the assessed pain in dogs of LIG group was significantly lower than BUP and SAL groups. The supporting reason behind it may be the intermediate duration (1 to 2 h) of the effect of lignocaine (Carpenter *et al.*, 2004; Lumb & Jones, 1996; Paddleford, 1999). The effect of LIG+A must be started earlier for acting efficiently and consistently because the added adrenaline slows the onset of action and approximately doubles the time required for complete absorption and prolong the analgesic (Hall *et al.*, 2001). The effect of bupivacaine after instillation on the wound area still showed comparatively higher pain scores than each of LIG and LIG+A groups. This could be due to its slow onset of action (Hendrix & Hansen, 2000; Paddleford, 1999).

At 2 h postoperatively, the LIG+A group measured lower pain scores but it was statistically most significant than each of LIG and SAL group. The present study showed that lignocaine+adrenaline is the most effective analgesic among all when followed by bupivacaine. The least effective analgesic is lignocaine. The probable reasons behind it might be that both lignocaine+adrenaline and bupivacaine could have started their action late and reached their peak at that point. The effect of lignocaine may have been prolonged due to the added adrenaline which not only slowed the onset but also prolonged the action of analgesic drugs at the infiltrated sites caused by vasoconstriction (Hall *et al.*, 2001). Bupivacaine used intraperitoneally and incisionally was more effective for analgesia following ovariohysterectomy in dogs than lignocaine (Carpenter *et al.*, 2004).

Likewise at 2, 3 and 4 h after operation, LIG+A dogs had significantly lower pain scores ($P < 0.001$) than LIG and SAL dogs but it was insignificantly a lower pain score than BUP dogs. The reasons could be the onset and duration of local analgesic effects of LIG+A and BUP. At 21 h postoperatively there was no significant difference between different experimental groups which is supported by the study of Selmi *et al.*, (2009) as well.

The pain scores of SAL group always remained significantly highest at each of the assessment time among all the treatment groups with the exception of BUP group at 0.5 h where there was significantly less marginal difference. These findings are consistent with the result of Carpenter *et al.* (2004) who reported that SAL group had significantly higher pain scores than BUP and LIG dogs. It also contradicts with the findings of Carpenter *et al.* (2004) who stated that there was a trend for LIG dogs to have lower pain scores than SAL dogs and there was no statistically significant difference. In this study, the scores of SAL dogs were significantly higher than LIG and BUP groups with the exception of having a marginal significant difference with BUP dogs at 0.5 h postoperatively. It appears that the results of this study are indeed inconsistent with the results of Carpenter *et al.* (2004) and Lascelles *et al.* (1999) with a due fact of pain threshold which varies widely between individuals as well as between species and is greatly affected by age, motivation, stress, previous experience, present state of mind, cultural background and analgesics (Kitchell, 1987).

Overall, the pain scores in this study were not particularly high. The SAL group scored an average of 64.30 out of 100 on the DIVAS-pain. The DIVAS-pain score is subjective, but would fall about half way between 'no pain' and 'worst imaginable pain' so it might be labeled as moderate pain. This moderate level of pain corresponds with the expected findings of Zimmerman (1986) who reported that there was mild to moderate level of pain after abdominal surgery in farm animals. A qualitative systemic review of incisional application of local anaesthesia for postoperative pain relief after abdominal operations in human beings also supported and showed significantly lower pain scores with VAS reductions of approximately 25 to 50 mm (Moiniche *et al.*, 1998). This finding is further consistent with previous studies that have concluded that the pain following an ovariohysterectomy is mild to moderate in severity and less than that associated with other surgical procedures (Carpenter *et al.*, 2004; Firth and Haldane, 1999; Hardie *et al.*, 1997; Hashim, 2004) although the variation in responses should be expected from the species to species as well as between individuals within the species (Wright *et al.*, 1990).

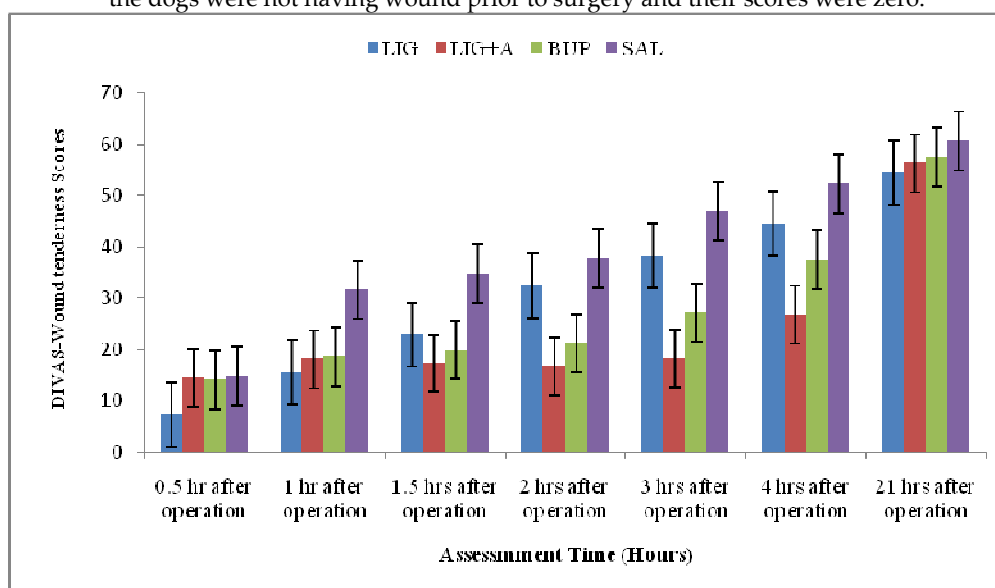
Results of the study reported here indicated that incisional instillation of LIG provided excellent analgesia for 0.5 h and 1 h of postoperative pain management followed by LIG+A and BUP. Similarly, the LIG+A and BUP provided outstanding postoperative analgesia at 2 h postoperatively.

Overall, the postoperative pain scores were increased ($P < 0.01$) irrespective of groups of dogs, indicating that the postoperative time is vulnerable for nociceptive pain if not properly managed and the findings are consistent with the observation made in small animals (Hashim 2004).

DIVAS-wound tenderness scores

Overall, there were significant differences between DIVAS wound tenderness scores at each assessment time from the baseline with a low values for wound tenderness scores occurring at 0.5 h and gradually increasing through other observation periods and reaching the peak at 21 h postoperatively in all the groups (Figure 2).

Fig. 2. Postoperative (mean \pm SD) DIVAS-wound tenderness scores (mm) in different treatment groups at each assessment time. Basal DIVAS-wound tenderness scores are not shown because the dogs were not having wound prior to surgery and their scores were zero.



The responsive or interactive behaviour after surgical wound palpation are recently considered a vital determinant for assessing the degree of postoperative pain. Here, the DIVAS scale was used and it is considered parallel with IVAS (Interactive Visual Analogue Scale) previously used as *per se* in cats (Cambridge *et al.*, 2000). The responsive or interactive behaviour after manipulation of surgical wound in the present study varied accordingly with the severity of pain, and the most dominant are hereby included—biting of the wound, painful bleating, falling on the ground towards opposite side of the wound, regaining of standing position and statue posture. These findings are consistent with the result of Wright *et al.* (1990).

At 0.5 h after operation, LIG dogs had significantly lower wound tenderness scores ($P < 0.001$) than each of LIG+A, BUP and SAL dogs. LIG+A dogs had significantly higher wound tenderness scores than LIG dogs and insignificantly higher than BUP dogs but lower than SAL dogs. Similarly, BUP dogs measured significantly higher wound tenderness scores ($P < 0.001$) than LIG dogs but insignificantly lower than rest of the experimental groups.

Overall, the wound tenderness scores increased significantly across each assessment time in LIG, BUP and SAL groups. Similar findings were also claimed by Hashim (2004) in dogs and cats where wound tenderness scores increased significantly irrespective of groups. In the present study, the wound tenderness scores of LIG+A group increased significantly up to 1 h but at 2 h, it again decreased below the assessed scores of 1 h.

At 1 h postoperatively, wound tenderness scores of LIG dogs were significantly lower ($P<0.001$) among all experimental groups. Similarly, LIG+A dogs measured significantly higher and lower wound tenderness scores ($P<0.001$) than LIG dogs and SAL dogs respectively, but it was insignificantly lower than BUP dogs. The wound tenderness score of the BUP dogs were significantly higher and lower than LIG and SAL dogs respectively, but it was insignificantly higher than LIG+A dogs.

On comparing, the LIG, LIG+A and BUP group with the SAL group, LIG group measured significantly lower wound tenderness scores at 0.5 and 1 h whereas LIG+A and BUP group showed insignificant lower wound tenderness scores at 0.5 h but significantly higher wound tenderness at 1 and 2 h postoperatively. However, the well designed affirmative study reported significantly decreased wound tenderness scores of LIG and LIG+A group at 1 and 1.5 h postoperatively (Hashim 2004). In the broad sense, there is not any rigid explanation of this disparity even though the probable reason may be the onset as well as the duration of action of different types of local analgesics used.

After 1.5, 2, 3 and 4 h of operation, LIG dogs measured significantly higher wound tenderness scores ($P<0.001$) than LIG+A and BUP dogs respectively but significantly lower wound tenderness scores than ($P<0.001$) than SAL dogs. The result of the present study contradicts the finding of Hashim (2004) who reported of a significantly decreased wound tenderness scores at 1.5 h postoperatively. The wound tenderness scores of LIG+A dogs resulted significantly lower ($P<0.001$) than rest of the experimental groups. Likewise, the BUP dogs showed significantly higher wound tenderness scores ($P<0.001$) than LIG+A dogs but significantly lower ($P<0.001$) than LIG and SAL dogs. There was significantly more erythema in dogs that received pre- incisional infiltration with saline solution at 4 h after the surgery (Fitzpatrick *et al.*, 2010)

At 21 h postoperatively, the assessed wound tenderness scores of LIG dogs were significantly lower ($P<0.001$) than BUP and SAL dogs but insignificantly higher than LIG+A dogs. The LIG+A dogs measured insignificantly higher wound tenderness than LIG dogs but insignificantly lower than rest of the experimental groups. Likewise, BUP dogs displayed significantly higher ($P<0.001$) than LIG dogs and significantly lower ($P<0.001$) than SAL dogs but insignificantly lower than LIG+A dogs.

There was significantly less erythema in dogs that received post-incisional infiltration with bupivacaine at 24 h after surgery, compared with other treatments and less complication–included excessive inflammation, splenic laceration, and herniation (Fitzpatrick *et al.*, 2010).

Conclusion

It is essential to consider the postoperative incisional local analgesics for the control of pain along with good postoperative care in dogs after ovariohysterectomy. The incisionally infiltrated lignocaine provided excellent analgesia for a short period whereas lignocaine plus adrenaline and bupivacaine provided analgesia for a longer period of time. A single dose of postoperative incisional local analgesic is unlikely to provide postoperative analgesia and therefore a multimodal analgesic approach with incisional local analgesics is suggested for the postoperative pain control. A multimodal approach using acepromazine, meloxicam along with incisional application of local analgesia should be recommended to provide better analgesia.

Acknowledgements

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Flow Monitoring and Leak Detection: An Integrated ICT Approach for Drinking Water Supply

Nanda Bikram Adhikari^{*}, Mandira Adhikari, Dinesh Baniya Kshatri, Utsav Bikram Gewali, Bibek Jang Karki, Ayush Tiwari and Sumit Bam Shrestha

Department of Electronics and Computer Engineering, Institute of Engineering, Pulchowk Campus, Tribhuvan University, Nepal

^{*}Email: adhikari@ioe.edu.np

Abstract: *Drinking water supply industries almost always suffer from unwanted water leakage due to damaged, rusty, broken or leaky pipes in water supply networks. Water supply networks are usually implemented underground, which makes it difficult to monitor and detect leaks. Advancements in the information and communication technology (ICT) these days add potential in the automated monitoring of the drinking water supply systems. In the context of developing countries like Nepal, such technology is yet to be introduced. This research hence introduces those ICT technologies (namely, a network of automated electromagnetic sensors and telemetry setups) and studies its integrated performances to monitor the water flow and pinpoint possible leaks. The measurements are divided into acoustic and microwave sensing, and pH readings. Observations are considered first with a modeled water distribution system and then verified in a real water supplying pipeline system of the country's water distribution authority. Results from both modeled and the real distribution system confirm the setups of the sensor system and verify the underground leak statistics.*

Keywords: *Information and communication technology, electronic sensor systems, data logging network, flow monitoring, leak detection, leak localization, leak sizing, pH reading, water supply.*

Introduction

Drinking water scarcity is closely related to numerous socio-economic and environmental problems. In the context of Nepal, the problem is alarming. The main reasons responsible for it are: lack of water resources, improper management of the available water supply system, lack of automated monitoring systems and significant amount of water loss due to leakage in the system. An information and communication technology (ICT) based automated water flow monitoring and leak detection system would be one of the solutions to mitigate these problems.

Nepal is rich in water resources and is ranked 43rd in the world based on annual total renewable water (210 km³/yr) (Newar, 2009). Kathmandu Upatyaka Khanepani Limited (KUKL), the country's water utility operator, mentions that the present water demand of the valley is 95 million liters per day (MLD), however, the total water production in wet and dry seasons is about 140 MLD and 100 MLD respectively. On top of that, approximately 40% water is lost due to leakage, indicating a poor distribution system in the valley. Water scarcity is one of the reasons for increased environmental and health risks as well as lost opportunities for economic growth.

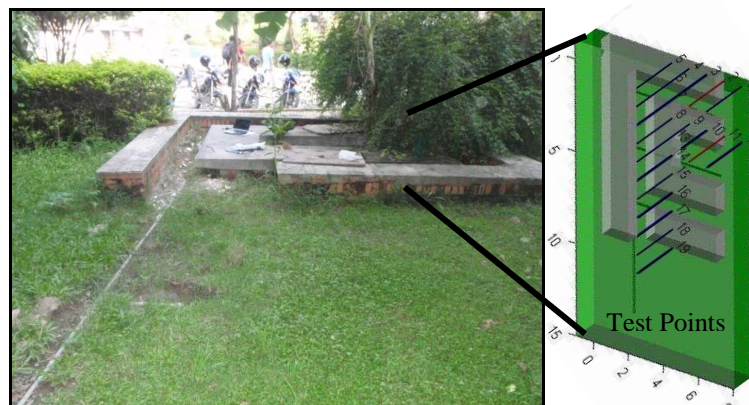
This research explores the idea of using acoustic and proximity sensing, microwave sensing and pH readings to identify the leakage areas. Observations are considered first with a modeled water distribution system and then at some field points of the real water supplying pipeline system of KUKL. The modeled study is aimed to confirm the setups of the sensor system and approximate the leaks. Once confident with the model study, a number of surveys at a certain pocket area of KUKL's Pulchowk site are considered to approximate the underground leak statistics. Results of this study are useful for planners working for the drinking water distribution system, like KUKL, for an efficient water management, monitoring, quality control and revenue collection by pinpointing possible leak locations and illegal tapings.

Methods and instrumentations

The research methodology is divided mainly into two categories, model study and field survey. With the model study, a prototype of a water distribution network is first set up, and then observations with sets of electronic sensor systems are considered to collect and log leak and no-leak data through sensor networking. Prototyping of the model is considered mainly to gain research confidence as well as to perform calibrations/validations of the electronics.

Water Distribution Model: For the prototyping of the drinking water distribution system, the vicinity of the Institute of Engineering (IOE), Pulchowk Campus, had been selected. The prototype was exactly locate at the Department of Electronics and Computer Engineering, as shown in Fig. 1.

Fig. 1. Modeled water distribution system with observation points



The model includes a water reservoir tank on the rooftop of a three-story building, distributing to both open and underground pipelines, where at each branching, systems of water flow sensors and communication devices are attached. The acquired data at each observation point is arranged to communicate with wireless devices to the centralized server system for logging which will, after proper analysis, provide information on the state of the flow of the water.

Sensor systems and networking: The observing sensor systems are considered to be of different kinds, namely acoustic and proximity sensors, microwave transceivers, and pH meters. Readings of the sensors are logged into a centralized server system via wireless communication systems.

Acoustic sensing using ground sensor: The acoustic sensor unit of Adler Technology (Model: ADL-III, as shown in Fig.1) is the core of the acoustic leak detection system. The unit consists of a ground sensor, a processing/control box and headphones. The sensor is placed above the pipeline on the ground to pick up any noise that may be created by underground leakages. The output of the sensor can be listened to via the headphones of the system. The accuracy of leak detection is hence, highly dependent on the hearing acuteness of the operator. Furthermore, it could be very tedious for the operator to analyze the sound from numerous test points and point out the leak location. Human error is inevitable. Hence, we tried to digitize the system and used computer analysis to detect the leak location.

In this study, the output of the sensor is logged on a computer via its audio port. Data are sampled at the highest sampling frequency possible in the computer i.e., the sampling frequency is of 44.1 KHz. Since the same sensor has to be used for all the locations, the data is recorded in a time window. Different timing windows are tested. A timing window of 1 second is long enough to record all the important variations and yet short enough to take the readings quickly. Hence, a windowing time of 1 second is used.

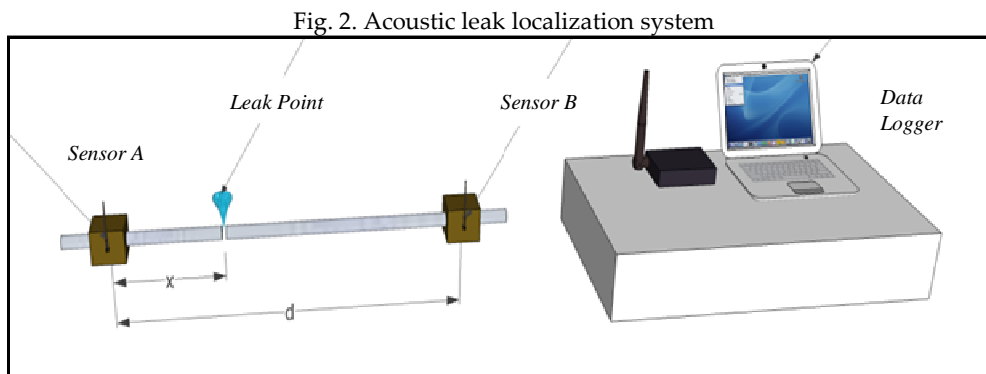
Since the leak points generate acoustic signals of higher amplitude, the average amplitude and the energy of the signal at leak points must also be high. However, the acoustic signal does not have any dc component and hence the average of the amplitude is always zero. The solution is the average of the absolute value of the signal intensity. Further, since the average intensity of the signal is zero, the energy of the signal is equal to the variance. With these defined parameters, the leak location is the point which has both intensity and energy distinctly higher than its neighbors. The acoustic data are recorded in a relative scale and the same relative scale is used throughout the analysis.

Proximity localizers: When a leak occurs in a pipeline, water rushes outside through the leak creating a pressure wave with frequency in audio range. Energy generated from

the leak is transmitted within the pipeline through the water. This in turn produces mechanical vibrations on the surface of the pipeline. An underground acoustic sensor attached to the outer surface of the pipeline can be used to pick up these vibrations.

A leak in a section of a pipe is detected and localized using two acoustic sensors placed at the opposite ends of that section. In fact, we used microphones as sensors to capture signals for proximity localization. Since we had only one specialized acoustic sensor (ADL-III) available, though we required two sensors for this study, we had to resort to using microphones as acoustic sensors. These sensors are connected to a computer through the audio port. In the computer, the signals from these sensors are digitized, recorded and analyzed.

A rise in the vibration levels of the signal caught by both these sensors implies the occurrence of a leak in the section. To localize the leak, a signal, caught by two sensors at the two ends is used, as shown in Fig. 2.



If d is the length (in meters) of the section, v is the velocity of sound in the pipe (in meters per millisecond) and T_d is time delay (in milliseconds), then leak position, x (in meters) can be derived as, $x = (d - vT_d)/2$.

The signal received from the sensor is first filtered to reduce noises and sounds from other sources. Then, the signal is squared and made smooth using a low pass filter to obtain the signal energy function. Then, a correlation function is calculated using the two energy signals. The value of time at which the value of correlation functions gives the largest time shift (time delay) between the signals.

Microwave sensing systems: Microwaves are well known for their behavior of backscattering from obstacles on their way of propagation. The backscattering efficiency depends strongly on the physical properties, mainly the dielectric properties, which in turn resemble the refractive indices of the objects (Nelson & Trabelsi, 2012). Hence, the objects that take part in the backscattering can be characterized. Water, for example, exhibits strong attenuation at microwave bands,

and hence can easily be discriminated from other objects (Somaraju & Trumpf, 2006). Also, the effect of attenuation appears differently at different microwave bands (Kaatze, 2007). The crux of the identification of water-leak in the environment using microwave propagation is based on the identification of refractive indices (Ray, 1972).

Fig. 3. Image of the microwave sensor system with modeled pipeline system



For the microwave-sensing portion, a set of transceiver at 10 GHz and 1.6 GHz with antenna system and a spectrum analyzer are used. Laboratory arrangement of the system is shown in Fig. 3. Details of these systems are given below.

(a) Microwave transceiver

The apparatus used to generate microwaves is the E15d Aerials manufactured by TecQuipment. The microwave generator consists of a sensitive variable gain receiver, with the power supplies and modulators for the two transmitters providing frequencies of 1.6 GHz and 10 GHz. The maximum power transmitted by the E15d Aerials is 200 μ W.

(b) Yagi antenna

The Yagi antenna's basic design consists of a resonant feed dipole with one or more parasitic elements. These parasitic elements are called reflectors and directors. The directors are used to provide the antenna with directional pattern and gain. The reflectors are used to determine the front-to-back ratio of the antenna.

(c) Pyramidal horn antenna

Its basic design consists of a short length with a rectangular or cylindrical metal tube (waveguide) closed at one end, flaring into an open-ended conical or pyramidal shaped horn on the other end. A pyramidal horn antenna is an antenna with the horn in the shape of a four-sided pyramid, with a rectangular cross section.

(d) Spectrum analyzer

For this project, we have utilized the HP 8593E spectrum analyzer. It has the capability to measure the power levels of signals in the range of 9 MHz to 26.5 GHz. Power was measured in dB μ V with the reference level set at 107 dB μ V.

A transmission model was setup in the lab whereby an obstacle, whose transmittance is to be measured, was sandwiched between the transmitter and the receiver. The obstacles in this case were plastic boxes filled with mud. The thickness of the obstacle was increased and decreased by adding and removing plastic boxes filled with mud. Transmittance measurements were performed using dry and wet mud at 1.6 GHz and 10 GHz. The transmittance model implemented in this project relied on the fact that the transmittance of wet mud is lower than that of dry mud.

To test our hypothesis of the transmission model, the modeled pipeline system was used. This was done using a network of Galvanized Iron (G.I.) pipes connected to a water tank. The flow of water in the pipes was controlled using manual valves. In a certain section of the G.I. pipe, a hole was drilled. The G.I. pipe used for testing was 80 cm in length. About 40 cm of the pipe was covered with dry mud and the remaining 40 cm with wet mud. Trenches were dug on both sides of the pipe to facilitate the placement of antennae as shown in Fig. 3. Measurements were made using both the Yagi antenna operating 1.6 GHz and the Horn antenna operating at 10 GHz.

GPS module: For acquiring the exact geographical locations surveyed, especially during the field survey, a Garmin eTrex Global Positioning System (GPS) module was used. This GPS module has an easy interface and can store up to 500 waypoints. The exact location and the altitude of the points were noted and then were plotted over the geographical map.

Hydrogen ion concentration (pH) readings: To test the salinity of water, we utilized the measurement of pH. Normal drinking water has a pH of around 8, so we wanted to test if we could distinguish normal drinking water from contaminated water coming from other sources. Both laboratory test and field samplings were considered for the leak contamination/verification.

Results and discussion

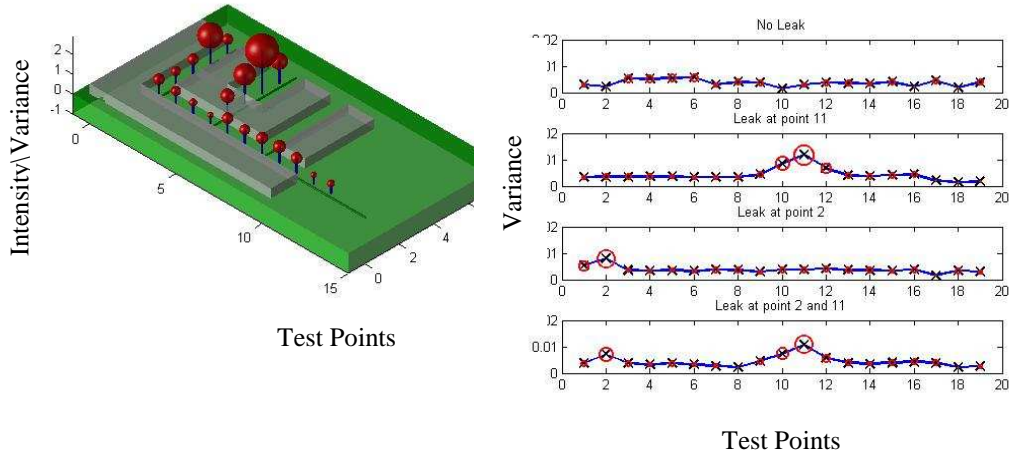
Typical results obtained from laboratory tests, modeled pipeline network and field surveys are presented below and discussed accordingly.

Modeled study using acoustic sensing

The water distribution model constructed in IOE was taken as the test site. Different points were marked along the pipelines with spacing between them. The sample spacing was taken as 12 inches. Nineteen tests points were selected and numbered from 1 to 19 as shown in the Figs. 1 and 5. The test points 2 and 11 were the

actual leakage points in the setup, with the leak in point 11 (diameter = 5 mm) larger than that in point 2 (diameter = 3 mm). From Fig. 5, it is evident that a high value of both the intensity and energy at a test point corresponds to a leak at that point.

Fig. 5. Test points over the modeled pipe network (left); No-leak point and leak-points (right)



Proximity sensing: For the localization of the leaks, a proximity sensing is applied in the same system. Sample signals taken from proximity sensors are shown in Fig. 6, while statistical analysis of the recorded signals are presented in Figs. 7 and 8 in terms of energy function (Fig. 7) and correlation functions (Fig. 8).

Fig. 6. Raw acoustic signal from sensor A (top), and sensor B (bottom)

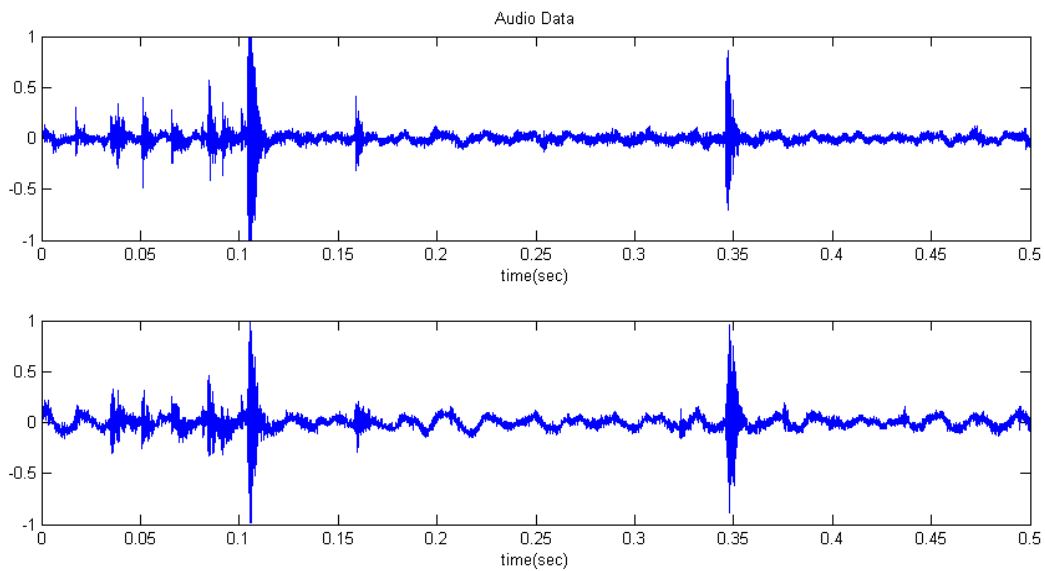


Fig. 7. Signal energy function obtained from sensor A (top), and sensor B (bottom)

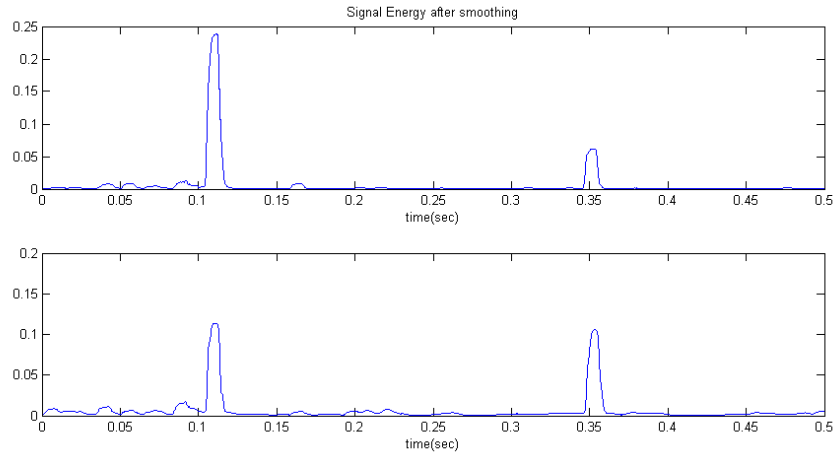
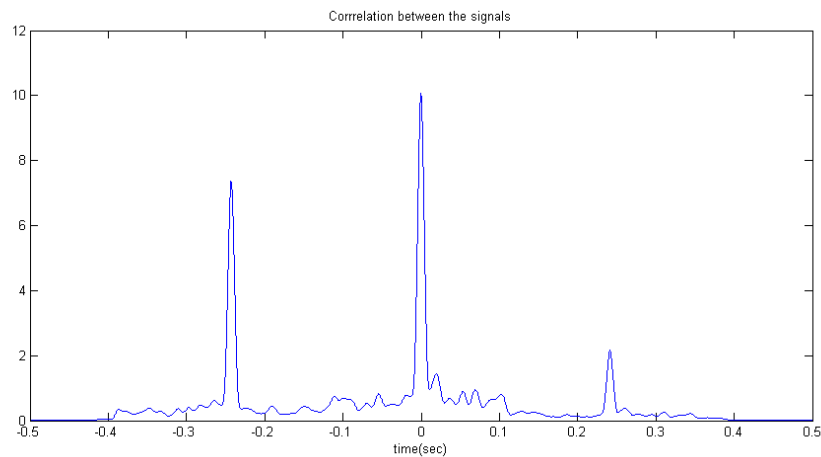


Fig. 8. Correlation between the energy signals, maximum correlation obtained at 0.362 ms



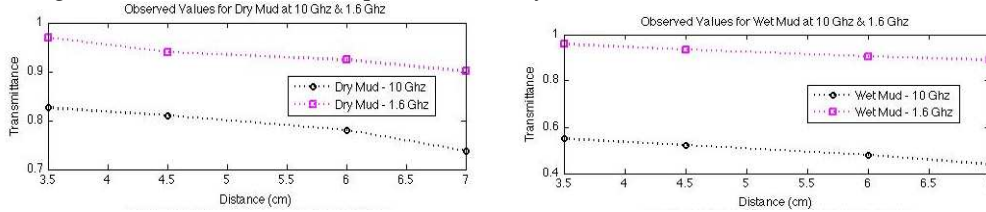
The results are indicative to approximate the local leak. However, our trials with the acoustic signals obtained from the microphones were not very exact in pinpointing the leak. The acoustic data were highly affected by background noise and usually distorted. We plan to use this method with other kinds of acoustic sensors in the future.

Microwave sensing: Microwave sensing experiments were performed both in the laboratory and on the modeled network; the results are presented accordingly.

Laboratory tests: From the measurements done in the lab, the following observations were made. The objective of this test was to figure out the transmittance profiles of two signals at 10 and 1.6 GHz over two mediums, namely dry and wet mud and to

compare them. Figure 9 shows the transmittance profile for dry mud (Fig. 9a) and wet mud (Fig. 9b) at 10 GHz and 1.6 GHz. It was found that the mean differential attenuation for dry mud at 10 GHz and 1.6 GHz is 0.153, while that for wet mud is 0.429.

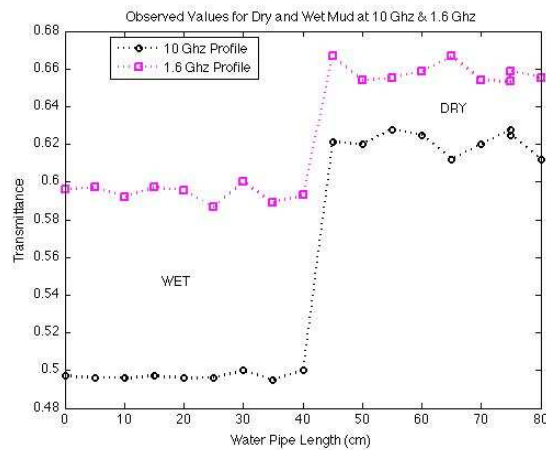
Fig. 9. Observed transmittance profile for (a) dry mud and (b) wet mud at 10 and 1.6 GHz



The test of reflectance profiles was also performed with pH variation. First, we poured normal drinking water in a plastic container and measured the reflectance profile using both 1.6 GHz and 10 GHz microwave rays. Then we added Alum to the water to change its pH to 3, that is, to make it more acidic. However, the reflection profile at both 1.6 GHz and 10 GHz were insensitive in detecting the salinity change. By adding Caustic Soda to water, we further changed its pH to 12.8, that is, to make the solution basic. In this case also, the reflectance profile at both 1.6 GHz and 10 GHz was unable to detect the pH change. Overall, the indirect method of pH measurement was found inconclusive.

Pipeline model tests: The test results obtained from the modeled pipeline network are presented and compared in Fig. 10. In this observation, we found that the mean differential attenuation between 1.6 GHz and 10 GHz at the wet section of the pipe was 0.085, and the mean differential attenuation between 1.6 GHz and 10 GHz at the dry section of the pipe was 0.045.

Fig. 10. Observed transmittance profile at 10 and 1.6 GHz along dry and wet pipelines.



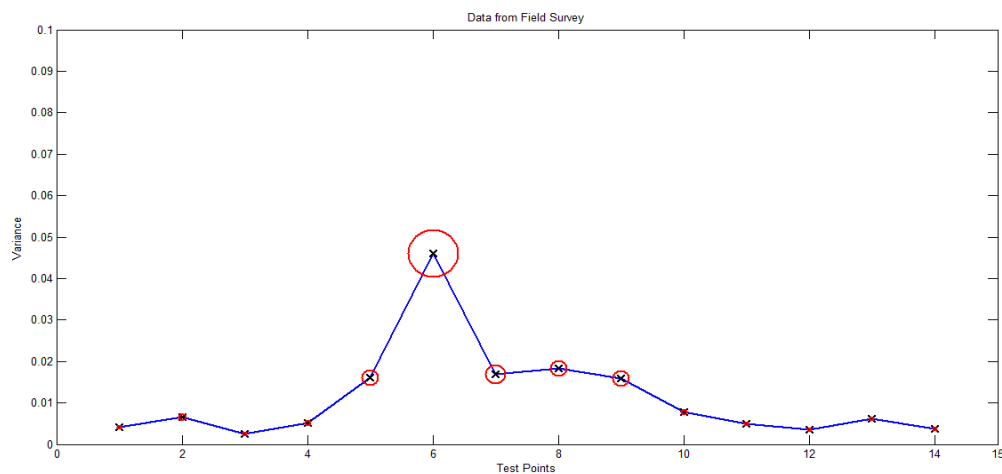
The results obtained from both laboratory and model tests were distinct in discriminating wet and dry environment along the pipeline. For scanning a large mud volume, however, we need a more powerful microwave transceiver.

Field surveys: The established test procedures were further applied in KUKL's water distribution system over Pulchowk area. The test points are shown in Fig. 11, indicated with circles.

Fig. 11. Survey around Pulchowk area indicating no-leak (circles) and a leak (triangle).



Fig. 12. Intensity and energy of the signal vs. test points for leakage point. The height represents the signal intensity and radius represents the signal energy.



After analyzing the data from the samples (shown in Fig. 12), a leak point was revealed in this distribution system, which is localized in Fig. 11 with a circle inside a triangle. We confirmed the leaks visiting the site with the personnel KUKL. Currently, we are working to identify the volume of the leak. Further, we are on the way of expanding our field survey to a larger area.

Conclusion

This research introduced different technologies related to ICT and studied the feasibility of applying them in monitoring for drinking water supply network to detect unwanted leaks. The research plan started with the study and implication of various sensor systems, data logging communication and processing systems for water flow monitoring and controlling. Specifically, a network of automated electromagnetic sensors and telemetry setups was used to monitor the flow of water and possible leaks. Along with the telemetry setups, the measurements were divided into three categories of acoustic sensing, microwave sensing and pH readings. Observations were considered first with a modeled water distribution system and then in some field points of the real water supplying pipeline system. The results from the modeled study confirm the setups of the sensor system and approximate the leaks. After getting confident with the model study, a number of surveys were conducted in Pulchowk area of KUKL's water distribution system to approximate the statistics of underground leaks. The study was successful in revealing a major leak in a actual water distribution system.

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Morphology and Some Physical Properties of Eco-friendly Bamboo Flour Reinforced Plastics Composites

Netra Lal Bhandari¹, Sabu Thomas², Chapal Kumar Das³, Jean Marc Saiter⁴, Goerg H. Michler⁵, Durga Prasad Pandey⁶, Rameshwar Adhikari^{1*}

¹Central Department of Chemistry, Tribhuvan University, Kirtipur, Kathmandu, Nepal ²School of Chemical Sciences, Mahatma Gandhi University, Kottayam, Kerala, India ³Materials Science Centre, Indian Institute of Technology (IIT), Kharagpur, India ⁴Institute of Materials, University of Rouen, Rouen, France ⁵Institute for Physics, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany ⁶Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Kirtipur, Kathmandu, Nepal

*Email: nepalpolymer@yahoo.com

Abstract: *This work deals with the comparative study on the compatibility of neat and delignified bamboo flour reinforced polymer composites based on aliphatic-aromatic copolyester (Ecoflex[®], a commercial product of BASF, SE). The composites were prepared by melt mixing followed by compression molding. The composites were characterized by Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), thermogravimetric analysis (TGA), tensile testing and water absorption testing. The results showed a low interaction between the filler and the matrix at the interface in composites readily to low compatibility. Still, the untreated fillers were found to be more compatible with the matrix compared with the treated filler and the effects were reflected on mechanical, morphological and thermal behavior of the composites. The enhanced properties would be obtained on using a suitable compatibilizer on treated filler loaded composites. The composites are found to be environment friendly and economically viable.*

Keywords: *Delignified fibers, eco-friendly, mechanical properties, natural fiber reinforced composites.*

Introduction

Nowadays, natural fibers from renewable resources such as pineapples, bananas, sisal, jute, rice husk, wheat flour, wheat straws, wood flour and saw dust are being extensively studied as reinforcing agents in different polymer matrices. The natural fiber reinforced composite materials offer a wide variety of mechanical, thermal, optical and chemical properties better than glass fiber and mineral filler based materials (Bledzki & Sperber, 2008). Wood polymer composites are generally cheaper, easy to treat, easily processible, relatively better in dimensional stability, stiffer and lower in density in comparison to mineral fillers; they are easily reproducible, cost effective and environment friendly (Bledzki & Gassan, 1999).

In wood polymer composites (WPCs), different types of wood flour of various particle size and content are used as fillers. The demand of wood plastic composites (WPC's) is very high in the global market so the production and research of such materials are increasing day by day.

The properties of WPC's basically depend on the type of flour, particle size, chemical modification and the polymers used (Bogoeva-Gaceva *et al.*, 2007). Polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polystyrene (PS), polyethylene terephthalate (PET) and other mixed copolymers are the commonly used polymers for the manufacture of composite materials. Most of the composites are biodegradable to some extent, but nowadays projects are also being started towards developing the totally biodegradable polymer composites (Bogoeva-Gaceva *et al.*, 2007).

Cellulose is the main constituent of wood flour. Cellulose is an important natural biopolymer produced by photosynthesis. Cotton fiber is the main source of cellulose, containing more than 95% of it by weight. In woody plants, cellulose content is less and is associated with lignin and other polysaccharides such as hemicelluloses, wax and pectin in considerable quantities. Bamboo flour consists of 26-43% cellulose, 30% hemicellulose and 21-31% lignin (Saheb & Jog, 1999, Joseph *et al.*, 1999 and Li *et al.*, 2000). The cellulose content in bamboo flour also depends on plant species, plant age and their geographical distribution.

All cellulosic natural fiber consists of cellulose microfibrils in an amorphous matrix of lignin and hemicellulose. The hemicellulose binds the microfibrils together to form a bundle and the lignin provides the mechanical strength (Bledzki & Sperber, 2008 and John & Anandjiwala, 2008). Lignin and hemicellulose from the wood flour are removed simply by treatment with alkalis, sulphites and chlorites (John & Anandjiwala, 2008 and Kumar *et al.*, 2010).

The cellulose chains are organized in crystalline fibrils by inter- and intramolecular hydrogen bonding, and due to the presence of extensive networks of hydrogen bonding, it is almost insoluble in water as well as in most other organic solvents but only swells in many polar protic and aprotic liquids (Mormann, 2003).

Wood polymer composites (WPCs) are processed with similar technology that are used in other plastic processing industries like extrusion, injection molding, thermoforming and pressing (Sperling, 2006). The choice of wood flour as a filler and the polymer as the matrix determines the process to be applied. The dehydration of the wood, degree of permissible moisture content, size of particles and additives are the decisive factors (Zaini *et al.*, 1996; Razi *et al.*, 1997; Kalaprasad *et al.*, 2004).

The biggest challenge in developing the wood flour-reinforced polymer composites is the problem of incompatibility between the hydrophilic fillers and hydrophobic polymers. High water absorption, low moisture resistance and insufficient adhesion to polymer matrix are the main factors responsible for the poor compatibility. The use of suitable compatibilizers or the chemical treatment of fillers and the matrix would be some alternatives to minimize the problem of compatibility (Rowell, 2005; Wu *et al.*, 2000; Nachtigall *et al.*, 2007). In wood flour-reinforced polypropylene composites, the maleic anhydride grafted polypropylene (MA-g-PP) is

used as a compatibilizer to enhance the tensile, impact and moisture absorption behaviors (Adhikari *et al.*, 2012). The mechanical, morphological and thermal properties of different wood flour (such as sisal, jute, flex, hemp, kneaf, bamboo, oil palm) of various sizes and composition have been studied and reviewed in detail (Adhikari *et al.*, 2012 and Chattopadhyay *et al.*, 2011).

In this paper different composition composites of aliphatic aromatic copolyester (Ecoflex®) with neat, alkali treated and bleached bamboo flour were prepared and the effect of the chemically treated bamboo flour on morphological and some physical properties were studied. The composites were prepared without using the compatibilizers.

Materials and methods

Fillers: The fillers used for this research were the flour of *Bambusa nutans* (local name: Taru Bans). The bamboo shoots were collected from a village nearby the Kathmandu valley. The shoots were chopped into small pieces, dried in the sun light for 12 days and powdered by mechanical grinding. The powder was sieved with 350 µm mess to get fine flour with uniform flour size.

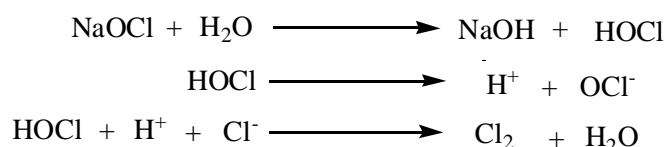
The flour was dipped in 4 wt.-% sodium hydroxide solutions of water for 8 h, neutralized by acetic acid till they turn slightly acidic and washed many times with distilled water (Kumar *et al.*, 2010). It was dried in an oven at 90 °C for 8 hrs. The objective of chemical treatment was to remove lignin and hemicellulose from the wood flour. The representative reaction of chemical treatment can be represented as in Scheme 1.



Scheme 1: Representative reaction of alkali treatment of wood fibers

Bleaching is usually carried out after the alkali treatment which gives out a white colored cellulose from the wood flour. The alkali-treated flour was boiled with 4% (mass/volume) sodium chlorite (NaClO₂) for 4 h. It was neutralized by formic acid, washed, filtered and dried in an oven again at 90 °C for 8 h. The standard procedures were mentioned in the literatures (Saheb & Jog, 1999 and Kumar *et al.*, 2010). It is very common in industries to bleach the cellulose/jute using oxidizing agents like sodium hypochlorite, calcium hypochlorite, hydrogen peroxides or sodium chlorites (Rowell, 2005). The simple mechanism of bleaching process is represented in Scheme 2.

a. With sodium hypochlorite



b. With hydrogen peroxide



Scheme 2: Reaction for bleaching process

Matrix: The polymer used is the aliphatic-aromatic copolyester of 1, 4-butanediol, adipic acid and terephthalic acid monomers. It is also called polybutylenes adipate-co-terephthalate (PBAT) and commercially called as Ecoflex®. It is a commercial product of BASF SE, (Ecoflex® FBX, 7011, Germany). It has a density of 1.26 g/cm³ and an average molecular weight of 150,000 g/mol. It has a glass transition temperature -30 °C, melting point 115 °C and is thermally stable up to 230 °C.

Sample preparation

The different composition composites of neat, alkali-treated and bleached bamboo flour reinforced Ecoflex (Ecoflex/bamboo flour compositions of 80/20 and 60/40) were prepared by melt mixing. The components were mixed in an internal mixture (Haake brabender, Plasto Mek) at 130 °C at 50 rpm (rotations per minute) for 10 minutes. The tensile bars were prepared by compression moulding at 140 °C at 120 bar pressure for 2 minutes.

Characterization techniques

The morphological and mechanical characterizations of the sample were carried out using different techniques.

Fourier Transform Infrared (FTIR) Spectroscopy: FTIR spectra of solid injection moulded samples were recorded in absorbance and transmittance mode using a Bruker Equinox 55 FTIR spectrometer in ATR mode.

Scanning Electron Microscopy (SEM) : Scanning electron microscopy (JSM 6300, JEOL) was used to visualise the structural details of the samples. The surfaces were sputter coated with a thin gold film to avoid charging and irradiation damage during the SEM observations.

Mechanical Testing: The mechanical testing was carried out by using a universal tensile machine. Tensile bars having dimensions of 40 × 5.1 × 1.8 mm were prepared in a compression molding machine by using the mold. At least four experiments were performed at a cross head speed of 50 mm/min at 23 °C and the average value was considered for the comparison.

Thermogravimetric Analysis (TGA): Thermal studies were performed by means of thermogravimetric measurements using TGA 209 balance (Netzsch, Germany) in nitrogen atmosphere from 20 °C to 600 °C at a heating rate of 10 °C/min.

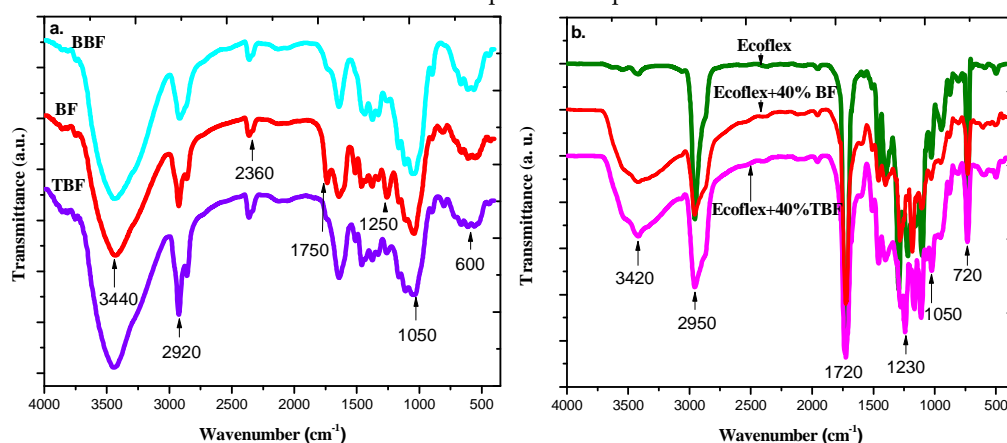
Water Absorption Test: Water absorption was determined according to the standard procedure mentioned in literary works (Chattopadhyay *et al.*, 2011). The test specimen were cut from composite sheets, dried at 60 °C, cooled and weighed till a constant weight (w_1) was obtained. The specimens were then immersed in a beaker containing distilled water at room temperature. After the regular time periods, the test specimens were removed from water, soaked with absorbent paper and weighed three times. The average weight (w_2) was calculated for each specimen. The weight was measured at regular intervals for 50 days. The increase in weight percentage was calculated by using equation (1).

$$\text{Water Absorption (\%)} = (w_2 - w_1) / w_1 \times 100 \quad (1)$$

Results and discussion

The FTIR spectra of the neat, alkali treated and bleached bamboo flour and their composites with Ecoflex (60/40 composition) are presented in Fig. 1. Neat, alkali treated and bleached BF clearly show characteristic cellulose peaks at 3420 cm^{-1} , 2900 cm^{-1} and 1050 cm^{-1} corresponding to the OH stretching, CH stretching and C-O-C stretching of the pyranose ring structure of cellulose respectively (Chattopadhyay *et al.*, 2011). The carbonyl (C=O, stretching) peak at 1750 cm^{-1} in neat BF is removed in alkali treated BF indicating the removal of the acetyl group of hemicellulose from the fiber surface. A group of complex IR absorbance of lignin in the finger print region (1300-700 cm^{-1}) might be due to the stretching of methoxy O-CH₃, ether C-O-C, and C=C stretching of aromatic ring compounds.

Fig. 1. Fourier transform infrared (FTIR) spectra of a. Neat, alkali treated and bleached bamboo flour b. Ecoflex/bamboo flour composites (60/40 composition) with neat and alkali treated bamboo flour compared with pure matrix



The lignin peaks at 1540 cm^{-1} (aromatic C=C stretching) and 1250 cm^{-1} (aromatic ether C-O-C stretching) in neat BF are much reduced in treated BF indicating the removal of lignin after the alkali treatment (Agarwal & Reiner, 2009; Yang *et al.*, 2007).

Peaks in the finger print region around 1050 cm^{-1} , 900 cm^{-1} , and 820 cm^{-1} were due to the methyl and methylene carbons. Further, the increase in the intensity of the OH stretching peak at 3420 cm^{-1} and CH stretching peak at 2900 cm^{-1} in treated BF also represents the increase in the cellulose content after the delignification. The strong absorption bands around 1360 cm^{-1} , 1250 cm^{-1} and 820 cm^{-1} in neat bamboo flour disappeared in treated bamboo flour indicating the removal of phenolic groups of lignin after the chemical treatment.

The FTIR spectra of the Ecoflex/bamboo flour composites of 60/40 composition with neat and treated bamboo flour are presented in Fig. 1b. The spectra of the composites show peaks corresponding to both the matrix and the filler. In composites, the peak at 3420 cm^{-1} represents the OH stretching of BF. The peaks at 2950 cm^{-1} (CH stretching), at 1720 cm^{-1} (CO stretching) and around $1400\text{--}1200\text{ cm}^{-1}$ represent the aromatic C=C stretching. It means the spectra of the composites show most of the peaks corresponding to the matrix and very few to that of the filler which suggests that the distribution of the filler in the matrix is not so uniform. Further, in the spectra of the composites (Fig. 1b), there are no significant peak shifts which implies that the composite has chemically weak filler matrix interface interactions.

The effect of the alkali treatment on morphology of the BF is clearly observed in the SEM micrographs shown in Fig. 2. In alkali treated BF (Fig. 2b) cellulose microfibrils are regularly aligned and clearly visible as compared to neat BF (Fig. 2a). The clear cellulose microfibrils in treated BF form bundles of about $50\text{ }\mu\text{m}$ size in the untreated bundles. The microfibers might appear even finer if the conditions of the alkali treatment were optimised. Alkali treatment has two effects on the fibers. First of all, it increases the fiber surface roughness due to the removal of wax, lignin and hemicellulose that bind the microfibers and bundles to each other. As a result, a larger area of contact between filler and matrix is formed. Secondly, it increases the amount of cellulose exposed on the fiber surface, thus increasing the number of possible reaction sites, although the effectiveness of the alkali treatment depends on the type of the wood flour and the matrix in which the filler is going to be incorporated (Viksne *et al.*, 2008; Bourmaud & Baley, 2007).

The SEM micrograph of the fracture surface of ecoflex/BF composites with neat (Fig. 2c) and treated BF (Fig. 2d) shows a clear picture of the filler and matrix. On surface analysis there is no fundamental difference in between the two composites. The BF is dispersed homogeneously and the fibrillar texture of BF appears clearly visible in the composites with the treated BF (Fig. 2d) than in the neat BF (Fig. 2c) composites. A large number of bamboo fibers pulled out from the matrix and the holes in the matrix polymer are seen in the micrographs both in neat and treated fiber composites showing the poor compatibility in between the matrix and fillers. It clearly shows that the filler matrix compatibility is very poor in the Ecoflex/BF composite and hence a proper compatibilizer should be used for the improvement of the morphology.

Fig. 2. SEM images of a. Neat BF b. alkali treated BF c. Ecoflex/neat BF (60/40) composite and d. Ecoflex/treated BF (60/40) composite

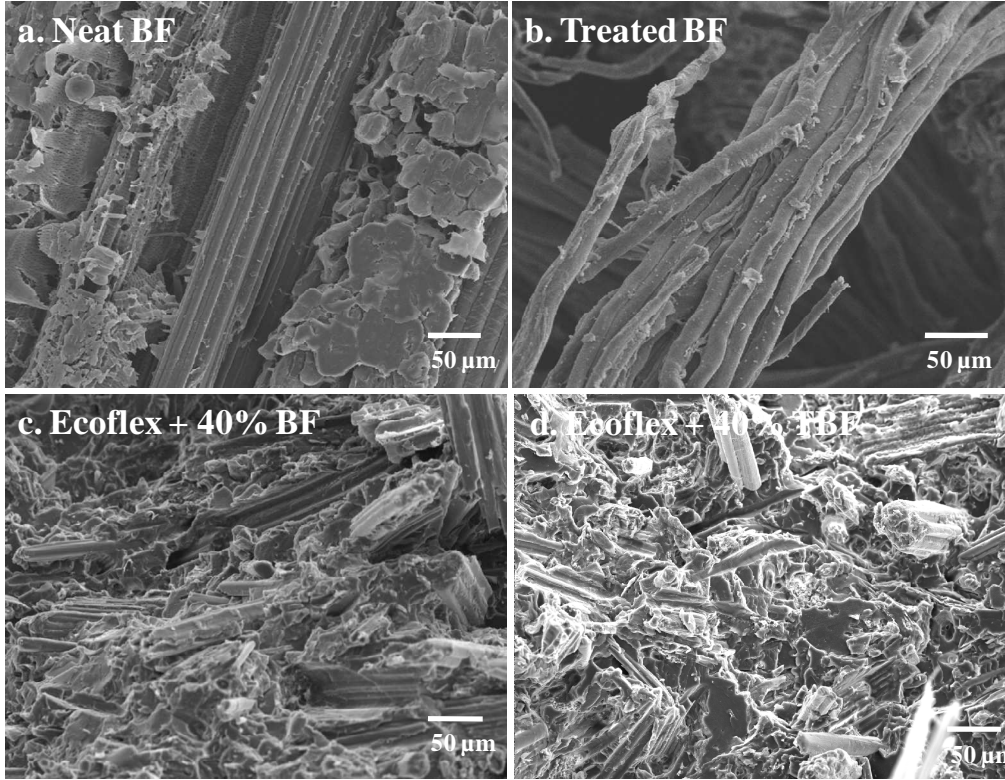
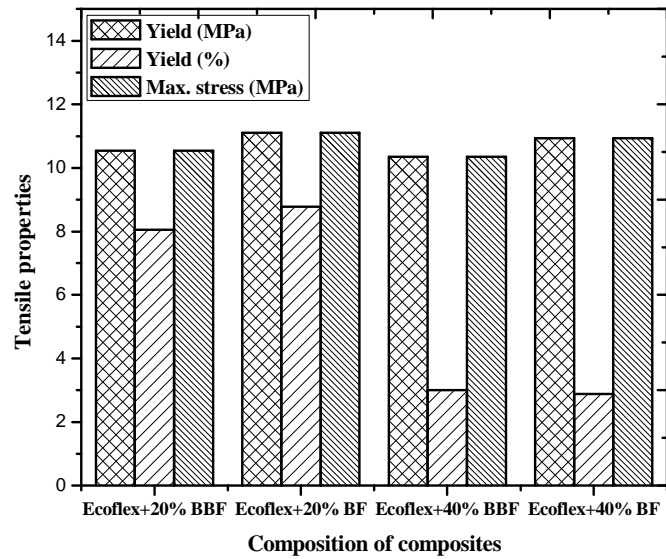
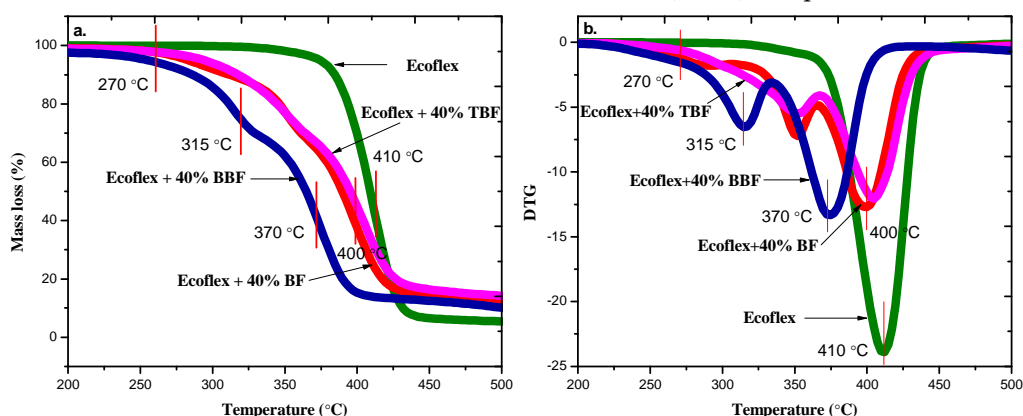


Fig. 3. Bar diagram showing tensile properties of Ecoflex/bamboo flour composites with neat and treated BF (80/20 and 60/40 compositions)



The bar diagram showing the tensile deformation behaviour of Ecoflex/BF composites (80/20, 60/40 compositions) with neat and bleached BF are presented in Fig.3. The nature of tensile properties of the neat and treated filler loaded composites looks similar. The tensile deformation behaviour of the pristine polymer is very high. It has an elongation at break about 800% and a tensile strength of over 30 MPa (plot is not shown) (Adhikari *et al.*, 2012). On increasing the filler content in composites, the elastic deformation and the elongation at break dropped significantly but the tensile strength, elastic modulus and tangent modulus increased. In Ecoflex/BF composites, the yield strength of composites increased with filler content. A little influence of the BF treatment was observed in 20 wt.-% of the filler incorporated into the composite. In case of a higher filler content of 40 wt.-%, the tensile strain as well as the elongation at break decreases and the composite becomes brittle so that it may be used only when there is a requirement of low load bearing applications. The results may be due to the poor compatibility between the filler and matrix interface which can be increased by the use of suitable compatibilizers.

Fig. 4. Thermal analysis of a. TGA curves of Ecoflex/bamboo flour (60/40) composites and b. DTG curves of Ecoflex/bamboo flour (60/40) composites

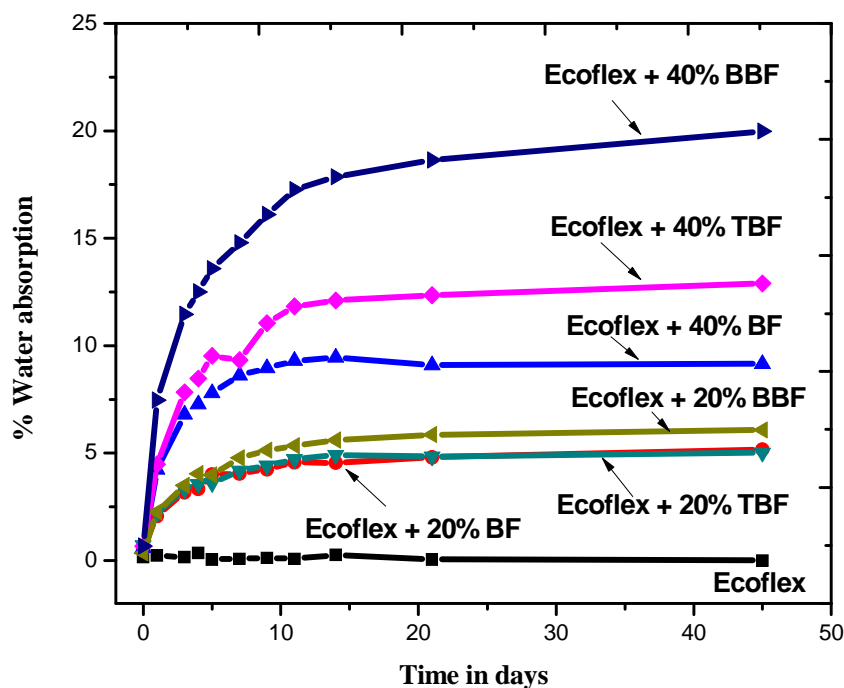


The thermogravimetric analysis of Ecoflex with neat, alkali-treated and bleached BF composites (60/40 composition) are shown in Fig. 4. The degradation of the pure matrix starts at about 300 °C and is almost completely degraded at about 410 °C with about 99% mass loss. In composites, the mass degradation starts a little bit earlier at 270 °C than in pure matrix. The final degradation temperatures of the composites are also decreased in composites to about 400 °C in neat and alkali treated fillers and to about 370 °C in case of bleached filler loaded composites which shows that there is some interactions in between the filler matrix interfaces. The thermal stability of the neat and alkali treated filler composite is found to be comparable but that of the bleached filler is very low as shown in Fig. 4. The curves shows that the bleached

fillers are still incompatible with the polymer matrix because in the treated fillers, more hydrophilic cellulose microfibrils are exposed towards the interfaces which are incompatible with the hydrophobic polymer matrix.

Further, the differential thermogravimetric analysis of the curves of the composites in Fig. 4b shows two clear peaks in composites and a single peak in pure matrix. In the composites, the first peak at 360 °C represents the degradation of the cellulosic material of the filler and the next peak around 400 °C represents the degradation of the matrix. This implies that the chemically-treated filler-loaded composite is less compatible and thermally less stable than that of the neat filler-loaded composites. Similar results were also obtained in the water absorption behaviour of the composites as shown in Fig. 5. This also indicates that the compatibilizer in the composites would improve the thermal stability of the composite by forming a proper bond at the interface (Jiang *et al.*, 2006; Adhikari *et al.*, 2012).

Fig. 5. Water absorption plots of Ecoflex/bamboo flour composites (80/20 and 60/40 composition) with neat, alkali treated and bleached bamboo flour



The water absorption behaviours of Ecoflex/bamboo flour composites (80/20, 60/40 compositions) with neat, alkali-treated and bleached bamboo flour are presented in Fig. 5. It clearly shows a clear trend of percentage water absorption by the Ecoflex/BF composites. The percentage water absorption in pure Ecoflex is almost zero and is represented by the straight line shown at the bottom of the plot. The percentage

water absorption increased with the increase of the flour content in the composites. The water absorption in bleached BF composites is extremely high as compared to that of the neat and alkali treated BF composites. In bleached BF composite (60/40 composition), the filler content increased by 20 wt.-% and the water absorption also increased by 15% which is only about 10% in alkali treated BF composites of similar composition. Similarly, in 80/20 composition, the percentage water absorption by neat BF and alkali treated BF is almost identical but it is quite different in 60/40 composition composites. This is because the cellulose content in the treated BF increases more than in the neat BF. The increase in water absorption in treated filler may be attributed to the increased hydrophilic cellulose content in the composites. Thus the increasing order of water absorption is found to be *neat BF composites < treated BF composites < bleached BF composites*.

In general, biological degradation of the composite increases as the water absorption capacity increases and hence the treated filler-based composites would be more eco-friendly in comparison to the untreated filler based composites.

Conclusion

The eco-friendly composite materials of different composition based on the commercially available biodegradable polymer Ecoflex with neat, alkali treated and bleached bamboo flour were prepared by melt mixing and characterized by infrared (IR) spectroscopy, scanning electron microscopy (SEM), thermogravimetric analysis (TGA), tensile testing as well as water absorption tests.

The SEM investigation showed that the alkali treated bamboo fibers have fine microfibrillar structures as compared to the untreated fibers which is due to the removal of hemicellulose and lignin binders from cellulose microfibril bundles. It was also confirmed by the FTIR spectra of the treated fillers. The surfaces from where the fibers were pulled out in the SEM image of the composite show the poor compatibility in between the filler matrix interfaces. This effect is also observed in the tensile deformation behaviors. The tensile properties are found to be a bit improved when treated fillers are loaded in low concentration although the effects are very nominal. The treated filler loaded Ecoflex/BF composites are also found to be thermally less stable. Further, the water absorption results are also consistent with the results obtained in mechanical and thermal behaviours. This implies that the use of an appropriate compatibilizer would be better to achieve compatible composites with enhanced physical and morphological properties through proper bonding at the filler matrix interfaces. The biodegradation of the treated filler loaded composite is also high due to the high water holding capacity.

Hence to obtain the low cost composite materials, the bamboo flour can be directly incorporated into the matrix which can be used for low load bearing applications like insulation (parquet flooring) in houses and making packaging

materials. To design the tough material with better tensile mechanical properties, the fiber matrix interactions should be enhanced by the use of suitable compatibilizers. The effect of compatibilizers would be more prominent in treated filler loaded composites than in the untreated filler based composites that might have resulted from the increased interfacial interaction due to larger surface to volume ratio of the treated fillers.

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Karyotypic Analysis of Eight Species of Asteraceae of Nepal

Pushpa Karna Mallick¹, Laxmi Manandhar² and Buddha Laxmi Vaidya¹

¹Tri-chandra Multiple Campus, Ghantaghar, Kathmandu, Nepal ²Central Department of Botany, Kirtipur, Nepal

Email: karnapushpa@yahoo.com

Abstract: Chromosome number and karyotypes of eight species of Asteraceae viz. *Artemisia abronatum* L., *Artemisia vulgaris* L., *Coreopsis grandiflora* Nutt. ex Chapm., *Crepis japonica* (L.) Benth., *Sonchus arvensis* L., *Spilanthes acmella* (L.) Murray, *Stevia rebaudiana* (Bertoni) Bertoni. and *Tridax procumbens* L., collected from different parts of Nepal, were observed. Chromosome number in somatic cells was recorded to be $2n=36$ in *Artemisia abronatum* and *Spilanthes acmella*; $2n=34$ in *Artemisia vulgaris*; $2n=24$ in *Coreopsis grandiflora*; $2n=16$ in *Crepis japonica*; $2n=18$ in *Sonchus arvensis*; $2n=26$ in *Tridax procumbens* and $2n=22$ in *Stevia rebaudiana* (Bertoni) Bertoni.. Chromosome number for *Spilanthes acmella* studied in this research is perhaps a new report. The chromosome number and karyotype of the taxa in the present study taxa viz. *Artemisia abronatum*, *Artemisia vulgaris*, *Coreopsis grandiflora*, *Crepis japonica*, *Spilanthes acmella*, *Stevia rebaudiana* (Bertoni) Bertoni and *Tridax procumbens* are new record for Nepal.

Keywords: Asteraceae, chromosome number, karyotype.

Introduction

Asteraceae is one of the largest families of flowering plants which comprise of c.1500 genera and 23000 species worldwide (Judd *et al.* 1999). In Nepal 111 genera and 417 species are reported from different regions (Press *et al.*, 2000; Ohashi, 1975; Hara & Williams, 1979), mostly of temperate to tropical.

Economically, the plants under study come under one of the most important families of flowering plants having medicinal, aesthetic, and ornamental values.

Plant paste of *Artemisia* is taken orally to control fever. Leaf juice is applied to treat ringworm and is taken orally to treat cough (Manandhar 2002). The species *Stevia rebaudiana* is commonly known as sweet leaf. It produces stevioside, a noncaloric sweetener considered to be 100-400 times sweeter than sucrose (Felippe 1977, Handro & Ferreira 1989, Kinghorn & Soejarto 1991). *Coreopsis* is used as ornamental flower in gardens. The leaves of *Crepis japonica* are edible. *Tridax procumbens* is used as ornamental or fodder plant. The flower heads of *Spilanthes acmella* are used to treat toothache, throat pain and gum infections and plant paste is applied on snake bite (Baral & Kurmi 2006). *Sonchus arvensis* is used as fodder, particularly for rabbits.

Objectives

The objectives of the present research include the collection of living specimens from different parts of the country and the identification and determination of chromosome number and karyotypic analysis of the given species.

Materials and methods

Eight taxa of Asteraceae were collected from different parts of the country. Cytological studies are made by squashing root tips for mitosis. The list of Voucher number of the collected plants, their names, spots of collection and Altitude are given in Table 1.

Table 1. List of the plants under the study with their voucher numbers, place of collection and altitudes.

V.N.	Taxa	Places of collection	Altitude
128	<i>Artemisia abronatum</i> L.	Lalitpur	1250 m
129	<i>Artemisia vulgaris</i> L.	Lukla	2800 m
130	<i>Coreopsis grandiflora</i> Nutt. ex Chapm.	Pokhara	700 m
131	<i>Crepis japonica</i> (L.) Benth.	Godawari	1515 m
133	<i>Sonchus arvensis</i> L .	Baneshwor	1300 m
132	<i>Stevia rebaudiana</i> (Bertoni) Bertoni.	Kuleshwor	1285 m
135	<i>Spilanthes acmella</i> (L.) Murray,	Lalitpur	1200 m
136	<i>Tridax procumbens</i> L.	Pokhara	700 m

Mitotic study was made from the healthy root tips. Roots were excised at 11 to 12 A.M. and were pretreated in 0.002 mol. 8-hydroxyquinoline for three hours. The pretreated root tips were fixed in glacial acetic acid and ethanol in 1:3 ratios. Fixed root tips were stained in 2% aceto-orcin and squashed with 45% acetic acid. For karyotype analysis, method of classifying chromosomes suggested by Leven *et al.* (1964-65) was followed. Photomicrographs of desired plates, Camera Lucida drawings and ideograms for each taxa were done.

Results and discussion

Morphological as well as karyotypic description, photographs of plants (Figs. 1a-8a), photomicrograph of desired plates (Figs. 2b-8b), Camera lucida drawings (Figs. 3c-8c) and ideograms (Figs. 1d-8d) for each taxa are given below. Cytological observations are summarized in Table 2.

Table 2. Karyotypic details of eight different species of the family Asteraceae

Name of the plants	Chrom. No. (2n)	Range of chrom. Length (µm)	Mean length (µm)	Absolute length (µm)	Karyotype formula	TF%	Fig no.
<i>Artemisia abronatum</i>	36	0.8-2.6	1.4	26.7	M ₁₈ +m ₄ +Sm ₁₂ +st ₂	41.9	1a,1b,1c
<i>Artemisia vulgaris</i>	34	0.4-1.2	0.68	11.6	M ₁₆ +sm ₁₈	40.4	2a,2b,2c
<i>Coreopsis grandiflora</i>	24	0.4-2.1	1.1	14	M ₁₀ +m ₂ +sm ₁₀ +st ₂	38.5	3a,3b,3c
<i>Crepis japonica</i>	16	0.8-1.6	1.1	9	M ₈ + sm ₈	42.2	4a,4b,4c
<i>Sonchus arvensis</i>	18	0.8-1.6	1.1	10	M ₁₂ +sm ₆	44	5a,5b,5c
<i>Spilanthes acmella</i>	36	0.6-1.7	1.1	20.1	M ₂₂ +Sm ₁₄ .	43.5	6a,6b,6c
<i>Stevia rebaudiana</i>	22	0.4-1.2	0.81	9	M ₁₀ +sm ₁₀ +st ₂	37.7	7a,7b,7c
<i>Tridax procumbens</i>	26	0.8-2.6	1.6	20.9	M ₁₈ +m ₄ +sm ₂ +st ₂	44.4	8a,8b,8c

***Artemisia abronatum* L (2n=36, V.N. 128)**

The plant is perennial, erect, undershrub which can reach to a height up to 1 m. Stems are woody. Leaves are grey-green and finely divided. They have strong-smelling heads in dense terminal corymbs.

The karyotype consists of 4 different types of chromosomes with centromere at median point, median region, sub-median region and sub terminal region. The length of chromosomes ranged from 0.6 to 2.6 µm with a mean length 1.4 µm and absolute length 26.7 µm. TF% is 41.9 Karyotype formula is M₁₈+m₄+Sm₁₂+st₂.

***Artemisia vulgaris* L (2n=34, V. N. 129)**

The taxa is a perennial erect herb, rhizomatous, aromatic, undershrub about 2 ft. tall abundantly found on open fields. Stem tends to be reddish-brown in color and becomes woody with age. They have simple leaves, alternate, deeply lobed, and have a distinctive aroma. Florets are brownish-red. Flowerheads are densely clustered in long narrow leafy panicle.

The karyotype consists of 2 different types of chromosomes with centromere at median point and subterminal region. The length of chromosomes ranged from 0.6 to 1.2 µm with mean length 0.68 µm and absolute length 11.6µm TF% is 39.6 Karyotype formula is M₁₆+sm₁₈.

***Coreopsis grandiflora* Nutt. ex Chapm. (2n=24 V. N. 130)**

It is a perennial herb. They are 50 cm tall plants with soft, green and have nonwoody stems. Leaves are long, lanceolates. Heads consists of a cluster of disc flower in the center, surrounded by 8 petals like ray florets. The ray floret is bright yellow having 3 teeth at the end.

The karyotype consists of 4 different types of chromosomes with centromere at median point, median region, sub median region and sub terminal region. The length of chromosomes ranged from 0.4 to 2.1 μm with the mean length 1.1 μm and absolute length 14 μm . TF% is 38.5. Karyotype formula is $M_{10}+m_2+sm_{10}+st_2$.

***Crepis japonica* (L.) Benth. (2n=16, V.N.131)**

The species is an annual erect herb, 30 cm tall. Leaves are mainly radicle. Heads yellow, many flowered in lax terminal paniced corymbs. Pappus hairs soft white.

The karyotype consists of 2 different types of chromosome with centromere at median point and submedian region. The length of chromosomes ranged from 0.6 to 1.6 μm with the mean length 1.1 μm and absolute length 9 μm . TF% is 42.2. Karyotype formula is M_8+sm_8 .

***Sonchus arvensis* L. (2n=18, V.N.133)**

The plant is 1.5 tall, annual, erect, herbacious, glabrous, hollow with milky sap. Leaves alternate, sessile, clasping, glabrous, dentate. Lower leaves lyrate pinnatifid, upper leaves oblong and linear. Flower heads terminating branches of inflorescence. Peduncles glabrous. Ray floret yellow disc floret absent.

The karyotype consists of 2 different types of chromosome with centromere at median point and submedian region. The length of chromosomes ranged from 0.8 to 1.6 μm with mean length 1.1 μm and absolute length 10 μm . TF% is 44. Karyotype formula is $M_{12}+sm_6$.

***Spilanthes acmella* (L.) Murray, (2n=36,V.N.125)**

The plant is collected from Lalitpur, 1200 msl. It is an annual ascending herb, 10 cm high. Leaves tringulate. The flower heads discoid, conical, big and centrally red surrounded by gold colour.

The karyotype consists of 2 types of chromosomes with centromere at median points and sub-median regions. The length of chromosomes ranged from 0.4 to 1.7 μm with mean length 1.1 μm and absolute length 20.1 μm . TF% was 43.5 Karyotype formula is $M_{22}+Sm_{14}$.

***Stevia rebaudiana* (Bertoni) Bertoni (2n=22, V. N. 131)**

The plant is an erect, perennial, herb about 2 ft. tall. It has a woody stem. Leafs are simple, opposite, margins slightly serrate, acute apex.

The karyotype consists of 3 different types of chromosomes with centromere at median point, sub-median region and sub-terminal region. The length of

chromosomes ranged from 0.6 to 1.2 μm with the mean length 0.81 μm and the absolute length 9 μm . TF% is 37.7. Karyotype formula is $M_{10}+sm_{10}+st_2$.

***Tridax procumbens* L. (2n=26,V.N.137)**

The plant is annual, prostrate and hairy. Stem branched, creeping at base, glabrous, woody purplish. The plants bears yellow disc floret and white three-toothed ray florets. The leaves are toothed and generally arrowhead-shaped. It is used as an ornamental or fodder plant.

The karyotype consists of 4 different types of chromosomes with centromere at median point, median region, sub median region and sub terminal region. The length of chromosomes ranged from 0.8 to 2.6 μm with the mean length 1.6 μm and the absolute length 20.9 μm . TF% is 44.4. Karyotype formula is $M_{18}+m_4+sm_2+ st_2$.

Fig. 1. (a) *Artemisia abronatum*, (b) Photomicrograph, (c) camera lucida drawing and (d) ideogram of the same).

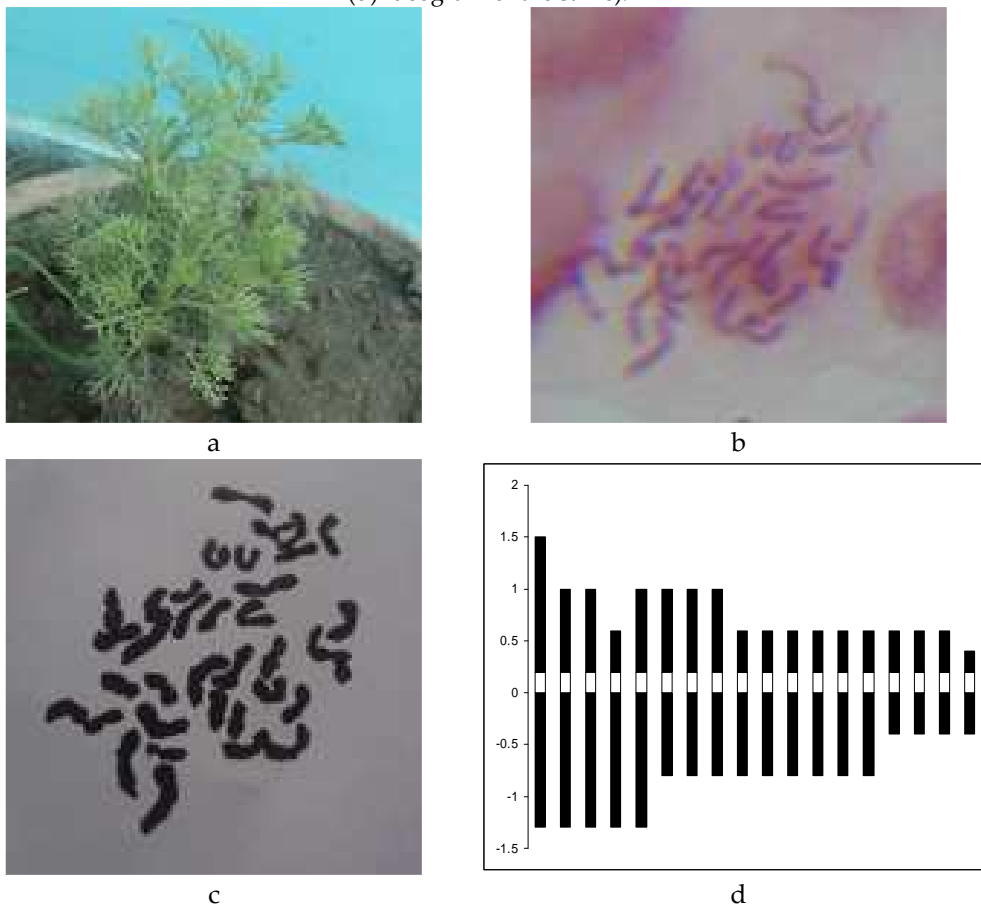


Fig. 2. (a) *Artemisia vulgaris*, (b) Photomicrograph, (c) camera lucida drawing and (d) ideogram of the same.

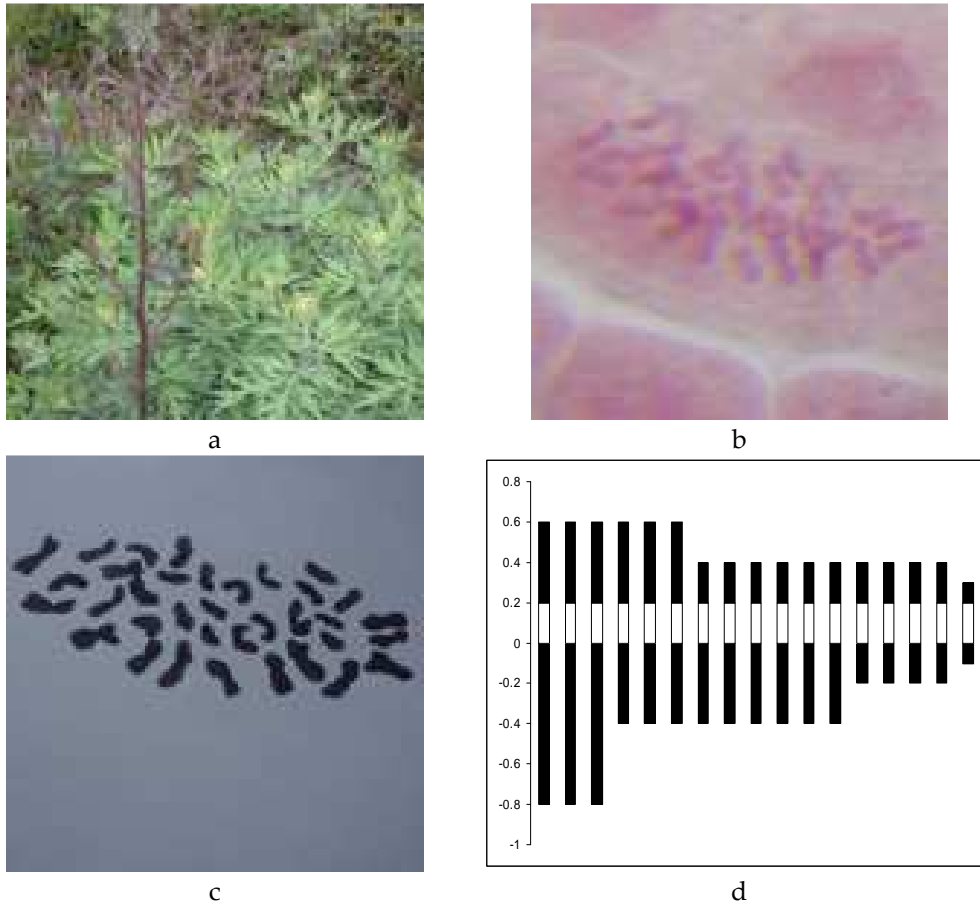


Fig. 3. (a) *Coreopsis grandiflora*, (b) Photomicrograph, (c) camera lucida drawing and (d) ideogram of the same.



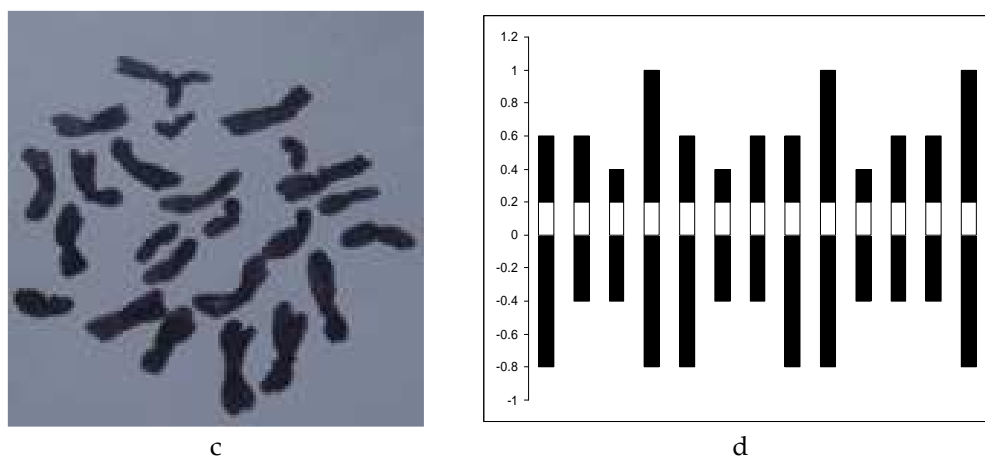


Fig. 4. (a) *Crepis japonica*, (b) Photomicrograph of mitotic metaphase, (c) camera lucida drawing and (d) ideogram of the same.

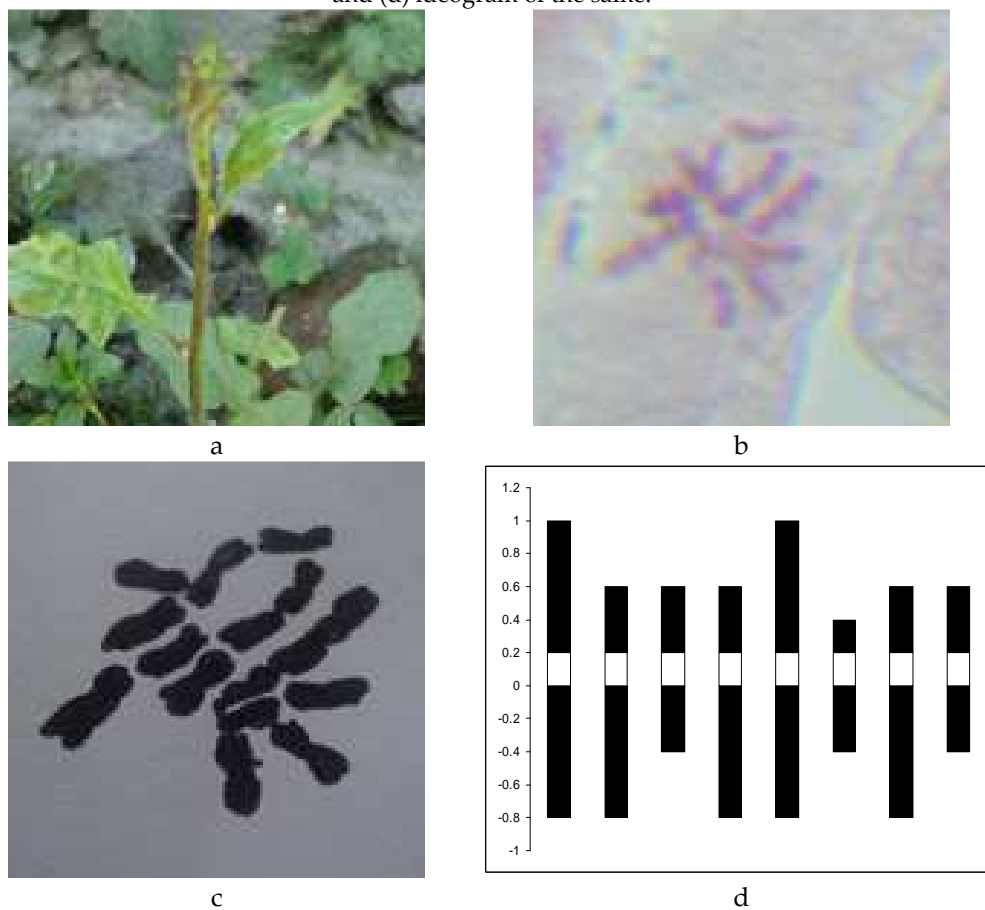


Fig. 5. (a) *Sonchus arvensis*, (b) Photomicrograph, (c) camera lucida drawing and (d) ideogram of the same.

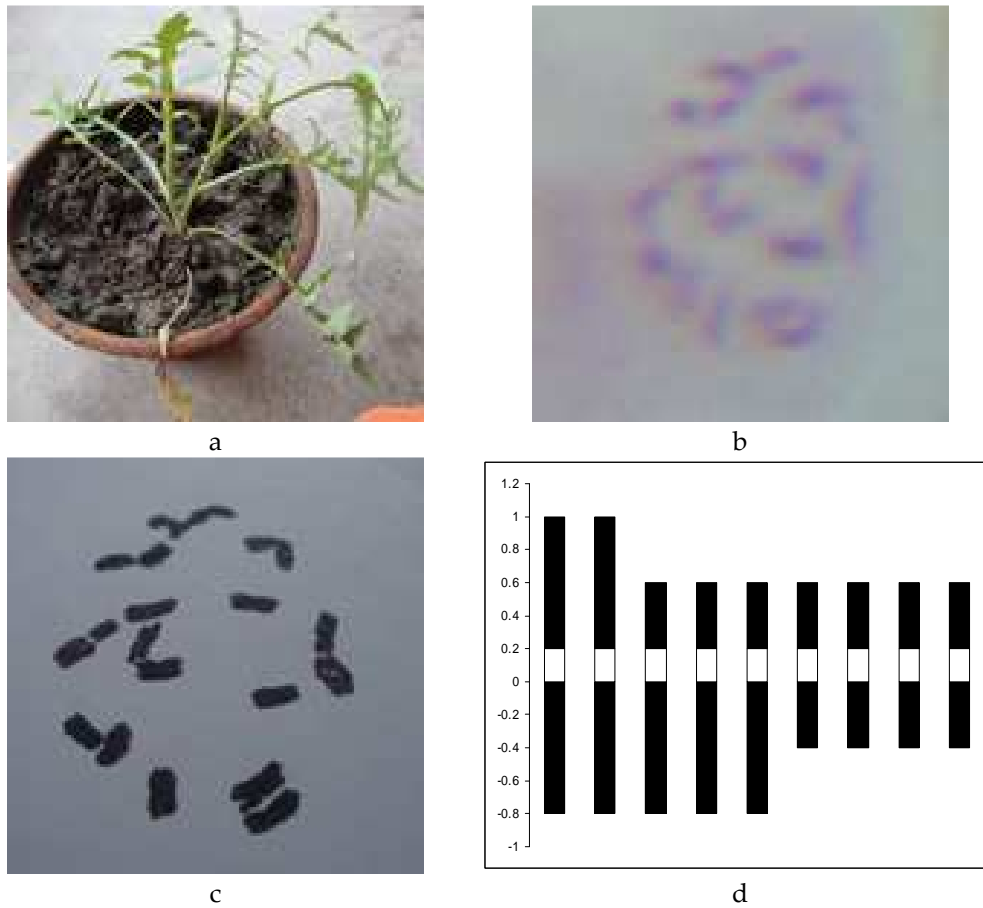


Fig. 6. (a) *Spilanthes acmella*, (b) Photomicrograph of mitotic metaphase, (c) camera lucida drawing and (d) ideogram of the same.



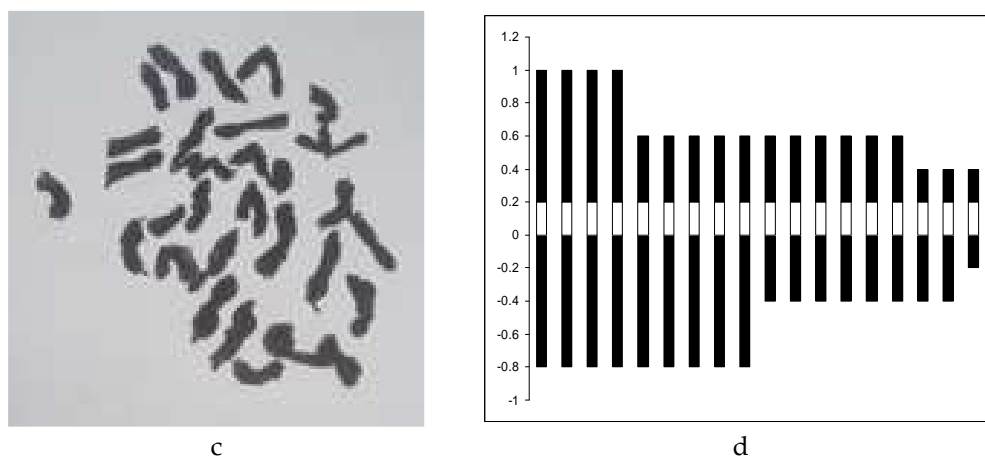


Fig. 7. (a) *Stevia rebaudiana*, (b) Photomicrograph of mitotic metaphase, (c) camera lucida drawing and (d) ideogram of the same.

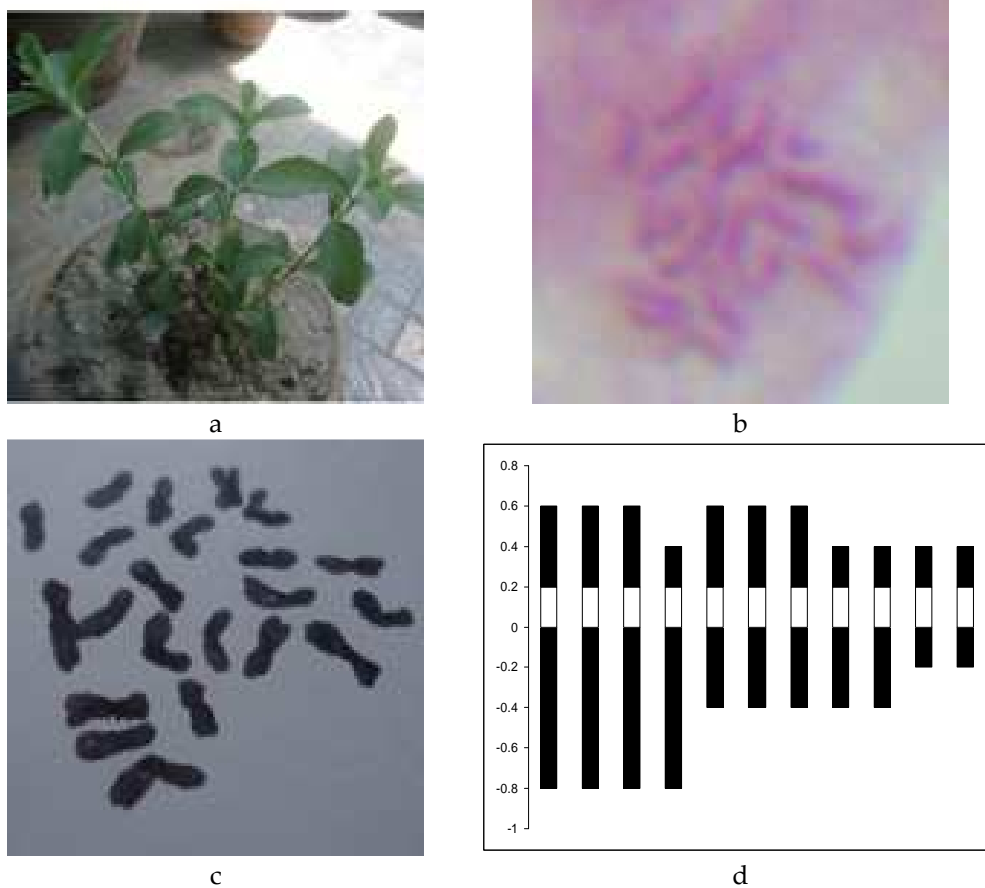
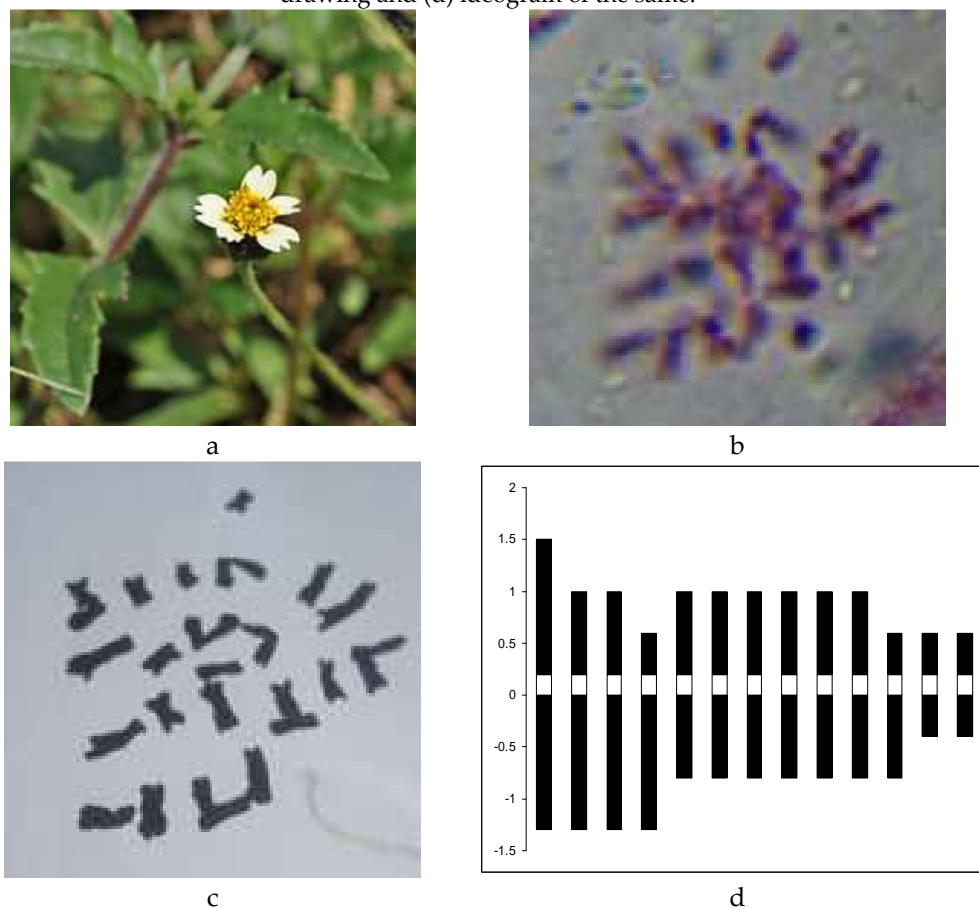


Fig. 8. (a) *Tridax procumbens*, (b) Photomicrograph of mitotic metaphase, (c) camera lucida drawing and (d) ideogram of the same.



Discussion

Present somatic chromosomes number in *Artemisia abronatum* ($2n=36$) tally with previously determined number by Kreitchtz and Vallis (2003). The haploid count $n=18$ by Johnson and Brantham (1997), Kreitchtz and Vallis (2003) confirmed the present count for *Artemisia abronatum*. But chromosome $2n=24$ determined by Mathew and Mathew (1988) differed from present count. Two haploid number $n=9$ (Stahevitch and Woitas 1988) and $n=10$ by Mathew and Mathew (1988) found for this species showed the numerical chromosome variation. So it is intraspecies variation among species as well as available in polyploidy form. Karyotype analysis of this plant shows advance nature as the length between the longest and the shortest chromosome varied by $2\ \mu\text{m}$; majority of chromosomes having centromere at (9 pairs) are at medians point. The general morphological characters of this plant also exhibit correlation with its chromosomal characters. The presence of finely divided compound leaves, high total form percentage (41.9) show its advance nature. Chromosome counts for *Artemisia*

vulgaris in present investigation ($2n=34$) tally with Khatoon and Ali (1993). But a great numerical chromosome variation is found by various authors viz., ($2n=30, 40, 50$ by Nirmala & Rao 1984; $2n=18$ by Maguleav, 1992; $2n=40$ by Nirmala & Rao 1989; $2n=24$ by Sharma, 1970; $2n=18, 36$; Kaul & Bakshi 1986; $2n=16$, Kuzmanov *et al.* 1986; Kaul & Bakshi 1984; Noguchi *et al.* 1983; Kartashova *et al.* 1974; Volkova & Boyko 1981; Loverenki *et al.* 1990, 1991, 1992; Xirau & Siljak-Yakovtev 1997; James *et al.* 2000; Alberes & Probsting 1998; Kiehnkn *et al.* 2000; Rostovtseva 1979a; Malakhova *et al.* 1979; Beleva & Siplivinsky 1975, 1976; Marton 1977; Zhukova & Petrovsky 1976; Hindakova 1974; Kartashova *et al.* 1974; Hoshi *et al.* 2004; Krasinikov 2006; Korovkon 2003).

Different haploid number also determined by different authors for *Artemisia vulgaris* was $n=8$ (Valles Xirau, 1987; Arohonka, 1982; Devesa & Viera, 1987; Aparicio & Martinez, 1986; Mulligan, 1984; Stahevitch & Woztas, 1988; Khatoon & Ali, 1993). Likewise $n=9$ by (Gupta & Gill, 1988, 1989; Gupta *et al.*, 1989). Similarly $n=27$ by (Gill *et al.* 1982) and $n=18$ (Gupta & Garg, 1987; Khatoon & Ali, 1993). So it shows the great intraspecies variations among the species also found in three different polyploidy form. Karyotypic classification of *Artemisia vulgaris* shows both advanced as well as primitive nature. The length between longest and shortest chromosomes varied by $0.6 \mu\text{m}$ only; majority of chromosomes having centromere at (9 pairs) are at sub medians region which shows its primitiveness. The chromosomes are comparatively smaller than those of *Artemisia abrotanum* which shows its advance nature. Likewise, the present counts for *Coreopsis grandiflora* $2n=24$ tally with Jose & Mathew (1995) also haploid number $n=12$ found by same author in same year supports the present count for *Coreopsis grandiflora*. But present count $2n=26$ differs from the previous number determined by other authors such (Mathew & Mathew, 1988; Gupta & Gill, 1981; Yang 2001).

Basic number for this species was $x=12, 13, 14$ (Darlington & Wylie 1955). The above result shows chromosome variations among the species in *Coreopsis grandiflora*. Karyotype analysis of this plant shows the primitive nature as the length between the longest and the shortest chromosome varied by $0.7 \mu\text{m}$ only; majority of chromosomes having centromere at (5 pairs) are at sub median regions. The general morphological characters of this plant also exhibit correlation with its chromosomal characters. Long lanceolate, radicle leaves, long petiole and low TF% and total form percentage (38.5) show its primitive nature.

Similarly, the present chromosome count for *Crepis japonica* $2n=16$ is supported by haploid number $n=8$ (Mathew & Mathew, 1988; Gupta & Gill, 1989). According to karyotypes classification *Crepis japonica* exhibit an advance as well as primitive character. High TF% and slender stem with slightly hairy leaves shows its advance nature. Presence of radicle leaves and a little difference in chromosomes length ($0.6 \mu\text{m}$) show its primitive nature. Present count for *Sonchus arvensis* $2n=18$ tally with

Prabha & Roy (1986), Mathew & Mathew (1988). The haploid number $n=9$ (Prabha, 1989; Mathew & Mathew, 1988) supports the above result for *Sonchus arvensis*. But it differed from the report $2n=36$ (Parfenov & Dmitrieva, 1985; Kuvmanov *et al.*, 1986; Nzarova, 1984, 1989; Dmitrieva, 1987, Gorzko *et al.* 1980, Joshi, 1988). So it is found in polyploidy form that *Sonchus arvensis* exhibit an advance as well as primitive character according to chromosome morphology and general morphology. Chromosome length varied only by $0.8 \mu\text{m}$, and the lyrate leaves show its primitive nature. High TF% with cauline leaves show its advance nature. The present report for *Spilanthes acmella* $2n=36$ is different from the previous report $2n=46$ (Mathew & Mathew, 1988; Nirmala & Rao, 1981, 1984, 1989). The haploid number $n=26$ (Gupta & Gill, 1989) showed chromosome variation among species for this taxa. Karyotype analysis of this plant shows advance nature as the length of chromosome varied by $1.3 \mu\text{m}$, high TF% (45.5) and majority of chromosomes have had centromere at median points. The branching stem with triangular leaves show its advanced nature. The present count for *Stevia rebaudiana* is $2n=22$ tally with the previously determined number (Li *et al.*, 1982; Frederico *et al.*, 1996) so it reconfirmed the previous number. The karyotype of this plant shows primitive nature. The length between the longest and the shortest chromosomes varied by only $0.8 \mu\text{m}$, TF% is also low (37.7) in comparison to another taxa. The woody stem and perennial habit show primitive character. The present count for *Tridax procumbens* $2n=26$ differed from the previously determined number $2n=36$ (Sidhu & Pelia, 1987; Baltisberger, 1990; Nirmala & Rao 1981, 1984, 1985); Xie & Zheng, 2003). But the haploid number $n=13$ determined by Gill & Omoigui (1988) supports the present report. Again the haploid number $n=18$ (Razaq *et al.*, 1985, 1988; Khatoon & Ali, 1982; Gill & Omoigui, 1988; Husaini & Iwo, 1990; Gill & Omoigui, 1987; Mathew & Mathew, 1988; Gupta & Gill, 1989; Jose & Mathew, 1995; Nirmala & Rao, 1981; Keil & Stuessy, 1975; Keil & Stuessy, 1977; Koul *et al.*, 1976a) is different from present report, so it showed chromosome variation among species in *Tridax procumbens*. Karyotype analysis of this plant shows an advance nature as the length between the longest and the shortest chromosome varied by $1.8 \mu\text{m}$; majority of chromosomes having centromere at (9 pairs) are at median points, which shows its advancedness. The general morphological characters of this plant also exhibit correlation with its chromosomal characters. The annual habit, branched stem, hairy leaves show an advance character.

The chromosome morphology of the studied taxa all differed from each other. The shortest chromosome length $0.4 \mu\text{m}$ (*Artemisia vulgaris*, *Coreopsis grandiflora* Nutt. ex Chapm., *Stevia rebaudiana* (Bertoni) Bertoni) was found and the longest chromosome length $2.6 \mu\text{m}$ (*Artemisia abronatum* L) was found. The highest absolute length of chromosome found is $26.7 \mu\text{m}$ (*Artemisia abronatum*) μm and the lowest $9 \mu\text{m}$ (*Stevia rebaudiana* and *Crepis japonica*). The total form percentage is highest in *Sonchus arvensis* 44 and lowest in *Stevia rebaudiana* 37.7. The highest chromosome number 36

found in (*Artemisia abronatum*, *Spilanthes acmella*) and lowest in *Crepis japonica* which is 16. There are four types of somatic chromosome found in the present research viz. chromosome with centromere at median point, at median region, at sub- median region, and at sub- terminal region.

Conclusion

Therefore it can be concluded that *Artemisia abronatum*, *Artemisia vulgaris*, *Coreopsis grandiflora*, *Spilanthes acmella* have been found to be with intraspecific variations and *Crepis japonica*, *Sonchus arvensis* shows both advanced as well as primitive character. The species *Stevia reboudiana* shows primitive character and *Tridax procumbens* shows advanced character among the studied taxa.

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Carbon Stock Assessment of Leasehold Forests: A Study of Katakuti VDC, Dolakha District

Tshering Dolma Lama¹ and Ram Asheshwar Mandal²

¹College of Applied Sciences, Kathmandu, Nepal ²REDD-Forestry and Climate Cell/MoFSC/GoN

Email: tshering_dolmalama@yahoo.com

Abstract: An assessment of carbon stocks of vegetation and soil was carried on ten leasehold forests of Katakuti VDC, Dolakha, to meet the research objectives. Random sampling was used to collect the biophysical data of trees/poles, sapling, root and leaf litter, herb and grass. Then, the biomass of trees/poles and sapling was calculated using regression model. Moreover, the samples of leaf litter, herbs and grasses were dried to get the biomass. Here, the below ground (root) biomass was estimated as 15% of the above ground biomass. Then, the biomass stock was converted into carbon stock multiplying by 0.47. Similarly, the soil samples were collected from different depths of 0-10 cm, 10-20 cm and 20-30 cm and were analyzed to determine the soil organic carbon (only soil carbon). Lastly, all analyzed data were compiled to get the total carbon stocks. The result showed that the total biomass stock was found to be dominant in Srijana leasehold forest with 52.389 t/ha among ten leasehold forests. The Soil Organic Carbon was found to be highest (0-10 cm) and the lowest (20-30 cm) in all leasehold forests. The estimated total carbon stock per ha was found to be highest in Srijana leasehold forest with 125.493 t C/ha. The estimated total carbon stock of 10 leasehold forests was found to be 1439.033 t. Leasehold forests have been playing a major role in promoting forest enhancement by increasing the potential to capture carbon. Hence, the study concluded that leasehold forests are potential in sequestering carbon, and such records of carbon stock play a vital role to link carbon credit with REDD+ programme in future.

Keywords: Carbon sequestration, leasehold forest, biomass, carbon, carbon stock.

Introduction

Carbon sequestration is an increase in carbon stock in any non atmosphere reservoir (IPCC, 2000). Carbon sequestration is appropriate from environmental and a socioeconomic point of view. The environmental perspective includes the removal of CO₂ from the atmosphere, the improvement of soil quality, and the increase in biodiversity (Batjes & Sombroek 1997; Batjes 1999; Lal *et al.*, 1995). The practices such as afforestation and rehabilitation of degraded forest land promote carbon storage and reduce emissions while enhancing the biodiversity value of ecosystems (Alonso *et al.*, 2012). Forest vegetation and soil share almost 60% of the world's terrestrial carbon (Winjum *et al.*, 1992). In Nepal under different types of community-based forest management system, the leasehold forest (LHF) was introduced with the twin objectives of regenerating degraded forest land and alleviating rural poverty.

It has been estimated that deforestation contributes to about 17.4 percent of global emissions of GHG (IPCC, 2007). Removal of trees from the forest displaces large amount of sequestered carbon and consequently reduces carbon held in terrestrial

biomass (IPCC, 2000). Globally, the rate of deforestation was decreased from 16 million ha to 13 million ha annually in between 1990 to 2000 (FAO, 2011). The extent of forest areas in Asia and the Pacific has changed dramatically over the past two decades. Forests were lost at the rate of 0.7 million ha per year in between 1990 to 2000 but grew by 1.4 million ha per year over the period 2000–2010 (FAO, 2011). Southeast Asia's forests cover was 214 million ha and constitutes 29% of the Asia-Pacific region's total forest area (FAO, 2011). The planted forest establishment in Southeast Asia increased from 261 million ha per annum between 2000 and 2005 to 298 million ha per annum between 2005 and 2010 (FAO, 2011).

Here, in Nepal the deforestation rate was 0.06% between 1990/91-2000/01 (DoF 2005) and the annual rate of deforestation in the hills was about 1.3% and in the Terai it was about 2.3% (DFRS, 1999). In Nepal, 7046 ha of plantation was carried out between 2000 to 2005 which was continuously conducted in open access basis (DoF, 2006). Under different types of community-based forest management system, the LHF's have become a crucial measure to address deforestation and forest degradation in Nepal.

It has been noticed that much of the research on carbon stock has focused on community forests in Nepal. Here, the leasehold forest in Nepal is a potential alternative mechanism for poverty reduction and the rehabilitation of degraded forest land. Therefore, an assessment of carbon stock of leasehold forests is significant. Thus, this study establishes the baseline information which might help claim the carbon credit under REDD+ programme in the future.

Materials and methods

Study area

The study was carried on four clusters of ten leasehold forests of Katakuti VDC, namely Janahit, Muna, Bhimsen, Kalidevi, Kalyankari, Srijana, Siddhiganesh, Setidevi, Sansarimai and Bhumithan leasehold forests. Katakuti VDC lies within Charnawati watershed of Dolakha district of the Central Development Region of Nepal. The latitude of Dolakha district ranges from 27°28' to 28°0' N to 85°50' to 86°32' E longitudes. Its altitude ranges from 732m to 7148m above the sea level. The average maximum and minimum temperatures with average annual rainfall of Dolakha district was 19 °C, 8 °C and 2043.5 mm respectively (DFO, 2009/10).

Sampling and methods of data collection

The map of individual LHF was prepared using the GPS (Global Positioning System) coordinates with the help of Arc GIS software. The study was carried on four clusters of ten leasehold forests. The first cluster consists of five leasehold forests—Janahit, Muna, Bhimsen, Kalidevi and Kalyankari. The second cluster consist of Srijana leasehold forest. Similarly, the Siddhiganesh and Setidevi leasehold forests occur in the third cluster and the last cluster consists of Sansarimai and Bhumithan

leasehold forests. The number of sample plot in each cluster of leasehold forest was determined by applying the proportion allocation method based on the area of leasehold forest.

Altogether 30 sample plots from 10 leasehold forests were carried for the study applying random sampling method with 1% sampling intensity for each cluster of leasehold forest (CFD, 2004). Then, the coordinates of sample plots were uploaded in the GPS receiver. With the help of the GPS receiver, the plot centre was navigated in the field and the nested plots were established for tree/pole, sapling, seedling, leaf litter, herb, grass and soil. The plot having 5.64 m radius was established for tree/pole, a sub plot of 2.82 m radius was established for sapling, a sub plot of 1.78 m radius was established for counting seedling/regeneration and a sub plot of 0.56 m radius was established for collecting sample of leaf litter, herb, grass and soil. Simultaneously, the slope correction in each sample plot was done wherever required. The DBH (at 1.3 m) and the height of individual trees/poles greater than or equal to 5 cm DBH were measured but for the saplings (1-5 cm) only, the DBH at 1.3 m above ground level were measured. The sample of leaf litter, herbs and grasses were collected and carried out in the laboratory to determine the oven dry weight of the biomass. Similarly, the soil samples were collected from three different layers (0-10 cm, 10-20 cm & 20-30 cm) and were brought to the laboratory for the analysis of soil organic carbon.

Data analysis

The allometric equation developed by Chave *et al.* (2005) and Brown *et al.* (1989) was used to estimate the above ground tree/pole biomass. If the specific gravity (wood density) of species were known, the equation developed by Chave *et al.* was used, whereas in case of unknown specific gravity (wood density) of species, the equation developed by Brown *et al.* was used. Here, the allometric equation was based on the amount of the rainfall in that area. The allometric equation for dry forest stand was used for the area having rainfall less than 1500 mm; the allometric equation for moist forest stand was used for the area having rainfall between 1500-4000 mm; and the allometric equation for wet forest stand was used for the area having rainfall greater than 4000 mm. For this study, the allometric equation developed by Chave *et al.* (2005) and Brown *et al.* (1989) for the moist forest stand was used to estimate the above ground tree/pole biomass. The regression model was used to calculate the above ground sapling biomass developed by Tamrakar (2000). Moreover, the samples of leaf litter, herb and grasses were dried to get the biomass. Here, the below ground (root) biomass was estimated at 15% of the above ground biomass (MacDicken, 1997). Then, the biomass stock was converted to carbon stock after multiplication by the IPCC (2006) default carbon fraction of 0.47. In the context of soil, the carbon stock was calculated as suggested by Pearson *et al.* (2007).

Lastly, the total carbon stock was calculated by summing the carbon stock of the individual carbon pools.

Total Carbon stock:

$$C (LU) = C (ABTG) + C (AGSB) + C (BB) + C (LHG) + SOC$$

Where,

C (LU) = carbon stock for a land use category (t C/ha)

C (ABTG) = carbon in above ground tree biomass (t C/ha)

C (AGSB) = carbon in above ground sapling biomass (t C/ha)

C (BB) = carbon in below ground (root) biomass (t C/ha)

C (LHG) = carbon in litter, herb and grass (t C/ha)

SOC = soil organic carbon (t C/ha)

Results and discussion

Carbon stock of leasehold forests

Table 1. Carbon stock (t C/ha) of leasehold forests

Name of LHF	AGT/P	AGS	BG	LHG	SOC	Total carbon stock
Kalyankari	2.087	1.712	0.3	1.348	33.905	39.352
Kalidevi	1.121	0.237	0.168	1.359	44.045	46.93
Bhimsen	8.421	0.031	1.263	1.356	51.97	63.041
Muna	3.223	0.148	0.484	1.978	55.53	61.363
Janahit	1.604	0.251	0.241	1.552	94.27	97.918
Srijana	18.702	0.652	2.805	2.464	100.87	125.493
Siddhiganesh	9.681	0.104	1.452	1.609	52.45	65.296
Setidevi	11.483	0.507	1.722	1.396	59.8	74.908
Sansarimai	0.679	0.477	0.102	1.155	85.86	88.3
Bhumithan	5.109	1.875	0.766	1.88	108.08	117.71

where,

AGT/P= above ground tree/pole

AGS= above ground sapling

BG= below ground

LHG= leaf litter, herb & grass

SOC= soil organic carbon

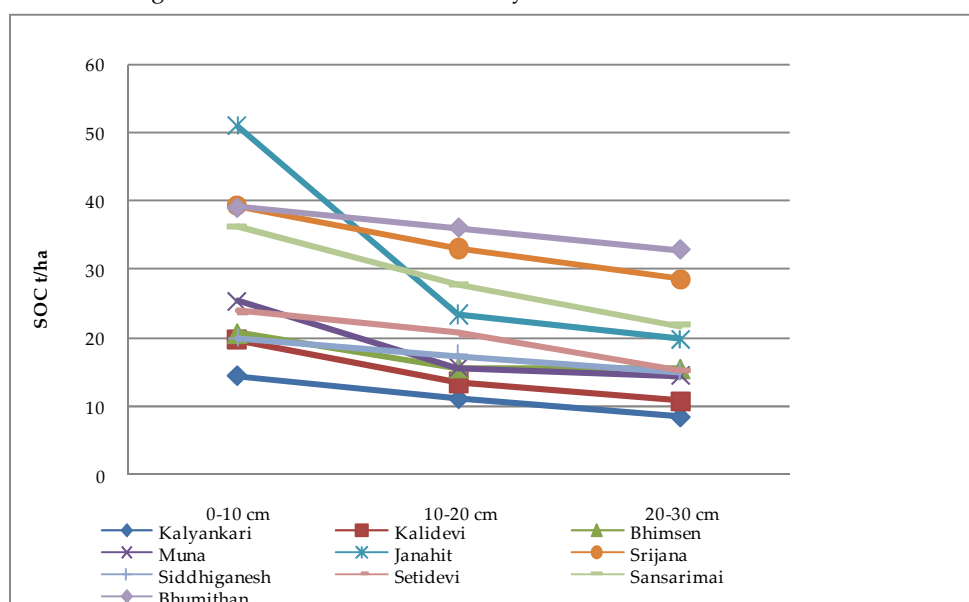
Here, the above ground tree/pole carbon stock, the below ground carbon stock and the carbon stock of leaf litter, herb and grass were found to be highest in Srijana leasehold forest with 18.702 t C/ha, 2.805 t C/ha and 2.464 t C/ha. The above ground sapling carbon stock and the soil carbon stock was found to be highest in Bhumithan leasehold forest with 1.875 t C/ha and 108.08 t C/ha (Table 1).

Carbon contribution by different carbon pools in leasehold forests

The soil organic carbon was consistently dominant in all leasehold forests comprised of 88% among all pools, and it was followed by the above ground tree/pole carbon stock with 8%, leaf litter, herb and grass carbon stock with 2% and the above ground sapling carbon stock and the below ground carbon stock with 1%. The soil carbon was found to be dominant in all leasehold forests than the above ground tree/pole carbon stock because the pole/tree stand was found to be fewer in number in the leasehold forests.

Trend of soil carbon with respect to soil depths

Fig. 1. Soil carbon in different soil layers in different leasehold forests



The soil carbon decreased with respect to soil depth in all leasehold forests (Fig. 1). The highest SOC was found between 0-10 cm and the lowest between 20-30 cm. This trend was similar in all leasehold forests. The soil organic carbon at the soil depth of 0-10 cm was found to be highest in Janahit leasehold forest with 50.93 t C/ha and the lowest in Kalyankari leasehold forest with 14.45 t C/ha. At the soil depth of 10-20 cm, the soil organic carbon was found to be highest in Bhumithan leasehold forest with 36.12 t C/ha and the lowest in Kalyankari leasehold forest with 11.055 t C/ha. Likewise at the soil depth of 20-30 cm, the highest soil organic carbon was found to be in Bhumithan leasehold forest with 32.88 t C/ha and the lowest in Kalyankari leasehold forest with 8.4 t C/ha. In the context of total soil organic carbon, Bhumithan leasehold forest was found to be the highest with 108.08 t C/ha and Kalyankari leasehold forest was found to be the lowest with 33.905 t C/ha.

Total carbon stock of leasehold forests

Table 2. Total carbon stock of leasehold forests

Name of LHF	Area (ha)	Total carbon stock (t C/ha)	Total carbon stock (t C)
Kalyankari	0.522	39.352	20.542
Kalidevi	0.89	46.93	41.768
Bhimsen	1.232	63.041	77.667
Muna	0.762	61.363	46.759
Janahit	1.009	97.918	98.799
Srijana	0.524	125.493	65.758
Siddhiganesh	0.664	65.296	43.357
Setidevi	1.051	74.908	78.728
Sansarimai	5.414	88.3	478.1
Bhumithan	4.142	117.71	487.555
Total	16.21		1439.033

Carbon stock was found varied according to the leasehold forest (Table 2). The estimated total carbon stock per ha was found to be highest in Srijana leasehold forest with 125.493 t C/ha. Thus, the estimated total carbon stock of ten leasehold forests was found to be 1439.033 t in 16.21 ha.

Hypothesis testing of the total carbon stock of leasehold forests

One-way ANOVA was done in order to test the difference in the total carbon stock of all ten leasehold forests.

ANOVA Test

H₀: There is no significant difference in the total carbon stock of leasehold forests.

H₁: There is a significant difference in the total carbon stock of leasehold forests.

One Way ANOVA

Table 3. Hypothesis testing of total carbon stock of leasehold forests

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23954.789	9	2661.643	11.290	.000
Within Groups	4715.049	20	235.752		
Total	28669.837	29			

Decision: Null hypothesis is rejected at 5% level of significance, and it can be concluded that there is a significant difference in total carbon stock of leasehold forests.

Discussion

As there were no studies done regarding carbon stock in leasehold forests, the literatures on community forest of Nepal were reviewed and the results were compared with community forests.

The above ground tree/pole carbon stock was found to be highest in Srijana leasehold forest (18.702 t C/ha) and it was followed by Setidevi, Siddhiganesh, Bhimsen, Bhumithan, Muna, Kalyankari, Janahit and Kalidevi leasehold forests because the above ground tree/pole biomass of Srijana leasehold forest was found to be dominant due to the occurrence of majority of pole-size stand.

The present study is supported by the study conducted by Khanal (2008) in Jarneldhara community forest and Lipindevi Thulopakho community forest of Palpa district. The above ground tree carbon stock in Lipindevi Thulopakho community forest was found to be higher (38.6 ± 3.9 t C/ha) than Jarneldhara community forest (35.5 ± 3.4 t C/ha) due to large-sized trees which consequently have higher biomass values.

The highest leaf litter, herb and grass carbon stock was found in Srijana leasehold forest (2.464 t C/ha) followed by Muna, Bhumithan, Siddhiganesh, Janahit, Setidevi, Kalidevi, Bhimsen, Kalyankari and Sansarimai leasehold forests because the leaf litter, herb and grass biomass was found to be more in Srijana leasehold forest than other leasehold forests. Removal of forest litters removes most of the nutrients that would otherwise add to the fertility of forest bio-mass and increase carbon (Pimentel *et al.*, 1981).

The highest SOC was found in Bhumithan leasehold forest (108.08 t C/ha) in comparison to other leasehold forests. This might be due to the moist and cool climate in Bhumithan leasehold forest. The SOC of a forest depends on the types of climate, moisture, temperature and variation in soil types (Shrestha, 2008). However, Smith *et al.* (2002) reported that SOC increased with elevation due to the increase in precipitation, decrease in temperature and production of greater amount of plant biomass at higher elevations.

The present study shows that the soil organic carbon decreased with the increase in soil depth in all leasehold forests. All the leasehold forests contained greater SOC in the upper layer of 0-10 cm followed by 10-20 and 20-30 cm depth. This may be attributed to the fact that higher amount of humus is present in the top layer of the soil profile in the studied leasehold forests with lower organic matter with the increase in soil depth. Likewise, the study shows that there is an abrupt decrease in soil carbon of Janahit leasehold forest. The upper layer (0-10 cm) of Janahit leasehold forest possesses black soil while at 10-20 cm and 20-30 cm, it contains red soil and bears gravels, stones and fine pebbles. This might be the reason why there is an abrupt decrease in soil carbon in Janahit leasehold forest than other leasehold forests.

Trujillo *et al.* (1997) reported that SOC diminishes with the depth regardless of vegetation, soil texture and clay size fraction that supports the decrease in soil carbon.

Conclusion and recommendation

The above ground tree/pole carbon stock, the below ground carbon stock and leaf litter, herb and grass carbon stock was found to be highest in Srijana leasehold forest. The above ground sapling carbon stock and SOC was found to be highest in Bhumithan leasehold forest. Soil organic carbon seems consistently dominant in all the leasehold forests. Here, the estimated total carbon stock of 10 leasehold forests was 1439.033 t.

As most of the studies assessing carbon stock have been conducted on community forests, this study on carbon stock of leasehold forests helps to create a carbon stock data of vegetation and soil of leasehold forests. Thus, it is recommended that such studies should be continued.

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Response of Bivoltine Silkworm Hybrids to Different Ecological Domains of Nepal

N.P. Ghimire, R.B. Thapa, S.M. Shrestha and F.P. Neupane*

Institute of Agriculture and Animal Science, Rampur, Chitwan, *Nepal Academy of Science and Technology, Khumaltar, Lalitpur

Abstract: Response of five bivoltine silkworm (*Bombyx mori* L.) hybrids were tested over three ecological domains during the hard period of June-July for two years. The highest egg hatchability of $N_{108} \times N_{112}$ during 2006 spring (99.69%), $C_{12} \times J_{12}$ eggs during 2006 and 2007 spring (98.83 and 98.81%), and $J_{12} \times C_{12}$ eggs during 2006 spring (98.67%) were in Khopasi, Kavrepalanchok district. Number of cocoons per liter was 57 (the lowest) with $J_{12} \times C_{12}$ reared in Khopasi during 2006 and 2007 spring. Average single cocoon weight was the highest in $N_{108} \times N_{112}$ reared in Khopasi during 2006 and 2007 spring (2.68 and 2.67g). $J_{12} \times C_{12}$ reared in Dhunibesi, Dhading district during 2006 spring had the highest average shell percent (23.99%). The highest amount of good cocoons (26.57kg/box) was harvested from $N_{108} \times N_{112}$ reared in Khopasi during 2006 spring. Location wise suitability of bivoltine silkworm hybrids were $J_{12} \times C_{12}$, $N_{109} \times N_{112}$ and $N_{108} \times N_{112}$ for Khopasi, $J_{12} \times C_{12}$, $N_{108} \times N_{112}$ and $C_{12} \times J_{12}$ for Pokhara and $N_{109} \times N_{112}$, $C_{12} \times J_{12}$ and $N_{108} \times N_{112}$ for Dhunibesi conditions.

Keywords: Silkworm, hybrid, response, ecological domain.

Introduction

Bivoltine silkworm (*Bombyx mori* L.) hybrids have more desirable economic characters over pure breeds and their adaptability varies with the ecology of different locations (Jolly, 1987; Thapa and Shrestha, 1999; Thapa and Takamiya, 2001). Similarly, their performances in egg hatchability, larval growth and cocoon production vary during different rearing seasons (SDD, 1998; Ghimire, 2002; Gautam 2006). The average single cocoon weight of $J_{12} \times C_{12}$ in Khopasi was 1.80g (Thapa, 2003) and in Bhandara 1.98g (Sahu, 2006), while it differed from one hybrid $J_{12} \times C_{12}$ to another hybrid $C_{12} \times J_{12}$ in the same location (Gautam, 2006). The good cocoon percent of $CHUL_{12} \times THAI_{12}$ also varied during spring rearing of 1995 in Bhandara, $SHUNREI \times SHOGETSU$ during spring rearing of 1997 in Syangja and $A \times K$ during autumn rearing of 1997 in Syangja, i.e. 95.73, 98.65 and 97.52%, respectively (SDD, 1998). Therefore, this study was conducted to find the location specific suitability of available bivoltine silkworm hybrids three different ecological domains-Khopasi, Dhunibesi and Pokhara of Nepal.

Material and methods

Five silkworm hybrids including two common silkworm hybrids, $J_{12} \times C_{12}$, $C_{12} \times J_{12}$, $N_{107} \times N_{112}$, $N_{108} \times N_{112}$ and $N_{109} \times N_{112}$ were reared in three ecological domains (Khopasi,

Dhunibesi and Pokhara) for two years (2006 and 2007). Sets of five silkworm hybrids each with 1000 six month preservation schedule hibernated eggs for the three ecological domains were incubated simultaneously selecting hard rearing time of June-July. Hibernating bivoltine silkworm eggs kept in incubation boxes were incubated in a incubation room with 25°C and 75% relative humidity. The incubated eggs were provided ample light (approximately 30 lux) in the morning on the 13th days for each batch. The hatched and non-hatched eggs were counted at 11:00 AM and hatching percentage was calculated. Neonate larvae were brushed variety-wise and reared in wooden trays on Kanva-2 mulberry leaves till the fourth moult. Fifth instar larvae of each silkworm hybrid were placed at the rate of 200 heads per four wooden trays and fed four times daily on Kanva-2 whole leaves. Mature larvae, ready for mounting, were mounted on a zig-zag mountage. The cocoons were harvested on the seventh day and relevant data was recorded on MS Excel spread sheet. The processed data was analyzed using MSTATC statistical software package. Evaluation index (EI) values were obtained for each parameter with the assistance of the following formulae adopted by Mano *et al.* (1993) :

$$EI = A-B/C \times 10 + 50$$

For each genotypic/variety parameter, subordinate function values were obtained with the assistance of the following formula (Gower, 1971) :

$$X_u = (X_i - X_{\min}) / (X_{\max} - X_{\min})$$

Results and discussion

Egg hatchability: Hatchability of C₁₂×J₁₂ silkworm eggs in Khopasi-2007 (98.83%), J₁₂×C₁₂ silkworm eggs in Khopasi-2006 (98.67%), C₁₂×J₁₂ silkworm eggs in Khopasi-2006 (98.81%) and N₁₀₈×N₁₁₂ silkworm eggs in Khopasi-2006 (99.69%) were the highest among all (Table 1) and were also at par with the egg hatchability of N₁₀₇×N₁₁₂ in Khopasi-2006 and N₁₀₉×N₁₁₂ in Khopasi-2006. The lowest egg hatchability (80.00%) was observed in N₁₀₈×N₁₁₂-Pokhara-2006. Egg hatchability of CHUL₁₂×THAI₁₂ (during spring rearing of 1995 in Bhandara), SHUNREI×SHOGETSU (during spring rearing of 1997 in Syangja) and A×K (during autumn rearing of 1997 in Syangja) was 95, 98 and 95%, respectively (SDD, 1998). According to SDD, (1998) egg hatchability in Khopasi during 1996 showed that long chilled silkworm pure breeds, Nepal-1, Nepal-2, Nepal-3, Nepal-4, Nepal-5, Nepal-6, Nepal-7, Nepal-8, Nepal-9, Nepal-101, Nepal-102, Khopasi-1, Khopasi-2, Khopasi-3, Khopasi-4, Khopasi-5, Khopasi-101, Khopasi-102, Khopasi-103 and Khopasi-104 were 88.4, 78.2, 93.4, 87.8, 93.2, 94.5, 94.4, 90.6, 93.2, 68.3, 82.0, 75.8, 95.0, 82.4, 84.0, 96.0, 98.0, 98.7, 94.0 and 95.0%, respectively.

Number of cocoons per liter: The number of cocoons per liter was the highest (93.00) in N₁₀₇×N₁₁₂-Dhunibesi-2007 and was on par with C₁₂×J₁₂-Dhunibesi-2007 (90.00) and N₁₀₈×N₁₁₂-Dhunibesi-2007 (89.00). The lowest numbers of cocoons per liter and the

highest size of the cocoons were observed in J₁₂×C₁₂-Khopasi-2007 (57.25) and N₁₀₉×N₁₁₂-Khopasi-2006 (57.26) as given in Table 1. The number of cocoons per liter of CHUL₁₂×THAI₁₂ (during spring rearing of 1995 in Bhandara), SHUNREI×SHOGETSU (during spring rearing of 1997 in Syangja) and A×K (during autumn rearing of 1997 in Syangja) was 78, 47 and 60 cocoons/liter, respectively (SDD, 1998). Further, such variations were found while conducting research in Syangja during 1996 rainy season on different hybrids (SDD, 1998).

Table 1. Variations on egg hatchability percent and number of cocoons per liter of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Egg hatchability (%)			Cocoon per liter (No)		
	Khopasi	Pokhara	Dhunibesi	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	94.67 bc (9.73)	89.80 ef (9.48)	87.00 f-h (9.33)	57.25 n	69.25 k	81.00 e-h
SWH ₂ × Y ₁	98.83 a (9.94)	85.10 hi (9.22)	91.00 de (9.54)	63.00 m	67.50 k-m	90.00 ab
SWH ₃ × Y ₁	91.14 de (9.55)	89.50 ef (9.46)	89.00 e-g (9.44)	69.50 k	68.00 kl	93.00 a
SWH ₄ × Y ₁	85.77 gh (9.26)	93.50 cd (9.67)	82.00 ij (9.06)	64.75 lm	81.50 e-h	89.00 a-c
SWH ₅ × Y ₁	82.50 ij (9.08)	95.00 bc (9.75)	85.00 hi (9.22)	63.50 lm	80.00 f-h	88.00 b-d
SWH ₁ × Y ₂	98.67 a (9.93)	90.00 ef (9.49)	88.00 e-h (9.38)	57.26 n	75.25 ij	74.00 j
SWH ₂ × Y ₂	98.81 a (9.94)	86.00 gh (9.27)	85.00 hi (9.22)	63.01 m	85.25 c-e	82.00 e-g
SWH ₃ × Y ₂	97.56 ab (9.88)	89.00 e-g (9.43)	70.00 k (8.36)	69.51 k	83.75 d-f	79.00 g-i
SWH ₄ × Y ₂	99.69 a (9.98)	80.00 j (8.94)	86.00 gh (9.28)	64.76 lm	81.25 e-h	78.00 g-j
SWH ₅ × Y ₂	97.36 ab (9.87)	90.00 ef (9.49)	85.00 hi (9.217)	63.51 lm	81.00 e-h	77.00 h-j
F-value		33.06			6.22	
CV (%)		2.24 (1.17)			3.86	
LSD (0.05)		2.82			4.06	
SEm (±)		1.00			1.44	

Weight of cocoon per liter: As shown in Table 2, the weight of cocoons per liter was the highest in N₁₀₇×N₁₁₂-Pokhara-2007 (177.75g), which was also at par with N₁₀₇×N₁₁₂-Dhunibesi-2007 (176.76g) and N₁₀₈×N₁₁₂-Dhunibesi-2007 (176.00g). The lowest weight the cocoons per liter was in J₁₂×C₁₂-Khopasi-2007 (135.64g) and J₁₂×C₁₂-Khopasi-2006 (135.65g). Gautam (2006) reported that J₁₂×C₁₂ and C₁₂×J₁₂, fed on Kanva-2, Khopasi-1, Ichinose, and Husan, had 108.12 and 127.74g/liter, 120.85 and 123.18g/liter, 119.89 and 118.76g/liter and 125.38 and 119.10g/liter, respectively.

Average single cocoon weight: The average single cocoon weight was the highest in N₁₀₈×N₁₁₂-Khopasi-2007 (2.668g) and N₁₀₈×N₁₁₂-Khopasi-2006 (2.679g). N₁₀₉×N₁₁₂-Khopasi-2007 (2.517g). N₁₀₉×N₁₁₂-Khopasi-2006 (2.520g) was in the second position. The lowest average single cocoon weight (1.717g) was observed in N₁₀₉×N₁₁₂-Dhunibesi-2007 (Table 2). The average single cocoon weight of CHUL₁₂×THAI₁₂ (during spring rearing of 1995 in Bhandara), SHUNREI×SHOGETSU (during spring rearing of 1997 in Syangja) and A×K (during autumn rearing of 1997 in Syangja) also differed by 1.99, 2.68 and 2.22g, respectively (SDD, 1998).

Table 2. Variations on weight of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Weight of cocoon per liter (g)			Average of 50 single cocoon weight (g)		
	Khopasi	Pokhara	Dhunibesi	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	135.64 j	140.13 ij	158.23 de	2.41 bc	2.09 fg	1.78 m-o
SWH ₂ × Y ₁	142.08 g-j	146.78 f-i	162.00 d	2.15 ef	2.27 de	1.74 no
SWH ₃ × Y ₁	161.71 d	177.75 a	176.76 ab	2.33 cd	2.16 ef	1.84 j-o
SWH ₄ × Y ₁	170.67 bc	147.55 f-i	176.00 ab	2.67 a	1.91 h-k	1.88 i-m
SWH ₅ × Y ₁	153.35 ef	149.45 fg	165.00 cd	2.52 b	1.93 h-k	1.78 o
SWH ₁ × Y ₂	135.65 j	141.00 h-j	147.65 f-i	2.42 bc	1.92 h-l	1.88 i-m
SWH ₂ × Y ₂	142.09 g-j	147.88 f-h	163.57 d	2.16 ef	1.80 l-o	1.90 h-m
SWH ₃ × Y ₂	161.72 d	159.83 de	160.05 de	2.35 cd	1.91 h-l	1.97 h-j
SWH ₄ × Y ₂	170.68 bc	147.25 f-i	162.21 d	2.68 a	1.86 j-n	1.99 g-i
SWH ₅ × Y ₂	153.36 ef	143.00 g-j	158.87 de	2.520 b	1.84 k-o	2.02 gh
F-value		2.64			3.32	
CV (%)		2.98			3.82	
LSD (0.05)		6.51			0.11	
SEm (±)		2.31			0.04	

Weight of male cocoon: The weight of male cocoons was the highest in N₁₀₈×N₁₁₂-Khopasi-2007 (68.63g/25 cocoons) and N₁₀₈×N₁₁₂-Khopasi-2006 (68.64g/25 cocoons) and was also on par with N₁₀₉×N₁₁₂-Khopasi-2007 (65.56g/25 cocoons) and N₁₀₉×N₁₁₂-Khopasi-2007 (65.57g/25 cocoons). The lowest male cocoon weight (45.00g/25 cocoons) was observed in N₁₀₉×N₁₁₂-Dhunibesi-2007 (Table 3). The weight of male cocoon of SHUNREI×SHOGETSU during the spring rearing of 1997 in Syangja station was 2.21g closer to this finding. Research conducted in various pure silkworm breeds during the spring season of 1997 in Khopasi also showed variations in cocoon weight greatly (SDD, 1998).

Weight of male shell: As stated in Table 3, male shell weights were observed to be the highest in J₁₂×C₁₂-Khopasi-2007 (15.68g/25 shells), N₁₀₈×N₁₁₂-Khopasi-2007 (15.73g/25 shells), N₁₀₉×N₁₁₂-Khopasi-2007 (15.65g/25 shells), J₁₂×C₁₂-Khopasi-2006 (15.69g/25 shells), N₁₀₈×N₁₁₂-Khopasi-2006 (15.75g/25 shells), N₁₀₉×N₁₁₂-Khopasi-2006 (15.67g/25 shells) and C₁₂×J₁₂-Pokhara-2007 (15.53g/25 shells) which were also at par with N₁₀₇×N₁₁₂-Khopasi-2007 (14.68g/25 shells) and N₁₀₇×N₁₁₂-Khopasi-2006 (14.69g/25 shells). Similar variations are have been observed on pure silkworm breeds in Khopasi and the average male shell weight of SHUNREI×SHOGETSU during the spring rearing of 1997 in Syangja station was 0.595g (SDD, 1998).

Table 3. Variations on weight of male cocoons and shells of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Weight of 25 male cocoons (g)			Weight of 25 male shells (g)		
	Khopasi	Pokhara	Dhunibesi	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	63.74 bc	59.40 de	48.50 ij	15.68 a	13.50 cd	11.00 gh
SWH ₂ × Y ₁	56.96 ef	63.00 b-d	48.50 ij	13.83 bc	15.53 a	11.50 f-h
SWH ₃ × Y ₁	61.66 b-d	60.08 c-e	49.50 hi	14.68 ab	13.73 bc	10.50 hi
SWH ₄ × Y ₁	68.63 a	53.48 f-h	49.50 hi	15.73 a	12.98 cd	10.00 i
SWH ₅ × Y ₁	65.56 ab	54.90 fg	45.00 j	15.65 a	13.35 cd	10.00 i
SWH ₁ × Y ₂	63.75 bc	55.50 fg	52.50 gh	15.69 a	12.50 d-f	12.50 d-f
SWH ₂ × Y ₂	56.97 ef	51.50 g-i	53.00 f-h	13.82 bc	11.75 e-g	12.50 d-f
SWH ₃ × Y ₂	61.68 b-d	53.63 fg	53.00 f-h	14.69 ab	11.63 fg	13.00 cd
SWH ₄ × Y ₂	68.64 a	53.50 f-h	54.50 fg	15.75 a	12.75 c-e	13.00 cd
SWH ₅ × Y ₂	65.57 ab	52.25 g-i	54.00 fg	15.67 a	11.50 f-h	13.50 cd
F-value		2.22			3.13	
CV (%)		4.38			5.07	
LSD (0.05)		3.49			0.95	
SEm (±)		1.24			0.34	

Male shell percent: The male shell percentages were the highest in J₁₂×C₁₂-Khopasi-2007 (24.60%), J₁₂×C₁₂-Khopasi-2006 (24.61%), C₁₂×J₁₂-Pokhara-2007 (25.85%), N₁₀₇×N₁₁₂-Dhunibesi-2006 (24.53%) and N₁₀₉×N₁₁₂-Dhunibesi-2006 (24.99%) which were at par with C₁₂×J₁₂-Khopasi-2007 (24.25%), C₁₂×J₁₂-Khopasi-2006 (24.26%), N₁₀₉×N₁₁₂-Pokhara-2006 (24.35%), N₁₀₈×N₁₁₂-Pokhara-2007 (24.17%), N₁₀₇×N₁₁₂-Khopasi-2007 (23.81%), N₁₀₉×N₁₁₂-Khopasi-2007 (23.87%), N₁₀₇×N₁₁₂-Khopasi-2006 (23.82%), N₁₀₉×N₁₁₂-Khopasi-2006 (23.89%), N₁₀₈×N₁₁₂-Pokhara-2006 (23.82%), C₁₂×J₁₂-Dhunibesi-2007 (23.71%), J₁₂×C₁₂-Dhunibesi-2006 (23.81%), N₁₀₈×N₁₁₂-Dhunibesi-2006 (23.86%) and C₁₂×J₁₂-Dhunibeshsi-2006 (23.58%). The lowest male shell percent (20.20%) was observed in N₁₀₈×N₁₁₂-Dhunibesi-2007 (Table 4). The average male shell percent of CHUL₁₂×THAI₁₂ (during the spring rearing of 1995 in Bhandara) and SHUNREI × SHOGETSU (during the spring rearing of 1997 in Syangja) also were 23.42 and 27.03%, respectively (SDD, 1998).

Weight of female cocoon: The female shell weight was the highest in J₁₂×C₁₂-Khopasi-2007 (16.65g/25 shells), N₁₀₈×N₁₁₂-Khopasi-2007 (17.24g/25 shells), N₁₀₉×N₁₁₂-Khopasi-2007 (17.21g/25 shells), J₁₂×C₁₂-Khopasi-2006 (16.66g/25 shells), N₁₀₈×N₁₁₂-Khopasi-2007 (17.24g/24 shells) and N₁₀₉×N₁₁₂-Khopasi-2006 (17.23g/25 shells). N₁₀₇×N₁₁₂-Khopasi-2007 (14.92g/25 shells), N₁₀₇×N₁₁₂-Khopasi-2006 (14.93g/25 shells), J₁₂×C₁₂-Pokhara-2007 (14.78g/25 shells), C₁₂×J₁₂-Pokhara-2007 (14.93g/25 shells), N₁₀₇×N₁₁₂-Pokhara-2007 (15.00g/25 shells) and N₁₀₉×N₁₁₂-Dhunibesi-2006 (15.00g/25 shells) were in the second position. The lowest female shell weights were observed in C₁₂×J₁₂-Pokhara-2006 (11.78g/25 shells) and N₁₀₉×N₁₁₂-Dhunibesi-2007 (11.50g/25 shells), which are given in Table 4. Such variations in pure breeds and hybrids were observed in previous studies in Khopasi and Syangja (SDD, 1998).

Table 4. Variations on male cocoon shell percent and female cocoon weight of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Male shell percent (%)			Weight of 25 female cocoons (g)		
	Khopasi	Pokhara	Dhunibesi	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	24.60 a (4.96)	22.65 c-f (4.76)	22.68 c-f (4.76)	80.71 c	65.93 e-g	58.00 jk
SWH ₂ × Y ₁	24.25 ab (4.925)	24.85 a (4.98)	23.71 a-d (4.87)	72.19 d	72.75 d	55.60 k
SWH ₃ × Y ₁	23.81 a-d (4.88)	22.90 b-f (4.78)	21.21 gh (4.60)	78.20 c	69.23 de	61.00 h-j

SWH ₄ × Y ₁	22.93 b-f (4.79)	24.17 a-c (4.91)	20.20 h (4.50)	91.28 a	61.28 h-j	63.00 g-i
SWH ₅ × Y ₁	23.87 a-d (4.89)	24.35 ab (4.93)	22.22 e-g (4.72)	85.45 b	60.86 h-j	58.00 jk
SWH ₁ × Y ₂	24.61 a (4.96)	22.54 d-g (4.75)	23.81 a-d (4.88)	80.73 c	59.38 i-k	60.00 i-k
SWH ₂ × Y ₂	24.259 ab (4.93)	22.83 b-f (4.78)	23.58 a-e (4.86)	72.20 d	56.25 k	61.00 h-j
SWH ₃ × Y ₂	23.82 a-d (4.88)	21.67 fg (4.66)	24.53 a (4.95)	78.22 c	60.85 h-j	65.00 f-h
SWH ₄ × Y ₂	22.94 b-f (4.79)	23.82 a-d (4.88)	23.86 a-d (4.88)	91.30 a	58.00 jk	65.00 f-h
SWH ₅ × Y ₂	23.89 a-d (4.89)	22.01 fg (4.69)	24.99 a (5.00)	85.47 b	57.75 jk	67.50 ef
F-value		2.68			3.57	
CV (%)		3.83			3.96	
LSD (0.05)		1.26			3.82	
SEm (±)		0.45			1.35	

Weight of female shell: As shown in Table 5, the weights of the female cocoons were the highest in N₁₀₈×N₁₁₂-Khopasi-2007 (91.28g/25 cocoons) and N₁₀₈×N₁₁₂-Khopasi-2006 (91.30g/25 cocoons). N₁₀₉×N₁₁₂-Khopasi-2007 (85.45g/25 cocoons) and N₁₀₉×N₁₁₂-Khopasi-2006 (85.47g/25 cocoons) were in second position. J₁₂×C₁₂-Khopasi-2007 (80.71g/25 cocoons), N₁₀₇×N₁₁₂-Khopasi-2007 (78.20g/25 cocoons), J₁₂×C₁₂-Khopasi-2006 (80.72g/25 cocoons) and N₁₀₇×N₁₁₂-Khopasi-2006 (78.22g/25 cocoons) were in third position. The lowest female cocoon weights were found in C₁₂×J₁₂-Pokhara-2006 (56.25g/25 cocoons) and C₁₂×J₁₂-Dhunibesi-2007 (55.60g/25 cocoons). According to SDD (1998), research conducted in Khopasi station during the spring season of 1997 on 19 different pure silkworm breeds also differed greatly on female shell weights.

Female shell percent: The highest female shell percent was recorded in J₁₂×C₁₂-Dhunibesi-2007 (24.17%) which was on par with C₁₂×J₁₂-Dhunibesi-2007 (23.38%) and N₁₀₈×N₁₁₂-Pokhara-2007 (23.51%) as shown in Table 5. The lowest female shell percent was observed in N₁₀₈×N₁₁₂-Khopasi-2007 (18.91%) and N₁₀₈×N₁₁₂-Khopasi-2006 (18.90%). The average female shell percent of CHUL₁₂×THAI₁₂ (during the spring rearing of 1995 in Bhandara) and SHUNREI×SHOGETSU (during the spring rearing of 1997 in Syangja) was very close to the present findings, i.e. 19.20 and 19.69%, respectively (SDD, 1998).

Table 5. Variations on female cocoon shells of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Weight of 25 female shells (g)			Female shell percent (%)		
	Khopasi	Pokhara	Dhunibesi	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	16.65 a	14.78 b	13.00 d-f	20.64 g-i (4.54)	22.40 cd (4.73)	22.41 cd (4.74)
SWH ₂ × Y ₁	14.54 bc	14.93 b	13.00 d-f	20.16 hi (4.49)	20.49 g-i (4.53)	23.38 ab (4.84)
SWH ₃ × Y ₁	14.92 b	15.00 b	13.00 d-f	19.10 jk (4.37)	21.69 d-f (4.66)	21.31 fg (4.62)
SWH ₄ × Y ₁	17.24 a	14.40 bc	12.50 e-g	18.91 k (4.35)	23.51 ab (4.85)	19.84 ij (4.45)
SWH ₅ × Y ₁	17.21 a	12.98 d-f	11.50 g	20.16 hi (4.49)	21.33 fg (4.62)	19.83 ij (4.45)
SWH ₁ × Y ₂	16.66 a	12.60 e-g	14.50 bc	20.63 g-i (4.54)	21.23 fg (4.61)	24.17 a (4.92)
SWH ₂ × Y ₂	14.55 bc	11.78 g	14.00 b-d	20.15 hi (4.49)	20.92 f-h (4.58)	22.95 bc (4.79)
SWH ₃ × Y ₂	14.93 b	12.23 fg	13.50 c-e	19.09 jk (4.37)	20.09 hi (4.48)	20.77 f-i (4.56)
SWH ₄ × Y ₂	17.24 a	12.25 fg	14.50 bc	18.90 k (4.35)	21.14 fg (4.60)	22.31 c-e (4.72)
SWH ₅ × Y ₂	17.23 a	12.38 fg	15.00 b	20.14 hi (4.49)	21.43 e-g (4.63)	22.22 c-e (4.72)
F-value		1.73			8.04	
CV (%)		4.78			2.76 (1.36)	
LSD (0.05)		0.96			0.82	
SEm (±)		0.34			0.29	

Average shell percent: The average shell percent was the highest in J₁₂×C₁₂-Dhunibesi-2006 (23.99%) which was at par with N₁₀₈×N₁₁₂-Pokhara-2007 (23.84%), C₁₂×J₁₂-Dhunibesi-2007 (23.55%) and N₁₀₉×N₁₁₂-Dhunibesi-2006 (23.61%). N₁₀₈×N₁₁₂-Dhunibesi-2007 (20.02%) was observed to be the lowest of all the interactions (Table 6). The present findings are also supported by such hybrids rearing, i.e. the average shell percent of SHUNREI×SHOGETSU during the spring rearing of 1997 in Syangja was 23.36% (SDD, 1998).

Good cocoon percent: As presented in Table 6, the good cocoon percent was the highest in N₁₀₇×N₁₁₂-Khopasi-2007 (98.65%) and N₁₀₇×N₁₁₂-Khopasi-2006 (98.66%) which were statistically the same as J₁₂×C₁₂-Khopasi-2007 (97.35%), N₁₀₈×N₁₁₂-Khopasi-2007 (97.06%), N₁₀₉×N₁₁₂-Khopasi-2007 (97.80%), J₁₂×C₁₂-Khopasi-2006 (97.36%), N₁₀₈×N₁₁₂-

Khopasi-2006 (97.07%), N₁₀₉×N₁₁₂-Khopasi-2006 (97.82%), J₁₂×C₁₂-Pokhara-2007 (91.39%), C₁₂×J₁₂-Pokhara-2007 (89.29%), N₁₀₇×N₁₁₂-Pokhara-2007 (94.52%), N₁₀₈×N₁₁₂-Pokhara-2007 (94.19%), N₁₀₉×N₁₁₂-Pokhara-2007 (92.62%), J₁₂×C₁₂-Pokhara-2006 (91.38%), C₁₂×J₁₂-Pokhara-2006 (92.57%), N₁₀₇×N₁₁₂-Pokhara-2006 (89.47%), N₁₀₈×N₁₁₂-Pokhara-2006 (94.32%), N₁₀₉×N₁₁₂-Pokhara-2006 (91.11%), J₁₂×C₁₂-Dhunibesi-2007 (91.23%), C₁₂×J₁₂-Dhunibesi-2007 (94.71%), N₁₀₇×N₁₁₂-Dhunibesi-2007 (95.71%), N₁₀₈×N₁₁₂-Dhunibesi-2007 (95.49%), N₁₀₉×N₁₁₂-Dhunibesi-2007 (96.20%), N₁₀₇×N₁₁₂-Dhunibesi-2006 (93.11%), N₁₀₈×N₁₁₂-Dhunibesi-2006 (94.30%) and N₁₀₉×N₁₁₂-Dhunibesi-2006 (96.76%). The lowest good cocoon percent was in C₁₂×J₁₂-Khopasi-2007 (71.14%) and C₁₂×J₁₂-Khopasi-2006 (71.15%). In support to the findings, the good cocoon percent of CHUL₁₂×THAI₁₂ (during the spring rearing of 1995 in Bhandara), SHUNREI×SHOGETSU (during the spring rearing of 1997 in Syangja) and A×K (during the autumn rearing of 1997 in Syangja) was 95.73, 98.65 and 97.52% respectively (SDD, 1998).

Table 6. Variations on mean shell and good cocoon percent of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Average shell percent (%)			Good cocoon percent (%)		
	Khopasi	Pokhara	Dhunibesi	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	22.62 d-g (4.76)	22.53 e-h (4.75)	22.55 e-h (4.75)	97.35 ab (9.87)	91.39 ab (9.56)	91.23 ab (9.55)
SWH ₂ × Y ₁	22.19 f-i (4.71)	22.67 d-g (4.76)	23.55 a-c (4.85)	71.14 c (8.39)	89.29 ab (9.45)	94.71 ab (9.73)
SWH ₃ × Y ₁	21.45 j-l (4.63)	22.30 f-i (4.72)	21.26 kl (4.61)	98.65 a (9.94)	94.52 ab (9.72)	95.71 ab (9.79)
SWH ₄ × Y ₁	20.91 l (4.57)	23.84 ab (4.88)	20.02 m (4.48)	97.06 ab (9.85)	94.19 ab (9.71)	95.49 ab (9.77)
SWH ₅ × Y ₁	22.00 g-j (4.69)	22.84 d-f (4.78)	21.03 l (4.59)	97.80 ab (9.89)	92.62 ab (9.62)	96.20 ab (9.81)
SWH ₁ × Y ₂	22.63 d-g (4.76)	21.89 h-k (4.68)	23.99 a (4.90)	97.36 ab (9.87)	91.38 ab (9.56)	88.86 b (9.43)
SWH ₂ × Y ₂	22.22 f-i (4.71)	21.88 h-k (4.68)	23.27 b-d (4.82)	71.15 c (8.39)	92.57 ab (9.62)	88.99 b (9.44)
SWH ₃ × Y ₂	21.46 j-l (4.64)	20.89 l (4.57)	22.65 d-g (4.76)	98.66 a (9.94)	89.47 ab (9.46)	93.11 ab (9.65)
SWH ₄ × Y ₂	20.93 l (4.57)	22.48 e-h (4.74)	23.08 c-e (4.80)	97.07 ab (9.85)	94.32 ab (9.71)	94.30 ab (9.71)
SWH ₅ × Y ₂	22.02 g-j (4.70)	21.72 i-k (4.66)	23.61 a-c (4.86)	97.82 ab (9.90)	91.11 ab (9.55)	96.76 ab (9.84)
F-value		7.76			0.41	
CV (%)		1.88 (0.93)			5.80 (3.21)	
LSD (0.05)		0.59			7.58	
SEm (±)		0.21			2.69	

Good cocoon productivity: The highest amount of good cocoons were harvested from N₁₀₈×N₁₁₂-Khopasi-2006 (26.57kg/box) followed by N₁₀₉×N₁₁₂-Khopasi-2006 (24.50kg/box). J₁₂×C₁₂-Khopasi-2006 (23.76kg/box) was in the second position and J₁₂×C₁₂-Khopasi-2007 (22.79kg/box), N₁₀₈×N₁₁₂-Khopasi-2007 (22.87kg/box), N₁₀₇×N₁₁₂-Khopasi-2006 (22.74kg/box) were in third position. The lowest good cocoon productivity (13.74kg/box) was observed in N₁₀₇×N₁₁₂-Dhunibesi-2006 (Table 7). Research conducted in Syangja during the 1996 rainy season on the silkworm hybrids; NDP×NB₄D₂, BDP×NB₄D₂, BDM×KA, BDM×T₂, BDP×CP, BDM×NDP, BDM×BDP, BDP×T₄FO, BDP×T₅SF, BDP×T₂ and BDP×T₃MO showed the cocoon yield as 25.11, 18.02, 18.80, 18.49, 25.52, 18.42, 19.44, 23.76, 20.38, 19.93 and 19.12kg/box, respectively (SDD, 1998).

Table 7. Variations on good cocoon productivity of bivoltine silkworm hybrids (SWH) with year and location interaction over two years under three ecological domains of Nepal

Interaction	Good cocoon productivity (kg/box)		
	Khopasi	Pokhara	Dhunibesi
SWH ₁ × Y ₁	22.79 c	18.76 ef	15.44 kl
SWH ₂ × Y ₁	21.27 d	19.26 e	15.79 j-l
SWH ₃ × Y ₁	21.25 d	19.29 e	16.39 i-k
SWH ₄ × Y ₁	22.87 c	17.88 f-h	15.38 kl
SWH ₅ × Y ₁	20.76 d	18.33 e-g	14.59 lm
SWH ₁ × Y ₂	23.76 bc	17.24 g-i	16.51 i-k
SWH ₂ × Y ₂	21.27 d	15.45 kl	16.16 i-k
SWH ₃ × Y ₂	22.74 c	16.98 h-j	13.74 m
SWH ₄ × Y ₂	26.57 a	14.87 lm	17.14 g-i
SWH ₅ × Y ₂	24.50 b	16.50 i-k	17.21 g-i
F-value		5.48	
CV (%)		4.29	
LSD (0.05)		1.13	
SEm (±)		0.40	

(Y₁: 2007; Y₂: 2006; SWH₁: J₁₂×C₁₂; SWH₂: C₁₂×J₁₂; SWH₃: N₁₀₇×N₁₁₂; SWH₄: N₁₀₈×N₁₁₂; SWH₅: N₁₀₉×N₁₁₂; means in each three-location columns followed by the same letters are not significantly different at $\alpha = 0.05$ by DMRT; figures in parenthesis are transformed values)

Based on mean EI and cumulative SF values (Table 8), over-all suitability of bivoltine silkworm hybrids ranked as most suitable three combinations were J₁₂×C₁₂ in Khopasi, N₁₀₉×N₁₁₂ in Khopasi and N₁₀₈×N₁₁₂ in Khopasi. Location-wise suitability of

bivoltine silkworm hybrids were $J_{12} \times C_{12}$, $N_{109} \times N_{112}$ and $N_{108} \times N_{112}$ for Khopasi, $J_{12} \times C_{12}$, $N_{108} \times N_{112}$ and $C_{12} \times J_{12}$ for Pokhara and $N_{109} \times N_{112}$, $C_{12} \times J_{12}$ and $N_{108} \times N_{112}$ for Dhunibesi conditions.

Table 8. Silkworm hybrids and location combination ranking for different yield related parameters based on mean EI and cumulative SF values

Silkworm hybrid × location combination	Mean EI	Cumulative SF	Overall ranking based on		Location specific ranking based on	
			Mean	Cumulative	Mean	Cumulative
			EI	SF	EI	SF
SWH ₁ × Khopasi	55.29	16.96	1	1	1	1
SWH ₂ × Khopasi	43.09	6.62	15	15	5	5
SWH ₃ × Khopasi	45.91	9.05	14	13	4	4
SWH ₄ × Khopasi	52.40	14.43	3	3	3	3
SWH ₅ × Khopasi	53.30	15.44	2	2	2	2
SWH ₁ × Pokhara	50.76	10.64	5	9	2	1
SWH ₂ × Pokhara	50.02	10.19	10	11	3	3
SWH ₃ × Pokhara	49.30	9.80	11	12	4	4
SWH ₄ × Pokhara	50.76	10.55	4	10	1	2
SWH ₅ × Pokhara	48.03	8.56	13	14	5	5
SWH ₁ × Dhunibesi	50.06	12.42	9	7	4	4
SWH ₂ × Dhunibesi	50.73	12.96	6	5	1	2
SWH ₃ × Dhunibesi	48.35	11.46	12	8	5	5
SWH ₄ × Dhunibesi	50.23	12.70	8	6	3	3
SWH ₅ × Dhunibesi	50.63	13.03	7	4	2	1

(EI: Evaluation Index; SF: Subordinate Function; SWH₁: $J_{12} \times C_{12}$; SWH₂: $C_{12} \times J_{12}$; SWH₃: $N_{107} \times N_{112}$; SWH₄: $N_{108} \times N_{112}$; SWH₅: $N_{109} \times N_{112}$)

Conclusion

The highest egg hatchability of $N_{108} \times N_{112}$ eggs during 2006 (99.69%), $C_{12} \times J_{12}$ eggs during 2006 and 2007 (98.83 and 98.81%), and $J_{12} \times C_{12}$ eggs during 2006 (98.67%) were in Khopasi. The number of cocoons per liter was 57 cocoons (the lowest) in $J_{12} \times C_{12}$ reared in Khopasi during 2006 and 2007. The average single cocoon weight was the highest in $N_{108} \times N_{112}$, reared in Khopasi during 2006 and 2007 (2.679 and 2.668g). $J_{12} \times C_{12}$, reared in Dhunibesi during 2006, had the highest average shell percent (23.99%). The highest amount of good cocoons (26.57kg/box) were harvested from $N_{108} \times N_{112}$ reared in Khopasi during 2006. Location wise, suitability of bivoltine silkworm hybrids were $J_{12} \times C_{12}$, $N_{109} \times N_{112}$ and $N_{108} \times N_{112}$ for Khopasi, $J_{12} \times C_{12}$, $N_{108} \times N_{112}$ and $C_{12} \times J_{12}$ for Pokhara and $N_{109} \times N_{112}$, $C_{12} \times J_{12}$ and $N_{108} \times N_{112}$ for Dhunibesi conditions.

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Contribution of Forest Resources to Rural Peoples' Livelihood in five VDCs of Morang District

Santosh Acharya

Vijay Memorial Higher Secondary School, Manmohan Memorial College and Schemes College, Kathmandu

Abstract: *This paper examines the use of natural resources named water (Riverbank product) forest products by the rural households. Using data from 200 households across five villages in the Morang district of Nepal, we estimate the gross and net income of major forest products and its share in total income of households. This study tries to analyze the contribution of natural resource income to household income, giving emphasis to the socio-economic characteristics. From the analysis of the benefits households get from forest products, it was found that the richer households are currently benefiting more in absolute terms than poorer households. In terms of dependency ratio, it was found that poorest were more dependent absolutely whereas they were less dependent relatively. Another analysis suggests that the income from forests is related to socio-economic characteristics and private resource endowments of households. It was found that households from disadvantaged group gain more from the forest products. Likewise, the distance from forest is the main determinant the benefit that the households get from forest products, while better educated households depend less on forest resources.*

Keywords: *Natural resources, forest products, common property resources, forest dependency, household income.*

Introduction

Poverty, a state of economic, social and psychological deprivation, is a global problem that affects the citizens around the world. About three in four poor people live in rural areas where they depend on natural resources for the livelihood (USAID, 2005). As a result, there is a direct relationship between poverty and natural resources. In fact, the dependency of rural poor on natural resources is more prominent than that of other people. Without a regular wage income, the rural poor often have no other choices than to depend on 'common pool resources' for food, firewood and medicine. They are basically involved in the activities such as collecting wild food, wood carving and collecting firewood and construction materials. Between 70 and 75 percent of poor people live in rural areas, where the poverty rate is around 30 percent globally (nearly 70 percent using the \$ 2 per day line); in contrast only 13 percent poor live in urban areas. Many of the rural poor are highly dependent on primary natural resources and ecosystem services (Millennium Ecosystem Assessment, 2004; World Resources Institute, 2005; cited in Lee and Neves, 2008). About 90 percent of them depend upon forest for at least some part of their income (USAID, 2005). Hence the poor derive a higher percentage of their income from natural resources.

The major natural resources available in Nepal are forest, water, land and minerals. A majority of the rural households heavily depends upon forest products to meet their daily requirements. Fuel wood is used for cooking and heating purposes, fodder and grass for the livestock, leaf litter for manure, and timber for constructing houses and for making agricultural implements (Chhetri, 2006). Water resource is mainly used for drinking, irrigation, fisheries, hydro-power, rafting and so on. Rural people use this resource for irrigation, drinking purpose and fisheries. Land resource is used mainly for cultivation.

Forest resources are considered the most important natural resources for people's livelihood and for the maintenance of ecological balance.

Statement of the problem

Loss of equity of forest resources to rural communities should be viewed in relation to the irreversible loss of forest resources in the environment. Both of them have serious threat to the lives and livelihood of millions of poor families. We should not forget to give more emphasis on environmental justice when we are considering the equity of resource distribution (Dahal, 2006).

In recent time, the issues of poverty reduction and equitable distribution of forest resources in Nepal have come into focus for a number of reasons. Rural poor households especially disadvantaged groups and marginalized people have less access today to forest products for subsistence use and income than they had before the community forestry intervention.

Different National and International organizations have given stress on the right of local and indigenous people to natural resources. Morang district has a sufficient Natural Resources: forest, water and land. Forest is the major natural resource found here. 24.5 percentage of the total land is covered by forest. Forest area distribution in per household is 1.07 hectare which is more than the national average (0.79 hectare) (MDG, 2006).

Water is another important resource. Medium as well as small rivers including *Bakraha, Gachhiya, Dans, Miklung, Chisang Khola* flows through this district. The rivers carry resources like sand, stone, and wood. They are also habitats for aquatic life. There are some households near the river bank that generate their livelihood by collecting stones, sand and woods.

During the period of political instability, between 2037 and 2046, many hectare of forest area has been destroyed for cultivation. In areas such as Ramailojhoda and Kaidalehoda deforestation has been acute (Dhakal, 2006). However, after the promulgation of Forestry Act, the forest has been considerably increased. In addition, the community forest development plan has increased people's participation in conservation. People are directly linked up with this resource. The rural people use firewood, tree fodder, timber and grass to fulfill their daily requirement. About 62.6

percent of the total population of this district use firewood for cooking purpose (MDG, 2006). The other major forest products are also equally used. As a result, there is dependency of rural population in Morang on natural resources.

All the VDC in Morang do not have equal access to the natural resource. Out of 65 VDC of the district, only 26 VDC have access to public forest resources. Similarly, out of 187601 households, only 24299 households have access to Common Property Resource (CPR) (forest) (District Profile, 2008). Different socio economic factors are responsible to determine the dependency of people on natural resources. This study has analyzed those factors and found the extent of dependency.

The study mainly focuses on the consumption of natural resource by the adjoining VDC. It attempts to find out the extent of dependency of the people on natural resources. The study also analyzes whether there is equitable distribution of forest products. It also determines the beneficiary groups among the rich, poor, high caste or lower caste groups. Particularly, it tries to find out–

1. socio-economic characteristics determine the dependency on natural resource?
2. Which classes of people get more benefit from natural resource?

Objectives

The study has following specific objectives:

- To examine and compare the share of income from natural resources in total income across classes.
- To examine dependency of the poor's on natural resources.

Study sites, methods and data collection

The study is based on both primary and secondary sources. The primary data were collected from structured questionnaire and interviews. It also uses data from the records of VDCs, DDC, Central Bureau of Statistics (CBS), National Planning Commission (NPC) and other different sources. In this study, multi-staged probability sampling technique was used. In the first stage, the district was selected purposively; in the second stage, stratified random sampling method was used. The entire VDC was divided into 5 strata on the basis of geographical location, socio-economic condition and natural resources available in the DDC. One VDC was selected from each strata following the random sampling method. So, in the second stage, stratified random sampling technique was used to select VDCs. The selected VDC were Ramitekhola, Madhumalla, Urlabari, Dulari and Hattimuda.

The third stage was the selection of wards in each VDC. Both systematic and purposive sampling techniques were used in the selection of wards. Each VDC consists of nine wards. Three wards were selected from each VDC. In order to use systematic sampling method, we assigned the ward by number in a sheet of paper.

These sheets were then folded and kept in a bowl and one piece was selected randomly. Thus, the first ward was number two. Then other two wards were selected after adding number 3 to each one, i.e. $2+3=5$ and $5+3=8$. Moreover, 5 wards were selected according to the purposive sampling technique based on the availability of natural resources like forest and water resources near by the wards.

The fourth stage was the selection of households. For the selection of the households, first of all the total number of households of the selected wards was determined. Then the sample size for each ward was determined according to the number of households. Then the households were selected by using systematic sampling technique as explained above. If the information couldn't be collected from the selected households, one of the three households next to it was selected.

Calculation of household benefits from forest product: Household benefits from community forests were assessed by valuing the goods collected and harvested from forests. The economic values of different forest products such as firewood, timber, fodder, grass, leaf litter, medicinal herbs and plants and some other direct and tangible benefits by the user households were estimated. Despite the fact that there are many potential forest products, only firewood, timber and fodder, and leaf litter significantly contribute to the household economy. Non-timber forest products (NTFPs) seem to contribute to either households' or forest user groups' income. The following procedure was adopted to value the household-level income from forest.

a. Calculation of gross income of forest products

Gross income is calculated by multiplying the quantity of forest product harvested by the price of the product minus the cost of hired labor, direct cash payment to Forest User Groups (FUGs) as monthly membership fee, etc. Since the amount of forest products collected varies with the seasons (due to climate changes, user group regulations, and seasonal agriculture work), information was collected for 12 consecutive months. The market price, barter method, and opportunity cost approach were used in valuing forest products. Firewood consumed at home or exchanged with kins was valued at retail purchasing price in the village at the forest-gate price (Gunatilake, 1998). Non-marketed NTFPs, trees and fodder were valued by the barter game method (Godoy *et al.*, 1993; Richards *et al.*, 1999). Leaf litter was valued based on the labour cost of time spent in collecting and transporting a *bhari* (load) of leaf litter from Community Forest (CF). This cost information was obtained during the group discussion with key informants. Since village wage rates vary with season, the average wage rate throughout the year was used. Differences in wage rates among villages were also considered since wage rates were not identical for all the study sites. Care was taken to avoid unrealistic estimation because the accuracy of recall information drops when people are asked to remember events in the distant past (Bernard *et al.*, 1984).

b. Calculation of net income

The forest net income refers to revenue less cash and imputed costs of labor as well as the cost of equipment and their depreciation costs (Wollenberg and Nawir, 1999). So the cost here includes labor cost of time directly spent while finding, extracting, processing and transporting forest goods from the forest to the village as well as the cost of tools and equipment (including depreciation) and the transaction costs incurred by households.

Three broad types of transaction costs were considered—costs of decision-making (TCD), costs to implement those decisions (TCI), and costs of monitoring (TCM) the implemented decisions. The TCD refers to costs incurred during the process of acquiring information about forest and community, and the costs of co-ordinating the activities such as identification of potential users, preparation of forest management plan, and negotiating with the Forest Department. These costs are mainly the time spent for community meetings, conflict resolution, and so on. TCI includes costs incurred for obligatory activities such as thinning, pruning, fire protection, and forest road repair and maintenance, etc., in order to comply with the management decisions. TCM refers to those costs incurred for monitoring and enforcement of agreed-upon rules, record-keeping, and maintaining minutes, financial monitoring of FUGs, and other monitoring-related activities. Transaction costs, therefore, were measured in terms of labour opportunity costs of time spent in these community activities.

Dependency on natural resource: This study analyzes "dependency" on the basis of household characteristics. This study has measured dependency on natural resources in three categories:

Gross absolute dependency (GAD): Gross Absolute Dependency (GAD), as indicated by the names does not consider the cost of collection. GAD has been calculated by using the following formula.

$$\text{Gross Absolute Dependency (GAD)} = \frac{\text{Gross Natural Resource Income}}{\text{Total Income}}$$

Net absolute dependency (NAD): Net Absolute Dependency (NAD) has been calculated by using the following formula

$$\text{Net Absolute Dependency (NAD)} = \frac{\text{Net Natural Resource Income}}{\text{Total Income}}$$

Relative dependency: Relative dependency is the ratio of natural resource income to the total income of household. Since absolute dependency has been measured in terms of gross and net income, the relative dependency has also been measured in terms of Gross Relative Dependency (GRD) and Net Relative Dependency (NRD) with the same token.

$$\text{Gross Relative Dependency (GRD)} = \frac{\text{Gross Natural Resource Income}}{\text{Gross Natural Resource Income} + \text{Total Income}}$$

Values of GRD lie between 0 and 1. If the value of GRD is higher, higher will be the dependency. For the ease of analysis, GRD has been categorized into four groups, viz. Very low if GRD value lies between 0-0.25, Low if GRD value lies between 0.25-0.5, High if GRD value lies between 0.5-0.75 and Very high if GRD value lies between 0.75-1.00. Similarly, the net relative dependency is given by,

Expected Wage Forgone = wage rate * time * probability of getting job

$$\text{Probability of getting job} = \frac{\text{Total days' worked}}{300}$$

In general, in our country we spend more than two months for festival and cultural ceremonies. Therefore, we have deducted 65 from 365 days to obtain the number 300.

Results and discussion

Forest products harvested by caste/ethnic groups: Table 1 shows the major forest products harvested by different caste and ethnic groups. The majority of rural people used fuel wood for cooking meals. According to Nepal Living Standard Survey (NLSS) 2003/04, eighty four percent of households use firewood for cooking. In our study, out of total, 67.5 percent households use firewood for cooking. Similarly, in an average 75 percent households collect fodder nationally (ibid). But in our study only 33.5 percent households were found collecting fodder.

Table 1. Forest products harvested by caste/ethnic groups

Forest Products	Advantaged		Disadvantaged		Dalits and other		Total	
	Total Qty.	Average	Total Qty.	Average	Total Qty.	Average	Total Qty.	Average
Fuel wood (Head Load*)	3913	52.87	11420	118.95	1452	48.4	16785	83.92
Tree Fodder (Head Load**)	1978	26.52	10479	109.15	1104	36.8	13561	67.8
Grass (Head Load***)	4540	61.35	641	6.67	280	9.33	5461	27.3
Sal and Non-Sal Timber (Cubic Feet)	78	1.05	76	0.79	20	0.66	174	0.87

Source: Field Survey, 2010.

Number of Households *One Head Load equivalent 40 to 50 Kg for fuel wood **One Head Load equivalent 25 to 30 Kg for tree fodder ***One Head Load equivalent 20 to 25 Kg for grass

Table 1 shows that per household harvesting of fuel wood is higher for *disadvantaged group* of households (118.95 head load) followed by the *advantaged group* (52.87) and *Dalits* (48.4) respectively. Similarly, per household harvesting of tree fodder is higher for the *disadvantaged group* of household (109.15) followed by *Dalits*

(36.8), and the *advantaged group* (26.52) respectively. Likewise, per household harvesting of green grass is higher for *advantaged group* households (61.35) followed by *Dalits* (9.33) and the *disadvantaged group* households (6.67) respectively. This means that different forest products harvested or obtained are not positively related to caste/ethnic groups (high and low caste/ethnic groups). Instead, it may be positively related with the degree of household wealth endowment (agricultural land and livestock ownership) rather than the degree of caste/ethnic groups. Because *Dalits* households are harvesting more of those forest products that have less importance in agricultural farming, i.e. fuel wood, because they have no sufficient agricultural land and livestock holding. The other possible reason is that Ramitekhola VDC has sufficient natural resources of its own. Similarly, this VDC also has a larger population of disadvantaged groups.

Distribution of household level forest products income by caste/ethnic groups: On an average, compared to other forest products, the share of firewood product per household is higher for all the households followed by tree fodder, green grass, and timber. Most households use fodder products after firewood followed by green grass. The Table 2 shows the share of gross and per household monetary value of different forest products use by different caste groups within five VDCs.

Table 2. Caste wise distribution of gross income from forest products

Caste/ Ethnic Group	Number of Household	Total Gross Income in NRs.	Average Gross Income NRs.
Advantaged	74	1280700	17306.76
	37%	29.87%	
Disadvantaged	96	2626830	27362.81
	48%	61.27%	
Dalits	30	379540	12651.33
	15%	8.53%	
Average/Total	200	4287070	21435.35
	100%	100%	

Source: Field Survey, 2010

Altogether, four forest products from Community/Private/State Forests have been used by four VDCs. The total and per household quantity and monetary values of benefits (gross value) are separately calculated from different forests: Community, State and Private.

Table 2 illustrates the product types and the share of monetary value of the benefits per household for each caste/ ethnic group. On an average, the total forest income distribution from the major forest products is higher for households of disadvantaged group at Rs. 27362.81 which is greater than the average gross value income for 200 households which stands at Rs. 21435. Dalits and advantaged group's gross value income from forest product is less than the average income of sampled

households. For the Dalit group, the average income is Rs. 12651.33, whereas for the advantaged group the average income is Rs. 17306.

Distribution of household level of forest products gross income by expenditure quintile group: On an average, compared to other forest products, the share of firewood product per household is higher for all the households followed by tree fodder, green grass, and timber. Most households use fodder products after firewood followed by green grass. The table 3 shows in detail the share of gross and per household monetary value of different forest products used by various expenditure quintile groups within five VDCs.

Table 3. Expenditure quintile wise distribution of gross income from forest products

Expenditure Quintile	Number of HH	Total Gross Income NRs.	Average Gross Income NRs.
Poorest	40 (20%)	708250 (16.52%)	17706.25
Second Quintile	40 (20%)	759860 (17.72%)	18996.5
Third Quintile	40 (20%)	1004980 (23.44%)	25124.5
Fourth Quintile	40 (20%)	878860 (20.50%)	21971.5
Richest	40 (20%)	935120 (21.81%)	23378
Total/Average	200 (100%)	4287070 (100%)	21435.35

Source: Field Survey, 2010

In terms of the total gross income from forest products, the largest share of NRs. 1004980 (23.44%) goes to the third quintile with the average income of Rs. 25124.5; whereas the smallest share of NRs. 708250 (16.52%) goes to the poorest families with average per household income of Rs. 17706.25. This table shows that the gross income of forest product is increasing for the richest group of Households (HH). The possible reason for this is that the richest families hold more land, livestock and they own private land so they have consumed more forest products than other households.

Natural resource income distribution for socio-economic heterogeneity: The following table (Table 4) shows the mean gross and net income distribution by different variables. This has significant relationship between the use of natural resources and these variables.

Table 4. Gross and net natural resource mean income by gender of HH

Sex	Gross Forest Resource Income NRs.	Net Forest Resource Income NRs.	Total + Gross NRI NRs.	Total + Net NRI NRs
Male	20140.78	9686.214	187802.5	177348
Female	22810	11028.66	180698.4	168917.1
Total/Average	21435.35	10337.3	184357	173259

Source: Field Survey, 2010

In term of gender, it is noteworthy that the households headed by male members benefit more from CF than those headed by females (Adhikari, 2006). Amacher *et al.* (1993) also observed that women are not the sole collectors of fuel wood. This observation is not similar to our study. But similar to Dahal (2006) who accepts women generally have high level of involvement in the entire forestry activities. The lack of alternative sources of income, households with women as the heads are more dependent on CF and hence they try to derive more income from CF than the households with males as the head. Males have alternative works and hence they need not to be limited to community forests for income. Moreover, men may not get involved to extract forest products due to the domestic financial responsibilities and other socio-political obligation. Our study found that Natural resource income is higher for household with females as heads while the total income is higher for household with males as head. The possible reason is that female-headed households find it difficult to get jobs and other source of income because of which they are dependent on the natural resource. However, there is no statistical evidence to conclude that female-headed households make more income from natural resource than male headed household (Amacher *et al.* 1993; Adhikari, 2006). While Adhikari's and Amacher's researches were conducted in community forest, our research is not only focused on community forest. Hence, the explanation of the contrary finding.

Table 5. Gross and net natural resource and mean income in terms of level of education of HH

Education of HH head	Gross Forest Resource Income (NRs.)	Net Forest Resource Income (NRs.)	Total + Gross NRI (NRs.)	Total + Net NRI (NRs.)
Illiterate	17330.56	9293.333	133738.9	125701.7
Literate	25265.09	10515.8	197411.9	182662.6
Under SLC	21050	12121.04	182080.2	173151.3
Intermediate	15595.67	10744	200387.3	195535.7
Bachelors	4000	1666.667	248166.7	245833.3
Masters	0	0	5100	5100
Total	21435.35	10337.3	184357	173259

Source: Field Survey, 2010

Table 5 shows that education is negatively and significantly related to forest income as the better educated households may have better earning opportunities outside the village commons and forest extraction activities may be less attractive for those households. This finding is similar to that of Gunatilake (1998) and Adhikari (2006).

Table 6. Gross and net natural resource and mean income in terms of the occupation of household head

Occupation of HH Head	Gross Forest Resource Income (NRs.)	Net Forest Resource Income (NRs.)	Total + Gross NRI (NRs.)	Total + Net NRI (NRs.)
None	23286.67	14553.33	187703.3	178970
Agriculture	27343.65	12661.76	208003.5	193321.6
Business	9709.375	7224.375	219693.8	217208.8
Public Service	16006.84	12748.95	202567.4	199309.5
Private Service	8969.231	7830.769	129573.1	128434.6
Wage Labor	19928.42	5630.658	104217.9	89920.13
Foreign Employment	15850	6343.75	257245.8	247739.6
Total	21197.32	10324.55	184805.1	173932.3

Source: Field Survey, 2010

Table 6 shows the Gross Natural Resource and Net Natural resource income, which is highest for the households that have adopted agriculture than those that are engaged in other professions.

This means that the gross and net natural resource income of forest products distribution is not equal because agriculture needs to have more forests products than other professions. Similarly, other possible reason is that in our study areas, the main occupation is agriculture. People who have adopted Agriculture as the main occupation tend to harvest more forest products than people with other occupations.

Table 7. Gross and net natural resource and mean income by distance to the nearest marketplace

Market Distance	Gross Forest Resource Income (NRs.)	Net Forest Resource Income (NRs.)	Total + Gross NRI (NRs.)	Total + Net NRI (NRs.)
Less than 3 KM	19816.59	10080.21	172807.4	163071
More than 3 KM	30608.33	11794.17	249805	230990.8
Total/Average	21435.35	10337.3	184357	173259

Source: Field Survey, 2010

Table 7 shows that the natural resource income increases with the increase in the distance to the market. This finding is similar to the Gunatilake (1998) who conducted their research in Sinharja forest of Srilanka and Adhikari (2006). The main reason behind it is that when the market centre is near, people find it easy to get a job. Furthermore, people sell their vegetables and other agriculture products to the market. The income thus obtained tends to be significantly higher than the income generated from natural resources. There is statistical evidence that the gross natural

resource income is significantly higher if the distance is more than three kilometers and less if it is less than three kilometer (t value -2.81).

Table 8. Gross and net natural resource and mean income by VDC*

VDC	Gross Forest Resource Income (NRs.)	Net Forest Resource Income (NRs.)	Total + Gross NRI (NRs.)	Total + Net NRI (NRs.)
Ramitekhola	30608.33	11794.17	249805	230990.8
Madhumalla	28841.56	7147.111	146397.1	124702.7
Urlabari	21334.44	10638.89	231702.2	221006.7
Dulari	18476.25	13535.38	189343.4	184402.5
Hattimuda	9296.25	9296.25	119726.3	119726.3
Total	21435.35	10337.3	184357	173259

Source: Field Survey, 2010

Table 8 shows that the distribution of gross income from forest products per household is higher in Ramitekhola VDC (Rs. 30608.33) followed by the Madhumalla VDC (Rs. 28841), Urlabari (Rs. 21344.44), Dulari (Rs. 18476.25) and Hattimuda (Rs. 9296.25) respectively.

This means that the gross and net income obtained from various forest products is not equal because Ramitekhola, Madhmalla and Urlabari VDCs have sufficient natural resource than others two VDCs. In Ramitekhola VDC, more than 90 percent of households are disadvantaged groups and their main occupation is agriculture and husbandry. Similarly, Hattimuda VDC is near to the District Headquarter so people from this VDC get other forms of employment than in other VDC. Likewise, in Hattimuda VDC, more than 75 percent households are Teraibasi and they use Guitha (dry cow dung) and (Facewa) for cooking. In our study, 60 percent of the sampled population in Hattimuda VDC use Guitha (dried cow dung) for cooking. Similarly, 7.5 percent use biogas and 20 percent use Facewa (wastage product of Jute mill) for cooking.

Dependency on natural (forest) resource distribution of household level forest gross income: Dependency on forests refers to contribution of natural resource to the livelihood as well as the fulfillment of subsistence needs of the local users of HH. The literature on poverty and the environmental/natural resources offers several disputed theories and hypotheses (agent hypotheses and victim hypotheses) about the linkages between poverty and environmental/natural resources. Under the agent hypotheses, poverty was seen to be a crucial cause of environmental degradation as the poor communities were forced to over-cultivate soil, or deforest in order to survive. According to the victim hypotheses, poor people are directly dependent on biological resources for their livelihood than richer people. The loss of flora and fauna is thus relatively more costly to the poor. Furthermore, poor people often are compelled to settle close to these resources commonly found in the open access areas.

Some scholars have hypothesized that compared to the non-poor, the poor may depend more on the commons in relative terms but in absolute terms, their dependency is lower (Dasgupta, 1993). While the poor may attempt to minimize the risk by using forest resources to mitigate shortfalls in consumption levels, the rich or the less poor may be interested in enhancing their earnings by selling these resources, particularly, when there are good market opportunities. There appears to be a consensus that poorer HH are more dependent on CPRs and consequently derive higher income from common (forest) resources. Thus, attacking poverty in rural areas is then necessarily a matter of improving poor people's ability to derive sustenance and income from more productively and sustainably managed natural resources. Due to the exhaustible and/or degradable characteristics of the forest resource, however, although a renewable resource, it is declining due to overexploitation. Therefore, it requires improved management techniques for resource users who continue to grow in both numbers and consumptive habits. Efforts to improve the management of natural resources, however, often focus narrowly on the technical characteristics of the exploitation or conservation of the resources while giving short shrift to the social and institutional structures that are needed to manage those resources in a more sustainable and equitable manner.

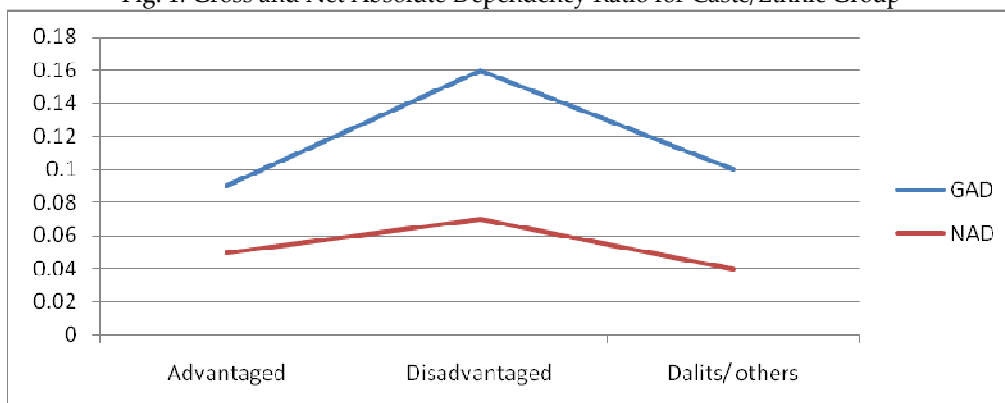
Absolute dependency on forests in terms of caste/ethnic and expenditure quintile: Absolute dependence on forest refers to the absolute contribution of forests to household income or gross income derived by HHs from forest. Those caste/ethnic or income groups of HHs, whose total contribution of gross forest products to the total household income is higher, are considered more dependent, in absolute terms. Similarly, those caste/ethnic or income groups of HH whose total contribution of gross CF income to total household income is lower, they are considered less dependent, in absolute terms, on community forests.

Based on empirical data summarized in Tables, the total gross and per household income were estimated to analyze the absolute dependency on forest of HH of different caste/ethnic groups. Those HHs of caste/ethnic groups whose total contribution of gross forest income to total household income is higher, they are considered to be more dependent, in absolute terms, whereas they are considered to be less dependent on the same if the condition mentioned above is lower.

Gross and net absolute dependency ratio for different caste/ethnic group: Fig. 1 shows the gross and net absolute dependency ratio for different caste/ethnic group.

The figures show that the disadvantaged group of households are being more dependent on forest products in absolute term than the advantaged and *Dalits* households.

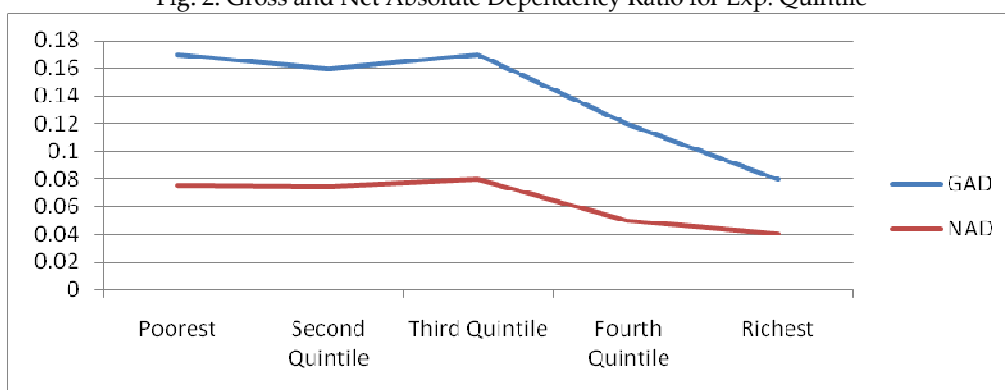
Fig. 1. Gross and Net Absolute Dependency Ratio for Caste/Ethnic Group



Source: Field Survey 2010

Gross and net absolute dependency ratio for different expenditure quintile: Fig. 2 shows the gross and net absolute dependency ratio for different expenditure quintiles. Fig. 2 shows the GAD is equal for the poorest and third expenditure-quintile group of households. It shows the Anti U shaped curve. This result is similar to Adhikari (2006) and Dahal (2006).

Fig. 2. Gross and Net Absolute Dependency Ratio for Exp. Quintile



Source: Field Survey 2010

The Figures shows that the richest people depend less on forest products than the poorest group of households in absolute term. It also shows the middle groups of households more dependent on forest.

Expenditure quintile wise relative gross dependency ratio: The table above shows the gross dependency ratio of the forest product income to the total income. The mean gross dependency ratio for our sampled household is 0.17003. In the same manner, its range for maximum and minimum is 0.897 and 0.00 respectively. For the analysis of dependency ratio, Table 9 shows the distribution of gross dependency ratio for different Expenditure quintile group of households.

Table 9. Expenditure quintile wise relative gross dependency ratio

Expenditure Quintile	Dependency Ratio				Average Dependency Ratio
	Up to 0.25	0.25-0.5	0.5-0.75	0.75-1	
Poorest	31	7	2	-	0.15
Second Quintile	33	5	2	-	0.19
Third Quintile	30	4	4	2	0.13
Fourth Quintile	32	6	2	-	0.17
Richest	37	-	1	2	0.15
Total	163	22	11	4	0.17

Source: Field Survey, 2010

Table 9 shows that most of the households have very low gross dependency ratio, while only 2-2 households, the third and the richest group, have very high dependency ratio. Almost equal number of households of all expenditure quintiles has low and high dependency ratio. The possible reason is that a few people who are proletariat highly depend on natural resources and a large numbers of people in the rural areas go for the foreign employment that may have caused the decreasing dependency ratio.

Caste wise relative gross dependency ratio: The table shows the relative dependency ratio for different caste/ethnic group.

Table 10. Caste wise relative gross dependency ratio

Caste/Ethnic Group	Dependency Ratio				Average Dependency Ratio
	Up to 0.25	0.25-0.5	0.5-0.75	0.75-1	
Advantaged	62 (83.78%)	5	5	2	0.15
Disadvantaged	75 (78.12%)	13	6	2	0.19
Dalits and other	26 (86.66%)	4	-	-	0.13
Total	163 (81.5%)	22	11	4	0.17

Source: Field Survey, 2010

Table 10 shows the low average dependency ratio for the *Dalit* group. A very low dependency ratio remains for all caste/ethnic groups. The number of households with low, high and very high dependency ratio of all caste/ethnic groups has smaller number. The possible reason is that a few people depend on natural resources who are proletariat. A large numbers of people in the rural areas go for the foreign employment that may have caused the decreasing dependency ratio.

Expenditure quintile wise relative net dependency ratio: Table 11 shows the relative dependency ratio for different caste/ethnic group.

Table 11. Expenditure quintile wise relative net dependency ratio

Expenditure Quintile	Dependency Ratio					Average
	Negative Dep. Ratio	0-0.25	0.25-0.5	0.5-0.75	0.75 and Above	
Poorest	6	32	1	1	-	0.09
Second Quintile	5	32	3	-	-	0.08
Third Quintile	2	31	4	1	2	0.17
Fourth Quintile	3	32	5	-	-	-0.01
Richest	2	35	2	1	-	0.09
Total	18 (9%)	162 (81%)	15 (7.5%)	3 (1.5%)	2 (1%)	0.08

Source: Field Survey, 2010

Out of total sampled HHs, the net dependency ratio of a percent HHs is negative. The net dependency ratio of most of the HHs (81 percent) is very low; these HHs distribution moreover equal all quintiles. Only 2 Households of third quintile group's dependency ratio is very high. Average dependency ratio for all quintiles is almost the same while the average net dependency ratio of the fourth quintile is negative.

Caste wise relative net dependency ratio: The table shows the relative dependency ratio for different caste / ethnic group.

Table 12. Caste wise relative net dependency ratio

Caste/Ethnic Group	Dependency Ratio of Households in percentage					Average	Total HH
	Negative Dep. Ratio	0-0.25	0.25-0.5	0.5-0.75	0.75 and Above		
Advantaged	8.10	82.43	5.4	2.7	1.3	0.05	74
Disadvantaged	7.29	79.16	11.1	1.0	1.0	0.12	96
Dalit & other	16.66	83.33	-	-	-	0.04	30

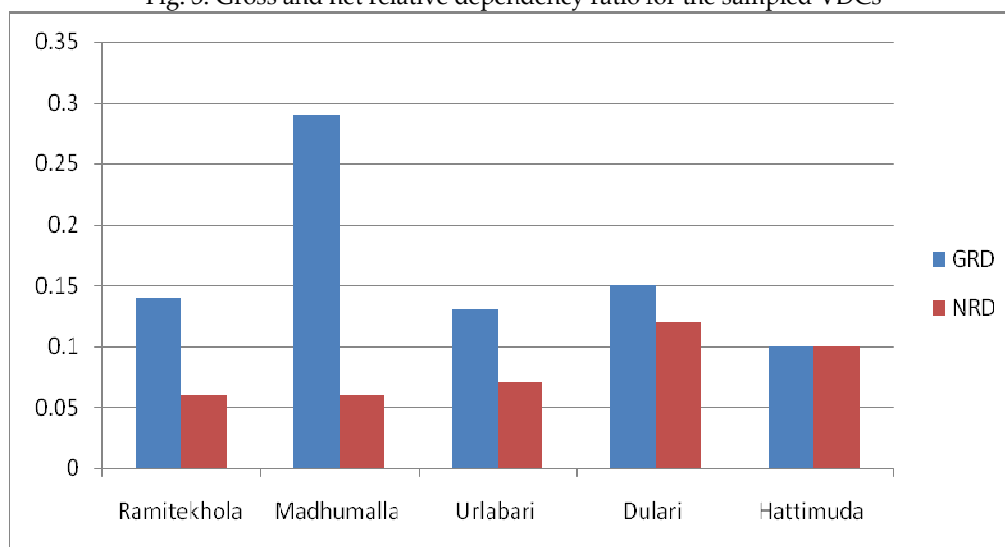
Source: Field Survey 2010

Table 12 shows that the net dependency ratio is very low for all caste and ethnic groups. Few households have very high dependency ratio.

Mean gross and net relative dependency ratio for the sampled VDC's: Figure 3 clearly shows that the Gross Relative Dependency Ratio is high for Madhumalla VDC, while the lowest is for Ramitekhola. Similarly, the Net Dependency Ratio is high for Dulari and low for Ramitekhola. Gross relative dependency ratio (GRD) and net relative dependency ratio (NRD) are equal for Hattimuda VDC. It is because Hattimuda and Dulari VDCs do not have community/state forest and the HHs get the supply of natural resources from their private forests. Transaction and other types of cost are not

included in the collection for private forest products. This fact also corroborates with Acharya (2010).

Fig. 3. Gross and net relative dependency ratio for the sampled VDCs



Source: Field Survey 2010

Conclusion and major findings of the study

This research compares the income from forest that the poor and non-poor households accrue. The results clearly shows the differences in gross income derived by households among different income classes. Poorer households of the communities obtain much less value from forests than the second, third, fourth and richer quintile households. The average 'poor' household obtains Rs. 17706.25 from forest annually, while the richer households obtain in average Rs. 23378 per year from the forest.

In terms of relative dependency, the study results are quite contrary to the previous findings. If the gross CPR income is considered as a percentage of household income, the results suggest that the wealthier households are more dependent on CPRs than poorer households. This finding is different from other studies such as Gunatilake *et al.* (1993), Cavendish (1998, 1999), who find that in relative terms the poor are the most dependent on forests resources. In addition, the findings of Adhikari (2003) and Dahal (2006) are similar with my present thesis. This relationship between CPR income and household income can be attributed to easier access to intermediate forest products, which benefit the wealthier households.

Another interesting result from this study is the distributional significance while comparing the gross income from the forest. A straightforward comparison of gross income shows that the third quintile of households gain the most from the forest, the fifth, fourth, and second quintile group gain less than the third quintile. Moreover, the

poorest households gain the least. However, when the net income from the forest across these income categories is compared, then an interesting inverted U shaped relationship emerges. In terms of the net income (taking all costs into consideration), the poorest, on average, obtain 7.65 percent of total household income from forest, second quintile households obtain 7.39 percent, third quintile households obtain 8.03 percent, fourth quintile households obtain 5.88 percent and, the richest households obtain 4.22 percent of their total income from forests. It seems that the relative dependency on forest resources declines as the income increases. This study, however, uses cross sectional data and categorical data on income. Therefore, a strong conclusion on this aspect is not warranted.

Regarding the testing of dependency ratio of people on forest products for income, to what extent forest products income had been contributing to the household level welfare (income) to the different caste/ethnic and income groups of households, the results clearly showed differences in the amount of forest products harvested and gross income derived by the different caste/ethnic groups. Another interesting result from this study is the distributional significance that emerges while comparing net and gross income from community forests. A straightforward comparison of gross income showed that the *Dalits* households had lower gross value/income from forest as a percentage of total income than other caste/ethnic groups.

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Food Belief in Pregnancy and Lactation

Manodhara Shakya

Department of Home Science and Women's Studies, Padma Kanya Campus, Tribhuvan University

Abstract: *Many studies point out that a large number of women are in poor health condition due to malnourishments, particularly during pregnancies and lactation period. Diet and nourishments depend on food practices which are often guided by food beliefs. Some beliefs are suitable nutritionally; some are adverse to nutritional concepts. In Nepal, particularly in villages, there are many food beliefs; however they are neither well-recorded nor analyzed from nutritional point of view. A case study of Futung Village Development Committee (VDC) in Kathmandu valley was undertaken with the objectives of exploring and interpreting different food and health beliefs that have implications on maternal health, and to analyse the nutritional aspects. This article lists some of the findings from the study and their analysis. It was found that the village women held popular notions such as "tagatilo khana", curative food, virtuous or pure food, polluted food, and harmful foods. Nutritional analysis of some of the widely held beliefs such as "green leafy vegetables and citrus foods cause cold and are harmful" can cause deprivation of important source of vitamins and minerals. The customary practice of "dahichiura khuwane", on the other hand, not only provides nutrition but also highlights the importance of nutrition socially with the family and friends supporting pregnant women. There is therefore a scope and need for analyzing food beliefs and practices to maximize their benefits nutritionally and socially.*

Keywords: *Food belief, diet, nutrition, pregnancy, lactation, maternal health, women and food.*

Introduction

Maternal diet is an important determinant of mother and child health and of child's well being. A well nourished and healthy mother gives birth to a healthy child and also ensures healthy upbringing. Malnutrition during pregnancy and its consequences maximally affect the health and outcome of the population. Many studies have shown that the food taken by a large section of pregnant women in Nepal is deficient in caloric content, protein and other micro nutrients—a leading cause of maternal and child morbidity and mortality. The Demographic health survey in 2011 shows that 12% of all children born in Nepal have a less than average birth weight.

Nepal is committed to the Millennium Development Goal to ensure the good health for all. However the conditions discussed above show that it is rather very challenging. Apparently the challenges are not only due to lack of food, but because of the lack of appropriate knowledge and practices regarding food, particularly during pregnancy and lactation period. Many studies point out that ignorance about nutritional needs for women, particularly during pregnancies and lactation, is the reason behind the poor health conditions of women in Nepal. This leads to the questions as to how informed are women of reproductive age in the villages regarding food needs during pregnancy and lactation? What are their food beliefs? What can be

the implication of such beliefs regarding nutrition? This study has been conceived with these questions in mind.

There are many food beliefs relating to pregnancy, lactation and child rearing. For example "*chaku* and *gheu*" are considered important food items for lactating mothers where as "*ghoti*" and "*chauthi*" are important items for infants. Green leafy vegetables are believed to cause health problems and therefore are items to be avoided during the lactating period, particularly in the first two months. In some communities of Nepal, it is believed that sour food, citrus fruits, hot and spicy foods or other nutritious food including eggs, meat should not be given to a pregnant woman because they can harm the health of both mother and the unborn child.

Seemingly, many of the beliefs have valid nutritional basis but many contradict modern understandings regarding food and nutrition. There has hardly been any study that lists the beliefs and explores their implications. Furthermore, there is scope for analysing the concepts behind such food beliefs to understand the possible implications of food beliefs in terms of physical health, culture/customs and social values.

Objectives

The study was conducted with the objectives of exploring different food beliefs related to pregnancy and lactation and to analyse them from a nutritional perspective. Specifically the study–

- explores different food beliefs related to pregnancy and lactation;
- delineates conceptual bases of the food beliefs;
- analyses the food beliefs from nutritional point of view; and
- analyses the factors that influence the beliefs.

Methods

The study is descriptive and exploratory in nature. It is based on a study of related literature as well as a field study in Futung Village Development Committee in the northern part of Kathmandu valley. The study of literature focused more on factors and underlying concepts of food belief to develop a conceptual framework. The field study attempted to get a cross section of the food beliefs in pregnancy and lactation and its underlying concepts in the village. An attempt has been made to analyze the underlying concepts and to come out with practical recommendations.

In the field study, key agencies such as the VDC office, health post and local leaders as well as social mobilizers were contacted for general information. Women of reproductive age group (15-49 years) were the main respondents from 60 selected households out of about 600 (537 according to the health post) households in the VDC. The households were selected purposively ensuring representation of the different major communities in the village namely, Chhetris (51%), Newars (22%), Brahmins

(12), Occupational castes (13), and others (2). About 47% of the respondents were literate, 14% had passed the school leaving certificate (SLC) examination. The majority (40%) of the respondents were in the agriculture profession followed by the service sector (20%), the rest worked as daily wage laborers, small shop keepers and housewives.

Field observation, interviews with the respondents from the selected village, and other resource persons constituted the primary source of information. Secondary information/data were collected from many sources including the VDC, Health Post, Schools etc.

Literature review

A balanced and adequate diet is highly important during pregnancy and lactation because of the increased needs for the mother to prevent *nutritional stress* in meeting the requirements of self recovery as well as the nourishment of the child. However, some studies show that pregnant and lactating women in some societies are forced to abstain from nutritious foods because of their traditional food beliefs. Women from many cultures throughout the world practice some sort of food avoidance after childbirth for various reasons (Fishman *et al.*, 1988; Mahrnood *et al.*, 1997; Santos-Torres & Vasques-Garibay, 2003; Koon *et al.*, 2005). The underlying explanation is that birth is a moment of extreme vulnerability accompanied by excessive loss of blood during the delivery. The mother should follow certain precautions which prohibit or encourage the consumption of certain foods to restore the mother to good health and to aid the flow of breast milk. Bronner (2000) mentioned that many cultures observe taboos during pregnancy which limit the intake of certain foods, thinking them to have an impact on the baby's temperament or appearance. The belief that certain foods will mark the baby is also popular. The belief that black eyed peas cause black spots and strawberries cause red spots etc. are some examples.

Some studies have been undertaken in Nepal listing food proscription, prescriptions and beliefs relating to pregnancy and lactation. A study done by Colburn and Pradhan (1990) had reported that cultural proscriptions and regulation in Nepal are widely affecting women's food intake during the crucial periods of pregnancy and lactation. Studies point to various beliefs behind prescriptions and proscriptions. For example, fish was avoided because people believed that the woman would have many children like a fish. Eggs were avoided because it was believed to cause skin infections in children. Earlier, Shrestha (1981) had reported that some communities in Baitadi district believed that by eating fish a pregnant woman develops problem in the eyes and skin of the child; the child may be born blind or develop an eye trouble later. They also believed that eating oily foods and citrus foods could result in eye and ear problems for the baby. According to Shrestha (2002), white

pumpkin was strictly restricted during pregnancy. Some in Khokana VDC of Lalitpur district believed that it could cause miscarriage. Similarly, green vegetables, pulses, fruits, as well as spicy foods were restricted during the lactation period because such foods were believed to cause several defects in the child's physiology. Gongal, *et al.* (1994) reported that Tharu women in Lumbini Zone believed that if they do not refrain from eating grain during the first week after the delivery, the gods/spirits will be angry and cause the milk dry up, causing illness, even death of the baby. A baseline survey carried out by New ERA (1986) reported that very few women eat fulfilling meal during pregnancy for the fear of having a big baby and difficulty in delivery. They inherited this belief from their mother-in-laws and traditional birth attendants. Sugar, nuts, beans and maize were believed to cause miscarriage. Similarly, buttermilk, orange and curd were not taken during pregnancy due to fear of harming the foetus. Contrary to many of the beliefs, Shrestha (1986) had noted that in Sindhupalanchowk village, pumpkin, fenugreek and molasses were given to nursing mothers to increase milk production. In the same study, it was reported that Newar and Tamang women drink alcohol after the childbirth in order to improve the breast milk supply.

Some studies in India indicate that food proscription and beliefs have been important issues in the country as well. Rajlakshmi (1971) had pointed out that, while poor availability of food is one of the major causes of malnutrition, even many available nutritious foods are excluded during the late pregnancy and early lactation due to wrong beliefs. For example, papaya which is nutritious and important food is restricted during pregnancy believing that it could result in miscarriage. International Foundation for Developing Countries (1997) had reported that people throughout the southern part of India believed that papaya should be avoided during pregnancy and lactation as it could cause dysmenorrhoea in women. This belief regarding papaya was also reported by a recent study by Patil *et al.* (2010). The report says that more than 80 percent of people in rural areas of Pondicherry held this belief. The majority of the respondents in the study also believed that consumption of saffron by pregnant woman results in a fair-skinned child.

Capoor (2000) in her paper "Women and nutrition: victims or decision makers", has listed some strange beliefs (that if a mother eats more food during pregnancy the child gets crushed in the womb; pregnant women would pass green stools if she eats green vegetables and these get stuck inside the intestine of the child; eating peanuts makes the placenta rot and the child gets a white layer on her/his body; consumption of banana and ghee causes the baby to stick in the uterus). In the same paper, it was mentioned that pregnant women are not allowed to consume milk as it is believed to cause tetanus.

Similar studies in other parts of the world (Gupta, 2006; Sood & Kapil, 1994; Ali *et al.*, 2004; Mahrnood *et al.*, 1997; Jimenez & Arriola, 2004; Santos-Torres & Vasquez-Garibay, 2003; Trigo *et al.*, 1989; Fishman *et al.*, 1988; Koon *et al.*, 2005; Issayas, 1996) have also listed different food beliefs, many of them leading to food proscriptions and some to prescriptions.

The literature review shows that the various food prescription and proscriptions and the beliefs cannot be generalized. However, concept like hot and cold food may extend beyond the boundaries of a country. The beliefs concern ensuring good health of the child during pregnancy, safe delivery, and milk production during the lactation period. A few studies used the concept of hot and cold food to explain the belief and the practices. Only a few studies have related nutritional aspects of such beliefs to prescriptions and proscription.

Conceptual framework

The main objective of the study was to understand the food beliefs regarding pregnancy, delivery and lactation and to understand the conceptual basis of the beliefs and analyse nutritional attributions so that a strategy for better practice can be accrued. A number of socio-cultural variables, values and practices are crucial in food beliefs and practices. The following table outlines the conceptual framework, linking the objectives of the study with the key aspects and approaches for information generation.

Table 1. Objectives, key aspects and study approach

Objectives	Key aspects	Approaches
Explore food beliefs relating to – Pregnancy – Delivery and recuperation – Lactation and post lactation	<ul style="list-style-type: none"> • Cultural/traditional practices • Harmful/restricted/avoided food • Beneficial/recommended/ normally given food • Effects of especial food items on child 	<ul style="list-style-type: none"> – Review of literature, – Key informants – Focused group – Observations – Interview – Knowledgeable experts consultation
Underlying concepts of beliefs	<ul style="list-style-type: none"> • Reasoning of the food belief • Perceptions social/ individual 	<ul style="list-style-type: none"> – focused group – Interview – Knowledgeable experts consultation
Analyse the food beliefs from nutritional point of view	<ul style="list-style-type: none"> – Beneficial/harmful – Scientific/logical – Nutritional perspectives 	<ul style="list-style-type: none"> – Review of modern concept – Interview & analysis – Expert consultation

Findings

Food contexts: Agriculture is the means of subsistence in this VDC. The main food products in this VDC include rice, maize, wheat, millet, soybean, and black gram. Besides potato and different types of vegetables like rye, mustard, radish, pumpkin, cauliflower, cabbage, French beans and cowpeas are cultivated. Fruits like plumes, peers, and lime are produced in small quantity. Cattle raising include cows, buffaloes and goats. Poultry farming is becoming increasingly popular in the village.

Futung basically relies on its own food production for subsistence, so food planning and practice takes place within the limit of the food production mentioned. Only a very small number of items in a very limited quantity such as instant noodles, bread and biscuits are imported for distribution in the village by retailers.

Food beliefs relating to pregnancy

Beneficial foods: In Futung, there are many strongly held traditional food beliefs linked to pregnancy. Many people in the village (about 51%) believed that “*Tagatilo Khana*” (energy food) is necessary to develop the baby in the womb. Meat, fish, fruits, pulses soup, ghee, vegetables are considered “*Tagatilo Khana*”. They believed that unpolished rice, liver, and blood serum help the mother gain good health and develop the child in the womb. Those who were literate were aware of the importance of iron tablets and foods containing iodine for the pregnant women and the foetus. Some respondents (about 27%) said that they have had usual food provision during their pregnancies and believed that it was good enough. There are also some people who have no idea regarding what to do regarding the food provision. A significant number of the respondents (23.3%) believed that it is the will of the god that ultimately determines the health of the baby in the womb.

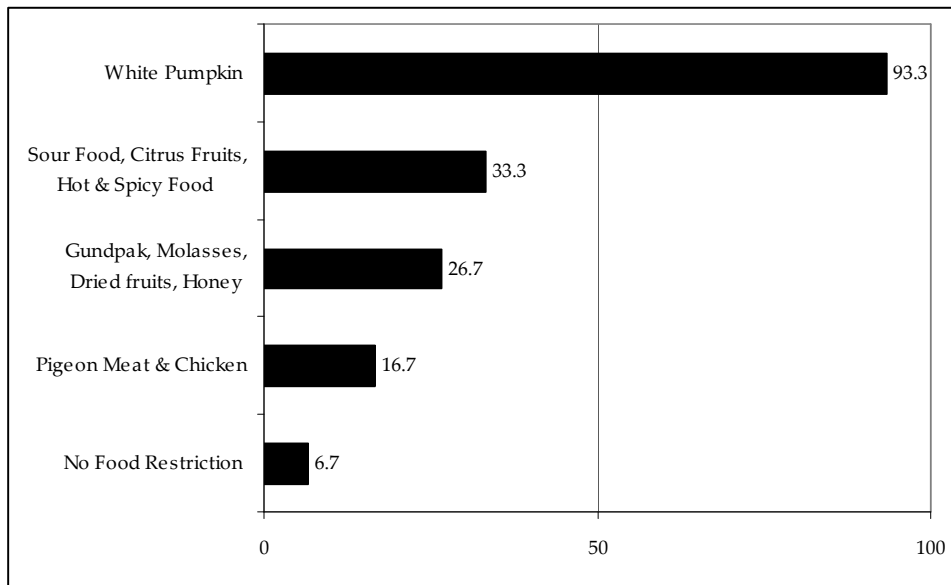
Dahi chiura (Yoghurt and beaten rice): One custom, initially practiced in the Newar community is *Dahi chiura khuwaune*, a special food treat during the later stage of pregnancy. During the last month of pregnancy, usually two weeks before the expected delivery date, her natal family and sisters of her husband send special food items on different days, taking turn. Customarily, the food items include beaten rice, meat, yoghurt, Jaggery/sugar, sweets, chutney, and fruits. Special attention is given to include items that the expecting mother cherishes. Second round of *Dahi chiura* is sent if the delivery is delayed. After delivery and the purification ritual, she is taken to her maternal home, *maiti*, for special care.

The custom is now very popular in the village as a whole. The respondents believed that *Dahi chiura* helps produce the energy needed for quick and easy delivery. Over half of the respondents (53%) believed that food items related to this custom such as curd/yoghurt, meat, egg, fish, and milk are important during pregnancy.

Restricted foods: The respondents believed that there are some foods that are harmful to the foetus. Many of them (51%) believed that a foetus or child in the womb is developed from blood and that any food taken would come to baby through blood. They therefore believed that sour foods, spicy foods and hot chillies would cause a burning effect to the baby. They also believed that hot food such as chicken, pigeon meat, honey, and molasses could even cause miscarriage. Some people also believed that eating oily and citrus fruits could result in eye and ear related problems in the baby. Similarly, there were some people who believed that eating eggs could cause boils on the body of the baby and could cause skin disease.

Almost all women (93%) were aware of the saying and also believed that white pumpkin can cause miscarriage and therefore should be strictly restricted during pregnancy. Many (33%) believed that hot and spicy food, sour food/citrus fruits, and dried fruits were harmful to the baby and therefore they should be avoided. Some respondents also believed that Gundpak, Molases (*Chaku*), dried food and honey should be avoided during pregnancy because they produce heat that could even cause miscarriage.

Fig. 1. Food avoided/restricted during pregnancy (% of responses based on multiple choices)



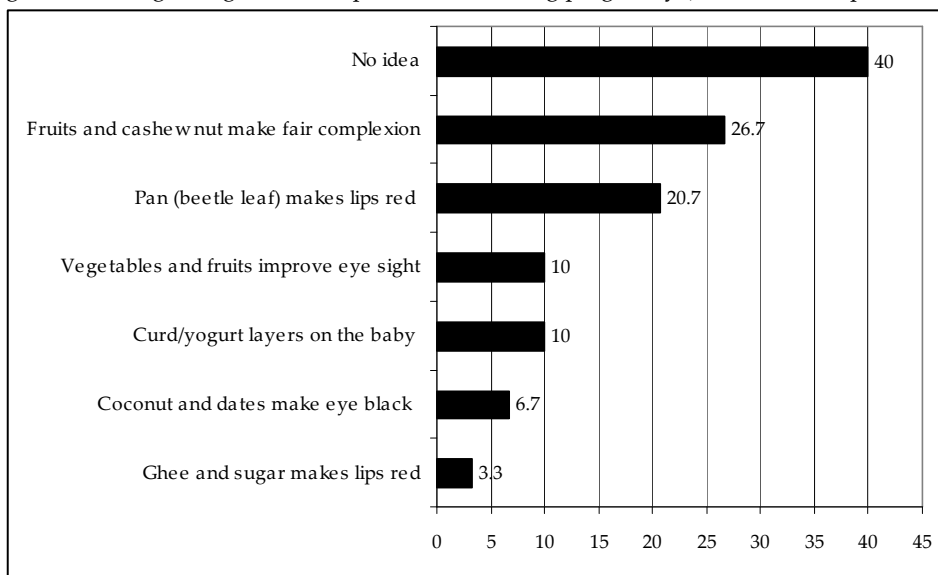
There were also some respondents (6.7%) who did not consider any restriction. They said they had eaten restricted foods and had experienced no harm. They believed that only medicines taken without consultation with doctors could be harmful to an unborn child, could even cause disability. They thought that heavy work such as lifting a heavy weight should be avoided as it could affect the baby in the womb.

About 23 percent of respondents also believed that after all it is the will of the god rather than food on which the fate of a child depends. They believed that the disability or mental retardation of a baby depended more on fate than on food.

Special food effects: Many respondents (26.7%) believed that eating fruits and cashews during pregnancy contribute to the baby's fair complexion. Some respondents (6.7%) said eating coconut and dates results in black eyes. Similarly, some (20.7%) believed eating *pan* (betel eaves) during pregnancy resulted in red lips.

There were also many respondents who did not have any idea of special foods and their effects.

Fig. 2. Beliefs regarding effects of special foods during pregnancy (based on multiple choices)



Ten percent of respondents, who were literate, said eating green leafy vegetables, papaya, carrots and fruits helped develop good eyesight of the baby due to the important vitamins contained in these foods. However, most of the other respondents said that they did not know and have not heard about such things.

There were also some respondents (10%) who believed that eating curd/yoghurt by pregnant women a few days before delivery can cause the baby to get a layer of curd on the body during the delivery causing difficulty in handling the delivery. They reported that they had seen such delivery cases among their relatives. A health worker of the sub health post also shared an incident that she had seen a baby born with a layer of curd and betel nut on its body to a woman who had eaten lots of curd and betel nuts during pregnancy.

Almost one third of the respondents also believed that on the whole it is the will of the god that brings different features and effects on the child being conceived.

Post delivery food beliefs

Beneficial foods during the post delivery period: All respondents said that women need hot foods immediately after the delivery to help them recover and regain their energy. Hot foods are considered to be especially beneficial immediately after delivery as they provide energy. In addition, they believed that there are special foods which are valuable in rebuilding tissues and help ease the contraction of uterus.

Among the Newars, a mixture of oil and molasses or just warm oil, hot rice with ghee and molasses, and minced meat were given the mother immediately after the delivery. Some respondents (13.3%) also said that warm alcohol and rice-beer should be given. The Chhetri women were given a hot drink of sugar, ghee, water, and oil with cumin seed, fenugreek seed, omum seed powders. Sarki and Sunar women considered that hot milk, *jaulo*, rice with ghee and molasses to be beneficial foods immediately after the delivery.

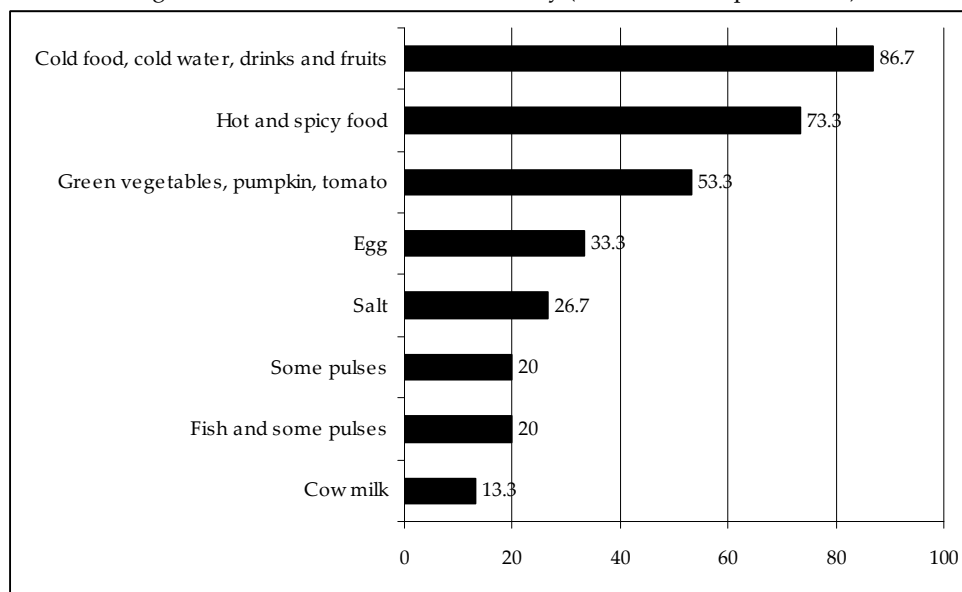
All respondents said that a warm mustard oil massage is beneficial for both the mother and the child. The majority of respondents said that in case placenta did not come out after the delivery, a lock of hair was kept into the mouth; this made the women vomit and caused contraction. There are even some extreme measures taken to prevent the placenta from moving back inside and to help bring it out. Some women said that smelling husbands' shoes also help to extract placenta. Perhaps these measures were used in the past in desperation.

Foods avoided/restricted after the delivery: In the village studied, some food were restricted immediately after the delivery. Restricted food (86.7%) included those considered cold, fruits, cold water and drinks. They thought that these foods could cause health problems to both the mother and the baby. Most of the respondents (73.3%) said that hot and spicy foods should be restricted for a few days after the delivery as they believed these foods could cause heavy bleeding due to uterine injury. Some respondents (33.3%) said egg should be avoided immediately after the delivery. They believed eating eggs could form gas in the stomach.

Other most commonly restricted foods included vegetables, fruits, sour food, pumpkin, tomatoes, fish, certain pulses, and potatoes.

Childbirth is considered a polluting process requiring a purification rite. Salt is restricted until the purification ceremony (which varies from 4 days to 11 days among different groups). It is believed that salt may be harmful causing eye problems and swelling of the body. Some Chhetri women said cow milk was also restricted until the purification ceremony, as cows were considered sacred and the women polluted during delivery were not allowed to drink cow milk.

Fig. 3. Restricted foods after the delivery (based on multiple choices)



Food beliefs and lactating mothers

All respondents in this VDC believed that additional and special foods are necessary after the childbirth for a period of few days to some weeks. The common notion was that “better foods help produce adequate breast milk.” They believed that inadequate food means inadequate breast milk. The respondents mentioned several food prescriptions and proscriptions regarding pregnancy, mostly to safeguard the health of the mother and the child.

Special food during lactation: *Gheu*, *chaku* and meat were the common food items given to women during lactation. However special food items varied from one ethnic groups to another. In the Chhetri community, a special dish consisted of rice with ghee and molasses, vegetables especially spinach, garden cress, saffron leaves, and parsley seed soup. Fermented mustard leaves (*Gundruk*) and meat was also given sometimes.

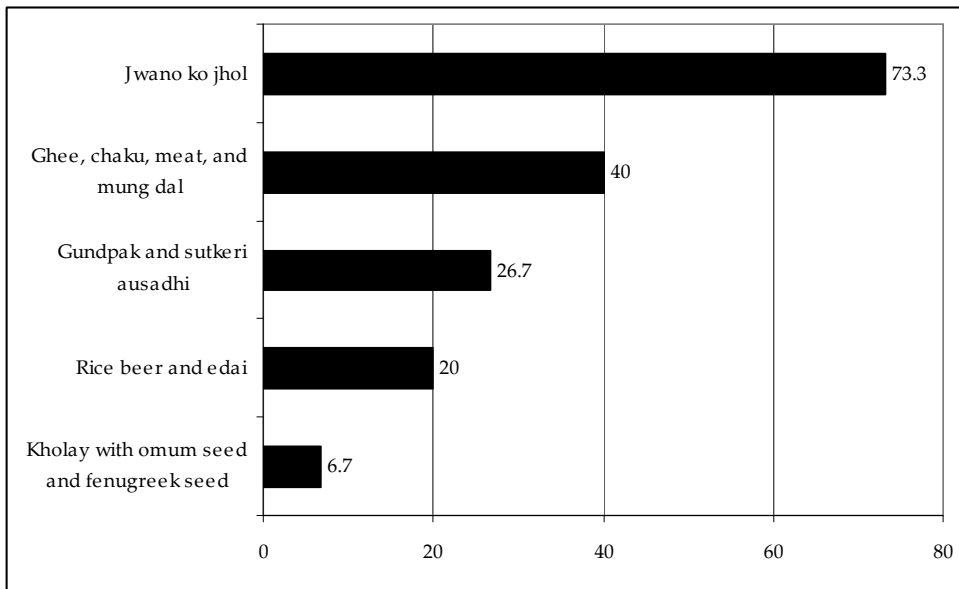
The special food taken during lactation as reported by Sunar and Sarki respondents, was similar to Chhetri respondents. However the study also showed that the respondents belonging to this community were poor and therefore could not afford a special or an extra food.

The Newar women in this VDC were given rice with ghee and boiled molasses, and minced meat curry about four times a day for the first four days. From the fourth day onward until the first month, they were given *Chiura* with minced meat, rice-beer, molasses, milk, dried fruits and sweets. Eating *chiura* during lactation is believed to help strengthen teeth and also help contract the uterus.

The Newar respondents also mentioned a custom known as ‘*Machabu swo onegu*’ which literally means post delivery visit by the relatives for caring, few days after the delivery. A set of various food items like beaten rice, meat ball and minced meat, *bara* (preparation of green lentils), rice beer, sweets, especially *jelebi* (special crunchy and syrupysweet), *pan* (betel leaf) and *kwati wasa* (medicinal soup) is sent from the natal home to the lactating mother. The Newar community also has a tradition of inviting the new mother to her parental home for relaxation and special care and recuperation. During this stay, the lactating mother is given special food items which are considered to help aid recovery, give strength and boost milk production.

Special foods for milk production: Some food items and drinks such as *jwano* (omum seeds), rice with ghee and *chaku*, *kwati wasa*, fenugreek seed, *mungralo* and meat were considered good food for milk production by all the respondents. ‘*Jwano ko jhol*’, a soup made from omum seeds was found widely used in the early stage of lactation to increase the milk production, especially among the Chhetri, Sarki and Sunar communities. Among the Newars, *ghee*, *chaku*, rice beer, *pousticari*, *edai* (a special preparation), *mung dal*, and minced meat were given to boost milk production. Some respondents belonging to the Sarki community also pointed out that *kholay* (a special porridge) with omum and fenugreek seeds were beneficial foods for lactating women.

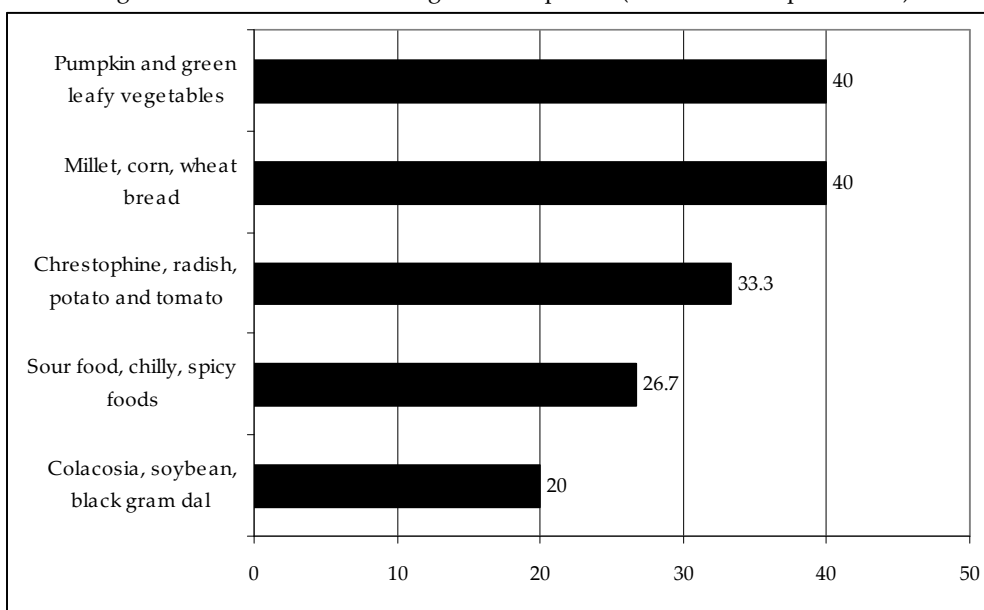
Fig. 4. Beneficial food for milk production (based on multiple choices)



Food avoided/restricted during the lactation: Most of the respondents believed that during lactation, foods taken by the mother pass through the breast milk to the baby; therefore, food items that have harmful effects need to be restricted. Most of them said

women should follow traditional food practices for at least during the first few months of breast-feeding. Certain foods were avoided for the first six months of breast-feeding until the baby began to eat supplementary food. Accordingly, food items that have cold attributes should not be given; instead, hot foods should be given to counteract the cold effects. They considered the newborn infants are very vulnerable and therefore, mothers need to take measures for adjustment in their diet to maintain the child's health.

Fig. 5. Restriction of food during lactation period (based on multiple choices)



The majority of restricted food items were cold attributed food. Pumpkin, radishes, potatoes, chrestophine and green leafy vegetables were mostly avoided during lactation. It was widely believed that green vegetables could cause diarrhea to the baby and cause green stools. It was believed that mustard leaves should not be eaten during lactation, but fermented mustard leaves were perceived beneficial to the lactating women. Some respondents (20.0%) also believed that colacosia, soybean, and black gram *dal* could cause itching and diarrhea. Sour, hot (chilly) and spicy food items were also avoided by the lactating women in the VDC. They believed that hot and spicy food items hurt the baby's stomach and cause illness. They can also result in stomach pain to the mother. They also avoided eating dry breads. Interaction with senior key informants and focused group discussion indicated that eating "Rukha Shukhha Khana" (for example millet, wheat and buck wheat breads prepared dry) were avoided by lactating mothers in the villages.

Foods harmful for milk production: Some foods were restricted due to their harmful effects on breast milk. Majority of the respondents (60.0%) believed the bread made from millet, wheat, buck wheat which are cooked especially in a *tawa* (pan) reduce breast milk supply. Many respondents (over 36%) believed that horse gram, *masyang*, and *musuro dal* reduce milk production. Some respondents (13.3%) also believed that turmeric powder, *timur* and clove cause dry up the milk. It was said that cloves were given to lactating mother to dry up her breast milk in the case of the death of the baby. One respondent reported that eating *babiya* also reduced breast milk supply.

Discussion

General food perceptions with health implications: “*Tagatilo Khana*” connotes “energy giving” and is directly relates to the concept of energy giving and body building food. The traditional belief of *tagatilo khana* however does not include the idea of balanced food intake. Also there is a lack of understanding regarding minerals and vitamins.

The study indicated that there was no consideration of foods focused on women’s health even during pregnancy. For example, green leafy vegetables, meat, fish and fruits, though important during pregnancy, are not given adequate considerations; instead, fruits were considered harmful and avoided. Such lack of focus on food needs during pregnancy can lead to anaemia of the mother and the child; particularly, in the case of teenage pregnancy, it can cause higher risk during the delivery even leading to maternal mortality. This could be contributing factor to high occurrence of anaemia among women of reproductive age—35 percent in general and 48 percent among pregnant women (New ERA, MOHPS and ICF International Inc. 2012).

Even though respondents did not have knowledge on nutritive value of various foods, they had good concept in taking daily diet to ensure good health in terms of energy and protein. Cooked rice eaten in combination with *dal* (lentils or pulses soup) provides good quantity of carbohydrates and protein. (Cereal or pulse alone cannot meet the protein requirement; however, when these two items are combined together they form complete protein. However, it has also to be noted that using pulses and *dal* soup in their daily meals are served only once a day, mostly in the morning. Many families did not serve *dal* when there was vegetable curry (*Tiuhn*).)

Nevertheless, there is scope for using some good traditional practices to illustrate holistic food sources. One such example is the custom of “*Dahi chiura Khuwanune*” in which the woman’s family, kin and relatives show care and concern with nutritious food during the last month of pregnancy. A food review and analysis regarding the food items given in “*Dahi cuiura Khuwaune*” shows that it consists of balanced food items that include all three basic food groups a) Energy giving food b) Body building food c) Body protecting food as the following table shows.

Table 2. Basic food groups and food items

Three basic food groups	Food items
Energy giving food	Beaten rice, Sweets, Jaggery, White beer
Body building food	Meat, curd/yoghurt
Body protecting food	<i>Tarkari, Chutney, Fruits</i>

Education is the most important factor for the awareness of nutritional needs. There is, therefore, a need to raise the level of awareness regarding holistic nutritional needs of pregnant women. It is to be noted that this custom, originally limited to the Newar community, is found being practiced among other communities as well with some variations. For example, Brahmin and Chhetry families do not include beer and meat. Some families do not include fruits and chutney. There is scope for community reviews to make this custom culturally as well as nutritionally more suitable. Also, the custom is limited to the last month of pregnancy which could be extended to the entire period of pregnancy as well as the lactation period.

Although most of the respondents were aware of the need of additional food during pregnancy, many of them did not have such extra food when they were pregnant. One of the major reasons was poverty. The other reason given was the fear of overgrowth of baby that would make delivery difficult and risky. In some cases, there was simply no special food consideration given to pregnant women. A review of the implementation of national nutrition strategies and development of sectoral action plans by Basnyat (1994) indicated that women do not get any extra care or food during pregnancy. Very often food intake even during pregnancy depended on the availability of food and appetite.

Concept of hot and cold foods: Food beliefs in this VDC regarding maternal health especially during pregnancy and lactation period were found related to the concept of hot and cold food and the notion of "*Tagatilo Khana*". Accordingly, most food items were given or restricted during these stages. For instance childbirth is considered to be cold condition; therefore certain food items considered hot food such as ghee, molasses, *juwano soup*, and meat were given immediately after the delivery; whereas dark green leafy vegetables which are considered cold are not served even up to two or three months after delivery. Modern food analysis however does not mention hot or cold food. The modern food concept is based on three essential function of body. For example energy for operation/running the system (energy giving food), growth and maintenance (body building food) and defence against disease (body protecting food). There are six important nutrients, which are essential to life: protein, carbohydrate, fat, vitamins, minerals and water.

Nonetheless, when it comes to analysing benefits or harms to maternal health of food items, many food beliefs tally with the modern analysis. However there are also

some beliefs which contradict with modern analysis. The following section discusses the existing beliefs on the basis of modern concept of food and nutrition.

Special food effects: In Futung VDC, the food items thought to be beneficial for milk production were found valuable from nutritional point of view. The widely believed and used food item "*Jwano soup*" is a good source of protein, calcium and iron. Similarly, *Ghee* and *molasses*, mixed *omum* and fenugreek seed and rice beer and *Poustikari* are rich sources of energy, protein, iron calcium and vitamin A which help increase the supply of milk as well as boost up the mother's health.

From the perspective of hot and cold foods, childbirth has been considered a condition requiring hot food. Therefore, mothers were given hot foods immediately after the child birth and for few days after delivery. The hot food items mostly considered good in this condition were rice cooked with *ghee* and *chaku*, warm oil with cumin seed, boiled sugar and water and mixed fenugreek and *omum* seed soup. These are good sources of energy, calcium, iron and protein, which help regain the health of the mother and also to facilitate lactation.

Restrictions of various other food such as dark green leafy vegetables and fruits considering them to be cold food to the mothers during pregnancy, child birth as well as lactation period have negative implications. Such restrictions limit the intake of essential nutrients such as iron, calcium, carotene and vitamin C. The restrictions, especially during lactation, can have negative effects on the nutritional status of the mother and the milk supply particularly if carried out for longer periods. Similarly, the another food misconception relates to the restriction on eggs to pregnant woman thinking that it could cause boils and skin disease on the baby. From nutritional point of view, the belief is not true. Contrary to the belief, they are good sources of protein, fat and vitamin A, which are essential for the growth of the body.

There are some interesting beliefs regarding foods with especial effects on the child in the womb. For example, fruits and cashew nuts produce a fair complexion; coconut and dates make the eyes black; and *pan* (betel leaf) make lips red. Similarly, there are especial foods, which the respondents believed and consumed for regaining energy, controlling excessive bleeding, and help contracting the uterus are important from nutritional and curative point of view.

Pure and impure food is another important perspective with nutritional implications. For example, salt is restricted after the delivery until the purification ritual; similarly, some families restricted milk, vegetables and meat on the basis of purity.

Conclusion

Food beliefs are tied-up with the concepts that go beyond the boundaries of a village. Obviously, changing concepts that are widely held would be more challenging than changing those held at the individual or family level. The beliefs and conceptual frames have their own scope, limitation and present both dilemmas and

potential. For example, there is no scientific basis for the beliefs regarding hot and cold food however they are widely held and go beyond the village or the country. Besides, they are also part of the ancient medicine system such as Ayurveda in Nepal and India, or the system in other parts of the world. These beliefs have some intuition and some experimental basis to claim credibility. Obviously there is high scope for further research in this area. Similar analysis hold true in the case of illness and food with curative values. Pure and impure food has a positive side. It helps safeguard health from unknown food items as well as link food to aesthetic values and considerations. On the other hand, it has implications on social aspects as well as practical aspects of food planning and use. The cultural aspect of food have similar dilemmas and potential. There is need to look at the food beliefs and practices critically and develop a way to maximise the benefits nutritionally, aesthetically and socially.

Based on the study outcomes, it can be suggested that a country like Nepal should prepare a nutritional policy framework and programs to make people aware of as well as follow the policy. The emphasis should be on the nutritional needs of the reproductive age of women, pregnant and lactating mother in particular. Second, communities should be mobilized in an organized way to discuss and reflect on their food beliefs from nutritional perspectives, encouraging and supporting them to strengthen beneficial beliefs and practices and correct the misconceptions.

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Exploring Indigenous Knowledge System and Limbu Cultural Identity in Nepal

Ramesh Kumar Limbu

Nepal Sanskrit University, Pindeshwor Vidhyapeeth, Dharan

Email: limburamesh123@gmail.com

Abstract: *The Limbu indigenous knowledge system and Limbu cultural identity are interdependent, and hence changes and crises in one inevitably affects the other; the loss of biodiversity causes loss of cultural identity, and vice-versa. Nowadays, the concept of indigenous knowledge is considered to be contradictory to the notion of modernity. This paper attempts to explore what sort of nexus exists between the Limbu indigenous knowledge system and the question of cultural identities, and what due considerations are required to be taken to identify and safeguard such cultural heritages in order to ensure unity in diversity.*

Keywords: *Limbu people, indigenous knowledge system, cultural identity, cultural heritage, traditional knowledge, biodiversity.*

Introduction

Nepal, although a small country in the world, is very rich in terms of culture and physical features—a haven of zealously preserved caste and native cultures, variegated bio-natural landscapes, snow-capped mountains and indigenous wonders. Within an area of 147,181 sq. km., about 26.6 million people (Census 2011) live with different religious beliefs such as Hinduism, Buddhism, Kirantism, Islam, and others. The National Census (2001) had identified 59 different indigenous nationalities comprising 37.2 percent of the total population. According to Yadava and Turin (2007), there are “100 officially recognized castes and ethnic groups who speak around 92 languages, officially-recognised by the state” (P. 2). National Population Census (2011) has recorded 125 different nationalities and 123 languages which show that it is home to different castes and indigenous ethnic people with distinctive culture, language, religion, history, tradition and mythology. Conceiving the very diversity of caste and ethnic people, Giuseppe Tucci (1962) has noted that “the ethnographical study of Nepal, despite the many researches undertaken, is still one of the most complexes in the world (P. 76).” These nationalities have their own language, culture, tradition, principles, understanding, way of livelihood, and belief in indigenous knowledge systems.

The practice of indigenous knowledge system (IKS) in Nepal has evolved from time immemorial as it is a home of diverse nationalities with a myriad of distinctive folk lives and folklores, cultures, traditions, practices and belief systems. Such knowledge has been transmitted through oral tradition from one generation to the

next, and it is based on holistic perspectives of the interconnectedness of various things direct and authentic experiences with the environment within the native cosmologies and values that frame it. Indigenous knowledge (IK), as a matter of fact is a valuable cultural heritage of the country. Indigenous knowledge system refers to an integrated body of knowledge which consists of many concepts “produced by and/or distinctive to a particular culture group or any loosely defined group of resource users in a given area” (Maden *et al.*, 2008, P. 31).

The Limbus, one of the significant groups among Kirant people, is an indigenous ethnic community of Nepal. The Limbu Kirantis, are traditionally known as wanderers and hunters, hill and mountain dwellers, indigenous knowledge holders, users of medicinal herbs and spices, physicians and architects; they are also known as the nature worshipers and animists, and indigenous land owners; they have a very strong attachment to native agro-pastoral tradition. The Limbus designate themselves as *Lungbongba Khambongbasa*-meaning ‘the lineage which emerged from the rock and the soil’. This confirms them to be autochthons of this country. Their connection with the hilly areas is very old. Chaitanya Subba (1995) says, “The Himalayan region [has] always [been] a favorable abode of Kiratas since the remote past” (P. 17). The Nepal census (2011) recorded 387,300 Limbus in Nepal. That is 1.46 percent of the total population, and 343,603 people with Limbu as their mother tongue. Moreover, more than 150,000 Limbu people live in different countries like India, Bhutan, Myanmar and other places of the world.

The Limbu indigenous knowledge system, an invaluable heritage transmitted from one generation to another, helps shape their identification. But now, this practice is bordering on disappearance precisely because it has been uncared for by the new generations of the concerned community as well as the government of Nepal. Moreover, it has been overshadowed by modernity and globalization. Therefore, the study of indigenous knowledge system is very imperative to show what kind of correlation it has with the cultural identity. Exploring the virgin area constituted by the interdependence and/or relationship between indigenous knowledge system and the cultural identity of Limbus, this paper focuses on the Limbu indigenous knowledge system and Limbu cultural phenomena including local ecology, biodiversity, Limbu culture and environmental changes of Tiringe VDC of Taplejung and Yangnam VDC of Panchthar districts as the domain of this study.

Indigenous knowledge system

The concept of Indigenous Knowledge (IK) has often been associated in the Western intellectual and cultural tradition as part of the primitive, the wild and the natural. At best, such representations have been charged with paternalistic or idealized condescending approaches rooted within the ideological framework of the colonial European paradigm of Modernity (Tuhivai-Smith, 1999). IK incorporates the

knowledge and skill of learning system, the adaptation of biophysical environment, natural phenomena like local flora and fauna; indigenous methods of counting and quantifying, skill and experience of caring and curing human as well as animal diseases, traditional medicines and the uses of herbal remedies. It also includes knowledge and skill of farming, animal husbandry, fishing, hunting and gathering; safeguarding of soil, water, vegetation, ecosystem, public places, and so on. It is also knowledge of handicraft, visual performing arts, weaponry, constructing and manufacturing of various things.

According to World Intellectual Property Organization (WIPO) (2005), Indigenous Knowledge is often referred to as Traditional Knowledge (TK), and it “encompasses the content or substance of traditional knowhow, innovations, information, practices, skills and learning of TK Systems such as traditional agricultural, environmental or medicinal knowledge” (cited in Maden, *et al.*, P. 4). Such knowledge, developed from the experience gained over time and adapted to the local culture and environment, has always played—and still plays—an important role in the daily lives of people globally, and it is considered to be an essential part of cultural identity.

Such indigenous knowledge systems of people or communities are being held on to as intangible cultural heritages by the United Nations Educational, Scientific and Cultural Organization (UNESCO) through 2003 Convention for Safeguarding of the Intangible Cultural Heritage (ICH). As per Clause 1 of Article 2 of the Convention, the ‘Intangible Cultural Heritage’ means the practices, representations, expressions, knowledge, skills—as well as the instruments, objects, artifacts and cultural spaces associated therewith—that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. Similarly, according to Clause 2 of the Article 2, the ‘Intangible Cultural Heritage’ is manifested *inter alia* under the following domains:

- a) oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;
- b) performing arts;
- c) social practices, rituals and festive events;
- d) knowledge and practices concerning nature and the universe;
- e) traditional craftsmanship

Although an interest in Indigenous Knowledge has begun to be expressed in a growing number of academic disciplines (Warren *et al.*, 1995), calls for the preservation of IK at the international level began in 1992 at the Conference of Rio de Janeiro on Bio-Diversity, and in December of the same year, the United Nations declared 1993 as the “International Year of the World’s Indigenous People.” Through

these activities, the significance of the indigenous knowledge system further gained momentum in the international arena.

Indigenous knowledge system implies the ways of living a life, preserving and performing traditional culture, rituals, festivals, *rites de passage*, etc. It also encompasses various traditions, ceremonies and practices of the community. Such a knowledge system provides us with a substantial idea about both tangible and intangible cultural heritages of indigenous people that help identify themselves as a distinct community with a distinctive identity. Thus, the recognition of such deep-rooted knowledge and skills has great value as a long practiced native episteme, and “the body of historically constituted knowledge is instrumental in the long-term adaptation of human groups to the biophysical environment” (Purcell 1998, P. 260).

Besides, Indigenous Knowledge is a transmission of information and knowhow constituted from the ancestral community practices to the present. It is about how traditional cultures in the distant past have differently organized their ancestral knowledge production concerning their cultural beliefs, linguistic practices, and the historical interpretations that have given meaning to their lives (Cajete, 2000; cited in Ortiz, P. 117). This knowledge comes out of the direct experience with the environment and within the native cosmologies and values that frame it. In the view of Marc G. Stevenson (1996), the term “indigenous knowledge,” which comprises traditional and nontraditional, ecological and non-ecological knowledge, “is proposed as an alternative that should allow aboriginal people, and the full scope of their knowledge, to assume integral roles in environmental impact assessment [EIA” (P. 278)]. Hence, to utilize such knowledge as a living and effervescent culture, it must be properly inventoried, protected, safeguarded and made viable in order to transmit it over generations to come.

Area of the study

The study area of this paper is what Limbu culture, biodiversity, traditional ecological knowledge, skills and tools of the Limbu dominated villages namely, Tiringe VDC of Taplejung and Yangnam VDC of Panchthar districts constitute.

Tiringe VDC is surrounded by eight VDCs which are Phawakhola VDC and Phurumbu VDC in the North, Hangdewa VDC and Dokhu VDC in the West, Nangkholyang VDC and Thechambu VDC in the South, and Dumrise VDC and Sikaicha VDC in the East. The Tiringe River runs from west to east in the centre of this VDC and joins with Phawa River that flows to the East of this VDC. This VDC is rich in natural vegetation and has a diverse topography. It is densely populated by the Limbus. Out of a total of 331 households, 208 are Limbu households and out of the total population of 1844, the Limbu population comprises of 1023. The detail of population distribution is given below (Table 1).

Table 1: Population and Household of Limbu and non-Limbu

Ethnic/Caste Group	Limbu	Brahmin/Chhetri	B.K/Damai/Sarki	Total
Total Households	208	108	15	331
Population	1023	742	79	1844

Source: Tiringe VDC Office Record (2012)

Another study area is Yangnam VDC of Panchthar District. The four VDCs that surround it are Ektin to the North, Bharapa in the West and North-west, Nagin to the South, and Sidin in the East. Henwa River runs as the northern borderline separating it from Bharapa and Ektin VDC and Khang River in west, Swoti River to the south, and Likhure River and Laksibung River flow in the east. This area is less diverse in terms of vegetation and topography than the earlier research domain. However, people of this VDC have also varied indigenous skills and knowledge. Limbu people densely populate this VDC comprising of 87.3 percent of the total population. Rest of the population, 4.3 percent is of Brahmin and Chhetri, 7.6 percent of Dalit groups and 0.8 percent is of other ethnic groups.

Limbu indigenous knowledge system and cultural identity

Limbu indigenous knowledge system refers to an integrated body of knowledge which consists of many concepts related to life-activities transferred from the old to new generations. David Pearson (1996) defines 'culture' as, "the ways that people in all societies draw upon a vast repertoire of knowledge to perform innumerable tasks, most of them so mundane that they take them for granted" (P. 248). For Clifford Geertz (1973), culture is "a historically transmitted pattern of meanings embodied in symbols, a system of inherited conceptions expressed in symbolic forms by means of which men communicate, perpetuate, and develop their knowledge about and their attitudes toward life" (P. 89). Cultural identities were primarily defined as given, and not as a matter of recurring construction, generation, and deconstruction. Later, scholars affiliated with the behavioral trend (such as Caldeira and Gibson 1995; Epstein and Kobylka 1992; Gibson 2004) have looked at identities as; fluid, transient and contingent over time and situation.

In both of the Village Development Committees, the Limbu communities possessed distinctive indigenous knowledge system practiced from the time immemorial. Mostly, they were found involved in traditional agricultural occupation. They cultivated the land and grew maize, paddy, millet, wheat, buckwheat, oat, potato, etc. and they also grew various kinds of vegetables and fruits. They loved growing various species of flowers at home and offered them in every ritual observation. They had their own farming calendar which they followed strictly. The rituals related to farming and harvesting were observed publicly twice a year around the month of November-December and April-May apart from other agrarian

observations and ceremonies which they observed individually on different occasions. The Limbus would first offer their major produces to the Gods and other agrarian-deities and then only consume themselves. They had a belief that anything they get from the nature was a gift received from these Gods and Goddesses.

In the study areas, the researcher have observed many Limbu households spare ripe crops and fruits to offer to the deities. Bom Bahadur Limbu (56) of Tiringe VDC had said that such produce should be spared and kept in a neat and clean place to offer to the gods. Otherwise, he added, the members of the household may be caught by different kinds of diseases. Likewise, Dilliman Limbu (71) of Yangnam VDC also made similar remarks. According to him, farming belongs to nature which was created through the power of Tagera Ningwafumang¹ and we get all food items from the nature. Therefore, he says, they have to take gods' help during cultivation and offer produces when they are harvested. Practice of offering to the nature deities in Limbu community is known as *chasok* and *thisok*. *Chasok* refers to the food cooked and *thisok* refers to the *thi* (liquor drinks) fermented from the initially harvested crops. As Limbus are considered to be the nature worshipers and animists, nature is the most powerful phenomenon for them and hence they worship and propitiate it in various ways and forms.

As per the seasonal calendar, the Limbus also abstain from entering and working in the field on days they believe to be inauspicious. They do not plow and dig their field on the day of Saune Sakranti, Ubhauri and Udhauri, new moon's day, etc. This shows that they carry out rituals in accordance with both the solar and lunar calendar. They also follow the calendar and choose auspicious days for harvesting crops, setting out to travel, starting new activities, worshipping gods and deities.

Traditional knowledge and skills are applied while husking paddy winnowing, and storing crops. Human as well as bulls are used to husk paddy. The chaffs are winnowed, made dry and then the clean paddy is stored into a bamboo basket. Paddy harvest is said to have started a culture of *ya?lang*, a popular agro-based folkdance performed in the Limbu community. The etymologically the word is derived from the word *ya?lang* or *ya?rakma*. *Ya?*—means paddy with pod, and *lang (ma)* or *rakma* means to dance over it to separate the grains or paddy seeds from its hunk. Such a practice helps promote a feeling of cooperation among people of the community. Although the origin of *ya?lang* "has a connection with paddy harvest and agricultural evolution, the major objective of *ya?lang* now is to create an atmosphere of intimacy, love, cooperation and sense of collectivity and recreation" (Limbu 2011, P. 81).

Likewise, the Limbus harvest corn and store the produce lying into small bunches of ears and hanging them on rows. Wheat, buckwheat and millet are also stored sometimes with stalks and at times by separating the grains from the husks.

1. Supreme Creator God/Goddess in accordance with the Mundhum

While storing grains, various locally available herbal plants' leaves, seeds and barks are used as pesticides and preservatives. These herbals protect food grains from insects, rodents, and cold and damp. They also cultivate a variety of seasonal vegetables and spice herbs and grow spinach, ginger, potato, turmeric, tomato, onion, radish, squash, pumpkin, chilly, etc. Above and beyond, the Limbus of these areas often preserve such vegetables by drying it so that it can be consumed during the off-season. They prepare *gundruk* from the leaves of spinach and *sinki* from radish. They are fond of growing yam and collecting wild yam and tubers as well. They grow a variety of fruits suitable to the altitude of their location such as guavas, mangoes, lemons, oranges and bananas in their field. They further gather several types of yams and fruits from the forests, cliffs, and steep lands too.

The Limbus love eating a variety of meat dishes like curry, roast, soup, pickle, sausage, spices, and so on. They rear chickens, pigs, goats, buffaloes and pigeons for meat. According to Man Bahadur Limbu (94) of Tiringe VDC, Limbus used to hunt wild animals and birds in the past but nowadays it is rarely done. Before setting off for hunting, they used to worship and pray to the hunting deity 'Sikari', and after killing animals and birds, they again offered food to him. At that time, many kinds of animals, birds, roots and fruits were found in the forest. Life was much more pastoral, beautiful and aesthetic. The feeling of collectiveness and mutual cooperation existed in the villages. But now, he said that such life-style is no more. The population is increasing but natural resources and the fertility of soil are decreasing. A similar situation was recounted by Brijahang Limbu (83) of Yangnam VDC. For him, the valuable natural and cultural things of the past were on the verge of disappearance as a result of ignorance of the Limbu youths and the encroachment of new systems and policies of the country.

However, although lesser in scale, the Limbus living in the study areas were found making use of various indigenous skills and knowledge relating to handicraft, weaving, agronomy, irrigation, animal husbandry, beekeeping, honey hunting, fishing, hunting, collecting and using local medicines, and so on. They had distinctive knowledge of learning system, counting and quantifying, building houses, and the use of tools, instruments and equipments. They possessed their own socio-cultural traditions, cultural heritages, folklore and folklife. Moreover, they had their own customary traditional institutions and legal, economic and political systems.

Medicinal knowledge and healthcare practice

The indigenous system of medication, widely practised in the Limbu community, is an important component of the indigenous knowledge system. The Limbus have reliable knowledge about forests, medicinal herbs and biospheric skills. But, as a result of the avaricious nature of both the state and the modern market economy and the process of globalization and modernity, "many such knowledge continue to either

disappear or [be] exploited by greedy outsiders, including pharmaceutical companies and other multinational companies" (Bhattachan, 1995, P. 12).

A considerable use of local medicines were found in the Yangnam VDC even though a health post is there in the village and there is also a District hospital in Phidim at a walking distance of two to four hours. While, there is no health post in the Tiringe VDC and the people of this VDC have to either go to the adjacent Thechambu VDC which lies at a walking distance of two to three hours, or they must reach Taplejung District hospital which is three to four hours walking distance. Limbu people of both of these VDCs have knowledge of the nature, local flora and fauna, herbaceous practices or traditional medicines and the uses of herbal remedies in the treatment of ailments; they possess the knowledge of the locations of medicinal and ritual plants, the proper times for collection, and methods for preparing and storing medicines. They also have knowledge of human health, nutrition and the system of classifying animal and human diseases. They have got notable treatment knowledge for making use of various kinds of herbs like root, shoot, rhizomes, fruit, seed, bark and leaf, and many other things that are found in the nature such as algae, fungi, lichen, fern, soil, rock, and organism of insect and animals. The specialists (herbalists and shamans) involved in treating different ailments through indigenous knowledge system simply do not always fancy sharing individual knowledge to other people.

The traditional treatment system of illnesses currently known as homeopathy has been found highly used in these areas for problems such as gastritis, injuries, jaundice, parasites, pneumonia, skin problem, ENT, problems relating to women and children, body pain, heart pain, chest pain, toothache, pyorrhea, headache, bruise, sprain, abscesses, cut wound, wound, burned, fractured, bleeding, dog bite, snake bite, etc. They also have knowledge for remedies of diarrhea, dysentery, indigestion and abdominal troubles. For instance, *Calvatea gigantean* is used for treating wounds; *Gonostegia hirta*, a herb known as *chiple jhar*, is used to treat bone fractures, cough and colds, and dandruff; *Rubus ellipticus*, known as *ainselu*, is used to treat vomiting, pneumonia and urine infection. The Limbus have been found to use *Swertia chirayita* (*sungkhingba* in Limbu) for various ailments. The plant is also used to make juice and is given to patients suffering from fever, headache and cold. *Valeriana jatamansi* is used for cut-wounds, cough and cold, musculo-skeletal problems, and respiratory problems.

Moreover, plants are used in different ways, that is, in the form of paste, juice, chewing, and so on. To make a paste, the plant parts are crushed or minced with a stone pestle and mortar. Juice is extracted by squeezing or crushing plant parts and filtering through a cloth. If intended for infusion, the plant parts are dipped into water for some time. Similarly, some parts of the plant are boiled in water and used as medicine. This is known as decoction. *Rajgante*, a kind of root tuber found in the root of *kharane* (*Symplocos ramosissima*) is used to control bleeding. Cooking oil is also

extracted from the seeds of *kharane* and *khorkhori* in the Limbu community and they believe that the extracted oil is useful in curing various kinds of diseases affecting both humans and animals. Some of the plants are used to cure more than one ailment. In total, "Seventy one plant species were found to be used by the Limbus as fruits, curry, spice, making thread or rope, and for religious and other various purposes" (Maden *et al.*, P. 70).

Khesung (yeast-cake), which is a source of the microorganisms of yeast, mold, and bacteria, is one of the Limbu community prerequisites. It is used in fermenting cereals in order to make *thi* and *raksi* in this community. It is believed that at the time the Limbus started making and drinking *thi* (homemade wine) and *raksi* (homemade alcohol), they knew the skill of making *khesung*. Therefore, making a *khesung* itself is another indigenous knowledge of Limbu people.

Limbu indigenous food and beverage

Limbu people were seen consuming a range of indigenous food items and local, homemade alcoholic drinks. Such food habits distinguish them from other community people. Amongst them, *Mangdak/le-pma*, *sigole*, *papanda*, *kinnema*, *yangben*, *sargyangma*, *warumchuruk/wachipa* are the traditional food items of the Limbus and *Thi* and *Raksi* are their beverages. The generic meaning of *mangdak* is "food of the god." It is a kind of porridge prepared from the flour of millet, wheat, maize and oat. It is also known as *le-pma* as it is kneaded dough. It is called *dhindo* in Nepali and considered to be the national food of Nepal. *Sigole* is another dish which is also prepared from the cereals listed above, but the cooking style and shape of the dish is different. For this, either round or cylindrical balls are made from the kneaded flour and are boiled or steamed either separately or placed over rice. *Papanda* is also a typical dish of the Limbus which looks like a thick-flat-bread and is cooked by heating the dough beneath the cinders of the firewood. *Kinnema* is another popular indigenous food item of the Limbu people. A traditional knowledge is used to prepare it, and it is eaten not only by the Limbus but also by other people of the Kirant community such as Yakkhas, Kōits Sunuwars and Rais. *Kinnema* is a bacteria-fermented food item made of soya-bean and generally used as an ingredient in curries, pickles and spices.

A very popular Limbu dish *yangben* comprises of a mixture of *yangben* (an edible species of lichen of thallophytic plant belonging to *parmelia*, *ramalina* and *usnea* group), minced pork, pork—blood and eggs. Such dishes are prepared on special occasions in Limbu households. Similarly, *sargyangma* holds a unique value for the Limbu people. Commonly, it is known as sausage made out of *keema* of pork entrails, blood, fat, *yangben*, rice and desired taste of spices, salt and chilly which are inserted in the pork intestines. Another special food item of the Limbus is *warumchuruk* or *wachipa* which is also called *teete* in Nepali as it has a bitter taste. The term *warumchuruk* or *wachipa* refers to the charred feathers (*wamurik*) of chicken. To prepare *warumchuruk*, it requires certain skill and knowledge.

Limbus are also very adept to various species of plants and animals. For example, they have got good knowledge about *paha* (one of the species of frog), fishes, honey-hunting, lichens, mushrooms, edible plants and so on. They possess knowledge about what kinds of things are edible and what aren't. On the other hand, the Limbus are skillful and knowledgeable in preparing alcoholic drinks such as *thi* and *sejangwa*. Both of these drinks have social and ritual values in the Limbu community. They have a belief that without *thi* and *sejangwa*, activities like hosting a guest and observing of any ritual are almost impossible. *Thi* is an alcoholic beverage made through fomentation process of millet, maize, wheat and rice with yeast-cake. The juice of it is brewed and taken as beer. *Tongba* or *Pipit* (in Limbu) is another very famous as well as respectable Limbu drink in which *thi* and boiled water are filled into a wooden vessel and it is sipped using a bamboo or silver pipette. *Raksi* or *sejangwa* is a distilled form of *thi* and is used as whisky or alcohol.

Apart from these, they eat rice, bread, pulse, curry, pickle, milk, ghee, curd, and the meat of different animals and birds, both domesticated and wild, as regular food items. Limbus are found to be fond of eating and drinking. They are also very good hosts to their guests.

Limbu indigenous life-activities and recognition

The Limbus can mainly be characterized through their pastoral activities. Therefore, most of the day-to-day activities that they engage in are closely linked to nature, vegetation, land, farming, art and craft, and animal husbandry. They have unique knowledge and belief system in such activities. For instance, they pay special attention in the conservation of different species of trees, faunas and floras. They have their own land management system, tradition of agronomy, soil management system-soil- conservation, soil-fertility enhancement practices, and formation of organic/bio-fertilizers. They have their own way of traditional water-management, traditional techniques for irrigation and drinking water supply. In agriculture, they have knowledge of indigenous indicators to determine the favorable time to plant, and harvest crops, prepare land-terracing, seed bed preparation, plowing, sowing, planting, weeding, collecting and threshing.

They also have knowledge on animals, including animal breeding and reproduction, and preparing traditional fodder; they also know the local taxonomic system of animal diseases and traditional ethno-veterinary medicines, and pastoralism. In addition, they have knowledge on textile and local crafts, building materials, and indigenous tools. Regarding agriculture and animal husbandry, the Limbus are also involved in traditional skill-based works. Limbu males are involved in weaving *dokos* (wicker basket), *namlos*, *damlos* (band of jute or bamboo strip), making ploughs, and many other items, while Limbu females are involved in weaving cloths such as shawl, *topi* (cap), etc. Limbu women were famously known as weaver of

clothes with hand-loom but it is becoming very limited now. Many age-old systems of craft traditions are threatened and challenged thanks to the pervasiveness of globalization and late capitalism.

Limbus of these both VDCs mostly use the local amenities, appliances, tools, trappings and means of mechanisms for producing, manufacturing and processing home appliances, articles, objects and foodstuffs. They have the knowledge necessary to make things such as wooden plough, vessels, mouse traps, bows and arrows, drums, and so on. They use *dhinki* as a rice mill and *janto* as a flour grinder.

Limbu people are involved in maintaining ecological and cultural balance by planting and conserving different species of plants, and nurturing animals and insects. Such species have religious, environmental and economical values. For them, every natural phenomenon is related to their life activities that help continue the life cycle. They know of the significance of natural things-how one is dependent upon another and how important they are for the lifecycle of an entire world. That is why they worship and conserve all natural phenomena. The practice of keeping balance in the ecosystem, biosphere and life-cycle is the result of their long experiences attained from the past generations and hence, is a valuable indigenous skill and knowledge system.

Limbu indigenous knowledge as cultural heritage

The Limbus are very rich in terms of indigenous knowledge and cultural heritages as they have their own mother tongue, folk culture, including folk literature, folk beliefs and practices, folk dance and music, folk art and artifacts, tools, games, food, clothing and housing, festivals, rituals, and traditional healing practices. They possess a very precious tangible and intangible cultural heritage that has been handed over them one generation to the next. The Limbu tangible cultural heritage refers to the all material cultural elements that have made the Limbu community distinctive. These include: costumes, food items and liquor, musical instruments for ritual performances, traditional weapons and instruments or tools, architectural designs, traditionally Limbu specific wooden products, bamboo-products, and many more.

The Limbu intangible cultural heritage (LICH) refers to a variety of categories: firstly, oral traditions/folklore such as Mundhums², proverbs, folk songs like *palams* and *khyali*, cultural songs like *hakpare*, riddles, various folk sayings, puns, charades, folktales, folk narratives, and so on. Secondly, LICH has been enriched by Limbu performing arts like *chyabrun* (a kind of Limbu drum) dance, ritual/shamanistic dances, *ya?lang* (paddy dance), and *hakpare*. Thirdly, LICH encompasses social practices, rituals and festive events: worships and rites of passage, births, wedding

2. Mundhum is the Kirat (Limbu) ritual/religious narrative texts, both in oral and written form, consisting of legends, folktales, prehistoric accounts, sermons; moral or philosophical exhortations and so on in poetic language.

and funeral rituals, kinship ceremonies, settlement patterns, culinary traditions, status ceremonies, seasonal ceremonies, gender-specific social practices, and hunting and gathering practices. Fourthly, LICH also encompasses knowledge and practices concerning nature and the universe including traditional ecological knowledge, ethno-biology, ethno-botany, ethno-zoology, traditional healing systems, rituals, beliefs, esoteric sciences, initial rites, cosmologies, shamanism, festivals, language, as well as visual arts.

In the Limbu community, the learning system of indigenous knowledge and skill is another notable practice. New generations learn a lot from the older generations. Traditional specialists like herbalists, shamans, old men and women impart knowledge and skills such as the study of Mundhum, origin myths, philosophies, legends, sermons, riddles, proverbs, charades, folklores, daily life activities, rituals, ceremonies, rite of passages, medication, among others are imparted from them.

In Limbu folk literature, the Mundhum is a broad umbrella term that incorporates legends, myths, folklores, prehistoric accounts, sermons and moral and philosophical exhortations in poetic language. They have a long tradition of narrating or reciting Mundhum and performing certain rituals and ceremonies in their own distinctive ways. The Limbus express their inner feelings and moral contents in beautiful proverbs and charades. The riddle is another popular genre among them. The Limbu youths sing *palam* in their daily lives on the way to forests, while working in fields and perform *ya?lang* or paddy dance on wedding ceremonies, death rites, fairs and festivals. Elderly Limbus narrate various types of secular and supernatural stories, heroic deeds and folktales. All these folk literatures are integral parts of the Limbu folklore.

Limbu folklore can be divided into narrative and non-narrative categories in accordance with the method of performance. The narrative category comprises of devotional Mundhum, myths and legends, and non-devotional folklores like folktales, supernatural stories, quasi-local and historical accounts, legendary characters and so on. The non-narrative one consists of songs, folk sayings, dances and dramas. The Limbus residing in Tiringe VDC and Yangnam VDC have been performing their own religious rituals guided by their oral religious texts. It is often recited orally by actants, ritual practitioners, healers, or shamans such as Phedanngma, Samba, Yeba, Yema, Mangba, Yuma and Ongsi. It contains legends, mythology, history, tales, songs, psalms and so on and that are recited during cultural and ritual occasions.

Among folk dances, *ya?lang* (paddy dance) and *Kelang* (drum dance) are the most popular dances in Limbu society. Such folksongs and folkdances, performed in the community, have great value and significance for they help demonstrate the socio-cultural and historical heritage as well as depict the tradition, culture, behavior and life styles of the people. Among Limbu folksongs, *palam* and *sarek* or *khyali* are recreational songs. They can be sung at any place and on any occasion. Even though

they are recreational songs, they also provide us with a lot of historical information, ongoing activities, and upcoming plans and aspirations. Limbu youths, while dancing *ya?lang*, exchange their feelings of love and affection, experience of pain and pleasure through melodious and heart-rending tune of *palam*, a folk song literally known as “a course of holding talks.” *Palam* is a folksong traditionally sung only during *ya?lang* performance. The *palam*, in the view of Nar Bahadur Yanghang (1995), “is a *ya?lang* song, a medium to exchange feelings of love and affection, [it] includes major elements of Limbu folk culture” (P. 1). Another poetic song called *Sarek* or *khyali* is an esteemed short-tuned and a versed tête-à-tête expressed in the dialogue. It is also called *panthak* (debate) or *panchang* (discuss) and is performed during before the beginning of the *ya?lang* and while bidding farewell (especially between male and female).

Similarly, *Hangsamlang*, or *Thebalang* typifies the ritual dance and is also known as the majestic power dance of *theba* (grandfather). It is performed by displaying weapons like *pheja* (khukuri), *li: tong* (bow and arrow), *kongphe* (sword), *kho* (shield) by playing musical instruments such as the *tangke* (kettledrum) and the *ta* (cymbals). *Tamkye-lang*, a dance relating to agriculture, is performed while weeding the corn plants. The devotional song called *Mang-sewa-samlo* and the dance *Manglang* are performed both in the communities of mainstream Mundhum followers and followers of the Satyahang group. The Limbu performing arts thus include numerous cultural expressions that reflect human creativity, a feeling of attachment towards a place, memories, and spirituality. Additionally there are cultural festivals such as Chasok-thisok (harvest festivals), Yokwa (celebrated with the worship of agricultural divinities before cultivating the field), Kokphetla teyan (the first day of *kokphetla* month, that is, on mid- January), Sisekla teyam (the first day of *sisekla* month that lies on mid-July), etc. Such rituals and festive events often take place at special places and time reminding the community’s worldview, historicity and memory, and hence they have marked the Limbu identity.

Limbu traditional garbs, musical instruments, and language hold great value in shaping their cultural identities. Traditionally, males put on *taga* (*ba*) and female wear *mekhli*. Limbu folk musical instruments are Niyari Hongsing Ke, Chyabrun, Miklakom, Simikla, Chethya/Yethala, Ta, Tungeba, Ungdung, Yalambar Baja, Tetlafakwa, Mephrama, Negra, Yea Pongey, Puttungey, Phakwa, Phamuk, Phenjekom and Megphama. For the Limbus, archery has always been considered the main traditional sport. Historically, Limbu cavalry archers were the key troops required to resist certain invasions during the pre-unification era of Nepal. But now, archery is only used during ritual demonstrations as parts of leisure activities.

Thus, social practices, rituals and festive events help structure or shape the lives of the Limbus and reinforce a sense of shared and common identity. It holds the

image of nature and daily activities, culture and surroundings. For instance, they call an elephant 'takmiba' which means as 'possessing a tail at the front.' Similarly, 'takka (t)' means 'a supporting object' or stick. They call mushrooms 'neghakring' or 'po (t)' which means 'resembling a *nebhak* 'an ear'. 'Po (t)' also means to an object which is 'raised up a bit.'

Hence, the Limbus have retained their own indigenous knowledge system and sets of cultural heritages which bear a very intimate and interdependent relationship. But today, these Limbu heritages suffer a lot from modernization, globalization and climate changes/global warming.

Conclusion

The Limbus, the original inhabitants of the research areas, possess much treasured indigenous skills and knowledge inherited from past generations. Because of their in-depth knowledge of the land, vegetation and biosphere, the Limbus have been playing particularly an important role in exploring and actively utilizing these skills and knowledge. Such an implicit indigenous knowledge system proves that they are the autochthons of these territories. They were found closely connected to the vicinity, ecological surroundings, vegetation and environment, and thereby formulating their deep-seated culture, tradition and way of life. There is a close nexus between their Indigenous Knowledge (IK) and their identity. The Limbus are recognized through various tangible and intangible cultural heritages that provide them with a sense of identity and continuity.

It is a fact that those who live on the land for long gain knowledge on resources, the functioning of ecosystems, and the relationship between the environment and their culture. Manila Declaration (2002) on 'Conflict Resolution, Peace Building, Sustainable Development and Indigenous Peoples' has declared that "States, indigenous peoples, broader society, and the international community must respect and nurture indigenous knowledge" (P. 558). Hence, the stakeholders need to understand what an indigenous knowledge is, how it evolves in response to changing living conditions and how it can be combined with an appropriate modern knowledge, particularly in areas such as biodiversity conservation, health promotion, agriculture, and cultural development.

If properly utilized, the indigenous knowledge has a great potential to develop a broader system of knowledge nationally and globally. But if it is misrepresented or misused, it can surely bring no positive results. Due to the impact of modernity, globalization and lack of empowerment, most of the Limbu youths are found disowning the practice of indigenous knowledge system and cultural activities. Although Limbu traditional skills and knowledge are invaluable resources, they are often thought to be primitive ones. Tradition and development are often seen as being paradoxical. The gradual erosion of the indigenous knowledge system owes to the

hegemonic nature of broader knowledge system and multinational corporations in the form of modernity and globalization. Therefore, for sustainable development and proper utilization of the Limbu indigenous knowledge system, the Limbu community itself has to know the significance of Limbu indigenous knowledge system and culture, and then the State and other stakeholders are required to preserve it. The state, multinational companies and institutions should assist in recognizing and enhancing Limbu native skills and knowledge. As Nepal has already ratified the UNESCO convention (2003) for the safeguarding of the intangible cultural heritage in 2010, works on identifying, inventorying, safeguarding and raising awareness programmes are to be carried out. The broader knowledge holders should take free, prior and informed consent (PIC) of local and indigenous communities for any access to and use of their indigenous knowledge, skills and practices. It is incumbent upon the government, industries and multinational companies to recognize the knowledge and skills of indigenous people including the Limbus and to incorporate their knowledge into policies, plans and programmes so as to mutually get benefit from it.

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Violence in Dating Relationship: Extent, Nature and Consequences

Ramesh Adhikari

Geography and Population Department, Mahendra Ratna Campus, Tribhuvan University, Kathmandu, Nepal

Email: rameships@gmail.com

Abstract: *Dating violence is an unexplored issue in Nepal. The objectives of this paper is to explore the nature, extent, and consequences of dating violence and to examine the underlying factors that contribute and perpetuate dating violence among college students in Nepal. Multivariate logistic regression was used for analysis of the responses of 1276 college students who responded to a self administered questionnaire in 2010. Nearly half reported of being a victim of dating violence, with females reporting higher incidences of victimization than males. Violence ranged in severity from unwanted physical touching to rape. Gender, education level, migration status, relationship with parents, and living arrangement had significant association with dating violence. Depression, lack of sexual desire, pain during the intercourse and suicidal feelings were the reported consequences of dating violence. High levels of dating violence and related negative consequences indicate a need for comprehensive programs to address the issue.*

Keywords: *Dating violence, victim, rape and college students, Nepal.*

Background

Dating violence among adolescents and youth is not only an important personal and social issue but also an important from the public health issue. Dating violence is a pervasive and serious problem worldwide (Straus, 2008). Dating violence encompasses several types of abusive behaviors, including emotional, physical, sexual, and psychological ones. Studies show that adolescents and youth are at a crucial developmental stage when a dating relationship is first initiated and when the risk of dating violence first emerges (Hickman, Jaycox, & Aronoff, 2004). Researchers have documented that dating violence has a negative impact on victims' physical, mental, sexual health, and social functioning (Banyard & Cross, 2008; Lewis & Fremouw, 2001; Silverman *et al.*, 2001).

Dating violence is associated with negative mental health outcomes, including depression (Howard *et al.*, 2003), and suicide ideation (Ackard *et al.*, 2003). Studies also found that dating violence is also associated with an increased participation in risky health behaviors including early initiation of sexual intercourse, unsafe sex, and intercourse with multiple sex partners (Howard & Wang, 2003). Similarly, studies also found that adolescents who had experienced dating violence were likely to use cigarette, alcohol, and twice as much drug as those who had not been the victim of dating violence (Ackard *et al.*, 2003).

Dating violence does not appear to be consistently associated with gender. Some studies found the prevalence of dating violence greater among females (Ackard *et al.*, 2003); others found the greatest prevalence among males (Jezl *et al.*, 1996; O'Keefe & Treister, 1998) while most studies of college students have found that men and women have similar rates of victimization (Foshee, 1996; Howard *et al.*, 2003; Harned, 2001; Katz *et al.*, 2002; Romito & Grassi, 2007).

Researches on sexual aggression have increasingly focused on dating violence, especially rape in a dating relationship (Ward *et al.*, 1994). However, there is not a single study that has focused on dating violence in Nepal. Most of the studies conducted in Europe and the U.S. found that reported rates of physical violence in dating relationship among high school students vary from 12% (Bergman, 1992) to 59% (Jezl *et al.*, 1996). One national survey conducted in the USA found that over the course of their college career, one fifth to one quarter of college women experienced a completed or attempted rape and 9.5% to 66.4% had experienced other forms of sexual victimization (i.e. unwanted sexual contact and sexual coercion).

In Nepal, more than one third of the country's population consists of adolescents and youths (CBS, 2012). Most of the college students are adolescent and youth. Despite the fact that young people comprise a significant proportion of the population of the country, poor attention is given to their behavioral patterns, sexual and reproductive health problems. Violence in dating relationship has always been a topic neglected by researchers, policymakers and program designers in Nepal as well as in most of the other Asian countries. Since sexual violence has negative impact on reproductive and sexual health such as unwanted pregnancy and sexually transmitted infections (STIs), the government has a major responsibility in protecting the vulnerable population from violence. However, no strategies or programs have been proposed in the newly developed adolescent reproductive health strategies of the government to prevent violence and provide care and support to the victims. This may be due to the fact that there is no systematic documentation on this issue in Nepal. Concrete evidence is needed for policy formulation and designing educational programs and health services.

This article explores the nature, extent and consequences of dating violence, and examines the potential underlying factors that contribute and perpetuate dating violence among college students in Nepal. The findings will help fill the gap in literature. The findings will also be useful for the government to devise a plan and initiate activities; it will help (I) NGOs and rights activists to advocate on the issue and to design appropriate sexual and reproductive health care interventions for young people in Nepal.

Methods

The data used in this paper comes from a cross-sectional survey entitled *Exploring the Nature and Extent of Dating Violence among College Students in Nepal* carried out in

2010. A multi-staged random sampling technique was employed for the selection of male and female college students. In the first stage, 20 colleges from five out of seventy-five districts of Nepal were selected randomly. In the second stage, two classes were selected randomly from each sampled college. In each class 32 students were selected randomly. A self-administrated structured questionnaire in Nepali language was used to obtain information from the students. The questionnaires were pre-tested among college students in a non-selected college and later refined as required. Four male students who were selected for interview refused to participate in the study. A total of 1,276 college students (636 males and 640 females) were interviewed.

A consent was obtained verbally from the participants before they were enrolled in the study. The consent form was signed in the Nepali language stating the study's objectives, nature of participant's involvement, risk and benefits, and ensuring confidentiality of the data. Students were requested to read the consent form carefully. Participants were given a clear option of voluntary participation. It was also made clear that they could refuse to answer any questions and terminate the interview whenever they desired. Confidentiality of information was also ensured by removing personal identifiers from the completed questionnaires.

Both bivariate and multivariate techniques were applied to identify the factors associated with the likelihood of being the victim of dating violence. The Chi-square test was used to test the association. The variables were re-examined in the multivariate analysis using binary logistic regression in order to identify the significant predictors after controlling other variables.

Results

Background characteristics of the sampled population: An overwhelming majority of the students (91%) were in the youth category (15-24 years) and 87% of the students were unmarried. More than two-thirds (70%) were migrants from different districts. About a quarter of the students were working part-time. Furthermore, about a third of the students reported that their relation with parents was neither good nor bad. More than half of the students (57%) reported that their source of family income was agriculture. More than a third of the students (37%) were living alone or with friends. About a fifth (18%) frequently consumed alcohol. More than three-fifths of the students had exposure to pornographic movies (Table 1).

Demographic, socio-economic and cultural correlates of dating violence: Slightly less than half (46%) of the 1276 students (n=588) had experienced dating. A significantly higher proportion of male (55%) than female (37%) reported that they had experienced dating. About half the students (47%) reported being a victim of dating violence. Females (55%) reported a higher incident of victimization than males (43%). Similarly,

violence was significantly higher among those who were aged 20-24, were from Mongolian ethnic group (Rai, Tamang, Gurung, Magar), who had Master's level education, who were migrants, and who did not have a good relation with their parents (Table 1).

Tables 1. Characteristics of students, and experience of dating violence interms of demographic, socio-economic characteristics and peer characteristics

	% of sample students (N=1276)	% of students who experienced violence from dating partner (n=588)
Sex of the respondents		**
Male	49.8	42.5
Female	50.2	54.9
Age group		*
15-19	23.5	37.3
20-24	67.7	50.5
25 and above	8.8	48.1
Level of education		*
Intermediate	34.8	49.5
Bachelor	46.2	42.4
Masters	19.0	57.1
Religion		ns
Non-Hindu	4.1	57.6
Hindu	95.9	46.8
Migration status		**
Non-migrant	29.8	37.9
Migrant	70.2	51.3
Working status		ns
Not working	76.4	47.8
Working	23.6	46.7
Relationship with parents		*
Very good/good	69.7	45.5
Neither good nor bad/bad	30.3	51.3
Living arrangement		*
With family members	65.1	46.0
Without family members	34.9	49.2

Alcohol consumption		ns
Never/rarely drunk	82.4	48.5
Frequently consumed	17.6	44.2
Exposure to pornographic		ns
No exposure	38.0	49.4
Moderate exposure	58.2	47.2
High exposure	3.8	41.0
Peer drinking habits		Ns
Never/rarely drunk	71.2	49.9
Frequently consumed	28.8	44.0
Have unmarried friends who have sexual intercourse		ns
No	58.7	46.5
Yes	41.3	48.0
Total	100.0	47.4

Note * Significant in Chi-square test at $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Multivariate analysis: These observed associations in bivariate analysis were reassessed by logistic regression to identify the adjusted association with the probably of being a victim of dating violence. The results are presented in table 2. As can be seen from the table, variables such as age, sex, level of education, migration status, relationship with parents, and the living arrangement were significant predictors of experience of dating violence after controlling other variables. For instance, female students were 2 times (aOR=2.09) more likely to experience dating violence than male students. Student aged 20-24 were more likely (aOR=1.76) to experience dating violence than the students of 15-19 age group. Those students who had a Bachelor's degree were 37% less likely (aOR=0.63) to experience dating violence than students who were studying intermediate level (11-12 grades). Migrants students were more likely to experience dating violence (aOR=1.68) than non-migrants students. Those students who had neither a good nor bad relation with their parents were 30% more likely (aOR=1.30) to experience dating violence than those who had a very good or good relation with their parents. Furthermore, those students who lived without parents were more likely to experience dating violence (aOR=1.23) than those who lived with family members (Table 2).

Table 2. Adjusted odds ratios (aOR) for experiencing dating violence by demographic, socio-economic and peer characteristics

		β	OR	95% CI
Sex	Male			
	Female	0.74	2.09**	1.33-3.32
Age group	15-19			
	20-24	0.57	1.76*	1.10-2.82
	25 and above	0.25	1.28	0.59-2.73
Education level	Intermediate			
	Bachelor	-0.46	0.63*	0.42-0.96
	Masters	0.093	1.09	0.63-1.92
Religion	Non-Hindu			
	Hindu	-0.086	0.92	0.39-2.16
Migration status	Non-migrant			
	Migrant	0.52	1.68*	1.11-2.54
Working status	Not working			
	Working	0.045	1.05	0.71-1.53
Relationship with parents	Very good			
	Neither good nor bad/bad	0.24	1.27*	1.08-1.83
Living arrangement	With family members			
	Without family members	0.21	1.23*	1.03-1.82
Alcohol consumption	Never/rarely drunk			
	Frequently consumed	-0.17	0.85	0.55-1.31
Exposure to pornographic movie	No exposure			
	Moderate exposure	0.28	1.33	0.84-2.09
	High exposure	0.29	1.34	0.59-2.99
Peer drinking habits	Never/rarely drunk			
	Frequently consumed	-0.01	0.99	0.66-1.48
Have unmarried friends who have sexual intercourse	No			
	Yes	0.13	1.13	0.76-1.69
Intercept			0.302*	
-2 Log likelihood			763.07	
Cox & Snell R Square			0.108	

Note * Significant at $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Types of dating violence: More than a quarter of females reported that they were victims of unwanted touching (28%) and unwanted kissing (28%), while more than a quarter males (26%) reported that their girlfriends became angry when they talked with other girls. Percentages of reporting victimization of unwanted kissing (6%) and unwanted

touching (4%) were low among males. The percentage of students reporting being slapped by their partner is higher among males (11%) than females (6%). Almost one out of ten (8%) females reported that their male partner had attempted rape. Notably, about one in twenty females (5%) reported that they were victims of rape by their partners (Table 3).

Table 3. Types of dating violence experienced by boys and girls

Forms of dating violence experienced (% yes only)	Boys	Girls	Total
Angry while talking to other	26.2	19.0	23.3
Slapped	11.4	5.9	9.2
Unwanted kissing	5.7	27.8	14.6
Unwanted physical touching	3.7	27.8	13.4
Attempted rape	-	8.4	4.1
Raped	-	4.6	2.2
N	351	237	588

Consequences of dating violence: Victimized students reported various consequences due to dating violence. For instance, more than half (56%) of the males and about half (47%) of the females had suffered periodic depression after the violence. About one in five male students (18%) reported that they had started having sexual intercourse at an early age while about a tenth (9%) reported that they had had sex with multiple partners. About a fifth of the males and a tenth of the females didn't use condoms during sexual intercourse. About a fourth of the (24%) females and a tenth of the males (12%) reported that they had lack of sexual desire. Eight percent of males reported that they have smoking and alcohol consuming habits due to dating violence. Furthermore, more than a tenth of the females (12%) reported that they had pain during sexual intercourse. Almost one in ten female victims (8%) had contemplated suicide due to dating violence (Table 4).

Table 4. Consequences of dating violence experienced by boys and girls

Consequences experienced	Boys	Girls	Total
Periodic depression	56.0	47.2	53.5
Smoking and alcohol consuming habits	8.0	-	5.7
Drug taking habit	3.1	-	2.2
Sex in the early age	18.2	3.4	14.0
Sex with multiple partners	8.9	2.2	7.0
Not using condom during sexual intercourse	18.7	9.0	15.9
Lack of sexual desire	11.6	23.6	15.0
Sexually transmitted disease	4.9	-	3.5
Pain during sexual intercourse	1.8	12.4	4.8
Suicidal ideation	0.9	7.9	2.9
N	351	237	588

Discussion

The main objective of the study was to examine the prevalence and the context of dating violence and to explore the underlying factors that contribute and perpetuate dating violence among students. As in other parts of the world, violence in dating relationships is a serious problem among college students in Nepal. This study shows that about a half of the students reported of being a victim of dating violence. As noted earlier, dating violence has received the majority of scholarly attention. Such studies mostly utilize U.S. college student samples and have shown that a third to a half of all girls and boys experienced some form of sexual violence (Barter, 2009).

Females who are between 20 and 24 years of age, who are migrants, and who didn't have a good relation with parents, and those who live without their family members were more likely to experience dating violence than their comparison groups.

This study found that female students are more likely to experience dating violence than males. The result is similar to many other studies (Ackard *et al.*, 2003). Similarly, this study also found that migrant students are more likely to experience violence than non-migrants students. It could be due to the fact that these students are far from their parents/relatives and do not have any family support. Since the students do not live with their parents, they have less parental supervision and thus are free to date or visit any place at any time.

The study found that being a victim of physical violence is more common among males than females which are consistent with the previous research (Simon *et al.*, 2010). Whereas, acts of sexual violence such as unwanted kissing, unwanted physical touching, attempted rape and experience of rape by their dating partners are more common among girls than boys. The findings are similar to previous studies (Hickman *et al.*, 2004). Other studies also reported that girls are more likely to be victims than boys, and the nature of the sexual coercion is different as well (Swan & Snow, 2002).

Both male and female students have experienced several consequences due to dating violence. Almost half of the boys and girls reported periodic depression. A substantial proportion of females reported a lack of sexual desire and pain during sexual intercourse as consequences of dating violence. Similarly, a higher proportion of females than males reported that they had contemplated suicide after the experience of dating violence. This could be due to the fact that female students had faced more severe sexual violence from their partners than the male students. The findings are similar to the finding of Chan and Straus (2008) who found that females reported higher levels of suicide ideation than the males.

This study has some limitations. First of all, the data is from a cross-sectional survey; all the factors analyzed in the study were measured at a single point in time. Therefore, the analysis can only provide evidence of statistical association between

variables. Secondly, all the information was gathered using self-administrated questions. The self-report method itself is subject to errors due to unreliable memory and intentional false responses, thereby possibly reducing reliability of date and validity of the findings. However, the use of anonymous self-administered questionnaire and the provision of privacy are likely to have minimized the purposeful misreporting.

The study contributes to the literature by comparing the occurrence of dating violence between males and females, thus offering a more complete picture about the issues related to dating violence and its consequences. The findings can be useful for policy makers and planners to design programs to improve the health among the youth population. Findings of this study will also be beneficial for governmental or non-governmental organizations and rights activists in designing appropriate interventions related to violence in Nepal and launching advocacy programs.

The study shows that nearly half of the sample surveyed reported that they had been a victim of dating violence, with females reporting a higher incidence of victimization than males. Moreover, violence ranged in severity from unwanted physical touch to rape. Gender, level of education, migration status, relationship with parents, and living arrangements had significant associations with dating violence. Depression, lack of sexual desire, pain during intercourse, and suicidal ideation were reported as consequences of dating violence. It would be beneficial if efforts include programs as well as support services for the victims. It would also be beneficial to launch education program not just for students but for the entire college community, which plays an essential roles in promoting the health and well being of young people.

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Mixed Methods Research: A Blessing

Krishna Bahadur Rai

School of Education, Kathmandu University, Kathmandu, Nepal

Abstract: *The purpose of the article was to review the existing literature on the strengths of mixed method research which is becoming a popular way of searching the realities by blending both quantitative and qualitative methods. Paradigm wars in research are the pertinent issues to claim truth (s). In this line, the researcher shows the significance of paradigmatic orientation as a milestone to measure findings, in the debate of using Mixed Methods. I argue that Mixed Methods Research (MMR) is a research paradigm that dismantles the dualism of qualitative and quantitative methods. In doing so, I argue that MMR is proved to be a blessing to explore human emotions, feelings, and their subjective realities along with quantifying the tangible indicators of truth wherever needed. The article reviews the established concepts, design and methodologies of MMR adjoining with pragmatism and transformative approach. Moreover, this article advocates that MMR is a blessing for rigorous methodological tool in searching practical results through the blending of QUAN and QUAL features.*

Keywords: *Mixed methods research, quantitative, qualitative, research paradigm.*

Introduction

Having reviewed the competing paradigms of research methodologies, I believe that Mixed Methods Research (MMR) can be a new generation of research praxis that mixes the features of both quantitative (QUAN) and qualitative (QUAL) methods as “championed by writers such as John Creswell, Abbas Tashakkori, Burke Johnson, Anthony Onwuegbuzie, Jennifer Greene, Charles Teddlie, and David Morgan. The mixed methods approach has come in practice as a research moment with a recognized name and distinct identity (Denscombe, 2008, p. 270). I found various writings that consider MMR, “as an alternative to the dichotomy of qualitative (QUAL) and quantitative (QUAN) traditions during the past 20 years” (Teddlie & Tashakkori, 2009, p. 4); they illustrate its applicability in social science research. The scholars have taken MMR as a combination of multiple ways of seeing and hearing (Greene, 2007, p. 20). It has also been called the third path (Teddlie & Tashakkori, 2009, p. 4). The question came to my mind, “how MMR is a *blessing* in the research world?” I found, many scholars who have accepted “the complexity of our research problems and call for answers beyond simple numbers in a quantitative sense or words in a qualitative sense. A combination of both forms of data provides the most complete analysis of the problem” (Creswell & Plano Clark, 2011, p. 21); thus, MMR might be increasingly articulated and applied in research practices but differences may arise due to the researchers’ state of articulations. MMR is recognized as the third approach or research paradigm (Johnson, Onwuegbuzie & Turner, 2007, p. 112). It combines both material-view-points and humanistic aspects, and produces the conclusions that are different from those that apply a single approach.

I believe on 'practice' and 'debate-free state' where a large numbers of researchers enjoy their lives and who guided by Pragmatism and transformative perspective as the rejection to forced choices between positivism/postpositivism and constructivism with regard to methods, logic and epistemology (Teddlie & Tashakkori, 2009, p. 87). Pragmatists are more likely to view research as a holistic endeavor that requires a prolonged engagement, persistent observation and triangulation (Lincoln & Guba, 1985 as cited in Onwuegbuzie & Leech, 2005, p. 383). It can be seen as a radical form of empiricism. However, it has also been interpreted as an integration of empiricism with elements of rationalism (Scott & Briggs, 2009, p. 226). Similarly, the transformative paradigm, with its associated philosophical assumptions, provides a framework for addressing inequality and injustice in society by using cultural competency through mixed methods strategies (Mertens, 2007, p. 212). Thus, the pragmatism and transformative perspectives inform MMR as a blending of the strengths of both QUAN and QUAL which drives the society towards positive changes.

Paradigm wars

The positivism and postpositivism could not satisfy all of the issues of human society. Therefore, the researchers identified the other methods of research like constructivism and interpretivism. The constructivists/interpretivists focus on micro understandings and believe that "knowledge of the world is mediated by cognitive structures" (Teddlie & Tashakkori, 2009, p. 72). The thesis of incompatibility, incommensurability, antipositivism and purism took the greater field of paradigm wars and as a result, it was divided into three camps rather than integrating the strengths of all types. As noted by Rossman and Wilson (1985), three major schools of thought have evolved from the quantitative–qualitative paradigm wars, namely *purists*, *situationalists* and *pragmatists*. These camps were conceptualized as lying on a continuum, with purists and pragmatists being on opposite ends, and situationalists remaining somewhere between the purists and pragmatists (as cited in Onwuegbuzie & Leech, 2005, p. 376). Purists posit that quantitative and qualitative methods stem from different ontological, epistemological and axiological assumptions about the nature of research (Onwuegbuzie & Leech, 2005, p. 375).

Quantitative purists believe that 'social science inquiry should be objective', that is, time and context-free generalizations are desirable and possible, and the real causes of social scientific outcomes can be determined reliably (Nagel, 1986). On the other hand, the qualitative purists (also called constructivists and interpretivists) reject what they call positivism (Johnson & Onwuegbuzie, 2004, p. 14). They challenge the quantitative purists stably that multiply-constructed realities abound, that time and context-free generalizations are neither desirable nor possible, that research is value-bound, that it is impossible to fully differentiate causes and effects, that logic flows

from specific to general and that knower and known cannot be separated because the subjective knower is the only source of reality (Guba, 1990 as cited in Johnson & Onwuegbuzie, 2004, p. 14). The purists do not accept the integration of qualitative and quantitative paradigms. It raises the question: how can the criticisms of each other be addressed without identifying the fusion-point of both purists' aspects? Can society exist without mixing both aspects (i.e. QUAN and QUAL) ? The lingering negative legacy of the paradigm wars of the 1980s (Denzin, 2010, p. 423) stressed on identifying a common way of addressing the opposite debates. As a result, the third moment was started with Pragmatism with multiple interpretive practices, and as a result bricolage became paramount (Denzin & Lincoln, 2005, p. 4).

The third moment

Amidst the paradigm wars, pragmatism is more preferable as many people, from historical figures such as Dewey, James, and Pierce to contemporaries such as Murphy, Rorty, and West have practised and advocated it. It believes on "what works," using diverse approaches and values both objective and subjective knowledge and blends both QUAN and QUAL approaches to make the research rigorous. The *pragmatic rule* or *maxim* or *method* states that the current meaning or instrumental or provisional truth value (which James, 1995 would term "cash value") of an expression (e.g., "all reality has a material base" or "qualitative research is superior for uncovering humanistic findings") is to be determined by the experiences or practical consequences of belief (Johnson & Onwuegbuzie, 2004, p. 16). The worldviews of material base (QUAN) which believes in generalizability and humanistic insights (QUAL) which consider multiple realities and credibility in the process of research for producing more contextual findings.

The first applicability of MMR has been to stop paradigm wars through pragmatism. As Creswell (2007) highlighted, pragmatism focuses on the outcomes not on the antecedent questions. It gives researchers a methodological freedom of choice. It rejects traditional dualisms and generally prefers more moderate and commonsense versions of philosophical dualisms based on how well they work in solving problems (Johnson & Onwuegbuzie, 2004, p. 18). I feel that the philosophical dualism spends more time in debates rather than accumulating energy. Pragmatism is a method of settling metaphysical disputes that otherwise might be interminable. Pragmatism focuses a practical consequences (James 1995, p. 18); the truth is, "what works" at the time and recognizes in research is always situated (as cited in Scott & Briggs, 2009, p. 225). In direct opposition to the 'purists', the pragmatists argues against a false dichotomy between the qualitative and quantitative paradigms and call for the efficient use of both approaches (Cameron, 2009, p. 140). It also rejects the *either/or choices* associated with the paradigm wars. Pragmatism invites mixed methods in

research and acknowledges that the researcher plays a large role in the interpretation of results (Teddlie & Tashakkori, 2009, p. 8).

Secondly, it recognizes the fact that realities are constructed and shaped by social, political, cultural, economic, and racial/ethnic values. Such values indicates the power and privilege, which are major determinants of the privileged reality in a research context (Mertens, 2007, p. 212). It also reveals the potential strength of combining qualitative and quantitative methods. Thus, pragmatism and transformative approach have mitigated the paradigm wars and promoted MMR. Thus, I argue that pragmatism and transformative approach I challenge the incompatibility thesis through the mixing of QUAL and QUAN, and call for a peaceful coexistence between two polarized paradigms. Today, many scholars take to mono-method research as a biggest threat to the advancement of the social sciences. Indeed, as long as we stay polarized in research, we cannot provide clearer ways to stakeholders who rely on our research findings to take our work seriously (Onwuegbuzie and Leech, 2005, p. 384).

The third methodological moment started from the early 1980s; it has been described as a 'quiet' revolution due to its focus on resolving the tensions between qualitative and quantitative methodological movements (Tashakkori & Teddlie, 2003, p. 697). I take this moment as a blessing in the research world. Hurmerinta-Peltomaki and Nummela (2006) stated that none of the viewers will capture the richness of the whole at one glance. This metaphor follows the reasoning of McGrath (1982), who argued that all research methods are imperfect and incomplete (p. 440). The qualitative researchers are perhaps 'handicapped by a lack of quantification and small numbers of observations', whereas quantitative researchers may sometimes suffer from 'procrustean quantification and a jumble of dissimilar cases' (Cameron, 2009, p. 141). Therefore, scholars have promulgated MMR as a way of minimizing such kinds of situations so as to the validity and credibility of research works.

Philosophically, the pragmatists reject the 'dogmatic position of either quantitative or qualitative' but believe in the *inductive-deductive research cycle* (Teddlie & Tashakkori, 2009, p. 87). The transformative perspective believes in the potential strength of MMR to provide a basis for social change (Mertens, 2007, p. 212). The intrinsic limitations of objective knowledge and the social construction of human inquiry require an acknowledgment of the subjective and rationalist dimensions as being unavoidable facts (Scott & Briggs, 2009, p. 231). The researchers may become stuck in a dilemma of either QUAN or QUAL debate. Social experiences and lived realities are multi-dimensional and our understandings are impoverished and, may be inadequate if we view these phenomena only along a single dimension (Mason, 2006, p. 10). Thus, methodological pluralism has been strongly encouraged as a means of triangulation. Mingers (1997) argues for a strong pluralism or multi-methodology which takes the position that most situations would be dealt with more effectively with a blend of methods from different paradigms (as cited in Cameron, 2009, p. 143).

Moreover, triangulation requires a combination of qualitative and quantitative approaches in the same study (Creswell & Plano Clark, 2011, pp. 8 - 9). In the first version of the third moment, triangulation discourse gets new legs. It appears in multiple-mixed and multiple models, from Morse (2003) to Creswell, and others. Triangulated designs, combining QUAN and QUAL methods have become a basic part of new language (Denzin, 2010, p. 422). Patton (2002) has stated four events of triangulation methods triangulation, triangulation of sources, analyst triangulation and theory/perspective triangulation (p. 556). The method triangulation introduced by Patton is more applicable to MMR practices.

MMR combines both exploratory and explanatory method to address the complexities of social realities. In this line, researchers use MMR with the belief that no single approach can fully investigate the phenomenon, particularly when the phenomenon is complex and multifaceted (Fidel, 2008, p. 226). The quantitative approach has the strength of accurate operationalization and measurement of a specific construct but the measurement typically detaches information from its original ecological "real-world" context (Moghaddam, Walker & Harre, 2003), a phenomenon referred to as *decontextualization* (Viruel-Fuentes, 2007). In contrast, the qualitative approach examines the "whole person" holistically within that person's natural environment—a fully *contextualized* approach (Castro, Kellison, Boyd & Kopak, 2010, pp. 342- 343). One step towards accomplishing this is to re-frame the concept of research in the social and behavioral sciences by de-emphasizing the terms quantitative and qualitative research and, instead, subdividing research into *exploratory* and *confirmatory* methods (Onwuegbuzie & Teddlie, 2003).

The third moment in MMR can be taken as a rejection of *either-or* position for producing the conclusions which would be the representation of lived realities. In this sense, MMR has been taken as the means of pragmatism and transformative approach where *social practices* are prioritized. I argue that the third moment is the need for social research, which allows us to be pragmatic and transformative.

Shared epistemology and axiology

The word 'epistemology' concerns the relationship between the knower (the researcher) and the known (the participants) (Teddlie & Tashakkori, 2009, p. 89). Epistemological questions include, "if I am to really know something is real, how do I need to relate to the people from whom I am collecting data?" So the knower is the researcher, and the would-be-knowns are participants in the study (Mertens, 2007, p. 215). Positivists and postpositivists perceive the relationship as being objective based on the dualism between the knower and the known. On the other hand, constructivists perceive this relationship subjectively with the researcher and participants working together to co-construct the social reality (Teddlie & Tashakkori, 2009, p. 90). My claim is that MMR shares the epistemological viewpoints of both the

sides (positivism/postpositivism and constructivism/interpretivism). Pragmatists reject the polarization of objectivity and subjectivity and play the role of a peacemaker in the paradigm wars (Scott & Briggs, 2009, p. 224). The peacemakers would be honest for establishing shared epistemology from both paradigms. In the same line, transformative scholars also value objectivity and subjectivity for changing the world positively. Mertens (2007) states that for the epistemology to be transformative, it is necessary to have an interactive link between the researcher and the participants. Knowledge is socially and historically located within a complex cultural context. Respect for culture and awareness of power relations is critical (p. 216). Epistemologically, MMR is open to multiple ways of knowing and thus, is a more credible and acceptable way of searching for realities.

Axiologically, positivists believe that an inquiry is value-free; whereas constructivists believe that the inquiry is value-bound. Postpositivists acknowledge both the value-free and theory-ladenness of facts (Teddlie & Tashakkori, 2009, p. 90). But the pragmatists and transformative scholars give equal importance to the enquiries, which are both value-free and value-laden. "Pragmatists believe that values play a large role in conducting research and drawing conclusions from their studies but they see no reason to be particularly concerned about it" (Teddlie & Tashakkori, 2009, p. 90). The axiological stance of the transformative paradigm is slightly different from pragmatists as they believe in three basic principles underlying the regulatory ethics in research: respect, beneficence and justice. Respect is critically examined in terms of the cultural norms of interaction within a community and across communities. Beneficence is defined in terms of the promotion of human rights and an increase in social justice. I found the axiological stand of MMR has three aspects: value-free, value-laden and social justice which invite the multistep testing of realities (Mertens, 2007). The axiological premise is broader than a single paradigm and new in the field of social research.

MMR thus is a new and comprehensive way of understanding social realities. Scholars who practise MMR have developed typologies of mixed design based on their characteristics and functions (Teddlie & Tashakkori, 2006, p. 12).

Methodological mixing

In the mid-1980s, scholars began expressing concern that they were indiscriminately mixing quantitative and qualitative methods and forms of data without acknowledging or articulating the reasons for doing so (Greene *et al.*, 1989). As a result, different reasons for mixing both forms of data in a single study were identified (Hanson *et al.*, 2005, p. 226). Viewed multidimensionally, these relationships are likely to involve elements and practices that are, in varying combination; emotional, sentient, imaginary, spiritual, habitual, routinized, accidental, sensory, temporal, spatial, locational, physical/bodily/corporeal, bio-genetic,

kinesthetic, virtual and probably more (Mason, 2006, p. 11). Thus, methodological mixing has become an alternative approach in the research. The blending of both forms (physical and human sentiments) carries the strengths of QUANs and QUALs, and it offers broader options to explore social realities.

Literally, methodology is a more abstract term than methods and refers to the theoretical assumptions and principles that underpin a particular research approach. It guides how a researcher frames the research questions and decides on what process and methods to use (Giddings & Grant, 2006, p. 5). It is only one of three elements of a paradigm that a researcher either explicitly or implicitly works with (Guba & Lincoln, 1994 as cited in Sobh & Perry, 2005, p. 1194). The ontology and epistemology drives the researchers to actually conduct MMR but the understanding about the philosophical paradigms like QUAN, QUAL and MMR provides the clear vision to look at social problems. "While any research design inherently requires mixing methods, attempts to mix divergent paradigms for data collection and data analysis can have significant consequences with respect to internal consistency among different methodological phases" (Williams & Petterson, 2007, p. 932). For the *consistency of mixing*, MMR requires the philosophical insights regarding ontology, epistemology, axiology and methodology.

From a pragmatist viewpoint, the research methodology captures the *diverse viewpoints* regarding social realities and the best explanations within personal value systems. Pragmatists agree with the positivists/ postpositivists on the existence of an external reality independent of our mind (Cherriholmes, 1992, p. 14). This is not to idealize the "quick and dirty" mode of knowledge production in everyday social practice, which is beleaguered by emotional biases and conceptual blindness. There are good reasons why social scientists are not usually satisfied with intuitive rules of thumb and prefer explicit and intersubjectively valid propositions instead (Friedrichs & Kratochwil, 2009, p. 714). On the other hand, they deny that truth regarding reality can actually be determined. They are also unsure if one explanation of reality is better than any other (Teddlie & Tashakkori, 2009, p. 92). Hence, the researchers of MMR search the realities through wider perspective so that the research findings will capture both the "micro and macro views" (Mason, 2006). This proves my argument that MMR is a blessing in the research world.

Typologies developed in MMR

The typologies introduced by different scholars provide the easy alternatives and clearly guide the researchers to conduct the study through MMR. The mixed method typologies developed by Caracelli and Greene (1997), Tashakkori and Teddlie (2003) and, Creswell and Plano Clark (2007) are taken for reference. These typologies have provided the ways for conducting research. these typologies have provided ways for conducting research and have allowed the researchers to have a clearer hold of the complexities of the research.

Table 1. A typology of mixed method designs from Greene and Caracelli (1997)

Design	Key Features
A. Component Designs	Data gathering methods implemented as separate aspects of the evaluation and remain distinct throughout
1 Triangulation	Findings from one method used to corroborate findings generated through other methods
2 Complementarity	Findings from one dominant method are enhanced or elaborated through findings from another method
3 Expansion	Different methods are implemented to generate results for distinct components of the research study; results presented 'side by side' (Greene & Caracelli, 1997, p. 23)
B. Integrated Designs	Methods integrated throughout the evaluation
1 Iterative	Dynamic interplay of findings generated through different methods throughout the evaluation
2 Embedded or nested	One method is located within another; framework of 'creative tension' (Greene & Caracelli, 1997, p. 24)
3 Holistic	Simultaneous integration of methods throughout the research study, building towards one integrated explanation of results
4 Transformative	Mixing methods to capture differing value commitments which can lead to "reconfiguring the dialog across ideological differences" (Greene & Caracelli, 1997, p. 24)

Source: Teddlie & Tashakkori (2009, p. 161)

Greene and Caracelli (1997) have introduced a typological frame (see table 1) for MMR (Teddlie & Tashakkori, 2009, p. 160) which provides mainly two broad classes of designs i.e. component and integrated. In component design, data collecting methods are implemented as separate aspects of evaluation and remain different throughout the process. The second is integrated design in which, methods are incorporated throughout the process.

Tashakkori and Teddlie (2009) have also developed the multi-strand design typologies in 2003 which is more comprehensive (see Table 2).

Table 2. Two-dimensional framework for multi-strand mixed designs

Design Types	Monostrand design	Multistrand design
Mono-method design	Monomethod monostrand design 1. Traditional QUAN designs 2. Traditional QUAL designs	Monomethod multistrand designs 1. Parallel monomethod a. QUAN + QUAN b. QUAL + QUAL 2. Sequential monomethod a. QUAN → QUAN b. QUAL → QUAL

Mixed method design	Sequential mixed method design	Sequential mixed model design
	Quasi-mixed monostrand design	Mixed methods multistrand designs
	Monostrand conversion design	<ol style="list-style-type: none"> 1. Parallel mixed designs 2. Sequential mixed designs 3. Conversion mixed designs 4. Multilevel mixed designs 5. Fully integrated mixed designs
		Quasi-mixed multistrand designs (designs mixed at the experiential stage only, including the parallel quasi-mixed design)

Source: Tashakkori & Teddlie (2009, p. 145)

The Two Dimensional Framework have been classified into two types i.e. monostrand design (employs a single phase that encompasses all of the stages from conceptualization to inference) and multistrand design (employs more than one phase; often multiple phases, with each encompassing all of the stages from conceptualization to inference) (Tashakkori & Teddlie, 2009, p. 144). The author has stated three stages of research strands/phases of a study i.e. conceptual stage, experiential (methodological/ analytical) stage and inferential stage. According to Tashakkori & Teddlie (2009), the monostrand conversion design is categorized as monostrand MM design, and there are five types of multistrand MM designs such as parallel, sequential, conversion, multilevel and fully integrated. The classification helps the researcher to get a clear path of conducting MMR.

Moreover, Creswell & Plano Clark (2007) have also published their constructive typology (see table 3) as the vital contribution to MMR.

Table 3. Typology of MM design and variants

Design Type	Timing	Mix	Weighting/Notation
Triangulation	Concurrent: quantitative and qualitative at the same time	Merge the data during interpretation or analysis	QUAN + QUAL
Embedded	Concurrent and sequential	Embed one type of data within a larger design using the other type of data	QUAN (qual) Or QUAL (quan)
Explanatory	Sequential: Quantitative followed by qualitative	Connect the data between the two phases	QUAN → qual
Exploratory	Sequential: Qualitative followed by quantitative	Connect the data between the two phases	QUAL → quan

Source: Creswell & Plano Clark (2007, p. 85)

Creswell and Plano Clark (2007) have distinguished the ways of conducting MMR in 4 major design types i.e. Triangulation, Embedded, Explanatory and Exploratory. The triangulation design is defined as a concurrent design from the beginning to the end and the embedded design might be either concurrent or sequential and either QUAN or QUAL remains as dominant. Explanatory will be dominated by QUAN and exploratory will be dominated by QUAL.

MMR is performed either as concurrent (+) or sequential (→) or conversion modality. Similarly, in MMR either QUAN and QUAL function equally or one of them remains as the dominant component.

Conclusion

MMR is the result of the paradigm wars and as such, it is a fusion point. The paradigm wars evolved taking different logics of QUAN and QUAL and was divided into three different camps i.e. purists, situationalists and pragmatists. Pragmatists and transformative perspective reject “the dogmatic either-or” and accept the combined methodology. These paradigms accept both credibility and generalizability. I argue that both the “accurate measurement and operationalization” and “original ecological real world” are important to establish practical conclusions of every research work. From pragmatic and transformative perspectives, I conclude that MMR is the only research methodology suited to arrive at the practical findings and conclusions.

This method has the collective features of multiple testing (QUAN and QUAL) for making contextual findings as well as being devoted to social change.

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Second Language Syllabus Designing: Reflections from the Past

Binod Luitel

Research Center for Educational Innovation and Development (CERID), Tribhuvan University, Kirtipur, Kathmandu

Abstract: *Through an extensive review of the relevant literature, the author has attempted to present some critical reflections on two major trends in second language syllabus designing evolved in the past that differed from one another over the issue of whether 'product' or 'process' is to be emphasized in teaching. Six important syllabus types developed under the two paradigms have been discussed, shedding lights on their theoretical assumptions, the focal concern for teaching-learning, internal organization, and strengths as well as limitations. Stressing on the need for specifying the content as well as methodology in any syllabus, readers' attention is drawn on the possibility of blending the task-based syllabus with the content-based ones as per the need. Given the development of task-based pedagogy as a significant achievement of the past, it has been suggested to understand 'task', particularly in the context of foreign language instruction, not only in terms of the simulation of real-life activities but in a broader sense that also includes purely pedagogic considerations.*

Keywords: *Product-oriented syllabus, process-oriented syllabus, structural syllabus, functional syllabus, lexical syllabus, procedural syllabus, process syllabus, task-based syllabus.*

Introduction

Syllabus designing is considered one of the crucial works in any pedagogic planning, whether it is at the macro level (e.g. determining the aims of national curriculum) or the micro level (e.g. deciding which vocabulary items are to be focused for practice in a particular course book). As a core document that gives direction to the entire educational process, syllabus provides a foundation for curriculum developers, material writers, teacher trainers, examiners and teachers to proceed on with their respective tasks (Yulin, 1984, p. vii). In language education, it is "an integral part of the total curriculum" (Nunan, 1988, p. vii), and it involves the "process by which linguistic content—vocabulary, grammar, notions, functions—is selected and organized" (Rodgers, 1989, p. 28).

In view of the importance of syllabus in language teaching-learning, it would be relevant to reflect on the previous attempts at approaching the matter of syllabus designing in language pedagogy. In this connection, this paper aims to discuss some major syllabus types with particular focus on the kind of language content or pedagogic process they emphasized for learning. In particular, the discussion presented here is expected to bring out a precise understanding of two major trends in second language syllabus designing that were developed in the twentieth century—the product-oriented and process-oriented approaches—and some major variations between them.

Product-oriented syllabuses

While specifying the end products of learning in terms of the linguistic contents or skills/knowledge such as grammatical structures, vocabulary items, language functions etc. (Nunan, 1988, p. 27), this kind of syllabus essentially tries to define the outcome of language learning "...in terms of the amount and type of knowledge which is expected or in terms of the type of competence..." (Olshtain, 1989, p. 136) that the learner is expected to gain after learning. Following Breen's (1987) that term, this kind of syllabus is a "propositional plan" rather than "process plan" (1987a, p. 85; 1987b, p. 157); it attempts to determine, select and organize the contents prior to the event of teaching.

A product-oriented syllabus has been rationalized on the ground that ensuring the destination of teaching-learning is very important in any pedagogic plan; and the more specific the destination in terms of the amount and type of knowledge to be learned, the better will be the learning achievement. A course material without such a specification is considered ineffective from this perspective. To quote from Brumfit (1984): "It is logically impossible to conceive of an educational process without believing that learners are going to be changed in a desirable direction, and ...we should try to specify that direction as closely as we can" (p. 115).

Going through the history of language pedagogy, we come across several points of view over the issue of what should be the content or linguistic knowledge to be pre-specified for teaching in a syllabus of product-oriented kind. Accordingly, various types of syllabuses have been practised, including the structural, functional and lexical syllabus, as discussed below.

Structural syllabus: This syllabus emerged in the days of structural linguistics and was "firmly established" in theory and practice in the 1950s and 60s (Read, 1984, p. ix), which was not seriously challenged until the beginning of the 1970s (Breen, 1987a, p. 86). Its theoretical assumption is that language consists of "a finite set of rules which can be combined in various ways to make meaning" (Nunan, 1988, p. 29), and "these rules can be learned one by one, in an additive fashion..." (ibid.). Following Rutherford's (1987) words, this is the 'accumulated entities' view on language learning (pp. 4-5). With this assumption, a structural syllabus aims to develop 'linguistic competence' in the learners through systematic practice through logically selected and graded structures, but there is no particular concern over 'communicative performance' (Widdowson, 1990).

As the content for teaching is derived from linguistic/grammatical description, attempts are made using this syllabus to teach language "as a system in its own right" with particular focus on syntax (Criper, 1976, p. 96). The contents to be taught are sequenced on the basis of the 'internal syntactic system' of language (Gibbons, 1984). Accordingly, as Widdowson and Brumfit (1981, p. 200) have pointed out, teaching items are organized "along the dimension of increasing complexity", with the assumption that learning follows 'simple to complex' principle. With less focus on fluency, a structural syllabus aims to develop learners' language ensuring maximum degree of linguistic correctness or accuracy (Breen, 1987a).

The advocates of structural syllabus have rationalized this by saying that since a limited set of language rules can generate a large number of sentences, learners can use the rules in a large number of situations once they learn them (Widdowson and Brumfit, 1981). So, to focus on the more important rules/structures will be an economical way of practising language. Moreover, the need to follow this syllabus has been stressed for the purpose of raising learners' metalinguistic awareness as well. Being metalinguistic in the new language to be learned, in Breen's (1987a) words, "will help the learner to understand and control it in a more efficient way than if the learner was merely exposed to the language in some spontaneous way and left to his or her own devices" (p. 87).

When structural approach to syllabus designing was criticized in the 1970s, issues were raised against its reliance on language structure for content selection and against language complexity as the criterion adopted in the sequencing of teaching items. The major problems and criticisms labelled against this type of syllabus are briefed below.

- 1) By focusing merely on the formal grammar or syntax, such a syllabus "misrepresented" the nature of language, which is a more complex phenomenon (Nunan, 1988, p. 30). Language accomplishment is concerned with 'knowing' as well as 'doing', but structural syllabus seriously lacks the methodology to address the aspect of 'doing' with language by isolating the words/sentences from context for learners' practice (Widdowson, 1990, p. 157). The units of teaching (usually the sentence structures) are presented to the learners as the abstract linguistic categories rather than the instances of real life utterances (Widdowson and Brumfit, 1981). Thus, the communicative purpose of language is neglected. In its radical form, this kind of syllabus had the aim of teaching the items "unrelated to the learners' communication needs" (Munby, 1984, p. 55), resulting into de-motivation among learners with a "devastating effect" (ibid.) of failing to use language.
- 2) Regarding the structural approach to the sequencing of items, it was pointed out that since language is an "extra-ordinarily complex system" consisting of many complicated subsystems, such an essentially "non-linear" character of language system can hardly form a satisfactory basis for a linear sequencing of teaching items in the way a structural organization claims to do (Gibbons, 1984, p. 135). In this connection, Das (1984, p. 322) has mentioned that though the syllabus designer thinks of a logical sequencing of language items in terms of 'linguistic system' while preparing a structural syllabus, there are doubts as to whether the learner in fact perceives the syllabus in the way as intended by the designer. Instead, the learner may perceive the items specified (or taught) through the syllabus in terms of his/her own 'learning system' (perhaps unknown to the designer) that is different from the intended system. Thus, though the designer's sequencing of items can be compatible with the complexity of language system, it may not be psycholinguistically valid. To quote from Nunan (1988), "Evidence from second language acquisition research suggests that learning does not occur in this simple, additive fashion" (p. 30).

Functional syllabus: From the beginning of the 1970s, functional syllabus was practised in the teaching of English and other European languages like French, German and Spanish (Trim, 1980) to the non-native speakers. It was initiated by the Council of Europe, which had worked out the beginning models of it including 'The Threshold Level for Modern Language Learning in Schools' (Van Ek, 1977), 'Waystage English' (Van Ek *et al.*, 1977), and 'Threshold Level English' (Van Ek and Alexander, 1980).

This syllabus essentially emphasizes the communicative functions of language rather than grammatical concepts and forms. There are also the practices of combining communicative functions with semantic notions. According to Krahnke (1987) while functions are tied into concepts from discourse analysis (such as defining, explaining, apologizing, and inviting), notions are drawn from conceptual/semantic categories such as dimensions, measurement, 'personal identification', 'education', 'journey or travel' (cited in Wong, 2006, p. 9). This model was first demonstrated by Wilkins (1976), with the aim of enabling the learners to express various types of meanings through the appropriate exponents so as to fulfill the requirement of specific communicative purpose or 'function'. The idea is that when notional and functional aspects are combined together, the syllabus becomes communicative; while a notion is concerned with the content of communication, a function is related to the purpose of using the language exponents in communication.

The functional approach recognizes language as part of socio-pragmatic behaviour and clearly adopts a "pragmatic rather than descriptive point of view" (Chamot, 1987, p. 86). This approach is based on the concept of 'communicative competence' proposed by Dell Hymes in 1971, which is based on a "broader view of language" suggested by the contemporary philosophers of language and sociolinguistics (Nunan, 1988, p. 35). A functional syllabus places emphasis on the situational appropriateness of language use rather than formal accuracy.

Functional syllabus derives the contents from sociolinguistic or pragmatic analysis of language use rather than from the core linguistic forms or grammatical elements (Breen, 1987a) with the ultimate focus on how people interact through language. Therefore, sequencing of the syllabus contents is done mainly on the basis of the complexity of situations that involve the use of specified language functions (Van Ek & Alexander, 1980), rather than based on the formal complexity of linguistic elements. In this way, students are expected to learn to handle the communicative situations one after another with the progressive increase in the complexity of situations.

The proponents of this syllabus have held the position that the contents of a syllabus should be specified considering their practical communicative needs, since language is primarily concerned with communication among people having diverse backgrounds. In order to specify the contents in this way, the task of identifying the communicative functions is crucial rather than recognizing "the apparatus of sentence formation" (Trim, 1980, p. x). For second and foreign language learners to participate in

the target language speaking society, functional units of language are considered “more immediately relevant” (Widdowson, 1990, p. 131). Contrary to the argument favouring a structural syllabus, the functional approach emphasizes that second language learners must practise the appropriate linguistic behaviour (not merely the structures) through their learning course; otherwise there will be no way for them to learn the behaviour out of the language class. In this regard, Widdowson (1979) has written: “Communicative competence needs to be expressly taught: the learner cannot be left to his own devices in developing an ability to communicate” (p. 248).

Despite its popularity in second language learning and teaching, doubts were raised against the functional approach from the early 1980s. Some of the critical points in this regard are as follows:

- 1) Sequencing functional items becomes more complex in this syllabus due to the lack of objective means to decide the relative complexity of functional items (Nunan, 1988, p. 37). Despite the aim of developing learners’ communicative ability, the functional-notional model actually follows a “reductionist approach”, by oversimplifying the vocabulary and structural complexity and thereby reducing the amount of knowledge to be mastered in language (Crawford-Lange, 1987, p. 130). In addition, this model does not consider language in discourse. Teaching the pre-selected chunks of language (that serve the specified functions) in absence of discourse, in essence, cannot account for the full realization of communicative competence, since ‘communicative competence’ is not simply the “compilation of items in memory”, but it also involves “a set of strategies or creative procedures” needed for the use of items in context (Widdowson, 1979). The context in which teaching items are presented in functional courses is much ‘reduced’, whereby the components of discourse occur only in isolation. This cannot provide room for a complete discourse procedure. For this reason, as Brumfit (cited in Meinhof, 1984) has pointed out, such a syllabus may be successful only for limited, routinized tasks of communication.
- 2) In most cases, the syllabus designers did not attempt to identify the learning needs on the basis of learners’ situation, problems or deficiencies. Instead, learners’ needs were derived directly from the native speakers’ needs of using language. Consequently, there were doubts regarding the compatibility of this syllabus with students’ learning. Critics have raised the issue that, apart from other things, learners need the “strategies” to make up for the learning deficiencies in any stage of their learning (Clark, 1987, p. 37); but the functional approach did not attempt to identify the needs in terms of learning problems. Moreover, little attention was paid to the development of classroom learner-centred methodology for the implementation of functional-notional approach, although content selection was emphasized much in this tradition (Read, 1984). Ultimately, the syllabus was practised through teacher’s presentation alone in the absence of the learners’ active participation, and it was virtually unable to bring about the intended changes (Willis, 1990).

Lexical syllabus: Lexical approach to syllabus designing emerged along with the development of new computer technology especially in the 1980s. After the technology made it possible to store very large computerized corpora, it became easy to study the various meanings, patterns and behaviour of lexical items very closely. This approach was further developed in the 1990s (Breen, 2001), when word-meanings and lexical patterns became a matter of massive interest for applied linguists. Unlike the structural and functional approaches, the lexical approach places emphasis on words, their combinations and meanings.

This approach, as its advocates have claimed, is better informed about the structure of language and its use compared to the earlier approaches to syllabus designing (White, 1995). The fundamental assumption here is that, since words have grammatical properties within themselves, learners will be in a position to create and use the structures themselves if word-meanings along with their structural properties are focused well in teaching-learning (Willis, 1990).

Following Sinclair and Renouf (1988, cited in Carter, 2001), a lexical syllabus tends to discourage the traditional piecemeal approach to vocabulary instruction and encourages the recombination of elements around lexis. In this way, more focus is given to the collocations and multi-word phrases rather than simply being limited to the individual words in the teaching of lexical items (Lewis, 1997). It has been stressed that it is natural for the learners to memorize the language being learned in terms of lexical phrases or 'chunks' (Nattinger & DeCarrico, 1992, p. 116).

The advocates of this approach have even claimed that "language production is not a syntactic rule-governed process but instead is a retrieval process of larger phrasal units from memory" (Zimmerman, 1997, p. 17). The scholars involved in the study of corpora have believed that grammatical structures need no specification and prior focus in teaching, since "...a syllabus based on lexis will inevitably provide the learner with the most appropriate exposure to grammar, albeit in an unpredictable manner" (Owen, 1993, p. 177). Usually, a lexical syllabus incorporates the items (words + word combinations) within it on the basis of their frequency of occurrence, ensuring the coverage of the most frequent ones occurred in natural, everyday use. In doing so, the core structural words (e.g. 'the', 'of', 'that' 'do', etc. in English), being the most frequent ones, automatically become part of the course. Teaching of such items with focus, in turn, incorporates a significant portion of grammar (Carter, 1998, pp. 224-225).

Tripp (1990) has proposed the idea of 'lexical meta-syllabus' which consists of "a structured list of words and phrases divided by relative frequency" (ibid., p. 218). Such a meta-syllabus can be useful as a guide for syllabus designers, which can define "a body of language which has been empirically determined to be central to native usage" (ibid.). Making a sound lexical syllabus, in this way, presupposes a thorough lexicographical analysis of language. A good course material prepared by following this approach incorporates multiple-level exercises for the holistic development of learner's

language with focus on word-meanings. For instance, it can have practices at word-level in stage 1, sentence level in stage 2, and discourse level in stage 3, etc. The work of Sim and Laufer-Dvorkin (1984), for example, has included such multiple-level exercises.

Process-oriented syllabuses: There is no pre-specification of the content to be taught in a syllabus of this kind. Instead of specifying the content plan, a “process plan” is prepared in advance that attempts to determine “how something is done” (Breen, 1987b, p. 160) by learners and teachers in the instructional setting. Doing so underlies the assumption that language content will be mastered automatically once the learners are involved in the process of performing some task. Since the learner’s playing with language is unavoidable during the task performance, language learning and the completion of tasks take place simultaneously.

Three different types of syllabuses have been discussed within the process-oriented category, termed as ‘procedural’, ‘process’, and ‘task-based’. Having a common feature of discarding the pre-specification of language contents for teaching but insisting on the specification of tasks for learners to work on, they differ in the way of handling such tasks in classroom practice. While some people tend to nullify the distinction and highlight the similarity between the three types (Nunan, 1988), others prefer to maintain the difference between them (Long & Crookes, 1992). This distinction seems relevant to be understood from a classroom-based perspective, as discussed below.

Procedural syllabus: This model was worked out and piloted for the first time by N.S. Prabhu and his associates in south India during 1979-84 (Prabhu, 1987), so it is also recognized as ‘Prabhu model’. The main assumption of this approach is that language is best learnt when the participants involved in teaching and learning are not “worrying about pieces of language” and grammar is best acquired by learners through focus on the teaching of meaning (Prabhu, 1984, p. 280).

With a focus on meaning instead of the form of language, this model makes use of the problem-solving tasks or activities that promote language acquisition, whereby tasks are selected based on two principles: i) the level of challenge (whether a task offers appropriate challenge for learners or not), and ii) the potentiality for engaging learners’ mind (whether it creates their understanding, thinking, saying, etc.) (Clark, 1987). Thus, a task is selected in the syllabus if it satisfies these conditions. Tasks are graded on the basis of the level of complexity involved in them; and the gradation is worked out by the teacher’s experience of teaching over the years (*ibid.*).

Prabhu had conceived of ‘communicative teaching’ in a way that is different from the contemporary western understanding of the meaning of this term (Long and Crookes, 1992). This term was considered in the sense of training “for” communication in the British tradition, but Prabhu laid emphasis on teaching language “through” communication. This conceptualization in terms of ‘through’ instead of ‘for’ brought about a vast difference in designing the process-oriented syllabus. It has been argued

that only the procedural syllabus is communicative in the true sense of the term since it places emphasis on the meaning to be communicated, though without the pre-selection of the linguistic items to be taught.

The hypothesis that grammar construction during second language learning does take place through a focus on meaning was confirmed after the evaluation of the communicative teaching project launched by Prabhu using the procedural model (Beretta and Davies, 1987). After its success in Bangalore project in the early 1980s, this model was highly admired in the world of second language pedagogy. Markee (1997), for instance, appreciated this syllabus to be 'innovative' compared to the traditional models, owing to the use of tasks as the principal carrier of language content, the meaning-focused methodology employed in the pedagogic process, and its attempt of avoiding explicit teaching of grammar rules.

Despite being an outstanding innovation in second language pedagogy, this model is not free from criticisms, as some of its problems have been pointed out in relevant literature. Unlike the other two syllabus types within the process-oriented category, this model does not favour peer interaction in the form of group work. This characteristic of procedural syllabus has been criticized. Following Allwright (1984, p. 157), this model firmly believes "...that 'communication' to be linguistically productive, does not need to be interactive in the sense of involving live person-to-person, face-to-face, talk". Prabhu holds the position that group work should be avoided in language classroom, task completion can take place on the learner's individual effort; and interaction is to be initiated between the class and the teacher if it is needed at all (Prabhu, 1987). As Brumfit (1984) pointed out, there was "a heavy emphasis on receptive teaching..." (p. 105), and classes became more teacher-centred in Bangalore Procedural Teaching Project. As such, in the absence of interpersonal sharing among learners (which is the essential element of communicative teaching-learning), it is difficult to say that procedural model is fully 'communicative'.

Process syllabus: Breen (1987b) has indicated that basically three types of syllabus versions are found in any classroom in the course of teaching-learning: i) the external syllabus that the teacher generally brings to the class; ii) the learners' internal syllabus/syllabi based on their understanding of the content matter derived from the external syllabus; and iii) the classroom syllabus that is actually implemented, which results from the negotiation or synthesis of the external and learners' internal syllabuses (p. 69).

This idea implies the fact that learners can have several versions of the understanding of syllabus contents depending on individual differences, though these are inexplicit. In actual practice, therefore, deriving the classroom syllabus through negotiation and consensus is essential. A process syllabus results from the teacher's and learners' consensus in the classroom. To quote from Breen: "The process syllabus is

proposed as the means whereby external and internal syllabuses are negotiated and, through such negotiation, a synthesized classroom syllabus may be created." (ibid., p. 69)

Thus, also known as the 'negotiated syllabus', this model assumes that reinterpretation of the content of any prescribed syllabus is inevitable in all classroom teaching-learning situations; therefore, the actual syllabus to be implemented in any classroom emerges after some sort of negotiation between the teacher's and learners' versions of the pre-planned syllabus.

Process syllabus directly involves the learners in decision making for content specification. This characteristic seems radically different from most of the practices of syllabus designing including the other designs of process-oriented category such as the procedural and task-based models. In its strong version, it has even been said that this model involves a "designless design" (Markee, 1997, p. 23) in that it attempts to pre-determine neither the language content nor the learning methodology. If this version is worked out in practice, the designer simply makes some sort of framework by which the teacher and learners work together to create their syllabus for implementation in an ongoing and adaptive way through negotiation (Breen, 1987b, p. 166; Rubdy, 1989, p. 4). At most, the process syllabus can appear in the form of "a bank of classroom activities" (Breen, 1987b, p. 166), from which the teacher and learners can select or decide the learning activities for implementation in the classroom, through negotiation. Thus, it can be said that a process model does not have any features "other than the element of negotiation itself" (Clarke, 1991, p. 15). Regarding the issue of 'focus on the form', this model differs from the procedural syllabus: while a procedural syllabus deliberately avoids focus on form in teaching, learners may decide to focus explicitly on form through their negotiation in the process syllabus, if they feel the need (Willis & Willis, 2001, p. 175). In this way, this syllabus is totally a learner-centred one—whether we consider the issues of content or instructional methodology.

This design has been rationalized by saying that a syllabus becomes meaningful only if we can take on-the-spot decisions in the classroom regarding content specification, methodology and evaluation, since every pre-planned syllabus is reinterpreted by the classroom teacher and learners. More importantly, as Bloor and Bloor (1988) have stressed, negotiation is "the only way to take into account the wants of the students" (p. 64). Here, 'wants' are distinguished from 'needs' saying that a 'need' refers to the inventory derived from the analysis of the target situation, while 'wants' are concerned with the students' own wishes and dreams. The proponents of process approach hold the position that motivation can be created in learners through the expression of their wants during negotiation, which plays a substantial role to promote learning particularly in the context of a second/foreign language teaching. Moreover, it is the process of syllabus negotiation that "encourages the students to take much more responsibility for their own learning" (ibid.). The advocates of this approach have even

claimed that an externally imposed syllabus can be transmissible only partially, as learners tend to ignore some of the contents presented to them and sometimes even learn the things other than those specified in the syllabus imposed upon them (Clarke, 1991, p. 16-17). This being the case, there is no way for the teacher other than to re-adjust the contents given in the externally defined syllabus, which infact ultimately results in some form of new syllabus.

Seemingly a revolutionary idea, this model has several limitations. As Brumfit (1979) has argued, the proposal for indifference to the specification of expected learning outcomes in advance makes little sense of learning a language through formal schooling. Brumfit has written: "If it does not matter what sort of language we produce, then there is little justification for going to school at all: we might as well leave pupils at home to produce language there" (1979, p. 185). It has been said that the process syllabus is an unnecessarily more ambitious proposal, since it assumes "unrealistically high level of competence in both teachers and learners" (Long & Crookes, 1992, p. 39). It is often argued that the negotiated syllabus model is not applicable in most situations, since total freedom to the classroom teachers or learners regarding the specification of contents or methodology is "neither possible nor desirable" (Clarke, 1991, p. 24). The educational set up that comes to play with language learning does not favour its application in many circumstances (Das, 1984), so the learners cannot be offered the responsibility of deciding what and how to learn in such cases. Furthermore, many teachers feel that "the idea of negotiation is likely to lead to that of anarchy and, in a sense, a dereliction of duty..." (Clarke, 1991, p. 20). In addition, as Freire and Faundez (1989) have remarked, learners in many parts of the world feel it uneasy to get involved in the dialogue regarding curricular matters, "seeing it as a sign of weakness on the part of their teachers" (cited in McDevitt, 2004, p. 4). Negotiation becomes "considerably more complicated" particularly in the classroom situations that involve a large number of students (Bloor & Bloor, 1988, p. 72). Insistence on such a model can result into a futile attempt in the context of foreign language teaching, particularly among the beginning or intermediate level learners.

Due to these problems, there are doubts regarding the successful implementation of the strong version of a process syllabus. Therefore, instead of attempting to create a new syllabus in the classroom, there are practices to follow its weaker version (Markee, 1997), whereby the externally prepared syllabus is brought to the learners and adapted therein to "fine-tune" its implementation (*ibid.*, p. 23).

Task-based syllabus: Task-based pedagogy has widely been discussed in the contemporary English language teaching literature; and this has been the 'most fashionable pedagogical approach' among foreign language teachers in recent years (Santos, 2011). In the words of Tang (2004) task-based learning has become "the orthodox of ESL/EFL (English as a second language/foreign language) teaching" (p. 14).

The changes it has brought about in second language pedagogy by restructuring the classroom teaching-learning in terms of the teaching input, learner-participation and curricular procedures have been so radical that this approach has even been referred to as the “pedagogic perestroika” (Kumaravadivelu, 1991, p. 99).

Two versions of task-based pedagogy are sometimes distinguished: strong and weak. Following Skehan (1996) the strong version demands that “tasks should be the ‘unit’ of language teaching, and ...everything else should be subsidiary” (p. 39), since tasks will be adequate and sufficient to “drive forward” learners’ language development in this view (*ibid.*). The weak version, on the other hand, holds the position that though tasks form a vital part of language pedagogy, they may not be the only means to be employed in teaching-learning. Instead, tasks may be “embedded” in the course that contains other materials having some content to focus for teaching (*ibid.*).

This kind of syllabus, unlike a procedural one, focuses on form in addition to meaning. The importance of ‘focus on form’ was recognized after some second language acquisition researches indicated that the neglect of form (in the sense of correctness) in instruction could cause harmful effects in learner’s language development. Clark (1987), for instance, has mentioned the findings of the Canadian immersion programmes which revealed the fact that due to the lack of such a focus learners’ interlanguage was completely fossilized and errors in their language production became very difficult to overcome, even though the learners could develop fluency.

Here, it should be noted that the idea of ‘focus on form’ maintained by the task-based approach is different from that of ‘focus on forms’ often stressed by the structural syllabus. Whereas the forms to focus are pre-determined in the latter case, they are not pre-selected but are still focused during the instructional proceeding if needed in the former case (Long, 1998). Following the task-based approach, when any sort of incorrect usage is found in the learner’s language production during the teaching-learning process, the teacher attempts to remove it through the activities/tasks that focus on formal correctness. The task-based language teaching differs from the procedural syllabus over the issue of learner’s participation as well. Here, participation through group work and peer interaction is highly encouraged, keeping the teacher’s active role to a minimum. Not only this approach particularly gives emphasis on “interactive process of learning”, it also involves “joint decision-making” (Foley, 1991, p. 71) for problem-solving on the part of the learners in many cases. Though this characteristic of a task-based syllabus looks similar to the process approach discussed earlier, these two differ over the issue of pre-selection and sequencing of tasks. Unlike in a process syllabus that does not favour pre-selection and sequencing, doing these things is considered essential in a task-based syllabus. Two sorts of tasks can be employed for teaching-learning in this syllabus: communication tasks and learning tasks (which are also called the ‘real world’ and ‘pedagogic’ tasks respectively) (Luitel, 2009, pp. 63-65).

The criterion of the inherent complexity of tasks is mostly applied in task sequencing. Since syllabus designing involves a prospective decision-making regarding the sequence of tasks, task complexity can be the reliable and “logical basis” for the work here (Robinson, 2001b, pp. 33, 287). To follow this criterion, as Dubin and Olshtain (1986) say, tasks should be presented “in a graded sequence from those that are less to more demanding” (p. 73). Even though ‘task difficulty’ has also been suggested for consideration, it may not be applicable to all learners in a uniform way since difficulty is a relative concept; and this “cannot be anticipated in advance of implementation of a syllabus” (Robinson, 2001a, p. 287). In addition, sometimes ‘task continuity’ is also stressed in sequencing, whereby the designer needs to maintain a logical relation between the previous and succeeding tasks—the succeeding ones to be based on the earlier one with a view to facilitate learning. According to Nunan (1989): “the successful completion of prior activities is a pre requisite for a succeeding one. Under this principle, activities are sequenced, not only according to the complexity... but also by the logic of themes and learning pathways” (p. 119).

This approach to syllabus designing has been defended by saying that it is by means of tasks or activities that a broad and rich language experience can be established among learners, since tasks create the ‘environment’ for learning (Cameron, 2001, p. 20). Theoretically, it is argued that task-based teaching provides “more space” for the learner to learn in his/her own way by maintaining a loose control over the content (White, 1995, p. 95), since the learner is guided in learning more through the tasks than through the content. This model seems to have appreciated the developmental approach to language learning, which suggests that learners do not acquire language as presented to them in the form of prescribed content but they can proceed ahead through their own developmental track—termed, as ‘interlanguage’. By getting the learners engaged in meaningful activities such as problem-solving, discussion, narratives etc., task-based approach essentially aims to develop the learners’ interlanguage system (Foster, 1999). Such an approach seems to be psycholinguistically justified, particularly in the case of foreign language learning. For these reasons, Yalden (1987) has stated that a task-based syllabus will be a more suitable option in foreign language learning situations, where there are limited linguistic resources at the learner’s disposal (p. 68).

Despite the strengths of a task-based syllabus, there are some limitations in regard to its effective implementation: that task-based works in the sense of involving learners in a ‘real’ or simulated task (rather than pedagogic one) require relatively “equal language proficiency” among learners (Wang, 2006, p. 209), which cannot be established in the classrooms where teachers have to face the problem of learner hierarchy very severely (Luitel, 2010). When learners vary considerably in terms of their level of competence and participation in learning, the methodology requiring identical proficiency of learners is difficult to implement.

Concluding remarks

The two major trends of second language syllabus designing discussed here revolve around the issue of what should be the prime focus of instruction—the content or the delivery process. Though each of the syllabus types under the two broad categories differs from others on several issues as explained above, we cannot totally discard the inevitable occurrence of content plus methodology while implementing any of them. No doubt, both elements of curriculum (content + pedagogy) are essential in second/foreign language instruction.

The learner-centred approach to pedagogy has been a very significant development in the past, particularly since the 1980s. It has contributed to the innovation of several new practices towards fostering the process of language learning. Barring some limitations, the task-based language teaching has so far been considered an influential strategic move towards increasing learner participation and thereby promoting their learning achievement. Therefore, whatever contents we focus through the second/foreign language syllabus design, the place of task must be ensured therein. While doing so, it would be advisable that a 'task' should be understood not only in the sense of simulation of real-life activities. Instead, it should be considered in a broader sense that also includes the pedagogic tasks (or exercises) purely meant for practising the specific language element or skill/knowledge such as vocabulary, grammar, comprehension, writing, and so on. This consideration is particularly implementable in the context of foreign language teaching like English in many countries, where the students rarely find the opportunity to use the language outside their classrooms. If we adopt this position regarding tasks, there can be the possibilities of blending the task-based syllabus, as per our need, with the content-based ones such as: a task-based syllabus with (i) lexical focus, (ii) functional focus, (iii) structural focus, (iii) listening comprehension focus, (iv) reading comprehension focus, (v) writing skills focus, and so on. The extreme form of 'process syllabus', however, is difficult to implement in most foreign language teaching contexts for teachers who are inadequately equipped with the ideas and insights regarding the ways of handling the complexities related to learner differences, despite the scope of this approach for research inquiries.

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Case Marking in Darai in a Typological Context³

Dubi Nanda Dhakal

Center Department of Linguistic, Tribhuvan University, Kirtipur, Kathmandu
Email: dubidhakal@yahoo.com

Abstract: *This paper discusses the case marking in Darai language in typological context relating this with its genetically related languages of Nepal. Some case markers are significant as they show typologically interesting features among Indo-Aryan (IA) languages. As Grierson (1904) noted, some case markers are useful in the sub-classification of IA languages. This suggests that the dative-accusative -ke shared by a number of languages is aligned to eastern IA languages. The minor IA languages of Nepal share some features of 'eastern' languages of outer sub-branch whereas they also exhibit the features related to Pahari group of inner sub-branch (Masica, 1991). This article is divided into 5 sections. In addition to a brief introduction to the Darai language given in section one, some issues related to case and postpositions are considered in section two. Section three analyzes the case marking pattern in Darai. Case markers are discussed in section four. The case markers of Darai are compared to other IA languages of Nepal in section five. Finally, section six sums up the findings.*

Keywords: *Case, case marking pattern, split ergativity, Darai language, linguistics.*

Introduction

Darai is an Indo-Aryan language of Indo-European family of languages spoken mainly in the Chitwan, Tanahun and Nawalparasi districts of central and Western Nepal. As recorded in the previous census (CBS, 2002), the total population of Darai is 14859 whereas only 10210 people speak their ancestral language. The number of speakers as recorded in the recent census is 11677 (CBS, 2012). Most of them are bilingual and speak Nepali, the language of wider communication. The language was formerly unclassified but Dhakal (2011, 2012) proposed that Darai makes use of a large number of features evidenced in eastern IA languages. Darai is therefore classified as an 'eastern' IA language and is closely related to Maithili, Bhojpuri and Majhi.

Case markers and postpositions

Blake (1994) mentions,

Case is a system of marking dependent nouns for the type of relationship they bear to their heads. Traditionally the term refers to inflectional marking, and, typically, case marks the relationship of a noun to a verb at the clause level or of a noun to a preposition, postposition or another noun at the phrase level (p. 1).

3 This article is a revised version of the chapter 4 of my dissertation, *Darai Language*, submitted to Tribhuvan University, 2011. Most of the examples are from discourse data. The information given after each sentence refers to the speaker and text the example is taken from.

Blake (1994) again mentions that case markers are affixes whereas there are other forms which may be complete words (p. 2). Darai nouns are marked for cases in two ways: case inflection and use of postpositions. A number of languages employ postpositions if they lack morphological case (Liljegren, 2008). When Darai pronouns inflect for cases, some of them have oblique stems (Dhakal, 2012). There are a few case markers whereas other case relation is carried out by postpositions. Masica (1991) maintains, “In NIA, case is vitally a syntactic as well as a morphological category” and further adds that it is “a problematic nominal category in NIA, whether for cross-linguistic, historical, or single-language descriptive analysis” (p. 230).

I will base the discussion of this article on two main argumentations. As Liljegren (2008) noted, longer words with more than two syllables are considered distinct postpositions rather than case markers (p. 161). The monosyllabic markers which are directly attached to the nouns are considered inflections. As Masica (1991) argues, some postpositions in IA languages may also be mediated by some case markers.

This leads to the argumentation that some postpositions follow the genitive marker (Masica, 1991, p. 231-32; Liljegren, 2008, p. 161)⁴.

Similarly, Payne (1997) maintains that it is sometimes difficult to distinguish case marking from adpositions because there is no necessary universal distinction between the two; like most structural distinctions, the two categories describe extremes of a continuum. In addition, he also provides the rule of thumb for this tendency:

Rule of thumb: Case marking is the morphosyntactic categorization of noun phrases that is imposed by the structure within which the noun phrase occurs. Adpositions are free of such configurational constraints (p. 86).

On the basis of this theoretical orientation, there are case markers for dative-accusative, locative, genitive, ablative, sociative and ergative-instrumental. They are monosyllabic and are directly attached to nouns. Nouns are either base (null marked) or followed by a case marker.

Case marking pattern

A first look into Darai shows that it is a nominative-accusative language. The subject in example (1) and the agent in example (2) are the same, viz. *məi* ‘I’. The patient in (2) is *uk^hrake* ‘him’. In (2), the subject of the intransitive clause and agent of a transitive clause are marked in the same way but the object or the patient is marked

4 Genetti (2007) discusses four criteria which distinguish case marking from postpositions: (a) they (case markers) have unique phonological properties that show they are bound morphemes; (2) they do not occur in the absence of a host; (3) they do not select a particular lexical class as their host; (4) they have scope over the entire noun phrase (p. 103).

distinctly. In other words, subject and agent are marked in the same way morpho-syntactically but patient is encoded differently. The patients in the examples are *māi* 'I' and *uk^hrake* 'him' in (1-2) respectively. The patient argument in example (2) is marked with an additional marker *-ke* 'DAT'. Let's compare examples (1-2) with (3-4).

- (1) *māi kāske dzaike*
māi kāske dza-ike
 I how go-INF
 'How (shall) I go (home) ?' (HP.BLD.068)

- (2) *lā māi adzuse uk^hrake b^hat rinike pārnei*
lā māi adzu-se u-ke b^hat rin-ike pār-nei
 PART I today-ABL he-[OBL] DAT rice cook-INF happen-OBL
 'Okay, from today onwards, I have to cook rice for him.' (HP.BLD.078)

Case marking pattern is not the same in examples (3-4). Unlike examples (1-2), the subject argument of a transitive clause has also encoded an ergative marker in (3) whereas the patient argument of a transitive clause (2) is null marked. The pattern of case marking presents a contrasting picture in these examples. While the subject *māi* 'I' does not encode any ergative marker, the agent argument in example (3) is with ergative marker, viz. *uhī* '3-ERG'. This suggests that Darai follows ergative- absolutive pattern.

- (3) *gaha dukhā paulā rāhāi uhī*
gaha dukhā pa-lā rāhā-i u-hī
 great suffering get-PST AUX.PST-3SG he-ERG
 'He had great suffering (pain).' (BF.SLD.002)

- (4) *u aite khāni tā*
u a-te khāni tā
 he come-SIM while PART
 'On his coming (as he comes) ...' (SQ.BLD.116)

This will be further discussed in section below.

Case markers

Morphologically unmarked case is the nominative and other cases are marked by suffixes. The subjects are nominative, ergative, or dative. The case markers include dative-accusative, locative, genitive, ablative, and sociative.

Nominative case: -Ø: Nominative case in Darai appears in null. I have used the symbol -Ø to indicate the nominative case in this section. Nominative is used for the subject complement in copular clauses. Nominative nouns appear in subject position in the intransitive clauses. Additionally, if the agent is the first and second person pronouns, in transitive clauses, they are in nominative case. The examples in (5-6) are nominative subjects. As Kotapish (1973) points out, the nominative subject may be patient such as *g^hoda morla* ‘horse die-PST’, ‘the horse died’. Thus nominative may appear in subject or in object positions.

(5) *məi dzəitəm*

məi-Ø	dza-tə-m
I-NOM	go-NPST-1SG

‘I go.’ (KAQ.SLD.104)

(6) *məi lestəm bubake b^hat*

məi-Ø	les-tə-m	buba-ke	b ^h at
I-NOM	take-NPST-1SG	father-DAT	rice

‘I’ll take the food to my father...’ (BF.SLD.094)

The null marking on subject and inanimate and indefinite nouns is common in Indo-Aryan languages (Mohan, 1990, p. 79; Bhatia, 1993, p. 167; Yadava, 2004, p. 254). Examples (5-6) exhibit that the subjects may be null marked in Darai. Thus, the subject may be either in nominative or ergative case (except in dative case). Similarly, the direct object may be nominative (8) and indirect object may be either in nominative or accusative-dative case. The objects of a transitive clause, if they are non-human and indefinite, do not index any case markers (8)⁵. The non-human object is encoded with accusative case in (9) but the human object (patient) is encoded with accusative case in (9).

Dative-Accusative case: -ke: Dative and accusative case marker is *-ke* in Darai. Patients as direct objects are in the dative-accusative case in (7). Dative-Accusative cases are coded in patient or recipient. In other words, the objects are in dative-accusative case.

(7) *abe məi bəinike dz^hikikun lestəm*

abe	məi	bəini-ke	dz ^h ik-ikun	les-tə-m
then	I	younger sister-DAT	bring out-SEQ	bring-NPST-1SG

‘Then I will bring my younger sister taking her out.’ (HP.BLD.087)

5 Mohanan (1990) and Yadava (2004) treat all instances of null marking as nominative case.

If there is a human argument that is affected (or the recipient), it will receive the dative case (7). We see that the object is *bəhini* 'sister' which receives the accusative-dative case in (7). Human objects or sometimes animate objects of a transitive verb appear to be able to get the accusative-dative case marker (9). We see that *bubake* 'father' has received the dative case in this example. In fact, this generalization is true for many south Asian languages (Masica, 1991; Mohanan, 1990). If the object is non-human it is generally not coded with the accusative-dative marker. For example animate object *goru* 'ox' in (8) does not code any case marker but the same noun in (9) codes the accusative-dative case. As Baerman and Brown (2008) note that higher animacy arguments are likely to have a distinct case form.

(8) *sipahĩ ledzlə duhai goru*

Sipahi-ĩ ledz-lə dui-həi goru

Soldier-ERG take-PRF two-EMPH ox

'The soldier took both of the oxen.' (BF.SLD.136)

(9) *məi merə goruke antəm*

məi məi-rə goru-ke an-tə-m

I I-[OBL]DAT ox-DAT bring-NPST-1SG

'I will bring my ox.' (BF.SLD.150)

Let's consider some statistical evidences of how the non-human object is marked with the dative case. The word *goru* 'ox' occurs about 12 times in object position in the corpus. Among these occurrences, this object is coded with the dative case only in one place. This is to show that the dative-accusative case rarely occurs with the inanimate object. Regarding the dative case in subject and object position, Masica (1991) notes:

The Object is not distinguished from the Subject by case marking in many NIA sentences... This is not to say that Objects are bereft of case marking. They may take it, in the form of the Dative marker (in the absence of an Accusative: the marker is sometimes called a *Dative-Accusative* as a result) (p. 365).

Unlike nouns, personal pronouns are obligatorily marked with the accusative when they function as objects as in (10).

(10) *merake dz^hun maruk*

məi-ke dz^hun mar-uk

I-[OBL]DAT NEG kill-IMP

'Don't kill me.' (GALK.PD.029)

Since the dative and accusative are marked in the same way, they have been treated as a category in this paper. Masica (1991) notes that there is no distinction between accusative and dative case marking in NIA. He further adds:

Historically, the Indo-Aryan Accusative merged with the Nominative.... That is, in the case of non-human nouns, it generally indicates a "definite" object, that is, one that is already known; in the case of human nouns, it stresses their Patienthood, marked status (human nouns normally being Agents) (p. 365).

Therefore, these two categories are treated as dative-accusative case and it is glossed as dative in this paper. Dative case also appears in the subject position. They show physical sensations and conditions, psychological or mental states, wanting or needing (Dhakal, 2011, 2012)⁶.

Locative: -jā, -hī: Locative *-jā* 'on/in/at' is attached to a noun which ends in a consonant. If the noun ends in a vowel, an epenthetic vowel occurs between the stem and locative marker and it is realized as *-ājā*. The locative is used to locate a person or thing in a physical place at an instant of time. It refers to static location. This occurs with inanimate nominals in the corpus. Locative in place is shown in (11). Similarly, it is also attached to show the location in time.

(11) *d^huruwarəjā pheri gai caralə*

<i>d^huruwarə-jā</i>	<i>pheri</i>	<i>gai</i>	<i>cər-a-lə</i>
Dhuruwa-LOC	again	cow	graze-CAUS-PST

'(He) again grazed the cows in Dhuruwa.' (PTP.CND.019)

The locative is also used with *khəna* 'while/during'. It generally follows the simultaneous converb *-te* in several places in the narratives. Emphatic locative is marked with *-hī* as in (12). Emphatic locative shows that the location is at a certain place but not in other locations.

(12) *sutkeri konahī bosī rəhit*

<i>sutkeri</i>	<i>kona-hī</i>	<i>bos-i</i>	<i>rəh-i-t</i>
child born woman	corner-LOC.EMPH	sit-ABS	remain-3SG-NPST

'The woman sits right in the corner (continuously).' (MTU.SD.013)

In (12), the emphatic locative marker shows that the woman who gives birth to a child should sit nowhere but right in the corner. In other words, she sits on the corner.

⁶ These categories are based on Masica (1991, pp. 346-47).

Genitive: -kə, -rə: Genitives are marked with *-kə* or *-rə*. It is marked *-rə* 'GEN' for first person pronouns, second and third person singular pronouns but it is marked with *-kə* 'GEN' with second and third person plural pronouns as well as other nouns. The genitive constructions in Darai consist of the possessor and possessed in that order and the possessor has the genitive case.

(13) *dzəbbəd b^halekə god^hik bandelə*

dzəbbəd	b ^h ale-kə	god ^h i-k	ban-i	de-lə
big	rooster-GEN	leg-3SG.POSS	tie-ABS	give-PST

'(He) tied the Bhothi fish to the leg of the rooster.' (BF.SLD.187)

As we see in (13) the possessor is *b^hale* 'rooster' and therefore the pronominal possessive marker *-k* is attached to the head noun *god^hik* 'his leg'. Since this is also related to genitive phrases, this needs to be discussed in some details.

Although several Indo-Aryan languages spoken in Nepal are dependent-marked in genitive construction, Darai is both head-marking and dependent-marking. In Darai, for example, nominal agreement markers must agree with the possessor.

According to Nichols (1986), the languages can be categorized into head-marking, dependent-marking, double-marking and split-marking (p. 56). Darai is categorized as a double-marking language in terms of these features. Some of the languages which are head and (or) dependent-marked are Burushaski, Finnish, Hebrew, Turkish and so on. Nichols does not, however, mention any other IA languages which are very close to Darai. The example (14) shows an instance of the head-marking in possessive phrases.

(14) *dulhak morlə*

dulha-k	mor-lə
husband-3SG.POSS	die-PST

'(Her) husband died.' (IMM.UN.001)

Example (14) shows that the pronominal possessive suffix occurs with the head noun in genitive construction with the possessor noun. In (14-15) the pronominal possessive suffix is coded whereas (8-9) lack it. The possessed items are often body parts, kinship terms, and personal belongings or objects.

(15) *herte gorum tə ledzi dehalek*

her-te	goru-m	tə	ledz-i	de-hale-k
look-SIM	bull-1SG.POSS	PART	take-ABS	give-PST-3SG

'While looking at it, (he said) it is they who took away my oxen. (BF.SLD.138)

In (15) *goru* 'ox' also hosts the pronominal possessive suffix.

Ablative: -se: Source is expressed by ablative marker *-se* 'from' to refer 'from somewhere' as in (16) or 'from the time' as in (17). This indicates the source of action. The source is spatial (16) or temporal (17).

(16) *hame pəhadse dz^hərlə ləmdzuzse*

hame	pəhad-se	dz ^h ər-lə	ləmdzuz-se
we	hill-ABL	climb down-PST	Lamjung-ABL

'We settled in the plains (lit. climbed down) from the hills, from Lamjung.'
(HWCTP.PD.001)

(17) *lə məi adzuse uk^hrake b^hat rinike pərnei*

lə	məi	adzuse	u-ke	b ^h at	rin-ike	pər-nei
PART	I	today-ABL	he-[OBL]DAT	rice	cook-INF	AUX-OBLIG

'From today onwards, I have to cook rice for him.' (HP.BLD.078)

In addition to these, *-se* has some other uses. The case marker *-se* is used to mark the 'point of growth' from one stage to the next as shown in (18).

(18) *lesnaik bhəite sipahise pheri həldar bhəilə*

lesnaik	bhə-te	sipahi-se	pheri	həldar	bhəi-lə
military post	become-SIM	soldier-ABL	again	military post	become-PST

'He became Haldar (a rank in army) as he became Nayak (a rank in army) from soldier. (OK.JD.041)

It is also used to show what something is 'made up of'. For instance, example (19) shows that yeast is made up of a kind of plant.

(19) *mərca ek kisimkə dz^hāgise banatahī*

mərca	ek	kisim-kə	dz ^h āgi-se	bən-a-tahī
yeast	one	type-GEN	bush-ABL	make-CAUS-NPST-1PL

'Yeast is made from a kind of bush (plant). (HWMW.SD.001)

Sociative: -se⁷: Sociative is coded by *-se* 'with' to show accompaniment. This indicates with whom or what something is done.

7 Although this form is homophonous with ablative case, I have given this a different category because ablative can also be expressed by a postposition. It is an instance of case syncretism (see Baerman & Brown, 2008).

(20) *tə dawa meṭit bəllə əse nunse b^hat k^həitahĩ*

tə	dawa	meṭ-i-t	bəllə	əse	nun-se
PART	death ritual	end-33SG-NPST	finally	then	salt- SOC
b ^h at	k ^h a-ta-hĩ				
rice	eat-NPST-1PL				

‘As Dawa (a death ritual) ends, the rice is eaten with salt.’ (DR.CND.10)

(21) *sāhatise məi maṇtəm*

sāhati-se	məi	maṇ-tə-m
friend-SOC	I	beg-NPST-1SG

‘I will ask (lit. beg) with my friends.’ (KAQ.SLD.095)

Ergative-instrumental case: -ĩ, -hĩ, -eĩ: The ergative and instrumental share the same case marker *-ĩ*, or *-hĩ*. The ergative is *-i* without nasalization in the Tanahun dialect (Kotapish, 1973, p. 29). Between the forms mentioned, the former form is realized if the nominal stem ends in a consonant and other vowel except *u*. Speakers also utter only *-eĩ* without nasalization. If a nominal stem ends in consonant, there is also an epenthetic vowel inserted thus the ergative marking resulting in *-ei*. Consider the example (22) where the case marker functions as an instrumental case.

(22) *səurke ləuriĩ marlə*

səur-ke	ləuri-ĩ	mar-lə
fish-DAT	stick-INST	kill-PST

‘A stick killed Saur (a kind of fish).’ (EL.CND.026)

Ergative marker encodes the agent of the transitive clause. Darai is not a consistently ergative language. The ergative marker is consistently present with the subject of the transitive clauses if the subjects are the third person pronouns and other nouns. Irrespective of tense, aspect and mood, the first and second person pronouns do not code ergativity (23-24)⁸. Therefore, the split begins between the second and third person pronouns. We see in (1-2) that the first person pronouns do not code any ergative marking.

(23) *toi cicər rinlə*

toi	cicər	rin-lə
you	snacks	cook-PST

‘You cooked snacks.’

8 Further details can be found in (Dhakal, 2007).

(24) *toisəb cicər rinlə*

toi-səb	cicər	rin-lə
you-PL	snacks	cook-PST

'You cooked snacks.'

A split ergative language is one in which some transitive clauses but not all require ergative construction (DeLancey, 1979, p. 626). The languages exhibit some kinds of split patterns. The kind of split we observe in Darai is a nominal (personal) split. DeLancey (1979) reiterates that, this (nominal split) pattern shows, " hierarchy of 'animacy', 'agentivity', topicality', 'salience' or 'empathy', by which 1st and 2nd persons outrank human 3rd persons, which outrank non-human animates, which in turn outrank inanimate" (p. 627). In Darai the split begins between the second and the third person pronouns. The subjects of (1-2; 23-24) and (39) are the first and the second person pronouns respectively but subject in (3) is the third person pronoun.

In example (3) the subject of the transitive clause codes ergative marker while in (23-24) the subjects of the transitive clauses do not index ergative marking although all of them are in the past tense. The ergative marking in Darai is not thus consistently ergative.

Darai can typically be described as a split ergative language in which ergativity is determined by nominal hierarchy. The third person pronouns and all other noun phrases with transitive clauses operate on an ergative/absolute basis.

Darai case marking from a typological perspective

This section surveys the case markers and case marking pattern in IA languages of Nepal in areal-typological perspective. Since the synchronic description of all languages is not adequate, the typological comparison will be confined to limited data⁹. The case markers of different IA languages are summarized in Table 1.

To begin with, the comparison shows that a large number of IA languages lack the ergative marker and characteristically follow nominative-accusative case marking pattern. A large number of languages follow this pattern, i.e. Bajjika, Bhojpuri, all Tharu varieties, Maithili, Churete (Miya Kura), and Rajbanshi. Most of them belong to

9 Data for this typological comparison come from a number of sources: Dhakal (2011, 2012) for Darai; Wilde (2008) for Rajbanshi; Dhakal (2008) for Majhi; Yadav (1997 [1996]) for Maithili; Chaudhari (2005) for Saptaria Tharu; Mahato *et al.* (2009) and Roy (2010) for Bajjika; Bhandari (2001) and Timilsina (2009) for Danuwar; Poudel (1999) and Bandhu *et al.* (1999) for Bote; Neupane (2002) for Churete; Parajuli (2000) for Kumal; Paudyal (unpublished) for Chitwania Tharu, Boehm (2008) for Dangaura Tharu and and Dhakal (unpublished) for Rana Tharu, Giri (2012) and (Shukla 1981) for Bhojpuri and ideas about Nepali from Pokharel (2056vs). The main language missing from this analysis is Awadhi.

eastern IA languages but Rana Tharu which shares many features with 'Western Hindi'. It lacks the ergative marking. In terms of forms of ergative marking, the languages belong to further two categories. Nepali, Kumal and Churete possess the case marking *-le*. By contrast, Darai and Bote have *-ĩ* and Danuwar encodes *-i* as ergative marker. Majhi is a single language which makes use of *-n* or *-in*. It stands out among these languages in terms of forms of case marking. However, Majhi has a high resemblance with Darai, Bote and Danuwar case markers to some extent.

The pattern of ergative marking of all languages considered in Nepal is yet to be investigated. Nepali is often described as a split ergative language based on perfectivity (Li, 2007), whereas Darai is a split ergative language based on nominal hierarchy (Dhakal, 2011, 2012). Preliminary observation shows that nominal based split ergativity is also seen in Majhi but the detailed analysis is still awaiting (Dhakal, 2008). Thus the following conclusions can be drawn about the ergative marking in IA languages of Nepal: (a) The languages without ergative marking, (b) The language with split ergativity (based on nominal hierarchy and perfectivity). Preliminary observations show that Majhi and Darai exhibit identical case-marking pattern.

Secondly, there is a case syncretism between ergative and instrumental if the languages make use of ergative marker¹⁰. By contrast, the languages without ergative marker have a distinct instrumental case. For example, *-se* as an instrumental marker is characterized in a number of languages. Thus, the instrumental marker in IA can be categorized as follow (a) *-se* (Bajjika, Chitwania Tharu, Bhojpuri, Saptaria Tharu, Rana Tharu, (b) *-le* (Nepali, Churete, Kumal) (c) *-ĩ* (Darai, Bote, Danuwar (without nasalization)) (d) *-de* (Rajbanshi) (e) *-səŋ* (Dangaure Tharu). The comparison suggests that the instrumental in Darai is similar to Bote, and to some extent to Danuwar. Note that Darai and Bote are spoken in the same geographical territories, whereas Danuwar is located to the east of Darai and Bote speaking territories.

While some of these languages have two genitive markers that begin with *-k* and *-r*, some other languages have only one of them. Those having only one genitive suffix *-r* are Maithili and Majhi which are geographically located in the eastern part of Nepal. By contrast, Dangaura Tharu contains only the genitive suffix *-k*. The rest of the languages make use of the genitive suffixes *-k* and *-r* although the precise form may differ from one language to another. Some forms are *-o* endings whereas others end in *-ə* or *-e*. Citing the sources, Masica (1991) notes that the genitive *-k* might have been developed via *kēra* although Chatterjee favours that it was developed through adjectival suffix *-kka* as its source (p. 243). Grierson (1903) notes, "The typical letter of genitive case is *r* in eastern language" (p. 8) adding that the typical letter of *k* is more

10 Garret (1990, p. 264) notes "It has been noticed before that ergative and instrumental case marking are identical in many languages, and it seems natural enough to speculate that in such situations ergatives have originated in old instrumentals."

common with western IA languages. Darai genitive suffixes resemble to a number of IA languages. However, it is to be noted that *ə* ending genitive markers are shared by Darai, Chitwania Tharu and to some extent by Maithili. By contrast, Nepali, Kumal, Bote make use of *-o* ending genitive marker.

Fourthly, dative-accusative case begins with *k* in a number of languages. The languages which do not have the dative-accusative marker *k* is limited in number. The dative-accusative marker is *lai* in Nepali and Majhi and *lai* in Danuwar, and *hənə* in Churete. Grierson (1904) notes that the dative marker in eastern languages is *-ke* (p. 4). The languages other than Nepali, Majhi, Danuwar and Churete stand out in this regard. All other languages have the dative-case marker mostly *-ke* and some others begin with *k*. The dative *-ka* is also found in old Bengali (Chatterji, 1926, p. 760). Darai shares this features with eastern Indo-Aryan languages, such as Maithili, Bhojuri and Rajbanshi. This presents a sharp contrast with other languages in Nepal, such as Nepali including some minor IA languages of Nepal.

Moreover, in an overwhelmingly majority of languages, the locative begins with *-m*. The only language which stands out in this regard is Majhi in which the form of locative marker is distinct, viz. *-ka,- ra*. Additionally, some languages have additional locative marker, viz. *pər*. Rajbanshi is also distinct in this regard because this makes use of the locative *mik^{hi}* including other forms. Darai has the locative marker *-jə̃* which still contains the nasalized element.

Furthermore, the ablative in these languages is mainly formed in two ways, either with *-se* or *batə*. Although the precise form differs in some languages, most of them share these markers. Masica (1991) notes that the suffix *-se* is found in various forms in Hindi areas from Bihar to Rajasthan (p. 247). Maithili ablative marker is *-sə* which is shared by a number of languages. Similar is the case with those languages which possess the ablative marker *batə*. Some slightly different phonological form for ablative, such as *bađi*, is also evident in Churete.

Lastly, almost all languages share a sociative postposition (or marker) except Bhojpuri. The sociative marker *səŋ* is evidenced in a number of IA languages. Added to this, there are some languages possessing *-se* as a sociative marker. As a passing note, case syncretism is seen mostly in ergative and instrumental if the languages possess both these markers. Many languages also share instrumental and sociative cases such as Bhojpuri, Darai, and Rana Tharu.

Summary

This article has discussed the case markers in Darai and then compared the case forms of Darai with other IA languages of Nepal. The discussion first of all shows that Darai exhibits the split ergative system based on nominal hierarchy. Secondly, there are some instances of case syncretism in Darai. For example, instrumental and ergative as well as sociative and ablative share identical case forms.

The comparison of case markers with case forms of other IA languages shows some interesting results. Firstly, the dative-accusative marker *-ke* is used in these languages. Grierson (1904) noted that this is a feature of 'eastern' languages. Secondly, ablative *-se* is another common case marker found in these languages. Darai not only shares identical case forms with other IA languages, but also their roles in grammatical relation. Despite the cases of ergativity, all other case forms show that Darai shares a number of features with 'eastern' IA languages. In a bird's eye view, minor IA languages such as Darai, Danuwar, Majhi, Kumal occupy intermediate position between 'eastern' and 'Pahari' languages. These minor IA languages share some case forms with Indo-Aryan, Inner subbranch, Pahari group (Masica, 1991, p. 448), whereas others are similar to Bhojpuri and Maithili of eastern outer branch.

Table 1. Case markers in Indo-Aryan languages in Nepal

Languages → Case markers ↓	Rana Tharu	Dagaura Tharu	Nepali	Churete	Kumal	Bote	Darai	Chitwania Tharu	Bajjika	Danuwar	Majhi	Bhojpuri	Maithili	Saptaria Tharu	Rajbanshi
Ergative	-	-	-le	-le	-le	-ī	-ī	-	-	-i	-n, -in	-	-	-	-
Instrumental	-se	-səŋ	-le	-le	-le	-ī	-ī	-se, mah ē	-se	-i	-n, -in	-se	-səə	-se	-de
Dative-accusative	-ke	hən ə	-lai	-kun	-ke	-ke	-	-ke, -k	-ke	-ləi	-lai	-ke	-ke	-ke	-k
Genitive	-	-ək ko, -ro	-ko, -ro	-ka, -ra	-	-	-	-rə -kə -ər	-ke -ər	-k, -r	-rə	-ke -ər	-ək -ər	-ke, -ra	-er
Locative	-	- me , -the -ke	-ma	-ma	-	-	-jəə	-ma -me	-pər -me	-ma	-	-e -me -pər	-me	-me	-pər, mikh i, biti, ṭina
Ablative	-se	-se	baṭə dek hi	baḍi dek hi	baṭ e	bhə i	-se	-se	?	baṭe	baṭ e	-se	-səə -sə	?	-se
Sociative	-	-səŋ sə ŋ	səŋg ə	sitə	sitə	sin	-	səŋe se, - sə ŋ	sath e	səŋg e	sin	-	səŋg ke/k e a jore	səŋg e	səŋe

Note: absence of marker is indicated by (-) and the gaps by (?).

Abbreviations

[1: first person; 2: second person; 3: third person; ABS: absolutive; ABL: ablative; ALL: allative; AUX: auxiliary; CAUS: causative; CLF: classifier; CONC: concessive; COND: conditional; COP: copula; DAT: dative; EMPH: emphatic; ERG: ergative; F: feminine; GEN: genitive; HOR: hortative; HYP: hypothetical conditional; IA: Indo-Aryan; IMP: imperative; INF: infinitive; LOC: locative; NEG: negative; NIA: new Indo-Aryan; NOM: nominative; NPST: non-past; OIA: old Indo-Aryan; OBL: oblique form; OBLIG: obligation; PART: particle; PL: plural; POSS: pronominal suffix; PRF: perfect; PROS: prospective; PST: past; PURP: purpose; SG: singular; SEQ: sequential converb; SIM: simultaneous converb; SOC: sociative]

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Gender Stereotype in Nepali TV Commercials

Indira Mishra

Mahendra Multiple Campus, Dharan

Abstract: *Patriarchy uses different tools and tactics to maintain the traditional gender roles assigned to men and women. Literature, films, paintings and advertisements are some of the cultural texts through which gender stereotypes are reconstructed and perpetuated. This article aims to analyze some of the commercials screened on Nepal Television because the way men and women are presented on the commercials go unnoticed as they are thought to be concerned with the transaction of the market. However, besides selling the goods they sell ideology, belief and value system that are pervasively patriarchal. Indeed, advertising has become the central meaning making process in the modern culture. Nonetheless, in the context of Nepali TV commercials, no serious study has been made analyzing gender roles representation in them. This article, though partially, aims to fill this gap.*

Keywords: *Stereotype, representation, masculinity, femininity, identity and hegemony, advertising.*

An overview of advertising

Advertising has been very much of a presence in our lives. Originated from the Latin term *ad verter* it means "to turn the mind towards" or "to draw attention to." In its basic meaning advertisement is concerned with getting attention. Advertisement, in simple statement, can be defined as "a paid, nonperson communication form used with persuasive intent by identified sources through various media" (Sandage *et al.*, 2000, p. 5). It is a kind of public notice designed to sell some commodities; and as a kind of communication, its purpose is to inform potential customers about products and services.

According to Cohen (1988), "Advertising is a business activity, employing creative techniques to design persuasive communication in mass media that promote ideas, goods and services in a manner consistent with the achievement of the advertiser's objective, the delivery of consumer satisfaction and the development of social and economic welfare" (p. 5). Cohen's definition focuses on the creative and persuasive aspects of ads.

Advertising, then, is an art and to an extent, applied as persuasive communication which must carry on, in the beginning to inform, incite, and interest the prospect in buying the product and later to reinforce the message. However, no audience is there to watch the advertisements. The uninvited presence of advertisements is irritating for the audience, especially on TV programs, because one has to postpone other important tasks for it. Whether one likes it or not, the TV commercials are the one who pay for the program. Without advertising the modern world of communication is simply unimaginable. A large amount of money is paid to get the audience's attention.

Thus it is not simply a matter of selling and buying products. It has ventured into the domain of persuasion and its rhetoric has become omnipresent in contemporary social discourse- in the content and delivery of the meanings that people exchange (Beasley & Danesi, 2002).

Gender stereotypes and Nepali TV commercials

A stereotype is depicted as a group's generated beliefs about the personal attributes of members of another group, where those members are viewed as a generic type, rather than as specific individuals. It is defined as "a rigid, over simplified, often exaggerated belief that is applied both to an entire category of people and to each individual within it" (*The Blackwell Dictionary of Sociology*, p. 282). As an exaggerated belief associated with a category, the main function of a stereotype is to justify or rationalize one's conduct in relation to that category. The belief, for example, that a man cannot take care of children like women and women cannot be professional like men is stereotyped.

Stereotypes are important because they form the basis of prejudice which in turn is used to justify discrimination. Though stereotypes can be positive, their negative aspects are stressed more often. Stereotypes are regarded as undesirable because of the prominent role they play in social oppression based on characteristics such as race, gender, ethnicity and sexuality.

A stereotypical representation involves simplification, deduction and naturalization. Stereotyping reduces, essentializes, naturalizes, and fixes difference and facilitates the binding or bonding together of all of "us" who are normal into one imagined community; and it sends into symbolic exile of them (Hall, 1997, pp. 324-344). In the process of stereotyping, power plays a vital role. Stereotyping tends to be directed at subordinate groups (ethnic minorities, women) and perpetuates hegemonic social order.

If we select images and analyze the content of those images, the result will be obvious that stereotyping is still prevalent in advertising; and Nepali TV commercials are no exception. Nepali television commercials reinforce gender stereotypes. In them masculine qualities are associated with strength, competence, independence, and rationality while female qualities are associated with fragility, passivity, and emotionalism.

Sex role stereotypes are found in almost all types of TV programs and the advertisements that go along with them. Advertisements have an important cultural impact on society in that they define the acceptable gendered behaviors. In this context, Anthony J. Cortese (2008), a researcher on media, while analyzing the images of women and minorities in advertising, argues that "advertising is one of the most powerful mechanism through which members of a society assimilate their cultural heritage and cultural ideology of domination" (p. 2). However, advertisements do not reveal reality about gender but instead offer what advertisers believe about gender roles.

Advertising uses stereotypes that can be shared by the mass and stereotypical depictions of men and women have become the norms. Advertisements have consistently confined women to traditional mother- home or beauty/sex oriented roles that are not representative of women's diversity. The coming sub- sections show how NTV commercials recreate and reinforce stereotypical notion of masculinities and femininities.

To analyze advertising as a type of discourse, the article will draw insights both from literary studies, especially gender and film studies. The research is qualitative in its method though it collects ads on NTV as data which are taken as primary texts. Purposive samples have been used as a sampling method. Four samples were taken deliberately from NTV that are aired on the month of June and July 2011 on NTV to justify the point. The ads are communicated in the Nepali language and they are translated using personal translation as free translation.

Homogeneity of femininity

Since biology determined that women give birth, most of the cultural setups consider child rearing acts as feminine roles, therefore, the sole responsibility of women. Our culture commonly accepts such gender roles and defines sexual division accordingly. Following such a division, women's work is restricted to the private sphere of the household, while men's work is extended to various occupations in the public sphere. Similar to many other patriarchal cultures, in Nepal, the basic definition of femininity and its surviving common theme is associated with virtues such as caring, nurturing, gentleness, kindness, tenderness, cooperation, patience, and passivity. Likewise, the basic definition of masculinity and its common motifs are linked to qualities such as assertiveness, ruthlessness, courage, valor, and so on. Even a cursory glance at the binary opposition described above shows that the masculine traits are more active compared to passivity associated with femininity. Because of these assumptions, it can be taken that gender roles have been so normalized in our day to day life that they often go unexamined. This can be illustrated by an analysis of the ad of *Clinic Plus Shampoo*.

The campaign *Clinic Plus Healthy Hair Contest* portrays a young mother who is enjoying playing and merry making with her daughter. Both of them are expensively dressed and have set their long, black, silky or healthy hair loose. They look as if they belong to the affluent family, as the mother is enjoying her leisure. The male voiceover that supports the ad explains the activity of an ideal/ loving mother: "A mother forgets herself caring her daughter feels pleasure in the daughter's happiness and gets proud upon the success of her daughter. Besides she worries for the bright future of her daughter."

Then another male voice urges the women to "take part in the *Clinic Plus Healthy Hair Contest* and make their daughter's future bright." The slogan is "Healthy Hair is the Basis for a Bright Future."

Fig. 1. Clinic Plus Healthy Hair Contest Advertisement NTV



The message is “make your and your daughter’s hair healthy and win the contest to receive scholarship for your daughter.” But it sells many things besides the product. The mother and the daughter look rich. The mother is educated as she is teaching her daughter. But she is associated with frivolity and wastage; the emphasis is on leisure and luxury. To make your daughter’s future bright you need not take part in healthy hair contest. Rather, you should work hard, earn the money and invest it in her education. But, traditionally, a woman makes no money and the property is of her husband and she cannot invest upon her daughter on her own. Indirectly, the mother is teaching the daughter about her future role as a woman. Because “the child becomes male or female in response to the females or males she encounters in her family and to the male or female images she constructs according to her experience...” (Jones, 1998, p. 92). The mother is playing a role model for the daughter.

Not only does beauty appear to be a typical feminine value and good in the commercial; motherhood is also upheld as an ultimate goal, without which a woman’s life would be incomplete. In her essay “Male Hegemony and Colonization of the Female Body” Rayamajhi (2001) questions, “Does not a woman have the right to make a choice about her role in reproduction?” (p. 7). Not being able to procreate a (male) child she constantly feels guilty. The hegemonic discourse of motherhood subsequently transforms her into a psychologically alienated victim. Her alienation is caused due to the social ideology that perceives motherhood as essential for feminine identity. As Rayamajhi states in the same article, “unfortunately this idealized concept of motherhood never did open up a space for women, but paradoxically, by this very process of idealization, a woman is imprisoned in her own body, which necessitates that only a male child take birth from her” (p. 5).

Hence the combination of myth and beauty and the family confines the models of successful women in these ads, and consequently their viewers, to the pursuit of beautification and motherhood. This leaves careers and other social achievements an option rather than a necessity for a woman.

The ad is misleading because a body is a composite part, a whole, organic unit. There should be a proportional health condition; one cannot have healthy hair irrespective of the body. It encourages the growing girls to beautify themselves by caring for their hair and skin. The ad is repressive as it underestimates the interest of the educated women. For educated women can be engaged in some income generating works and add to the family purse to secure their children's future.

Likewise, the ad made for *Vaseline Whitening Cream* depicts women only as a flesh; the women inclination is only towards their body.

Fig. 2. Vasline White Cream Advertisement NTV



In it the popular Indian actress Anushka Sharma is shown walking confidently. She is wearing a revealing, sleeveless, fitting dress which shows her fair complexion that matches the fairness and smoothness of her body. Her confidence is the result of her fair complexion which has made her attractive. She encounters another girl in a pink color, sleeveless dress. Her revealed parts are darker than her face. As a result she seems to feel insecure/ low self esteem; the way she walks illustrates this. Then the actress suggests the solution with the *Healthy White Cream* that has triple sun screen.

The space is provided to women who are tall, thin and have fair complexion. The flawless, symmetrical body without pores and wrinkles is promoted. This creates

hegemonic beauty. Aged women, women with short height and dark complexion are excluded from the sphere of beauty; so are women who do not attract the attention of heterosexual males or masculine women with strong muscles. Advertisers know very well that physical appearance, facial beauty and fair complexion play central role in sexual desire. Through such advertisements, the commercials are colonizing women's body as they are constrained in such a way that they cannot walk without putting on a mask of cosmetics. Women who refuse to wear makeup are termed as unfeminine in the present consumerist culture.

The desire to look beautiful has negative effects on women as pointed by Nomi Wolf (2002). She argues (with regards to cosmetic surgery) that it is something that runs counter to the feminist stance on their body. For Kathryn Pauly Morgan, cosmetic surgery is "primarily self-imposed surveillance of the body under patriarchal power . . . a form of colonization of women's bodies" (cited in Tong, 2009, p. 277). Wolf, like Morgan, postulates that women's desire to be beautiful "is the result of nothing more exalted than the need in today's power structure, economy, and culture to mount a counter-offensive against women." Beauty industries help the producers, manufacturers and the advertisers earn money and more powerfully as claimed by Wolf serve for the power that want women keep economically, politically and socially stagnated. Because women are forced to focus on their looks they have little time to focus on far more important issues (Wolf, cited in Tong, 2009, p. 88). This type of representation degrades or deprives women of their profession, seeking to reduce them to sex objects.

These representations assume that the female gender is a homogeneous category made of women with identical interest and desires, regardless of caste, ethnicity, class, and geographical locations. These representations also function as supportive materials that exclude alternative forms of femininity. The representations still reflect, reconstruct and largely reconfirm existing stereotypes.

Male, muscle and masculinity

The importance of gender inequality is often felt at the instance of the birth of a child. The first question parents ask at the birth of a child, in all societies is perhaps the same "is it a boy or a girl." Men and women are not treated alike, given the same status and guaranteed social equality. On the contrary, in every society, certain rights and opportunities have been denied to women. A social rationale given for this discrimination is that the talents and potentials of the sexes are different in many respects. Throughout the history the inferior status of women has been seen as a self-evident fact of nature.

The patriarchal ideology exaggerates biological differences between men and women, making certain that men always have the dominant, or masculine, roles and women always have the subordinate or feminine ones. This ideology is so powerful,

said Millett that men are usually able to secure the apparent consent of the very women they oppress. Men do this through institutions such as the academy, the church, and the family, each of which justifies and reinforces women's subordination to men, resulting in most women's internalization of a sense of inferiority to men. Should a woman refuse to accept patriarchal ideology by casting off her femininity—that is, her submissiveness/subordination—men will use coercion to accomplish what conditioning has failed to achieve. Intimidation is everywhere in patriarchy, according to Millet. The streetwise woman realizes that if she wants to survive in patriarchy, she had better act feminine, or else she may be subjected to "a variety of cruelties and barbarities." (Millet, cited in Tong, 2009, p. 52).

An interpretation of the advertisement made for *Nepal Bank Ltd.* aired by NTV stages a patriarchal desire to continue women's subordination to men. Nepal Bank Ltd. is the sponsor of the economic news of NTV. The advertisement depicts the ideal family, a nuclear family in a comfortable house with two kids, a boy and a girl who are about to go to the school in their uniform. The feudal social mechanism governs the notion that only riches provide happiness. The tea table, the husband taking his breakfast hurriedly in the business man like manner and the alluring wife serving him, all show the feudal tendency of the advertisement. The wife is shown in the secondary role; she is subjugated to him only as a helper. She needs to serve him because he is the upright man who has been able to accumulate the desired prosperity for the family. The triviality of the wife is reflected by the fact that she helps him put his coat, and waves her hands to the children going to school.

Fig. 3. Nepal Bank Ltd. Advertisement NTV



In a medium shot it shows a middle aged man, well groomed; a tie on his neck shows he is about to leave for his office. Then another shot shows his alluring young

wife coming from the interior to the drawing room carrying his coat; she helps him wear his coat and then hands over his phone. The man then drives the children to school on his way to the office whereas she waves standing at the door; being limited to the domestic periphery, she does not cross the boundary of the house. Here, the man stands for knowledge, command, mastery, expertise, intelligence, enlightened, professional, and so on. One woman, by contrast, stands for ornamentation, beautification, glamour, pretentiousness, extravagance, kitsch, flashiness, artificial, skin-deep, cosmetic, trivial, frivolous and so on.

The family is an ideal, happy family and the couple are living a happy married life. The secret of Hindu marriage is silence: order, authority on the part of the husband and submission, beauty, innocence on the part of the wife.

Moreover, the strong male voiceover that supports the ad and the use of assertive sentences also shows masculine enterprise of accumulation of wealth and remaining commendable:

Let there be faithful company. And the company will always be strong. Let the strength be ultramodern. Nepal bank limited accompanies you in your every decision for ever. It is an ultramodern bank having its history.

The use of words like strong, strength, decision etc. in the ad suggests that the banking and finance are masculine fields. In addition to this, the closure in the sentences, *hos* symbolizes the authenticity of the father—governing, phallogocentric language, which Kristeva (1988) recognizes as the “symbolic” use of language (p. 239) which is to support male domination. The male voice-over that supports the ad retains the continuation of male domination.

The stereotypical notion that the husband is the breadwinner and he has to deal with difficulties outside and the wife should provide him emotional refuge is continued. The portrayal of family life and roles with regard to womanhood explores no other possibility than to cultivate the value of the traditional family model, thus reinforcing the existing societal norms and stereotypes.

In the same way, the patriarchal ideology blinds us towards these discriminatory practices and we take them for granted. The objective realism of modern ads are not objective at all. The models are presented in the way the patriarchal ideology wants them to appear. Heroism and health are related to masculinity/action men, fathers are the figures of authority. The human physical strength has always been associated with masculinity, whereas fragility and vulnerability go with femininity; and such discourses construct the gendered truth about men and women. The campaign of *Jagadamba Cement*, clearly supports this *status quo*.

Fig. 4. Jagadamba Cement Advertisement NTV



The location is outer, open space. Here masculinity is constructed as a hardworking person with strong muscles. The sweat is the result of physical labor in outdoor activities. The participant is a strong, macho man with large muscles performing different athletic activities. As a macho man, he is invincible and is able to cope with the adverse situation, the extreme weather: wild wind, hot sun and the pouring rain. He is a determined man in his Herculean attempts. He is thoroughly sweating, but does not stop. His revealed body, unlike the women in the above mentioned commercials, is neither for seduction nor for pleasure for the opposite sex. Rather it is to enhance the fact that to carry out the rough and tough outdoor activities one should have strong muscles. This shows his bravery, courage and faithfulness. The participant is the embodiment of ideal masculinity; he is fearless, athletic and confident. The strong male voiceover that supports the ad further conforms the strength of masculinity and its association with the strength of cement, an ingredient for construction, like buildings, bridges and pillars, these things are exposed to the extremities of weather and protect the human being from the hardship of nature, and so is the macho man:

There is faith and expectation. Everyone's confidence rests upon one's shoulder; there is no fear of sun, rain and storm. It neither succumbs nor surrenders, rather it keeps on standing like a rock. The most trusted cement of Nepal is Jagadamba Cement, Nepali's Cement.

The choice of words: sun, storm, rock, trust, shoulder etc. suggest masculine activities associated with building and construction. This type of work demands strength and labor. Men possess the capacity of expressing violently and confidently. Thus the superior voice of male dominates. The authorial voice, the focused attention and the strong muscle appropriate the hegemonic masculinity. The person has a strong determination and commitment to the task which he is going to accomplish.

According to Connell (2002) masculinity is associated with expertise and technical skills (p. 246). The association of male's muscle and masculinity with building and construction, which require technical skills, is justified by the advertisement.

Conclusion

The commercials on NTV assign different tasks and cultural values to men and women as if they belong to different worlds and have significantly different interests. Mostly the ads associate females with domesticity where their main task is cooking, cleaning and looking after the children. The female models are juxtaposed with beauty products, homemaking, fashion and food and beverage. On the contrary, they locate men with construction, education, transportation, banking and finance and other types of roles which demand both brain and brawn. These ads retain the myth of femininity and masculinity of women and men in which a man is projected as the bread winner professional who is engaged in a productive and paid work whereas a woman is either a loving wife or a caring mother who is mostly engaged in unpaid works and very often in frivolity and wastage. Even if she is projected as a confidential professional, which is rarely done, her confidence comes from her beautiful look. Thus, her main aim is to look beautiful to the exclusion of other productive and creative works. The commercials dictate her to set herself in a particular appearance. Obviously motivated by the patriarchal ideology, the TV commercials treat the female as the inferior being and subjugate her to the male. Hence, these representations still reflect, reconstruct and largely reconfirm the existing gender stereotypes.

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The Reader–Editor Relationship: A Study of News Contents in Nepali Print Media

Laxman Datt Pant

Department of Journalism and Mass Communication, National Integrated College, Kathmandu, Nepal

Email: laxmankasyap@gmail.com

Abstract: *The space allocation to different categories of news in Nepali newspapers convincingly match the readers' preferences. 'Development' and 'Politics' stand as the two most important categories for both the readers and editors. Additionally, the editors' estimate of readers' interest in various news topics also match with the readers' actual interest. However, there were differences in views between readers and editors regarding the attributes of a high quality newspaper.*

Keywords: *Newspaper, Nepal, media, news worthiness, reader's interest, Nepali broadsheet dailies, Journalism, mass media.*

Background

Journalism in Nepal has already become a profession not just a hobby or a political mission. It is even considered an industry in its own right. Besides, various educational institutions are offering a wide range of courses on journalism and related field. Moreover, Journalism has already been recognized as a discipline of knowledge.

However, the rise of journalism, both as a profession and a discipline, has yet to witness a growth in research. Some researches have been conducted, and magazines, journals, and in-house publications publish some research articles but many aspects and approaches still remain unexplored. The editor-reader comparative research is not an exception. No study has yet been conducted in Nepal regarding the editor-reader relationship. It is against this background that the present research has been carried out.

The present research explores new avenues of media research in Nepal, especially the assessment of the perceptions of the editors and readers regarding the news values in the newspapers. Both the editors and the readers have a significant role in shaping the media content. The editors play a crucial role in gate-keeping the news content, whereas it is the readers who are to receive and 'read' the content. Since the editors' work is aimed for their readers it is pertinent for them to consider their readers' expectations and assessments.

The present research focuses on the congruence between the editors' consideration of their readers and the readers' assessment of Nepali newspapers. It aims to find out whether the space allocation to different categories of news made by editors match the readers' preferences, and whether there is correspondence between

the perceptions of the editors and the readers regarding the news values. For this, the study compares the editors' estimates of readers' interest in various news topics, the readers' actual interest, and the perceptions of editors and readers regarding the quality of a newspaper.

There are various areas of research in print media. As Wimmer and Dominick (2005) observe, newspaper and magazine researchers conduct six basic types of studies: readership, circulation, management, typography/makeup, readability, and online media use (p. 308). Among them, readership study is the most extensive area; such research determines who reads a publication, what items are read and what gratifications the readers get from their choices. Readership study is among the most important types of evaluative research in print media today, particularly in determining which media are most appropriate in targeting information to the key stakeholders (Boone, Meisenbach & Turner, 2000). Such studies represent one of the most cost-efficient and direct ways of staying in touch with readers' needs and interests (Redding, 1982).

Research into newspaper readership is composed primarily of five types of studies: reader profiles, item-selection studies, reader-nonreader studies, uses and gratification studies, and editor-reader comparisons (Wimmer and Dominick, 2005). Thus, an editor-reader comparison is a type of readership study. Here, a group of editors is questioned about a certain topic, and their answers are compared to those of their readers to see whether there is any correspondence between the two groups (Gunter, 2000, p. 109; Wimmer & Dominick, 2005, p. 312).

Bogart (1989) has developed a model of comparative study of reader-editor relationship. In his research, a group of several hundred editors was asked to rate different attributes of a high quality newspaper. According to Bogart, there was little congruence between the two groups in their perceptions of the attributes of a high-quality newspaper. The editors ranked "high ratio of staff-written copy to wire service copy" first, "high amount of non-advertising content" second, and "high ratio of news interpretations... to spot news reports" third. But, the editors' top three attributes were ranked 7th, 11th, and 12th respectively by the readers. The readers rated "presence of an action line column" first, "high ratio of sports and feature news to total news" second, and "presence of a news summary" and "high number of letters to the editor per issue" in a tie for third.

In another study, Bogart (1991) focused on the space allocation to news of different categories. In the study, first, the contents of a sample newspaper were analyzed to find out the space allocations made by editors. Second, the readers were provided with 34 subjects and given an opportunity to design their own newspaper. Then, the two set of data were compared to see whether the space allocations made by editors matched the readers' preference. The study showed that consumer news

related to health, nutrition, medical advice, home maintenance and travel were the most preferred contents of the readers. The space allocations made by the editors to different categories of news did not match the readers' preference.

Gladney (1996) tried to determine whether editors and readers agreed on what makes a good newspaper. According to Gladney, both groups agreed on the importance of many journalistic standards, but readers did not value professional staffing goals and enterprise reporting as highly as the editors did.

Bernt *et al.* (2000) has compared editors' estimates of readers' interest in certain news topics with actual interests taken from a survey. The results demonstrated that editors overestimated readers' interest in crime, religion, stock market, and local business news. The finding showed that readers wanted more health-related and other consumer news than what they were getting.

Materials and methods

This research is a kind of readership research, based on the survey consisting of two groups—one representing the editors and another, the readers. The groups were questioned about certain issues, and their answers were compared to see whether there was any congruence between the perceptions of the two groups.

The research uses of triangulation method using both quantitative and qualitative methods. While it uses the quantitative approach for data collection, it uses both quantitative and qualitative approaches for data analysis. While the breadth of the research is ensured through the quantitative technique, the depth is ensured by the qualitative analysis.

The research employs a co-relational design in which surveys do not measure actual behavior, instead conclusions about behavior are drawn from self-reports or other-reports. Here, the responses of the editors and the readers are studied to compare their assertions and assessments respectively.

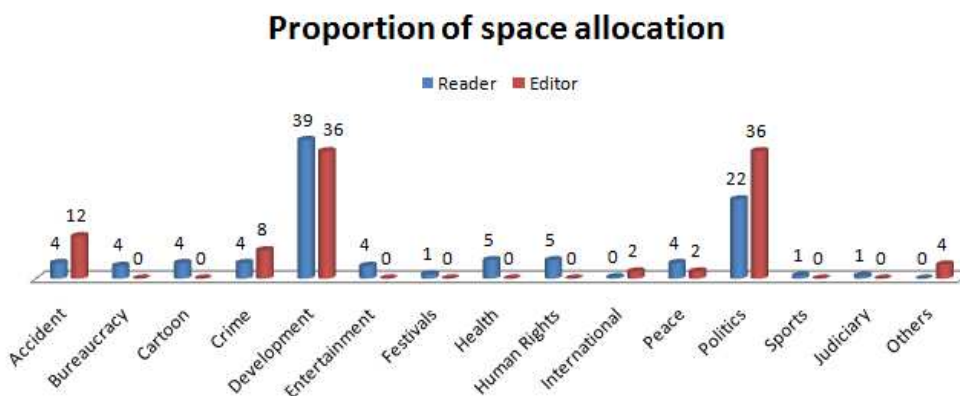
The editors of different newspapers and the readers in general constitute the universe of the present research. A total of 250 respondents (200 readers and 50 editors) from Kathmandu, Lalitpur, and Bhaktapur had been selected employing non-probability sampling technique. Of 250 respondents, 66% were male and 34% were female. The newspapers consulted for the front page content include *Kantipur*, *Nagarik*, *Gorkhapatra*, *Samacharpatra*, *Nayapatrika*, *Himalayan Times*, *Rajdhani* and *Annapurna Post* dailies.

This research is a self-administered survey which involves primary data. It uses questionnaires for data collection. The research has been designed to use *descriptive statistics* for data analysis. In addition, a focus group discussion consisting of editors, readers, and media educators has been conducted in order to facilitate the data analysis and provide it the depth of qualitative analysis.

Discussion: Comparison of readers and editors views on Nepali broadsheet dailies

Proportion of space allocation

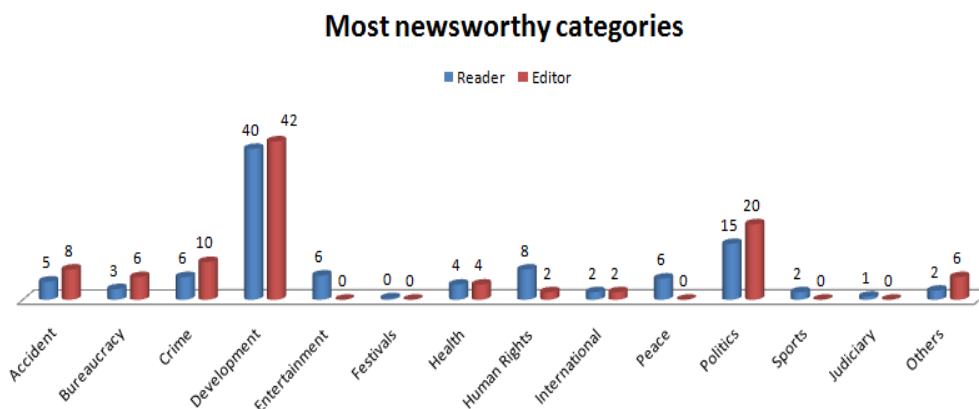
Fig. 1. Showing the respective proportion of space allocation on different categories of news according to readers and editors



In the figure 1, it is quite visible that ‘Development’ and ‘Politics’ stand as the two most important categories for both readers and editors in terms of space allocation. The figure shows that relatively more readers (39%) allocated more space for ‘Development’ news in comparison to editors (36%). Similarly, less number of readers (22%) allocated more space to ‘Politics’ in comparison to editors (36%). Likewise, ‘Accident’ is found to have received more importance by editors (12%) in comparison to readers (4%). Also, categories including ‘Bureaucracy’, ‘Cartoon’, ‘Entertainment’, ‘Festivals’, ‘Health’, ‘Human rights’, ‘Peace’, ‘Sports’ and ‘Judiciary’ received more space allocation by readers (cumulatively 29%) in comparison to editors (cumulatively 8%).

Most newsworthy categories

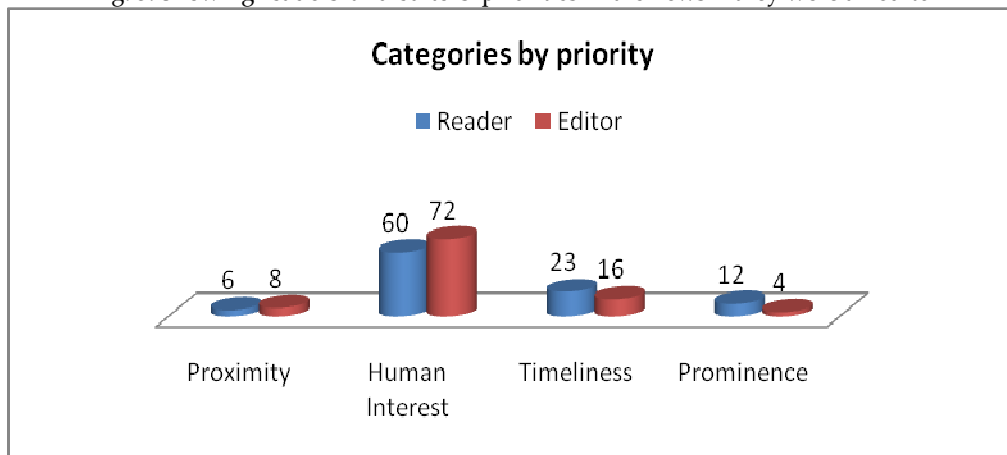
Fig. 2. Showing most news worthy categories of news according to readers and editors



As shown in figure 2, both editors and readers have selected ‘Development’ and ‘Politics’ as the most newsworthy categories. ‘Development’ as a category has been found to be considered newsworthy by 42% of the readers and almost equal proportion (40%) of the editors. However, relatively more editors (20%) in comparison to readers (15%) have selected ‘Politics’ as the newsworthy category. This is followed by 10% editors choosing ‘Crimes’ in comparison to relatively fewer readers (6%). Likewise, ‘Human rights’ has been chosen as the most newsworthy category by 8% reader and 2% editor. In the same way, 6% of readers have chosen ‘Entertainment’ in comparison to 0% of editors. While 6% of readers chose ‘Peace’ in comparison to 0% of editors. None or very few readers and editors chose the remaining categories as the most newsworthy category.

Categories by priority

Fig. 3. Showing readers' and editors' priorities in the news if they were an editor

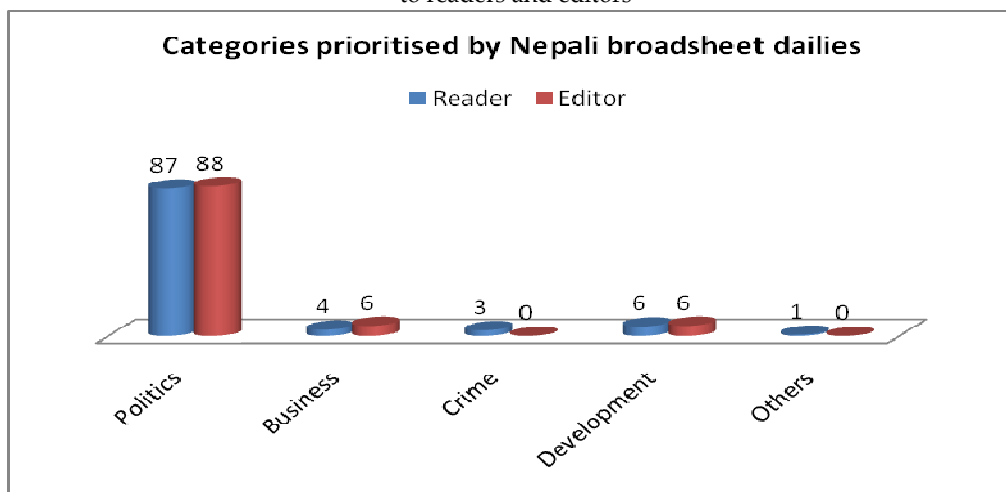


As shown in figure 3, while publishing news based on different news values, both readers (60%) and editors (72%) have agreed to give ‘Human interest’ in the top priority. For 23% of readers and 16% of editors, ‘Timeliness’ is the top priority. ‘Prominence’ has been chosen as the top priority by relatively more readers (12%) in comparison to 4% of editors. Also, 8% of readers prioritized ‘Proximity’ to 6% of editors.

Categories prioritised by Nepali broadsheet dailies

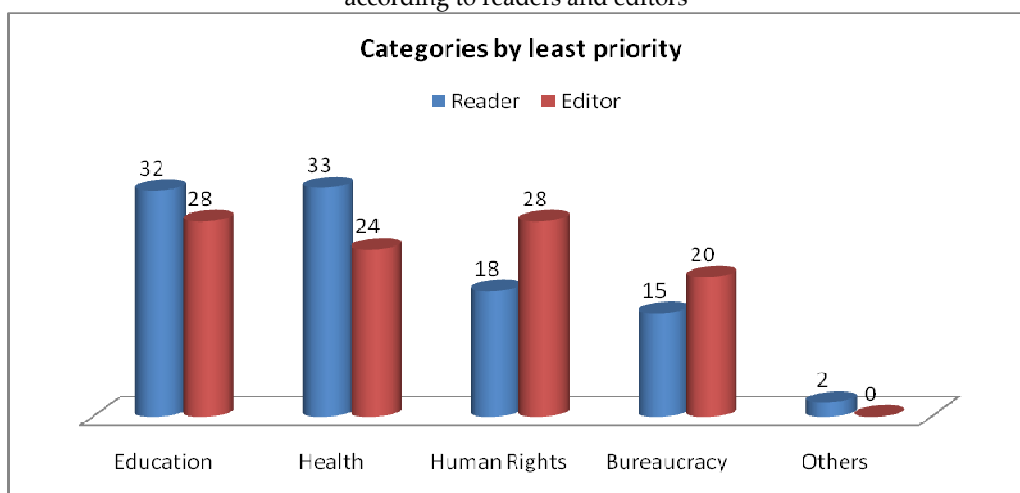
As shown in figure 4, almost nine-tenth of editors (88%) and readers (87%) opined that Nepali broadsheet dailies have given top priority to news related to ‘Politics’; readers and editors seem to have an unanimous agreement regarding the issue. Similarly, very few editors and readers think that the categories like ‘Business’, ‘Crime’, and ‘Development’ are given top priority.

Fig. 4. Showing the categories of news given top priority by Nepali broadsheet dailies according to readers and editors



Categories by least priority

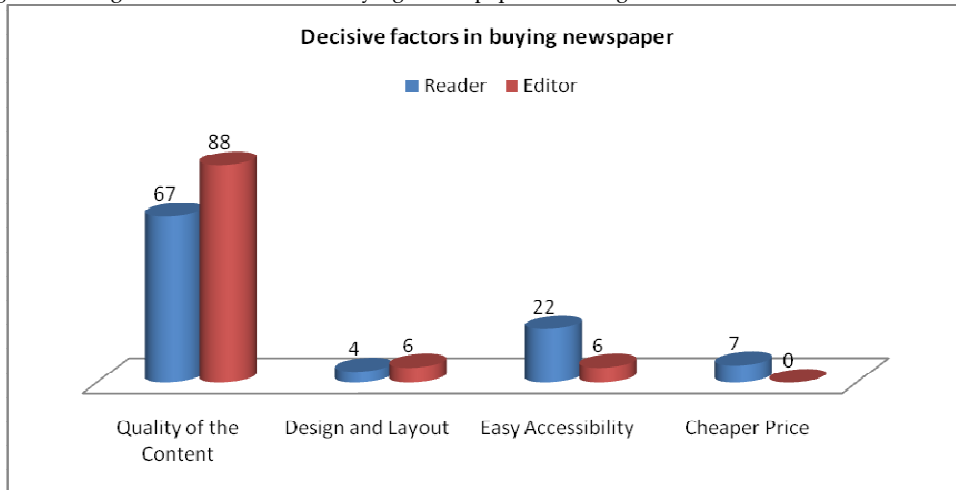
Fig. 5. Showing the categories of news given least priority by Nepali broadsheet dailies according to readers and editors



As shown in figure 5, 'Education' and 'Health' remain the least prioritized categories in Nepali broadsheet dailies. More than one quarter of readers (32%) and editors (28%) complained that 'Education' was the least prioritized category while 33% of readers and 24% of editors selected 'Health' as the least prioritized one. Compared to 18% of readers, 28% of editors view that 'Human rights' has been the least prioritized category. Similarly, according to 15% of readers and 20% of editors 'Bureaucracy' is the least favored news category by Nepali broadsheet dailies.

Decisive factors in buying newspaper

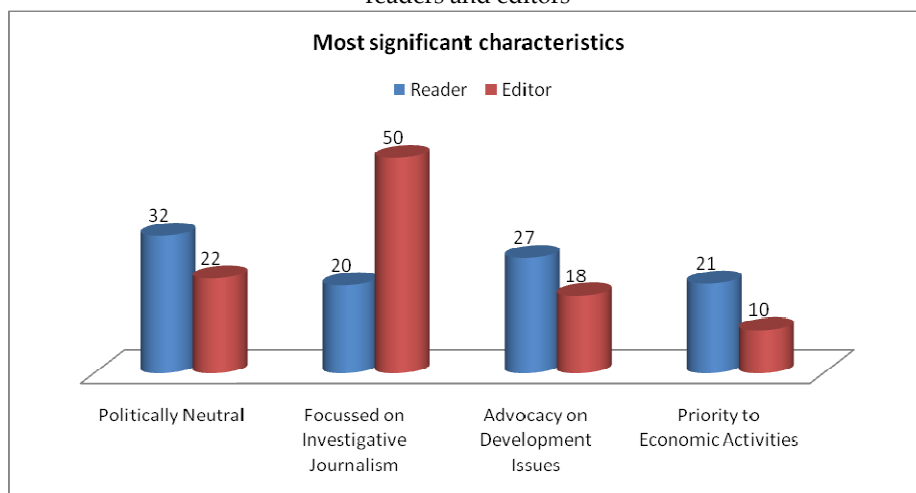
Fig. 6. Showing the decisive factors in buying a newspaper according to readers and editors



Both readers and editors agree that the ‘Quality of the content’ is the decisive factor in buying a newspaper. As shown in figure 6, more than two-third of readers (67%) and 88% of editors have chosen ‘Quality of the content’ as the decisive factor, while a relatively higher number of readers (22%) have chosen ‘Easy Accessibility’ in comparison to 6% of editors. Similarly, ‘Design and Layout’ is a decisive factor according to 4% of readers and 6% of editors. ‘Cheaper Price’ of newspaper is decisive factor according to 7% of readers but none of the editors think that price can be a decisive factor in buying a newspaper.

Most significant characteristics

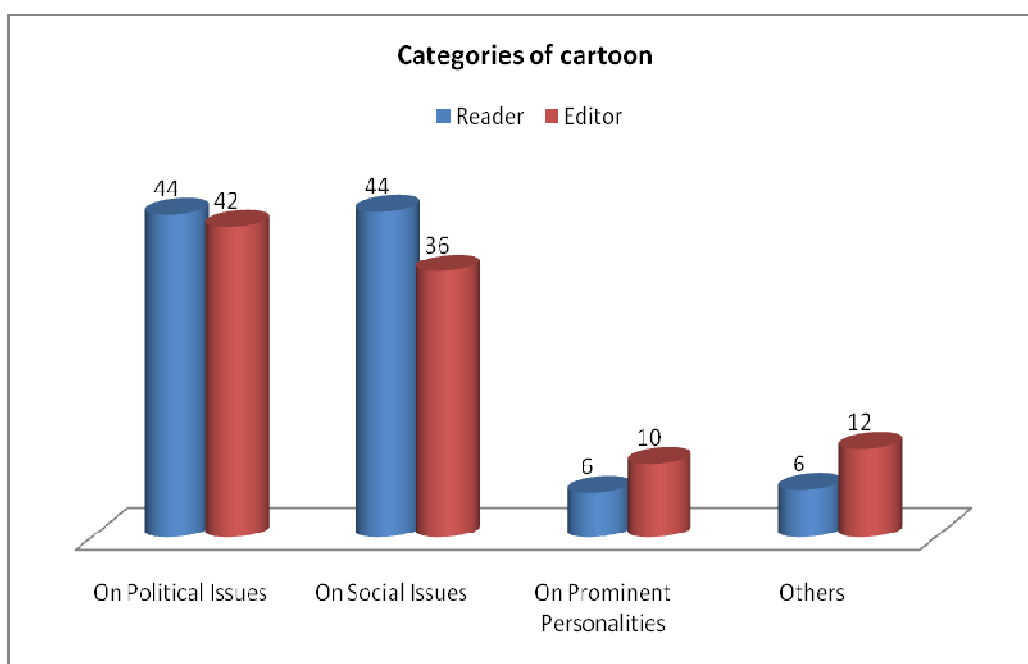
Fig. 7. Showing the most significant characteristics of a Nepali broadsheet daily according to readers and editors



As shown in figure 7, readers and editors differed on significant characteristics of a Nepali broadsheet dailies. Half of the editors selected 'Focused on investigative journalism' as the most significant characteristics in comparison to 20% of readers. 'Politically Neutral' was selected by a relatively higher number of readers (32%) in comparison to 22% of editors. Similarly, more readers (27%) in comparison to editors (18%) selected 'Advocacy on development issues' while a fewer editors (10%) chose 'Priority to economic activities' as the most significant characteristics in comparison to 21% of readers.

Categories of cartoons

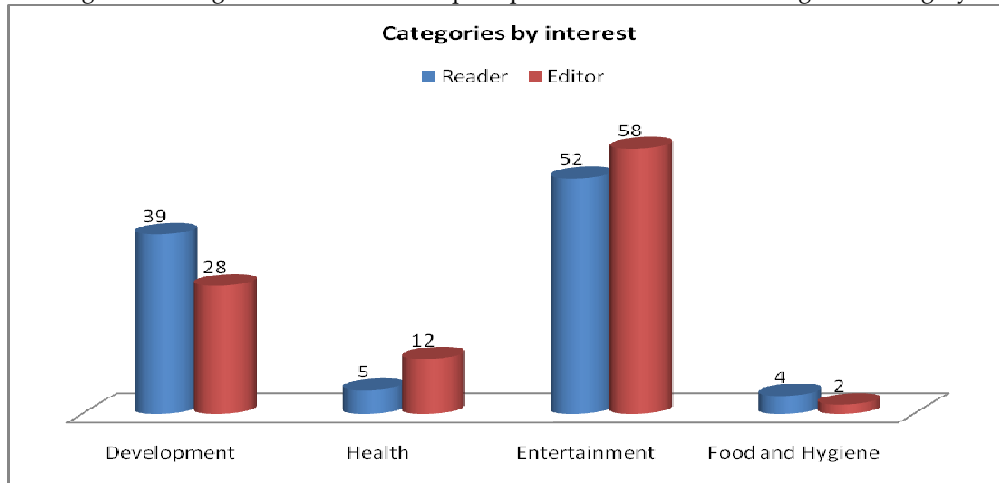
Fig. 8. Showing the kind of cartoons that the readers and editors liked to see on the front page of Nepali broadsheet dailies



As shown in figure 8, more than two-third of both readers and editors like to see cartoons on 'Political' and 'Social' issues in the front page of Nepali broadsheet dailies. Less than half of the readers (44%) and editors (42%) would like to see cartoons on 'Political issues' while 44% of readers and 36% of editors like to see cartoons on 'Social issues'. One-tenth of editors (10%) like to see cartoons on 'Prominent personalities' in comparison to 6% of readers.

Caterories by interest

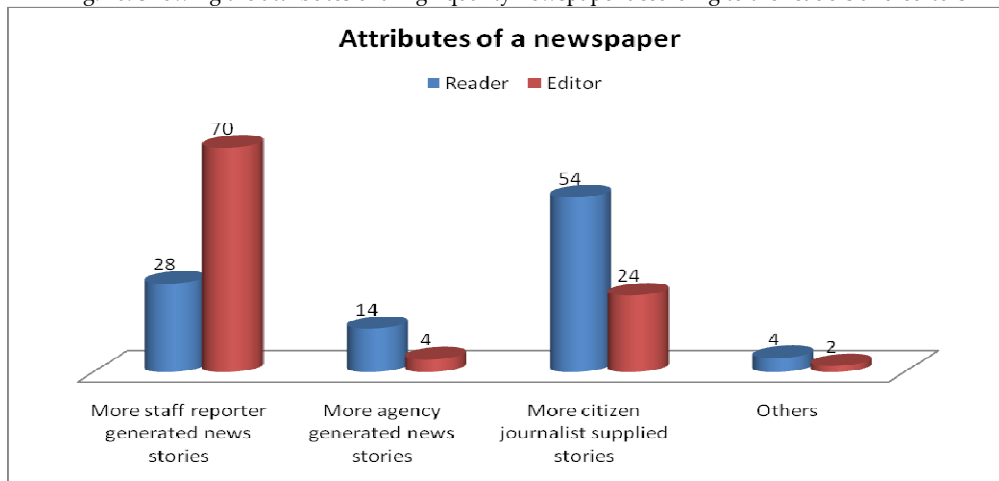
Fig. 9. Showing readers' and editors' perception of the must interesting news category



As figure 9 shows, more than half of the readers (52%) and editors (58%) have undisputed views about 'Entertainment' being the category that most interests the readers. However, there are differences among readers and editors on 'Development' and 'Health' category. A relatively high number of readers i.e. more than one-third (39%) think that 'Development' is more interesting to readers in comparison to 28% of editors. Similarly, 5% of readers selected 'health' category in comparison to 12% of editors. Similarly, 4% of readers and 2% editors of chose 'Food and Hygiene' as the more interesting category of news.

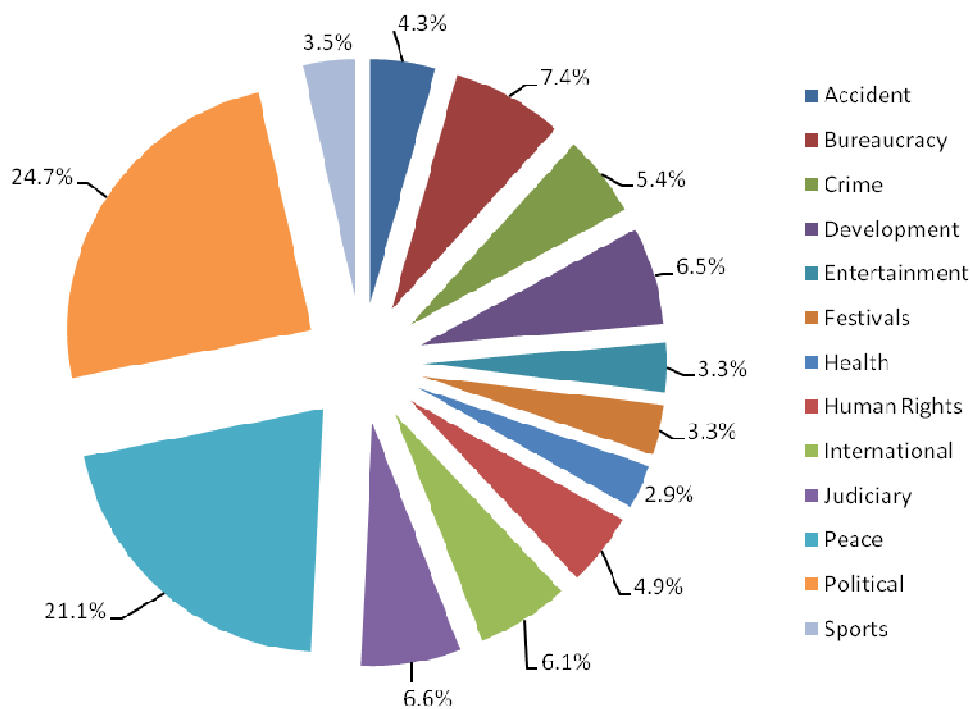
Attributes of a newspaper

Fig. 10. Showing the attributes of a high quality newspaper according to the readers and editors



As shown in the figure 10, readers and editors showed differences regarding the attributes of a high quality newspaper. More than two-third of editors asserted that 'More staff reporter generated news stories' should be the attributes of a high quality newspaper while relatively few readers (28%) agreed. The differences are prominent in choosing another category too: A relatively high number of readers, i.e more than half (54%) in comparison to 24% of editors chose 'citizen-journalist supplied stories'. Similarly, 14% of readers selected 'More agency generated news stories' as the attributes of a quality newspaper in comparison to 4% of editors.

Fig. 11. Showing coverage (number of news stories) given by newspapers to different news categories on the front page of the newspaper



A total of 1,249 news stories published on the front page of the eight newspapers were studied. Out of the total, almost one-fourth of the stories were related to 'Politics' (24.7%) followed by news related to 'Peace' (21.1%), which occupies more than one-fifth of the total number of news stories published. This means, 'Politics' and 'Peace' together occupy almost half of the news stories published in the newspapers. Among all the remaining categories, no other category has accounted for one-tenth of the total news stories published.

About 54.2% of the total news stories published in the newspapers were from the remaining 11 categories. Among the remaining 11 categories, news stories related to 'Bureaucracy' (7.4%), 'Crime' (5.4%), 'Development' (6.5%), 'International' (6.1%) and Judiciary (6.6%) have at least a 5% share on the total number of news published. The remaining 5 categories have less than 5% share on the total number of news published. According to the figure, 'Health-related' news stories (2.9%) have been the least prioritized ones by the newspapers.

Results

The space allocation to different categories of news in Nepali newspapers convincingly match the readers' preferences. 'Development' and 'Politics' stand as the two most important categories for both readers and editors in terms of space allocation. Both readers (60%) and editors (72%) have agreed that 'Human interest' news should receive top priority. More than two-third of editors prioritized 'Human Interest' news (72%) while less than one-fifth of editors said that 'Timeliness' (16%) should be the priority. Similarly, 'Proximity' and 'Prominence' were prioritized cumulatively by one-tenth of the total editors (12%). 'Prominence' has been chosen as the top priority by relatively a large number of readers (12%) in comparison to 4% of editors. Also, 8% of readers prioritized 'Proximity' in contrast to 6% editors.

The editors' estimation of readers' interest in various news topics reasonably match the readers' actual interest. More than half of the readers (52%) and editors (58%) have undisputed view about 'Entertainment' being the category of more interest to the reader. However, there are differences among readers and editors regarding 'Development' and 'Health' category. A relatively high number of readers i.e. more than one-third (39%) think that 'Development' is of more interest to the readers in comparison to 28% of editors. Similarly, 5% of readers selected 'health' category in comparison to 12% of editors.

There were differences in views between readers and editors regarding the attributes of a high quality newspaper. More than two-third of editors asserted that 'More staff reporter generated news stories' should be the attributes of a high quality newspaper while relatively fewer readers (28%) thought that way. The differences are prominent in choosing another category too-'More citizen journalist supplied stories' which was chosen by relatively high number of readers (54%) in comparison to 24% of editors. Similarly, 14% of readers selected 'More agency generated news stories' as the attributes in comparison to 4% of editors.

Acknowledgements

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