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2017 Calendar Year, Myanmar Academy of Arts and Science Award Winning Doctoral Dissertation

Research Reports



၂၀၂၀ ပြည့်နှ<mark>စ်၊ ဇန်နဝါရီလ</mark> 2020 January



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Study on the Ichthyoplankton of Myanmar Coastal Water

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Detection of Insecticides Susceptibility of Aedes Aegypti (Linnaeus, 1762) and Ae.Albopictus (Skue, 1894) from Selected Townships in Mandalay and Determination of Resistance based on Biochemical Assay

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Fabrication and Characterization of NiO Anodic Electrochromic Layer for Smart Window Application

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Developing a Training Model for Early Childhood Teachers in Building Students' Resilience

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Industrial Agglomeration of Weaving Firms in Amarapura Township

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FOREWORD

It cannot be denied that education plays a vital role in increasing the family income, promoting the general well-being of an individual as well as that of his family, invigorating the cooperative spirit of communities, developing the country's economy, and last but not least, contributing positively to all endeavours for national unity and peace.

Our country has been engaged vigorously in the task of enhancing the quality of education with a view to raising it from the current ASEAN standard to that of the developed countries. In order to achieve that objective, the Ministry of Education drew up the National Education Strategic Plan 2016-2021 and has since been implementing the projects under that plan.

Section 28 on page 13 of The Republic of the Union of Myanmar National Education Law (2014) stipulates that all colleges and universities under the Department of Higher Education give priority to carrying out research programmes and education development.

The Myanmar Academy of Arts and Science, instituded in 1999, is fully committed to:

- 1) The dissemination of modern methods and techniques of teaching and learning,
- 2) The promotion of research and providing guidelines for research programmes and projects,
- 3) The dissemination and propagation of knowledge and expertise among the general public, and
- 4) The promotions of measures aimed at the generation and proliferation of competent researchers, academicians and Technocrats.

Ever since its institution, the Academy has endeavoured to meet those commitments through national and international networks.

From the year 2000, a year after its inception, the Academy has been holding Annual Research Conferences, and from the Fifth Annual Research Conference onwards, the Academy commenced bestowing the Best Paper Award. The number of quality research papers has increased from year to year; it is most gratifying to find that a total of 25 researchers won the Best Paper Award at the 2017 Research Conference.

In 2006, the Academy initiated a nationwide Contest of Research Reports of doctoral theses in various fields of study, with a view to bestow the Myanmar Academy of Arts and Science Award to the best researcher of the year; there was a total of 120 contestants. Currently, the Academy is making an all-out effort to raise the prize money in order that there would be

more and more research aspirants in every field of study. The initial Academy of Arts and Science Awards were borne by the Academy, the Tun Foundation and the Thiri-mon Foundation. Today, donations made by:

- a) Retired President of the Board of Examinations U Maung Maung Sein and his spouse in commemoration of Sayagyi Dr Htin Aung, Rector of Rangoon University
- b) Yangon University of Economics in commemoration of Sayagyi Saw William Paw
- c) Department of Myanmar, University of Yangon, in commemoration of its 75th anniversary, and
- d) Sayamagyi Daw Khin Thein, Retired Professor of the Department of Oriental Studies, University of Yangon in commemoration of Sayagyi U Pe Maung Tin

have been established as a Foundation and the bank interest accrued upon it is used as the means to meet the expenses of the awards.

In addition, since 2017, the Ministry of Education has been sponsoring the Best paper Award as well as the Myanmar Academy of Arts and Science Award.

The ability of an academician is commensurate not only with his or her educational accomplishments but also with the knowledge he or she gains from the research projects he or she carries out.

The best research report of doctoral theses for the year 2016 are:

(a) Arts

Psychology

Resilience to Childhood Abuse and Neglect in University Students from Yangon Region

English

A Study of the Use of Parallelism in the Novel *A Tale of Two Cities* by Charles Dickens

- Myanmar (Language)
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- Myanmar (Literature) a&Ivd hpwbwmf t z9 pmayrsm
- History

Socio-economic Conditions of Myothit Township in Magway Region (1800-1900)

- (b) Physical Sciences
 - Geology

Geology, Geochemistry and Ore Genesis of the MODI-MOMI Gold Deposit, Yamethin Township, Mandalay Region Marine Science

Study on the Ichthyoplankton of Myanmar Coastal Water

Zoology

Detection of Insecticides Susceptibility of *Aedes Aegypti* (Linnaeus, 1762) and *Ae.Albopictus (Skue*, 1894) from Selected Townships in Mandalay and Determination of Resistance based on Biochemical Assay

Physics

Fabrication and Characterization of NiO Anodic Electrochromic Layer for Smart Window Application

(c) Social Science

Methodology

Developing a Training Model for Early Childhood Teachers in Building Students' Resilience

Economics

Industrial Agglomeration of Weaving Firms in Amarapura Township

All the Eleven authors of those Research Reports of doctoral theses were awarded the Myanmar Academy of Arts and Science Award. The Myanmar Academy of Arts and Science is delighted to publish this book for the benefit of the Contestants concerned, the academicians in the universities and colleges as well as the general public.

President Myanmar Academy of Arts and Science

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- **Ustfacgi (p01** Detection of Insecticides Susceptibility of *Aedes Aegypti* (Linnaeus, 1762) and *Ae. Albopictus* (Skue, 1894) from Selected Townships in Mandalay and Determination of Resistance Based on Biochemical Assay
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RESILIENCE TO CHILDHOOD ABUSE AND NEGLECT IN UNIVERSITY STUDENTS FROM YANGON REGION

1. Introduction

- 1.1 Objectives
- 1.2 Hypotheses

2. Methods

- 2.1 Participants
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- 3.1 Results
- 3.2 Discussion

4. Summary and Conclusion

- 4.1 Limitations and Direction for Future Research
- 4.2 Implications

References

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J->1 RESILIENCE TO CHILDHOOD ABUSE AND NEGLECT IN UNIVERSITY STUDENTS FROM YANGON REGION

Hnin Thandar Linn¹

Abstract

The purpose of this study is to explore the protective factors that are associated with resilience in university students who were abused and neglected in childhood. Participants were 420 undergraduate students from Yangon University, East Yangon University and Dagon University. As measures, the Myanmar version of the Childhood Maltreatment Questionnaire, Abuse and Neglect Scale, Life Events Questionnaire-Adolescent Version, College Adjustment Questionnaire and Social/Emotional Influences Inventory (Shirley and Roséns, 2010) were used in this study. Pearson correlation coefficient, Chi-square analysis and multiple regression analyses were used for data analyses. Results of the correlation analyses showed that individual protective factors were more related with resiliency than family and community protective factors among university students who were abused and neglected as children. Individual protective factors were more related with resiliency than family and community protective factors among male students. The findings of the hierarchical multiple regression analysis indicated that negative life events have impact on the correlation between abuse and neglect and college adjustment. Results also indicated that maltreated women have more resilience outcomes than maltreated men in university and several reasons for this difference were discussed. Overall, negative life events and social/emotional resources are thought to be two important variables in understanding the relationship between maltreatment and adjustment.

Keywords: resilience, child abuse and neglect, protective factors

Introduction

Research on abuse and neglect has consistently found that many children who were neglected and abused experience serious negative effects on their social and emotional functioning. The effects of abuse and neglect tend to be long-term and contribute to poor adjustment and functioning in victimized children even as adults (Collishaw, Pickles, Messer, Rutter, Shearer, & Maughan, 2007). Research on child abuse and neglect, however, has also revealed that some children do not seem to be negatively impacted in the long run by their experience with early adversity and instead, over time, appear to function as well as their non-maltreated peers (Collishaw et al., 2007; Mullen et al., 1996). A resilience framework has been used to explain the hardiness of these children and has informed much of the research on this topic in recent years. Resilience is the ability to recover quickly from some type of misfortune or adversity; resilience results in a heightened likelihood of success in school and in other aspects of life, despite environmental adversities (Wang, Haertel, & Walberg, 1995). Terms such as emotional hardiness, bouncing back, buoyancy, developmental adaptivity, standing upright, being invincible, becoming invulnerable and re-centering are common in resilience literature (Benard 2004; Masten and Garmezy 1985).

Although there are difficulties with quantifying the number of people who experience negative outcomes after experiencing abuse and neglect in childhood, there is no question that

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there is a considerable number of individuals who appear to be largely unaffected by the adversity they experience early in life. McGloin and Widom (2001) found that about 20% of individuals with abuse and neglect histories were functioning well in adulthood. Additionally, in a review of 21 studies examining individual responses to maltreatment, Walsh, Dawson, and Mattingly (2010) reported that 3% to 18% of children were found to be doing well despite experience with maltreatment. Walsh et al. (2010) reported even higher rates of success for adolescents, ranging from 11% to 48%. In terms of adult outcomes, many studies have revealed that many, if not most, of the adults studied are doing well and demonstrate few or no negative effects of the abuse and neglect they experienced in childhood(i.e., Collishaw et al., 2007; MacMillan et al., 2001; Mullen et al., 1996).

Resilience has been defined in many ways, but can best be described as the "process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances" (Masten, Best, & Garmezy, 1990). Accordingly, individuals are considered resilient when they have experienced a significant threat or trauma and their adaptation or development is judged to be good (Masten & Coatsworth, 1998).

As researchers began to recognize that a number of children were developing competently despite the adversity they faced, attention shifted from simply examining the deleterious outcomes of "at-risk" children and refocused on understanding the hardiness or *resilience* of those children who were doing well. Researchers also began to examine the factors that promote healthy development in resilient children, which resulted in the identification of numerous "protective factors" that are typically grouped into three broad categories: family factors, community factors, and individual factors (Masten & Coatsworth, 1998).

One of the most reported familial protective factors is having a close relationship with a caring parent figure where the relationship is warm, consistent, and minimally critical. Research has repeatedly shown that parental support and connectedness is closely associated with good outcomes for maltreatment survivors and may play a crucial role in resilience. Additionally, having connections to extended family networks has been shown to be protective in that it allows access to additional caregivers and parent figures. Positive family changes, such as interventions aimed at reducing abuse or otherwise reducing the impact/incidence of maltreatment, have also been found to act protectively.

Community factors also serve to promote resilience. Bonds to prosocial adults outside the family are often important in the development of resilience (Masten & Coatsworth, 1998). Connections to prosocial organizations are useful because they can help connect at-risk children with resources and supportive individuals outside of the family (Masten & Coatsworth, 1998). Attending effective schools has also been found to serve a protective function. More broadly, research suggests that positive school experiences are promoting resilience (Masten, 1990). At most, it appears that neighborhood advantage might moderate the relationship between other factors and resilience (i.e., household stability and resilience).

Individual characteristics have also been found to play an important role in the development of resiliency. Research suggests that resilient children are usually those who have a positive self-concept, high self-esteem and self-efficacy (Werner & Smith, 1982). They also tend to be socially competent and show curiosity about people and ideas. Findings robustly support

that having an easygoing temperament, an internal locus of control and a sense of purpose and future-orientation are positively associated with the development of resiliency(Werner & Smith, 1982). Other individual factors that are thought to promote resilience are faith or a sense of spirituality and having a talent. Good intellectual functioning has also been thought to be a protective factor (Masten & Coatsworth, 1998), but recent studies have not found resilience to be a function of higher intelligence, leaving researchers to questions if intelligence should truly be considered a protective factor.

1.1 Objectives

- 1. To identify the factors that are associated with resilience in university students who were abused and neglected as children
- 2. To examine protective factors that contributes to gender differences in resiliency

1.2 Hypotheses

- *Hypothesis 1*: Individual protective factors will be more related with resiliency than family and community protective factors among university students who were abused and neglected as children.
- *Hypothesis* 2: Individual protective factors will be more related with resiliency than family and community protective factors among male students.
- *Hypothesis 3*: Family protective factors and community protective factors will be more related with resiliency than individual factors among female students.
- *Hypothesis 4*: There is a correlation between abuse and neglect and college adjustment when other negative life events are controlled for.

Method

2.1 Participants

As participants, 420 undergraduate students from Yangon University, East Yangon University and Dagon University participated in this study. This consisted of 252 female (60%) and 168 male (40%) students. Their age ranged from 16 to 24 years old.

2.2 Procedure

Sampling of undergraduate students was pursued through a random selection of general departmental units. Four hundred and twenty undergraduate students of eight departments (Geology, Mathematics, Psychology, Philosophy, Chemistry, Physics, Library and Information Studies and Industrial Chemistry) in Yangon University, East Yangon University and Dagon University were pooled, and questionnaires were administered to all undergraduate students present in the class on the scheduled day. All data were collected in classrooms by the researcher herself and trained teachers. Before the participants filled in the questionnaire, the researcher gave a short announcement to the participants, stating that all data would be kept confidential and informed that participants should feel free to answer the questionnaire. Participants were given an informed consent form that provided a description of the study as well as an assurance of anonymity and confidentiality. All students filled out questionnaires containing the CMQ, LEQ,

CAQ and SERI. Participants' names were not linked with the questionnaires in any way so as to maintain confidentiality and avoid any reporting issues that could emerge with the maltreatment questionnaires. Each student received the small present (a ball pen) at the end of the study and was thanked for their participation.

2.3 Measures

The questionnaire packet contained four measures: the Myanmar Version of the Childhood Maltreatment Questionnaire (CMQ) - Abuse and Neglect Scales, Life Events Questionnaire (LEQ), College Adjustment Questionnaire (CAQ) and Social/Emotional Resource Inventory (SERI). Under the advice and guidance of the supervisor, co-supervisor and experienced psychologists, all items were translated and adapted into Myanmar Language. Initially, the pilot study was conducted with the small group of students from Dagon University.

Childhood Abuse and Neglect: The Childhood Maltreatment Questionnaire (CMQ) Abuse Neglect Scales developed by Shirley and Rosén (2010) was used to measure Childhood Abuse and Neglect. The CMQ was originally designed to look at five domains of maltreatment (physical abuse, sexual abuse, emotional abuse, physical neglect, and emotional neglect), as well as more positive aspects of caregiving (called a "Love scale"). Respondents were presented with specific experiences in childhood and adolescence that are considered to be indicative of maltreatment. Participants then rated the frequency of occurrence on a 5-point Likert scale ranging from 1(never) to 5(very often). The Myanmar version of the CMQ-Abuse Scale consists of 17 items across four subscale: Sexual Abuse (three items), Physical Abuse (five items), Emotional Abuse (four items), and Love (five items). The CMQ-Abuse scale used in this study was conducted item analysis and tested for internal reliability using the Cronbach's alpha. These subscales demonstrate good reliability, with alphas of .70, .70, .80 and .76, respectively for this sample. A full scale score was computed by summing the 12 items from the three abuse categories (physical, sexual, and emotional; the love subscale is excluded). The CMQ-Abuse measure also demonstrates good construct validity (Shirley and Rosén, 2010).

The Myanmar version of the CMQ-Neglect Scale also demonstrates good reliability, with alphas of .54, .85, .80 and .70. The CMQ-Neglect Scale measure also demonstrates good construct validity (Shirley and Rosén, 2010). The full scale is comprised of 12 items from the three neglect categories (emotional, physical, and supervision) and excluded the Love subscale.

For the purpose of this study, the items used to create the full scale scores for the CMQ-Abuse and CMQ-Neglect scales were combined to create a total maltreatment score labeled "CMQ Total Score". Any time the term "CMQ" is used the data analysis section of this paper, it is the CMQ Total Score variable that is being referenced.

Negative Life Events: In order to assess for other traumatic life events that might qualify as a "threat to development" for an individual and potentially confound the results, traumatic life events were assessed by using a modification of the Life Event Questionnaire-Adolescent version (LEQ-A; Gest et al., 1999; Mastern et al., 1994). The 67 items questionnaire asks respondents to indicate whether or not particular life events have occurred in their life time. Scores on this measure were planned to be held constant in the analyses so that negative life events outside of childhood abuse and neglect were not able to influence the relationship between abuse and

neglect and college adjustment. Preliminary results, however, indicated that negative life events were important in understanding the relationship between childhood maltreatment and college adjustment. It was found that the reliability coefficient of the Life Event Questionnaire was found to be .84. *Resilience*: Resilience was classified by using the College Adjustment Questionnaire (CAQ) developed by Shirley and Rosén (2010). The CAQ has 14-items divided into subscales that measure Academic Adjustment (five items), Social Adjustment (five items), and Emotional Adjustment (four items). The measure also provides a Full Scale score. Participants rate their responses on a 5-point Likert type scale ranging from *not true* to *completely true*. The Myanmar version of the College Adjustment Questionnaire (CAQ) reported subscales reliabilities in this sample are good, with alphas of .77, .71, and .60. Full scale reliability in this sample is also good (alpha= .81).

Social/Emotional Resources: Participants used the revised version of the Social/Emotional Influences Inventory (Shirley & Rosén, 2010; Cole et al., 2007, 2008) to identify the individual, family, and community factors that may have played a role in their resilience. The measure asks participants to indicate on a 5-point Likert-type scale the degree to which various lifetime influences enabled them to overcome life stressors. Responses range from *not at all* to *very true*. The SERI has 26-items spread across nine subscales: Intelligence (three items), Positive Caregiving (three items), Good Schools (three items), Parental Expectations (two items), Self-Esteem (three items), Talent (three items), Faith (three items), Family Connectedness (three items), and Financial Resources (three items). For the purposes of this study, full scale, domain scale, and subscale scores were be calculated and used in data analysis. In the sample of the Myanmar version of the Social/Emotional Influences Inventory also demonstrate internal consistency reliability estimates for the 9 subscales ranged from .70 to .89 and the coefficient alpha for the full scale was estimated to be .91.

Results and Discussion

3.1 Results

Item Analysis

According to the Results of the item analysis for the Childhood Maltreatment Questionnaire, it was found that each item can discriminate between high-scoring respondents and low-scoring respondents on all subscales and full scales, except for 2 items. The two subscales (CMQ-Abuse and CMQ-Neglect scales) were then incorporated into single test format and it is called the Myanmar version of the Childhood Maltreatment Questionnaire. This study showed that the 23 items included in Myanmar version of the Childhood Maltreatment Questionnaire is an appropriate measure for the Myanmar cultural setting.

And then, the result of an item analysis conducted for the 14-item College Adjustment Questionnaire. It was found that all of the items on each subscale were significant at .001 levels. The result of an item analysis conducted for the 26-item Social/ Emotional Resources Inventory. It was found that all of the items on each subscale were significant at .001 levels. Regarding the Life Event Questionnaire, it was found that all of the items on the scale were significant at .05 or .01 or .001 levels, except for 5 items. Owing to a lack of variance, these five items were deleted in

the study. This study showed that the Myanmar versions of these scales are appropriate measure for the Myanmar cultural setting.

Reliability Analysis

In order to examine internal consistency reliability of the Myanmar version of the all these scales, the data were checked by the Statistical Package for the Social Science (SPSS, 22.0 versions). Then, coefficient alpha available in SPSS was used to calculate the internal consistency reliability for these scales. As the result of internal consistency reliability analysis, the coefficient alpha was found to be .84 for Childhood Maltreatment Questionnaire- Abuse Scale (full scale). And then, As the result of the result internal consistency reliability analysis, the coefficient alpha were found to be .85 for Childhood Maltreatment Questionnaire- Neglect Scale, .81 for College Adjustment Questionnaire, .91 for Social/ Emotional Resources Inventory (full scale) and .84 for Life Event Questionnaire. As shown in Table 1, the results indicated that the Myanmar versions of the all scales are reliable test for this study. So, it is obvious that the values of reliability coefficients for these scales are high enough to warrant a safe application.

Scale	Alpha
Childhood Maltreatment Questionnaire - Abuse Scale(full scale)	.84
Childhood Maltreatment Questionnaire - Neglect Scale (full scale)	.85
College Adjustment Questionnaire (full scale)	.81
Social/ Emotional Resources Inventory (full scale)	.91
Life Event Questionnaire	.84

Table 1: Internal consistency reliability coefficient (Cronbach's Alpha)

Sample Description

A total of 420 university students participated in this study. Descriptive information about the sample was gathered using a Demographic Information Form developed for this study. Categories of information included, Universities, age, gender, year in school, race/ethnicity, relationship status, mother's level of education, mother's occupation, father's level of education, and father's occupation. Description of the participants' demographic was shown in Table 2. This data was used to make comparisons between maltreated and non-maltreated students regarding group characteristics.

Maltreatment in the sample

Scores on the Childhood Maltreatment Questionnaire (CMQ) - Abuse and Neglect Scales were used to quantify maltreatment in this sample. Initial analysis of the maltreatment variable (CMQ total score) immediately revealed that most people had either no maltreatment or a very low level of maltreatment.

Chi-square tests of independence were conducted to compare the individuals in the group on several demographic variables. Results indicated that the proportion of individuals in the none and some maltreatment groups was not significantly related to the following domains: university, $\chi^2(2, N=420) = 2.42, p = .30$; year in School, $\chi^2(3, N=420)=2.67, p=.45$; ethnicity, $\chi^2(9, N=420)$ = 7.25, p = .61; relationship, $\chi^2(2, N=420) = 2.29, p = .32$; mother's level of education, χ^2 (4, N = 420) = 5.07, p = .28; mother's occupation, χ^2 (32, N= 420) = 34.61, p = .34; father's level of education, χ^2 (4, N = 420) = 3.88, p = .42 and father's occupation, χ^2 (65, N= 420) = 55.43, p = .80. There was a significant relationship between maltreatment and specialization, χ^2 (1, N = 420) = 5.548, p = .012, such that there was a significantly smaller proportion of individuals in the maltreated group with specialization (p < .05) than in the non-maltreated groups.

Variables	\mathbf{F}	%				
University						
Yangon University	140	33.3%				
East Yangon University	163	38.3%				
Dagon University	117	27.9%				
Gender						
Male	168	40%				
Female	252	60%				
Age						
20 and below	407	96.9%				
21 and above	13	3.1%				
Year in school						
First Year	225	53.6%				
Second Year	135	32.1%				
Third year & first year (Honours)	32	7.6%				
Fourth year & second year (Honours)	28	6.7%				
Specialize						
Science	236	56.2%				
Arts	184	43.8%				
Ethnicity						
Bamar	313	74.5%				
Kachin	4	1%				
Kayin	13	3.1%				
Chin	2	0.5%				
Mon	18	4.3%				
Rakhine	14	3.3%				
Shan	14	3.3%				
Chinese	8	1.9%				
Indian	16	3.8%				
Mix	18	4.3%				
Relationship						
No relationship	279	66.4%				
Relationship	138	32.9%				
Married	3	0.7%				

 Table 2: Description of the participants' demographic
Variables	F	%
Mother's education		
Primary	36	8.6%
Secondary	87	20.7%
High school	122	29%
Under graduate	44	10.5%
Graduate	131	31.2%
Father's education		
Primary	24	5.7%
Secondary	74	17.6%
High school	144	34.3%
Under graduate	33	7.9%
Graduate	145	34.5%

An independent samples *t*-test was conducted to compare age for the no maltreatment and maltreatment groups. There was a no significant in scores for non-maltreated (M = 1.03, SD = .18) and maltreated individuals, M = 1.03, SD = .17, *t* (418) =.019, *p* = .985 (two-tailed). And then, an independent samples t-test was also used to compare gender for the no maltreatment and maltreatment groups. There was a significant difference in scores for non-maltreated (M = 1.69, SD = .47) and maltreated individuals, M = 1.57, SD = .50, *t* (418) =2.00, *p* = .046 (two-tailed).

Prevalence of types of maltreatment

The prevalence of specific forms of maltreatment varied from as low as 7% of the sample to as high as 54% of the sample. See Table 3 for details. Overall, physical abuse and emotional neglect were the most common form of maltreatment with 54.3% of the entire sample experiencing physical abuse and inadequate emotional support in their childhood. The next most common form was emotional abuse (48.6%), followed by physical neglect (30%) and supervision neglect (27.9%). Sexual abuse was the rarest form, occurring in only at a rate of 7.1% of the sample.

As Table 4 demonstrates, the correlations between types of maltreatment were highly variable, with some forms of neglect and abuse demonstrating large correlations and other types correlating very little. Specifically, emotional abuse, physical abuse and emotional neglect were highly related, with Pearson r values in the .56 to .65 range. Conversely, sexual abuse correlated minimally with the other types of maltreatment.

 Table 3: Rates of maltreatment by sample and maltreatment type

	Overall Maltreatment	Emotional Abuse	Physical Abuse	Sexual Abuse	Emotional Neglect	Physical Neglect	Supervision Neglect
Whole Sample (N=420)	77%	48.6%	54.3%	7.1%	54.3%	30%	27.9%
Maltreated Sample (N = 324)		63%	70.4%	9.3%	70.4%	38.9%	36%

Table 4: Correlations between the Childhood Maltreatment Questionnaire subscales and full scale (N = 420)

	1	2	3	4	5	6	7
1. Emotional Abuse	_						
2. Physical Abuse	.56**	_					
3. Sexual Abuse	.31**	.29**	_				
4. Emotional Neglect	.65**	.49**	.24**	_			
5. Physical Neglect	.32**	.30**	.22**	.47**	_		
6. Supervision Neglect	.49**	.43**	.20**	.56**	.35**	_	
7. Maltreatment Total	.82**	.73**	.39**	.88**	.58**	.73**	_

Note: **p<.01

Prevalence of maltreatment by gender

The prevalence of maltreatment was also examined by gender (see Table 5 for details). Across the whole sample, 44.3% of women and 32.9% of men reported some form of maltreatment. A chi-square test of independence shown that gender and maltreated were significance, χ^2 (1, N= 420) = 3.97, p = .030, with roughly equal proportions of men and women experiencing some forms of neglect and abuse. There were, however, a few significant differences between men and women in the rate of specific types of maltreatment that occurred. Specifically, a chi-square test for independence indicated that there was only one significant association between gender and physical neglect, χ^2 (8, N= 420) = 16.38, p = .037, with a greater proportion of men (52.4%) experiencing physical neglect than women (47.6%).

With regard to co-occurring maltreatment across men and women, there was not a significance difference between men and women in the rates of comorbid abuse and neglect (females: M = 2.85, SD = 1.51, males: M = 2.92, SD = 1.38), t (322) = .433, p = .665.

Of the individuals who were maltreated, only 21.3% just experienced one type of maltreatment. The remaining 78.7% reported experiencing two or more forms of maltreatment

during childhood. Specifically, 23.1% experienced two types of maltreatment, 22.5% experienced three types, 15.4% experienced four types, 13.3% also experienced five types, and 4.3% experienced every type of abuse and neglect assessed in this study (see Table 6 in detail).

	Overall	Emotional	Physical	Sexual	Emotional	Physical	Supervision
	Maltreatment	Abuse	Abuse	Abuse	Neglect	Neglect	Neglect
Women(N)	186	123	125	19	134	60	69
% of total N=420	44.3%	29.3%	29.8%	4.5%	32%	14.3%	16.4%
% of all mal N=324	57.4%	38%	38.6%	5.9%	41.4%	18.5%	21.3%
% of specific type		60.3%	54.8%	63.4%	58.8%	47.6%*	59%
Men (N)	138	81	103	11	94	66	48
% of total N=420	32.9%	19.3%	24.5%	2.6%	22.4%	15.7%	11.4%
% of all mal	42.6%	25%	31.8%	3.4%	29%	20.4%	14.8%
N = 324							
% of specific type		39.7%	45.2%	36.6%	41.2%	52.4%*	41%

 Table 5: Rates of maltreatment by gender and sample

Notes: *p < .05 difference between men and women

	1 Type	2 Types	3 Types	4 Types	5 Types	6 Types
Women (N)	42	47	39	21	30	8
% of total N=420	10 %	11.2%	9.3%	5%	7%	1.9%
% of all mal N=324	13%	14.5%	12%	6.5%	9.3%	2.5%
Men (N)	27	28	35	30	12	5
% of total N=420	6.4%	6.7%	8.3%	7%	2.9%	1.2%
% of all mal N=324	8.3%	8.6%	10.8%	9.3%	3.7%	1.5%

Table 6: Rates of co-occurring maltreatment by gender and sample

Childhood maltreatment and college adjustment

Good college adjustment in individuals who have experienced childhood maltreatment indicates a positive outcome. For Mastern and colleagues (1999), this positive outcome is a necessary condition in order to demonstrate resiliency. "Good adjustment" for maltreated students was conceptualized as "doing as well as non-maltreated peers" and was calculated by subtracting one standard deviation (SD = 8.19) from the mean CAQ Full Scale (FS) score for the non-maltreated group (M = 55.28). Scores falling above this value (47.09) were considered evidence of good adjustment as they were no more than one standard deviation below the average score for non-maltreated peers and therefore fell into the "average or better" category we

were trying to capture. Scores falling below this value were considered evidence of poor adjustment. Results indicate that of the 324 students, who reported some form of maltreatment, 71% (230 students) demonstrated good adjustment and 29% (94 students) demonstrated poor adjustment. Using the same definition of good adjustment for the non-maltreated sample, 82.3% (79 students) demonstrated good adjustment and 17.7% (17 students) demonstrated poor adjustment. A chi-square test indicated a significant association between adjustment and maltreatment, χ^2 (1, N= 420), = 4.87, *p* =.017, phi = .027, with a greater proportion of maltreated individuals demonstrating poor adjustment than non-maltreated individuals. An independent samples *t*-test also revealed that maltreated individuals scored significantly lower on the CAQ-FS than their non-maltreated counterparts (maltreated groups: M =51.69, SD =8.36, non-maltreated group: M =55.28, SD =8.19), *t* (418) = 3.72, *p* = .000. College Adjustment was also examined by gender (see Table 7). In the non-maltreated sample, 86.4% of women and 73.3% of men demonstrated good adjustment.

Group	Level ofDescriptiveadjustmentStatistics		Female	Male
	Poor	Ν	9	8
	Adjustment	% of gender	13.6%	26.7%
Non-Maltreated		% of non-mal	9.4%	8.3%
		group		
	Good	N	57	22
	Adjustment	% of gender	86.4%	73.3%
		% of non-mal	59.4%	22.9%
		group		
	Poor	Ν	47	47
	Adjustment	% of gender	25.3%	34.1%
		% of mal	14.5%	14.5%
Maltreated		group		
	Good	Ν	139	91
	Adjustment	% of gender	74.7%	65.9%
		% of mal	42.9%	28%
		group		

Table 7: Proportion	of students with	poor or good a	diustment by	gender and	maltreatment
Lable / Liopol don		poor or good u	a abuntone by	Source and	

 Table 8: Mean scores and standard deviation scores on College Adjustment for females and males university students with the maltreated and non-maltreated

	Maltreated				Non-maltreated					
	Male		-	Fema	male Male		Female			
	Mean	SD	Mean	SD	Т	Mean	SD	Mean	SD	Т
Adjustment	50.65	8.39	52.45	8.28	-1.92 [†]	53.90	9.09	55.91	7.73	-1.12

Notes: p < 0.10

A chi-square test of independence indicated that there was not a significant association between adjustment and gender in the non-maltreated group, χ^2 (1, N = 96) = 2.4, p = .105, phi = .121 Similarly, adjustment was not a significant association with gender in the maltreated group, χ^2 (1, N = 324) = 2.97, p = .055, phi = .085, with the maltreated men demonstrating poor adjustment (34.1%) than of maltreated women (25.3%).

Consistent with our research questions regarding adjustment, two planned comparison independent samples *t*-tests were conducted to examined differences in CAQ-FS mean scores for men and women across maltreatment (see Table 8). The first *t*-test revealed that there was approached significant difference in CAQ-FS scores between maltreated women and maltreated, with maltreated men scoring an average of 1.8 points lower on the CAQ than maltreated women. The second *t*-test indicated that there was not a significant difference in CAQ-FS scores between non-maltreated women and non-maltreated men. Overall, these results indicate that maltreated men have significantly poorer outcomes than maltreated women. This leads us to wonder what might contribute to this disparity in outcomes between maltreated men and women, with men demonstrating negative effects from maltreatment and women appearing to largely demonstrate resilience.

Childhood Maltreatment and Negative Life Events

The relationship between maltreatment (CMQ total score) and negative life events (LEQ) was first examined using the Pearson product moment correlation coefficient. There was a large correlation between the two variables, r = .51, N = 420, p < .000, with increasing levels of maltreatment associated with higher levels of negative life events. Then, a series of planned comparisons *t*-tests were conducted to examine differences between men and women at the two levels of maltreatment, which revealed that there was not a significant difference in negative life events between maltreated men (M = 77.65, SD = 6.99) and maltreated women (M = 78.55, SD = 7.03), *t* (322) = -1.14, *p* = .256, but there was a significant difference in negative life events between non-maltreated men (M = 72.93, SD = 4.96) and non-maltreated women (M = 70.18, SD = 4.55), *t* (94) = 2.66, *p* = .009. Overall, these results indicate that there was not a significant difference in negative life events between in negative life events between maltreated men and women (M = 70.18, SD = 4.55), *t* (94) = 2.66, *p* = .009. Overall, these results indicate that there was not a significant difference in negative life events between maltreated men and women.

Childhood Maltreatment and Social/Emotional Resources

The relationship between maltreatment (CMQ total score) and social/ emotional resources (protective factors; SERI Full Scale (FS) score) was also investigated. A Pearson product moment correlation coefficient of -.395 (n = 408, p = .00) indicated a moderate correlation between the variables such that as CMQ total scores increased SERI-FS scores decreased. A series of planned comparison *t*-tests were conducted to examine differences in SERI-FS by gender and maltreatment, which revealed that there was not a significant difference between maltreated men (M = 103.74, SD = 13.09) and maltreated women (M= 105.18, SD = 13.50), t (310) = -.945, p = .345, nor was there a significant difference between non-maltreated women (M = 114.59, SD = 8.80) and non-maltreated men (M= 111.47, SD = 18.17), t (94) = -1.14, p = .258, in SERI full scale scores. These results indicate that men and women did not differ on full scale SERI scores at either level of maltreatment, although it appears that there may be a difference between the maltreated and non-maltreated groups overall.

We were also interested in looking at differences in specific types of protective factors, not just SERI full scale score, by gender and maltreatment. There were three domains of protective factors – Individual Factors, Family Factors, and Community Factors – were computed by combining scores for each protective factors that fell within the domain (i.e., Individual Factors is the sum of scores from SERI – Talent, SERI– Intelligence, SERI – Faith, and SERI – Self-Esteem; Family Factors is the sum of scores from SERI – Positive Caregiving, SERI – Parent Expectations, and SERI – Family Connectedness; Community Factors is the sum of scores from SERI – Good Schools and SERI – Financial Resources). A series of planned comparison *t*- tests were conducted to examine differences in Individual, Family, and Community Factors by gender and maltreatment.

An independent *t*-test comparing maltreated men and maltreated women on the three domains of protective factors indicated that there was not a significant difference in Individual Factors (men: M = 46.32, SD = 7.49; women: (M = 47.04, SD = 7.98, t (310) = -.804, p = .422). Maltreatment men and women also did not have significantly different Family Factors (men: M = 34.25, SD = 4.62; women: M = 34.14, SD = 5.08, t (310) = .194, p = .846). There was a significant difference in Community Factors (men: M = 23.17, SD = 3.58; women: M = 24.00, SD = 3.77, t (310) = -1.98, p = .049).

An independent *t*-tests comparing non-maltreated men and women on the three domains of protective factors indicated that there was not a significant difference in Individual Factors (men: M = 49.70, SD = 9.67; women: M = 50.33, SD = 6.13), t (94) = -.388, p = .699). There was a significant difference between Family Factors (men: M = 36.17, SD = 5.20; women: M = 37.74, SD = 2.33), t (94) = -2.06, p = .042). There was not a significant difference between Community Factors (men: M = 25.60, SD = 4.51; women: M = 26.52, SD = 3.03, t (94) = -1.17, p = .245.

Overall, the results of the *t*-tests for both the maltreated and non-maltreated groups indicate that men and women differed in Family Factors and Community Factors, with maltreated women having significantly more Community Factors than maltreated men and non-maltreated women having significantly more Family Factors than non-maltreated men. As shown in Table 9, gender was significantly correlated with Community Protective Factors (r = .14, p = .006).

	Mean	SD	1	2	3	4	5
1. Gender	1.60	0.49	_				
2. Adjustment	52.51	8.37	.12*	_			
3. Individual Protective Factors	47.53	7.81	.06	.53**	_		
4. Family Protective Factors	34.91	4.78	.05	.43**	.49**	_	
5. Community Protective	24.25	3.83	.14**	.46*	.48**	.63**	_
Factors							

Table 9: Means, standard deviations, and intercorrelations between the Gender,Adjustment and Protective Factors

Note: **p* < .05, ***p*<.01

	Mean	SD	1	2	3	4
1. Adjustment	51.23	8.59	_			
2. Individual Protective Factors	46.94	8.10	.51**	_		
3. family Protective Factors	34.60	4.77	.44**	.60**	_	
4. Community Protective Factors	23.61	3.87	.48**	.58**	.67**	_

Table 10: Means, standard deviations, and intercorrelations among study variables on Adjustment and Protective factors for males students

Note: **p<.01

 Table 11: Means, standard deviations, and intercorrelations among study variables on

 Adjustment and Protective factors for female students

	Mean	SD	1	2	3	4
1. Adjustment	53.36	8.27	_			
2. Individual Protective Factors	47.93	7.66	.54**	_		
3. family Protective Factors	35.11	4.78	.41**	.42**	_	
4. Community Protective Factors	24.68	3.75	.43**	.40**	.61**	_

Note: **p<.01

Table 10 shows that adjustment was significantly positively correlated with Individual Protective Factors, Family Protective Factors and Community Protective Factors in male students. Findings reveal that Individual Protective Factor was more related with Adjustment than Family Protective Factors and Community Protective Factors in male students.

Table 11 states that, adjustment was significantly correlated with Individual Protective Factors, Family Protective Factors and Community Protective Factors in female students. Results show that Family Protective Factors and Community Protective Factors were less related with Adjustment than Individual Protective Factors in female students.

A final analysis using SERI variables was conducted to know what specific protective factors are associated with adjustment in maltreated and non-maltreated students. We conducted two simultaneous multiple regressions, one for the maltreated group and one for the non-maltreated group, where CAQ-FS scores were regressed in a single step on all nine protective factors of the SERI.

For the regression in the maltreated group (see Table 12 for details), all nine protective factors accounted for a significant amounted for the variance in CAQ-FS scores, $R^2 = .363$, F (9, 302) =19.13, p < .001. Of the nine protective factors in the model, five were significant predictors: SERI – Intelligence, p < .001, SERI – Positive Caregiving, p < .05, SERI – Good Schools, p < .05, SERI- Self Esteem, p < .01 and SERI – Financial Resources, p < .05.

Variable	В	SE(B)	β	t	Sig (<i>p</i>)
Constant (Intercept)	18.96	3.74			
SERI-Intelligence	.84	.18	.27	4.73	.000
SERI-Positive Caregiving	.50	.19	.16	2.65	.009
SERI-Good Schools	.57	.21	.15	2.67	.008
SERI-Parental Expectations	39	.38	05	-1.01	.314
SERI- Self-Esteem	.65	.19	.19	3.37	.001
SERI-Talent	.04	.17	.01	.21	.836
SERI-Faith	.14	.17	.05	.81	.417
SERI-Family Connectedness	05	.25	01	20	.838
SERI- Financial Resources	.44	.17	.14	2.57	.011

Table 12: Summary of Multiple Regression Analysis for CAQ-FS on SERI Protective Factors in Maltreated Sample (N = 324)

Note. $R^2 = .363$

Table 13: Summary of Multiple Regression Analysis for CAQ-FS on SERI Protective Factors in Non-Maltreated Sample (N = 96)

Variable	В	SE(B)	В	t	Sig (<i>p</i>)
Constant (Intercept)	15.64	7.66			
SERI-Intelligence	.81	.39	.22	2.10	.039
SERI- Positive Caregiving	1.15	.55	.23	2.08	.041
SERI- Good Schools	.92	.41	.26	2.26	.026
SERI- Parental Expectations	42	.94	06	44	.659
SERI- Self-Esteem	.61	.52	.15	1.16	.250
SERI- Talent	00	.44	00	00	.997
SERI- Faith	.28	.34	.09	.80	.427
SERI- Family Connectedness	.11	.57	.02	.18	.855
SERI-Financial Resources	49	.37	13	-1.30	.196

Note: R² = .381 CAQ-FS = College Adjustment Questionnaire (Full Scale), SERI = Social/Emotional Resources Inventory

For the regression in the non-maltreated group (see Table 13 for details), all nine protective factors accounted for a significant amount of the variance in CAQ-FS scores as well, $R^2 = .381$, F(9, 86) = 5.88, p < .001. Of the nine protective factors in the model, three were significant predictors: SERI – Intelligence, p < .05, SERI – Positive Caregiving, p < .05 and SERI – Good Schools, p < .05. Therefore, on the base of these regressions, it appears that five factors – Intelligence, Positive Caregiving, Good Schools, Self-Esteem and Financial Resources – are associated with adjustment in maltreated individuals, whereas three factors- Intelligence, Positive Caregiving and Good Schools- are associated with adjustment in non-maltreated individuals. According to the findings of regression analysis, Individual Protective Factors; SERI- Intelligence and SERI- Self-Esteem were strong predictors of resilience in men and women.

Hierarchical Multiple Regression

Hierarchical Multiple Regression was used to evaluate the impact of negative life events (LEQ) and social/emotional resources (SERI-FS) on the relationship between childhood maltreatment (CMQ total score) and college adjustment (CAQ-FS) in men and women. Separate regressions were conducted for men and women, given that initial analyses indicated that the two groups differed on negative life events and social/emotional resources, as well as the relationship between maltreatment and adjustment.

In the hierarchical regression for women (see Table 14 for details), CAQ-FS scores were regressed onto a dummy coded maltreatment variable in Step 1 ("0" equals no maltreatment, "1" equals some maltreatment). Maltreatment explained a significant amount of variance (3.2 %) in CAQ scores, $R^2 = .032$, F (1, 243) = 8.16, p = .005. The unstandardized coefficient for maltreatment was -3.33, indicating that for every one unit increase in maltreatment (i.e., going from no (0) maltreatment to some (1) maltreatment), college adjustment dropped by 3.33 points.

Next (step 2), LEQ was added to the model and accounted for an additional 6.5% of variance, which was a significant increased, p = .004. With LEQ in the model, the unstandardized coefficient for maltreatment increased to -1.39, indicating that when LEQ is held constant, a one unit increase in maltreatment is associated with a 1.39 point drop in CAQ. Put another way, controlling for LEQ weakened the impact of maltreatment on CAQ-FS so that CAQ-FS decreased less as maltreatment increased than it had when LEQ was not controlled.

In Step 3, SERI-FS was added to the model which was a significant increased, p = .000. Adding SERI to the model completely eliminated the relationship between maltreatment and CAQ, such that maltreatment was no longer a significant predictor of CAQ. This pattern of results suggested that the SERI might mediate the relationship between maltreatment and CAQ.

In step 4, an interaction term of SERI and maltreatment was entered. An original hypothesis of the study had been that social/emotional resources impact the relationship between maltreatment and adjustment, so a moderation analysis was planned to look at the interaction between SERI and maltreatment scores. The interaction term was not a significant predictor, p = .925, and only accounted for an additional 0% of the variance in CAQ, indicating that SERI-FS scores do not moderate the relationship between maltreatment and CAQ-Fs in women.

	Variable	В	SE(B)	β	t	Sig (p)
Step 1	Some Maltreatment	-3.33	1.17	18	-2.86	.005
Step 2	Some Maltreatment	-1.39	1.33	08	-1.05	.294
	LEQ	23	.08	21	-2.91	.004
Step 3	Some Maltreatment	.88	1.13	.05	.78	.439
	LEQ	10	.07	09	-1.46	.146
	SERI-FS	.36	.04	.57	10.24	.000
Step 4	Some Maltreatment	1.97	11.57	.11	.17	.865
	LEQ	10	.07	09	-1.46	.146
	SERI-FS	.37	.09	.59	3.90	.000
	Interaction Term	01	.10	06	10	.925
	(SERI-FS X Some					
	Mal)					

Table 14: Summary of Hierarchical Multiple Regression Analysis for women (N = 252)

Note. Final $R^2 = .348$. LEQ = Life Event Questionnaire

Table 15: Summary of Hierarchical Multiple Regression Analysis for men (N = 168)

	Variable	В	SE(B)	β	t	Sig (<i>p</i>)
Step 1	Some Maltreatment	-3.49	1.69	16	-2.07	.040
Step 2	Some Maltreatment	-2.67	1.74	12	-1.53	.128
	LEQ	17	.10	14	-1.71	.090
Step 3	Some Maltreatment	68	1.50	03	45	.653
	LEQ	08	.08	07	94	.348
	SERI-FS	.31	.04	.54	7.94	.000
Step 4	Some Maltreatment	1.53	9.52	.07	.16	.872
	LEQ	08	.08	07	94	.348
	SERI-FS	.33	.07	.56	4.54	.000
	Interaction Term (SERI-FS X Some Mal)	02	.09	10	24	.814

Note. Final $R^2 = .314$.

See Table 15 for details about the hierarchical regression for men. Step 1 of this regression identical to Step 1 of the regression for women. Maltreatment explained a significant amount of variance (2.6%) in CAQ-FS for men, $R^2 = .026$, F(1,161) = 4.30, p = .040. Adding LEQ in Step 2 and controlling for negative life events did not improve the relationship between maltreatment and CAQ-FS, with the model remaining non-significant , $R^2 = .043$, F (1,160) = 2.91, p = .090. And then, SERI was added in step 3 and the model became significant, $R^2 = .318$, F (1,159) = 62.98, p = .000. In Step 4, an interaction term of SERI times maltreatment was entered. An original expectation of the study had been that social/emotional resources impact the relationship between SERI and maltreatment scores. The interaction term was not a significant predictor, and accounted for an additional 31.5% of the variance in CAQ, $R^2 = .315$,

F (1,158) = .055, p = .814, indicating that SERI-FS scores do not moderate the relationship between maltreatment and CAQ-FS in men.

3.2 Discussion

The primary purpose of the present study was to investigate the relationship between childhood maltreatment and college adjustment and identify the factors that are associated with resilience in university students who were abused and neglected as children. This study was also interested in looking at gender differences in the identified protective factors, particularly as they relate to resilient outcomes for maltreated students. Results indicate that there are not only approached significant differences between maltreated men and women in the relationship between maltreatment and college adjustment, but also significant differences in the protective factors that play a role in resilient outcomes for these students.

In order to examine the relationship between childhood maltreatment and college adjustment, the maltreatment characteristics of the sample were first identified. Analysis of the prevalence of maltreatment in this sample indicated that childhood maltreatment, at least at a low level, is a relatively common experience for many college students. This finding is consistent with other research that has found that childhood abuse and neglect to be a fairly common phenomenon in both college samples and the community at large (Elliott, Alexander, Pierce, & Richmond, 2009; Scher et al., 2004, Shirley and Roséns', 2012), and the present study's prevalence rate of 77.1% matches closely with a comparable study of maltreatment in college students from a study by Arata and colleagues (Shirley and Roséns', 2012). It is important to note, however, that several other studies (Clemmons et al., 2007; Elliott et al., 2009; Rich et al., 1997) have reported slightly lower rates ranging between 30% and 40%, which may be due to differences in measuring and classifying maltreatment and may indicate that the classification of maltreatment in this study was too liberal.

The reported rates of the various types of abuse and neglect in this sample are also consistent with previous research, especially with regard to the high rate of co-occurring maltreatment. This study found that 78.7% of the students who were abused or neglected experienced two or more forms of maltreatment during childhood, which fits well with the rates provided in a summary of research on co-occurring maltreatment by Herrenkohl and Herrenkohl (2009) that range between 60% and 90%.

The prevalence of maltreatment was found to be not significantly different between men and women, although there was only one significant difference between the proportion of men and women experiencing specific types of abuse. Specifically, men experienced significantly more physical neglect than women. From the perspective of gender socialization, this pattern of results makes sense, as men in Myanmar culture are typically expected to be physically tough, independent, and self-sufficient. At the extreme end of the spectrum, these expectations might translate into a tendency to physically neglect boys because "they can and should be able to handle it."

Although there were no differences in the rate of childhood abuse and neglect for men and women, there were approached significant differences in college adjustment between maltreated men and women. Interestingly, women not only had higher average scores on the CAQ than men (M = 52.45 vs. 50.65, a difference of 1.8 points), but they also demonstrated higher rates of "good adjustment" than men (74.7% vs. 65.9%), which was a more meaningful difference since good adjustment in maltreated individuals is considered evidence of resilience. Thus, it was concluded that although men and women are experiencing the same rate of maltreatment, abused and neglected women seem to be demonstrating more resilient outcomes than men.

With regard to why maltreated women are more resilient than maltreated men, or conversely why maltreated men seem to have poorer outcomes, there seem to be several possible explanations. One possible reason for this, suggested by Hunt, Auriemma, and Cashaw (2003), is that men tend to minimize the disclosure of coping strategies out of fear of being perceived as weak. Another reason that may help to explain female participants having higher reports of protective factors is that women tend to seek out support more often and value support from relationships in different ways than men. In fact, Barbee et al. (1993) suggested that females tend to emphasize support through nurturance (e.g., providing support for others) and emotional expressiveness (e.g., talking out problems with friends), making it easier for women to seek support from close relationships. Yet a more typical male role may emphasize achievement, autonomy, and emotional control, making it difficult for men to seek out and obtain social support (Barbee et al., 1993). As women are more likely to utilize support as a coping skill, this may contribute to female participants reporting higher levels of adjustment in comparison to men, as men more typically value masculine norms such as independence, invincibility, and power, which may be a barrier for adequate identification of a supported system (Davies et al., 2000). Disclosing high levels of stressors or support may threaten college men's beliefs about their own masculinity (Brougham, Zail, Mendoza, & Miller, 2009).

In order to test hypotheses, the result indicated that Individual protective factors were more related with resiliency than family and community protective factors among university students who were abused and neglected as children. This finding is also consistent with the previous study (Shirley and Roséns, 2012; Aye, 2012). Thus, hypothesis 1 was supported.

On the other hand, individual protective factor was more related with resiliency than family and community protective factors among male students, resulting in support for hypothesis 2. Research shows that men and women do indeed tend to uphold the gender-stereotypic forms of coping, with women using more emotion focused and support-seeking strategies and men using more avoidant and active strategies (Sigmon, Stanton, & Snyder, 1995).

However, the results indicated that individual protective factors were more related with resiliency than community protective factors among female students. Thus finding does not support hypothesis 3. However, this finding was consistent with the other studies. Some studies do not report gender differences (Sameroff *et al.*, 1999); Certain findings also suggest that resilient girls tend to display autonomy and independence, and resilient boys tend to be emotionally expressive, socially perceptive and nurturing (Bauman, 2002). Parents are in a position to encourage these characteristics in children.

There are differences in protective factors at the individual level between the nonmaltreated and maltreated groups. In order to get a sense of the factors that were most associated with adjustment for both the maltreated and non-maltreated groups, a simultaneous multiple regression analysis was conducted using a simplified model that just contained the nine protective factors. For maltreated students, Intelligence, Positive Caregiving, Good Schools, Self-Esteem, and Financial Resources were significant predictors of adjustment. For the nonmaltreated students, Intelligence, Positive Caregiving and Good Schools were significant predictor of college adjustment.

Hypothesis 4 stated that there is a correlation between abuse and neglect and college adjustment when other negative life events are controlled for. It was found that Negative life events have impact on the correlation between abuse and neglect and college adjustment. Therefore, Hypothesis 4 was not supported. Previous studies indicated that stressful life events were associated with several adjustment outcomes, even after controlling for multiple sociodemographic indicators. Adolescents who experienced more recent negative life events had lower perceptions of control and competence, and greater self-reported internalizing and externalizing symptoms. Consistent with previous research (Ge, Lorenz, et al., 1994; Ge et al., 2001) the association between life events and depression was significant across genders, but stronger among girls.

The previous study indicated that adolescent reported life events were associated with lower perceptions of control and competence (Elizabeth S. Flamm, Wendy S. Grolnick, 2013). In turn, lower perceived control and competence explained adolescents' depressive symptoms, and lower perceived competence partially explained adolescents' externalizing symptoms.

Thus, when adolescents experience recent negative life events - events which likely disorganize their environments and disrupt the normal contingencies between their actions and what's happening around them- their associated emotional problems are to some extent attributable to a poorer understanding and a lesser sense of efficacy for achieving goals and impacting their surroundings. Recent life events also related to adolescent externalizing directly. Perhaps adolescents responded with anger to the frustrating events themselves, or perhaps factors not measured in this study would explain the relation. Further research on possible mediators is necessary.

Summary and Conclusion

The purpose of the present study was to examine the protective factors that are associated with resilience in university students who were abused and neglected in childhood, as well as examine potential gender differences in factors that are reported. This study also attempts to develop the Myanmar version of the Childhood Maltreatment Questionnaire, Abuse and Neglect Scale, Life Events Questionnaire-Adolescent Version, College Adjustment Questionnaire and Social/Emotional Influences Inventory (Shirley and Roséns, 2010) were used in this study.

In order to do so, firstly Shirley and Roséns's general emphasis in drawing upon the initial Myanmar version of the Childhood Maltreatment Questionnaire was accepted, which consists of 19 items from Shirley and Roséns. The 19 items of the English version of the scale were translated into Myanmar by the author and checked by the supervisor against the original version to ensure the conceptual equivalence of the Myanmar version to the original version. To produce final version of the scale, the data were analyzed using item analysis program. According to the results, all of the items on each subscale were significant at .05 or .01 or .001 levels, except for 2 items. According to the results of internal consistency reliability analysis, the

reliability coefficient were found .84 for Childhood Maltreatment Questionnaire-Abuse Scale (full scale), .70 for physical abuse, .70 for sexual abuse, .80 for emotional abuse, and .70 for Love-Abuse Scale.

In order to test hypotheses, Chi-square analysis, correlation analysis, *t*-test analysis and multiple regression analysis were used in this study. Results of the correlation and *t*- test analyses showed that Individual protective factors were more related with resiliency than family and community protective factors among university students who were abused and neglected as children. Individual protective factors were more related with resiliency than family and community protective factors among male and female students.

According to the results of hierarchical multiple regression analysis indicated that negative life events have impact on the correlation between abuse and neglect and college adjustment. Results also indicated that maltreated women have more resilience outcomes than maltreated men in university and several reasons for this difference were discussed. Overall, negative life events and social/emotional resources are thought to be two important variables in understanding the relationship between maltreatment and adjustment.

4.1 Limitations and Directions for Future Research

As with any study, several limitations to this study exist. First, the study's small sample size kept us from being able to examine the impact of different types of neglect and abuse on college adjustment. It was originally hoped to look within the five types of abuse and neglect measured for the study to understand the resilience processes specific to each type of maltreatment, but it became clear that this would not be possible because there were a few students in each category. Also, given the high rate of co-occurring maltreatment, there were a few students with "pure" types of maltreatment to be able to carry out our analyses without having convoluted results.

Another limitation comes from possible restriction of range. Most students in the study had only low levels of maltreatment, if any at all, and this could represent a restriction of range in that individuals with severe maltreatment might not be making it to college by virtue of their incredibly impactful trauma, thereby preventing their inclusion in this study. If this is the case, this study ends up highlighting resilience processes for individuals with low-level maltreatment and may not be generalizable to many forms of maltreatment.

A third limitation is that the criterion used to classify maltreatment may have been too liberal. If the students endorsed anything other than *never occurred* on the maltreatment scales, they were considered maltreated. In reviewing the items of the CMQ abuse and neglect scales, however, perhaps a *rare* occurrence on a single item may not always be maltreatment. For example, the item "I had to fend for myself because there was no one around to supervise me," when at a low level of occurrence, likely doesn't represent maltreatment but rather reflects any number of normal family dynamics in which the parents weren't always available to supervise their children. This issue may be particularly salient when looked at the results for men, who were most likely to be classified as experiencing supervision neglect. By labeling those as maltreated there may have diluted the strength of the relationship between maltreatment and adjustment in men, resulting in the non-significant results obtained with the hierarchical

regression. On the other hand, even a "rare" occurrence of sexual abuse or physical abuse is likely maltreatment.

A fourth limitation was related to the nature of data collection. Data collection was retrospective and participants were required to remember and report the occurrence of negative events in their lives. Data was therefore dependent on the accurate recollection of life events, and potential bias always exists when recall is included in data collection.

Future research studies should seek to collect data from community samples in addition to a college sample so that restriction of range with regard to severity of maltreatment might be avoided. Although this study was specifically interested in college adjustment of abused and neglected students, future studies would benefit from having a much larger sample size so that there is enough power to examine the relationship between specific types of maltreatment and adjustment, rather than just conducting analyses on an aggregate maltreatment variable. A larger sample size and more power will also allow future researchers to examine in greater detail how protective factors influence adjustment and vary as a function of gender. For this study we had to stay at the domain level due to a lack of power and it was not able to look individually at the several types of protective factors measured by the SERI.

Researchers should also seek to clarify the timing of maltreatment and negative life events so that a casual model of maltreatment and negative life events can be further examined. As noted previously, the results of this study suggest that negative life events mediate the relationship between maltreatment and adjustment in women, but without more information about whether maltreatment occurs before negative life events, we are left with the possibility that maltreatment could be a mediating variable between negative life events and college adjustment.

4.2 Implications

Previous literature has documented the relationship between maltreatment, protective factors, and resilience. This study has helped to clarify facts about childhood maltreatment and resilience in college students. This study confirmed that maltreatment is a relatively common phenomenon that is associated with poor outcomes for abused and neglected students in Universities. This study have improved on previous research by looking at five different types of maltreatment, as well as co-occurring maltreatment, which makes the results of this study more representative of the real-world outcomes of neglect and abuse.

This study has examined gender differences in rates of maltreatment in outcomes in response to maltreatment, and in protective factors that promote more positive outcomes for students with abuse and neglect histories. Specifically, this study found that maltreated men seem to demonstrate less resilience to maltreatment and no difference in protective factors with maltreated women. This study contributed to greater cohesion and clarity of protective factor research by using a previously developed measure of protective factors and found that protective factors seem not vary by gender. This study proposed an explanation for this based on gender socialization and in doing so provide future researchers with the opportunity to test several more theory-based hypotheses about how gender impacts protective factors.

Finally, this study demonstrated that resilience is quite common - 74.9% of maltreated women and 65.7% of maltreated men demonstrated good adjustment in our sample. Importantly, however, this study was also identified that male resilience is not as "common" as female resilience, indicating that perhaps the resilience processes in men are different from women and that for men; "extraordinary magic" may need to happen in order for good adaptation to occur. This information could be used to provide many benefits to maltreated men and women and could be used to inform the development and implementation of interventions designed to address the reduced resilience of abused and neglected men.

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J-J' A STUDY OF THE USE OF PARALLELISM IN THE NOVEL A TALE OF TWO CITIES BY CHARLES DICKENS

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Abstract

Parallelism is a literary style of writing which is used to convey related thoughts in a line or in successive lines. Parallelism is commonly found in the bible and proverbial prose. This research shows that parallel structures can also be seen in literary works such as poems, proses, novels and short stories. The use of a wide range of parallelism can be found in the novel *A Tale of Two Cities* by Charles Dickens. This paper highlights the use of parallelism in the novel with focus on how parallelism highlighted the elements of novel such as plot, setting, character, point of view, theme, symbol and allegory, and style and tone. Ten types of parallelism – synonymic parallelism, antithetic parallelism, synthetic parallelism, clarification parallelism, progression parallelism, intensification parallelism, repetition parallelism, semantic parallelism, Janus parallelism and parallelism of numbers proposed by different scholars – were used to prove that parallelism is used not only in the poetic writing but also in the novel. According to the results of the research, the most frequent types of parallelism in the novel were clarification parallelism and semantic parallelism and they were mostly used to highlight plot and character.

Keywords :Parallelism, synonymic or synonymous parallelism, antithetic or antithetical parallelism, synthetic parallelism, clarification parallelism, progression parallelism, intensification parallelism, repetition parallelism, semantic parallelism, parallelism of numbers

Introduction

According to Bullinger (1898), parallelism refers to the repetition of similar, synonymic or opposite thoughts or words in parallel or successive lines. Parallelism means giving two or more parts of the sentences in a similar form so as to give the passage a definite pattern. According to Twist (2014), parallelism is a poetic device in which two or more words, phrases or lines of a poem reflect each other's contents. It emphasizes the sounds or ideas expressed in the parallel elements through repetition, development or contrast. The rhetorical and poetic traditions of many civilizations have recognized the power of parallelism. Previous researchers pointed out the use of parallelism in biblical texts. Jakobson (1960) initiated the secular study of parallelism in poetic-linguistic traditions around the world in addition to his own Russian tradition as parallelism is mostly found in poetic writing. There is a need to observe whether there is potential for parallelism found in the novel *A Tale of Two Cities* by Charles Dickens will be discussed. It is expected to find out that the use of parallelism can help readers understand complex ideas and structures in the novel *A Tale of Two Cities* by Charles Dickens.

1.1 Rationale of the study

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Parallelism serves as a bridge between the writer and the text, and the reader. It is of vital importance in making even a simple event intriguing. It also helps us to infer what is implied in the text, what will come next, and the tone and unsaid feelings of the author. The main reason for doing this research was to firmly prove that the poetic style of writing can be seen in the novel as well. In this paper, the novel *A Tale of Two Cities* was chosen to analyze because Dickens was famous for employing a wide range of the use of parallelism and the adverse effects of the clashes between England and France were not only historical and realistic but also intriguing.

1.2 Scope of the study

The novel *A Tale of Two Cities* by Charles Dickens was analyzed through the use of different types of parallelism and their effects on the description of the elements of novel. As the material chosen to analyse is a novel written in prose form, parallelism based on syntax and semantics was mainly used.

Of all different types of parallelism by different scholars, only 10 types of parallelism – chiastic parallelism, synonymic parallelism, antithetic parallelism, synthetic parallelism, clarification parallelism, progression parallelism, intensification parallelism, repetition parallelism, semantic parallelism, Janus parallelism and parallelism of numbers are selected to analyze as the rest of the types of parallelism were found mostly in the biblical prose.

1.3 Aim and Objectives

This research aims to study the effectiveness of the use of parallelism in the novel, In particular, this study will find out different types of parallelism and their effects on the description of the elements of novel.

The following research questions will be answered in this paper.

- (1) What types of parallelism are found in the novel?
- (2) What are the most frequently used types of parallelism and the least frequently used ones?
- (3) How does the use of parallelism highlight the elements of the novel plot, character, setting, point of view, style and tone, symbol and allegory, and theme of the novel?

Literature Review

It is important for the researcher to choose the appropriate approach and suitable method which help come up with accurate data and reliable results. Moreover, previous researches are of vital importance as they give useful resources and supportive ideas.

2.1 Definitions of Parallelism

Parallelism is a literary style of writing which is used to add more ideas about what is being said, to clarify what the writer conveys and to repeat what is important. Bullinger (1898) said that parallelism is the repetition of similar, synonymic or opposite thoughts or words in parallel or successive lines. Bhatti (2013) showed that there is "always a relationship in the structures and ideas generally in the form of synonymy, repetition, antithesis, apposition and so on *[in parallelism]*".

2.2 Types of Parallelism

Different scholars propose different types of parallelism. According to Lowth (1753), 4 types of parallelism are synonymic parallelism, antithetic parallelism, synthetic or constructive parallelism and intensification parallelism. Bullinger (1898) said that parallelism can be divided into simple and complex parallelism. Simple parallelism consists of synonymic or gradational parallelism, antithetic or opposite parallelism and synthetic or constructive parallelism whereas complex parallelism is composed of alternate parallelism, repeated alteration parallelism or repetition parallelism, extended alternation parallelism and introverted parallelism.

Copeland (1951) mentioned 5 types of parallelism – synonymic parallelism, antithetical parallelism, synthetic parallelism, progressive parallelism, star-like parallelism, climatic parallelism and introverted parallelism. In A Student's Dictionary for biblical and theological studies by Huey and Corley (1983), 5 types of parallelism are antithetic parallelism, chiastic parallelism, emblematic parallelism, formal parallelism or progressive parallelism or projecting parallelism or synthetic parallelism or expanded parallelism, and synonymic parallelism.

Freedman (1992) proposed 7 types of parallelism called synonymic parallelism, antithetic parallelism, synthetic parallelism, chiastic parallelism, staircase parallelism, emblematic parallelism and Janus parallelism. Carpenter (1992) defined 4 types of parallelism - synonymic parallelism, antithetic parallelism and synthetic parallelism and climatic parallelism. Kee, Rogerson, Meyers and Saldarini (1997) categorized parallelism into three types known as synonymous parallelism, antithetic parallelism and synthetic parallelism.

Klein, Blomberg and Hubbard (1993) presented 6 types of parallelism namely parallelism of subordination, parallelism of contrast, parallelism of continuation, parallelism of comparison, parallelism of specification and intensification. According to Bulkeley (2001), 7 types of parallelism are chiasm, synonymic parallelism, antithetic parallelism, synthetic parallelism, clarification parallelism, progression parallelism and intensification parallelism. McCoy (2003) pointed out the importance of three types of parallelism known as chiastic parallelism or chiasm, antithetic or antithetical parallelism and synthetic parallelism.

In addition to various types of parallelism mentioned above, types of parallelism proposed by Gaultney (2005) are tautological (synonymic) parallelism, antithetic parallelism, synthetic parallelism, word-step parallelism, acrostic parallelism, AB-AB arrangement or alternating parallelism, stair-like parallel arrangement, chiasmus and alternating parallelism. Parry (2007) mentioned ten types of parallelism in his book "Poetic Parallelism in the Book of Mormon". They are chiasmus and inverted parallelism, simple synonymic parallelism, extended synonymic, repeated alternate, synthetic parallelism, extended synthetic parallelism, progression parallelism, parallelism of numbers and antithetical Parallelism or Opposites.

Lauer (2011) proposed four types of parallelism – chiastic parallelism, synonymic parallelism, synthetic parallelism and repetition parallelism. Three main types of parallelism by Coutler (2011) are known as synonymic parallelism, synthetic or step parallelism and antithetical parallelism. Moreover, Kostenberger and Patterson (2011) distinguished parallelism into 5 types – antithetic parallelism, progressive parallelism which can again be differentiated into stair-case

parallelism and terrace pattern parallelism, emblematic parallelism, ladder parallelism and similar parallelism in their book title "Invitation to Biblical Interpretation: Exploring the Hermeneutical Triad of History, Literature and Theology".

Chaffey (2012) categorized parallelism into 5 types which are known as synonymic parallelism, antithetic parallelism, synthetic parallelism, emblematic parallelism and introverted or inverted parallelism. Types of Parallelism by Constable (2014) are synonymic parallelism, antithetic parallelism, synthetic parallelism, climatic parallelism and emblematic parallelism. Gilham (2014) proposed four types of parallelism called synonymic parallelism, antithetic parallelism and intensification parallelism. According to Stone (n.d.), parallelism can be grouped into synonymic parallelism, antithetic parallelism, introverted parallelism or chiastic parallelism and alternate parallelism.

2.3 Elements of Novel

Elements of novel are of vital importance in understanding literary texts in detail. It is through plot, setting, character, point of view, theme, symbol & allegory and style & tone that the writer conveys his message. Hallett (1996) defined "novel" "any imaginative re-creation of life in prose narrative form". He pointed out the aim of novel writers which reflects real-life situations.

Pickering and Hoeper (1986) proposed 7 elements of novel: plot, setting, character, point of view, theme, symbol & allegory and style & tone. Plot refers to the events happening in chronological order. It is usually composed of exposition, rising action, climax, falling action and denouement. Setting can be defined as time, place and weather in a literary text. One of the most important elements of novel is character. The nature of the characters can be observed through characterization. There are five ways for portraying characters - characterization through the use of names, characterization through the appearance, characterization by the author, characterization through the dialogue and characterization through the action. Point of view serves as a bridge between what the writer means and what the readers understand. Pickering and Hoeper (1986) showed four points of view - omniscient point of view in which the writer serves as "all-knowing" character, limited omniscient point of view in which the writer selects one character as the centre of revelation, first person point of view using "I", stream of consciousness which "renders from the inside" - the conscious and unconscious content of the human mind, and dramatic point of view in which the story is told "ostensibly" by no one. They added that theme also serves as the central idea of the story. It expresses some opinions on a particular topic and helps the readers understand the writer's ideas. In most literary texts, the writer's art of writing can be seen through the use of symbol and allegory. In addition to these, a wide variety of literary devices can also be observed in analyzing the writer's style of writing. Although literary texts like novels are in written form, the tone of the writer can be inferred through the use of word choice, sentence structure, pitch and so forth.

2.4 Summary of a Tale of Two Cities by Charles Dickens

At the beginning of the novel, Mr. Jarvis Lorry who was an official of Tellson's Bank in London informed Lucie Manette that her father was still alive. When they went to the wineshop of Defarge to rescue Dr. Manette, they realized that Dr. Manette was forced to make shoes in order to get a place to stay and food to eat. They took Dr. Manette back to London. Five years

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later, in 1780, Lucie and Dr. Manette was summoned by the court to give testimony for a young Frenchman, named Charles Darnay, who was accused of being a traitor and a spy. It is Sydney Carton, an advocate present in the courtroom, who pointsed out the resemblance between the prisoner and himself to the defense lawyer Mr. Stryver. Darnay was acquitted due to the fact that it could be a case of mistaken identity.

As time went by, both Darnay and Carton fell in love with Lucie Manette. As Carton was a reckless man who spent time by drinking, Lucie got married to Darnay. With the breakout of French Revolution, Darnay got a letter which informed him that his old friend Gabelle was erroneously arrested. He came to Paris to save Gabelle along with Lucie, her daughter, Dr. Manette and Mr. Lorry. However, Darnay was imprisoned as he relinquished his noble family title. The story ended dramatically when Sydney Carton saved save Darnay's life by taking his place. That sacrifice was made to fulfill a promise to Lucie whom he loved. Carton thought it was worth sacrificing for he knew that he would live in the hearts of the Darnays forever.

2.5 Previous Researches

Approaches, methods and the results of previous researches come in handy for the researcher. Four previous researches included in this paper are the works done by Dahlberg (1984), Hildebrandt (1985), Gaultney (2005) and Klaussnner (2013) were presented.

In his MA thesis titled "An Exegetical Study of Psalm 127", Dahlberg (1984) aimed to exegetically understand this psalm as a basis for valid application for the modern day believer. He used Berlin's approach to biblical parallelism – grammatical parallelism, semantical parallelism and rhetorical parallelism which was composed of climatic parallelism and chiastic parallelism. Dahlberg (1984) proved that although two wisdom sayings in Psalms 127 by Solomon appear separate at first, they had a unifying structure. The unification of the psalm lied predominantly in the semantic sphere where the house and family were seen in connection, and the city and gate were of a member class association.

Hildebrandt (1985) mentioned the potentialities of poetic expression and provided a model for capturing the profundities of the syntax of Hebrew poetry in his PhD thesis titled "Proverbial Poetry: Its Settings and Syntax". He used vocabulary approach, motif approach, form approach, Lowth-Gray-Robinson semantic parallelism approach and grammatical approach. He adopted Whybray's perceptive categories of vocabulary approach. He justified the views by Roland (1963) that (1) the motif must be clearly and concisely defined within the wisdom corpus itself, if it is going to be used as a criterion; (2) it must be shown that the idea being used to detect wisdom's presence is not characteristic of other traditions; and (3) careful scrutiny must be given as to the transformations which the concepts will go through when they are interfaced with historical, psalmic and prophetic genres. The results of the research showed that "the rhythmical equivalences and creative variations of Hebrew poetic expression should not be limited to phonetic features (meter, alliteration, paronomasia et al.); nor should one myopically employ a method which merely observes semantic parallelism without semantically specifying precisely what the components of the parallel relationships are".

In his MA thesis titled "The Parallel Structure of Proverbs", Gaultney (2005) aimed to provide ways to find out different types of parallelism in Proverbs. He used different types of parallelism proposed by Breck (1994), Kugel (1998) and Coogan (2001). The types of

parallelism he used were tautological (synonymous) parallelism, antithetic parallelism, synthetic parallelism, word-step parallelism, acrostic parallelism, AB-AB arrangement or alternating parallelism and chiasmus. At the end of the research, he came up with *The Six Steps Process for Locating Parallelism* in Scripture known as (1) Identify and separate each colon, (2) Highlight or mark repetitious words, (3) Identify the basic forms of parallelism used, (4) Determine the possible arrangements, such as chiasmus, word-step, or stair-like, (5) Select the most likely arrangement, and (6) Questions, comments, and observations. In conclusion, he stated (i) The teaching and writing style are directed at practitioners rather than scholars, and (ii) Form and content are inseparable.

Klaussner (2013) wrote a thesis titled "Shedding Light on Dickens' Style through Independent Component Analysis and Representativeness and Distinctiveness". In his thesis, he presented an insight into the diverse aspects of non-traditional style analysis of past and present literary works. He did statistical analysis of Dickens' texts with that of contemporary writer by using Corpus Linguistics' Approach to Dickens' Style, attributing Dickens' "Temperance" and Tabata's Random Forests. He stated that a method has to fulfill the criteria – testability or falsifiability, peer review and publication, known or potential error rate and general acceptance. He dealt with statistical basics and explained the experiments and the evaluation of the methods presented. Klaussnner (2013) said that "findings may even overlap with studies using different approaches, which additionally support their validity and general applicability". He concluded that no matter what kinds of methods used for a particular style of writing, they all will come to similar conclusions.

Unlike the research done by Dahlberg (1984), Hildebrandt (1985) and Gaultney (2005), this study focused on the use of parallelism, and the effects of parallelism on the description of plot, character, setting, point of view, symbol and allegory, style and tone, and theme. All previous researches in this section except Klaussnner (2013) chose the Bible and the poem as texts to analyze and showed the presence of parallelism in these texts. However, this dissertation studied the use of parallelism and its effects on the description of the novel.

Research Methodology

Methodology can be regarded as the lifeblood of a research. Some researchers adopt the methods and approaches used in earlier researches whereas others adapt them. In this paper, only 10 types out of 22 types of parallelism proposed by 20 scholars were adapted to come up with a suitable model for the analysis. Different types of parallelism mentioned earlier in previous chapter can be seen in the following table.

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	Chiastic Parallelism	Synonymic Parallelism	Extended Synonymous Parallelism	Antithetic Parallelism	Synthetic Parallelism	Extended Synthetic Parallelism	Clarification Parallelism	Progression Parallelism	Intensification Parallelism	Repetition Parallelism	Semantic or Emblematic Parallelism	Alternate Parallelism	Extended Alternation Parallelism	Composite Parallelism	Climactic Parallelism	Staircase Parallelism	Janus Parallelism	Word-step Parallelism	Acrostic Parallelism	Star-like Parallelism	Gradation Parallelism	Parallelism of Numbers
Lowth (1753)	×	\checkmark	×	\checkmark	\checkmark	×	×	×	\checkmark	×	×	×	×	×	×	×	×	×	×	×	×	×
Bullinger (1898)	\checkmark	✓	×	✓	✓	×	×	×	×	\checkmark	×	\checkmark	\checkmark	×	×	×	×	×	×	×	×	×
Copeland (1951)	✓	~	×	✓	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ludlow (1982)	×	\checkmark	×	\checkmark	\checkmark	×	×	×	×	×	\checkmark	×	×	\checkmark	\checkmark	x	×	×	×	×	×	×
Huey & Corley (1983)	~	✓	×	✓	✓ ✓	×	×	✓ ✓	×	×	✓	×	×	×	×	×	×	×	×	×	×	×
Freedman (1992)	\checkmark	\checkmark	×	\checkmark	\checkmark	×	×	×	×	×	\checkmark	×	×	×	×	\checkmark	\checkmark	×	×	×	×	×
Carpenter (1992)	×	✓	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Klein, Blomberg and Hubbard (1993)	×	✓	×	✓	✓	×	✓		✓	×	✓	×	×	×	×	×	×	×	×	×	×	×
Kee, Rogerson, Meyers and Saldarini (1997)	×	~	×	~	~	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Bulkeley (2001)	\checkmark	✓	×	✓	✓	×	✓	✓	\checkmark	×	×	×	×	×	×	×	×	×	×	×	×	×
McCoy (2003)	✓	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Gaultney (2005)	✓	✓	×	✓	✓	×	×	×	×	×	×	\checkmark	×	×	×	×	×	✓	✓	✓	×	×
Parry (2007)	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	×	\checkmark	×	×	×	\checkmark	×	×	×	×	×	×	×	×	\checkmark	\checkmark
Laurer (2011)	>	\checkmark	×	×	>	×	×	×	×	>	×	×	×	×	×	×	×	×	×	×	×	×
Coutler (2011)	×	\checkmark	×	\checkmark	\checkmark	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Kosten-berger and Patterson (2011)	×	✓	×	✓	×	×	×	✓ ✓	×	×	✓	×	×	×	×	×	×	×	×	×	×	~
Chaffey (2012)	\checkmark	✓	×	\checkmark	\checkmark	×	×	×	×	×	\checkmark	×	×	×	×	×	×	×	×	×	×	×
Constable (2014)	×	\checkmark	×	\checkmark	\checkmark	×	×	×	×	×	\checkmark	×	×	×	\checkmark	×	×	×	×	×	×	×
Gilham (2014)	×	✓	×	✓	✓	×	×	×	\checkmark	×	×	×	×	×	×	×	×	×	×	×	×	×
Stone (n.d)	\checkmark	\checkmark	×	\checkmark	×	×	×	\checkmark	×	×	×	\checkmark	×	×	×	×	×	×	×	×	×	×

Table 1: Types of Parallelism Suggested by Scholars

3.1. Selection of the Model

Of all 22 types of parallelism, only 10 types were selected as some are the extension of the main type of parallelism such as extended synonymous parallelism, extended synthetic parallelism and extended alternation parallelism. Types of parallelism mostly found in poetic writing such as chiastic parallelism, alternate parallelism, composite parallelism, climatic parallelism, staircase parallelism, word-step parallelism, acrostic parallelism, star-like parallelism and gradation parallelism were excluded in doing this analysis. This paper looked at the use of different types of parallelism proposed by scholars mentioned earlier such as Lowth (1753), Bullinger (1898), Bulkeley (2001), McCoy (2003), Laurer (2011), Coutler (2011), Chaffey (2012) and Gilham (2014) in the novel *A Tale of Two Cities* by Charles Dickens.

The following model was adapted in doing the analysis of the novel in this paper. In order to indicate different types of parallelism concisely, abbreviations shown in the following table were used.

No.	Types of Parallelism	Abbre.
1.	Synonymic or Synonymous Parallelism	Syn
	According to Lowth (1753), lines are echoic. The second line is a	±Syn
	mere variation of the first. In other words, the thought of the first line	
	is repeated in the second, expressed in different words or emphasis.	
	The LORD also thundered in the heavens,	
	And the Highest gave his voice;	
	Hail stones and coals of fire. (Psalms. 18:13, KJV)	
2.	Antithetic or Antithetical Parallelism	+An
	Bullinger (1898) stated that opposite ideas and thoughts are presented	-An
	in order to give rise to the prominent difference between two	
	different things. Sometimes, antithetic parallelism is used to create	
	ironic effect on the text.	
	Faithful are the wounds of a friend,	
	But deceitful are the kisses of an enemy"	
	(Proverbs. 27:6, KJV)	
3.	Synthetic Parallelism	SySy
	Synthetic parallelism can be seen when the thought simply	
	progresses. Themes in the second line may explain, emphasize or	
	embellish the first line or the second line may show the results of	
	actions described in the first line. (McCoy, 2003)	
	9They set their mouth against the heavens,	
	And their tongue walks through the earth.	
	10 Therefore his people return here,	
	And waters of a full cup are drained by them.	
	(Psalms. 73:9-10, NKJV)	

 Table 2: Types of Parallelism Used to Analyze the Novel A Tale of Two Cities by Charles Dickens

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No.	Types of Parallelism	Abbre.
4.	Clarification Parallelism	Cl
	Bulkeley (2001) proposed that in clarification parallelism, the	+Cl
	clarification is given in greater precision. In other words, more	
	information is added to a particular noun or noun phrase.	
	The One enthroned in heaven laughs;	
	the Lord scoffs at them. (Psalms. 2:4, NIV)	
5.	Progression Parallelism	P
	Progression parallelism is a poetical device where there is an	Pr
	apparent moving forward from one sense or idea to another until, at	Pro
	the pinnacle is a culmination of thought. (Parry, 2007)	Prog
	The LORD takes his place to plead a cause,	Progr
	and stands to judge the people. (Isaiah 3:13, KJV)	
6.	Intensification Parallelism	In In
	In intensification parallelism, the information given in the first line is	
	intensified in the other lines. The writer uses words which are	
	stronger in meaning to reinforce the seriousness in his text.	
	I made the earth,	
	and created man upon it:	
	it was my hand that stretched out the heavens,	
	and I commanded all their host. (Isaiah. 45:12, KJV)	
	'my hand stretched out the heavens' \leftarrow 'I made the earth'	
	'I commanded all their host' \leftarrow 'I created man'	
7.	Repetition Parallelism	Re
	The same sentence, phrase or word is used again in order to highlight	Re
	what the writer wants to focus. (Lauer, 2011)	
	Sing joyfully to the Lord, you righteous;	
	it is fitting for the upright to praise him.	
	Praise the Lord with the harp;	
	make music to him on the ten-stringed lyre.	
	Sing to him a new song;	
	play skillfully, and shout for joy. (Psalms. 33:1-3, NIV)	
8.	Semantic Parallelism	Sm
	Semantic parallelism occurs when two poetic lines show progression	
	of thought involving simile, metaphor and so on. (Kostenberger and	
	Patterson, 2011)	
	As a father has compassion on his children,	
	so the LORD has compassion on those who fear him.	
	(Psalms 103: 15, NIV)	

No.	Types of Parallelism	Abbre.
9.	Janus Parallelism	Ja
	Janus parallelism focuses on the use of a single word with two	
	different meanings, one of which forms a parallel with what precedes	
	and the other with what follows. Such parallelism faces in both	
	directions conveying a sense of a double entendre. (Freedman, 1992)	
	The blessings of your father	
	Surpass the blessings of my ancestors/mountains [hwry]	
	To the utmost bounds of the eternal hills.	
	(Genesis. 49:26, ESV)	
10.	Parallelism of Numbers	PfN
	According to Parry (2007), n semantic language, "numbers have no	
	synonym, with the exception of twenty/score. Equal balance in	
	English like twelve/dozen and fractions, have a hundred/fifty, do not	
	exist."	
	If Cain shall be avenged sevenfold,	
	truly Lamech seventy and sevenfold. (Genesis. 4:24, KJV)	

3.2. Research Procedures

Mixed method which includes both quantitative and qualitative approaches was used. 10 types of parallelism – synonymic or synonymous parallelism, antithetic or antithetical parallelism, synthetic parallelism, clarification parallelism, progression parallelism, intensification parallelism, repetition parallelism, semantic parallelism and parallelism of numbers – were used to analyze the novel *A Tale of Two Cities* by Charles Dickens. After that, the frequency of types of parallelism was counted quantitatively. Next, how parallelism highlighted the elements of the novel – plot, character, setting, point of view, style and tone, symbol and allegory and theme – was discussed.

3.2.1. Data Collection and Data Analysis

The text used to collect data was the novel *A Tale of Two Cities* by Charles Dickens. After analyzing the novel using 10 types of parallelism and the elements of novel by Pickering and Hoeper (1986) highlighted by the use of parallelism were elucidated. 10 types of parallelism used in this paper were synonymic parallelism, antithetic parallelism, synthetic parallelism, clarification parallelism, progression parallelism and parallelism of numbers. After the analysis, the data were interpreted in terms of the effects of the use of parallelism on the description of the elements of novel and how parallelism was used to highlight the elements of novel with regard to the theories mentioned in literature review section. In the novel *A Tale of Two Cities*, there are 3 books which include 45 chapters. There are 6 chapters in Book I, 24 chapters in Book II and 15 chapters in Book III. In this research report, only sample analyses from Book I, Book II and Book III were presented.

Sample Analysis of the Effects of the Use of Parallelism on the Description of the Elements of Novel in A Tale of Two Cities

Of all three books of *A Tale of Two Cities*, there are 6 chapters in Book I, 24 chapters in Book II and 15 chapters in Book III. In this section, only the sample analysis of the first chapter from each will be presented.

The followings are the analysis of the effects of the use of parallelism on the description of the elements of novel. The sentences in which 10 types of parallelism – antithetic parallelism, clarification parallelism, intensification parallelism, progression parallelism, synonymous parallelism, repetition parallelism, synthetic parallelism, semantic parallelism and parallelism of numbers – are found are put into the table along with the description of the elements of novel on which parallelism had effects.

4.1 Sample Analysis of the Effects of the Use of Parallelism on the Description of the Elements of Novel in Book I: *Recalled to Life*

The following table shows how the use of parallelism highlights the elements of the novel in Book I.

	T inc		T	Elements of the Novel
No.	Line	Sentence(s)	I ype of Domollolium	Highlighted by the Use of
	190.		1 al anensin	Parallelism
1	1-5	IT WAS (Re1) the best of times,	Re1Re1	Setting
		it was (Re1) the worst of times, it		- describes the setting – time,
		was (Re1) the age of wisdom, it		age, epoch, season,
		was (Re1) the age of foolishness,		spring/winter, impermanence
		it was (Re1) the epoch of belief,		of things and heaven or hell
		it was (Re1) the epoch of		
		incredulity, it was (Re1) the		
		season of Light, it was (Re1) the		
		season of Darkness, it was (Re1)		
		the spring of hope, it was (Re1)		
		the winter of despair, we had		
		everything before us,		
		IT WAS the best of times (Re2),	Re2Re2	Setting
		it was the worst of times (Re2), it		- presents the situation of the
		was the age of wisdom,		1770s, foreshadowing that that
				situation is the best of times
				for some people but the worst
				of times for others. Since the
				beginning of the novel, he uses
				the harbinger that for those
				who have power and wealth, it
				is the best of times whereas it
				is the worst of times for poor
				people

Table 3: Analysis of the use of parallelism in Book I: Recalled to Life

No.	Line No.	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism
		IT WAS the best of times, it was the worst of times, it was the age (Re3) of wisdom, it was the age (Re3) of foolishness, it was the epoch of belief,	Re3Re3	Setting - points out the unstability of the state since the beginning of the novel
		IT WAS the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch (Re4) of belief, it was the epoch (Re4) of incredulity, it was the season of Light,	Re4Re4	Setting - highlights that it is the historical period in which people dare not believe everything due to inequality under the unfair reign
		IT WAS the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season (Re5) of Light, it was the season (Re5) of Darkness, it was the spring of hope,	Re5Re5	Setting - shows that it is the time when people do not know what is right and what is wrong or what is good and what is evil
		it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had (Re6) everything before us, we had (Re6) nothing before us,	Re6Re6	Point of View - emphasizes the transient nature of our possession and persuades his readers to become involved in the situation mentioned in the novel
		it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct (Re7) to Heaven, we were all going direct (Re7) the other way – in short, the period was so far like the present period,	Re7Re7	Point of View - describes that everyone has to go to either the heaven or the hell when he or she dies
		IT WAS the <u>best</u> (+An1) of times, it was the <i>worst</i> (-An1) of times, it was the age of <u>wisdom</u>	+An1An1	Setting - points out the unstability of the state since the beginning of the novel

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No.	Line No.	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism
		it was the <i>worst</i> (-An1) of	+An2An2	Setting
		times, it was the age of wisdom		- points out the unstability of
		(+An2), it was the age of		the state since the beginning of
		foolishness(-An2), it was the		the novel
		epoch of <u>belief</u>		
		it was the epoch of <u>belief</u>	+An3An3	Setting
		(+An3), it was the epoch of		- points out the unstability of
		incredulity (-An3), it was the		the state since the beginning of
		season of <u>Light</u>		the novel
		it was the season of <u>Light</u>	+An4An4	Setting
		(+An4), it was the season of		- points out the unstability of
		Darkness(-An4), it was the spring		the state since the beginning of
		of <u>hope</u>		the novel
		it was the spring of <u>hope</u>	+An5An5	Setting
		(+An5), it was the winter of		- points out the unstability of
		<i>despair</i> (-An5), we had <u>everything</u>		the state since the beginning of
				the novel
		we had <u>everything</u> (+An6)	+An6An6	Setting
		before us, we had <i>nothing</i> (-An6)		- points out the unstability of
		before us, we were all going		the state since the beginning of
		direct to <u>Heaven</u>		the novel
		before us, we were all going	+An7An7	Setting
		direct to $\underline{\text{Heaven}}$ (+An7), we were		- points out the unstability of
		all going direct the other way (-		the state since the beginning of
		An7)– in short,		the novel
		the period was so far like the	Cl+Cl	Setting
		present period (Cl), that some of		- points out the unstability of
		its noisiest authorities insisted on		the state since the beginning of
		its being received, for good or for		the novel
		evil, in the superlative degree of		
		comparison only. (+Cl)		
2	11-13	There were a king with a large	ReRe	Characterization
		jaw and a queen (Re) with a		- uses the noun phrase "a king
		plain face, on the throne of		with a large jaw" to reflect the
		England; there were a king with		king's powerful reign and
		a large jaw and a queen (Re)		cruelty through his physical
		with a fair face, on the throne of		appearance
		France.		

No.	Line No.	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism
		There were a king with a large jaw (Sm) and a queen with a plain face, on the throne of England; there were a king with a large jaw (Sm) and a queen with a fair face, on the throne of France.	Sm	Characterization - uses the noun phrase "a king with a large jaw" as symbolism to reflect the king's powerful reign and cruelty through his physical appearance
3	17,18	It was the year of Our Lord one thousand seven hundred and seventy-five.	PfN	Setting - illustrates the most significant period at which laypeople in France and England suffer from poverty whereas authorities enjoy their luxury
4	26-30	Mere messages (Cl) in the earthly order of events had lately come to the English Crown and People, from a congress of British subjects in America: <u>which, strange to</u> relate, have proved more important to the human race than any <u>communications yet received</u> through any of the chickens of the <u>Cock-lane brood</u> . (Cl)	Cl+Cl	Point of View - presents the importance of such kind of mere messages as they are directly concerned with the state and its people through omniscient point of view
5	32-34	France (Cl), <u>less favoured on the</u> whole as to matters spiritual than her sister of the shield and trident (+Cl),	Cl+Cl	Point of View - reveals that poor people face the struggle for their survival whereas rich people squander the money they get easily
		France, <i>less favoured on the</i> <i>whole as to matters</i> (In) spiritual than her sister of the shield and trident, (In) rolled with exceeding smoothness down hill, making paper money and spending it.	InIn	Point of View - reveals that poor people face the struggle for their survival whereas rich people squander the money they get easily

4.2 Sample Analysis of the Effects of the Use of Parallelism on the Description of the Elements of Novel in Book II: *The Golden Thread*

 Table 4: Analysis of the use of parallelism in Book II: The Golden Thread

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No	Line	Sentence(s)	Type of	Elements of the Novel
	No		Parallelism	Highlighted by the Use of
	110			Parallelism
1	1-5	Tellson's Bank by Temple Bar was	Re1Re1	Setting
	_	an old-fashioned place (Re1), even		- presents the setting -
		in the year one thousand seven		Tellson's Bank which is an
		hundred and eighty. It was very		old-fashioned place which
		small, very dark, very ugly, very		is not a convenient place to
		incommodious. It was an old-		live and work
		fashioned place (Re1) moreover		nvo und work
		moreover in the moral attribute	Re? Re?	Setting
		that the partners in the House were	102102	- presents the setting -
		nroud of (Re2) its smallness nroud		Tellson's Bank which is an
		of $(\mathbf{P}_{\mathbf{P}}^2)$ its darkness, proud of		old fashioned place which
		(Re2) its ualiness, proud of $(Re2)$ its		is not a convenient place to
		(Rez) its uginiess, produ of (Rez) its		is not a convenient place to
				Stule and Tone
		It was very small, very aark, very	+AnAn	Style and Tone
		ugiy, very incommodious (+Ah) It		- inustrates that people
		was an old-fashioned place,		from Tellson's Bank are
		moreover, in the moral attribute that		proud of its smallness,
		the partners in the House were proud		darkness, ugliness and
		of its smallness, proud of its darkness,		incommodiousness, using
		proud of its ugliness, proud of its		ironic tone
		<u>incommodiousness</u> (-An)		
		It was an old-fashioned place,	Sm	Style and Tone
		moreover, in the moral attribute that		- illustrates that people
		the partners in the House were		from Tellson's Bank are
		proud of its smallness, proud of its		proud of its smallness,
		darkness, proud of its ugliness,		darkness, ugliness and
		proud of its incommodiousness		incommodiousness, using
		(Sm)		ironic tone
2	2-6	It was an old-fashioned place,	Syn ±Syn	Setting
		moreover, in the moral attribute that		- presents the setting -
		the partners in the House were		Tellson's Bank which is an
		proud of (Syn) its smallness,		old-fashioned place which
		They were even boastful of (±Syn)		is not a convenient place to
		its eminence in those particulars, and		live and work
		were fired by an express conviction		
		that, if it were less objectionable, it		
		would be less respectable		
		They were even boastful of its	+AnAn	Style and Tone
		eminence in those particulars, and		- shows that people from
		were fired by an express conviction		Tellson's Bank believe that
		that, if it were less objectionable		if the bank is a pleasant
		(+An), it would be less respectable (-		place, it will not be very
		An)		much admirable. using
		<i>,</i>		ironic tone

No	Line	Sentence(s)	Type of	Elements of the Novel
	No		Parallelism	Highlighted by the Use of
				Parallelism
3	7.8	This was no passive belief, but an	Cl+Cl	Setting
-	- , -	active weapon (Cl) which they		- describes the setting of
		flashed at more convenient places of		Tellson's Bank as a place
		business (+Cl)		inconvenient to do business
4	8-11	Tellson's (they said (+Cl)) wanted no	C1 + C1	Setting
'	0 11	elbow-room Tellson's wanted no	01+01	- describes the setting of
		light Tellson's wanted no		Tellson's Bank portraying
		embellishment (Cl) Noakes and Co		that it is not well-decorated
		's might or Snocks Brothers' might:		nlace
		but Tellson's thank Heaven!		place
		Tellson's (they said) wanted no	$+\Delta n - \Delta n$	Setting
		albow room Tallson's wanted no		describes the setting of
		light Tallson's wanted no		- describes the setting of Tallson's Bank portraying
		amballishmant ((An) Noakes and		that it is not well decorated
		Co 's might or Spooks Prothers'		nlass
		$\frac{CO}{S}$ might (An):		prace
		Tallaan's (they said) wanted no	Sm	Style and Tone
		albeer room Talleon's wonted no	5111	style and Tone
		elbow-room, Tellson's wanted no		- snows that Tellson's Bank
		light, Tellson's wanted no		is so old-fashioned that its
		embellishment Noakes and Co s		partners will disinnerit
		might, or Shooks Brothers might;		their sons who suggest to
		but Tellson's, thank Heaven!-Any		rebuild it, using sarcastic
		one of these partners would have		tone
		disinnerited his son on the		
~	11 10	question of rebuilding Tellson's		a
5	11-13	In this respect the House was much	CII+CII	Setting
		on a par with the Country (CII);		- portrays the political
		which did very often disinherit its		setting in France where the
		sons for suggesting improvements in		authorities forbid to
		laws and customs that had long been		improve the laws and
		highly objectionable, but were only		customs
		the more respectable (+CII)		
		In this respect the House was much	CI2+CI2	Theme
		on a par with the Country; which did		- highlights that laws and
		very often disinherit its sons for		customs in France are
		suggesting improvements in laws		meant for the good of the
		and customs (CI) that had long been		authorities but are the
		highly objectionable, but were only		weapon to oppress the poor
		the more respectable (+Cl)		~ –
		In this respect the House was much	+AnAn	Style and Tone
		on a par with the Country; which did		- illustrates that like
		very often disinherit its sons for		Tellson's Bank, the
		suggesting improvements in laws		country's offensiveness
		and customs that had long been		makes it more respectable,
		highly objectionable (+An), but were		using ironic tone

No	Line No	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism
		only the more respectable (-An)		

4.3. Sample Analysis of the Effects of the Use of Parallelism on the Description of the Elements of Novel in Book III: *The Track of a Storm*

In the following table, the elements of the novel highlighted by the use of parallelism are displayed.

Table 5: Analysis of the use of parallelism in Book III: The Track of a Storm

No	Line No	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism
1	1 - 5	The traveller (Cl) fared slowly on his way, <u>who fared towards Paris</u> from England in the autumn of the year one thousand seven hundred and ninety-two (+Cl)	Cl+ Cl	Plot - displays that Darnay arrives in Paris in 1792
		More than enough of bad (Re) roads, bad equipages, and bad (Re) horses, he would have encountered to delay him,	Janus	Setting - presents the setting - poor quality roads in the autumn of 1792 - as antagonists
		More than enough of bad roads, bad equipages, and bad horses, he would have encountered to delay him, though the fallen (Syn) and unfortunate (±Syn) King of France had been upon his throne in all his glory;	Syn ± Syn	Setting - illustrates the political setting in France in the late 18th century in which the King of France faced the revolutionists who threatened and usurped his throne
		More than enough of bad roads, bad equipages, and bad horses, he would have encountered to delay him, though the fallen and unfortunate King of France had been upon his throne in all his glory (+An); but, the changed times were fraught with other obstacles than these (-An)	+AnAn	Setting - illustrates the political setting in France in the late 18th century in which the King of France faced the revolutionists who threatened and usurped his throne

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No	Line No	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism			
2	6 - 11	Every town-gate and village taxing- house had its band of citizenpatriots (Cl), with their national muskets in a most explosive state of readiness, <u>who</u> <u>stopped all comers and goers, cross-</u> <u>questioned them, inspected their</u> <u>papers, looked for their names in</u> <u>lists of their own, turned them back,</u> <u>or sent them on, or stopped them</u> <u>and laid them in hold (+Cl),</u>	Cl+ Cl	Setting - portrays the setting of Paris where town-gate and taxing house can be seen at the entrance			
		Every town-gate and village taxing- house had its band of citizenpatriots, with their national muskets in a most explosive state of readiness, who stopped all comers and goers (P), cross-questioned them (Pr), inspected their papers (Pro), looked for their names in lists of their own (Prog), turned them back (Progr), or sent them on (Progre), or stopped them and laid them in hold (Progres), as	PPrPr oProg ProgrPro greProgr es	Setting - portrays the setting of Paris where town-gate and taxing house can be seen at the entrance			
3	14-19	Whatever might befall now, he must on to his journey's end Not a mean village closed upon him, not a common barrier dropped across the road behind him, but he knew it to be another iron door in the series (Cl1) <u>that was barred between him</u> <u>and England</u> (+Cl1)	Cl1+ Cl1	Characterization - illustrates the diligent character of Darnay who will go on until he reaches his destiny through the narration of the writer			
		The universal watchfulness so encompassed him (Cl2), that if he had been taken in a net, or were being forwarded to his destination in a cage, he could not have felt his freedom more completely gone (+Cl2)	Cl2+ Cl2	Characterization - illustrates the diligent character of Darnay who will go on until he reaches his destiny through the narration of the writer			
		The universal watchfulness so encompassed him, that if he had been taken in a net (Syn), or were being forwarded to his destination in a cage (±Syn), he could not have felt his freedom more completely gone	Syn ± Syn	Characterization - illustrates the diligent character of Darnay who will go on until he reaches his destiny through the narration of the writer			

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No	Line No	Sentence(s)	Type of Parallelism	Elements of the Novel Highlighted by the Use of Parallelism
4	20-24	but retarded his progress twenty times in a day, by riding (Re) after him and taking him back, riding (Re1) before him and stopping him by anticipation, riding (Re1) with him and keeping him in charge	Re1Re1	Plot - shows that Darnay's travel to Paris is hard and rush
		This universal watchfulness not only stopped him on the highway twenty times (Re2) in a stage, but retarded his progress twenty times (Re) in a day,	Re2Re2	Plot - shows that Darnay's travel to Paris is hard and rush
		This universal watchfulness not only stopped him on the highway twenty times (Re2) in a stage, but retarded his progress twenty times (Re) in a day,	PfN	Plot - shows that Darnay's travel to Paris is hard and rush
		He had been days upon his journey in France alone, when he went to bed tired out, in a <i>little</i> (+An) town on the <u>high</u> (-An) road, still a long way from Paris	+AnAn	Plot - shows that Darnay's travel to Paris is hard and rush
5	26-29	His difficulty at the guard-house in this small place had been such, that he felt his journey to have come to a crisis (Sy) And he was, therefore, as little surprised as a man could be, to find himself awakened at the small inn to which he had been remitted until morning, in the middle of the night (Sy)	SySy	Plot - displays that Darnay stays in a small inn in Paris
		And he was, therefore, as little surprised as a man could be, to find himself awakened at the small inn (Cl) to which he had been remitted until morning, in the middle of the night (+Cl)	Cl+ Cl	Plot - displays that Darnay stays in a small inn in Paris

Findings and Discussion

After analyzing the novel, it was found that the use of parallelism dramatically highlighted the elements of novel. Among them, characterization was the most significant one and it was illustrated through the use of clarification parallelism and plot was developed through the use of progression parallelism. Abundant use of semantic parallelism can be noted in using symbols and allegory and in developing style and tone.

5.1. Findings and Discussion on Book I: Recalled to Life

In Book I, it was found that different types of parallelism were used to highlight different elements of novel. The followings are the data table and figure which show the relationships between types of parallelism found in Book I: *Recalled to Life* and the elements of novel.

	Antithetic	Clarification	Intensification	Progression	Repetition	Synonymic	Synthetic	Semantic	Janus	Parallelism of Numbers	Total	⁰∕₀
Plot	9	48	5	44	17	6	7	15	2	0	151	16
Characterization	44	115	23	56	37	17	19	46	0	1	357	37
Setting	16	57	6	12	22	7	6	27	0	5	153	16
Point of View	14	37	6	8	15	6	4	25	0	1	115	12
Symbol and Allegory	8	28	3	7	4	3	3	23	0	0	79	8
Style and Tone	3	15	2	2	4	0	1	17	0	0	44	5
Theme	16	24	4	5	11	2	0	11	0	1	73	8
Total	110	324	49	134	110	41	40	164	2	8	972	100
%	11	33	5	14	11	4	4	17	0	1	100	

Table 6: Elements of novel highlighted by the use of parallelism in Book I



Figure 1: Elements of novel highlighted by the use of parallelism in Book I

According to the table and the figure mentioned above, the most frequent types of parallelism used in Book I are clarification parallelism (33%) and semantic parallelism (17%) and these are used especially in illustrating character (37%), plot (16%) and setting (16%). As Book I is the first book of the novel, the writer put his focus on character, plot and setting.

The writer depicted the political and social setting in England and France and foreshadowed the upcoming events. He highlighted the situations in which rich and powerful people squander their money easily whereas poor people had to struggle for their survival as in the following lines:

France (Cl), *less favoured on the whole as to matters* (+Cl) (In) **spiritual than her sister of the shield and trident**, (In) rolled with exceeding smoothness down hill, making paper money and spending it.

She entertained herself, besides, with such humane achievements (+An) as sentencing a youth to have his hands cut off, his tongue torn out with pincers, and his body burned alive (Sy), (-An) because he had not kneeled down in the rain to do honour to a dirty procession of monks which passed within his view, at a distance of some fifty or sixty yards (Sy). (Sm)

(Chapter 1, lines 32-40)

The writer used clarification parallelism in giving more information about France and portrayed the economic situation in France. The use of intensification parallelism can be seen in the phrase "less favoured on the whole as to matters spiritual than her sister of the shield and trident". This reinforced that wealthy French were not interested in religion but in luxury. In addition, the use of synthetic parallelism can be seen in illustrating the unfair reign and punishment. The adverse political situation was vividly portrayed through the antithetic sentence "She entertained herself, besides, with such humane achievements as sentencing a youth to have his hands cut off, his tongue torn out with pincers, and his body burned alive". The writer's ironic tone can be seen in these sentences which show that poor people were punished even though they were innocent.

The writer introduced the characters such as the Woodman, the Farmer, the hangman, a wretched pilferer, the passengers on coach, Mr. Lorry and Miss Manette mainly through the use of clarification parallelism, semantic parallelism, progression parallelism, synthetic parallelism and antithetic parallelism. For instance, the use of clarification parallelism, semantic parallelism and repetition parallelism can be found in introducing the secretive character of the passengers in the coach. The writer clarified the sentence - So with the three passengers shut up in the narrow compass of one lumbering old mail coach – by showing that they did not know one another and therefore they behaved as if they were in their own coaches as in the following lines:

So with the three passengers shut up in the narrow compass of one lumbering old mail coach (Cl); they were mysteries to one another, as complete as if each had been in his own coach (Re) and six, or his own coach (Re) and sixty, with the breadth of a county between him and the next (+Cl) (Sm).

(Chapter 3, lines 20-23)

The noun phrase "his own coach" was repeated to emphasize the social distance among the passengers. Moreover, the use of semantic parallelism can be seen in comparing the social distance among passengers with the distance among them when they were in different coaches in different countries.

Moreover, the writer introduced the character, Mr. Lorry through the use of clarification parallelism and progression parallelism. He added more information about the way Mr. Lorry emptied his glass to illustrate that he tried to calm down before he met Miss Manette as in the following lines:

The gentleman from Tellson's had nothing left for it but to empty **his glass** (Cl) <u>with an air of stolid desperation</u> (+Cl), (P) settle his odd little flaxen wig at the ears, (Pr) and follow the waiter to Miss Manette's apartment. (Pro)

(Chapter 4, lines 98-100)

In addition, the writer developed the plot through the use of progression parallelism. He described the nervous actions of Mr. Lorry before he went to Miss Manette's room and therefore the reader could visualize the actions of Mr. Lorry in his mind's eyes. In Book I, Mr. Lorry was going to look for the lost daughter of his old master Monsieur Manette. Therefore, he came to France to look for her and was excited to tell her that her father was still alive. At the same time, he felt anxious to let her know that her father was not in normal state of mind. That is why he was worried and nervous on the way to her.

Two main types of parallelism used in Book I were clarification parallelism and semantic parallelism. The reason is that clarification parallelism is used to add more information about a person, a thing or an event and to clarify whatever is stated vaguely. Furthermore, semantic parallelism is used to compare two situations, things or people or to depict someone or something clearly. The use of clarification parallelism and semantic parallelism was seen mostly in illustrating setting, plot and character. As this book is the beginning of the novel, the writer gave background information about the setting – socio-political situations in France and England. As the scene progressed, the emphasis was on depicting plot. The progressive actions of the characters like the farmer, the woodman, the hangman, the passengers, Mr. Lorry and Miss Manette were portrayed not only to develop the plot but also to imply their inner character.

5. 2. Findings and Discussion on Book II: The Golden Thread

It was noted in Book II that the writer emphasized character and setting, but the plot is not as significant as that in Book I. The reason is that most of the characters such as Monsieur Manette, Mr. Lorry, Miss Manette and Defarges had been introduced to the reader in Book I. Style and tone become more significant in Book II and it is used mostly in depicting the characters of Monsieur the Marquis, Mr. Cruncher and his son, Carton and Stryver.

	Antithetic	Clarification	Intensification	Progression	Repetition	Synonymic	Synthetic	Semantic	Janus	Parallelism of Number	Total	%
Plot	23	159	20	29	47	25	11	45	0	0	359	13
Characterization	83	319	49	58	101	55	22	176	2	1	866	32

Table 7: Elements of novel highlighted by the use of parallelism in Book II



Figure 2: Elements of novel highlighted by the use of parallelism in Book II

The writer mostly used clarification parallelism (35%) and semantic parallelism (27%) mainly to describe character (32%) and setting (20%).

The writer's use clarification parallelism and semantic parallelism in describing the character of Monseigneur and his inner room using an ironic tone. In showing the extravagant character of Monseigneur, the writer depicted:

Monseigneur (Cll), <u>one of Great lords in power at the Court</u>(+Cll), held his fortnightly reception in his grand hotel in Paris. Monseigneur was in **his inner** room (Cll),, <u>his sanctuary of sanctuaries, the Holiest of Holiests to the crowd</u> <u>of worshippers in the suite of rooms without (</u>+Cl2) (Sm).

(Chapter 7, lines 1-3)

From these lines, it can be seen that Monseigneur was a powerful man at the Court and a party animal who liked to hold reception every two weeks. The writer adds more information about Monseigneur's inner room to reinforce the powerful character of Monseigneur. His room was regarded as a place where a lot of people came to pay respect to him. Through the use of semantic parallelism, the writer uses an ironic tone in describing the inner room as a sacred place.

The writer's use of clarification parallelism and semantic parallelism portrayed the character of Monsieur the Marquis and points out Monsieur's inclination to hunting. The writer provided additional information about the riding-rods and riding-whips to illustrate the peasants who died as they were cruelly beaten by Monsieur's riding-rods and riding-whips. Equipment in his hall vividly depicts the cruel character of Monsieur as seen in the following lines:

Great door clanged behind him, and Monsieur the Marquis crossed a hall grim with certain old boar-spears, swords, and knives of the chase; grimmer with **certain heavy riding-rods** (Sm1) **and riding-whips** (Cl), <u>of which many a peasant, gone to **his benefactor Death** (Sm2), had felt the weight when his lord was angry (+Cl).</u>

(Chapter 9, lines 15-18)

Through the use of an ironic tone, the writer illustrated the lives of poor people who might feel better to die than work under Monsieur. The manifestation of boar-spears, swords and knives of the chase shows Monsieur's hobby – hunting.

The writer portrayed the character of Mr. Stryver and that of two ancient clerks from Tellson's Bank through the use of semantic parallelism, clarification parallelism and synonymous parallelism. He described the way Mr. Stryver ran out of the Bank, using a humour. From his actions, it can be inferred that he was a quick-tempered and thick-headed man who tended to do actions instantly without much thinking as in the following lines:

Then Mr. Stryver turned and burst out of the Bank, causing such a concussion of air on his passage through, that to stand up against it bowing behind the two counters, required the utmost remaining strength of <u>the two</u> <u>ancient clerks</u> (Sm) (Cl). <u>Those venerable</u>(Syn) <u>and feeble(±Syn) persons</u> (+Cl) were always seen by the public in the act of bowing, and were popularly believed, when they had bowed a customer out, still to keep on bowing in the empty office until they bowed another customer in.

(Chapter 12, lines 139-144)

The use of clarification parallelism can be found in depicting the character of two ancient clerks. The writer gave additional information about two ancient submissive clerks who always gave a bow to any customer like robots. He employed a sarcastic tone in illustrating that those two clerks bowed continuously even when there was no one in the bank. Then, through the use of synonymous parallelism, venerable and feeble, he illustrated the old and feeble clerks.

In Book II, the most frequent used types of parallelism were clarification parallelism and semantic parallelism. They were mainly used to illustrate the characters such as Monsieur the Marquis, Monsieur Manette, Mr. Cruncher and his son, Miss Maanette, Miss Pross, Darnay, Carton, Stryver and Mr. Lorry. The writer's significant use of style and tone can be found in depicting the extravagant character of Monsieur the Marquis, Mr. Cruncher's pride, Carton's obsession with alcohol, Miss Pross' boastfulness and so on.

5.3 Findings and Discussion on Book III: The Track of a Storm

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Plots in Book III of *A Tale of Two Cities* can be said to have the most important elements of plot – the climax, falling action and denouement. With the uprising of French Revolution, the Manettes and Carton tried to save Darnay to be out of prison. Carton who seemed to be a ruthless tyrant became the one who sacrificed his life for the lady he loved. The book ended with the reconciliation of the Manette family and Carton's death at guillotine. The writer used a number of parallelism in describing different elements of novel as in the following table and figure.

	Antithetic	Clarification	Intensification	Progression	Repetition	Synonymic	Synthetic	Semantic	Janus	Parallelism of Number	Total	%
Plot	45	204	28	90	65	35	25	62	1	0	554	29
Characterization	62	227	44	57	73	54	22	80	0	0	619	33
Setting	13	86	11	15	21	18	7	31	1	2	202	11
Point of View	18	53	11	8	16	14	5	34	0	0	159	8
Symbol and Allegory	12	48	9	7	9	5	2	99	0	0	191	10
Style and Tone	6	29	3	4	11	6	0	36	0	0	95	5
Theme	9	12	22	3	1	3	1	9	0	0	60	3
Total	165	659	128	184	196	135	62	351	2	2	1880	100
%	9	35	7	10	10	7	3	19	0	0	100	

Table 8: Elements of novel highlighted by the use of parallelism in Book III



Figure 3: Elements of novel highlighted by the use of parallelism in Book III

The most frequent types of parallelism used by the writer in Book III are clarification parallelism (35%) and semantic parallelism (19%). The writer's focus on the description of

characters (33%) and the illustration of plot (29%) can be seen in this book. He described the characters of Darnay, Lucie, Miss Pross, Defarges and Carton most and focused on the plot in which Carton gave up his life for the happiness of Miss Manette.

The use of clarification parallelism and antithetic parallelism can be seen in depicting the character of Mr.Lorry and illustrating the plot. The writer provided the additional description about one thing which appeared in Mr, Lorry's mind to show that he is business-minded, loyal to his old master and ready to sacrifice his soul for the good of the Manettes as in the following.

One of the first considerations (Cll) which arose in the husiness mind of Mr. Lorry when business hours came round(+Cll), was **this** (Cl2):- <u>that he had no</u> right to imperil Tellson's by sheltering the wife of an emigrant prisoner under the Bank roof (+Cl2). *His own possessions, safety, life, he would have hazarded for Lucie and her child, without a moment's demur*(+An); <u>but Great trust he held was not his own, and as to that business charge he was a strict man of business</u>(-An).

(Chapter 3, lines 1-5)

The writer used two opposite ideas together-his sacrificing mind for the Manette family and his doing so not because of his own will but because of his duty to reinforce that he is a loyal man. The writer then developed the plot-Mr. Lorry's plan to rescue Darnay so that Miss Manette could lead a happy family life.

The writer illustrated the plot and character through the use of semantic parallelism and repetition parallelism. He used alliteration in the phrase "emphatic entreaty" to reinforce that Carton forgave and forgot about Darnay's taking away his beloved girl and came to help him. It also showed the character of Carton who was willing to do whatever it is to make his beloved girl happy as in the following lines.

"A most earnest, pressing, and emphatic entreaty (Sm), addressed to you in the most pathetic tones of the voice so dear to you, that you well remember."

"You have **no time** (Re) to ask me why I bring it, or what it means; I have **no time** (Re) to tell you. You must comply with it-take off those boots you wear, and draw on these of mine."

(Chapter 13, lines 114-118)

The phrase "no time" was repeated to imply that Carton came to Darnay in secret and that he wanted to rescue Darnay so that his beloved girl could be happy ever after with Darnay.

The writer used progression parallelism and semantic parallelism in describing the plot in which Carton who took the place of Darnay was about to be executed. He illustrated the progressive actions of the scene using action verbs such as ploughed, crumble, close, pass on and so on. These verbs are of help for the reader in visualizing what was happening on the scene as in the following lines.

The clocks are on the stroke of three (P), and the furrow ploughed among the populace is turning round (Pr), to come on into the place of execution (Pro), and end (Prog). The ridges thrown to this side and to that, now crumble in and close

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behind the last plough (Progr) as it passes on, for all are following to the Guillotine (Progre). In front of it, seated in chairs, as in a garden of public diversion, are a number of women, busily **knitting** (Progres) (Sm). On one of the fore-most chairs, stands The Vengeance (Progress), looking about for her friend (Progressi).

(Chapter 15, lines 60-66)

In addition, the writer used the word "knitting" to symbolize that there were still lots of people to be killed under the guidance of Defarges as knitting means marking the names of victims using special symbols.

Book III can be regarded as the profusion of important scenes of the novel as it is the last book of the novel. It can be seen that the writer focused on the description of characters and the illustration of plots mostly through the use of clarification parallelism and semantic parallelism. The writer's tactical use of symbols, similes and metaphors are also of importance in capturing the essence of the novel.

Conclusion

In this paper, the novel A Tale of Two Cities was analysed using 10 types of parallelism. In the whole novel, the writer gave more detailed information about the characters, plot and setting as they play an important role in novel through frequent use of clarification parallelism, semantic parallelism, intensification parallelism and antithetic parallelism. Clarification parallelism can be seen when Dickens used parenthetical construction, wordiness and complex syntax like the use of relative clauses and -ing participle construction to add more information about a particular person, thing or event. It is the style of Dickens to depict plot through the use of complex syntax. The use of semantic parallelism had effects mainly on illustrating characters and on reinforcing the use of symbol and allegory. Metaphors, similes, hyperboles, personification, irony, tone, alliteration, rhyme, consonance and so forth were mostly found in illustrating the characters and symbol and allegory. Moreover, the use of semantic parallelism helped readers notice the Dickenian style of writing and hallucinate the tone of the writer. The results of the research showed that there is no one-to-one relationship between the use of certain types of parallelism and its effects on a particular element of novel. Another variable is that a particular type of parallelism might have effects on more than one element of novel. In addition, there is possibility for one type of parallelism to be found in the same word, phrase, clause, sentence or paragraph. All in all, this research has proved that parallelism is significantly used in Dickens' novel, how the use of parallelism highlighted the elements of novel, and how it helps the writer to convey his meaning effectively. It is suggested that further research on the use of parallelism in other novels can be done to find out the role of parallelism in helping readers have better understanding of the text. In this paper, only 10 types of parallelism which were frequently used by scholars were focused. Types of parallelism like staircase parallelism, star-like parallelism and climatic parallelism can be included in further research on parallelism if the selected text is written in poetic style of writing. It is anticipated that this research will come in handy for teachers teaching English through literature and Dickenian style, and for students who are studying the use of parallelism.

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position of the tongue

² position of the lip

monothong

⁴ pure vowel

dipthongs

no audible release

⁷ word

jzpóní² pumvkrsnjzpátmi í wnáqmu&mwß í pumvk tpolvítyli (rsmtjzpí $\frac{1}{2}$ rsm yg0i&onftwů (yg0i&onf2y&i (wi trsktpmE\$h oabmobn0 wiuk vn (avkrwi jyxmygon (rkhle, f&bmonpum&) $\frac{1}{2}$ /// $\frac{1}{2}$

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internal structure ×@firi 100? 2002? 230/ morpheme free morpheme bound morpheme simple word complex word compound word 9 simple noun 10 complex noun 11 compound noun 12 simple verb 13 complex verb 14 compound verb 15 John Okell, 1969, 122.

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- (2) yk iwpt kvi ften i qk Opaqmi pum, vkwpt ESh, i i Na&&EShemu iwi fypin i wpt k ygEll i ygoni
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noun particle

verb particle

dependent clause marker

final particle/ sentence particle

affixing system

duplicating system

noun phrase

verb phrase

basic noun phrase

extended noun phrase

¹¹ x@{jril00?2004?140/

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simple sentence

² complex sentence

³ at mifri DD? a' quívvn? 2016? 10/

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¹ Dr Bladen

² Mr. R. Halliday

³ Mr. Shorto

⁴ Mathias Jenny

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ဂကောံသင်သွတ်အနာဂတ်မန် / (၂၀၀၅) / အနာဂတ်မန် ကူပ်(၆)/ ရန်ကုန်။

rêpmayE\$h, **Obuşrkျybumívið (1993)/** *လိက်ဗွဟ်မန် တန်ကောန်ငှာ်* (မွန်ဖတ်စာ သူငယ်တန်း)။ ရန်ကုန်၊ မဉ္စူပုံနှိပ်တိုက်။ **rêpmayE§h , ပါန္းလြုγန်ပါ၏// (1993)/** *လိက်ဗွဟ်မန် တန်ပထမ* **(မွန်ဖတ်စာ ပထမတန်း)။ ရန်ကုန်၊ မဥ္ထူပုံနှိပ်တိုက်။**

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a0'*/ (cEpryg)/ லீன்க்கிரைக்கை &elue/

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ရွှေတိဂုံခေတီတော်အဖွဲ့ စာပေများ (စာပေ)

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- 2/ ent (or [kv) enterrs;
- 3/ awgcsurs;
- 4/ vytaqmitsutrsm;
- 5/ awletsurm;

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SOCIO-ECONOMIC CONDITIONS OF MYOTHIT TOWNSHIP IN MAGWAY REGION (1800-1900)

- 1. Introduction
- 2. Aims and Objectives
- 3. Methods/Procedure
- 4. Results/Findings
- 5. Discussions
- 6. Summary Acknowledgements References

J-9' SOCIO-ECONOMIC CONDITIONS OF MYOTHIT TOWNSHIP

IN MAGWAY REGION (1800-1900)

Aye Mya Thwin¹

Abstract

This is an attempt to assess social and economic conditions of a rural society of Myothit Township that fell under two different political systems: Myanmar traditional hereditary system and the British colonial administrative system. The purpose of this dissertation is to fulfill the need for the history of socio-economic conditions of Myothit Township (1800-1900), meaning in the middle and late Konbaung periods and in the earliest part of colonial period. In writing this dissertation, primary sources such as parabaiks, peis and stamped papers are used greatly. These sources are collected from monks and laymen of twenty villages in Myothit Township. Secondary sources such as papers and books are obtained from Libraries and Archives. In order to get local records and personal notes, I have to make several field-trips to Myothit Township and its area. Based on those sources, the descriptive method is used for clearer understanding of the economic function and social structure existed in Myothit Township. The analytical method is used for assessing the data collected and visual sources surveyed. The comparative study is also used for taking comparison primary sources with secondary documents. As the results, Myothit also known as Kathit had once been a satellite town of Taungdwingyi before the British annexation of Upper Myanmar and it later became a full-fledged township, parallel in status to Taungdwingyi in the Colonial Period. Hereditary system in rural administration traditionally practiced in the monarchical period was dissolved in the colonial period. In place of former long-lived selfsufficient agriculture, a market-oriented one or cash crop economy came in the Colonial Period. No crown service groups could be seen and they became free cultivators or waged labourers. It led to an appearance of modern society with its new social aspects and new mode of living style.

Keywords: Agriculture, Konbaung Period, Myothit; Sittans, Socio-economy, Taungdwingyi

Introduction

Researchers on Myanmar History agree the fact that the indigenous historical sources – inscriptions, *peis* (palm-leaf manuscript) and *parabaiks* (folding books made of Shan-paper) on *Razawins* (Chronicles), Epic, *Ayeidawbons* (Memoirs of royal affairs), *Hluttaw Hmattans* and *A-meint-daws* (Court Records and Royal Orders), *Sittans* (Revenue Inquests), Notes – are indispensable for gaining realization of Myanmar History from earliest historic times.

There were many dissertations concerned with administration, economy and society during the Konbaung and colonial periods. As the local histories, some researchers also attempted to present theses and dissertations regarding towns (or districts) by taking the historical perspective. But there is no dissertation written for some townships. There are problems that the dissertation is capable of establishing the socio-economic figure of the township targeted or not; and that the figure could contribute to the socio-economy of the entire Country of those times or not.

In this dissertation, a historical examination is focused on Myothit that had been a satellite town of Taungdwingyi, under the jurisdiction of Taungdwingyi *Myo Wun* (Governor of Town) in the Konbaung period; and that had been a region situated under the jurisdiction of

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Taungdwingyi Subdivision of Magway District; and that had been a township administered by a *Myo-ok* (Administrative Representative) in the British colonial government. The town now called "Myothit" was known as "Kathit" during the reign of King Narapati Sithu (r. 1173-1210) of Bagan period.

In order to expose the socio-economic conditions (figure) of Myothit, this dissertation is divided into four chapters: Chapter One - Social Structure, Chapter Two - Life of Crown Service Groups and Commoners, Chapter Three - Economy and Chapter Four - Assessment. The candidate focused on its socio-economy under the pressure of administrative system.

At present, Myothit Town is situated between North Latitude 20° 1' and 20° 19' and between east Longitude 95° 12' and 95° 48'. Myothit is situated sixteen miles to the north of Taungdwingyi and forty-five miles to the north of Pyinmana. Natmauk is twelve miles away and Kyaukpadaung is twenty-seven miles away from the south of Myothit. Myothit is situated on the Pyinmana-Kyaukpadaung railroad. To the east of Myothit, there is Bago mountain range, Yin *Chaung* (Stream) in the west. The total area is about 606.25 sq. miles.

Although the candidate has made an utmost effort to complete this dissertation, there might be some flaws and weaknesses. The candidate alone is responsible for such defects.

Aims and Objectives

Originally, the term "Socio-economy" was used by the American economists and sociologists in 1940s. It means an economy considered together with the society in which it functions as an integrated whole; the relationship between economic and social factors in the community or the country concerned.

Aims of this research are: (1) to expose the economic conditions of Myothit Township during the period 1800-1900, meaning in the middle and late Konbaung periods and in the earliest part of colonial period; (2) to examine the social structure of people living in Myothit Township under the pressure of the administrative and economic systems at those times; and (3) to reveal the development of Myothit Township (1800-1900) resulted from the socioeconomy managed by the ruling people within the frame of monarchy.

This research has objectives: (1) it is headed that the socio-economic conditions of Myothit Township contributed a close resemblance to those of other townships in the monarchical period of Myanmar; (2) it is expected that the examination of socio-economy of a township was capable of portraying the economic function and social structure of the whole country; and (3) it is proved that socio-economic managements of the crown service groups could establish reciprocity between the people of Myothit Township and royal administrators.

For the third objective, it is necessary to understand a theory relating to study on socioeconomy (social economy): "Reciprocity is the social mechanism that makes associational life possible. When reciprocity finds economic expression for the provision of goods and services to people and communities, it is the social economy that results."

Methods / Procedure

In writing this dissertation, primary sources such as *parabaiks*, *peis* and stamped papers are used greatly and these sources are collected from monks and laymen of twenty villages in Myothit Township. Some of primary sources had been collected since the time of writing the Thesis for M.A. Degree and they are taken by the candidate in the form of private collection. Secondary sources such as papers and books are obtained from National Archive (Yangon), National Library (Yangon), Universities' Central Library, Yangon University Library, Mandalay University Library and Magway University Library.

In order to get local records and personal notes, I have to make several field-trips to Myothit Township and its villages. From the field-trips, I got rare data about socio-economy of the Township and also experienced with visual sources and oral information.

Based on primary sources, secondary documents, local records and personal notes, the descriptive method is used for clearer understanding of the economic function and social structure existed in Myothit Township. And, the analytical method is used for assessing the data collected and visual sources surveyed. The comparative study is also used in writing this research work. All of the accounts mentioned in primary sources such as *parabaiks* and *peis* are compared with the accounts mentioned in secondary sources and reliable documents by means of critical examination.

In **Contents** of the Dissertation, ten portions aiming at portraying Aims and Objectives are arranged as follows:

Abstract Abbreviations Glossary Introduction Chapters Conclusion Maps Photographs Appendices Bibliography

In the portion of **Chapters**, the research candidate arranged four Chapters: Social Structure; Life of Crown Service Groups and Commoners; Economy; and Assessment. In order to gain fuller understanding of descriptions and examinations, the candidate attempts to include **Tables** in Chapter Two and Chapter Three of the Dissertation. In needs of procedure, fifteen Tables are included by the candidate. They are: Table - I , A Case Study of Hereditary Headmanship in Saparkyikyat Village; Table - II, Lieutenants and Sergeants of Musketeer Groups in Villages of Myothit Township; Table - III, The Judicial Cases (1782-1885); Table - IV, The Category of Cases; Table - V, Apportion of *Dama-u-cha* lands owned by Boe Kyaw Bu

and wife Mae Hnaing San to their sons and daughters; Table - VI, List the parents gave their children religious legacy by povitiation: Table - VII. List of villages with glebe lands and royal

children religious legacy by novitiation; Table - VII, List of villages with glebe lands and royal lands separated apart; Table - VIII, *Thetkayits* so far collected from Myothit Area; Table - IX, List of Money-lenders and Debtors; Table - X, Myothit Area (1800-1900) Interest rate and frequency (on 10 *kyats* per month); Table - XI, Land mortgage deed and money lending of crown service men in Myothit area (1800-1900); Table - XII, Price of paddy in Myothit area; Table - XIII, Price of Edible Oil; Table - XIV, Designation of the Value of Cow (1800-1900); Table - XV, Kind of Currency and Weights found in Myothit area.

In the portion of **Maps**, the research candidate attempts to show Maps for clearer understanding. They are: Map (1) - Map of Myothit; Map (2) - Findings of *Thetkayits* so far collected from Myothit Township; and Map (3) - Finding of *Thetkayits* so far collected from Myothit Township.

In the portion of **Photographs**, the research candidate attempts to show Photos for scene relating to accounts. They are: Photo (1) - Land mortgage Deed written on Palm-leaf; Photo (2) - Land mortgage Deed written on *Parabaik*; Photo (3 a) - Land Mortgage Deed written on Stamped Paper (Five Rupees Obverse); Photo (3 b) - Land mortgage Deed written on Stamped Paper (Five Rupees Reverse); Photo (3 c) - Land mortgage Deed written on Stamped Paper (Two Rupees - Obverse); Photo (3 d) - Land mortgage Deed written on Stamped Paper (Two Rupees - Reverse); Photo (4 a) - One *Kyat* (Coin of Copper) (Obverse); Photo (4 b) - One *Kyat* (Coin of Copper) (Reverse); Photo (4 c) - One *Kyat* (Coin of Silver) (Obverse); Photo (5 b) - One Rupee (Reverse); Photo (6 a) - One Rupee (Obverse); Photo (6 b) - One Rupee (Reverse); Photo (7) - Arsenal; and Photo (8) - *A-mway-sit Phaya*.

In the portion of **Appendices**, the research candidate attempts to present Appendices for further realization of accounts. They are: Appendix (1) - Land mortgage Deed written on Palmleaf; Appendix (2) - Land mortgage Deed written on *Parabaik*; Appendix (3) - Land mortgage Deed written on Stamped Paper (Five Rupees & Two Rupees); Appendix (4) - List of Village Headmen and Wives from Myothit Township; Appendix (5) - List of *Thwe-thauk-su* composed of *Myauklet* of Taungdwingyi (1783-1802); Appendix (6) - List of *Thwe-thauk-gyi* from Myothit Township; Appendix (7) - List of *A-kyats* and *Thugyi A-kyats*; Appendix (8) - List of Money to Contribute for Military Expenditure from Taunglet and Myauklet *Thwe-thauk-su* of Taungdwingyi; Appendix (9) - List of Men, Horses and Equipment to Reinforcement to the Military Expedition Maukmae; Appendix (10) - The designation of value of land in Myothit Township (1800-1900); Appendix (11) - The Title Recipient *Thwe-thauk-gyi* and *Thugyi*; Appendix (12) - Title Recipient Persons from Other Crown Service Groups; Appendix (13) - List of *Sanghas* resided in the Surrounding Areas of Myothit Township; Appendix (14) - List of the Uninvited *Sanghas*; Appendix (15) - List of Persons who made *Ko Nay Thetkayit*; and Appendix (16) - Amount of Money and Types of Stamp.

Originally, the research candidate was capable of collecting many *peis* and *parabaiks* as primary sources from Myothit and its area. In the portion of Bibliography (**References**), the candidate used thirty-six *parabaik* manuscripts, three *pei* manuscripts, two documents of royal orders, a report, a stamped paper as primary sources for writing the Dissertation. The candidate

was able to make interviews with three old persons (school teachers) who have knowledge and experiences.

The research candidate studied several books as secondary sources from archives and libraries. Of these books, the candidate selected and used five books (unpublished books), thirty-five books (published books in Myanmar), nine books (published book in English), and nine papers (published articles in Myanmar and English) for writing the Dissertation. Moreover, the candidate made several field-trips for the research work to Myothit area.

Results/Findings

According to "*Shwe Taik Win Taungdwingyi Ne-myay Sittan*" (Revenue Inquest of Taungdwingyi), it is learnt that "Myothit" was called "Kathit"; and that Myothit as a town had been in existence since the Bagan period; and that the territorial extent of Myothit was 360 *Tar* (0.147 square miles) in circumference. Myothit had once been a satellite town of Taungdwingyi before the British annexation of Upper Myanmar and it became a full-fledged township, parallel in status to Taungdwingyi in the British colonial period.

Due to Myanmar administrative system of the late Konbaung period (1819-1885), Myothit is included in the provincial administration. It was under the jurisdiction of Taungdwingyi and it was *Thwe-thauk* land of Taungdwingyi Myauklet. Myothit was administered by *Thugyis* and *Thwe-thauk-gyis* (See Appendix (11).}. Hereditary system in rural administration traditionally practiced in the monarchical period was dissolved in the colonial period. In place of former long-lived self-sufficient agriculture, a market-oriented one or cash crop economy came in the colonial period. No crown service groups could be seen and they became free cultivators or waged labourers.

Although there was no reference to express the number of households and population of Myothit during the Konbaung Period, it is found that after the British annexation of Upper Myanmar, the population of Myothit increased. In 1891, there were 33,994 people and after ten years later, there were 42,925 people. Only one-fourth of the total populations of Myothit were literate persons. There was no evidence about the slave as a distinct class in Myothit. In making mortgaging, the person was designated as insurance. There was no slave class in Myothit and it can be deduced that Myothit had a fair social standard. The monks also participated in the social welfare works. Some learned monks were conferred royal titles. The learned monks (*Sanghas*) {See Appendix (13) and Appendix (14).}

Both crown servicemen {See Appendix (12).} and common people were mentioned in the written contracts, but the majority of people mentioned in the *Thetkayit* were cultivators. Among the crown servicemen included all ranks from *Thugyi* up to the military servicemen (*Thwe-thauk A-su*, *Myin A-su*, *Thenat A-su* and those who had to serve at the royal Court with their families). Some *Thugyis* were found in association with the title "*A-kyat*" and so they might serve the duty of administering the village and military duty. *Thwe-thauk-gyi* had to serve military duty at Myauklet *Thwe-thauk-gyi A-su* and they had to obey the instructions of Taungdwingyi *Myo Wun. Thugyi A-kyat* (significant rank in Myothit) and *Thwe-thauk-gyi* had to carry out the duty of collecting taxes and settling lawsuits {See Appendix (4), Appendix (5), Appendix (6) and

Appendix (7).}. Significantly, the crown servicemen in Myothit area also encountered economic hardships and they had to borrow money.

In order to overcome the economic hardships, the people used land as medium. Mortgage of lands {See Photo (1), Photo (2), Photo (3a), Photo (3b), Photo (3c) and Photo (3d).} were found more than selling of lands. When the socio-economy of the people of Myothit based on the written contracts, the cultivators made different kinds of works, such as cultivating by themselves the land, leasing the land, buying the land, mortgaging the land, etc. in Myothit area {See Table - IX, Table - X and Table - XI.}. The agricultural products were sold not by cash-down system, but selling in advance, and barter system by designating the price. Lending-money was carried out as a business and economic hardship was settled by mutual support. There were some people who did not have their own property and so they had to mortgage or sell themselves or their children definitely for bondage loan {See Appendix (1), Appendix (2) and Appendix (3).}. It is found that *Thugyi* of Saparkyikyat Village had to mortgage his administrative office to contribute to the war-expenditure {See Appendix (8).}. There were political instabilities broke out by the war of succession among the feudal lords and weather changes made the yield of crops declined and the local people into poverty stricken.

The socio-economic conditions of Myothit can be known by studying these *Thetkayits* {See Map (2) and Map (3).}. In Myothit area, there were *Thetkayits* concerned with business transactions and cultivation of *Kaing* and *U-yin*. Money-lending *Thetkayits* are found only two times during King Tharawaddy's reign, and *Thetkayits* are mostly found in the reigns of King Mindon, King Thibaw and in the early colonial period {See Table - VIII.}. In Myothit area, various interests were charged on the loans and there were also kinds of money-lending called "*Let Hlet Thone Thetkayit*" and "*Ko Nay Thetkayit*" (See Appendix (15).}. The factors mentioned in the *Thetkayits* reveals the economic hardships of subject people, corruption of social customs and political instability of those times.

During the years 1800-1900, Myanmar was transformed from feudal society into capitalist society. It was the transitional period and so the British colonial government could not carry out restoration of peace and tranquility. Instead, it had to suppress the revolt and internal insurgency. During the period of British rule, the crown servicemen turned into the anti-British resistant leaders.

During the reign of Myanmar kings, Myothit Township was mentioned with the name "Taungdwingyi". When a research work is made on Myothit area, it must commence with "Taungdwingyi". When it is described about Taungdwingyi, Myothit will be mentioned as the important satellite town. During the period of the British rule, Myothit came into existence as the township which was different from Taungdwingyi.

Discussions

According to two sources: Taungdwingyi *Sittan* (Revenue Inquest of Taungdwingyi) and Taungdwingyi *Thamaing* (History of Taungdwingyi), it is learnt that the town of Myothit had been in existence with the name "Kathit *Myo*" since the Bagan Period (A.D. 536). In the Taungdwingyi *Sittan* collected during the reign of King Badon (r. 1782-1819) in 1783, it is mentioned that Myothit and Myolulin located in the north of Taungdwingyi were the satellite

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towns of Taungdwingyi. In regard with the emergence of Myothit, facts mentioned in Taungdwingyi *Sittan* and Taungdwingyi *Thamaing* are mostly similar. But there are differences in the territorial extent of the town and name of western gate. In Taungdwingyi *Sittan*, it said that Myothit was an earthen fort with 360 *Tar* in territorial extent (one *Tar* is equal with 7 *Taung*). In Taungdwingyi *Thamaing*, it is stated that Myothit was 1,200 *Tar* (1.36 miles) in area which is two times of the territorial extent mentioned in Taungdwingyi *Sittan*. King Narapati Sithu of Bagan marched with 20,000 armed men to capture Taungdwingyi. The town of Taungdwingyi would be rather large as it was founded to station for the armed men, forces of elephants and horses with foods. So it can be assumed that the territorial extent mentioned in Taungdwingyi *Thamaing* is reasonable.

In Myanmar, according to the *Sittan* collected in the years (1764-1826), separate list of *A*-*thi* (Tax-paying people) and crown servicemen of Myothit is not found because Myothit was existed as a satellite town to the north of Taungdwingyi throughout the Konbaung period and so it is supposed that Myothit was put in the population list of Taungdwingyi. Therefore, it can be deduced that the population of Myothit of the Konbaung period is not found.

In the times of the British colonial administration, the population of Myothit was 33,994 in 1891 and it increased to 42,925 in 1901. There were arsenal or police station {See Photo (7).}, *Bo-tel* (circuit house), railway station, and bazaar. Therefore, the population of Myothit increased in the colonial period and developed to the level of township. In the year 1903-04, Myothit Township has 403 square miles in areas, including 107 square miles of cultivated areas, of which 37 square miles of land are paddy-growing areas. There are 19 square miles of irrigated areas, the second most-irrigated area after Satthwa Township within the Taungdwingyi subdivision.

In the feudal period of ancient Myanmar, society could be classified into the ruler, crown servicemen, monk, *A-thi, A-la, Win-nay* and *Kap-pa*. The social strata found in Myothit Township were the traditional social hierarchy. Among the Crown service groups included the *Su- yin A-hmu-dan*, such as *Thwe-thauk-su*, *Myin-su*, and *Thenat-su*. The *Su-yin A-hmu-dan* was the highest in rank designation. Out of *Thugyis* (Chiefs of villages) from Myothit area, the crown service men with the titles "*Thugyi-A-kyat*" (Counsel) is found. It can be assumed that *Thugyi-A-kyat* was the chief who had to take both the administrative duty of a *Thugyi* and military duty of an *A-kyat*. *Thugyi-A-kyat* is found only in this region and it is noted as the extraordinary post of crown servicemen. Among the crown servicemen of Myothit area included the *Htan Ko* (military men who had to stay at the royal city). *Hlut-sei-lay-yat Tan-lei-tan* included in *Htan Ko* servicemen.

Myothit area was the region which had good tradition in regard with the Sangha. Within the Myothit area, learned monks and lay persons appeared in the successive periods. The prominent monks of Myothit Township were Shin Maha Thilawantha and Shin Uttamakyaw from Myolulin Village (Inwa period), Khin Gyi Phyaw from Patikone Village (Konbaung period), Shin Thubawga (Yahanda Kone *Sayadaw Phayagyi*) from Chaungyoe Village (Konbaung period) and Shin Nyanna from Chinkitekone Village (colonial period).

In the course of time, the prominent persons emerged from Myothit area. They were U Kyaut (*Sohn Nant Thar Myaing* U Kyaut) from Kaing Village in 1839, Ma Shwe Myin (*Sin Khoe*

Ma Galay) from Nyaungzin Village in 1852, U Ohn Maung (*Wunna Kyaw Htin Mingalar* U Aung Maung) from Leilu Village in 1897.

If lawsuit broke out over in heritage, the people from Myothit came to the pagoda, taking an oath and accepted decision. Moreover, succession of hereditary post or boundary disputes broke out among the *Thugyi*, *Thwe-thauk-gyi* and *Thugyi* made decisions. *Thwe-thauk-gyi* and *Thugyi* were selected with the recommendation of the villagers by voting and it took the nature of being fair and justice. In the field of administration and judiciary of that period in Myothit area, opinion of the majority people was paid attention.

During the reigns of Myanmar kings, the cases in Myothit area were settled by influential elders, monks, *Thugyi*, and *Thwe-thauk-gyi*. When the British administration was introduced, *Myo-ok*, *Ne-paing*, and *Wun-dauk* made judicial settlements. The method of arbitration was still used in rural areas. The British colonial government came to prescribe the laws by force to settle the cases at law courts and method of arbitration disappeared.

In order to know the real economic conditions of a period, it is necessary to study the political conditions of that period. In 1812, there broke out catastrophe in Myanmar and a number of people starved to death. In the years 1824-1826, they suffered the effects of First Anglo-Myanmar War. In 1852, the Second Anglo-Myanmar War broke out. This area was on the route of military operation which caused serious miseries. In 1864, there appeared again a serious starvation. In 1866, there broke out the rebellion of Prince Myin-gun and Myin-khon-taing. From the time of British occupation of Myanmar in 1885 to 1891-1892, the people suffered economic hardship. As the crop yield was not good, a number of households moved to Lower Myanmar. In 1896-1897, there emerged again the natural disaster. Due to the less rainfall, economic disorder broke out again as in 1892. In the years (1800-1900) were the periods when Myanmar suffered both natural disasters and effects of war. When the kingdom of Upper Myanmar faced decline of political power and economic hardship, all the people throughout the country suffered the socio-economic effects.

The majority of people living in Myothit area were cultivators and the lands were hereditary ones. When the people suffered economic hardship, they had to sell or mortgage their lands. The fundamental cause for selling or mortgaging the lands was the necessity of judicial expenditure over land disputes, no money for judicial fee and no cattle for cultivation works, no food for living, and contribution for military expenditure, exaction of taxes, no money for funeral ceremony, etc.

Some people had no property of land and so they had to make borrowing money by entering into bondage. These *Thetkayits* were called "*Ko Nay Thetkayit*" (Bondage Loans). The list of persons was mentioned in *Ko Nay Thetkayit*. The *Ko Nay Thetkayit* shows that there were those who entered into bondage because they could not give back the debt and those who were sold as slaves. The person who had no land as guarantee, or the person who could not borrow money with high interest rate, had to enter bondage. Not like other regions where the people borrowed money by entering into bondage, the people in Myothit area entered their children into bondage because they had no property to repay their debt.

During the early times of Myanmar kings, in Myothit area, the cash system was not found when the commodities were sold. They used barter system, or sale or mortgaging land, money borrowing, sale of crops in advance, and buying on credit. As there was no cash system, it is not easy to know the real value of commodities.

Under the British rule, Myothit, Natmauk, and Taungdwingyi townships were the trading centers in inland region. There were bazaars in these townships, and bullock-cart was mainly used for transportation. The principal exports were paddy, sesame, sesame edible oil, timber, jaggery, leather, horn and other vegetables. From Lower Myanmar, fish-paste, salt, salted fish, rice, betel quid, coconut oil, and iron were imported.

There were good relations between the royal servicemen, monks and common people who paid mutual support among them. The prominent learned monks and literati, and artists also appeared. During the years 1800-1900, Myanmar was transformed from feudal society into capitalist society. It was the transitional period and so the British colonial government could not carry out restoration of peace and tranquility. Majority of them became helpless and suffered economic hardship. During that period, education and healthcare of the people did not improve. It was only in 1903 that such works could be carried out in some townships. The education for the children of people was taken responsibility by the monastic schools.

During the reign of Myanmar kings, Myothit Township was mentioned with the name "Taungdwingyi". In fact, Myothit existed as the important satellite town of Taungdwingyi. During the period of the British rule, Myothit came into existence as a township which was different from Taungdwingyi.

Summary

"Myothit" was known as "Kathit" during the reign of King Narapati Sithu (r. 1173-1210) of Bagan period. Myothit had been a satellite town of Taungdwingyi. In the boundary demarcation during the late Konbaung period, there were 32 villages in Myothit. In the times of the British rule, Myothit is a region situated under the jurisdiction of Taungdwingyi Subdivision of Magway District.

Because of Myanmar administrative system of the late Konbaung period (1819-1885), Myothit was included in the provincial administration. By the hereditary rules and regulations, the properties that inherited could never be confiscated by the king. Orders were strictly prescribed not to violate the hereditary laws by any authoritative person. The hereditary chiefs had the right to settle over cases of revenue and criminal cases first and then over the various civil cases.

The responsibilities of the chiefs were to carry out security, maintenance of law and order, collection of tax, and judicial administration. They had to carry out the functions for the peace and prosperity of Myothit area. The descendants of hereditary chiefs had to give presents to their superior chiefs when they succeeded the position. As Myothit was a satellite town of Taungdwingyi, it might assume that it exacted the same rate with Taungdwingyi in collection of taxes. When the socio-economy of the people of Myothit based on the written contracts, the

cultivators made different kinds of works, such as cultivating by themselves the land, leasing the land, buying the land, mortgaging the land, etc. in Myothit area.

Significantly, when war broke out, *Thugyis* had to go along with the military column not only with the post "*Thugyiship*", but also with the post "*A-kyat*" (Sergeant) and so they were serving the military duty under the name "*Thugyi A-kyat*". These posts were found only in the reigns of King Mindon (r. 1853-1878) and King Thibaw (r. 1878-1885). In village's administration, *Thugyi* was the most senior post and under him were *Ywa-gaung*, *Se-ein-gaung* (Chief of group of above five households to less than 20 households) and *Ywa-saw* (Convener of the affairs of village). *Thwe-thauk-gyi*, *A-kyat* and armed men from Myothit area also has to settle the lawsuits appeared in the areas under their jurisdiction. It is found that there were 48 judicial cases settled by crown service men including *Thugyi A-kyat* and *Thwe-thauk-gyi*, *Khonmin* from Myothit area {See Table - III.}. Among the crown servicemen from Myothit, there were "*Htan-ko*" who had to serve at the royal Capital together with families.

Among the armed crown servicemen, cavalry unit was the second most senior group after *Thwe-thauk-su*. During the reign of King Mindon, Pin, Natmauk, Kyaukpadaung, Poppa and Taungdwingyi included in the Shwe Pyi Yan Aung west cavalry force. Myothit was an area of Myauklet, and so they had to serve in Shwe Pyi Yan Aung west cavalry force. In the written contracts found in Myothit area, servicemen of cavalry forces are found, such as *Myin-su-gyi Wun* (Minister in charge of the cavalry units), *Myin Gaung* (Leader of ten *Myin-zi*), *Myin-tat-bo*, *Myin-zi*, etc. The *Thenat A-su* crown servicemen (musketeers) found in Myothit.

In the society of Myothit, there were social classes, such as monks, administrative chiefs, nobilities, crown servicemen, *a-thi* (tax-paying people) and *kyun* (bondsman). Generally, the classes living in the Myothit area could be divided into three kinds: monks, the ruler and the ruled. Out of the classes, the rulers and the ruled will be highlighted. The rulers could be called "the Crown Servicemen". The crown servicemen meant the persons who carried out the functions of the King or Government. Myothit was a town which fell under the jurisdiction of provincial administration. Therefore, the crown service groups living in Myothit are recognized as two groups: crown servicemen and commoners liable to payment of various taxes.

Being an export good, *Shar Say* (Cutch) was produced as a business during the reign of King Mindon (r. 1853-1878) and King Thibaw (r. 1878-1885). In Taungdwingyi, cutch producing business flourished. In Upper Myanmar, cutch boiling industry was carried out with royal money from the king's agents of King Mindon. The people in Myothit area accepted money and carried out industry of boiling cutch. In Myothit Township, there were those who made their livelihood by giving medical treatments, or by teaching, so also there were those who made their livelihood by various occupations, such as puppeteers, painters, Bamboo bark mat weavers, and brokers. In Myothit Township, as many ancient pagodas and *stupas* are found, there might be those who made their livelihood by such occupations as craft of mason, blacksmith, goldsmith, sculpture and brick making.

In Myothit area, there were monks who had carried out the religious affairs during the successive periods and those who helped the secular matters. *Gaing-ok*, *Gaing-dauks* and the *Sanghas* made appeal to the king over the reduction of taxes, as well as they served as arbitrators in the land disputes. The *Sanghas* took responsibility for the education of the children, the people

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erected monasteries which was one of the four necessities and offered foods to the *Sanghas*. It is learnt that only one fourth of the total populations of Myothit were literate persons. In the tax collection in Myothit area, the Buddhist monks had a great influence on both the administrative chiefs and the subordinate people. In the society of Konbaung Period, the *Sanghas* played an important role. *Gaing-ok*, *Gaing-dauks* and the *Sanghas* made appeal to the king over the reduction of taxes, as well as they served as arbitrators in the land disputes.

In the society of Myothit Township, regarding the bondage loan, only three *Thetkayit* (Dated contractual deed) documents are found, and so it might suppose that the number of persons who became *kyun* (bondsman) was very small in Myothit Township. It is known that a separate social class as "slave" did not exist in Myothit society and bondage loan can be assumed as social degradation due to the economic hardship. The crown servicemen were involved by various ways in the money lending and land mortgages. In the *Thetkayits* (Written Contracts), the crown servicemen were found as money lender, borrower, *Ngwe Chein, Ngwe Khat*, clerk and witnesses, as well as plaintiff, accused, and *Khon Min* (Judge). In the written contract, it has to mention the day, month, name of mortgager and creditor, extent of land, name of assayer, name of person who weighs silver, name of person who recorded the mortgage, name of clerk, kind of silver, kind of weight and measure, and witnesses.

In addition to land mortgage deeds, there were also written contracts of doing business in partner called "*Loke-phet-pay Thetkayit Sar-choke*" (money-lending contracts) in Myothit area. In the *Loke-phet-pay Thetkayit*, it is stated that the land to be cultivated in partner would be undertaken by debtor and the crops produced would be shared equally between creditor and debtor. This is the distinct social relations in the society of Myothit.

As the sons and daughters received legacy from the parents, they had to share the expense for burial when their parents died. The relatives and friends from neighboring areas and remote regions also contributed money for the burial. Among the presents included paddy, banana, betel leaf, tobacco, fish-paste, etc. The dead were at sometimes cremated.

On the basis of social stratification, land ownerships were also varied under the rule of Myanmar kings. The land ownership can generally be divided into three: land possessed by the king (*A-ya-daw Myay* - Royal Land), land owned by religious institutions (Glebe land) and private land (*Bobabaing Myay*) {See Table - VII.}. When the people from Myothit are mortgaged their lands for various reasons, socio-economic factors were mentioned, such as the location of land and land measurement, contracts, duration for redemption, kind of currency and weights used in business transaction, etc. When the land was mortgaged, the location of land was mentioned in conjunction with its surrounding areas. The land was mentioned with the four cardinal directions, name of the owner of land in adjacent areas, or name of trees, name of bullock cart tracks and high land, etc. Moreover, name of stream, ditch or dam from which their land was irrigated were also referred. In Myothit area, the extent of mortgaged lands and designation of value of land are varied. The extent of land was measured by the amount of plot land or number of cultivators or yield of crop, and the amount of seeds. To estimate the economic condition of the kingdom under these kings, the land mortgage deed or land selling deeds are mentioned with dynastic chronology {See Table – VIII.}.

Significantly, in Myothit area, there were cases that some debtors absconded or run away. In that event, the guarantor shall be responsible for repayments of the bondage loan of the debtor.

Therefore, it is supposed that the crown servicemen had to mortgage or sell their lands for administrative causes or social matters and taxation. It is impossible that the crown service men mortgaged their lands because of economic hardship. Similarly, it can be said that the common people had to mortgage or sell their land because of their socio-economic hardship. In Myothit area, some people did not have their own property to mortgage and so they had to take loan by mortgaging themselves or their children. Being unable to pay back the loan, some people became slavery and some people were sold out rightly as slave. By studying the *Thetkayits*, the persons who became bondsmen could be divided into two: person who became slave for debt and person who was sold as slave. In Myothit area, there was no secluded slave society

In designation of the price of farm products in Myothit area, if the person bought it in credit, the price was higher than current price. When crop was sold in advance, the price was less than current price. It is supposed to be a basic principle of feudal economy. In Myothit area, *Tha-tha-me-da* tax was exacted at the rate of two *kyats* in 1858, 8 *kyats* in 1860, 10 *kyats* in 1861 respectively. But in this region, soil was poor and people were poverty-stricken and crown service men like musketeers were living and so in the later period, only eight *kyats* was collected as *Tha-tha-me-da* tax.

When comparison is made between households which paid more tax and households which paid less tax, the ratio is 1.4:1. Therefore, it had the general trend that one household had to share the tax of another household. Although the sum of tax must be 1,368 *kyats* one *mat*, only 1,365 *kyats* was collected as tax. It is supposed due to the error of copying. By the list of tax collection, this region had appropriate economic progress. It can be said as the socio-economic symptom of giving mutual support within the rural society.

Significantly, monetary system of the late Konbaung period was divided into metal piece currency and coins. The metal pieces were used by weighing and there were weights to measure currency. The weights were casted in figures of animals in accordance with the born-day of the kings.

Acknowledgements

I am very greatly beholden to my Teachers: Professor Dr. U Than Tun, (the deceased) Professor Dr. U Khin Maung Nyunt (Member, Myanmar Historical Commission - MHC); Professor Daw Ohn Kyi (1) (the deceased); Professor Daw Ohn Kyi (2) (Member of MHC), Professor Dr. U Kyaw Win (Secretary, MHC); Professor Dr. U Toe Hla (Vice-Chairperson, MHC); Professor U Kyaw (Member, MHC); Professor U Tin Choan (Member, MHC); Professor Dr. Sai Nor Khay, Professor Dr. Daw Yee Yee Win (Head of History Department, University of Mandalay), Professor Dr. Daw Mo Mo Thant (Head of History Department, University of Yangon), Professor Dr. Daw Thi Dar Myint (Head of History Department, Magway University), Professor Dr. U Ko Ko Naing (History Department, University of Mandalay), Dr. Daw Wai Wai Hein (Associate Professor, History Department, University of Mandalay) for their effective supervision, guidance and suggestion.

I especially pay homage to *Sayadaws* (the noble and learned monks) who helped in field-trips, aiming at searching for primary sources. In addition, I would like to express my appreciation to all the holders of *pei*, *parabaik* documents for allowing reading and copying those documents.

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2.	U Ko Lay	74	Ex-Headman of Myolulin	30-9- 1997	Myolulin
3.	U Chit Po	71	(Headmaster of Primary School) (Retired)	17-7-2016	Phogyi

Field Trips

17-7-2016	Myolulin Village Tract
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GEOLOGY, GEOCHEMISTRY AND ORE GENESIS OF THE MODI-MOMI GOLD DEPOSIT, YAMETHIN TOWNSHIP, MANDALAY REGION

- 1. Introduction
- 2. Deposit Geology of the Study Area
- 3. Nature of Gold-bearing Quartz Veins
- 4. Mineralization
- 5. Ore Deposit Model
- 6. Recommendation for Future Exploration Implications
- 7. Summary
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J-6" GEOLOGY, GEOCHEMISTRY AND ORE GENESIS OF THE MODI-MOMI GOLD DEPOSIT, YAMETHIN TOWNSHIP, MANDALAY REGION

Kyaw Linn Zaw¹

Introduction

The Modi Taung area is located 370 km far from north of Yangon. The segment of gold mineralization is of interest as it is the firstly reported gold deposits of slate-hosted mesothermal quartz-gold veins (orogenic gold deposit) in Myanmar. This slate belt consists the argillaceous rocks namely Mergui Group (Late Palaeozoic age) and which is largely engulfed by many plutons.

The deposit is hosted within three major vein systems, from east to west these are: Htongyi, Sakhangyi and Shwesin. Htongyi and Shwesin are made up of several veins which are spatially grouped into their respective system. Vein textures are mostly of three types; book-andribbon texture, laminated and stylolitic texture and massive texture.

1.1 Location

The Modi Taung area is located in central Myanmar, 150 km from southeastern part of Mandalay and 370 km far from North of Yangon (Figure 1). The area coverage of the area is the approximately 6105 Acre (24.71 sq. km) permitted by Ministry of Mines to National Prosperity Gold Production Group Limited.



Figure 1: Location Map of the Study area

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1.2 Aims and objectives

The aims of the proposed research are following.

- 1. To undertake deposit-scale studies characterizing local geology, mineral paragenesis, alteration patterns by surface sampling, petrographic and textural studies.
- 2. To study micro-structures at a local scale. This will help to reveal tectonic structural deformation that affected the ore bodies and establish structural history of the deposits.
- 3. To study quantitative chemical analysis of host rocks and related intrusions by using electron microprobe, and XRF.
- 4. To study LA ICP-MS trace element analysis and imaging of different textures of ore minerals, in particular pyrite to constrain the source of metal and ore fluids.
- 5. To document ore fluid characteristics and age relationships using stable isotope geochemistry and U-Pb and Ar-Ar geochronology.
- 6. To study fluid inclusions microthermometric studies of quartz veins and quartz phenocrysts for reconstruction of P-V-T-X evolution of paleo-fluids and the mineralizing processes.
- 7. To reconstruct depositional models of the gold/ore deposits.

This research is aimed to solve several questions in order to achieve the main objectives of the research. Some critical questions to answer include:

- 1. How do the distribution of gold and various mineral assemblages match the sequence of events that took place during ore formation?
- 2. What is the absolute age/timing of vein formation in gold/ore formation?
- 3. What are the origin, source and types of the gold/ore deposits?
- 4. What are the main mineralizing process constraints?

1.3 Field work methods

Fieldwork includes the following:

- 1. Geological mapping with emphasis on structures at mine scale. Document major controls and styles of mineralization and alteration.
- 2. Investigate lithological, geological controls on mineralization, microstructure and alteration.
- 3. Collect outcrop samples and core samples to establish mineral paragenesis, alteration patterns and fluid geochemistry of the gold systems. Rock and drill core samples were shipped from Myanmar to Akita, Japan and Hobart, Australia.

1.4 Laboratory work methods

The following laboratory research methods conducted at Geology Department of University of Yangon and University of Hinthada, GeoMin Unit of PT ANTAM Persero Tbk,

Indonesia, CODES, University of Tasmania, Australia and ICREMER of Akita University, Japan:

- 1. Petrographic study carried out by optical examination of thin sections and polished sections using transmitted and reflected light microscopy. This attempted to establish the mineralization and alteration paragenesis on the deposit- scale, and results will be used to construct the temporal and paragenetic relationship linking to Au mineralization at different deposits.
- 2. Detailed age dating of the deposits to determine the timing of mineralization using LA ICP-MS U-Pb zircon method to determine host rocks and intrusion ages as well as Ar/Ar (sericite) and K-Ar (clay alteration) to determine ages of alteration.
- 3. LA ICP-MS analysis and imaging of different pyrite types and lead. Sulphur isotopic compositions of sulphides (galena and pyrite) to help trace of the source and age information for the fluids and metals associated with mineralizing events.
- 4. Microthermometry analysis of fluid inclusions to provide information about the salinity, temperature and pressure of formation of the ore-forming fluids.
- 5. X-ray Fluorescence (XRF) analysis and whole rock geochemistry to help identify petrogenetic characteristics of intrusive-volcanic phases through major, trace element and REE analysis.
- 6. X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) analysis to identify alteration assemblages.
- 7. Electron microprobe and mineralogical studies involving qualitative and quantitative analyses.

Deposit Geology of the Study Area

In Modi Taung area, there are two formations, Kogwe mudstone and Poklokkale Pebbly wackestone. The Kogwe mudstone mainly consists of massive to laminated and locally calcareous mudstone and siltstone interbedded quartzose sandstone which is generally dips to northeast beneath Poklokkale Pebble Wacke. In the lower part of the Kogwe Mudstone includes channel-fill disorganized conglomerates with rafts of mudstones. It passes up transitionally into the Poklokkale Pebbly Wacke. This pebbly quartz wackes and pebbly mudstones or diamites are interbedded with massive and laminated mudstones and siltstones, variably phyllite. The deposit geological map produced from field observations is shown in Figure 2.

2.1 Sedimentary units

The oldest stratigraphic unit exposed in the Modi Taung lease area is a pebbly siltstone which crops out in the Eastern extreme of the lease area. The siltstone is characterized by occasional sub-centimeter scale lithic clasts which are supported by a weakly banded quartz dominated silty matrix.



Figure 2: Deposit geological map of the Modi-Momi area.

Two mudstone units were observed in the Modi Taung lease area. The older unit is exposed in both the east and west of the study area where it conformably overlies the pebbly siltstone unit. This mudstone has an estimated thickness of ~ 40 m. The younger mudstone crops out throughout the central region of the lease area where it overlies a slate unit. This second mudstone is the youngest sedimentary unit exposed within the Modi Taung lease area, the thickness of this unit unknown as it appears to have been thicknesd by east-west shortening.

The sandstone is weakly bedded to massive and is quartz dominated although rare magnetite is also present. This sandstone unit hosts gold mineralization in the Shwesin vein system and is overlain by slate which hosts gold mineralization in the Htongyi vein system.

Age analysis of maximum sedimentation zircons (Figure 3), found in Sample A1-25 from the sandstone unit in the lower level Adit 1, gives an age of 515.9 ± 5.1 Ma (Figure 4). This sample was taken from the oldest attainable visible unit of the lowest level. This confirms that the depositional age of the Kogwe Mudstone is between the Late Proterozoic to the Early Ordovician.



Figure 3: Microphotograph CL images of zircon grain from Sample A1-25 mount for U-Pb analysis with laser spot. A. Image shows zircon grain with zonation and laser spot, B. secondary laser image for clarity of outline and laser spot



Figure 4: Repeat probability maximum depositional age of the Shwesin sandstone unit (sample A1-25) from Adit 1, determined by U-Pb detrital zircon analysis

2.2 Igneous units

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Geochemical results were investigated by plotting the alkali content Vs silica on the TAS (Total Alkali Silica) diagram (Le Bas et al., 1986) which gave a variety of rock types, and the Ti/Zr ratio (Halberg, 1984), to classify the rock types as andesite, but these diagrams/ratios rely on the use of unaltered rocks and therefore results were unreliable in the case of the heavily altered rocks in the Shwesin system. Two sets were found the ~0.02 ratio series, which can be classified as andesite, and the ~0.04 ratio series classified as dacite. A more robust diagram that uses immobile REE such as the Zr/Ti Vs Nb/Y diagram (Winchester and Floyd, 1977). which is specifically used for altered rock types, was used (Figure 5). This plot shows that there are three igneous classifications, a dacite, andesite and alkali-basalt series.

Sample	Reclassification	Zr	TiO ₂	Ti	Zr/Ti	Nb	Y	Nb/Y	P_2O_5	Р	Cr
		ррт	%	ррт	Ratio	ррт	ppm	Ratio	%	ррт	ррт
A1-20	Dacite	134	0.27	2700	0.049	7.7	15.1	0.51	0.11	0.048	9.8
A1-30	Alkali-Andesite	148	0.71	7100	0.021	14.0	19.9	0.70	0.84	0.366	441
A6-04	Alkali-Andesite	198	0.90	9000	0.022	17.9	26.3	0.68	1.10	0.480	377
TE10	Alkali-Andesite	N/A	0.79	7900	N/A	N/A	N/A	N/A	0.91	0.369	N/A
A8-11	Alkali-Andesite	153	0.73	7300	0.021	14.0	20.2	0.69	0.87	0.380	383
A8-12	Andesite	223	0.46	4600	0.048	10.4	22.6	0.46	0.33	0.144	142
A8-13	Alkali-Andesite	154	0.74	7400	0.021	14.4	20.3	0.71	0.87	0.380	434
A8-15a	Andesite	77.8	0.34	3400	0.023	6.7	11.4	0.58	0.37	0.161	130
A8-15b	Andesite	80.4	0.32	3200	0.025	6.5	11.9	0.55	0.33	0.144	126

Table 1: Supplementary simplified table of results used for rock type calculations.



Figure 5: Igneous data plotted on Zr/Ti vs Nb/Y altered igneous rock diagram

The sedimentary sequence has been intruded by at least three generations of igneous rocks. The oldest of these is a basalt which subcrops near the northern end of the Htongyi vein system. The basalt is mineralized; however, mineralization is interpreted to be due to weathering processes and fluid mixing after the emplacement of this unit. An andesite dyke subcrops in Adit 6 where it cuts a mineralized vein. This unit has an age of $\sim 95 \pm 30$ Ma obtained via Pb isotope analysis of samples collected during this study. This unit can be used to constrain the minimum age of mineralization. The youngest igneous unit is a biotite bearing reduced granodiorite. It outcrops in several locations in the north east of the Modi Taung lease area and has a U-Pb zircon age of 49 ± 1 Ma. (Figure 6) This age means that the granodiorite post-dates mineralization.



Figure 6: Results of U-Pb zircon analysis conducted on granodiorite during this study demonstrating that zircons formed ~ 49 Ma.

2.3 Geological structure of the study area

Two distinct generations of cleavage were observed in the Modi Taung lease area during the course of mapping the area (Figure 7). These were best preserved in the shale units but were occasionally apparent within the sandstone unit. For the purposes of this study these cleavages will be described as S_1 and S_2 , however it is possible that cleavage generation took place in the area prior to these events. The S_1 cleavage plane is shallow (~ 35° E), it can be poorly preserved in the rock and therefore is not as well represented in the structural analysis of the area as S_2 . S_1 is interpreted to have been rotated from a steeper orientation during the event responsible for the generation of S_2 . The S_2 cleavage plane dips steeply (~ 75° N) and is better preserved in the rock than S_1 . Because of this S_2 is well represented in this structural analysis. S_2 is interpreted to have formed in response to the most recent compressional event and has been subjected to only minor rotation since this time.



Figure 7: Stereonet showing cleavage as poles. S_1 cleavage (blue) dips gently to the east while S_2 cleavage (yellow) dominantly dips steeply to the north.

 S_1 demonstrates that this deformation (D₁) occurred in a dominantly east/west orientation to produce upright open folds with a wavelength greater than 5 km (based on map interpretation). This folding does not appear to be associated with any faulting which implies that folding took place under ductile conditions; the folding event is also interpreted to be pre-mineralization.

 S_2 was produced by north-south compression and has resulted in a steeply dipping cleavage which strikes roughly east-west; this deformation event is labelled D_2 . The change from D_1 to D_2 appears to have been gradual rather than immediate (Figure 8). This has led to a rotation of the pre-existing fold axis resulting in the formation of southeast trending fold structures rather than the east trending structures expected under this compressional regime. D_2 is associated with north trending faults and shear zones and is therefore likely to have formed under brittle and ductile conditions. D_2 is also associated with mineralization with book and ribbon vein textures showing evidence of syn-shear mineralization.



Figure (8) A. Inferred principal stress direction for the generation of S₁ cleavage within the Modi Taung stratigraphy. D₁ is shown as a major east-west compressional event resulting in north-south folds. B. Inferred principal stress direction for the generation of S₂ cleavage within the Modi Taung stratigraphy.

Nature of Gold-Bearing Quartz Veins

The Modi Taung gold deposit is hosted within three major vein systems, from east to west these are: Htongyi, Sakhangyi and Shwesin. Each vein occurs within a narrow shear zone with well-defined boundaries, which rarely exceeds two meters in width and shows oblique reverse sense of movement. Although they clearly represent substantial faults, on a regional scale they are likely to be second or third order faults probably related to the major regional thrust faults that are illustrated in the geological cross-section.

The book and ribbon, laminated, stylolaminated textures are typical of shear veins in mesothermal deposits (Figure 9). These textures are generally considered to result from repeated fracturing and quartz deposition during shear movement parallel or sub-parallel to the shear zone (Figure 10). If the country rock is mudstone, it is generally strongly foliated, chlorite altered, may contain pyrite and may be partly silicified. The quartz rich zone may be made up of an amalgamation of many quartz veins where the country rock silvers have variable separation widths or contain only very thin parallel silvers or exhibit stylolitic lines parallel to the vein boundary. The stylolitic laminations attest to high-pressure solution after vein formation.



Figure 9: A. Book and ribbon texture in shear quartz vein. The dark patches are remnant mudstone of country rock. (Htongyi). B. Laminated quartz shear vein.



Figure 10: A. Stylolaminated quartz shear vein formed by high pressure and dissolution of country rock after vein formation. **B.** Massive quartz vein.

Slickensides commonly occur on discrete surfaces of individual quartz veins and adjacent country rock and are typically oblique with steep southerly plunge. Minor offset of shear veins and rock silvers along faults occur occasionally and the faults may offset the boundary shears or many appear to join them (Figure 11). The apparent joining of the two faults may be due to the late reactivation of the main boundary shear.



Figure 11: A. en echelon gash vein. B. Sigmoidal gash veins showing sinistral rotation.

Mineralization

The highly variable gold grades within the deposit have a strong control on the style of gold mineralization. Where gold grades are less than 60 ppm gold tends to be invisible, however above this grade gold can generally be observed in hand sample. Gold and arsenic have a strong correlation at lower gold grades suggesting that lower grade gold mineralization is likely to occur within the crystal lattice of pyrite and arsenopyrite.

4.1 Paragenetic sequences

The paragenetic sequence represents only the gold-bearing quartz veins of mineralization at the study area. Stage I is characterized by the deposition of major oxide ore minerals of pyrite which is followed by the deposition of chalcopyrite. Deposition of these two major sulphides ore minerals may be overlapped. Pyrite I is deposited at the same time or a little earlier than that of chalcopyrite. Pyrite II is later formed but pyrite I is earlier than the other later formed sulphides.

Table 2: Paragenetic sequences of the mineralized area



4.2 Sulphide mineralization

Pyrite, both euhedral and fractured, is present in most vein and occurs as patches and concentrated in vein-parallel laminations. The only other recognizable sulphides are arsenopyrite, galena and rare sphalerite occurring as grains associated with pyrite. Vein intercepts at less than 70 m sub-surface are at least partially oxidized, with coarse visible gold occurring in fine quartz boxworks from which pyrite has been leached. The presence of crystalline and wire gold in the boxworks and in vugs indicates supergene deposition (Table 3).

Vein			Ofe N	linerals	5 (0 = 1	najor , \Box = minor, \Box = trace)
System	Pyrite	Chalcop yrite	Sphaler ite	Galena	Gold	Gold Occurrence
Shwesin	•	۵	٥	٥		Gold (10-1000 µm) is infilied along quartz fractures
Sakhangyi	•	٥		٥	0	Gold (<10 µm) is infilied along pyrite fractures and inclusions in sphalerite
Htongyi	•	٥	•			Gold (<100 µm) occur in fine-grained gangue materials (mainly quartz)

Table 3: The presence of sulphide minerals at representative vein systems.

4.3 Sulphur isotopes

A narrow range of δ^{34} S values were recorded from the Modi Taung gold deposit. Values range from + 1.33%₀ (closest to standard) to + 4.78%₀ (most enriched). The lowest δ^{34} S values were from Sakhangyi vein; the Htongyi vein system had intermediate values and the Shwesin vein system had the highest δ^{34} S values.

The limited spread in δ^{34} S values and their close fit with CDT data are evidence of a magmatic sulphur source and coincide with the orogenic gold field (Figure 12). The lack of negative values suggests that the sulphur was sourced from mineralizing fluids I type magma, rather than a melted sedimentary unit (Ohmoto and Rye, 1979). It also demonstrates that little significant mixing or fractionation of the fluid occurred as it passed through the sedimentary host rocks. A lack of major fluid fractionation is likely to indicate that most of the fluids passed through the host rocks rapidly through shears and fractures, rather than by permeating through pore spaces in the sedimentary units. The δ^{34} S values are the highest (most positive) in the Shwesin vein system and lower in the other systems. This may indicate that the magmatic fluid passed from the west to the east and became slightly fractionated through the process.

Sample ID	CSL ID	Vein	Adit	Mineral	δ ³⁴ S CDT (‰)
TE03a_1	4038	Htongyi	929	pyrite	2.761920193
TE03a_2	4039	Htongyi	929	pyrite	3.384004744
TE03a_3	4040	Htongyi	929	pyrite	3.377160981
TE05_1	4046	Htongyi	929	pyrite	3.584934124
TE05_2	4047	Htongyi	929	pyrite	3.194642391
TE17_1	4048	Shwesin	6	pyrite	4.784470174
TE17_2	4056	Shwesin	6	pyrite	3.313769513
TE17_3	4057	Shwesin	6	pyrite	3.557676553
TE26	4058	Sakhangyi	Adder	pyrite	1.792101957
TE28	4062	Shwesin	13	pyrite	4.689115710
TE31	4063	Htongyi	929	pyrite	1.332253069

Table 4: Showing the locations and relative enrichment of $\delta^{34}S$ from vein hosted pyrite as compared with the CDT standard.



Figure 12: δ^{34} S values for Modi Taung compared with typical δ^{34} S values.

4.4 Lead isotopes

Five samples were selected to represent the isotopic composition of the Modi Taung gold deposit. The samples were chosen to represent each vein of the Modi Taung gold deposit. Pb isotope compositions from galena and pyrite have very similar values giving strong evidence that these were both due to the same thermal event. This event appears to have occurred $\sim 215 \pm 30$ Ma. The similar values between pyrite and galena gives confidence to the results. The model age obtained from Pb isotope analysis may reflect the true age of mineralization or the age of a significant thermal event.

Pb isotope analysis was also conducted on feldspar from andesite sample which truncates the Shwesin vein Sh1. The Feldspar age of 95 ± 50 Ma has a much larger error than that obtained from the sulphides. The error is larger in the feldspar samples due to a lower availability of Pb for analysis in feldspars when compared with sulphide minerals. The younger nature of the intrusion also means that the error encountered for these samples is more significant than for the older Pb values.

By comparing the Pb isotope values from the sulphides and feldspar analyses it may be possible to constrain the age of mineralization between ~ 200 and 100 Ma, however as previously stated the Pb model age of mineralization may be younger than the true age of mineralization.

Figure 13 shows the 207Pb/204Pb versus 206Pb/204Pb ratios of galena and pyrite samples obtained from Modi Taung compared with other deposits. The graph shows the Modi Taung data conforming to the upper crustal Growth curve of Cumming and Richards (1975), however it also suggests that the values could be attributed to an S-type melt.

The following graphs exhibit the averaged results of ${}^{207}\text{Pb}/{}^{204}\text{Pb}$ versus ${}^{206}\text{Pb}/{}^{204}\text{Pb}$ and ${}^{208}\text{Pb}/{}^{206}\text{Pb}$ versus ${}^{207}\text{Pb}/{}^{206}\text{Pb}$.



Figure 13: ²⁰⁷Pb/²⁰⁴Pb versus ²⁰⁶Pb/²⁰⁴Pb plots for galena, pyrite and feldspar from andesite shown with crustal growth curves from Cumming and Richards, (1975)

4.5 Fluid inclusion analysis

A total of three samples have been analyzed fluid inclusions, and as many as 1 (one) samples revealed no fluid inclusions. Fluid inclusions were found in the parent mineral quartz, and fluid inclusions composed primarily by one rich liquid phase (monophase water rich). Fluid inclusions are composed by water and steam (biphasic) in addition to its size is very smooth, the involvement it can be and was very rare, and often get damaged. Based on the homogenization temperature, the calculation of the fluid depth would be 2.3 km from the paleosurface (Ohmoto & Rye, 1979)

N. Commis		N	Two	T1-		Ave	erage	Salinity	(%wt NaCl)
INO	Sample	INO	1 111	11	туре	Tm	Th	Roedder, 84	Average
		1	-0.5	205	Secondary		228	0.89	0.85
		2	-0.5	205	Secondary			0.89	
		3	-0.4	210	Secondary			0.71	
1	7.0510	4	-0.5	230	Secondary	0.40		0.89	
1	Z 2510	5	-0.5	235	Secondary	-0.48		0.89	
		6	-0.4	241	Secondary			0.71	
		7	-0.5	242	Secondary			0.89	
		8	-0.5	242	Secondary			0,89	
		9	-0.5	242	Secondary			0.89	
2	2 72411		-0.5	243	Primary	0.5	220.5	0.89	0.80
	L 2411	2	-0.5	198	Primary	-0.5	220.3	0.89	0.89
		1	-0.3	280	Secondary			0.53	
		2	-0.3	289	Secondary	-0.3	302.3	0.53	
3	Z16B	3	-0.3	280	Secondary			0.53	1.07
		4	-0.3	290	Secondary			0.53	
		5	-0.3	290	Secondary			0.53	
		6	-0.3	385	Secondary			0.53	

 Table 5: Fluid Inclusion measurement microthermometry

Biphasic inclusions formed by primary growth zone that is formed on the parent crystal, isolated, sometimes in groups), and secondary to the main minerals quartz and general calcite. In fluid inclusions (Z 16B, Z 2510 and Z 2411) derived from water-rich mesothermal environment and has a low-moderate salinity. With a relatively low salinity, Z 16B are on-mesothermal environment.



Figure 14: Photomicrograph of Z 16B, there is a water-rich fluid inclusion in quartz host mineral composed of biphasic and monophase inclusions

4.6 Residences of gold and pyrite chemistry of Modi Taung Deposit

Gold and pyrite chemistry at the Modi Taung deposit was undertaken at the Centre of Excellence in Ore Deposit, University of Tasmania using microscopy and Laser ICP-MS analysis. Pyrite is a common sulphide mineral in this deposit and hosts a number of trace elements including gold and silver. In this report, pyrite geochemical maps are compiled and documented in order to gain insights into the residence of gold and chemistry of pyrite from the Htongyi, Shwesin, and Sakhangyi in the Modi Taung mining district for efficiency and adding value chain in mining, processing and exploration.

4.6.1 Pyrite textural characteristics

The Modi Taung deposit is comprised of major three locations (vein systems) in which host rocks contain a significant amount of sulphide minerals: Htongyi, Shwesin and Sakhangyi. Their pyrite textural characteristics are as below.

- Htongyi area pyrite types are: (1) euhedral pyrite which has two zones, a spongy core (pyrite 1) overgrown by a cleaner zone (pyrite 2). Some pyrite grains have a clean core zone overgrown by later spongy pyrite (pyrite 3). The size of pyrite grains varies from 50 to 500µm (partially >1,000µm)
- Shwesin area pyrite types are: (1) quartz-sulphide vein, highly deformed, anhedral spongy pyrite (Pyrite 1); size >1,000µm) is associated with galena, and (2) homogeneous subhedral pyrite (pyrite 2; size 100 200µm) is associated with abundant electrum, trace sphalerite and hematite after pyrite.
- 3. Sakhangyi area pyrite types are: (1) Mixed texture of spongy anhedral/subhedral type (py 1) and homogeneous (py 2) which sizes range from 50 to 1,000µm across.

LA-ICP-MS images of samples (Figures 15), analysis of the sample shows two stages of pyrite but the chemistry is very different to the two previous samples of figures 5.19 and 5.20. Levels of Au, Ag, As and Ni are all elevated in the euhedral outer pyrite and lower in the pyrite core. Investigation of the LA-ICP-MS images shows that the inner pyrite core are chemically closer to the previous samples Py2 and therefore the inner core will be classified as Py2. The outer euhedral pyrite will therfore be classified as Py3.

Pyrite samples analyzed from samples show similar textural and chemical aspects. Both these samples show an inner core pyrite Py1 with similar elevated levels of Sb, Bi, Cr, Ba, Mn, As and Au which are depleted in the outer euhedral pyrite Py2. The elevated As and Au in Py1 suggests that this pyrite is likely of diagenetic type from a depositional sedimentary source and that this Py1 has been remobilized by later metamorphic-magmatic fluids to form Py2 with lower concentrations of Py1 elements. The chemical signature of the inner pyrite core is closer in similarity to Py2. It is therefore suggested that this samples inner core is in fact a metamorphic type pyrite Py2. This pyrite has then been overgrown by hydrothermal pyrite associated with the quartz veining event and been enriched in Au and other elements such as Ni and As. Py3 has increased levels in all trace elements compared to the other pyrite types. The increased Au suggests that the pyrite has formed from an enriched hydrothermal source that formed after peak metamorphism. A summary of the pyrite samples analyzed and the pyrite types is supplied in Table 6.



Figure 15: Pyrite map shows Co and Ni zoning patterns typical of hydrothermal origin. Remarkably, Cu, Ag, Pb, and Sb follow a similar mineralization fashion. Au has preferably concentrated in the pyrite rim implying a late stage mineralizing Au-rich fluids.

4.6.2 Discussion for pyrite chemistry

Study of the pyrite chemistry indicates two main episodes of Au mineralisation: 1) syngenetic Au precipitation in Py1 and an epigenetic Au mineralisation which also contributed to the formation of free gold in Py2 and Py3. Py1 is interpreted to be of syngenetic/diagenetic origin because of its higher Ag, Ni, V contents and the ratio Au/Ag is less than 1. Py2 and Py3 are of hydrothermal origin as they have low levels of Ni, V, and Ag with Co/Ni ratio and Au/Ag more than 1. Evidence of pulsed hydrothermal mineralising fluids is also consistent with the presence of cobalt and nickel zoned micro-bands in the pyrite structure.

Pyrite type	Au (ppm)	Ag (ppm)	As (ppm)	Ni (ppm)	V (ppm)
Py1	0.85	1.92	2681.80	306.45	4.98
Py2	0.77	0.77	1991.32	308.95	1.70
Py1	0.17	12.12	1103.59	145.47	-
Py2	0.052	3.33	760.91	156.09	-
Py2	0.041	0.44	51.82	15.50	2.62
Py3	0.33	0.81	1257.71	183.13	0.50

 Table 6: Sumary comparison of sample numbers and their pyrite types with relavant element levels in ppm. Py1 (green), Py2 (blue), and Py3 (purple).

Au in Py1 could have been remobilised by circulation of later magmatic and metamorphic fluids and concentrated enhancing the gold content in later generations of pyrite (Py2 and Py3). This interpretation is supported by the occurrence of pyritic slaty mudstone and the effect of low-grade metamorphism with the capacity to mobilize sulphur and iron from early pyrite to form later hydrothermal pyrite (Large et al., 2007).

4.7 Scanning electron microscopy (SEM) and Energy-dispersive X-ray spectrometry (EDX)

Two gold ore samples from Htongyi vein samples was analyzed in (ICREMER) at Akita University, Japan for analysis to identify the chemical and mineralogical composition of the samples (Figure 16).



Figure 16: Scanning Electron Microscope in ICREMER (JEOL; JSM 6610LV).

The EDX data show comparison between the gold minerals between the infilled gold mineral and the grains of gold mineral. Gold content are much higher in the grains structure compare with infilled structure (Figure 17 and 18).



Figure 17: Back Scattered images of in-filled and rounded crystal of pyrite structure.



Figure 18: SEM- EDX data graph of the MM1 sample from Htongyi vein system. (red color is spectrum 1 and yellow color is spectrum 2)



Figure 19: Back Scattered image of galena infilled structure.



Figure 20: SEM-EDX data graph of galena of the MM2 sample from Htongyi area.

The next step was to identify the chemical composition of the major ore minerals using the Energy-dispersive Spectroscopy (EDX) and try to identify where any gold encapsulation could be happening, and possibly relate that back to the pyrite occurrences in the feed.

This is a particle whose gold content would be leached very well into solution and does not contribute to low gold extraction percentages. Figure 5.33 shows galena seen in pyrite texture the analysis done by BSE imaging. Both galena and pyrite which are infilled in quartz texture groundmass. This infilled texture of much interest, especially with numerous occurrences of filling of this type in the weaker zone of micro vein in the quartz groundmass. The texture was investigated further with the EDS instrument, with spectra produced of different composition with the previous thought that is pyrite in-filling which are composed of Pb and S composition (Figure 20).

The analyzed was go to another field of the MM2 sample from Htongyi area. This is much interested some of the gold minerals are associated with silver minerals which is much closer to the electrum rather than the gold minerals alone (Figures 5.35 and 5.36).

These three figures provide strong indication that the most sulphide ore minerals are pyrite, chalcopyrite, galena and some electrum. All three spectra show matching peak location to their chemical element composition.

Ore Deposit Model

Mineralization is confined to within sub-vertical quartz veins of the Modi Taung gold deposit. Massive, book and ribbon, and brecciated vein textures were all encountered during underground mapping. These textures demonstrate that mineralization occurred within an existing fault, within an active shear zone, and that at least two fluid events have followed the same conduit. All of these textures are indicative of orogenic gold mineralization.

Sulphur isotope analysis was conducted on samples of ore stage pyrite from the three veins of the Modi Taung gold deposit. Values for δ^{34} S fit within a narrow range from 1.33%₀ to 4.78%₀, the small number of samples measured (n = 11) means that while a sedimentary source for the Au cannot be ruled out, a magmatic source is likely. Pb isotope analysis demonstrates that Pb has been sourced from the upper crust. Together the two analyses point towards S-type granite

emplacement, possibly due to post-collisional melting of sedimentary rocks. While the interpretation of these analyses is largely speculative due to the small number of samples analyzed and the imprecise nature of Pb isotope studies, the lack of evidence of I type granites involved in mineralization means that the Modi Taung gold deposit can be more confidently considered as an orogenic gold deposit and model of gold deposition at modi Taung as shown in Figure 21.



Figure 21: Interpreted genesis of the Modi Taung gold deposit involving A. Post deformation pluton emplacement. B. Mixing of magmatic fluids through the deformed sedimentary units leeching ore minerals from the sedimentary rocks. C. Mineralized fluids following the pressure gradient into semi ductile shear zones and dropping ore minerals into these structural trap sites. D. Post mineralization intrusions occurring close to, and in some cases truncating mineralized veins.

5.1 Mechanism of Au deposition

The rapid and massive uplift and erosion in the slate belt or Mogok Metamorphic Belt in the western margin of Shan Plateau region (east of Sagaing Fault), probably facilitated by pulses or cycles of oxygenation of the earth's atmosphere, accumulation of gold occurred together with other redox sensitive trace elements such as Mo, Ni, As, and V trapped in organic muds in continental-derived sediments such as black shales or carbonaceous shales (Kogwe Mudstones) at the margin of Sibumasu Terrane (Figure 21). Increased oxygenation leads to more active continental erosion and increased supply of gold, consequently producing higher levels of gold pre-concentration in the carbonaceous shale source rocks (Large et al., 2011). This first stage involves pre-concentration of gold in sedimentary pyrites in continental basin margins, and the second stage was associated with repeated and widespread metamorphic-magmatic processes and collision-accretion associated with structural deformation that released gold-arsenic-rich metamorphic fluids in favorable structural sites to form Modi Taung (Figure 22). We suggest that this two-stage model may have important implications for mineral exploration and future research on sediment-hosted/orogenic gold deposits in Myanmar and SE Asia.



Figure 22: Cartoon showing two-stage model for formation of sediment hosted/orogenic gold deposits at Modi Taung. A. Accumulation of gold occurs together with other redox sensitive trace elements such as Mo, Ni, As, V trapped in organic muds.
B. Subsequent remobilization and reconcentration structural deformation that released gold-arsenic-rich metamorphic fluids in favorable structural sites to form Modi Taung. Adapted after Khin Zaw et al. (2014).

Table 7: Comparison summary features of Modi-Momi Taung, Bendigo Goldfield and
Macraes Goldfield. Bendigo Goldfield and Macares Goldfield data are taken from
Khin Zaw, et al., 2014

Feature	Modi-Momi Taung	Bendigo Goldfield	Macraes Goldfield
Host Rock Type	metasedimentary turbidite	metasedimentary turbidite (Willman and Wilkinson, 1992)	metasedimentary turbidite (Craw et al., 1999)
Host Rock Age	Upper Neoproterozoic – Lower Ordovician	Ordovician (~450 Ma) (Willman, 2007)	Mesozoic (Craw et al., 1999)
Style of Mineralization	Veins (Banded + Brecciated + Massive)	veins (Willman, 2007) (banded + brecciated + saddle reef)	veins (De Ronde et al., 2000) (hanging-wall shear+flat+lateral ramp+stockwork)
Ore Minerals	gold, minor galena and chalcopyrite	gold, sphalerite, galena and PGE's (Willman, 2007)	gold, sphalerite, chalcopyrite, galena and scheelite (Petrie et al., 2005)
Gold (Host Rock)	~4-300 g/t	~0.37 g/t (Bull and Large, 2014)	~1.5-5 ppb (Craw et al., 1999)
Gangue Minerals	quartz, phengite, ankerite, calcite	quartz, marcasite, chalcopyrite, calcite. (Bull and Large, 2014) pyrite and arsenopyrite contain gold	quartz, pyrite, illitic muscovite, siderite albite and graphite (Craw et al., 1999)
Alteration Minerals (Ore Zone)	pyrite, arsenopyrite, chlorite, phengite, muscovite, ankerite, calcite, graphite	pyrite, arsenopyrite, carbonate, sericite and graphite (Bull and Large, 2014)	pyrite, arsenopyrite, albite, phengitic muscovite, graphite and chlorite (Large et al., 2012)
Alteration Minerals (Non-mineralized Zone)	phengite, chlorite, calcite, ankerite	phengitic illite, albite, chlorite, carbonate and graphite (Bull and Large, 2014)	albite, muscovite, graphite and chlorite (Large et al., 2012)
Alteration/Minerals (Original Sediments)	muscovite, phengite, kaolinite	illite, smectite and kaolinite (Bull and Large, 2014)	quartz, epidote, twinned albite and feldspars (Large et al., 2012)
Fulids	Low salinity	low salinity CO ₂ and/or CH ₄ (Bull and Large, 2014)	low salinity CO ₂ (DeRonde et al., 2000)
Trace Elements	Au, As, Ag, Ni, Co, Sb, Bi, Cr, Ba and Mn	Au, As, Mo, V, Ni, and Zn (Large et al., 2009)	As, Ni, Au, Sb, W, Mo C, S and Bi (Craw et al., 2002)
VAMSNAZ Score	~315 pyrite in host rock (orogenic style)	250-1500 (orogenic style) (Calculated, Large et al., 2009)	~272 host rock (orogenic style) (Calculated- Craw et al., 2002)
Organic Carbon (Host Rock)	N/A	0.2-2.0 wt % (Bull and Large, 2014)	0.2 - >2.0 wt % (Large, 2010)
Pb Isotope Model Age	215 ± 30 Ma	400 Ma (Bierlein and McNaughton, 1998)	142-135 Ma and 106-101 Ma (Mortensen et al., 2010)
δ^{34} S range (Pyrite)	+ 1.33 ‰ to + 4.78 ‰	- 7.4 ‰ to + 8.1 ‰ (Jia et al., 2001)	-3 ‰ to -1 ‰ (Craw, 2002)

Recommendation for Future Exploration Implications

The vein system at Modi-Momi Taung can be compared to other similar metasedimentary turbidite quartz-Au vein deposits such as Bendigo Goldfield and Macraes Goldfield (Table 7). Both the Bendigo and Selinsing orogenic gold deposits occur as clusters of mineralized zones which are spatially controlled by major fold and fault structures. This suggests that Further gold mineralization is likely to occur to the north and south of the Modi Taung gold deposit along the trend of the Sagaing Fault. If the orogenic gold deposit model is applied to the Modi Taung gold deposit, gold grades can be expected to show little variation with depth and mineralization may occur down to $\sim 1-2$ km (Groves et al., 1998). Although some mineral assemblages have been demonstrated to show high grade zones within orogenic gold deposits, exploration generally requires a sound understanding of the structure of the system. Although some structural observations were made in the field and remarked upon throughout the current study, more work is required in this field to better constrain the source, timing and nature of the trap sites in the Modi Taung gold deposit.

Future exploration within the Modi-Momi Taung lease area should be directed away from the current mining operations and concentrated towards the NNE end of the current lease A and in the lease area B. Initial surface exploration should be conducted along the same trend as the current three main systems to find their northern extensions. This gold district may one day be classified as a world class goldfield and become a major asset to the people of Myanmar.

Summary

The interpreted genesis of the Modi Taung gold deposit based on the observations and analyses conducted within this study. Sedimentary rocks are considered to be the source of ore mineralization. The occurrence of multiple generations of ore minerals and the narrow range of δ^{34} S values obtained from vein pyrite suggest that the primary ore minerals have been remobilized via a magmatic or metamorphic fluid event. Pb isotope analysis suggests that an S type melt may have supplied the fluid involved in the remobilization of ore minerals. Mineralized fluids formed veins within active shear zones as evidenced by the book and ribbon textures common to the Htongyi and Sakangyi vein systems. Mineralization is shown to have occurred pre ~95 Ma by the truncating of the Shwesin Vein system by an andesite dyke which was dated using Pb isotope. The area has been intruded by at least two generations of igneous rocks since mineralization, however, these appear to have had not only a limited effect on the mineralization characteristics displayed by the veins.

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STUDY ON THE ICHTHYOPLANKTON OF MYANMAR COASTAL WATER

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J-2" STUDY ON THE ICHTHYOPLANKTON OF MYANMAR COASTAL WATER

Naung Naung Oo¹

Abstract

A total of 31153 specimens of fish larvae consisted of 40 families were identified area 26 economically important fish larvae families were found in Myanmar coastal water. In this study, Gobiidae, Scombridae, Lutjanidae, Carangidae, Elopidae, Megalopidae, Bothidae, Clupeidae and Engraulidae were recorded as the most abundant families. Based on the family-wise biodiversity, Taninthayi Coastal Region has maximum larval diversified area and followed by Rakhine Coastal Region and Ayeyawady Delta and Gulf of Martaban Coastal Region in relation to all investigated stations. In Mon coastal water, a total of 83614 specimens in which 45 species of 6 orders, 21 families and 32 genera of ichthyoplankton were identified. Species diversity of ichthyoplankton were found to be regulated by the changes of species frequency of occurrence related to seasonal phenomenon. The similarity of cluster values between sampling months ranged from 0.22 (minimum similarity at July) to 0.66 (maximum similarity at August) in 2014 and from 0.18 (minimum similarity at April) to 0.58 (maximum similarity at December) in 2015, respectively. The binary similarity coefficient of species composition characterized by nine stations of sampling areas was a high similarity and clusters linked with species. The oceanographic characteristics of Mon coastal estuaries are not highly variable in the sense that parameters do not fluctuate largely both temporally and spatially. In this study, high diversity of community structures and frequency of occurrence of fish larvae were determined in August; the reason for this being that the spawning period of many fish species in Mon coastal water reached at monsoon period. This report comprises baseline data for future research on larval fish population dynamics and fishery management.

Keywords: Fish larvae, Myanmar coastal water, diversity, similarity, baseline data.

Introduction

Myanmar is a large fishing nation in Southeast Asia with a continuous coastline of almost 2400 km extending along the Bay of Bengal and Andaman Sea. The coast of Myanmar can be divided into Rakhine, Ayeyawady Delta and Gulf of Martaban and Taninthayi Coastal Region. Ichthyoplanktons are found in all regions and are widely distributed across the entire Myanmar coastline.

Fish eggs and larvae are only temporary members of the plankton and their occurrence in samples is related to spawning activity in adult fish. The abundance, composition, distribution and the major characteristics of early life stages of fishes of Myanmar water are highly developed and greatly diversified. Early life stages of demersal species found in plankton must eventually settle to the bottom, but that can be delayed for months where as many go through these stages in a few days or weeks.

Pelagic species usually have floating eggs which are released directly into the sea which then pass directly to free swimming yolk-sac stage followed by a free swimming and feeding larval stage and then followed by the juvenile stage. Mesopelagic and bathypelagic fishes follow

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a similar pattern with their eggs and larvae found in the mixed surface layer where there is an abundance of food.

The early life stage is the most important stage for determining annual recruitment of fishes supporting various major commercial fisheries, and many studies were focused on ecological aspects of the larval stage such as the distribution, growth and survival (Harrison 2005). An oceanic condition, such as currents, eddies, and tidal fronts, play important roles in determining the spatial and temporal distributions of ichthyoplankton in the various seas of the world (Richards 2008).

The Bay of Bengal and the Andaman Sea are the largest marine ecosystem of the world ocean that lacks large scale seasonal upwelling and defined as moderately productive ecosystem (Madhupratap *et.al* 2003). Generally, the three coastal regions of Myanmar are considered to have a high biological productivity than other Indian Ocean waters. To provide more information of fish larvae for fishery management, the study on diversity and community structure of fish larvae from northern Rakhine coast to southern part of the Taninthayi coast was conducted. The study also invited the localized study on the ichthyoplankton of Mon State Coastal water. The result provided the basic information to evaluate the existing of fish stocks and preliminary for the future investigations in relation to ecosystems of Myanmar water.

Objectives of Research

The objectives of the present investigation on ichthyoplankton along Myanmar coastal water were to study:

- 1. the systematic identification of early life stages of fish characteristics;
- **2.** the species distribution, occurrence, composition, abundance, density and diversity of fish larvae;
- **3.** the relationship between environmental and oceanographic parameters of seawater and ichthyoplankton; and
- 4. the biomass and community structures of ichthyoplankton in the study areas.

Materials and Methods

The following protocols were adopted for the collection of samples and data analysis:

3.1 Study area and sampling depth

The study area (Fig. 1) included the Rakhine Coastal Region (RCR, 15 stations, R1-R15: 1144-1211); the Ayeyawady Delta and Gulf of Martaban Coastal Region (ACR, 11 stations, A1-A11: 1218-1289) and the Taninthayi Coastal Region (TCR, 12 stations, T1-T12: 1295-1354). The survey was conducted by the extensive ecosystem cruise of R/V Dr Fridtjof Nansen during November 13- December 19 in almost 6 year. The three coastal regions of Myanmar can largely be defined into three distinct water layers according to the general physical features characterizing the area as follows: (1) Shallow water depth (0-30) m, (2) Intermediate water depth (30-100) m, (3) Deep water depth (100-500) m.

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Ichthyoplankton	Fridtjof Nansen	Locations	Dates				
Sampling	Sampling						
stations	stations						
Rakhine Coastal Region (RCR)							
R 1	1144	Lat 19° 32' N, Long 92° 41' E	15.11.2013				
R 2	1145	Lat 19° 35' N, Long 92° 46' E	15.11.2013				
R 3	1148	Lat 19° 41' N, Long 92° 54' E	15.11.2013				
R 4	1158	Lat 18° 52' N, Long 93° 25' E	16.11.2013				
R 5	1160	Lat 18° 48' N, Long 93° 20' E	16.11.2013				
R 6	1162	Lat 18° 47' N, Long 93° 18' E	16.11.2013				
R 7	1172	Lat 17° 55' N, Long 93° 49' E	18.11.2013				
R 8	1175	Lat 18° 01' N, Long 93° 58' E	18.11.2013				
R 9	1178	Lat 18° 12' N, Long 94° 16' E	18.11.2013				
R 10	1187	Lat 17° 04' N, Long 94° 23' E	19.11.2013				
R 11	1191	Lat 17° 06' N, Long 94° 13' E	19.11.2013				
R 12	1194	Lat 17° 07' N, Long 94° 09' E	19.11.2013				
R 13	1204	Lat 16° 13' N, Long 93° 45' E	20.11.2013				
R 14	1207	Lat 16° 12' N, Long 93° 55' E	21.11.2013				
R 15	1211	Lat 16° 09' N, Long 94° 05' E	21.11.2013				
Ayeyawady Delta	and Gulf of Marta	ban Coastal Region (ACR)					
A 1	1218	Lat 15° 00' N, Long 93° 26' E	22.11.2013				
A 2	1221	Lat 14° 24' N, Long 93° 22' E	22.11.2013				
A 3	1236	Lat 14° 01' N, Long 94° 21' E	24.11.2013				
A 4	1239	Lat 14° 22' N, Long 94° 24' E	24.11.2013				
A 5	1244	Lat 15° 35' N, Long 94° 33' E	25.11.2013				
A 6	1257	Lat 15° 27' N, Long 95° 34' E	27.11.2013				
A 7	1261	Lat 14° 42' N, Long 95° 28' E	27.11.2013				
A 8	1265	Lat 13° 58' N, Long 95° 22' E	28.11.2013				
A 9	1277	Lat 13° 40' N, Long 96° 13' E	29.11.2013				
A 10	1280	Lat 14° 18' N, Long 96° 32' E	30.11.2013				
A 11	1289	Lat 15° 04' N, Long 96° 37' E	30.11.2013				
Taninthayi Coasta	al Region (TCR)						
T 1	1295	Lat 13° 20' N, Long 98° 02' E	6.12.2013				
T 2	1298	Lat 13° 23' N, Long 97° 09' E	6.12.2013				
T 3	1301	Lat 13° 24' N, Long 96° 26' E	6.12.2013				
T 4	1315	Lat 12° 22' N, Long 96° 37' E	9.12.2013				
T 5	1319	Lat 12° 22' N, Long 97° 12' E	9.12.2013				
T 6	1320	Lat 12° 22' N, Long 97° 53' E	9.12.2013				
Τ7	1331	Lat 11° 21' N, Long 97° 59' E	11.12.2013				
T 8	1334	Lat 11° 22' N, Long 97° 21' E	11.12.2013				
Т 9	1337	Lat 11° 22' N, Long 96° 36' E	11.12.2013				
T 10	1348	Lat 10° 21' N, Long 97° 55' E	15.12.2013				
T 11	1351	Lat 10° 21' N, Long 97° 27' E	15.12.2013				
T 12	1354	Lat 10° 22' N. Long 96° 32' E	16.12.2013				

Table 1: Position of ichthyoplankton sampling in Myanmar coastal water

Symbols: (R1-R15) = Rakhine Coastal Region sampling stations; (A1-A11) = Ayeyawady Delta and Gulf of Martaban Coastal Region sampling stations; (T1-T12) = Taninthayi Coastal Region sampling stations.



Figure 1: Map indicating the collection sites of the specimens used in present study

Symbols: Δ = specimens collection sites of Rakhine Coastal Region; Δ = specimens collection sites of Ayeyawady Delta and Gulf of Martaban Coastal Region; Δ = specimens collection sites of Taninthayi Coastal Region. (source: R/V Dr Fridtjof Nansen survey, November 13-December 19 in 2013)

3.2 Description of sampling procedures in Myanmar coastal water

The Hydrobios Multinet is modified from Hassel *et.al* (2013) which provides the opportunity of obtaining up to five vertically stratified samples during one haul. This Multinet has a total length of 560 cm, 300 μ m mesh size at the mouth and 180 μ m mesh size at the cod end consists of a stainless steel frame where five 250 cm long plankton nets are attached by zippers, and has a mouth opening area of 0.25 cm² (50 x 50 cm). For vertical hauls, the five cod-

ends must be placed in a protective frame, which due to its weight helps the nets to hang vertically. The nets are released from a deck-unit by means of an electronic cable. Digital flow meters can be mounted both on the in and outside of the frame which enables control with the water volume filtered and potential bucket effects during each tow. The sampling period was about 30 minutes with oblique tow at ship speed of 1.5 knots. The survey transects were made perpendicular to depth isobaths and spaced 20 nautical miles (NM) apart. They covered the depth-interval between ~ 20 m depth near the coast to 500 m depth offshore. Every third transect was termed an "Ecosystem transect" with a more elaborate sampling program. These transects extended to 1000 m depth. Collected specimens were preserved in 10% formaldehyde sea water buffered with borax. Each fish larva was later sorted out from zooplankton and transferred to 4% formaldehyde sea water solution. Ichthyoplankton samples were standardized to numbers caught per 1,000 m³ of sea water volume filtered.

3.3 Processing of ichthyoplankton samples onboard

The ichthyoplankton samples are generally used for two purposes:

- 1) Size fractioned ichthyoplankton biomass estimates
- 2) Samples preserved for taxonomic identification of ichthyoplankton organisms

In most cases each ichthyoplankton sample is split into two subsamples, where one is used for estimation of biomass and the other is preserved with formalin for subsequent taxonomic analysis on shore. Description of the work flow is for processing of zooplankton samples to obtain biomass and taxonomic samples. This method applies to samples from the WP 2 as well as the Multinet. To minimize the possibility of putrefaction of the biological material, it is vital that all samples are kept cool in the refrigerator until treated in the laboratory.

3.4 Preservation of samples

The part of the divided plankton sample that is dedicated for taxonomic analysis (*i.e.* the part that is not for estimation of biomass) is to be preserved with formalin. Eliminate excess water by filtering the sample through a sieve with mesh-size equal to or smaller than the meshsize of the sampling gear (normally 180 µm). In case of very large samples, additional splitting by the Motoda plankton divider can be made. The fraction of the total sample preserved for taxonomic analysis must be noted, both on the sample bottle and in the journal. The sample is stored on a sample bottle (generally a 100 ml polyethylene bottle fitted with an inner cap and an outer screw cap). Use a funnel and spray with seawater to transfer sample from sieve to sample bottle, thereafter add concentrated formalin in the relation 1 part formalin (ca. 40% strength) to 9 parts of seawater. Do not preserve the samples in freshwater. If the volume of the plankton exceeds more than about half of the total volume, use additional bottles. Add 1 ml of borax powder to each plankton-sample to buffer the solution. Shake the bottle carefully to mix the borax and formalin. Protective glasses and gloves are to be used whenever handling formalin, which is only to be done in a ventilation cabinet or in open air outside. Likewise, formalin samples are not to be kept in the lab outside of the ventilated cabinet. Mark the sample both on the foil of the bottle using a waterproof "permanent" pen and on a label stuck at the side of the bottle using a lead pencil. Formalin-resistant paper marked with pencil can be placed inside the bottle (e.g. between the inner and outer caps) for additional labeling. The samples must be

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marked with the following information: 1) Ship name; 2) Cruise number; 3) Station-number; 4) Date; 5) Sampling gear (e.g. WP 2); 6) Mesh size of plankton net; 7) Depth-range for sampling; 8) Proportion of total sample preserved; and 9) Type of preservative. Always use plastic bottles (e.g. polyethylene) with an inner cap in addition to the screw cap, preferably square bottles of the brand "Kartell". Other relevant bottle-volumes are 50 ml and 250 ml.

3.5 Storage of preserved ichthyoplankton samples

Sample-bottles are stored station-wise in white plastic boxes protected by a lid. The plastic boxes should be labeled with: 1) Ship name; 2) Cruise name and/ or number; 3) Date; 4) Project; and 5) Area. Formalin samples are not to be kept in the lab, laboratory except in the ventilation cabinet.

3.6 Identification of samples

Larval fish were identified, enumerated, and measured by dissecting microscopes equipped with cross-polarized light. Ichthyoplankton taxonomic identifications were made to the lowest level possible (usually family) according to Ahlstrom and Moser (1976), Miller, Watson and Leis (1979), Fahay (1983), Leis and Rennis (1983), Tamoikine and Pandare (1994), Neira *et.al* (1998), Leis and Carson-Ewart (2000), Nakabo (2002), Richards (2006, 2008) and Konishi *et.al* (2012). Unidentified larvae were placed in 'unknown' category due to the samples that were too small to identify and damaged larvae were placed in 'incomplete' category stored at laboratory of Marine Science Department, Mawlamyine University.

3.7 Determination of the constancy of occurrence

The number of total fish larvae and the top five most abundant families which were standardized to number caught per $1,000 \text{ m}^3$ of sea water volume filtered were mapped for spatial distribution. Determination of the constancy of occurrence was based on the ecological index proposed by Dajoz (1983) cited in Chamchang (2006).

$C = P/Q \times 100$

Where: C = Constancy of occurrence of the family (%), P = Number of samples where the family occurred, Q = Total number of samples. The families were then divided into three categories: Constants (when C > 50%), Accessories (when $25\% \le C \le 50\%$) and Accidental (when C < 25%). Determination for the type of fish larvae were grouped into 5 categories based on the adult habitat (Smith and Heemstra 1986). Group 1: Freshwater fish; Group 2: Neritic fish; Group 3: Inshore fish; Group 4: Shallow to oceanic fish, and Group 5: Oceanic fish.

3.8 Determination of the mean density and frequency of occurrence

- (i) Fish densities were calculated using the number of fish collected in a given sample, divided by the total volume of water sampled (No. fish/m³). Mean fish densities were calculated by averaging the individual fish densities (Sum of fish densities/ Number of samples) or by averaging mean fish densities (Sum of mean fish densities/Number of samples).
- (ii) The frequency of occurrence (percentage of catch) of larvae across different sites was worked out. Frequency of occurrence of individual species was calculated by the total number of sampling areas in which species occurred/total number of sampling areas studied \times 100.



Figure 2: Flow diagram showing the processing of ichthyoplankton onboard **Source**: R/V Dr Fridtjof Nansen survey, November 13-December 19 in 2013
3.9 Determination of the diversity index

The Shannon-Wiener Diversity Index (H') was used to describe the diversity of taxa collected. This diversity index has two properties: (1) H'=0 if and only if there is one species in a sample, and (2) H' is maximum only when all species are represented by the same number of individuals, that is, a perfectly even distribution of abundance. Diversity Index (H') for determining the number of individuals of each species in the study areas, Species Evenness (J') for measure the relative abundance of the various population present in the study areas and Species Richness (R') for measured the number of different species present in the study areas were also calculated by using the Shannon-Wiener Index (1963), Pielou's (1975) and Margalef, (1958). These formulae are as follow:

$H' = -\Sigma (P_i \ln P_i), J' = H'/\ln S, R' = S-1/\ln N$

where H' = measured Shannon-Wiener diversity, P_i = the proportional abundance of its species (n_i/N), n_i = the no. of individuals of the species, N = the total no. of individuals of the species, S = number of species, n = the total number of individuals of given species.

3.10 Measurement of parameters in study area

- (i) Air temperature, air pressure and sea surface temperature (SST) 5m depth were logged automatically every 60 seconds with a WIMDA meteorological sensor.
- (ii) Vertical profiles of temperature, salinity, fluorescence and oxygen were obtained by the Seabird 911 plus probe. The CTD was equipped with an uncalibrated Aquatracka MK III fluorometer, SEB 3plus temperature sensor, SEB 4C conductivity sensor and SEB 43 oxygen sensor. Real-time logging and plotting was done using the Seabird Seawave software installed on a PC. Above the shelf and slope the profiles ranged from the surface to within a few meters above the bottom. Offshore the maximum sampling depth was 1500m. Horizontal near-surface 5m depth distributions of temperature (°C), salinity (‰), oxygen (ml/l) and fluorescence (index on relative scale) for various regions of the Myanmar coastal area were made by use of the software Ocean Data View, interpolating by DIVA gridding (Ocean Data View: Schlitzer 2013, <u>http://odv.awi.de</u>).
- (iii) In this study, there are 8 Niskin water bottles (10 L) attached to a CTD mounted rosette was used to collect water at predefined depths.
- (iv) A Portasal salinometer (mod. 8410) was used to validate/calibrate the salinity (conductivity) measurements from the CTD.
- (v) For calibration of the oxygen measurements from the CTD mounted sensor, the oxygen concentrations in seawater samples from all Niskin bottles at selected deep plankton stations were analyzed by the Winkler redox titration method following the procedures of Hagebø (2008). To further improve the calculation of oxygen concentration per weight unit of seawater, a water sample for oxygen analyses was collected first from the Niskin bottles and subsequently the water temperature from the same bottle was measured. These temperature data were used to calculate potential temperature at the time when the Winkler reagents were added.

- (vi) Seawater samples (20 L) for nutrient analyses (nitrite + nitrate, phosphate and silicate) were taken from Niskin water bottles at 25, 5 and 0 m at the shallow plankton station (30 m bottom depth), at 100, 75, 50, 25, 5 and 0 m at the intermediately deep plankton station (100 m bottom depth) and at 500, 300, 200, 100, 75, 50, 25, 5 and 0 m at the deep plankton station (500 m bottom depth). The water samples were stored in 20 ml polyethylene vials, conserved with 0.2 ml chloroform and stored cool and dark in refrigerator onboard at 4°C for subsequent analysis on shore (Hagebø and Rey, 1984). The analyses were made on shore by Institute of Marine Research (Bergen, Norway), using a modified Alpkem Auto Analyzer C (OI Analytical USA) and following standard procedures (Strickland and Parsons, 1972). Extra standards were added during the analysis in order to cover the whole measurement range.
- (vii) For analysis of chlorophyll *a* and phaeopigment concentrations, water samples (263 ml) were collected from the CTD mounted Niskin bottles at the same standardized depths as described above for the nutrients but also from surface samples collected with a bucket. The water samples were filtered on Munktell glass fiber filters (GF/C 25mm diameter) using a custom made filtration system. The filters were then stored in the dark at 18°C for subsequent analysis on shore. After the cruise, the pigment samples were transported to the laboratory in a cooling box with freezing elements. The pigments were then extracted with 90% acetone in darkness over night in the laboratory and the extracts centrifuged and analyzed using a Turner Design fluorometer model 10 AU calibrated with pure chlorophyll *a* (Jeffrey and Humphrey, 1975).
- (viii) Fluorescence was measured before and after acidification by a drop of 5% HCL and concentrations of chlorophyll *a* and phaeorbides estimated according to Holm-Hansen *et.al* 1965.
- (ix) The Mk III Aquatracka fluorometer measures *in situ* fluorescence on relative scale which after the cruise was related to absolute chlorophyll *a* concentrations obtained from the laboratory analyses of the samples collected from the water bottles.
- (x) The SBE 21 Seacat thermosalinograph was running continuously during the survey obtaining samples of sea surface (5m depth) salinity and relative temperature every 10 seconds. An attached in line C3 Turner Design Submersible Fluorometer measured turbidity and chlorophyll *a* levels.
- (xi) The current profiles were continuously recorded along the path of the vessel by the vessel mounted Ocean Surveyor 150 kHz ADCP. The ADCP has a maximum range between 200-400 m depth and transmission of transducer pulses was synchronized with the echo sounder. The system was run in narrow band mode and data were averaged in 8m vertical bins and stored on files for post survey processing. A Louvered ADCP (L-ADCP) consisting of two Workhorse 300 kHz ADCP's mounted on the CTD carousel fazing upwards to the surface and downwards respectively was used on every 1000 m station to obtain more detailed information about current pattern, especially in deeper waters beyond the range of the vessel mounted ADCP. All data from the ADCP's will be processed on land after the survey.

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3.11 Determination of the correlation between the parameters and larvae

(i) Analysis of variance was used to compare the total ichthyoplankton between the sampling stations using Microsoft Excel statistical programme (2008). Quantification of the relation between total ichthyoplankton and physical and chemical parameters was done by linear regression the coefficient of correlation of the type (product moment formula):

$$\mathbf{r} = \frac{\sum xy}{\sqrt{(\sum x^2) (\sum y^2)}}$$

- Where: r = linear regression the coefficient of correlation, xy = between the ichthyoplankton station X and Y.
- (ii) The relationship between environmental parameters concentration in study area and the species richness of the fish larvae community present in the collected specimens were examined the Spearman's rank correlation coefficient (r_s) by using the following formula:

$$r_s = 1 - 6\Sigma d^2/n^3 - n$$

Where: d = the different between the ranked x and y values, n = number of paired values, i.e. sample units.

3.12 Description of study area in Mon coastal water

In this present study, all of the sampling areas are located between the Gulf of Martaban and northern part of Taninthayi coast. The samples were collected from Koe-te-su (Lat.17° 12' N, Long. 97° 46' E) at Kyaik-hto Township; Zot-ka-li (Lat. 17° 07' N, Long. 97° 08' E) at Be-lin Township; Aung-kan-tha (Lat. 16° 52' N, Long. 97° 14' E) at Tha-hton Township; Ahlyat (Lat. 16° 37' N, Long. 97° 27' E) at Paung Township; Zee-gone (Lat. 15° 10' N, Long. 96° 46' E) at Chaung-zone Township; Hin-tha-kyun (Lat. 16° 27' N, Long. 97° 36' E) at Mawlamyine Township; Ka-don-paw (Lat. 16° 15' N, Long. 97° 43' E) at Mu-don Township; Setse (Lat. 15° 52' N, Long.97°34' E) at Than-byu-zayat Township and Kyun-gyi (Lat.15° 04' N, Long. 97°46'E) at Ye Township in Mon coastal water (Fig 3).

3.13 Description of sampling procedures in Mon coastal water

Sampling was carried out monthly during day time at high tide, from January 2014 to December 2015 at nine stations distributed in Mon coastal water. Samples were collected by standard ichthyoplankton net (mesh size: 335 μ m, mouth diameter: 0.5 m and total length: 1.5 m) equipped with T.S.K flow meter to calculate the volume of seawater and towed at horizontal subsurface or sometimes underneath the surface at approximately 6 m. The duration of the horizontal tows were limited to 5 minutes. After collection, the samples were preserved in 5% buffered formaldehyde seawater solution (Wickstead, 1965). Additionally, at each site, salinity (‰), water temperature (°C), dissolved oxygen (ml/l), pH and transparency (Secchi disc depth, m) were also recorded. In the laboratory of Department of Marine Science, Mawlamyine University, the ichthyoplankton was sorted, counted (number of individuals per 100 m³) and identified to possible taxonomic separation (Ahlstrom and Moser: 1976; Miller, Watson and Leis: 1979; Fahay: 1983; Leis and Rennis: 1983; Tamoikine and Pandare: 1994; Neira: 1998; Leis and Carson-Ewart: 2000; Nakabo: 2002; Richards: 2006 & 2008 and Konishi: 2012).

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3.14 Quantitative analysis of ichthyoplankton samples

In this study, all the specimens present in the subsample are counted. The total numbers of specimens are later calculated for the whole sample depending on the percentage of subsamples examined.

(a) Biomass

The volume of ichthyoplankton collected was estimated by settlement volume method. The samples are allowed to settle for at least 24 hours before recording the settled volume. For biomass study, the samples were thoroughly stirred with a glass rod and an aliquot subsample of 2 ml was taken, examined and counted under the microscope with small magnification. The process was repeated for five times, that is, a total of five aliquot subsample 10 ml in volume was taken and the number of ichthyoplankton counted.

(b) Species' frequency of occurrence (F)

It is calculated taking into account the number of samples in which the organism was found, relative to the total number of samples collected, in percent.

F = Ts.100 / TS (Harris 2001)

Where: Ts = the number of samples in which the taxon (species) is present, and TS = the total number of samples. The results are presented in percentage (%), being used the following approach: > 70% = Much Frequent; 70% - 40% = Frequent; 40% - 10% = Less Frequent and < 10% = Infrequent/Sporadic.

3.15 Determination of community similarity

As with binary similarity coefficient analysis, binary occurrence or non-occurrence of each data set used to compare in the form of community similarity by using the Sorensen similarity index (S_s) (Sorensen, 1948).

$S_s = 2C/A + B$

Where: C = the number of species the two communities have in common, A = the total number of species found in community 1, B = the total number of species found in community 2. For comparing the community structures of fish larvae by station, a cluster analysis was used in the form of a dendrogram. The analysis used Sorensen coefficients of similarity and followed the average linkage method.



Figure 3:. Map indicating the collection sites of ichthyoplankton in Mon coastal water

Results

4.1 Identification of ichthyoplankton in Myanmar coastal water

The ichthyoplankton of Myanmar coastal water is a typical Bay of Bengal and the Andaman Sea assemblage, characterized by great taxonomic diversity. A total of 10 orders and 40 families of fish larvae are found in the coastal regions in this area down to depths of 500 m. The benthopelagic assemblage (bottom, near-bottom and near-bottom-pelagic species) and the pelagic assemblage included 14960 individuals and 16193 individuals, respectively. The 40 larval fish families collected and identified: the family Synodontidae of order Aulopiformes; the

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family Exocoetidae of order Beloniformes; the family Holocentridae of order Beryciformes; the family Engraulidae, Clupeidae and Chirocentridae of order Clupeiformes; the family Elopidae and Megalopidae of order Elopiformes; the family Mugilidae of order Mugiliformes; the family Acropomatidae, Carangidae, Coryphaenidae, Drepaneidae, Gobiidae, Gerreidae, Labridae, Leiognathidae, Lethrinidae, Lutjanidae, Menidae, Mullidae, Nemipteridae, Sciaenidae, Scombridae, Serranidae, Siganidae, Sphyraenidae, Teraponidae, Trichiuridae, Polynemidae and Priacanthidae of order Perciformes; the family Bothidae, Cynoglossidae and Pleuronectidae of order Scorpaeniformes; the family Balistidae, Ostraciidae, Tetraodontidae and Triacanthidae of order Tetraodontiformes. These were recorded in three coastal regions of Myanmar water at present study.

Phylum	Chordata		
Class	Actinopterygii		
Order	Family	Larvae	
Aulopiformes	Synodontidae	1. Synodontid larva	
Beloniformes	Exocoetidae	2. Exocoetid larva	
Beryciformes	Holocentridae	3. Holocentrid larva	
	Engraulidae	4. Engraulid larva	
Clupeiformes	Clupeidae	5. Clupeid larva	
-	Chirocentridae	6. Chirocentrid larva	
F1	Elopidae	7. Elopid larva	
Elopitormes	Megalopidae	8. Megalopid larva	
Mugiliformes	Mugilidae	9. Mugilid larva	
	Acropomatidae	10. Acropomatid larva	
	Carangidae	11. Carangid larva	
	Coryphaenidae	12. Coryphaenid larva	
	Drepaneidae	13. Drepaneid larva	
	Gobiidae	14. Gobiid larva	
	Gerreidae	15. Gerreid larva	
	Labridae	16. Labrid larva	
Perciformes	Leiognathidae	17. Leiognathid larva	
	Lethrinidae	18. Lethrinid larva	
	Lutjanidae	19. Lutjanid larva	
	Menidae	20. Menid larva	
	Mullidae	21. Mullid larva	
	Nemipteridae	22. Nemipterid larva	
	Sciaenidae	23. Sciaenid larva	
	Scombridae	24. Scombrid larva	
Perciformes	Serranidae	25. Serranid larva	
	Siganidae	26. Siganid larva	
	Sphyraenidae	27. Sphyraenid larva	
	Teraponidae	28. Teraponid larva	
	Trichiuridae	29. Trichiurid larva	
	Polynemidae	30. Polynemid larva	
	Priacanthidae	31. Priacanthid larva	

Table 2: Identification of ichthyoplankton in Myanmar coastal water

Phylum	Chordata			
Class	Actinopterygii	Actinopterygii		
Order	Family	Larvae		
	Bothidae	32. Bothid larva		
Pleuronectiformes	Cynoglossidae	33. Cynoglossid larva		
	Pleuronectidae	34. Pleuronectid larva		
Scorpaeniformes	Platycephalidae	35. Platycephalid larva		
	Scorpaenidae	36. Scorpaenid larva		
Tetraodontiformes	Balistidae	37. Balistid larva		
	Ostraciidae	38. Ostraciid larva		
	Tetraodontidae	39. Tetraodontid larva		
	Triacanthidae	40. Triacanthid larva		

4.2 Diversity of ichthyoplankton in Myanmar coastal water

Surveys of fish larvae diversity are increasingly being used to monitor the spawning areas and stock status of commercially important species. These surveys have contributed to improve the knowledge of the ecological relations among the communities, based on the analysis of the species distribution, occurrence, composition, abundance and its time and space variability. A total of 31153 specimens of fish larvae consisted of 40 families were found in the study areas. Taninthayi Coastal Region has the richest fish larvae diversity and also the highest average number per station (Table 3). Rakhine Coastal region and Ayeyawady Delta and Gulf of Martaban Coastal Region rank second and third respectively. Twenty-six economic important families of fish larvae were identified in these study areas and all of them were found in Taninthayi Coastal Region. Only 21 and 23 economic important families were found in Rakhine Coastal Region and Ayeyawady Delta and Gulf of Martaban Coastal Region, respectively (Table 3). Among the collected larvae, thirty-one families of fish larvae such as Synodontidae, Exocoetidae, Holocentridae, Engraulidae, Clupeidae, Chirocentridae, Elopidae, Megalopidae, Mugilidae, Carangidae, Coryphaenidae, Gobiidae, Gerreidae, Labridae, Leiognathidae, Serranidae, Lutjanidae, Menidae. Mullidae, Nemipteridae, Sciaenidae, Scombridae, Sphyraenidae, Trichiuridae, Polynemidae, Priacanthidae. Bothidae, Cynoglossidae, Pleuronectidae, Tetraodontidae and Triacanthidae were obtained in all three coastal regions.

Study on family diversity of ichthyoplankton in Myanmar coastal water was conducted at three specific regions, namely, Rakhine Coastal Region, 11 stations, Ayeyawady Delta and Gulf of Martaban coastal region encompassing 11 stations and of Taninthayi Coastal Region. encompassing 12 Stations. Larvae occurring within sampling periods were collected at shallow water depth (0-30) m, intermediate water depth (30-100) m and deep water depth (100-500) m respectively.

Fish larvae were more abundant in the near shore stations than in the offshore stations, but the situation was reversed for fish eggs. The numbers of fish species were also higher in the nearshore stations than in the offshore stations. These results indicate that most pelagic eggs were spawned in offshore waters, and the diversity of fish larvae was more diverse in nearshore waters than in offshore waters. Occurrence, composition, abundance and density of fish larvae were based on calculating of spatial distribution data. Diversity index, taxonomic richness and evenness values were compared for each station by ecosystem transects.

C- N-	Larval family	Tota	Total no. of larvae (larvae/1000 m ³)			
5r. No.		RCR	ACR	TCR	Total	
1	Synodontidae *	225	175	368	768	
2	Exocoetidae	221	261	218	700	
3	Holocentridae	197	280	234	711	
4	Engraulidae *	409	286	923	1618	
5	Clupeidae *	449	493	1211	2153	
6	Chirocentridae *	219	60	342	621	
7	Elopidae	572	521	878	1971	
8	Megalopidae	458	599	665	1722	
9	Mugilidae *	327	363	143	833	
10	Acropomatidae *	0	0	205	205	
11	Carangidae *	592	459	693	1744	
12	Coryphaenidae *	157	55	280	492	
13	Drepaneidae	157	0	171	328	
14	Gobiidae	858	584	806	2248	
15	Gerreidae *	274	288	285	847	
16	Labridae	200	94	128	422	
17	Leiognathidae	265	138	223	626	
18	Lethrinidae *	0	204	177	381	
19	Lutjanidae *	607	345	369	1321	
20	Menidae *	172	141	168	481	
21	Mullidae *	291	221	114	626	
22	Nemipteridae *	205	166	113	484	
23	Sciaenidae *	280	115	176	571	
24	Scombridae *	647	332	625	1604	
25	Serranidae *	367	222	139	728	
26	Siganidae	182	0	124	306	
27	Sphyraenidae *	215	127	203	545	
28	Teraponidae *	0	96	175	271	
29	Trichiuridae *	284	164	277	725	
30	Polynemidae *	148	217	110	475	
31	Priacanthidae *	77	96	206	379	
32	Bothidae *	504	170	385	1059	
33	Cynoglossidae *	431	227	354	1012	

Table 3: Total number of ichthyoplankton in Myanmar coastal water

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Sn No	Larval family	Total no. of larvae (larvae/1000 m ³)			
SI. NO.		RCR	ACR	TCR	Total
34	Pleuronectidae	189	198	93	480
35	Platycephalidae	178	0	155	333
36	Scorpaenidae	151	0	121	272
37	Balistidae *	0	0	131	131
38	Ostraciidae *	0	0	101	101
39	Tetraodontidae	159	111	122	392
40	Triacanthidae	107	183	177	467
Total fisl	n larvae	10774	7991	12388	31153

Symbols: RCR = Rakhine Coastal Region; ACR = Ayeyawady Delta and Gulf of Martaban Coastal Region; TCR = Taninthayi Coastal Region; * = Economic fish.

4.3 Diversity indices on three coastal regions of Myanmar

Rakhine Coastal Region: A total of 35 larval families were recorded from 15 stations, Rakhine Coastal Water in the present study. The larvae dominantly observed in the study areas were : Synodontid, Exocoetid, Holocentrid, Engraulid, Clupeid, Chirocentrid, Elopid, Megalopid, Mugilid, Carangid, Coryphaenid, Drepaneid, Gobiid, Gerreid, Labrid, Leiognathid, Lutjanid, Menid, Mullid, Nemipterid, Sciaenid, Scombrid, Serranid, Siganid, Sphyraenid, Trichiurid, Polynemid, Priacanthid, Bothid, Cynoglossid, Pleuronectid, Platycephalid, Scorpaenid, Tetraodontid and Triacanthid. The number of larvae occurred at the stations ranged from 77 to 858. The diversity, evenness and richness values 2.677, 0.989 and 1.508, respectively, were recorded in this area.

Ayeyawady Delta and Gulf of Martaban Coastal Region: A total of 33 larval families were recorded from 11 stations, Ayeyawady Delta and Gulf of Martaban Coastal Water in the present study. The larvae dominantly observed in the study areas were described as follow; Synodontid, Exocoetid, Holocentrid, Engraulid, Clupeid, Chirocentrid, Elopid, Megalopid, Mugilid, Carangid, Coryphaenid, Gobiid, Gerreid, Labrid, Leiognathid, Lethrinid, Lutjanid, Menid, Mullid, Nemipterid, Sciaenid, Scombrid, Serranid, Sphyraenid, Teraponid, Trichiurid, Polynemid, Priacanthid, Bothid, Cynoglossid, Pleuronectid, Tetraodontid and Triacanthid. The number of larvae occurred at the stations ranged from 55 to 599. The diversity, evenness and richness values 2.381, 0.993 and 1.113, respectively, were recorded in this area.

Taninthayi Coastal Region: A total of 40 larval families were recorded from 12 stations, Taninthayi Coastal Water in the present study. The larvae dominantly observed in the study areas were described as follow; Synodontid, Exocoetid, Holocentrid, Engraulid, Clupeid, Chirocentrid, Elopid, Megalopid, Mugilid, Acropomatid, Carangid, Coryphaenid, Drepaneid, Gobiid, Gerreid, Labrid, Leiognathid, Lethrinid, Lutjanid, Menid, Mullid, Nemipterid, Sciaenid, Scombrid, Serranid, Siganid, Sphyraenid, Teraponid, Trichiurid, Polynemid, Priacanthid, Bothid, Cynoglossid, Pleuronectid, Platycephalid, Scorpaenid, Balistid, Ostraciid, Tetraodontid and Triacanthid. The number of larvae occurred at the stations ranged from 93 to 1211. The diversity, evenness and richness values 2.446, 0.984 and 1.167, respectively, were recorded in this area.

4.4 Physico-chemical parameters relation to ichthyoplankton in Myanmar coastal water

This portion displays the findings regarding the physical and chemical characteristics of different water masses of the Rakhine Coastal Region (RCR), the Ayeyawady and Gulf of Martaban Coastal Region (ACR) and the Taninthayi Coastal Region (TCR) along the coastal waters of Myanmar. The role of nutrients in Myanmar coastal water is to support the marine food chains. Generally, nutrient is also present in sea water in very small amounts but only minute quantities of these are required by living organisms. The outlay of the baseline study involved collection, analysis and assessment of the following relevant environmental, physical, chemical and biological parameters:

- 1. Climatic conditions: Winds, Rainfall, Humidity, Evaporation.
- 2. **Physical variables:** Air/surface water temperature (C^o), pH (hydrogen ion concentration), Salinity (‰), Transparency (m).
- 3. **Chemical variables**: Dissolved Oxygen (DO₂), Trace metals (Nutrients): phosphate, nitrite + nitrate and silicate.
- 4. **Marine productivity:** Assessment of primary production in terms of pigment (chlorophyll *a*) analysis in coastal and marine environment as an index of water fertility in the area.

Field and laboratory works have to be conducted adopting standard methodology and techniques. This is important in order to have sufficient reliable baseline data required for the environmental impact assessment (EIA) study (to be prepared prior to construction of the new planned port).

4.4.1 Environmental parameters of Rakhine Coastal Region

- 1. In all stations, the least recorded air temperature was 25°C (dry) and the highest was 29°C (dry). Water temperature was 23.67°C (shallow water) and the highest was 29.90°C (intermediate and deep water).
- 2. Transparency was 2.5 m (St. 1178) and the highest was 4 m (St. 1160).
- 3. Salinity ranged from 31.02 ‰ (intermediate water) to 35.01 ‰ (shallow water), but in shallow water stations of 1145, 1160, 1175 and 1191 the value was 34 ‰ (at 25 m depth as a consequence of inshore water influx) and then shoot up to 34.69 ‰ (mean salinity).
- 4. The pH readings ranged from 7.06 (shallow water) to 8.40 (intermediate water).
- The nutrients in mg/l ranged from 0.15 (shallow water) to 3.13 (deep water) for PO₄-P;
 4.04 (shallow water) to 37.34 (deep water) for NO₂+NO₃-N and 0.01 (intermediate water) to 32.44 (deep water) for SiO₄-Si.
- 6. In all stations the least recorded dissolved oxygen ml/l was 2.0 (intermediate and deep water) and the highest was 5.8 (shallow water).

The chlorophyll *a* and phaeopigment concentration recorded was 0.12 (intermediate and deep water) to 0.53 (shallow water) mg/m³ in Rakhine coastal water depths.

4.4.2 Environmental parameters of Ayeyawady Delta and Gulf of Martaban Coastal Region

- 1. In all stations, the least recorded air temperature was 28°C (dry) and the highest was 30°C (dry). Water temperature was 26.11°C (deep water) and the highest was 29.74°C (intermediate water).
- 2. Transparency was 0.5 m (St. 1221) and the highest was 1.5 m (St. 1289).
- 3. Salinity ranged from 27.59 ‰ (intermediate water) to 34.67 ‰ (shallow water) but in all stations of three water layers, the range of salinity was not noticeable than 30 ‰ (along the ecosystems transect line) and then shoot up to 34 ‰ (Sts. 1221, 1239, 1261, 1277).
- 4. The pH readings ranged from 7.00 (intermediate water) to 8.89 (shallow water).
- The nutrients in mg/l ranged from 0.12 (shallow water) to 3.24 (deep water) for PO₄-P;
 2.38 (shallow water) to 37.10 (deep water) for NO₂+NO₃-N and 1.84 (intermediate water) to 34.88 (deep water) for SiO₄-Si.
- 6. In all stations the least recorded dissolved oxygen ml/l was 1.8 (intermediate water) and the highest was 5.9 (shallow water).
- 7. The chlorophyll *a* and phaeopigment concentration recorded was 0.12 (intermediate water) to 0.37 (shallow water) mg/m³ in all stations of Ayeyawady and Gulf of Martaban coastal water depths.

Across the shelf of Ayeyawady Delta and Gulf of Martaban coastal region included, 11 hydrographic transects were made especially near Nicobar, Pathein-west, Pathein-east and Yangon. Surface temperatures along these transects were high, typically above 28°C. This area showed little variation in temperature between the coastal and offshore upper waters. The temperatures decreased with depth and at 100 m depth the temperatures were typically about 27°C. Temperatures at 500 m were roughly 10°C and at transect Yangon the value at almost 1000 m was approximately 6.7°C.

4.4.3 Environmental parameters of Taninthayi Coastal Region

- In all stations, the least recorded air temperature was 25°C (dry) and the highest was 32°C (dry). Water temperature was 27.09°C (intermediate water) and the highest was 29.54°C (shallow water).
- 2. Transparency was 2 m (St. 1301) and the highest was 3.5 m (St. 1354).
- 3. Salinity ranged from 31.03 ‰ (intermediate water) to 33.45 ‰ (shallow water), but in intermediate stations the range of salinity is nearly 31 ‰ 32 ‰ between the shallow water and deep water stations.
- 4. The pH readings ranged from 7.09 (shallow water) to 8.99 (deep water).
- 5. The nutrients in mg/l ranged from 0.11 (shallow water) to 3.12 (deep water) for PO₄-P; 4.67 (shallow water) to 37.60 (deep water) for NO₂+NO₃-N and 0.13 (shallow water) to 45.67 (deep water) for SiO₄-Si.
- 6. In all stations the least recorded dissolved oxygen ml/l was 2.5 (deep water) and the highest was 4.8 (shallow water).

7. The chlorophyll *a* and phaeopigment concentration recorded was 0.10 to 0.46 mg/m³ in all stations of Taninthayi coastal water depths.

In Taninthayi coastal region, 12 hydrographic transects were made across the shelf. The temperatures at depth of 5 m in this region tended to be slightly cooler than in the regions further north. The temperatures were typically about 27-29 °C at this depth though slightly lower ~ 26.5 -27 °C at some north-eastern stations near the coast. Salinity at 5 m was generally above 31 ‰ and increasing towards the east and south. The highest 5 m levels were encountered in the most southerly area in some cases with values between 31-34 ‰. Oxygen concentrations at 5 m depth in this region were generally between 2.4-4.8 ml/l with levels in the higher part of this range and at some stations also > 4.8 ml/l in the eastern part of the area near the coast. The fluorescence levels throughout the Taninthayi coastal region were comparatively low, only with a few stations in the north-eastern part displaying slightly higher values. One particular station, 1331 displayed very high fluorescence at the shallow water depth 0-30 m also had a high chlorophyll *a* level ~ 5 m.

The gradual increased numbers of ichthyoplankton was observed and that might be possibly due to a gradual increase the nutrients that most substantial import of phosphate into the Rakhine Coastal Region occurs by subsurface inflow of the water mass from Ayeyawady Delta and Gulf of Martaban Coastal water from study period. Physical and chemical factors have a significant impact in the increase and decrease of ichthyoplankton; during the present study, a model was adopted to show the correlation between physical and chemical factors and total ichthyoplankton numbers. Accordingly, in all intermediate and deep water stations showed the highest correlation while shallow water stations showed the least correlation. This may be explained by natural (rain water runoff for instance) and or human impact (port activities).

The present work was the relation of regression analysis to correlate total ichthyoplankton with the physical and chemical parameters in Myanmar waters. The parameters with high attribute to total ichthyoplankton numbers and the most parameter affecting them. Dissolved oxygen, transparency and NO₂+NO₃-N were positively correlated with total numbers of ichthyoplankton. The impact of other parameters varies from one station to the other with highest frequency for oxygen followed by NO₂+NO₃-N and pH. It was clear that salinity was the most significant factor affecting ichthyoplankton community as shown in the numbers of ichthyoplankton and salinity values. Matrix analysis and regression analysis showed that there was a linear correlation between the ichthyoplankton and environmental parameters from Myanmar coastal waters.

In all the stations, the environmental correlation factors have a tendency to control or regulate fluctuations of fish larvae. According to the nutrients and hydrology analysis, the distribution of larvae was found positive relationship in southern part of the Rakhine Coastal Region. These nutrients and physical data can be related in more detail for instance by evaluating different geographical areas as well as individual stations regions separately. All of the physico-chemical parameters showed the physical and biological processes governing the nutrient patterns, data can be related to datasets for ichthyoplankton variables obtained during the study.

All analyzed samples for size-fractioned ichthyoplankton biomass were completed at the IMR (Institute of Marine Research, Bergen, Norway) laboratory facilities during the first months

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of 2014. Initial exploration of the results from the WP 2 net samples show that the stations with the largest biomass are positively correlated with areas of high fluorescence, nutrient levels and frontal zones with high rates of mixing water masses and areas with high phytoplankton diversity. In a couple of cases the high biomass was highly influence by incidental collection of large individuals on the > 2000 μ m size fraction. The different size fractions also display a tendency of gradually larger fractions with smaller individuals from the deeper shelf areas towards the coast.

4.5 Community structure of ichthyoplankton in Mon coastal water

In the present study, 45 species of fish larvae namely Saurida tumbil, Coilia dussumieri, C. ramcarati, Setipinna taty, Stolephorus insularis, Thryssa hamiltonii, Anodontostoma chacunda, Dussumieria acuta, D. elopsoides, Reconda russeliana, Sardinella longiceps, S. brachysoma, Chirocentrus dorab, Elops machnata, Megalops cyprinoides, Alepes djeddaba, A. melanoptera, Carangoides ferdau, C. malabaricus, Megalaspis cordyla, Apocryptes bato, A. lanceolatus, A. serperaster, Periophthalmus barbarus, Gerres abbreviates G. filamentosus, Thalassoma lunare, Lutjanus lutjanus, L. russelli, L. sebae, Upeneus tragula, Nemipterus japonicas, Johnius coitor, Otolithoides ruber, Rastrelliger brachysoma, Scomberomorus commerson, S. guttatus, Epinephelus radiates, E. fasciatus, Terapon jarbua, Trichiurus lepturus, Engyprosopon grandisquama, Cynoglossus cynoglossus, C. lingua, and Gastrophysus lunaris, were observed in nine sampling sites of Mon coastal water. The systematic classification of ichthyoplankton in Mon coastal water was shown in table 4.

Phylum	Chordata			
Class	Actinopterygii			
Order	Family	Sr. No.	Genus and species	
Aulopiformes	Synodontidae	1	Saurida tumbil	
		2	Coilia dussumieri	
		3	C. ramcarati	
	Engraulidae	4	Setipinna taty	
		5	Stolephorus insularis	
		6	Thryssa hamiltonii	
Chunciformos	Clupeidae	7	Anodontostoma chacunda	
Ciupenonnes		8	Dussumieria acuta	
		9	D. elopsoides	
		10	Reconda russeliana	
		11	Sardinella longiceps	
		12	S. brachysoma	
	Chirocentridae	13	Chirocentrus dorab	
Floniformos	Elopidae 14		Elops machnata	
Liophonnes	Megalopidae	15	Megalops cyprinoides	

Table 4: List of ichthyoplankton in Mon coastal water

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Phylum	Chordata			
Class	Actinopterygii			
Order	Family Sr. No. Genus and spec		Genus and species	
		16	Alepes djeddaba	
		17	A. melanoptera	
	Carangidae	18	Carangoides ferdau	
		19	C. malabaricus	
		20	Megalaspis cordyla	
		21	Apocryptes bato	
	Cabiidaa	22	A. lanceolatus	
	Goolidae	23	A. serperaster	
		24	Periophthalmus barbarus	
	Correideo	25	Gerres abbreviatus	
	Generuae	26	G. filamentosus	
	Labridae	27	Thalassoma lunare	
Doroiformoo		28	Lutjanus lutjanus	
Perciformes	Lutjanidae	29	L. russelli	
		30	L. sebae	
	Mullidae	31	Upeneus tragula	
	Nemipteridae	32	Nemipterus japonicus	
	Sciaenidae	33	Johnius coitor	
		34	Otolithoides ruber	
	Scombridae	35	Rastrelliger brachysoma	
		36	Scomberomorus commerson	
		37	S. guttatus	
	Serranidae	38	Epinephelus radiatus	
	Serramaae	39	E. fasciatus	
	Teraponidae	40	Terapon jarbua	
	Trichiuridae	41	Trichiurus lepturus	
	Bothidae	42	Engyprosopon grandisquama	
Pleuronectiformes	Cynoglossidae	43	Cynoglossus cynoglossus	
	Cynogiossidae	44	C. lingua	
Tetraodontiformes	Tetraodontidae	45	Gastrophysus lunaris	

Identification of ichthyoplanktons was based from collections made at different kinds of aquatic habitats (river mouths, estuaries and shallow marine waters) and from nine stations: namely, Koe-te-su, Zot-ka-li, Aung-kan-tha, Ahlyat, Zee-gone, Hin-tha-kyun, Ka-don-paw, Setse and Kyun-gyi, of Mon coastal waters during the study period from January 2014 to December 2015. On the basis of their morphological characteristics the following 45 species of marine and estuarine fish larvae were identified and recorded in Mon coastal water. Each characteristics description of ichthyoplankton was mentioned by the following procedure.

CHARACTERISTICS OF ICHTHYOPLANKTON



Photographs showing important characters

4.6 Physical environmental parameters of Mon coastal water

Mon coastal water is characterized by a wide variation in physical parameters. The movement and distribution of fishes in Mon estuaries and coastal waters are mainly affected by physical factors. Physical structures of the environment such as the bottom substratum and mangrove root structure also influence the composition and distribution of estuarine fishes. Physical environmental parameters such as water temperature, salinity, dissolved oxygen and transparency of Mon coastal waters were measured during the two years study period of 2014 and 2015.

Rainfall in Mon State which contributes to alteration in river flow, salinity and turbidity exerts a great influence on the dynamics of estuarine fishes namely, the breeding cycle, recruitment and maintenance. Freshwater inflow into the estuary changes the flow rates and influences the salinity and turbidity. Currents is a dominant feature of estuarine tidal flux but only used by fishes that are able to orientate at the surface (Mundy 1990).

During the study period, temperature is also one of the physical orientation factors for larvae because fish exhibit both temperature tolerance and preference. The majority of studies on the relationship between temperature and migration however, describe temperature-initiated migration out of an area. The effects of temperature on larval abundance and distribution are more obvious in temperate countries experiencing marked seasonal variations of temperature than in tropical countries.

In this study the earliest developmental stages for fish after hatching represent a critical phase for the survival of a species especially in estuaries where the salinity varies widely. Hence, the variations in salinity can affect larval distribution but only to a lesser extent compared to the effect of turbidity. Turbidity attenuates light penetration in the water and thus, affects larval distribution. Depending on the nature of the suspended particles, some wavelengths are absorbed which consequently affect the colour and the transparency of prey and predator.

Transparency of study areas is positively correlated to the water current and surface wind speed and could reduce larval mortality by predation. High turbidity increases zooplankton density in surface waters which in turn, promotes an increase in the number of filter-feeding fish in turbid areas. Changes in the estuarine turbidity gradient associated with the monsoons have been proposed as a cue for postlarvae and juveniles to locate their nursery grounds.

The pH also affects the survival of fish larvae along the Mon coastal water. For example, an increase in pH from 6.5 to 7.5 greatly improves the survival of American shad larvae, but had little effect on their growth rate (Lawler *et.al* 2004). On the other hand, a sudden drop of pH from 7.0 to 6.0 can be lethal to these larvae.

The positive correlation between the abundance of primary producers, secondary producers and larval abundance has been reported in many studies (e.g. Welker *et. al* 1994 on the Peruvian anchovy; Tunvilai *et. al* 1986 on fish larvae in Thailand). Phytoplankton and zooplankton abundance and diversity have been positively related to rainfall, and subsequent river flow which carries a relatively high amount of nutrients from run-off. Therefore, in Mon coastal waters which experience little annual temperature fluctuations, the onset of two monsoon seasons with higher rainfall, appears as favorable period for larval survival and has been linked to the main breeding season for marine fishes (e.g. *Stolephorus* species).

4.6.1 Physical environmental parameters in 2014

The overall month-wise reading of each parameter at the station was given in the followings were apparent:

- 1. In all stations, the least recorded water temperature was 23.0°C at Setse station in December and the highest water temperature was 32.0°C at Koe-te-su station in October, Setse station in May and Kyun-gyi station in November.
- 2. Highest salinity ranged was 34.5 ‰ at Zot-ka-li station in May, but in shallow water station of Ka-don-paw water approximately showed the lowest salinity was 20.9 ‰ in May.
- 3. The pH readings ranged was 8.80 (highest value) at Zee-gone station in June and the lowest pH value was 7.04 at Koe-te-su station in March.
- 4. The dissolved oxygen in ml/l ranged was 9.3 (highest amount) at Ahlyat station in September and 4.5 (lowest amount) at Koe-te-su station in October and Hin-tha-kyun station in September.

5. In all stations the least recorded transparency was 0 m at Koe-te-su station in June, July, August and September; Zot-ka-li station in July; Ahlyat station in May, June, July, August, and September; Zee-gone station in January, March, April, May, June, July and December; Hin-tha-kyun station in July, August, September, October, November and December; Ka-don-paw station in January, June, July, August and September; and the highest turbidity was 6 m at Aung-kan-tha station in February and May; and Kyun-gyi station in February.

4.6.2 Physical environmental parameters in 2015

The over all month-wise reading of each parameter at the station was given in the followings were apparent:

- 1. In all stations, the least recorded water temperature was 25.5°C at Ahlyat station in April and the highest water temperature was 31.0°C at Aung-kan-tha station in December and Kyun-gyi station in January.
- Highest salinity ranged was 32.5 ‰ at Zot-ka-li station in March, May, September and November; Aung-kan-tha station in September; Ahlyat station in February; Hin-tha-kyun station in March; Ka-don-paw station in December; Setse station in May and Kyun-gyi station in January but in shallow water station of Setse showed the lowest salinity was 28.5 ‰ in August.
- 3. The pH readings ranged was 9.21 (highest value) at Zee-gone station in May and the lowest pH value was 7.07 at Ahlyat station in January.
- 4. In all stations, the least recorded dissolved oxygen ml/l was 4.5 at Koe-te-su station in April and Aung-kan-tha station in January and the highest was 7.8 at Kyun-gyi station in February.
- 5. In all stations the least recorded transparency was 0 m at Koe-te-su station in May, July and October; Zot-ka-li station in May, June, September and November; Aung-kan-tha station in September, October, November and December; Ahlyat station in June, July, August, September, October and November; Zee-gone station in March, July, August, September and October; and Ka-don-paw station in April and May and the highest turbidity was 6 m at Kyun-gyi station in July, September and October, respectively.

4.7 Biomass and diversity of ichthyoplankton in Mon coastal water

During the two years study period of 2014 and 2015, ichthyoplankton biomass ranged between 2.491 ml/m³ and 0.311 ml/m³ in 2014, and 2.724 ml/m³ and 0.389 ml/m³ in 2015. In 2014, the highest biomass values were *Sardinella brachysoma* (2.491 ml/m³) followed by *Alepes djeddaba* (2.335 ml/m³), *Trichiurus lepturus* (1.635 ml/m³), *Saurida tumbil* and *Carangoides malabaricus* (1.401 ml/m³) and *Nemipterus japonicus* (1.323 ml/m³). The least biomass in 2014 was *Upeneus tragula* (0.311 ml/m³). In 2015, the highest biomass values were *Saurida tumbil* (2.724 ml/m³) followed by *Alepes djeddaba* (2.491 ml/m³), *Coilia ramcarati, Apocryptes lanceolatus* and *Gastrophysus lunaris* (1.401 ml/m³), *Nemipterus japonicus*, *Scomberomorus guttatus* and *Cynoglossus lingua* (1.323 ml/m³) and *Coilia dussumieri*, *Stolephorus insularis*,

Upeneus tragula, Epinephelus radiates and *Cynoglossus cynoglossus* (1.245 ml/m³). The least biomass in 2015 was *Alepes melanoptera* (0.389 ml/m³).

According to the species frequency of occurrence, the most frequent species were Sardinella brachysoma (75%), Alepes djeddaba (100%), Carangoides malabaricus (91.67%), Megalaspis cordyla (75%), Nemipterus japonicus (100%), Otolithoides ruber (75%), Scomberomorus commerson (75%) and Trichiurus lepturus (100%) recorded in 2014. Single infrequent species of less than 10% was Upeneus tragula (8.33%) recorded from shallow estuaries of Mon coastal shoreline in 2014. The most frequent species of 2015 were Saurida tumbil (100%), Coilia ramcarati (75%), Stolephorus insularis (75%), Alepes djeddaba (91.67%), Upeneus tragula (75%), Nemipterus japonicus (83.33%), Epinephelus radiates (75%), Cynoglossus (75%), Cynoglossus lingua (75%) and Gastrophysus lunaris (83.33%), respectively. In 2015, infrequent species of ichthyoplankton were not recorded.

The species diversity of ichthyoplankton in Mon coastal water was observed by using the three diversity indices such as Shannon-Wiener (1963) species diversity index (H') for determining the number of individuals of each species in the study areas, Pielou's (1975) species evenness (J') for measuring the relative abundance of the various population present in the study areas and Margalef' (1958) species richness (R') to measure the number of different species present in the study areas. During the present study, ichthyoplankton diversities ranged between 2.451 and 0 for species diversity (H'), 1.009 and 0 for species evenness (J') and 1.548 and 0 for species richness (R') in 2014, and 2.459 and 0.693 for species diversity (H'), 1.000 and 0.980 for species evenness (J') and 1.484 and 0.177 for species richness (R') in 2015.

In 2014, the highest species diversity (H) was observed in Trichiurus lepturus (2.451) followed by Nemipterus japonicus (2.449); Alepes djeddaba (2.423); Carangoides malabaricus (2.394) and Megalaspis cordyla (2.191). The highest species evenness (J') of 2014 was Saurida tumbil (1.009) followed by Dussumieria acuta (1.0); Coilia ramcarati, Carangoides malabaricus and Lutjanus lutjanus (0.998); Setipinna taty, Anodontostoma chacunda, Megalaspis cordyla and Lutjanus russelli (0.997) and Elops machnata and Cynoglossus lingua (0.996), respectively. The highest species richness (R') was Nemipterus japonicus (1.548) followed by Alepes djeddaba (1.515); Trichiurus lepturus (1.502); Carangoides malabaricus (1.384) and Scomberomorus commerson (1.191) recorded in 2014. The least species diversity, species evenness and species richness was Upeneus tragula (0) found in river mouth areas of Mon coastal water.

In 2015, the highest diversity (H') was observed in Saurida tumbil (2.459) followed by Alepes djeddaba (2.351); Gastrophysus lunaris (2.292); Nemipterus japonicus (2.291) and Stolephorus insularis (2.187). The least species diversity (H') was Alepes melanoptera (0.693) recorded during the study period of 2015. The highest species evenness (J') of 2015 was Alepes melanoptera (1.0) followed by Dussumieria elopsoides, Megalops cyprinoides and Gerres filamentosus (0.999); Thryssa hamiltonii, Elops machnata, Carangoides malabaricus and Lutjanus lutjanus (0.998); Carangoides ferdau, Apocryptes serperaster, Lutjanus russelli and Johnius coitor (0.997) and Lutjanus sebae (0.996). The lowest species evenness (J') of 2015 was Alepes djeddaba (0.980). The highest species richness (R') was Saurida tumbil (1.484) followed by Alepes djeddaba (1.363); Nemipterus japonicus (1.264); Gastrophysus lunaris (1.254) and

Epinephelus radiates (1.134) recorded in 2015. The lowest species richness (R') of 2015 was *Alepes melanoptera* (0.177).

The range of standard deviation of ichthyoplankton in Mon coastal waters was 0 ± 76.46 (*Upeneus tragula* \pm *Sardinella longiceps*) in 2014 and 5.66 \pm 48.76 (*Alepes melanoptera* \pm *Alepes djeddaba*) in 2015. According to the percentage constancy of occurrence, the maximum and minimum occurrence was *Sardinella brachysoma* (3.92%) and *Upeneus tragula* (0.42%) in 2014, and *Saurida tumbil* (3.83%) and *Alepes melanoptera* (0.65%) in 2015. The total composition and abundance of ichthyoplankton was 40341/m³ and mean abundance was 896.467/m³ in 2014. In 2015, the total composition and abundance of ichthyoplankton was 961.622/m³. The most species distribution was found in June, 2014 and the least species distribution was recorded in June and January 2015.

4.8 Community structure of ichthyoplankton in Mon coastal water

The similarity cluster indicated the presence of four major groups based on larval number in species with roughly similar abundance and constructed with 10 clades and 12 leaves. The first group was characterized by two months which were January and February. They were similar sharing of five months namely March, April, May, June and July. Within the first group January $(1982/m^3)$ was the first and February $(1868/m^3)$ was the second most abundant. The second group comprised five months, March, April, May, June and July. Likewise, June (4942/m³) was the most abundant and July $(4364/m^3)$ larvae ranked the second. This group can be divided into 4 subgroups. In the months of March and April, the first subgroup comprised March-April $(2668/m^3 - 3444/m^3)$ and followed by the second subgroup April-May $(3444/m^3 - 3795/m^3)$, the third subgroup Mav-June $(3795/m^3 - 4942/m^3)$ and the last subgroup June-July $(4942/m^3 -$ 4364/m³) respectively and was sharing by 5 months. The third group consisted of two months August $(5077/m^3)$ and September $(4173/m^3)$; these two months not comprised subgroup. The fourth group was shared by three months of October (2668/m³), November (2849/m³) and December $(2511/m^3)$. This fourth group included 2 subgroups of October-November $(2668/m^3 -$ $2849/m^3$) and November-December ($2849/m^3 - 2511/m^3$). Based on the simple linkage analysis of dendrogram, the maximum and minimum similarity of cluster range was August $(5077/m^3)$ in group 3 and February (1868/m³) in group 1 in 2014. The binary similarity coefficient analysis of Sorensen similarity index (S_s) values comparing species composition between sampling months were recorded and they ranged from 0.22 (minimum similarity at July) to 0.66 (maximum similarity at August).

The similarity cluster analysis indicated the presence of four groups in this study period of 2015. The dendrogram classification of ichthyoplankton assemblage with composed of 10 clades and 12 leaves. The first group was characterized by two months, January (1936/m³) and February (2946/m³). This group was shared by group 2. The second group was given to three months, March (3486/m³), April (3636/m³) and May (3612/m³). The sharing months belonged to this group were January, February, march, April and May. The second group comprised 2 subgroups, March-April (3486/m³-3636/m³) and April-May (3636/m³-3612/m³). The third group consisted of four months, June (4569/m³), July (4153/m³), August (4889/m³) and September (5480/m³). The third group was distinguished as 3 subgroups, June-July (4569/m³-4153/m³),

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June-August ($4569/m^3$ - $4889/m^3$) and June-September ($4569/m^3$ - $5480/m^3$). In this subgroup, the similarity cluster of June comprised three months of third month group of July, August and September. The fourth group of similarity was October ($2978/m^3$), November ($3391/m^3$) and December ($2197/m^3$). The fourth group was shared by 2 subgroups October-November ($2978/m^3$ - $3391/m^3$) and November-December ($3391/m^3$ - $2197/m^3$). Based on the simple linkage analysis of dendrogram, the maximum and minimum similarity of cluster range was September ($5480/m^3$) in group 3 and February ($1936/m^3$) in group 1 in 2015. The binary similarity coefficient analysis of Sorensen similarity index (S_s) values comparing species composition between sampling months were recorded and they ranged from 0.18 (minimum similarity at April) to 0.58 (maximum similarity at December). The four groups of 1, 2, 3 and 4 were characterized by 9 stations of Mon coastal waters and where comprised 21 families and 45 species was a great similarity and clusters linked with species by monthly survey of 2014 and 2015.

4.9 Seasonal composition and abundance of ichthyoplankton in Mon coastal water

The different monsoon seasons and environmental conditions are likely to affect composition and abundance of ichthyoplankton in estuarine and open sea habitats. In Mon coastal water, the effect of monsoon has been considered as one of the most important variable affecting the seasonal patterns of fish abundance. The correlation between larval fish abundance and monsoon season is usually associated with an increase in plankton availability at the onset of the rainy season. The abundance of total fish larval density in the present study was significantly higher during monsoon than premonsoon at the river mouth of Sittaung and Thanlwin. There were 45 species recorded for the two years studies during the premonsoon (February-May), monsoon (June-September) and postmonsoon (October-January) season, out of which two families were dominant, Gobiidae and Engraulidae. Both families were also found in great numbers in the mangrove estuary and adjacent waters during the two years sampling where 21 fish larval families were found. In this study, estuary-spawing of ichthyoplankton showed highest abundance during the premonsoon and postmonsoon season while the coastal-spawning species during the monsoon season. The composition and abundance of ichthyoplankton ranged from 10010/m³ (postmonsoon) to 18556/m³ (monsoon) in 2014 and from 10502/m³ (postmonsoon) to 19091/ m³ (monsoon) in 2015. The seasonal composition and abundance of ichthyoplankton recorded 1868/m³ (February) - 3795/m³ (May) in premonsoon, 4173/m³ (September) - 5077/m³ (August) in monsoon and 1982/m³ (January) - 2849/m³ (November) in postmonsoon, 2014 and $2946/m^3$ (February) - $3636/m^3$ (April) in premonsoon, $4153/m^3$ (July) - $4889/m^3$ (August) in monsoon and 1936/m³ (January) - 3391/m³ (November) in postmonsoon, 2015 at different nine stations in estuarine and marine habitat of Mon coastal water.

Discussion

In Myanmar coastal water, a total of 40 families of fish larvae were collected and analyzed for identification from the Rakhine Coastal Region (RCR, 15 stations, R1-R15: 1144-1211); the Ayeyawady Delta and Gulf of Martaban Coastal Region (ACR, 11 stations, A1-A11: 1218-1289) and the Taninthayi Coastal Region (TCR, 12 stations, T1-T12: 1295-1354). The survey was conducted by the extensive ecosystem cruise of R/V Dr Fridtjof Nansen during November 13- December 19 in 2013.

All of the fish larvae were identified to the taxonomic level of family. Each of the recognized larval characteristics was significantly similar or different in their family key structures. There are many variations in schemes used to classify the early life stages of fish. Identification and distinct morphological features of fish larvae in Myanmar coastal water based on parts of their body shape, larval pigmentation and morphometric characters of family specific characteristics agreed with Hubbs & Lagler 1964; Moser & Ahlstrom 1970; Miller & Jorgenson 1973; Miller & Sumida 1974; Ahlstrom & Moser 1976; Weihs & Moser 1981; Moser *et.al* 1977; Theilacker 1980; Moser 1981; Moser 1981; Fujita 1990; Puewkhao 1996; Richards 2006; Konishi 2012; Servidad 2014; Duangdee 2015 and Termvidchakorn 2016.

Ichthyoplankton diversity in Myanmar coastal water showed a considerable community of fish eggs, larvae and postlarvae. The highest diversity value was found at Taninthayi coastal water in Andaman Sea. This result was similar to previous studies of ichthyoplankton abundance and diversity in Andaman Sea (Chamchang 2006). Annual production of fish in the northwest Indian Ocean of Red Sea, Arabian Sea and Persian Gulf and southeast Indian Ocean of NW continental shelf, Australia depend on ichthyoplankton diversity reported by Nellen (1973). The total fish larvae of 40 families found in this present study seem to have lower diversity than the previous works that conducted in more productive area of the other part of the Indian Ocean. In 1987, Predalumpaburt reported that the composition and abundance of 55 and 62 families of fish larvae were found from the west coast of Thailand in 1982 and 1983, respectively. This information indicated that the Andaman Sea was an area of high diversity of fish larvae in the Indian Ocean.

The ratio of constancy of occurrence in RCR and TCR were 3:1: 0, but ACR was 14:2: 1. This study was similar to Chamchang (2006) who reported a relatively low number of constant families suggesting the system appeared not to be stable in the Andaman Sea along the west coast of Myanmar. The relatively large numbers of inshore-reef families and neritic families, particularly area TCR, may also indicate that the Andaman Sea is the connected boundary of inshore and oceanic currents. In addition, the occurrence of many accidental families possibly reflects that the majority of the adult fish existing in the Andaman Sea are commonly inshore residents and their larvae are occasionally carried out offshore by currents. In this study the most abundant families were Gobiidae, Scombridae, Lutjanidae, Carangidae, Elopidae, Megalopidae, Bothidae, Clupeidae and Engraulidae.

Larvae of the commercially important fish were not very high in number. The total abundance of larval families was common in three coastal regions of Myanmar water which in addition appeared in considerable quantities at some stations in the Andaman Sea. Very important to high sea fisheries, inshore-reef fish (Gobiid larvae, Lutjanid larvae, Bothid larvae and Cynoglossid larvae), neritic fish (Clupeid larvae, Carangid larvae and Engraulid larvae), and shallow-oceanic fish (Elopid larvae, Megalopid larvae and Scombrid larvae), oceanic fish (Exocoetid larvae, Acropomatid larvae and Trichiurid larvae) appeared more frequently in TCR but their density was not remarkably high at any stations. This present study showed that mean occurrence was the highest in RCR (9.286) followed by TCR (7.850) and ACR (7.182) respectively.

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Considering area TCR which is in the southern part of the Myanmar coast, both in hydrographic conditions and fisheries resource information are not available except a few information in the lower part along the coast of Myanmar. Within TCR and RCR, fish larvae samples contained higher total densities (43.60 and 34.69 No/m³) than those for ACR samples (23.51 No/m³). There were no considerable differences in larval composition between day and night samples during the study periods. Based on the family-wise occurrence and abundance, the values of diversity index, the evenness and richness indices, Rakhine Coastal Region was characterized by the highest degree of larvae diversity and richness in relation to all investigated stations. The analysis showed that during the sampling period there was a significant positive correlation between environment and collecting larvae which as already stated, were found in the Bay of Bengal is influenced by open sea.

The physico-chemical parameters of the Myanmar coastal water followed a pattern of seasonal variation which is typical of many inshore coastal waters in tropical countries. The variation of some parameters such as air and water temperature, transparency, salinity, pH, phosphate, nitrite+nitrate, silicate and D.O were observed while for the nutrients, Chlorophyll *a* content in seawater, the data were taken only for the extensive ecosystem study cruise of R/V Dr Fridtjof Nansen during November 13- December 19 in 2013. At Rakhine Coastal Region the total mean index of parameters was analyzed based on a set total ranged of three water layers. Low diversity of pelagic species was found in Ayeyawady Delta and Gulf of Martaban Coastal Region. The planktonic larvae and nutrients distribution were generally found at longer distance from the coast line than in RCR, but at the same depth. In the delta area collected rates generally declined compared to the Rakhine Coastal Region. The most common species group and nutrients collection slightly related to the inner shelf (20-50 m) depth.

In the southern region, the Taninthayi coast, collection rates were generally higher than in the delta region and Rakhine coast. Highest related rates for fish larvae were found on the outer shelf and on the slope. On the inner shelf the ichthyoplankton species was the most abundant. Deeper than 400 m stations, the concentration of phosphate, nitrite+nitrate and silicate were relatively high and larvae species were found in some quantity in the region in addition to the group of other species with average correlation value ~ 1 . Matrix analysis and regression analysis showed that these areas were highly affected correlation between the ichthyoplankton and environmental parameters. The correlation value ~ 1 showed that the positive relationship between the larvae and parameters at various water depths.

Nutrients concentration generally varied strongly with depth, and particularly nitrate, silicate and phosphate concentration spanned large ranges. The concentrations of nitrite were typically highest at depth of about 50 m, although never reaching to above 21 mg/l at any station or depth. Silicate and phosphate values were higher in the 0-25 m stratum for stations closer to the coastline compared to the same depth stratum for stations with bottom depths of 100 and 500 m. A few comparatively high? or low? values of Chlorophyll *a* between 0.21-0.25 mg/m³ were observed near the coast, comprising two stations in the Ayeyawady Delta and Gulf of Martaban Coastal Region as well as one coastal station further south in the Taninthayi Coastal Region where fluorescence also was very high at depth of 6 m. The measurements of some physico-chemical parameters of Myanmar waters were carried out concurrently with the study of ichthyoplankton community structure, covering all the 38 environmental sampling stations.

The community of ichthyoplankton correlated with depth-wise environmental parameters in Myanmar coastal water. The regression values showed that dependence levels of fish larvae abundance and sampling rates on temperature, salinity and nutrients were strong correlation coefficients between the water layers of 0-30 m, 0-100 m and 0-500 m. In contrast to these findings, Madhupratap *et.al* (2003) studied on the distribution of nutrients in the Bay of Bengal pointed out that there was direct relationship between the plankton collection and physicochemical parameters. Chamchang (2006) also found a significant positive correlation between spatial monsoonal nutrients and ichthyoplankton communities in the Andaman Sea.

In 2014 and 2015, the community structures of ichthyoplanktons were emphasized on different areas of Mon coastal waters such as Koe-te-su, Zot-ka-li, Aung-kan-tha, Ahlyat, Zee-gone, Hin-tha-kyun, Ka-don-paw, Setse and Kyun-gyi. During the two years study period, the morphology description of ichthyoplankton and tentative key on systematic position such as phylum, class, order, family, genus and species of 45 species of fish larvae were described mainly based on external morphologies such as myomeres counts, snout, mouth and body shape, gut style, gas bladder position, head spination formed, eyes position, fin formation, meristics characters and pigmentation of the species.

According to Htay Htay Mon (1995) observation, 8 fish larvae families such as Chirocentridae, Tetraodontidae, Polynemidae, Periophthalmidae, Mugilidae, Sciaenidae, Gobiidae and Engraulidae were found in small number from February to October although Gobiidae was found in Mawlamyine River during November, December and October. In November it was very rare and in December it was present in appreciable number whereas in October it was taken in fairly large number. The only family commonly found or encountered throughout the year was Periophthalmidae. Although the planktonic fish larvae of Periophthalmidae was rarely found during premonsoon months which is known to be its breeding season, this fish larvae reached its maximum abundance during monsoon month of August.

Species-specific behavioral responses to physical factors may result in different distributions among fish larval families within the vertical turbulence and mixing processes (Sundby 1996). The water characteristics of Mon coastal estuaries are not highly variable in the sense that parameters such as salinity, temperature, pH, transparency and dissolved oxygen concentrations do not fluctuate greatly both temporally and spatially. Rissik *et.al* (2009) reported the distribution and dispersal of early life stages are linked to physical and biological conditions as well as to larval developmental stage. In this study, the recorded values of physical parameters correlated with species-environmental parameters in both study periods. Salinity appeared to be the most significant factor influencing the distribution and abundance of most larval fish.

Lutjanid, Sciaenid, Cynoglossid, Carangid and Scombrid larvae generally preferred more saline, well oxygenated offshore waters. All larval stages of the Gobiidae, the postflexion and postlarvae of Elopidae and Mullidae were more abundant in the less saline, zooplankton richer water inside the mangrove estuary. Also in the mangrove estuary were the Trichiuridae and Teraponidae which preferred the more turbid, cooler and greener water. Madhupratap *et.al* (2003) reported the physico-chemical parameters and primary productivity effects related with ichthyoplankton diversity in central and western Bay of Bengal. Temperature is critical for the development of temperate marine phytoplankton and zooplankton populations or communities. Highly variable temperature may influence species diversity that led to the dominance of larval fish communities by a few species. The mean temperature inside the Mon coastal waters fluctuated between 24.2°C and 31.5°C.

Higher turbidity level during the rainy season could lead to higher abundance of engraulids in this study. The pH and DO concentrations could be an important factor influencing predator-prey interactions (Harris *et.al* 2001). In the present study, flexion, postflexion and juveniles of fish larvae were also closely associated with higher pH and their planktonic food found in the river mouth and mangrove estuary. The shallow water shelf of Mon coastal estuaries were typically characterized by larvae of estuary-resident species in the families Engraulidae, Clupeidae, Chirocentridae, Elopidae, Gobiidae, Gerridae, Labridae, Lutjanidae, Mullidae, Nemipteridae, Sciaenidae, Teraponidae, Trichiuridae, Bothidae and Cynoglossidae. These families are also the most abundant in larval fish assemblages in warm-temperate (Franco *et.al* 2006; Harrison & Whitfield 2006).

In this study, distribution and occurrence, composition and abundance, biomass and diversity of ichthyoplankton were detectable in river mouth areas, mangrove estuaries, inner shallow shelf and offshore waters of Mon State. Pattrick *et.al* (2007) proposed that the highest composition, abundance and seasonal distribution of ichthyoplankton were found at Mngazi Estuary of South Africa. In 2014 and 2015, the highest distribution of fish larvae recorded in June and the lowest distribution in January. The total occurrence and mean occurrence of fish larvae were 301 and 6.689 in 2014 and 311 and 6.911 in 2015, respectively. The total composition and mean abundance of ichthyoplankton were 40341/m³ and 896.467/m³ in 2014 and 43273/m³ and 961.622/m³ in 2015, respectively. The highest biomass value was *Sardinella brachysoma* (2.491 ml/m³) in 2014 and *Saurida tumbil* (2.724 ml/m³) in 2015. Postel *et.al* (2000) and present research (2014-2015) observed that *Sardinella brachysoma* and *Saurida* were highest biomass and the most frequency of occurrence in shallow coastal waters.

Larval fish densities and species richness of Mon coastal areas were higher in late summer and rainy season than in any other season sampled. However, there were no statistically significant differences in community structure between seasons. This phenomenon was attributed to the dominance of estuarine residents, which were present in all seasons sampled. Similar findings were obtained by Strydom *et.al* (2003), Pattrick *et.al* (2007) and Taylor *et.al* (2015) in estuaries from the southeast coast of South Africa. The evaluation of similarity revealed that coefficient of cluster analysis in 2014-2015, respectively ichthyoplankton species associated between the 8 clusters were (0.22-0.66 and 0.18-0.58). It indicated the positive association among individuals and species.

In 2014, the highest species diversity (H') was 2.451 for *Trichiurus lepturus* species evenness (J') was 1.009 for *Saurida tumbil* and species richness (R') was1.548 for *Nemipterus 188aponicas* (1.548). The highest diversity (H') was *Saurida tumbil* (2.459), species evenness (J') was *Alepes melanoptera* (1.0) and species richness (R') was 1.484 for *Saurida tumbil* recorded in 2015. This finding was similar to Vinayachandran *et.al* (2002) and Wen-Yu *et.al* (2010) who reported that the numbers of individuals of each species, the relative abundance of the various populations present and the number of different species present of ichthyoplankton in Bay of Bengal were not differ between the indices during the summer monsoon period.

Summary

In the present study, a total of 40 larval families were collected and identification is based on their morphologies of external characteristics. 26 families represented economically important group from the continental shelves, the offshore banks and oceanic regions of Myanmar. The deep water areas of the Rakhine and Ayeyawady Delta were characterized by a low number of family and high numbers of individuals of mesopelagic or mesopelagic species. It was observed that not many families distributed widely in the Bay of Bengal and the Andaman Sea whilst a large number accidentally occurred. Overall, TCR appeared to have the richest diversity of fish families and also the highest average abundance of fish larvae compared to RCR and ACR. Moreover, larval fish abundances were higher in the Andaman front region than in the RCR and ACR shelf region, but abundances of relatively different species significantly varied between the shelf and off the shelf. Thus, it could be concluded that the spatial distribution of the dominant species associated with the Andaman front strongly affect the survival strategy of the early life stages by larval transport.

Along the different water masses of Myanmar coastal water showed the distribution of nutrients; nitrite+nitrate, silicate and phosphate uniformly increased with depth at all stations. The present study revealed the physical characteristics and the distribution of nutrient concentrations together with their associated chlorophyll *a* on the long and short-terms basis. According to the Chl *a* contents with the existing nutrient levels, the water quality of the study area from the point of production and fertility is considered high and healthy in Taninthayi Coastal Region. The coastal water of Myanmar including the area adjacent to the shoreline was generally considered clear. Sea surface salinity variations in Myanmar continental shelf was relatively high in shallow water mass. This positive correlation of salinity and ichthyoplanktons showed the sharp and strong relation of north-south gradients along the shelf.

The community structures of ichthyoplankton in nine different stations of Mon coastal waters were conducted from January, 2014 to December, 2015. A total of 45 species, 32 genera, 21 families and 6 orders belonging to class Actinopterygii under the phylum Chordata were identified. The estuarine species represented as the dominant group followed by the marine species as the second group in Mon coastal areas. The distribution and abundance of fish larvae were related to environmental parameters and the water characteristics of Mon coastal estuaries are not highly variable both temporally and spatially. The total composition and mean abundance were correlated with minimum amd maximum similarity of ichthyoplankton assemblages. Ichthyoplankton biomass values are in the same range (0-2 ml/m³) and there is a clear uniformity of ichthyoplankton composition in 2014-2015.

The significant variations of diversity index, richness index and evenness index of ichthyoplankton were found to be regulated by the changes of species frequency of occurrence related to the seasonal phenomenon. Future studies need to clarify seasonal variations of fish larval diversity relation to hydrographic conditions of Bay of Bengal and the Andaman Sea. This study contributes a baseline data for the observation of ichthyoplankton in Myanmar waters. This research works provide the following useful information: From this research, the data information on fish larval distribution patterns at selected sites in Myanmar coastal water has been recorded. The research provides a comprehensive baseline data for fish larvae that would be

useful for fishery management and fishery biology of the study area in future. Data of biomass and diversity obtained from this study will help in determining possible population of larval assemblages in study areas. The results of this study will also provide a baseline for the assessment of the life history of fish larvae in the entire area of the environment.

Acknowledgements

There are many people that need to be thanked for their supports during my PhD journey; it will be hard to name them all. First and foremost I would like to thank Professor Dr Aung Myat Kyaw Sein, Acting Rector; Professor Dr Mie Mie Sein, Pro-rector and Professor Dr San Tha Tun, Head of Marine Science Department, Mawlamyine University for their supporting of this research. Thanks to Professor Dr Tint Swe, Head of Marine Science Department (Retd.), Mawlamyine University for his supervision, invaluable input and critical insights into the design of this study. My deepest thanks go to my colleagues, Mr Bjørn Krafft and Mr Espen Bajøien, Institute of Marine Research, Bergen, Norway, for their encouragement and patience, their assistance in the sample collections and laboratory works. I would like to thank the skipper and the crews from the R/V Dr Fridtjof Nansen for their assistance during the whole survey of ichthyoplankton. My special thanks go to my education. Mr. Richards and Mr. Al-Yamani, undertook a painstakingly critical review of the entire study, corrected omissions, inconsistencies, and errors of fact, and made suggestions which markedly improved its organization and presentation. I am very grateful for their investment of time and expertise. My final thank goes to local people from my study areas in Mon coast, for their assistance in the sample collections and my friend, Dr Laurence who has put in back breaking hours studying ichthyoplankton but more importantly has kept me focused.

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DETECTION OF INSECTICIDES SUSCEPTIBILITY OF Aedes aegypti (Linnaeus, 1762) AND Ae. albopictus (Skue, 1894) FROM SELECTED TOWNSHIPS IN MANDALAY AND DETERMINATION OF RESISTANCE BASED ON BIOCHEMICAL ASSAY

- 1. Abstract
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J-ON DETECTION OF INSECTICIDES SUSCEPTIBILITY OF Aedes aegypti (Linnaeus, 1762) AND Ae. albopictus (Skue, 1894) FROM SELECTED TOWNSHIPS IN MANDALAY AND DETERMINATION OF RESISTANCE BASED ON BIOCHEMICAL ASSAY

Yi Yi Mya¹

Abstract

The study was carried out to investigate the susceptibility of Aedes aegypti and Ae. albopictus from Mahaaungmye, Aungmyethazan and Chanayethazan (except Ae. albopictus) Townships against three insecticides (5% malathion, 0.05% deltamethrin, 0.75% permethrin), following the WHO (1998) susceptibility procedures during June 2013 to July 2015. The results showed that the mortality of Ae. aegypti was 100% to malathion after 24 hours exposure period in three study areas. The mortality of Ae. aegypti in three study areas ranged from 35.23% to 79.49% against deltamethrin and from 5.17% to 13.98% against permethrin. Aedes aegypti showed some degree of resistance to synthetic pyrethroids (deltamethrin and permethrin). According to ovitrap index, Ae. albopictus revealed a range from 10% to 85% in Mahaaungmye and from 10% to 75% in Aungmyethazan. Hundred percent mortality of Ae. albopictus to three insecticides at two study areas (Mahaaungmye and Aungmyethazan) were recorded. The determination of resistance based on biochemical assay in Ae. aegypti and Ae. albopictus was collected from selected townships during January 2015 to May 2016. By biochemical assay, 10% of Ae. aegypti strain from Aungmyethazan, 30% of the strain from Chanayethazan and 78% of the strain from Mahaaungmye showed the resistance level of mixed function oxidase (MFO) enzyme activity. For esterase enzyme activity, 8% of Ae. aegypti strain from Chanayethazan and 50% of the strain from Mahaaungmye revealed moderate level of resistance to esterase activity. However, 3% of Ae. aegypti strain from Aungmyethazan showed resistance to esterase activity. In Ae. albopictus, 95% of the strain from Aungmyethazan and 85% of the strain from Mahaaungmye were recorded as moderate resistance level in MFO activity. For esterase enzyme activity, both study areas showed 56% of moderate resistance in Ae. albopictus. The increasing level of MFO and esterase appeared to have led to resistance development in Ae. aegypti against deltamethrin and permethrin.

Introduction

Many arboviral infections including dengue, chikungunya, yellow fever and zika fever are transmitted by *Aedes* mosquitoes. Globally, 2.5 to 3 billion people are approximated to be at risk of infection with dengue viruses and the range of case fatality rates from less than 1% to 10% (average 5%) affecting mostly children (www.bvsde.paho.org). In most tropical countries of the world, dengue outbreaks exert a burden on public, health systems and economies (WHO, 2012).

Aedes aegypti (Linnaeus, 1762) and *Ae. albopictus* (Skuse, 1894) have been known as the vectors involved in disease transmission such as dengue fever (DF) and dengue haemorrhagic fever (DHF) in most urban areas of south east Asia (Rudnick, 1967) (Cited by Chen *et al.*, 2006). The primary vector of DF/DHF in Myanmar is *Ae. aegypti* while *Ae. albopictus* is the secondary vector. *Aedes aegypti* is a principal vector in urban areas and it is widespread around residents of human being whereas *Ae. albopictus* is an important vector in the rural and undeveloped areas

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(WHO, 1986). Both *Ae. aegypti* and *Ae. albopictus* are highly attracted to humans especially as source of blood rather than animals (anthropophilic) and day time biters.

The first epidemic of dengue fever/dengue haemorrhagic fever (DF/DHF) was recorded in Yangon city, Myanmar in 1970 and then epidemic or outbreak of DF/DHF has occurred cyclically throughout the country every 3 to 4 years (Cho Min Naing *et al.*, 2002). Dengue cases in Myanmar recently increased, causing a major public health problem. In Mandalay Region, there were 224 cases of DHF resulting in one death in 2012 (VBDC, 2012), however there were 2288 DHF cases with eight deaths in the year 2013 (VBDC, 2013). Moreover, the numbers of dengue cases 2025 with 20 fatal cases have been reported in 2014 (VBDC, 2014). Currently, available vaccine and antiviral drugs have not been established to prevent or to fight against dengue or dengue haemorrhagic fever.

For this reason, the prevention and control of this disease is currently dependent on vector surveillance and vector control methods. Most vector surveillance strategies depend solely on indicators that have been planned to detect the presence or absence of vector larvae or pupae (Thanispong, 2008). Vector control methods such as environmental modification and manipulation, biological control, chemical control, genetic control and community participation/health education have been successfully used as a long time control for mosquito borne diseases in worldwide.

The application of chemical insecticides has been effective to control vectors during diseases transmission in the public. Insecticides can be classified into inorganic such as sulphur and lime, natural organic such as botanical and mineral, and synthetic organic such as organochlorines, organophosphates, carbamates and pyrethroids by their chemical nature. Synthetic organic insecticides are somewhat important and available for use in mosquito borne diseases control.

Organophosphates (OPs) were initially widely applied for agricultural areas but caused by vector resistance to DDT and BHC, at present they are also commonly applied in the role of public health. Organophosphates insecticide was made using a number of highly active compounds as malathion, fenitrothion, temephos and others. These compounds are generally highly toxic effect to mammals and target insects.

Currently pyrethroid insecticides are represented as important compound against insect pests of both economic and medical importance (Pennetier *et al.*, 2005). These products exhibit remarkably high toxic effect and quick action against a wide range of insects, but comparatively low toxic effect to mammalian. The most widely used synthetic pyrethroids include permethrin, deltamethrin and cypermethrin.

Worldwide, mosquito control depends primarily on pyrethroids (e.g., permethrin, resmethrin, and phenothrin), organophosphates (e.g., malathion, temephos and chlorpyrifos), carbamates (e.g., propoxur and carbosulfan), insect growth regulators (IGRs, primarily methoprene), and biological control (*Bacillus thuringiensis israelensis* and *Bacillus sphaericus*) (Paul *et al.*, 2006).

In Myanmar, temephos 1% sand granule (Abate) has been used into water containers around the human dwelling and other breeding sources for larval control since 1979. Malathion

5% concentration is mainly applied for adult mosquitoes control as thermal fogging since 1974 (VBDC, 1999). Moreover, pyrethroid, mainly deltamethrin is used for dengue control as impregnated bednet and curtain since 2010.

The extensive and inadequate usage of chemical insecticides on mosquitoes have been affected its susceptibility and developing resistance to the insecticides. Insecticide resistance mechanisms have enzyme basis and the two major forms; target-site resistance and detoxification enzyme-based resistance are biochemical resistance (Brogdon and McAllister, 1998).

Enzyme-based resistant is commonly resistance mechanism that take place in insect pests. All insects possess the enzyme based systems to help the resistance mechanism to detoxify naturally occurring foreign materials. Enzyme-based resistance happens when increased levels or modified activities of esterases, mixed function oxidases (MFO) or glutathione S-transferase (GST) inhibit the insecticide from reaching its site of action (Selvi *et al.*, 2007).

The development of resistance in mosquitoes to various kinds of conventional insecticides has caused a serious problem for vector control program (WHO, 1992). World Health Organization (WHO) has developed bioassay tests for susceptibility of houseflies, cockroaches, bedbugs, ticks, fleas, mosquitoes, blackflies, lice and reduviid. The WHO test kits have been used for many years for detection and monitory of resistance in vectors.

Many studies have been investigated all over the world to understand the mechanisms of insecticide resistance in insect using biochemical assay. In the north-east of Thailand, Pimsamarn *et al.* (2009) indicated that pyrethroid-resistance creating in *Ae. aegypti* seems to be associated with monooxygenase, esterase and glutathione-S-transferase activity. Ganesh *et al.* (2003) showed that *An. stephensi* in India was found a higher activity of A-esterase and GST enzymes to be tolerant to deltamethrin, whereas that of B-esterase and G6PD has affected in the development of tolerance to permethrin in *An. culicifacies*.

Biochemical assays have been method of choice to understand the insecticide resistance mechanism among insects. Biochemical assays are sophisticated and sensitive, now it is possible to analyze insecticide resistance mechanisms with a fair degree of accuracy (Muthusamy *et al.*, 2014).

In Myanmar, dengue haemorrhagic fever is one of the growing public health problems and this disease is infected across the nation. Continuous monitoring of susceptibility of insecticide in mosquitoes is important for effective mosquito control. The determination of the insecticide susceptibility in *Aedes* mosquitoes (*Ae. aegypti* and *Ae. albopictus*) against synthetic insecticides and resistance level of detoxification enzyme activities are needed to understand the mechanism of insecticide resistance in *Aedes* mosquitoes, dengue vectors. The objectives of this study were:

- (1) to determine susceptibility of *Ae. aegypti*, yellow fever mosquito to three insecticides
 (5% malathion, 0.05% deltamethrin and 0.75% permethrin) from three selected study areas
- (2) to investigate susceptibility of *Ae. albopictus*, Asian tiger mosquito or forest mosquito to three insecticides (5% malathion, 0.05% deltamethrin and 0.75% permethrin) from two selected study areas and
- (3) to examine resistance level based on biochemical assay (Mixed Function Oxidase and esterase) in *Aedes aegypti* and *Ae. albopictus* from selected study areas

Materials and Methods

Study Area

First information about the number of dengue cases were gathered from the Vector Borne Disease Control (VBDC) Unit, Mandalay Region and that broke out in different quarters and the places where intensive insecticides had been implemented during 2010 to 2012. Based on the above information, *Aedes aegypti* and *Ae. albopictus* were collected from Mahaaungmye, Aungmyethazan and Chanayethazan (except *Ae. albopictus*) Townships where were chosen as the study sites.

Study Period

The study period was from June 2013 to May 2016.

Collection of Aedes aegypti (Larvae and Pupae)

Aedes aegypti larvae and pupae were collected from 50 houses of each of the study areas using allocation of proportion to site methods (Htay Aung *et al.*, 1999). Collected larvae and pupae were reared in insectarium of Medical Entomology Research Division in Department of Medical Research (Pyin Oo Lwin Branch). The F_1 (the first filial generation) was used in bioassay.

Collection of Aedes albopictus (Larvae and Pupae)

The oviposition trap (ovitrap) technique was used to obtain *Ae. albopictus* eggs from the study areas except Chanayethazan Township. It was showed to be an effective trap for *Aedes* mosquitoes sampling. The ovitrap was a simple trap consisting of a black colour painted plastic cup (500 ml), filled with 250 ml tap water and a puncture each side of cup, to prevent overflow of water during heavy rainfall (Yap and Thiruvengadam, 1979). A bamboo paddle (approximate1.5 cm x 15 cm x 0.2 cm) was hanged vertically in the ovitrap to provide an egg laying surface for gravid mosquito. Twenty ovitraps were kept randomly outdoors in each study area and continuous ovitrap surveillance was conducted bimonthly in both study sites between August 2014 and July 2015. The paddle and content water kept in a clear plastic bottle were brought back to the DMR (POL Branch). The collected eggs and larva were colonized to adult for mosquito identification.

Identification of Adult Aedes aegypti and Ae. albopictus

Aedes aegypti and Ae. albopictus were identified referring to Rattanarithikul and Panthusiri, (1994) and Leopoldo (2004).

Laboratory Aedes aegypti and Ae. albopictus Mosquitoes (Laboratory Strain)

A laboratory colony of *Ae. aegypti* species (over 25 generations) and *Aedes albopictus* (F_6 generation) maintained at the insectarium of Department of Medical Research (Pyin Oo Lwin Branch), which was used as laboratory strain.

Insecticides

For adult bioassay testing, 5% malathion, 0.05% deltamethrin and 0.75% permethrin (diagnostic dosages) treated papers were procured from Vector Control Research Unit, University Sains, Malaysia.

Insecticide Susceptibility of Adult Mosquitoes

Sucrose fed females between three to seven days old of *Aedes aegypti* and *Ae. albopictus* mosquitoes were randomly selected in insecticide susceptibility tests. Batches of 15-20 mosquitoes were exposed to insecticides impregnated test paper. The bioassay kit, mosquito (adult) Diagnostic test kit WHO/VBC/81.806 was applied. The knockdown effect of different insecticides on mosquitoes was performed every 5 minutes during one hour exposure period. Then mosquitoes were moved to a recovery tube. Then, the mosquitoes from a recovery tube were transferred again to a paper cup by using aspirator. Each paper cup was supplied with 5% sucrose solution. Final mortality was recorded after 24 hr post exposure. Batches of mosquito in control groups from each area were exposed to control papers (Plate 5).

Rapid Screening Kits

Mixed function oxidase (MFO) and esterase kits (each kit for 30 samples) were purchased from Unit of Medical Entomology, Institute for Medical Research, Malaysia.

Biochemical Assay

The adult (*Ae. aegypti* and *Ae. albopictus*) unfed (non-blood) 3-7 days old female mosquito that was used for biochemical assay. Biochemical assay was done using oxidase and esterase kits as per the manufacturer's protocol. For oxidase, changes of colour took place from light blue to dark blue colour immediately. For esterase, changes of colour took place from dark pinkish color to brownish immediately. The optical density of each well was read by using Enzyme-Linked Immunosorbent Assay (ELISA) reader (IRE 96) at 450 nm wavelength for esterase and 630 nm wavelength for mixed function oxidase (MFO) (Plate 6, 7 & 8).

Data Analysis

WHO criteria was used to evaluate the resistance/susceptibility status of tested mosquitoes (WHO, 1998). According to WHO criteria (1) susceptible when mortality was 98% or higher, (2) possible resistant when mortality was from 80% to 97% inclusive and (3) resistant when mortality was lower than 80%. Fifty and 95% knockdown times (time for knockdown of 50% and 95% mosquitoes) were acquired by using the log-time model *Ldp Line*^{*R*} software (Ehabsoft). If control mortality was between 5% and $\leq 20\%$, the percentage mortalities were corrected by Abbott's formula. The results of 50% knockdown time (KDT₅₀) of *Ae. aegypti* from three study areas were compared with KDT₅₀ value of laboratory strain, *Ae. aegypti* to calculate the resistant ratio (RR).

Abbott's formula =
$$\frac{\% \text{ test mortality} - \% \text{ control mortality}}{100 - \% \text{ control mortality}}$$
 (WHO, 1998)

Resistance ratio (RR) =	LT ₅₀ of field strain	$(I_{o}k_{0} at al 2012)$
	LT ₅₀ of laboratory strain (susceptible)	(LOKE et al., 2012)

The insecticide susceptibility of mosquitoes (*Aedes aegypti* and *Ae. albopictus*) was determined by the colour presentation in microtitre plate. The intensity of colour was determined by eye score method. The optical density values (mixed function oxidase and esterase) were differentiated to three levels of susceptibility of insecticide as shown in below;

Optical density (OD) value < 0.4</th>= susceptible to insecticideOptical density value>between 0.4 and 0.7 inclusive = moderate resistance

Optical density value > 0.7 = resistance to insecticide

Results

Classification of Aedes aegypti and Aedes albopictus

Phylum	-	Arthropoda
Class	-	Insecta
Order	-	Diptera
Family	-	Culicidae
Subfamily	-	Culicinae
Genus	-	Aedes
Species	-	Ae. aegypti (Linnaeus, 1762),
		Ae. albopictus (Skuse, 1894)

Aedes aegypti adult short description

Adult *Ae. aegypti* was identified by clypeus of head with white scale patches and proboscis without a white band; scutum black or brown with a pair of submedian-longitudinal white stripes and with a pair of white lyre-shaped markings; mesepimeron with two well separated white scale patches; femora with white knee-spot, anterior portion of midfemur with a longitudinal white (Plate 1 & 2).

Aedes albopictus adult short description

Adult *Ae. albopictus* was identified by clypeus of head without white scale patches; Scutum with a long median-longitudinal white stripe; mesepimeron with white scale patches not separated, forming V-shaped white patch; Anterior portion of midfemur without a longitudinal white stripe (Plate 3 & 4).

Insecticide susceptibility

Aedes aegypti and *Ae. albopictus* from selected areas were tested in laboratory conditions for susceptibility of different insecticides. All experiments were done at $27\pm 2^{\circ}$ C temperature and 65%–80% relative humidity. In this study, there was no mortality recorded in control group over a 24 hours holding period for all paired tests.
Aedes aegypti adult insecticide susceptibility

(1) Percent Knockdown

The results of 50% and 95% knockdown times (KDT₅₀ and KDT₉₅) of *Ae. aegypti* mosquitoes exposed to 5% malathion were 28.24 minutes and 39.10 minutes from Chanayethazan, 30.52 minutes and 41.35 minutes from Mahaaungmye and 31.31 minutes and 41.49 minutes from Aungmyethazan. *Aedes aegypti*, laboratory strain was compared with KDT₅₀ value of Chanayethazan, Mahaaungmye and Aungmyethazan strains to obtain the resistance ratios were 1.05, 1.14 and 1.17 (Table 1).

Based on the KDT₅₀ value of *Aedes aegypti* from Aungmyethazan needed a little more time to achieve 50% mortality when compared with laboratory population against 5% malathion (Fig. 1). Fifty percent knockdown time (KDT₅₀) values of *Ae. aegypti* from field and laboratory strains were conducted with diagnostic dosage of deltamethrin (0.05%). The KDT₅₀ of laboratory strain to 0.05% deltamethrin was 34.03 minutes. However, Aungmyethazan, Mahaaungmye and Chanayethazan strains were 48.15 min, 74.23 min and 81.45 min, respectively. Then, KDT₅₀ value of Aungmyethazan, Mahaaungmye and Chanayethazan strains was compared with laboratory strain KDT₅₀ value, showing the resistance ratios were 1.4, 2.2 and 2.4 fold of resistance, respectively (Table 2). Based on the KDT₅₀ values, *Ae. aegypti* in all field strains needed more time to achieve 50% mortality when compared with laboratory strain against 0.05% deltamethrin (Fig. 2). However, the KDT₅₀ of laboratory strain of *Ae. aegypti* to 0.75% permethrin was 53.35 min. The RR₅₀ for 0.75% permethrin was not calculated because the mosquitoes were not knocked down in all field strains at the end of the exposure time (one hour). Therefore, all field strains (Chanayethazan, Mahaaungmye and Aungmyethazan) showed very high resistance to 0.75% permethrin (0% mortality) in one hour (Table 3).

(2) **Percent Mortality**

Aedes aegypti from Chanayethazan, Mahaaungmye and Aungmyethazan like laboratory strain, indicated complete susceptibility (100% mortality) to 5% malathion after 24 hr post exposure period (Table 4).

Bioassay results indicated that the adult of *Ae. aegypti* field strains was found to be the development of resistance to deltamethrin and permethrin. The mortalities of *Ae. aegypti* in all field strains were recorded at 24 hr after post exposure period to 0.05% deltamethrin and 0.75% permethrin. The mortality of all field strains ranged from 35.23% to 79.49% against 0.05% deltamethrin (Table 5).

The mortality of all field strains was also found ranging from 5.17% to 13.98% against 0.75% permethrin (Table 6).

Aedes albopictus adult insecticide susceptibility

(1) Percent knockdown

The results of 50% and 95% knockdown time (KDT₅₀ and KDT₉₅) of *Ae. albopictus* were 32.62 min and 52.18 min in Mahaaungmye, and 30.93 min and 44.71 min in Aungmyethazan against 5% malathion. *Aedes albopictus* laboratory strain was compared Mahaaungmye and Aungmyethazan strains and the resistance ratios were 1.17 and 1.11 fold of resistance than laboratory strain (Table 7).

The KDT₅₀ values of *Ae. albopictus* to 0.05% deltamethrin were 14.49 min from Mahaaungmye and 17.24 min from Aungmyethazan Townships. Then, *Aedes albopictus* (Laboratory strain) was compared with Mahaaungmye and Aungmyethazan strains and the resistance ratios were 1.02 and 1.21 fold of resistance than laboratory strain (Table 8).

In addition, the KDT_{50} values of *Ae. albopictus* from two study areas (Maha- aungmye and Aungmyethazan) were showed 18.23 min and 17.98 min against 0.75% permethrin. Then, laboratory strain, *Aedes aegypti* was compared with Mahaaungmye and Aungmyethazan strains and the resistance ratios were 1.03 and 1.01 fold of resistance than laboratory strain (Table 9).

Hundred percent knocked down of all field strains (Mahaaungmye and Aungmyethazan) were found to insecticides (5% malathion, 0.05% deltamethrin, 0.75% permethrin) at the end of the exposure time (one hour) (Fig. 3, 4 and 5).

(2) **Percent Mortality**

Aedes albopictus from Mahaaungmye and Aungmyethzan strains like laboratory strain, demonstrated complete susceptibility with 100% mortality to 5% malathion after 24 hr post exposure period (Table 10).

The mortality rates of *Ae. albopictus* after 24 hr post exposure were 100% with 0.05% deltamethrin and 0.75% permethrin in both study areas (Mahaaungmye and Aungmyethazan) (Table 11 and Table 12).

Biochemical Assay for Aedes aegypti

(1) Mixed Function Oxidase (MFO)

The higher level of mixed function oxidase, MFO (OD₆₃₀) value in laboratory strain (30%) was found in the 0.5-0.6 range. Moreover, the MFO enzyme value of 38% of Aungmyethazan strain and 40% of Chanayethazan strain were in the 0.5-0.6 range. However the MFO enzyme value of 19% of Mahaaungmye strain was found within 0.7–0.8 range and 0.8-0.9 range. Moreover, the high resistant population was observed 11% of Mahaaungmye strain ranged from 1.1-1.2 (Fig. 6).

The result of microplate assay, 30% of *Aedes aegypti* in Chanayethazan was indicated resistance level. It had high level of MFO enzyme value (0.82 ± 0.1). The 10% of *Ae. aegypti* in Aungmyethazan showed resistance level with MFO enzyme value, 0.78 ± 0.1 . Moreover, 78% of Mahaaungmye strain obviously indicated present of resistance due to MFO enzyme value, 0.94 ± 0.2 . The population of 4% in laboratory strain was found resistance level due to MFO enzyme (0.71 ± 0.0) (Table 13).

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The mean MFO enzyme value of total samples in the laboratory strain was 0.53 ± 0.1 and, in Chanayethazan and Aungmyethazan strains were 0.64 ± 0.1 and 0.54 ± 0.1 , respectively. The highest mean MFO enzyme value was observed in Mahaaungmye strain which was 0.87 ± 0.2 (Table 13).

(2) Esterase

Based on the level of esterase, the optical density value (0.3-0.4) was found 75% of laboratory strain and 92% of Chanayethazan strain. However, the majority level of esterase enzyme value was observed 50% of Mahaaungmye strain with 0.4-0.5 range. Moreover, 50% of Aungmyethazan strain was indicated in the 0.5-0.6 range (Fig. 7).

The result of Chanayethazan and Mahaaungmye strains showed that 8% and 50% of the population had moderate level of esterase activity. Their mean OD values were 0.41 ± 0.01 in Chanayethazan strain and 0.45 ± 0.1 in Mahaaungmye strain. However, 3% of *Ae. aegypti* in Aungmyethazan had showed high level of esterase activity with 0.72 ± 0.0 mean OD value (Table 14).

The mean optical density values (total samples) of esterase of *Aedes aegypti* in Chanayethazan, Mahaaungmye and Aungmyethazan were 0.38 ± 0.03 , 0.39 ± 0.1 and 0.58 ± 0.1 , respectively (Table 14).

Biochemical Assay for Aedes albopictus

(1) Mixed Function Oxidase (MFO)

The higher level of mixed function oxidase (MFO) of laboratory strain (37%) and Aungmyethazan (45%) was found within 0.5-0.6 range. However, the MFO enzyme level of 50% of Mahaaungmye strain was indicated in the 0.4-0.5 range (Fig. 8).

The result of microplate assay showed that 95% of *Ae. albopictus*, Aungmyethazan strain had moderate resistance level of MFO enzyme activity with enzyme OD value 0.52 ± 0.1 . However, 85% of *Ae. albopictus* in Mahaaungmye and 84% of laboratory strain were found in moderate resistance level of MFO enzyme activity. The moderate resistance level of MFO enzyme value was 0.50 ± 0.1 in Mahaaungmye and 0.55 ± 0.1 in laboratory strains, respectively (Table 15).

The mean MFO enzyme values of total samples of *Ae. albopictus* in laboratory, Aungmyethazan and Mahaaungmye were 0.51 ± 0.1 , 0.52 ± 0.1 and 0.48 ± 0.1 , respectively (Table 15).

(2) Esterase

Based on the level of esterase (OD₄₅₀) enzyme, 53% of laboratory strain and 56% of Aungmyethazan were found within 0.4-0.5. However, 44% of Mahaaungmye strain was indicated in the 0.3-0.4 range (Fig. 9). The populations of 56% of both Aungmyethazan and Mahaaungmye were found in moderate resistance level of esterase enzyme. The moderate esterase enzyme values were found 0.43 ± 0.03 in Aungmyethazan and 0.48 ± 0.1 in Mahaaungmye strains, respectively. However, resistance mechanism due to esterase was not observed in Aungmyethazan and Mahaaungmye (Table 16).

The mean esterase enzyme values of total samples of *Ae. albopictus* in laboratory, Aungmyethazan and Mahaaungmye were 0.41 ± 0.1 , 0.41 ± 0.04 and 0.43 ± 0.1 , respectively (Table 16).

		-	
Strain	KDT ₅₀ (minute)	KDT ₉₅ (minute)	RR ₅₀
Chanayethazan	28.24 (27.73-28.73)) 39.10 (38.16-40.22)	1.05
Mahaaungmye	30.52 (30.03-31.00)) 41.35 (40.35-42.52)	1.14
Aungmyethazar	n 31.31 (30.89-31.72)) 41.49 (40.65-42.45)	1.17
Laboratory (F >	>25) 26.79 (26.33-27.23)) 38.84 (37.85-39.98)	0.0

Table 1:	Knockdown Time (KDT ₅₀ and KDT ₉₅) values of 5% malathion tested	against
	Aedes aegypti mosquito collected from three study areas	

Parenthesis = 95% confidence interval

Table 2: Knockdown Time (KDT50 and KDT95) values of 0.05% deltamethrin tested aga	inst
Aedes aegypti mosquito collected from three study areas	

Strain	KDT ₅₀ (minute)	KDT95 (minute)	RR ₅₀
Chanayethazan	81.45 (73.80-94.26)	190.74 (150.09-274.15)	2.4
Mahaaungmye	74.23 (69.23-81.67)	155.52 (130.83-198.20)	2.2
Aungmyethazan	48.15 (46.89-49.54)	93.52 (87.18-101.68)	1.4
Laboratory (F >25)	34.03 (33.48-34.58)	51.94 (50.64-53.42)	0.0

Parenthesis = 95% confidence interval

Table 3: Knockdown Time (KDT₅₀ and KDT₉₅) values of 0.75% permethrin tested against *Aedes aegypti* mosquito collected from three study areas

Strain	KDT ₅₀ (minute)	KDT ₉₅ (minute)	RR ₅₀
Chanayethazan	0	0	*
Mahaaungmye	0	0	*
Aungmyethazan	0	0	*
Laboratory (F $_{>25}$)	53.35 (52.48-54.32)	80.70 (77.12-85.20)	0.0

Parenthesis = 95% confidence interval

* Not calculated

Strain	No. of tested sample	Tested mortality (%)	No. of control sample	Control mortality (%)
Chanayethaza	229	100	250	0
Mahaaungmye	300	100	250	0
Aungmyethazan	358	100	250	0
Laboratory (F >25)	352	100	250	0

 Table 4: Mortality of Aedes aegypti adult recorded at 24 hours after post exposure to 5 % malathion

 Table 5: Mortality of Aedes aegypti adult recorded at 24 hours after post exposure to 0.05% deltamethrin

Strain	No. of tested sample	Tested mortality (%)	No. of control sample	Control mortality (%)
Chanayethaza	229	40.18	200	0
Mahaaungmye	264	35.23	200	0
Aungmyethazan	234	79.49	200	0
Laboratory (F >25)	322	100	200	0

Table 6: Mortality of Aedes aegypti adult recorded at 24 hours after post exposure to0.75% permethrin

Strain	No. of tested sample	Tested mortality (%)	No. of control sample	Control mortality (%)
Chanayethazan	329	5.17	200	0
Mahaaungmye	289	11.42	200	0
Aungmyethazan	329	13.98	200	0
Laboratory (F >25)	352	90.05	200	0

 Table 7:
 Knockdown Time (KDT₅₀ and KDT₉₅) values of 5% malathion tested against

 Aedes albopictus mosquito collected from two study areas

Strain	KDT ₅₀ (minute)	KDT ₉₅ (minute)	RR ₅₀
Mahaaungmye Aungmyethazan	32.62 (31.80-33.42) 30.93 (30.34-31.51)	52.18 (50.09-54.72) 44.71 (43.46-46.16)	1.17 1.11
Laboratory (F_6)	27.82 (27.18-28.44)	38.78 (37.47-40.39)	0.00

Parenthesis = 95% confidence interval

Strain	KDT ₅₀ (minute)	KDT ₉₅ (minute)	RR ₅₀
Mahaaungmye	14.49 (13.60-15.26)	26.14 (24.95-27.64)	1.02
Aungmyethazan	17.24 (16.77-17.70)	27.76 (26.69-29.03)	1.21
Laboratory (F_6)	14.23 (13.62-14.81)	25.67 (24.30-27.39)	0.00

 Table 8: Knockdown Time (KDT₅₀ and KDT₉₅) values of 0.05% deltamethrin tested against *Aedes albopictus* mosquito collected from two study areas

Parenthesis = 95% confidence interval

 Table 9: Knockdown Time (KDT₅₀ and KDT₉₅) values of 0.75% permethrin tested against *Aedes albopictus* mosquito collected from two study areas

Strain	KDT ₅₀ (minute)	KDT95 (minute)	RR ₅₀
Mahaaungmye	18.23 (17.68-18.76)	30.33 (29.23-31.62)	1.03
Aungmyethazan	17.98 (17.43-18.50)	27.12 (25.96-28.62)	1.01
Laboratory (F_6)	17.77 (17.28-18.26)	30.12 (28.98-31.46)	0.00

Parenthesis = 95% confidence interval

Table 10:	Mortality of Aedes albopictus adult recorded at 24 hours after post exposure to
	5% malathion

Strain	No. of tested sample	Tested mortality (%)	No. of control sample	Control mortality (%)
Mahaaungmye	164	100	100	0
Aungmyethazan	212	100	100	0
Laboratory (F ₆)	158	100	100	0

Table 11: Mortality of Aedes albopictus adult recorded at 24 hours after post exposure to 0.05% deltamethrin

Strain	No. of tested sample	Tested mortality (%)	No. of control sample	Control mortality (%)
Mahaaungmye	217	100	100	0
Aungmyethazan	254	100	100	0
Laboratory (F ₆)	169	100	100	0

Strain	No. of tested sample	Tested mortality (%)	No. of control sample	Control mortality (%)
Mahaaungmye	203	100	100	0
Aungmyethazan	202	100	100	0
Laboratory (F_6)	255	100	100	0

 Table 12: Mortality of Aedes albopictus adult recorded at 24 hours after post exposure to 0.75% permethrin

 Table 13: Susceptibility/resistance status of Aedes aegypti based on mixed function oxidase level by microplate assay

Strain	r	Fotal		Susce	ptible	Mod	erate	resistance]	Resist	ance
		Mean			Mean			Mean			Mean
	n	OD	n	%	OD	n	%	OD	n	%	OD
	_	(± SD)			(± SD)			$(\pm SD)$			(± SD)
Chanayethazan	40	0.64	1	3	0.36	27	67	0.58	12	30	0.82
		± 0.1			± 0.0			± 0.06			± 0.1
Aungmyethazan	32	0.54	2	6	0.37	27	84	0.53	3	10	0.78
		± 0.1			± 0.02			± 0.07			± 0.1
Mahaaungmye	36	0.87	-	-	-	8	22	0.61	28	78	0.94
		± 0.2						± 0.1			± 0.2
Laboratory	23	0.53	5	22	0.37	17	74	0.57	1	4	0.71
(F>25)		± 0.1			± 0.01			± 0.09			± 0.0

Table 14: Susceptibility/resistance status of *Aedes aegypti* based on esterase level by microplate assay

Strain	Total		S	Susceptible			Moderate resistance			Resist	ance
	n	Mean OD	n	%	Mean OD	n	%	Mean OD	n	%	Mean OD
		(± SD)			(± SD)			(± SD)			(± SD)
Chanayethazan	36	0.38	33	92	0.37	3	8	0.41	-	-	-
		± 0.03			± 0.02			±0.01			
Aungmyethazan	40	0.58	-	-	-	39	97	$0.58 \pm$	1	3	0.72
		± 0.1						0.1			± 0.0
Mahaaungmye	30	0.39	15	50	0.35	15	50	$0.45 \pm$	-	-	-
		± 0.1			± 0.04			0.1			
Laboratory	20	0.37	15	75	0.36	5	25	0.42	-	-	-
(F>25)		± 0.03			± 0.03			± 0.02			

OD = Optical Density

Strain	-	Total		Susce	ptible]	Mode resista	rate ince]	Resist	tance
		Mean			Mean			Mean			Mean
	n	OD	n	%	OD	n	%	OD	n	%	OD
		(± SD)			(± SD)			(± SD)			(± SD)
Aungmyethazan	20	0.52	1	5	0.38	19	95	0.52	-	-	-
		± 0.1			± 0.0			± 0.1			
Mahaaungmye	20	0.48	3	15	0.37	17	85	0.50	-	-	-
		± 0.1			± 0.03			± 0.1			
Laboratory (F ₆)	19	0.51	3	16	0.34	16	84	0.55	-	-	-
		± 0.1			± 0.02			± 0.1			

 Table 15: Susceptibility/resistance status of Aedes albopictus based on mixed function oxidase level by microplate assay

Table 16: Susceptibility/resistance status of *Aedes albopictus* based on esterase level by microplate assay

Strain	r	Fotal	1	Suscej	ptible	ľ r	Mode esista	rate ince	F	Resist	tance
		Mean			Mean			Mean			Mean
	n	OD	n	%	OD	n	%	OD	n	%	OD
		(±SD)			(±SD)			(±SD)			(±SD)
Aungmyethazan	18	0.41	8	44	0.38	10	56	0.43	-	-	-
		± 0.04			± 0.02			± 0.03			
Mahaaungmye	18	0.43	8	44	0.36	10	56	0.48	-	-	-
		± 0.1			± 0.02			± 0.1			
Laboratory (F ₆)	15	0.41	6	40	0.36	9	60	0.45	-	-	-
		± 0.1			± 0.02			± 0.1			

OD = Optical Density



Figure 1: Percent knockdown of *Aedes aegypti* adult exposed to 5% malathion for one hour (60 minutes)



Figure 2: Percent knockdown of Aedes aegypti adult exposed to 0.05% deltamethrin for one hour (60 min)



Figure 3: Percent knockdown of Aedes albopictus adult exposed to 5% malathion for one hour (60 min)



Figure 4: Percent knockdown of Aedes albopictus adult exposed to 0.05% deltamethrin for one hour (60 min)

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Figure 5: Percent knockdown of *Aedes albopictus* adult exposed to 0.75% permethrin for one hour (60 min)



MFO (OD_{630}) value

Figure 6: Percent population of *Aedes aegypti* among different strains based on optical density values of MFO



Figure 7: Percent population of *Aedes aegypti* among different strains based on optical density values of esterase



Figure 8: Percent population of *Aedes albopictus* among different strains based on optical density values of MFO



Esterase (OD $_{\rm 450}$) value

Figure 9: Percent population of *Aedes albopictus* among different strains based on optical density values of esterase



Plate 1 Aedes aegypti (Female)



Plate 3 Aedes albopictus (Female)



Plate 2 Aedes aegypti (Male)



Plate 4 Aedes albopictus (Male)



Plate 5 Insecticide susceptibility test



Plate 7 Biochemicmical assay for MFO



Plate 6 Enzyme-Linked Immunosorbent Assay reader



Plate 8 Biochemicmical assay for esterase

Discussion

Mosquito-borne diseases are an increasing cause of death and suffering throughout the world. According to epidemiological data of Ministry of Health and Sports, several mosquitoes borne diseases such as malaria, dengue haemorrhagic fever (DHF), chikungunya, Japanese encephalitis and lymphatic filariasis are public health problems in Myanmar. Dengue haemorrhagic fever (DHF) is one of the important among mosquito borne diseases because of a completely effective vaccine against dengue is not yet available. The reduction of human-vector contact is mainly depended on using synthetic chemical insecticides to prevent and control vector borne diseases.

The insecticide susceptibility level of insecticide mosquitoes is considered one of the major factors influencing the effective vector control. The present study investigated the susceptibility of *Aedes aegypti* and *Ae. albopictus* against insecticides, namely organophosphates (5% malathion) and synthetic pyrethroids (0.05% deltamethrin, 0.75% permethrin) by using WHO standard test kits.

The mortality of *Ae. aegypti* in all field strains (Chanayethazan, Aungmyethazan and Mahaaungmye) against 5% malathion was observed 100% after 24 hr post exposure. *Aedes aegypti* in all field strains (Chanayethazan, Aungmyethazan and Mahaaungmye) has been found to be susceptible to 5% malathion. This result may be due to 5% malathion was not routinely used to

control mosquitoes adult control. This study suggested that 5% malathion is still effective in control programs by using as thermal fogging during dengue outbreaks.

Similar result was found in other study conducted by Ponlawat *et al.* (2005) showed that *Ae. aegypti* in Thailand was susceptible to 5% malathion. However, in India, 76.6% mortality was observed among *Ae. aegypti* adults when exposed to 5% malathion by Mukhopadhyay *et al.* (2006). He found that the long-term effect of irregular spraying operation with malathion as thermal fogging became resistance to mosquitoes.

In contrast, the mortalities of *Ae. aegypti* were investigated 35.23% in Mahaaungmye, 40.18% in Chanayethazan and 79.49% in Aungmyethazan against 0.05% deltamethrin. Moreover, the mortalities of *Aedes aegypti* were found 5.17% in Chanayethazan, 11.42% in Mahaaungmye and 13.98% in Aungmyethazan against 0.75% permethrin. Therefore, the field-collected *Ae. aegypti* strains (Chanayethazan, Aungmyethazan and Mahaaungmye) demonstrated comparatively high levels of resistance to synthetic pyrethroids (0.05% deltamethrin and 0.75% permethrin). The reason for this may be *Ae. aegypti*, which was found closely to humans and this species have a chance to contact with commercially available household insecticides for insect control.

Grieco *et al.* (2007) reported that the most of ingredient of household insecticides has comprised especially synthetic pyrethroids, which has possessed low toxic to humans and great potency at minimum doses, rapidly immobilizing and killing insects. Ponlawat *et al.* (2005) revealed that resistance to synthetic compounds has been resulted in *Ae. aegypti* in Thailand. They found that *Aedes aegypti* was resistant to permethrin, a compound which is applied for pest control in households and *Ae. aegypti* has a chance to resist permethrin because this species likes to breed and rest indoor. Another study by Kamgang *et al.* (2011) showed that a high level of DDT and pyrethroid resistance in *Ae. aegypti* in Central Africa.

In this study, enough numbers of *Ae. albopictus* mosquitoes could not be collected from Chanayethazan, it could be due to urbanite *Ae.aegypti* mosquitoes population in Chanayethazan were more dormant than *Ae. albopictus* population. Insecticide susceptibility test for *Ae albopictus*, the mortality of Aungmyethazan and Mahaaungmye strains was observed 100% after 24 hr post exposure period. *Aedes albopictus* was found susceptible to insecticides (5% malathion, 0.05% deltamethrin and 0.75% permethrin). This may be due to the habit of *Ae. albopictus* preference to outdoor site to rest. The outdoor site is opening and *Ae. albopictus* mosquito therefore have less contact with household insecticides, thus they appeared more susceptible to test concentrations.

Singh *et al.* (2011) observed that *Ae. albopictus* mosquitoes were susceptible to 0.05% deltamethrin (98.26% - 100% mortality) and 0.75% permethrin (100% mortality), but they were tolerant to malathion (95.83% - 97.67% mortality) in India. In central Africa, *Ae. albopictus* from Yaounde was found to be resistance to DDT and developing resistance to deltamethrin (Kamgang *et al.*, 2011).

Enzyme assay is a simple, rapid, sensitive method and it has been commonly used for the identification of mechanisms underlying the insecticide resistance in mosquito population even at low frequencies (Lee, 1990). The results from biochemical estimation of enzymes level

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showed that the resistance level of MFO enzyme was found in *Ae. aegypti* in the three selected areas (Chanayethazan, Aungmyethazan and Mahaaungmye). Moreover, the resistance level of esterase enzyme was found in *Ae.aegypti* in Aungmyethazan except Chanayethazan and Mahaaungmye. The increased level of MFO and esterase had affected low mortality in *Aedes aegypti* to synthetic pyrethroids (0.05% deltamethrin and 0.75% permethrin) and the levels of MFO and esterase enzymatic detoxification have been activated. The resistance of *Ae. aegypti* in three selected areas to deltamethrin and permethrin could be cross resistance, which is resistance to different insecticides that have same mode of action. Thus, the cross resistance from permethrin to deltamethrin had occurred due to the same mode of action of both pyrethroids on the voltage-dependent sodium channel of nerve axons (Brooke *et al.*, 1999).

Similar study conducted by Yaicharoen *et al.* (2005), *Aedes aegypti* from Bangkok and Pathum Thani the central Thailand showed the elevation of mixed function oxidase (MFO) enzyme activitiy, leading to the resistance to deltamethrin and cross resistance to DDT. Cross resistance between pyrethroid and nonpyrethroid compounds may occur in mosquito vectors since they share the same target-site mechanisms such as cross-resistance between pyrethroid (lambdacyhalothin) and organophosphate (malathion) was observed in *Cx. quinquefasciatus* and it may be due to overproduced esterase (Bisset *et al.*, 1997).

However, during this study cross resistance between synthetic pyrethroids (0.05% deltamethrin and 0.75% permethrin) and organophospate (5% malathion) in *Ae. aegypti* in three selected areas (Chanayethazan, Aungmyethazan and Mahaaungmye) was not observed because of high level of MFO and esterase activities. Nevertheless, *Ae. aegypti* in the study areas revealed to be still susceptible to malathion.

In the case of *Ae. albopictus*, resistance to MFO and esterase was not detected in two selected areas (Aungmyethazan and Mahaaungmye). Insecticides (5% malathion, 0.05% deltamethrin and 0.75% permethrin) caused 100% mortality in *Ae. albopictus* in the above two selected areas since the levels of MFO and esterase enzymatic detoxification had not been activated.

Conclusion

Resistance to pyrethroids (0.75% permethrin and 0.05% deltamethrin) has developed in *Ae. aegypti* in three study areas (Chanayethazan, Aungmyethazan and Mahaaungmye Townships). However as the level of MFO and esterase (particularly in Aungmyethazan strain) was high could play a role in resistance to deltamethrin and permethrin.

Aedes albopictus in two study areas (Mahaaungmye and Aungmyethazan Townships) is still susceptible to insecticides (5% malathion, 0.05% deltamethrin, 0.75% permethrin). The resistance level of MFO and esterase was not observed in *Ae. albopictus* in two study areas (Mahaaungmye and Aungmyethazan).

In Myanmar, the effect of focal spraying regularly practice to control dengue vector became susceptible to malathion in *Ae. aegypti*. Malathion appeared to be still effective in controlling the vectors (*Ae. aegypti* and *Ae. albopictus*) of dengue haemorrhagic fever. The use of impregnated synthetic pyrethroids (including deltamethrin and permethrin) on bed nets and

curtain to control *Ae. aegypti* species should be managed carefully to prevent infection of vector borne diseases. It is alarming us to control the vector borne diseases for public health.

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FABRICATION AND CHARACTERIZATION OF NiO ANODIC ELECTROCHROMIC LAYER FOR SMART WINDOW APPLICATION

- 1. Introduction
- 2. Objective
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J-CI FABRICATION AND CHARACTERIZATION OF NIO ANODIC ELECTROCHROMIC LAYER FOR SMART WINDOW

APPLICATION

Sau Swang¹

Abstract

Nickel oxides (NiO) are well-known anodic materials in electrochromic devices (ECD) for smart window application. In the present work, pure NiO and titanium doped NiO (NiO/Ti) composite films with various Ti concentration of 5-25 mol% were fabricated on indium-doped tin oxide coated glass substrates by sol-gel spin-coating technique. The first part of the work investigates the effect of Ti dopant on the optical, electrical and electrochemical properties of NiO/Ti composite films. At the highest Ti content (25 mol%), the lowest Eg value of 3.5 eV was realized which would favor the electron transition. The electrical conductivities (σ) of NiO/Ti films (25 mol%) were measured by four-point probing method. It was found that σ increased with increasing Ti contents and was as high as 0.6 S m⁻¹ for Ti (25 mol%). Cyclic voltammetry study showed that more positive energy levels (highest occupied molecular orbitals) and higher electrochemical stability were observed in the NiO/Ti films. In addition, in-situ transmittance measurement indicated that the NiO/Ti composite films exhibited a faster switching between coloration and bleaching states. In the second part of the work, the ECDs were fabricated and their coloration efficiencies (n) were evaluated. The 1 V biased NiO/Ti ECD outperformed the pure NiO ECD producing the maximum η_{650nm} of 34 cm²/C and 23 cm²/C respectively. Thus, Ti doping has an impact on optical and electrical properties of electrochromic NiO, and hence the coloration efficiency with fast switching and high stability.

Keywords: Electrochromic devices, sol-gel, Cyclic voltammetry, In-situ transmittance, Coloration efficiency

Introduction

Electrochromic materials and devices are a reversible change in color, or optical density, with a change in voltage or electric potential (O'Brien, Gordon, Mathew & Hichwa, 1999). Such devices are used, for example, in smart windows, electrochromic mirror and electrochromic displays. Desirable attributes for an electrochromic device include complete transparency and lack of color in the "off" state, and very dark color in the "on" state (Monk & Mortimer & Rosseinsky, 1995). Electrochromic devices can be made from either organic or inorganic materials.

Nickel oxide (NiO) is one of the popular low-cost electrochromic materials. Specifically, it is an anodic electrochromic material used as an optical active counter electrode in electrochromic devices (Gillaspie, Tenent & Dillon, 2010). Nickel oxide thin films are grown using many different chemical and physical methods: sputtering, evaporation, sol-gel or laser ablation deposition (Granqvist, 1995). Among these, the sol-gel method is the most cost-effective for producing large-area films, and provides excellent control of the composition and homogeneity.

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If doped with other substances, their structures would be affected and much effect were observed in the electrochromic properties of NiO based thin films. Pure NiO layers showed a poor adhesion to the substrate, a permanent brown coloration after a few cyclic voltammetry cycles and were easily degraded in the electrolyte (William, Jones, Bickely & Steiner, 2001). Annealing temperature would change the structural, morphological, electrical and optical properties of the materials. The electrical conductivity of the films would also change with changing the light intensity and exposure time. Modifying the properties of anodic electrochromic layer would thus improve the electrochromic performance of the device.

Objective

The main objective of the present work is to study the electrochromic properties of the sol-gel deposited NiO thin films and the effect of doping concentration on optical, electrical and electrochromic properties such as stability, switching time and coloration efficiency for smart window applications.

Research plan and Methodologies

- To fabricate nickel oxide (NiO) thin films by sol gel spin coating method.
- To study the effect of surface treatment on surface microfeature of NiO thin films using optical microscopy.
- To examine the effect of light intensity and UV exposure time on electrical conductivity and optical properties of NiO films using Van der Pauw four probing and UV-vis spectroscopy.
- To study the effect of Ti doping concentration on optical and electrical properties.
- To determine the electrochemical properties of pure NiO and NiO/Ti composite films by cyclic voltammetry (CV).
- To fabricate the electrochromic device (ECDs) with the structure of ITO/NiO/Electrolyte (1M KOH)/TiO₂/ITO and TO/NiO/Ti/Electrolyte (1M KOH)/TiO₂/ITO.
- To explore the electrochromic performance such as stability, response time and coloration efficiency of the ECDs.

Experimental Details

Preparation of NiO and NiO/Ti Composite Films

Pure NiO films and NiO/Ti composite films have been fabricated by sol-gel route. In the preparation of NiO sol-gel, nickel acetate tetra-hydrate Ni(CH₃COO)₂.4H₂O(6.2 g) was dissolved in 50 ml of ethanol followed by addition of hydrochloric acid (0.5ml). The resulting solution was refluxed for 1 h at 60°C and allowed to cool at room temperature. The solution was greenish transparent in nature. As NiO reveals poor adhesion to the substrate, several surface treatments mentioned below were employed so as to improve adhesion to the substrate and the film uniformity.

- (1) The glass substrate was washed with methanol then shook in hydrochloric acid (HCl) (10%) for 5 sec [hereafter called HCl treatment]
- (2) The substrate was placed under UV lamp for 1h [hereafter called UV treatment]
- (3) The substrate was dipped in sodium hydroxide for 20 min, then rinsed with distilled water and dried in nitrogen [hereafter called NaOH treatment] and
- (4) The glass substrate was heated at 300°C for 30min [hereafter called heat treatment].

NiO solution was prepared using the same procedure mentioned above and Ti isopropoxide solution was separately prepared in 10 ml of ethanol and stirred for 30 min at room temperature. Both solutions were then mixed and stirred for 30 min at room temperature obtaining NiO /Ti composite solution. Prior to deposition of composite films, the substrates were cleaned in the sequence: ultrasonic clean with detergent, distilled water, acetone, and iso-2 propyl alcohol (IPA). As a surface treatment, the substrates were placed under the UV lamp (8 W) for 1h.Then the NiO and NiO/Ti solution were spin-coated on substrates at 2000 rpm for 15 s. The as-deposited NiO films and NiO/Ti composite films were annealed at the temperatures 450°C for 1.5h. Fig. 1 shows the flow chart for preparation of pure NiO films and NiO/Ti composite films. The thin films deposition process is shown in Fig. 2. KOH crystal (5.6 g) was dissolved in distilled water (100 ml) under stirring for a few minutes to get aqueous KOH electrolyte of 1 molar concentration.



Figure 1: Flowchart for preparation of pure NiO and NiO/Ti composite films



Nickel acetate precursor

Synthesis



Sol-gel solution

Spin-coater (T-200)

Figure 2: Process of thin films deposition of the present work

Characterization

Characterization tools used in the present work are UV- vis spectroscopy, optical microscopy, surface profilometry, four point probe and cyclic voltammetry.

UV-Vis spectroscopy is a technique to measure either absorbance or transmittance of the sample in ultraviolet and visible region. The optical characterization of NiO based films was performed using Genesys 10S UV-Vis spectrophotometer. The absorption and transmission spectra of pure NiO and NiO/Ti composite films on glass substrates were recorded in the wavelengths ranging from 300 to 900 nm. The baseline scan using a bare glass substrate was taken prior to the measurement.

Optical microscope is used to study the surface microfeature of NiO thin films. The optical microscope consists of five objective lenses, (4x, 10x, 20x, 40x and 100x magnifying powers) and eyepiece (10x magnifying power). The eyepiece coupled with objective lens can magnify the image up to 1000 times. In this work, we have taken the images with magnification of 200 times (10 x times 20x). From our own calibration, a view of the image is known to be 0.8×0.8 mm.

Surface profilometry is a technique to measure the roughness, waviness and step height of thin films. The thicknesses of NiO and NiO/Ti thin films were determined by surface profiler (Tencor Alpha-Step IQ). In our measurement, we set the scan length of 1000 μ m and scan speed

of 50 μ m/s. During the measurement, the stylus force is 21.6 mg. The average thickness of pure NiO film and NiO/Ti composite films is ~250 nm.

Four point probe is a technique to measure the average resistance of a thin layer by passing current through the two points of the probe and measuring the voltage across the other two points. They are two common techniques: the four point collinear probe method and the Van der Pauw method. Here, we utlized four point Van der Pauw method to perform electrical characterization of NiO and NiO/Ti composite films. The Van der Pauw configuration is widely used in the semiconductor industry to determine the resistivity of uniform samples. In this method, we can use an arbitrarily shape, thin-plate sample containing four very small ohmic contacts placed on the periphery, preferably in the corners, of the plate.

The sheet resistances (R_S) of the films were calculated by using eq (1),

$$R_{s} = \exp\left(-\frac{\pi R_{A}}{R_{s}}\right) + \exp\left(-\frac{\pi R_{B}}{R_{s}}\right) = 1$$
(1)

Using the obtained R_s values, the resistivities of the samples were calculated.

$$\rho = t x R_{\rm S}, \tag{2}$$

where, t is film thickness measured by surface profilometry. The electrical conductivity values were obtained by taking reciprocal of ρ .

$$\sigma = 1/\rho \tag{3}$$

The electrical conductivity of the films were also determined under the illumination of AM 1.5 solar cell and ultraviolet (UV) light with different intensities. The visible white light source is Xenon lamp housed in the solar simulator (Newport Oriel). Light intensities were varied by adjusting the power supplied. Light intensities of 1 SUN (1000W/m²), 0.8 SUN, 0.6 SUN and 0.4 SUN were calibrated using a NREL certified reference Si Solar cell (2x2 cm) and digital reference meter (Newport). The UV source we used is 8W UV lamp. UV light intensities were also varied by adjusting the distance between the UV lamp and the sample and measured by LUX meter (Victor 1010 A). The samples illuminated under white light and UV light where a home-made four point probes and Tektronix (DMM-4050, Digital) multimeter were used.

Cyclic voltammetry is a technique in which the potential of the working electrode against the reference is swept periodically and linearly between two fixed values at a certain scan rate and the current flow between the working electrode and the counter electrode is recorded. This has the advantage that the product of the ion and electron transfer reaction that occurred in the forward scan can be probed again in the reverse scan.

The cyclic voltammetry experiments were performed using computer-controlled potentiostat (Digi-Ivy, DY 2000) with three electrodes electrochemical cell. The NiO based electrochemical films deposited on ITO/Glass were used as working electrode (WE), the silver/silver chloride (Ag/AgCl) was used as a reference electrode (RE) in a potential range from 0 to + 0.6V, the platinum wire was used as a counter electrode (CE) at a scan rate of 20mV/s and the film working area was 1 cm².

Fabrication of Electrochromic (EC) Device

The EC device configuration for sol-gel deposited NiO/Ti composite film was ITO / NiO or NiO/Ti / KOH) / TiO₂/ ITO. The schematic diagram and the photograph of the EC device is shown in Fig.3 (a and b). NiO/Ti composite films deposited on ITO coated conducting glass substrate acts as a working electrode and TiO₂ thin film acts as a counter electrode were assembled together with double sided tape of 1mm thickness to produce an electrochromic device. Conducting silver paste was glued to the free edge of each substrate for electrical connection. The 1 M KOH liquid electrolyte was finally injected through a small hole with a syringe into the mounted cells.

The measuring system for the transmittance spectra of the EC device is made of a spectrophotometer, a computer and a power supply. The electrochromic device is fixed on the sample holder between the light source and the detector, the working electrode and counter electrode are connected with the power supply.



Figure 3: Electrochromic device (a) Schematic diagram (b) Photograph

In-Situ Transmittance for Response Time Measurement

For the response time measurement, time varying transmittance at $\lambda = 650$ nm for the films is measured in-situ during switching between + 1 V and - 1 V. In-situ means the simultaneous measurement of the transmission while the cyclic voltammetry is running in coloring and bleaching. The measurements were carried out for the layers in the three electrode electrochemical cell in 1 M KOH electrolyte, the electrochemical cell is put into the UV vis spectrophotometry between the light source and the detector.

Results and Discussion

Effect of Surface Treatment on Surface Microfeature of NiO Thin Films

Before the deposition process, various surface treatments on the glass substrates have been done. In order to improve adhesion and uniformity of film, surface treatments were done prior to the deposition of NiO films by four different surface treatments (HCl, UV, NaOH, Heat treatments).

Fig. 4 (a-d) shows optical micrographs of NiO thin films annealed at 450°C on surface treated substrates by four different methods. It is obvious that HCl treatment would not yield the cracking of the films. It is most likely that the films are very thin or unevenly formed. For the

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NiO thin films on UV, NaOH and heat treated substrates the cracking is seen on the surface of the films upon annealing at 450°C Fig. 4 (b, c and d). According to the literature, when the films are thicker than 100 nm, the film cracking is detected after annealing. In the preparation of films for electrochromic layer, it necessitates thicker films of about thickness 200 nm. The UV treatment, NaOH treatment and heat treatment are deemed as the more suitable methods for our further processing. Among the three optimum surface treatment methods, the UV treatment method is more convenient and easy compared to those of the companion methods. Thus, it is noted that the adhesion properties and the thickness of the films can be tuned by performing various surface treatment on the underlying glass substrates.



Figure 4: Optical micrographs of NiO thin films annealed at 450°C on the substrate where (a) HCl treatment, (b) UV treatment, (c) NaOH treatment, and (d) Heat treatment are applied

Effect of Ti dopant Concentration on Optical and Electrical Properties of NiO/Ti Films

The optical transmission spectra of pure NiO films and NiO/Ti composite films annealed at 450°C are presented in Fig. 5(a). Ti dopant concentration varied from 5mol% to 25mol%. The transmission of NiO/Ti films was lower than that of pure NiO film. Changes in transmission do not follow a regular tendency for increasing Ti molar concentrations. The lowest transmission value of about 53% was observed for NiO film with highest Ti doping (25%) attributing to increased optical scattering with higher Ti doping in NiO.

The optical band gap (E_g) of NiO/Ti composite films annealed at 450°C is calculated on the basis of optical absorption spectra using the following equation:

$$\alpha = \frac{A(E_g - h\nu)^n}{h\nu} \tag{4}$$

where, α is the absorption coefficient, 'A' is a constant, 'E_g' is the band gap of the samples and 'n' is a number equal to $\frac{1}{2}$ for direct band gap and 2 for indirect band gap. The plots of $(\alpha h \upsilon)^2$ versus h υ of films annealed at 450°C are shown in Fig.5(b). Extrapolation of this curve to photon energy axis reveals the optical band gap energy. Upon increasing Ti dopant concentration, the optical band gap energy of NiO/Ti film decreased from 3.7 eV to 3.5 eV. The values of band gap energy obtained from the plot of $(\alpha h \upsilon)^2$ and h υ of pure NiO and NiO/Ti composite films annealed at 450°C are listed in Table 1. The lowest band gap energy of 3.5 eV is obtained for 25 mol% Ti doped films annealed at 450°C. This may be due to the fact that sub-band state may be created by doping impurities.



Figure 5: (a) Transmission spectra and (b) Plot of $(\alpha h \upsilon)^2$ versus h υ of pure NiO films and NiO/Ti composite films annealed at 450°C

Table 1: Band gap energy (Eg) of NiO/Ti composite films with varying Ti molar concentration that were annealed at 450°C

Sampla	Band gap Energy
Sample	450°C
Pure NiO	3.70 eV
Ti 5%	3.67 eV
Ti 10%	3.51 eV
Ti 15%	3.56 eV
Ti 20%	3.51 eV
Ti 25%	3.50 eV

To evaluate the effect of Ti dopant concentration on electrical properties of NiO thin films, the molar concentration of dopant Ti was varied from 5% to 25% in steps of 5%.

In order to know the effect of visible light intensity on the electrical conductivity of the films, we investigated the electrical property of the NiO/Ti composite films under illuminating

various light intensity. Fig. 6(a) shows the electrical conductivities of the films as a function of Ti molar concentrations under illumination of white light intensity (0.4 - 1 SUN). As displayed in Fig. 6(a), the electrical conductivity of the films does not significantly change with varying visible white light intensity for all samples with different Ti molar concentrations. It is speculated that exposed visible white light energy is not sufficient to promote the electrical conductivity of NiO/Ti composite films. Further increasing white light intensity up to 1 SUN does not affect the electrical conductivity of the samples.

Since the conductivity could not change with low energy visible light, more energetic UV light was used to irradiate the NiO and NiO/Ti thin films. Fig. 6(b) shows the conductivity against Ti doping concentration as a function of UV exposure time (UV intensity was fixed at 130 lux). It is observed that the electrical conductivity distinctly increased at UV exposure time of 30 min. It is most pronounced in the NiO/Ti composite sample. It is anticipated that photon energy of UV light is energetic and permitted the photogenerated electrons to move quickly to the conduction band, thereby increasing electrical conductivity. The electrical conductivity is as high as 6.1×10^{-1} Sm⁻¹ for the sample annealed at 450°C.

Electrochemical Properties of NiO/Ti Composite Films

To investigate the effect of scan rate on the current of the films, the electrochemical study was performed by the cyclic voltammetry with different scan rates. The scan rates would directly affect to the photocurrent. Fig. 7 shows the cyclic voltammograms of NiO thin film recorded at different scan rates of 2-100 mV/s in the voltage range (0 to + 0.6V) vs Ag/AgCl in 1M KOH electrolyte. These voltammograms show that the anodic current for NiO oxidation increases rapidly with increasing the scan rate. At the higher scan rates the time window for NiO oxidation process becomes very narrow avoiding the facile electron transfer between substrate and the layer. It implies that the oxidation transformation process is remarkably faster at higher scan rate. In the higher scan rate cyclic tests, high potential would be needed to be applied, but in the higher potential range the oxidation process of the films will be disturbed due to the higher oxygen evolution. Thus the scan rate 20mV/s would be chosen as a suitable scan rate for NiO and NiO/Ti composite films for further investigations.



Figure 6: Electrical conductivity of NiO/Ti composite films as a function of Ti dopant concentration (a) under white light with different intensity (0.4 – 1 SUN) (b) UV exposure time (10 -30 min). UV-intensity was fixed at 130 lux.

The electrochromic activity of NiO films with Ti molar concentrations varying between 5 mol% to 25 mol% annealed at 450°C has been tested in 1 M KOH for 15 cycles. The cyclic voltammogram for 15 cycles are present in Fig. 8. The potential was cycled between 0 and + 0.6 V versus Ag/AgCl at a scan rate of 20 mV/s. After 15th cyclic test, the increase in the current density with increasing cycle number indicated that the amount of coloring sites available for the redox reaction increased and did not reach the limit of saturation yet. It was reported by different researchers, that charge density increases in a certain number of cycles and then saturates at higher number of cycles. After that, it is reduced due to the decomposition of the electrochromic layer or dissolution of the NiOOH phase structure.

In order to evaluate the electrochromic performance, the investigation of energy level is also important. The energy levels of NiO and NiO/Ti composite films were determined by electrochemical cyclic voltammetry (CV) measurement. The CV (5th cycle) was regenerated and plotted in Fig. 9 for determination of energy levels. Electronic absorption from ground state to excited state determines the energy gap between the HOMO and LUMO. From the onset oxidation potential in CV, the HOMO levels were calculated using the following equation:

$$E_{HOMO} = -e \left(E_{oxd}^{onset} + 4.4 V \right) \tag{5}$$

where, E_{oxd}^{onset} are the onset potentials of oxidation. The onset potentials are determined from the intersection of the two tangents dawn at the raising current and baseline charging current of the CV traces. The onset potentials for oxidation were observed to be 0.34eV, 0.31eV, 0.32eV, 0.29eV, 0.28eV for NiO, NiO/Ti (5%), NiO/Ti (10%), NiO/Ti (15%), NiO/Ti (20%) and NiO/Ti (25%) respectively. The corresponding HOMO values are -4.74 eV, -4.71 eV, -4.72 eV, -4.69 eV, 4.69 eV and -4.68 eV. LUMO energy levels of the films were calculated by adding band gap energy (Eg) to the HOMO value, i.e,

$$E_{LUMO} = E_{HOMO} + E_g \tag{6}$$

The optical band gap energies were taken from Table 1. The calculated HOMO and LUMO energy level along with the band gap energies of NiO and NiO/Ti composite films with different Ti molar concentration are listed in Table 2. The energy level diagram is presented in Fig. 10.



Figure 7: Cyclic voltammograms of NiO thin films at different scan rates (2-100 mV/s)



Figure 8: Cyclic voltammograms of NiO and NiO/Ti composite films with different Ti molar concentrations for 15 cycles

(e)



Figure 9: The 5th cycled cyclic voltammograms (0 to +0.6V, scan rate 20mV/s) in 1 M KOH of NiO/Ti composite films with different Ti molar concentration

Sample	$E_{oxd}^{onset} \ \mathbf{eV}$	HOMO(eV)	E _g (eV)	LUMO (eV)
Pure NiO	0.34	- 4.74	3.70 eV	- 1.04
Ti 5%	0.31	- 4.71	3.67 eV	- 1.04
Ti 10%	0.32	- 4.72	3.51 eV	- 1.21
Ti 15%	0.29	- 4.69	3.56 eV	- 1.13
Ti 20%	0.29	- 4.69	3.51 eV	- 1.14
Ti 25%	0.28	- 4.68	3.50 eV	- 1.18

Table 2: Energy levels of NiO and NiO/Ti composite films



Pure NiO NiO/Ti 5% NiO/Ti 10% NiO/Ti 15% NiO/Ti 20% NiO/Ti 25%

Figure 10: The energy level diagram for NiO/Ti composite films with different Ti dopant concentrations

Electrochemical Stability and Switching Response of NiO/Ti Composite Films

Electrochromic stability of the films is a key issue for their application in electrocchromic devices. The durability of the NiO film and NiO/Ti (25%) composite film (1 cm x1 cm) was examined in 1 M KOH solution. The cyclic voltammograms were generated using the sweeping voltage range (-1 V to +1 V versus Ag/AgCl). It is noted that the cycling life of the thin films follows three-step process involving an activation period, a steady state, and a degradation period. For NiO film in Fig. 11(a) steady state is retained during $15^{th} - 45^{th}$ cycle. It is degraded beyond 45^{th} cycle. For NiO/Ti composite film, there is a steady state from 30^{th} cycle to 60^{th} cycle (Fig. 11 b) and a degradation state beyond 60^{th} cycle. This study indicated that as compared to NiO film, the NiO/Ti films exhibited long cycle life, thus having better electrochemical stability.



Figure 11: Cyclic voltammograms of (a) NiO film and (b) NiO/Ti (25%) composite film for several tens of cycles

In-situ transmittance measurement was employed to investigate the switching response characteristics of the electrochromic NiO thin film and NiO/Ti composite film. Transmission (T) was recorded at 650 nm and the applied potential is switched between ± 1 V. The single coloration–bleaching cycle for NiO and NiO/Ti films are shown in Fig.12. The switching

responses, including the coloration time (t_c) and bleaching time (t_b), are very crucial for the performance of the electrochromic devices. Shorter switching responses represent better performance in the electrochromic devices. The switching response is determined as the time required for 80% change in ΔT . The response times, t_c(80%) and t_b(80%) of the electrochromic NiO thin film are 18 s and 20 s, while those of NiO/Ti composite film are 16 s and 18 s. The switching responses of the NiO/Ti composite films are faster than those of the NiO thin film. It is noted that the OH⁻ ion insertion and de-insertion are primarily dependent on the electrolyte and the sample surface. High-density array of the film can easily enhance the OH⁻ ion insertion and de-insertion of OH⁻ ions to and from the sample surface. Due to the faster switching response of NiO/Ti film as compared to NiO films, the NiO/Ti composite films would be better candidate for their application in smart windows. Fig. 13 shows the coloring and bleaching state of NiO/Ti composite film during CV measurement.



Figure 12: Switching response of electrochromic NiO film and NiO/Ti composite film during an oxidation – reduction (coloration – bleaching) cycle



Figure 13: Photographs for coloring and bleaching state of NiO/Ti composite film

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Coloration Efficiency of NiO/Ti Composite Film

Electrochromic devices were fabricated following the procedure described in the previous using NiO and NiO/Ti composite layers as anodic layer and TiO₂ thin film as cathode layer. The device configuration is ITO/NiO or NiO/Ti/electrolyte/TiO₂/ITO Fig. 14 (a) and the photographs taken at its bleached and colored states are shown in Fig. 14 (b). The devices were tested in the applied potential ranges ± 1 V, ± 1.5 V and ± 1.7 V. No applied potential (0 V) represents the bleached state of the device.

In order to determine optical density (ΔOD), the optical transmittance spectra showing the colored and bleached states of the NiO and NiO/Ti electrochromic devices in the wavelength range (300 - 900 nm) at three different potentials (1.0 V, 1.5V and 1.7 V) were acquired as Fig. 15. The color of the device is brown. For NiO EC device, at the potential 0 V in bleached state the transmittance is 64% at the wavelength of 650 nm. The applied potential of 1.0 V, 1.5 V and 1.7 V in colored state the transmittances are 52%, 46% and 45% at the wavelength of 650 nm. For NiO EC device, the optical transmittance difference (ΔT) is11% at applied voltage (1 V), 18% at (1.5V) and 19% at (1.7 V). The optical density ΔOD is 0.19 at the voltage 1 V, 0.33 at 1.5 V and 0.35 at 1.7 V. For NiO/Ti EC device, at the potential 0V in bleached state the transmittance is 50% at 650 nm. The potential applied by 1.0 V, 1.5 V and 1.7 V in colored state, the transmittances are 38%, 37% and 36% at 650 nm The optical transmittance difference ΔT is 12% at the voltage 1 V, 13% and 14% at the potential 1.5 V and 1.7 V. The optical density ΔOD is 0.0.26, 0.29 and 0.32 at the voltage 1 V, 1.5 V and 1.7 V. In both devices the transmittances are not significantly varied at the potential 1.5 V and 1.7 V. The change in optical density (ΔOD) was calculated using the measured transmittance of the device in the colored (T_c) and bleached (T_b) state by applying the equation,

$$\Delta OD(\lambda) = \ln\left(\frac{T_b}{T_c}\right) \tag{7}$$

where $\Delta OD(\lambda)$ is the optical density at specific wavelength, T_b and T_c represent transmitted light intensity in bleached and colored state, respectively.



Figure 14: EC device (a) configuration and (b) bleached and colored states

The amount of charge (Q) transferred per unit colored area is calculated as the area under the CV curve for the oxidation peak. The active working area of the film is 1 cm^2 . The Q value is calculated by the equation below,

$$Q = \int_{t_1}^{t_2} J(t) dt$$
 (8)

where t_1 is the starting time when external voltage is applied, t_2 is the time when the EC cell is fully colored/bleached, J is the current density.

Cyclic Voltammetry (CV) was employed to investigate the electrochromic (cathodic/anodic) behavior of NiO thin film and NiO/Ti composite film. Fig.16 presents the CV of the sol gel deposited NiO and NiO/Ti composite films, which were recorded for first cycles at a scan rate of 20 mV/sec in 1 M KOH electrolyte with the potential ± 1 V, ± 1.5 V and ± 1.7 V Vs. AgAg/Cl. In order to observe the coloration efficiency of the films in different potentials, the CV measurements were performed for the films at different potential windows. In the positive sweep direction a peak of anodic current density corresponding to a value of 0.73 mA was obtained at a potential of 0.37 V for pure NiO film and 0.61mA at a potential of 0.38 V for NiO/Ti composite film. For the NiO EC device, the Q values for coloring and bleaching process are 8.4 mC/cm² and 7.2 mC/cm², respectively. The Q values for the NiO/Ti EC device are 7.67 mC/cm² and 6.75 mC/cm² in coloring and bleaching states.

Another important criterion for identifying the electrochemical performance of ECDs is the coloration efficiency (CE). The coloration efficiency η determines the amount of optical density change (Δ OD) as a function of the injected/ejected electronic charge (Q) at a specific wavelength, express as,

$$CE(\lambda) = \eta = \frac{\Delta OD(\lambda)}{Q}$$
 (9)

The coloration efficiency of the sol gel deposited NiO device at the wavelength of 650 nm was found to be 23 cm²/C, 22 cm²/C and 17 cm²/C at the potentials 1.0 V, 1.5 V and 1.7 V. The coloration efficiency of the NiO/Ti device was 34 cm²/C at the potential 1.0 V, 25 cm²/C and 19 cm²/C at the potential 1.5 V and 1.7 V at the wavelength of 650 nm for NiO/Ti device. When the potential 1.5 V and 1.7 V was applied longer switching time was taken to change the color. For this reason the coloration efficiency was reduced at the applied potential 1.5 V and 1.7 V.

Table (3) shows the calculated coloration efficiency, optical density and charge density of NiO and NiO/Ti composite film based devices at a wavelength of 650 nm with three different applied potentials. In both devices, we observed that increasing the applied potential decreases coloration efficiency. The maximum coloration efficiency was obtained at the potential 1.0 V. The characteristics of good electrochromic performance of an electrochromic device are maximum reversibility, highest coloration efficiency, minimum switching time, low potential window and maximum stability in terms of color/bleach cycles.

	Voltage	ΔOD	$Q (mC/cm^2)$	η (cm/C)
NiO	1.0 V	0.19	8.40	23.62
EC	1.5 V	0.33	14.50	22.76
Device	1.7 V	0.35	19.57	17.88
NiO/Ti	1.0 V	0.26	7.67	34.00
EC	1.5 V	0.29	11.25	25.77
Device	1.7 V	0.32	16.38	19.54

Table 3: Coloration efficiency (η) at λ = 650 nm for NiO and NiO/Ti electrochromic devices









Figure16: Cyclic voltammogram of the NiO and NiO/Ti films (a) ± 1 V (b) ± 1.5 V and (c) ± 1.7 V

The wavelength (λ) – the coloration efficiency (η) plots for the electrochromic performance of the devices are shown in Fig. 17. As we observed from the figures, the larger is the wavelength, the higher is the coloration efficiency. At a wavelength of 650 nm, Q = 7.67 mC/ cm², T_b = 50.3% and T_c = 38%, the coloration efficiency was 34cm²C⁻¹ the coloration efficiency was determined to be 34 cm²C⁻¹ in the NiO/Ti EC device. By doping Ti into NiO the device obtained enhance coloration efficiency, good stability and shorter switching time. For those good characteristics NiO/Ti composite films are suitable for smart window application.



Figure 17: The coloration efficiencies of (a) NiO and (b) NiO/Ti EC devices as a function of wavelength (400-700 nm)

Summary and Conclusion

In this work, solution processed nickel oxides (NiO) and titanium doped NiO (NiO/Ti) composite films with various Ti concentration of 5-25 mol% were developed in order to study their optical, electrical and electrochemical properties, and to integrate them in electrochromic devices (ECDs) which are for smart window application. First of all, four surface treatments (UV, heat, NaOH and HCl) were applied on the underlying substrates and tested for better film
formation. The first three treatments turned out as the suitable methods and the UV treatment was used throughout this work since it is easier and more convenient in practical aspect.

In part I, the effect of Ti dopant on the optical, electrical and electrochemical properties of NiO/Ti composite films was investigated. The optical study indicated that upon doping Ti in NiO, both optical transmission and band-gap energy (E_g) decreased which (the former one) is attributed to higher light scattering due to larger sized Ti integrated in NiO matrices and (the latter one) to creation of sub-band states by doping impurities. At the highest Ti content (25 mol%), the lowest E_g value of 3.5 eV was realized which would favor the electronic transition. The electrical conductivity (σ) of NiO/Ti films increased with increasing Ti contents and the conductivity was as high as 0.6 Sm⁻¹ for Ti dopant (25 mol%). Electrochemical study indicated that more positive electrochemical energy levels (highest occupied molecular orbitals) and higher electrochemical stability were observed in the NiO/Ti films. In addition, in-situ transmittance measurement indicated that NiO/Ti composite films exhibited a faster switching between coloration and bleaching states which is ascribed to an improved OH⁻ ion insertion and de-insertion actions at sample surface and electrolyte solution which may be related to better electrical conductivity, lower band-gap, more favorable energy levels of NiO/Ti composite films.

In part II, the electrochromic devices (ECDs) were fabricated using NiO or NiO/Ti (25%) as anodic electrochromic layers, TiO₂ as cathodic electrochromic layer and 1M KOH as electrolyte and their coloration efficiencies (η) were evaluated at the applied potentials of 1 V, 1.5 V and 1.7 V. At the applied potential of 1 V, the optical transmittance at the wavelength of 650 nm is 53% in the colored state and 64% in the bleached states for NiO ECD and is 38% in the colored state and 50% in the bleached states for NiO/Ti ECD which resulted in the maximum coloration efficiency 23.62 cm²/C in NiO ECD and 34 cm²/C in NiO/Ti ECD. It can be concluded that, Ti dopant has an influencing effect on the optical, electrical and electrochemical properties of NiO/Ti films, and as a consequence, on the electrochromic performance (coloration efficiency) of ECDs.

Acknowledgement

I am deeply grateful to Professor Dr Lei Lei Win, Head of Department of Physics, University of Mandalay, for her kind permission to carry out this research work. I would like to thank my Supervisor Dr Than Zaw Oo, Associate Professor, Department of Physics, University of Mandalay for giving very helpful comments, encouragements, valuable ideas, true line guidance, supervision and editing this thesis. The research grant provided by Mandalay University project No. 8 (2013-2014) and Project No. 49 (2014-2015) is gratefully acknowledged. Special thanks go to members of Materials Research Laboratory, Department of Physics, University of Mandalay for their help in experimental work.

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DEVELOPING A TRAINING MODEL FOR EARLY CHILDHOOD TEACHERS IN BUILDING STUDENTS' RESILIENCE

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J-201 DEVELOPING A TRAINING MODEL FOR EARLY CHILDHOOD TEACHERS IN BUILDING STUDENTS' RESILIENCE

Su Su Thwin¹

Abstract

The purpose of this study is to develop a training model for early childhood teachers in building their students' resilience. The study intends to investigate whether there would be significant difference in participant early childhood teachers' pedagogical knowledge level and resilience level in terms of their personal variables. It also investigates the relationship between their knowledge and practices. The factors and processes which are contributing to building resilience were found out.

Both quantitative and qualitative methodologies were used to build and verify the applicability of the training model. Purposive sampling method was used: 309 early childhood teachers were selected as participants. IPC values, independent sample *t* test, one way ANOVA, post hoc test by Tucky HSD, Games-Howell, Pearson product-moment correlation and simultaneous multiple regression were used for the analysis of quantitative and qualitative data.

According to the IPC values obtained, most of the participant teachers had pedagogical knowledge regarding resilience concept: 98 teachers (3.72%) in satisfactory level and 211 (68.28%) in above satisfactory level. For the resilience level, no participant teacher was in *Struggling* level, 10 (3.24%) were in *Need to Improve* level, 267 (86.40%) were in *Resilience level* and 32 (10.36%) were in *Pro-Resilience level*. Statistically significant differences were found between the groups of teachers in the areas of *Being Able to Control Events* (df=6, F=3.65, p<.01), *Navigating* (df=6, F=3.34, p<.01), *Bing Body Wise* (df=6, F=2.23, p<.05), *Managing Energy* (df=6, F=3.55, p<.01) and *Bounce Back* (df=6, F=3.08, p<.01). The combination of variables significantly predicted the participant teachers' practices in building their students' resilience, F(8,309) = 15.63, p < 0.001.

Based on the quantitative findings and the review of related literature, the training model of early childhood teachers in building students' resilience is built and it is also verified by five Resilience Awareness Training Workshops. And the relationship between teachers' perceived importance of building resilience level and performance level (r=.27, p = .07) was found out. A qualitative follow up study was conducted through interviews and observation. The information obtained from the interviews and workshops were complementary to the quantitative findings.

Keywords: Resilience, early childhood teachers, training model

Introduction

This study attempted to find out the pedagogical knowledge of early childhood teachers from selected schools and to develop a teacher training model for their professional development, specifically, in building their students' resiliency.

Importance of the Study

Life can be challenging and may include many stressful situations. In the face of increasing levels of toxic stress and psychosocial trauma, there is an urgent need to build human resilience so people have the ability to cope with, grow through, and transcend adversity (Marti,

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2016). The 2016 Resilience Summit is the Premiere Resilience Building Event of the year. In 2016, the summit encouraged to learn the following: three professional tasks including resilience skill building, promoting student resilience and military-concerned resilience. Children are born with the capacity for resilience. But resilience is not something they have or don't have. Children work on it throughout their lives. And they need to start as early as possible.

Resilience has been shown to be more than just the capacity of individuals to cope well under adversity. Resilience is better understood as the opportunity and capacity of individuals to navigate their way to psychological, social, cultural, and physical resources that may sustain their well-being, and their opportunity and capacity individually and collectively to negotiate for these resources to be provided and experienced in culturally meaningful ways. And also, resilience is about the ability to deal with and succeed in difficult situations and events. Resilience is a mix of key skills and characteristics of a person and the social supports and environment in which they live. Resilience, from the Latin "resilire" (to recoil or leap back), is a general concept related to positive adaptation in the context of challenge. In the physical sciences and engineering, resilience typically refers to the capacity to withstand stress or strain without breaking, or to recover original form, like a spring or rubber band. In the science of human development resilience has broad and diverse meanings, including recovery from traumatic experiences, overcoming disadvantage to succeed in life, and withstanding stress to function well in the tasks of life. Essentially, resilience refers to patterns of positive adaptation or development manifested in the context of adverse experiences. Resilience is also defined as a group of skills and qualities that lead people including children, to be able to cope with difficulties in a positive way (Wikipedia, 2013).

World Health Organization announced the importance of early childhood in 2014 as "Early child development . . . strongly influences wellbeing, obesity / stunting, mental health, heart disease, competence in literacy and numeracy, criminality, and economic participation throughout life. What happens to the child in the early years is critical for the child's developmental trajectory and life course. "(World Health Organization, 2014). The quality of a child's early environment and the availability of appropriate experiences at the right stages of development are crucial in determining the strength or weakness of the brain's architecture, which, in turn, determines how well he or she will be able to think and to regulate emotions." (National Scientific Council on the Developing Child, 2007).

Children need both outside supports and inner strengths to build their resilience. Outside supports include: caring relationships, positive role models in families and communities and community resources such as community centers, parent-child drop-in centers, faith groups, or support programs for children with special needs. Inner strengths include: self-control, thinking skills, confidence, positive outlook, responsibility and participation. Outside supports and inner strengths work together to develop one's resilience.

Building a close, loving relationship with the children is the most important thing adults can do to support their children's resilience. Children do best when they feel loved, understood and accepted, and are protected from harm. Feeling wanted and loved helps them to get through the hard times in life. Children learn to feel safe and secure through a close attachment with at least one caring person. They also learn that their needs will be met. All of this gives them the confidence to explore their world. Caring relationships provide accepting places where children

can learn to regulate their: bodies, feelings, attention, thoughts and behavior. Positive daily interactions with parents teach children how to have caring relationships with other important people in their lives. And it makes it easier for them to reach out to other.

Early childhood teachers are important people to help build their student's resilience. Children learn a lot by watching their teachers. When teachers cope well with everyday stress, they are showing their students how to do the same. Resilience makes a big difference in people's lives. People who respond to hardships with resilience are: healthier and live longer, happier in their relationships, more successful in school and work and less likely to get depressed. Resilience is the ability to steer through serious life challenges and find ways to bounce back and to thrive. Many of the things that support healthy development in young children also help build their resilience. These things include: a secure bond with a caring adult, relationships with positive role models, opportunities to learn skills, opportunities to participate in meaningful activities. Teachers need to learn how they can help their child develop strengths and gather supports that build resilience.

Children's social-emotional well-being, established in their earliest relationships, provides the foundation for success in school. Children who are able to manage their emotions, form trusting relationships with adults, and get along with their peers are more likely to be engaged learners. The relationship between preschool children's social skills had significant effect on children's learning achievement (Naing Naing Maw, 2007). A child's social-emotional domain of development is as important as, and is related to, other domains of development, such as cognitive, language, and physical health. Research has emphasized the importance of early childhood as a time for promoting resilience (Masten & Gewirtz 2006). Positive relationships and environments that support healthy cognitive, social, emotional, and physical development provide the foundation for young children to develop the resources and skills they need to cope and adapt to adversity throughout childhood and the rest of their lives.

Pedagogical Knowledge is a key to successful teaching. A teacher with deep pedagogical knowledge understands how students construct knowledge and acquire skills: develop habits of mind and positive dispositions towards learning. As such, pedagogical knowledge requires an understanding of cognitive, social and development theories of learning and how they apply to students in their classroom (Koehler, 2011). Therefore, this study tried to find out and analyzed the current situation; concerning early childhood teachers' pedagogical knowledge and practices in building their students' resilience. It is hoped that the findings of this study will somehow support in training early childhood teachers in building their students' resilience.

Theoretical Framework

The aim of this theoretical framework is to accommodate the many complex and overlapping factors that influence early childhood teachers' practices in building their students' resilience. This is largely informed by

- the research questions;
- the review of research literature;
- the knowledge bases that underpin the concepts of early childhood resilience; and
- the key descriptors that define the concepts of early childhood resilience building.

The recurring theme emerging from the literature is the surrounding sociocultural, familial and societal; environments that influence young children's worlds and lives. Researchers argue that it is almost impossible to discuss about building children's resilience isolation from the home, family community and wider environment in which children develop and grow. The following theories and concepts gave the strong foundations for this research study.

Ecology Theory by Brofenbrenna: The Russian-American theorist and psychologist Uri Brofenbrenner (1995) highlights the powerful influence of the environment on children's development and overall well-being. He used the term "ecology" to refer to the layered system of settings and institutions that both influence and are influenced by the child, maintaining that the child's family, school community and government must all be taken into account a comprehensive, holistic perspective of children's development. Building on Brofenbrenner's paradigm, existing research propose that there are different environmental systems or layers which children interact with directly and indirectly, and the synergy of all these different levels and factors affect children's overall development and engagement with resilience building a local, national and international level.

Figure 1 provides a visual image of the conceptual framework of early childhood and resilience building that has been used to guide the review. The framework proposes an ecological paradigm in which child is positioned at the center of the system, within a series of layers or concentric circles, illustrating the complex web of inter-relating and overlapping environments and factors that affect the child's life experiences and worlds. The model is composed of five intertwined systems, each depicting a distinct domain and level 1 the child's world (ARNEC & UNICEF, 2014).



- Figure 1: An ecological model of reciprocal effects between levels or layers in which risk and protective factors can exist
- Source: Andershed, 2012, Ricks and Proactive Factors among Preschool Children for Future Psychological Problem, p.12

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Risk factors: There are a number of 'risk factors' that can prevent children from developing resilience. In order to understand resilience, one needs to know about the particular risk factors that can lead to serious life problems, such as not completing education or being unable to get a job, mental illness or getting into trouble with the law. Research indicates that the more risk factors in their lives, the more difficult it is for children to have the ability to adapt successfully. This is where resilience is so important because it builds adaptive qualities and skills (Wikipedia, 2013).

The systems, cultures and relationships within which children live interact with the personal qualities that the children bring to the development of resilience. There are many different factors involved in resilience including:

- *factors in the individual person*: qualities such as optimism and problem-solving skills help people to have hope and to know that there is a way through when they face difficulties
- *Relationship factors*: knowing that there is someone who believes in you and will be with you is invaluable in difficult situations
- *Actors in the community*: communities that provide resources and supports also provide a context for resilience.

Eight Key Protective Factors of Resilience

The Devereux Centre of Resilient Children (DCRC) focuses on eight key within-person protective factors that have been found to be particularly important of school-aged children.

- 1. **Self-Awareness**: A child's realistic understanding of her/his strengths and limitations and consistent desire or self-improvement
- 2. **Self-Management**: A child's success in controlling her/his emotions and behaviors to compete a task or succeed in a new or challenging situation
- 3. Social- Awareness: A child capacity to interact with others in way that shows respect for their ideas and behaviours, recognizes her/his impact on them, and uses cooperation and tolerance in social situations
- 4. **Relationship Skill**: A child's consistent performance of socially acceptable actions that promote and maintain positive connections with other
- 5. Goal-directed Behaviour: A child's initiation of, and persistence in completing, tasks of varying difficulty
- 6. **Decision Making**: A child's approach to problem solving that involves learning from others and from previous experiences, using values to guide action, and accepting responsibility for her /his decision
- 7. **Personal Responsibility**: A child's tendency to be careful and reliable in her/his actions in contributing to group efforts
- 8. **Optimistic Thinking**: A child's attitude of confidence, hopefulness, and positive thinking regarding herself/himself and her/his life situations in the past, present, and future.

Mackrain, M. & Cairone, K. (2012) suggested tips and strategies that promote resilience in their wiriting *Promoting Resilience for Now and Forever* as (a) Support Self-Awareness, (b) Support Self-Management, (c) Support Social -Awareness, (d) Support Relationship Skills, (e) Support Goal-Directed Behaviour, (f) Support Decision-Making, (g) Support Persona Responsibility and (h) Support Optimistic Thinking (Mackrain, M. & Cairone, K., 2012).

A Model for the Study of Classroom Teaching

Research on teaching according to Mizel (1960), has investigated four types of variables in order to understand and thus encourage effective teaching. These variables form a general sequence of instructional events. First come presage variables or those characteristic that teachers carry with them to the classroom – characteristics such as sex, training experiences, and various personality traits such as motivation or intelligence. Existing side by side with presage variables in the sequence are context variables. These are the givens or conditions to which teachers must adapt. Context variables include pupil characteristics such as sex, social class, or abilities as well as characteristics of the school and community in which teaching and learning are embedded. Process variables are human transactions that occur in the classroom during the course of teaching and learning; they may include all observable behaviours of teachers and pupils directly related to teaching-learning activities as well as other seemingly unrelated observable behaviours of teachers and pupils. Product variables, the final category in the sequence, are outcomes of teaching as measured in terms of immediate pupil growth or long-term pupil effects. Learning to read, write, calculate, or acquire job skills and mature into an adult have been used by researchers as product measures.

The above mentioned Theoretical Framework leads to the following research work.

Objectives of the Study

General Objectives

To develop a training model for early childhood teachers in building their students' resilience

Specific Objectives

- 1. To investigate the pedagogical knowledge levels of the early childhood teachers in building their students' resilience
- 2. To investigate the resilience level of the early childhood teachers for building their students' resilience
- 3. To study the current practices of the early childhood teachers in building their students' resilience
- 4. To study the relationship between the personal variables and their pedagogical knowledge of the early childhood teachers for building their students' resilience
- 5. To examine the factors and processes which contribute to building resilience in early childhood

- 6. To find out the difficulties of the early childhood teachers in building their students' resilience
- 7. To develop a training model for early childhood teachers in building their students' resilience
- 8. To verify the training model for early childhood teachers in building their students' resilience

Research Questions

- 1. To what extent of pedagogical knowledge level do early childhood teachers have in building their students' resilience?
- 2. To what extent of resilience level do the early childhood teachers have for building their students' resilience?
- 3. To what extent do the early childhood teachers practise their pedagogical knowledge in building their students' resilience?
- 4. Are there any significant differences in early childhood teacher's pedagogical knowledge with respect to teacher personal variables?
- 5. Are there any relationship between pedagogical knowledge and practices of the early childhood teachers in building their students' resilience?
- 6. What are the difficulties do the early childhood teachers have in building their students' resilience?
- 7. Which factors and processes are contributing to building resilience in early childhood?
- 8. What are the major components that should be included in the "Resilience Aawreness Teacher Training Workshop"?

Limitation of the Study

- This study was geographically limited to Yangon Region.
- Participants of this research were early childhood teachers at preschools and Basic Education High, Middle, primary, Ba-Ka (Monastery) schools and Faith-based schools.
- This study was designed to develop a training model for early childhood teachers in building their students' resilience.

Definitions of Key Terms

Definitions of key terms were included in an attempt to clarify the definitions and terms pertinent to the study. Terms are listed and defined for the purpose of the research.

Resilience: In the context of exposure to significant adversity, resilience is both the capacity of individuals to navigate the way to the psychological, social, cultural, and physical resources that sustain their wellbeing and their capacity individually and collectively to negotiate for these resources to be provided in culturally meaningful ways. (Ungar 2011, the resilience research center, 2016, Sept.)

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Early Childhood Teacher refers to a qualified certified, licensed or accredited teacher of ECCE (SEAMEO and UNESCO, 2016).

Early Childhood Care and Education (ECCE) refers to programmes that, in addition to providing children with care, offer a structured and purposeful set of learning activities either in a formal institution (pre-primary) or as part of non-formal child development programme. ECCE programmes are usually designed for children from age 3 and include organized learning activities that constitute, on average, the equivalent of at least 2 hours per day and 100 days per year. This term is oftentimes referred to as pre-school and/or early childhood education (ECE). (SEAMEO and UNESCO, 2016)

Teacher Training refers to activities directly focused on a teacher's present responsibilities and is typically aimed at short-term an immediate goal. It involves understanding basic concepts and principles as prerequisite for applying them to teaching an ability to demonstrate principles and practices in the classroom. And also involves trying to new strategies in the classroom, usually with supervision and monitoring and getting feedback from others on one's practice (Carter & Curtis, 1994).

Pedagogical Knowledge refers to a deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses (among other things) overall educational purposes, values and aims (Koehler, 2011).

Operational Definitions

Resilience level was operationally defined as levels of Mean Values Showing the Resilience Level of Participant Early Childhood Teachers measured by the *Resilience Scale Questionnaire* which contained twenty-four questionnaire items in eight components: Being Able to Control Events, Consider himself/herself to be Resilience, Preparation, Navigating, Bing Body Wise, Managing Energy, Building Optimism and Bounce Back.

Early Childhood Teacher refers to a qualified certified, licensed or accredited teacher of primary schools, Basic Educational Primary/ Middle/ High schools or Faith-based schools, purposively, who took the responsibility of educating pre and Kindergarten students.

Pedagogical Knowledge of child development was operationally defined as the knowledge level categorized by the mean value of the participant early childhood teachers' responses to the Multiple-Choice questionnaire items relating to the child development principles which were essential to know for building student's resilience. **Pedagogical Knowledge of resilience** was operationally defined as knowledge level categorized by the mean value of the participant early childhood teachers' responses to the Open-Ended and Multiple-Choice questionnaire items relating to the teachers' general practices of building student's resilience.

Resilience Awareness Training workshop was operationally defined as the short training workshop especially a school-focused type given by the researcher in a school setting.

Scope of Research

Basic Education preschools, primary schools, middle schools, high schools and Religious/Faith based schools from four townships in Yangon City Development Area.

Method

This study aimed at developing a training model for early childhood teachers in promoting students' resilience. After developing the model for early childhood teachers, it is necessary to verify its applicability. Both quantitative and qualitative methodologies were used to test the applicability of the training model. It began with a quantitative study as a primary method and then qualitative study was conducted to observe real teaching-learning situation and to facilitate the interpretation of quantitative results. This study is designed as a participatory action research to investigate early childhood teachers' competency in promoting students' resilience. In doing so, awareness training workshop, school-focused training was conducted in four locations.

A Process to Develop a Model

Step (1) Conduct Research: Gather and analyze background information.

- Step (2) Develop draft model framework
- Step (3) Gather feedback from subject matter experts
- Step (4) Refine the teacher training model framework
- Step (5) Validate the model framework
- Step (6) Finalize the model framework

The framework for teachers training model was be displayed as a graphic representation of the content building blocks. It was verified through five Resilience Awareness Training Workshops in five different settings: preschool, primary school, middle school, high school, and training for mentors

The training model of this study was school-focused training. First and foremost, the pedagogical knowledge level of early childhood teachers of a specific school was examined. Based on the findings, the contents and emphasis on each portion was identified. After meeting with the principal, dean of kindergarten, and teachers who would participate in the workshop, the dates (3 days), time, and duration were set. Location of workshop was also decided. Needed materials and electronic devices were taken by researcher.

Sample

The participants of this study were early childhood teachers including preschool teachers; primary and junior assistant teachers even senior assistant teachers whoever took care of or teach the preschool or Kindergarten children. They were from 4 townships of 4 districts in Yangon Division. From the selected townships, 75 schools including High schools, Middle schools, Primary schools, Ba-Ka (monastery) schools, Faith-based school and preschool were selected using cluster sampling method. Participants were selected from these schools by using purposes sampling method. A total number of participants from these selected schools were 309. A valid response rate was 100%.

Instrument

Table 1: Number of Items in Questionnaire for Early Childhood Teachers

Sr.	Content Area	Type of Questions	Number of Items
1	Concept concerning child development	Multiple	10
		choice	
2	Concept concerning resilience	Open-ended	12
		questions	
3	Practices on building students' resilience in the classroom	Matching	5
4	Early childhood teachers' resilience level	Multiple	20
		choice	

Data Analysis

The data obtained from questionnaires survey were analyzed by using SPSS version 20. Descriptive statistics was used to tabulate the frequency count, percentage, mean and standard deviations for individual item and group of items. Independent sample *t*-test was used to examine whether there were significant differences between two groups by gender, years of age, and years of teaching Kindergarten students. One-way ANOVA was conducted to test significant differences between three groups and more for the school location, school levels, teacher's position, total teaching services, teachers' qualifications and types of teacher training. Furthermore, the two statistics namely Item Percent Correct (IPC) and Mean Percent Correct (MPC) were also used in order to describe the early childhood teachers' pedagogical knowledge in the area of child development principles and building students' resilience. The marking scheme for assessing the participant teachers' pedagogical knowledge level were 1 mark for the right answer on each item multiple choice items. The MPC value formulated the extent of pedagogical knowledge of early childhood teachers regarding child development principles and building students' resilience.

For taking the differences of early childhood teachers' pedagogical knowledge regarding child development and building students' resilience in terms of their gender, age, school level, rank, total teaching services, years of teaching KG, academic qualification and teacher training attended. Mean percent values are used to compare the pedagogical knowledge level of each group. Based on this mean percent value, the variation of pedagogical knowledge scores was categorized into three groups, namely, unsatisfactory (1.00% to 49.00%), fairly satisfactory (50% to 74%) and satisfactory (75 to 100%).

In addition, Independent Sample *t* Test was used to find out the significant differences in pedagogical knowledge scores for pedagogical knowledge score for child development and building students' resilience of early childhood teachers grouped by gender, age, school level, rank, total teaching services, years of teaching KG, academic qualification and teacher training attended. To reveal the significant differences between three or more groups, One Way of Analysis of Variance (ANOVA) followed by Tucky post hoc analyses was conducted. Moreover, to determine the best predictors of performance of participant early childhood teachers, Multiple Regression were also conducted.

For open-ended questions, the same responses of each item were collected to investigate the participants' perceptions and opinions regarding resilience concept and current practices.

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Besides, the frequency and percentage of each response were calculated to investigate their knowledge of resilience.

Phase I: Quantitative Research Findings

The analysis of collected data concerned with early childhood teachers as research findings is discussed in this phase. The questionnaires for teachers were distributed to the early childhood teachers (N=309). Response rate was 100%. First and foremost, the level of participant early childhood teachers' pedagogical content knowledge on child development principles, the level of participant early childhood teachers' pedagogical content knowledge on resilience concept and level of resilience of participant were investigated. Then the participants' perceived degree of importance and their perceived degree of performance in eight areas for building students' resilience such as support self-awareness, support self-management, support social awareness, support relationship skill, support goal-directed behaviour, support decision making, support personal responsibility, and support optimistic thinking were investigated. After that, the variations on the level of participant teachers' resilience, perceived degree of importance, level of performance in terms of personal factors, and school related factors, were analyzed. Moreover, the inter-correlation of participant teachers' resilience, perceived importance level and degree of performance were analyzed and presented in this phase.

Data Screening

The data was screened for univariate outliers. The out-range values, due to administrative errors, were examined and recorded with the original responses from questionnaire. In scoring these items, 2 marks were given for one correct answer. If a participant teacher can give correct answers for 5 out of 10 items, the score will be 10 marks and average score percent will be 50%. Scoring the Resilience Advantage Questionnaire was in two ways: to count the score across rows looking at the individual's level of Resilience and to sum total of participant teachers' score down the last column. Both the scores across the rows and sum total of participant teachers' score down the last column were calculated by using SPSS version 20.

		Resilience Advantage	Item	Score	Item	Score	Item #	Score	Total
		Concepts	#		#				score
	1	Being Able to Control Events	14						
	2	Consider himself/herself to be	16						
		Resilience							
Resilience	3	Preparation through hardness	5		10		15		
	4	Navigating Successfully	1		6		9		
Continuum	5	Bounce back and recovery	2		8		18		
Resilience	6	Being Body wise	4		12		20		
Advantage	7	Managing Energy	3		13		17		
Skill	8	Building Optimism	7		11		19		
Total Score									

Table 2: Elements of Resilience Advant	tage Concepts
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Interpreting resilience score: The Resilience questionnaire was designed to provide a baseline assessment of an individual's Resilience. The maximum score on the assessment is 100. Each of the 6 Resilience Advantage Concepts can have a score as high as 15.

Score: 100-80: Pro-Resilient (Scoring Range: Mean Value 4.00-5.00)

Score: 79-60: Resilient (Scoring Range: Mean Value 3.00-3.99)

Score: 59-40: Need to Improve (Scoring Range: Mean Value 2.00-2.99)

Score: 35-18: Struggling (Scoring Range: Mean Value 1.00-1.99) (Source: Citrin, 2012)

Component	Topic and Contents
1	Principles of child development
2	Brief theoretical overview of resilience
	Importance of developing resilience at an early age
3	Risk and protective factors
4	Prerequisites of developing child resilience
	Resilience rich environment
	quality of teacher-student relationship
	characteristics of "resilient classroom"
	role of early years teachers in child resilience development
5	Model of resilience development
	strengthening protective factors and reducing risk factors
	teaching resilience by direct action
	creating secure and supportive environment
6	Resilience Thinking Habits

Table 3: Resilience Awareness Teacher Training Workshop Content

Findings

This chapter deals with research findings based on quantitative and qualitative studies. The analysis of collected data as research findings will be discussed into three phases: quantitative research findings, qualitative research findings, and findings from the "Resilience Awareness Teacher Training Workshop".

Quantitative Research Findings

Investigating the Pedagogical Knowledge Levels of Early Childhood Teachers for Building their Students' Resilience

Pedagogical knowledge levels of participant early childhood teachers for building their students' resilience were investigated in two main parts, namely pedagogical knowledge of child development and pedagogical knowledge of resilience.

(a) Pedagogical Knowledge Levels of Child Development of Early Childhood Teachers for Building their Students' Resilience

Participant early childhood teachers' levels of pedagogical knowledge of child development for building their students' resilience were investigated with IPC values in multiple-choice items.

Scoring Range	No. of Teachers (%)	Remark
<50%	-	Below Satisfactory Level
50% - 74%	3 (0.97%)	Satisfactory Level
≥75%	306 (99.03%)	Above Satisfactory Level

Table 4: Number and Percentages of the Participant Teachers Showing the Level of Knowledge of Child Development

Scoring range: <50% below satisfactory, 50% - 74% = Satisfactory Level, ≥75% = Above Satisfactory Level

In Table 4, according to scoring range, there is no participant teacher who possessed *below satisfactory* level, there were three (0.97%) participant teachers possessed *satisfactory level* and 306 (99.03%) possessed *above satisfactory level* of pedagogical knowledge for child development principles. So, it can be assumed that most of the participant early childhood teachers in this study had above satisfactory of pedagogical knowledge for child development principles.

(b) Pedagogical Knowledge Levels of Resilience of Early Childhood Teachers for Building their Students' Resilience

Participant early childhood teachers' levels of pedagogical knowledge of resilience for building their students' resilience were investigated with IPC values in matching items.

Table 5: Number and Percentages of the Participant Teachers Showing the Level of
Knowledge for Building Students' Resilience(N=309)

Scoring Range	No. of Teachers (%)	Remark
<50%	-	Below Satisfactory Level
50% - 74%	98 (31.72%)	Satisfactory Level
≥75%	211 (68.28%)	Above Satisfactory Level

Scoring range: <50% below satisfactory, 50% - 74% = Satisfactory Level, ≥75% = Above Satisfactory Level

In Table 5, according to scoring range, no participant teacher possessed below satisfactory level, 98 (31.72%) of the participant teachers possessed satisfactory level and 211(68.28%) possessed above satisfactory level of pedagogical content knowledge concerning resilience concept. So, it can be assumed that most of the participant early childhood teachers in this study had above satisfactory of pedagogical content knowledge concerning resilience concept.

Investigating the Resilience Levels of the Participant Early Childhood Teachers for Building Their Students' Resilience

The participant teachers were requested to give responses on 20 items with regard to their resilience level. There were eight major components namely: *Being Able to Control Events* (item number14), *Consider Himself / Herself to be Resilience* (item number16), *Preparation through Hardness* (item numbers 5, 10 and 15), *Navigating Successfully* (item numbers 1, 6 and 9), *Bounce Back and Recovery* (item numbers 2,8,and 18), *Bing Body Wise* (item numbers 4, 12 and

20), *Managing Energy* (item numbers 3, 13 and 17), and *Building Optimism* (item numbers 7, 11 and 19).

	Mean	Std. Deviation
Being Able to Control Events	3.79	.71
Consider himself/herself to be Resilience	3.57	.78
Preparation through Hardness	3.60	.57
Navigating Successfully	3.19	.57
Bounce Back	3.88	.47
Bing Body Wise	3.55	.49
Managing Energy	3.73	.51
Building Optimism	3.39	.50
Teacher Resilience (Total)	71.40	6.96

 Table 6: Mean Values and Standard Deviations Showing the Resilience Level of Participant

 Early Childhood Teachers
 (N=309)



Figure 1: Mean Values and Standard Deviations of Participant Early Childhood Teachers' Resilience Level

Table 7: Number	and	Percentages	of	the	Participant	Teachers	Showing	the	Level	of
Resilienc	e						(]	N=30	9)	

Scoring	g Range	No. of Teachers (%)	Remark			
Total Score	Mean Value					
35-18	1.00 - 1.99	-	Struggling			
59-40	2.00 - 2.99	10 (3.24%)	Need to Improve			
79-60	3.00 - 3.99	267 (86.40%)	Resilient			
100-80	4.00 - 5.00	32 (10.36%)	Pro-Resilient			

In Table 7, according to scoring direction, no participant teacher was in *Struggling* level, 10 (3.24%) of the participant teachers were in *Need to Improve* level and 267 (86.40%) were in *Resilience level* and 32 (10.36%) were in *Pro-Resilience level*. So, it can be assumed that most of the participant early childhood teachers in this study, 299 (96.76%) were in *Resilience* level.



Figure 2: Total Number and Percentages of the Participant Teachers Showing their Resilience Level

The Current Practices of the Early Childhood Teachers in Building their Students' Resilience

The participant early childhood teachers were asked to give responses on 24 items with regard to their current practices for building their students' resilience. There were eight major components namely Support Self Awareness (SSA), Support Self-Management (SSM), Support Social Awareness (SSOA), Support Relationship Skill (SRS), Support Goal- Directed Behaviour (SGDB), Support Decision Making (SDM), Support Personal Responsibility (SPR) and Support Optimistic Thinking (SOT). Each component contains three questionnaire items for both the level of importance and the level of performance. In order to respond these questionnaire items, five-point-Likert-type scale was used (1=not at all important/ not at all perform, 2= slightly important/ seldom perform, 3=moderately important / often perform, 4=very important/ usually perform and 5=extremely important / always perform.

Table 8: Mean Values and Standard Deviations of Participant Early Childhood Teachers'
Perceived Degree of Importance and Performance on Building Students'
ResilienceResilience(N=309)

Components of building students' resilience											
		SSA	SSM	SSOA	SRS	SGDB	SDM	SPR	SOT		
Importance	Mean	4.14	4.13	4.56	4.66	3.91	4.55	4.30	4.01		
	(SD)	(.43)	(.58)	(.30)	(.22)	(.62)	(.36)	(.49)	(.51)		
		SSAP	SSMP	SSOAP	SRSP	SGDBP	SDMP	SPRP	SOTP		
Performance	Mean	3.79	3.89	4.27	4.44	3.69	3.77	4.38	3.80		
	(SD)	(.42)	(.49)	(.49)	(.52)	(.52)	(.48)	(.50)	(.46)		

SSA= Support Self Awareness, SSM= Support Self-Management, SSA=Support Social Awareness, SRS= Support Relationship Skill, SGDB= Support Goal- Directed Behaviour, SDM= Support Decision Making, SPR= Support Personal Responsibility and SOT= Support Optimistic Thinking





SSA= Support Self Awareness, SSM= Support Self-Management, SSOA=Support Social Awareness, SRS= Support Relationship Skill, SGDB= Support Goal- Directed Behaviour, SDM= Support Decision Making, SPR= Support Personal Responsibility and SOT= Support Optimistic Thinking.

Variations in Early Childhood Teacher's Pedagogical Knowledge Level and Practice Level with Respect to Teacher's Personal Variables

In order to investigate the best predictors of teachers' performance levels in building their students' resilience, simultaneous multiple regression was conducted by identifying seven variables as predictors: Total Knowledge on Child Development, Total Knowledge on Resilience, Total Resilience Score, Importance Level, Age, Rank, Total Teaching Service, Teaching Service in KG Qualification, and Teacher Training Course. The beta coefficients were presented in Table 9, Performance Factors in Building Students' Resilience: Support Self Awareness (Performance), Support Self - Management (Performance), Support Social Awareness (Performance), Support Relationship Skill(Performance), Support Goal- Directed Behaviour (Performance), Support Decision Making (Performance), Support Personal Responsibility(Performance) and Support Optimistic Thinking (Performance) significantly predicted Performance Total when all eight variables were included.

According to the β weights, Support Decision Making (Performance variable) ($\beta = .60, p$ <0.001) appears to be the best predictor of teachers' performances in building students' resilience. Support Goal- Directed Behaviour (Performance variable) ($\beta = .34, p < 0.001$) appears to be the second-best predictor of teachers' performances in building students' resilience. Support Social Awareness (Performance variable) ($\beta = .28, p < 0.001$) appears to be the third best predictor of teachers' performances in building students' resilience. Support Social Awareness (Performance variable) ($\beta = .27, p < 0.001$) appears to be the fourth best predictor of teachers' performances in building students' resilience.

The Regression Equation is

Total performance in building resilience = .386 + .078 SSAP + .150 SSMP + .147 SOAP + .123 SRSP + .181 SGDBP + .335 SDMP +113SRSP + .124 SOTP

			Coefficients	6		
Model		Unstand Coeffi	lardized icients	Standardized Coefficients	t	Р
		B Std. Error		Beta		
	(Constant)	.386	.152		2.542	.019
	SSAP	.078	.027	.11**	2.942	.008
	SSMP	.150	.021	.27***	7.012	.000
	SOAP	.147	.026	.28***	5.706	.000
1	SRSP	.123	.026	.22***	4.772	.000
	SGDBP	.181	.026	.34***	6.867	.000
	SDMP	.335	.085	.60***	3.954	.000
	SPRP	.113	.021	.22***	5.274	.000
	SOTP	.124	.025	.22***	4.990	.000
a. Depe	ndent Variabl	e: Performance	Total			

 Table 9: Simultaneous Multiple Regression Analysis for Performance Factors in Building Students' Resilience

 $R = .55, R^2 = .31, F(7,582) = 36.42, *p < 0.05, **p < 0.01S, ***p < 0.001, n.s = no significance$

SSAP= Support Self Awareness (Performance), SSMP= Support Self -Management (Performance), SOAP=Support Social Awareness (Performance), SRSP= Support Relationship Skill (Performance), SGDBP= Support Goal-Directed Behaviour (Performance), SDMP=Support Decision Making (Performance), SPRP= Support Personal Responsibility(Performance) and SOTP= Support Optimistic Thinking (Performance)

Table 10: Inter-Correlations for Participant Teachers' Performance and Predictors Variables

		М	РТ	TK	TKR	TR	IR	Α	R	TTS	TS	Q	TTC
		(SD)		CD							KG		
	DТ	.41		.12	.21	.09	.27	20	.08	.00	.08	18	.17
	P1	(.26)		(.25)	(.12)	(.30)	(.07)	(.13)	(.32)	(.49)	(.32)	(.17)	(.17)
	TKCD	1.7			.24	04	03	.24	00	06	.00	.20	.14
	IKCD	(.10)			(.09)	(.40)	(.42)	(.09)	(.48)	(.37)	(.49)	(.14)	(.21)
		16				18	18	- 07	- 38	- 45	- 23	08	13
	TKR	(.25)				(.16)	(.16)	(.34)	(.10)	(.00)	(.10)	(.32)	(.23)
		()				()	()	()	()	()	()	()	(.==)
	TR	3.57					.08	.10	.00	.03	.08	03	.01
Pearson	IK	(.31)					(.32)	(.29)	(.48)	(.42)	(.32)	(.43)	(.47)
Correlation	IТ	4.30						30	26	32	25	12	_ <mark>.40</mark>
Correlation		(.30)						(.52)	(.82)	(.04)	(.08)	(.26)	(.00)
~.	А	2.40							.48	.52	.36	23	<mark>32</mark>
Sig.		(.49)							<mark>(.00)</mark>	(.00)	<u>(.02)</u>	(.10)	(.04)
(1-tailed)	R	1.13								.57	.10	11	- .71
		(.34)								<mark>(.00)</mark>	(.28)	(.27)	(.00)
	TTS	1.56									.58	20	47
	TO	(.82)									<mark>(.00)</mark>	(.13)	(.00)
	TS VC	1.36										04	03
	KG	(.49)										(.39)	(.43)
	Q	2.8											.13
	`	(1.15)											(.23)
	TTC	.56 (2.04)											





*correlation is significant at the 0.05 level (2-tailed), **correlation is significant at the 0.05 level (2-tailed) without * correlation is not significant

The combination of variables significantly predicted the participant early childhood teachers' practices in in building their students' resilience, F (8, 309) = 15.63, p < 0.001, with all seven variables significantly contributing to the prediction. This can also be seen in Table 9 and Figure 4.

Relationship between Pedagogical knowledge and Practices of the Early Childhood

Teachers in Building their Students' Resilience

In order to find out the Relationship between Pedagogical knowledge on importance of building and Practices of the Early Childhood Teachers in building their students' resilience, simultaneous multiple regression was conducted. The means, standard deviations, and intercorrelations can be found in Table 4.30 and Figure 5.

Teacher's Personal Variables



Figure 5: Potential Factors Affecting Participant Early Childhood Teachers' Practice in Building Students' Resilience

*p <0.05, **p <0.01

Qualitative Research Findings

Open-ended Questions Responses

All participants (309) were asked open-ended questions regarding resilience.

Open-ended question No.1: What do you understand by the term "resilience? The participant teachers responded this question by mentioning the key components of resilience as zest and zeal, enable to solve every day problems, enable to solve problems without other's help, self-confidence, decide correctly, good ideas, enable to overcome obstacle, enable to face various adversities enable to understand and control his/her emotions, good social skills, affectionate, healthy, motivated, active, tolerance, high Self-esteem, imperturbable and matured.

Open-ended question No.2: What are the characteristics of resilient child? The participant teachers responded this question as *healthy, courageous, initiative, active/motivated, considerate, clever, serious, good problem-solving skill, fearless, happy, inquisitive, ambitious, collaborative, have eye-contact, decisive, playful willing to answer, like to discuss with teachers, calm, well disciplined, have smiles, talkative, jumping, dare to commit, enjoy volunteer services and tuff.*

Open-ended question No.3: What are the characteristics of non-resilient child? The participant teachers responded this question as *indecisive, over protected, fearful, low self-esteem, uninitiated, low academic achievement, avoid eye-contact, avoid to answer questions, sad/sorrow, easy to cry, stay alone, dependent, non-collaborative, unable to solve problem, low social skill, rude, aggressive, at a low ebb and dejected.*

Open-ended question No.4: What are the factors which weaken the resilience level of the child? The participant teachers responded this question as being separated from parents, nurtured to be dependent, have no opportunity to be self-regulated, discourage the child's active participation, weaken the child's social dealing, lack of self-confidence, lack of support from family member, over protected parents, broken home, low income family, bad health, maltreatment from environment, tortured, bawl out, being bullied, being jeered, have low IQ, being beaten, insecure environment, being orphan, being criticized, being blamed, being neglected, bad self-care and being unsatisfied.

Open-ended question No.5: What are the benefits of being resilience? The participant teachers responded this question as: become optimistic, more self-confident, get higher IQ, become productive citizen, get reasoning ability, can work well, get successful life, do or behave without others' influence, decisive, satisfied, speak loud enough, become a good leader, collaborative, initiative, good relationship with others, more motivated, behave well, have good problem-solving skill, tolerant, feeling good, popular, happy, know what is right and what is wrong, get oral reward, considerate, philanthropic and school friendliness.

Open-ended question No.6: What are the drawbacks of being non- resilience? The participant teachers responded this question as problematic, emotional, pessimistic, disengage from others, unsuccessful life, slow improvement, mentally unhealthy, deviate from life-ambition, vulnerable, wavering, depressed/ disappointed, non-collaborative, suicide, easily persuaded by others fearful, weak in social dealing, low self-confidence, stay alone, low academic achievement, make wrong/ bad decision, low reasoning power, have psychological problems, negatively affect

his/her environment, make errors, unable to decide correctly, withdrawal, get heart disease, unhappy, run away from school, make bully and destroy.

Open-ended question No.7: Who and how a child could be helped in building his/her resilience and how? The participant teachers responded this question as parents, teachers, relatives, environment, friends/ peers, head masters/ head mistress and sibling's trough encouragement.

Open-ended question No.8: Should "resilience" be taught to children as a specific subject or embedded in other subjects or across the curriculum? Give comments. The participant teachers responded this question as follow:

Forty-five percent of respondents prefer to build the students' resilience in the classroom by teaching resilience *embedded in other subjects (caught)*

Open-ended question No.9: Should "resilience" be taught to children as a specific subject? Give comments.

The participant teachers responded this question as follows:

Fifty-five percent of respondents prefer to build the students' resilience in the classroom by teaching as a special subject (taught).

Open-ended question No.10: Do you have any resilient student in your class? Discuss. The participant teachers responded this question as follows:

Sixty-five percent of participant teachers revealed that they have resilient students in their class.

Open-ended question No.11: Do you have any non-resilient student in your class? Discuss. The participant teachers responded this question as follows:

Seventy two percent of participant teachers revealed that they have non-resilient students in their class.

Open-ended question No.12: When facilitating students in a classroom:

Teachers should use role-play, imaginative pay, illumine stories, illumine historical incidents/ stories, cooperative play, group assignments/ works, stores on national heroes, illumine songs, illumine rhymes, national anthem, creative play, excursion, toys which can give experiences of win and lose, games which can build team spirit, child-centered method, physical training, exercises and lively dances.

Teachers should use games or play which can promote children' cooperation, team-spirit, reasoning power, learning, illustrative/ portrayal and age-appropriate. Moreover, football, basketball, badminton, golden brown kite, Indian girl trading on lines game, snake and ladder, domino, chess, backgammon, banyan tree spirit, turtle egg and mother turtle game, salts, see-saw, swing, dosed, coloring and roping.

Teachers should use dice, ball, toy sets for role play such as pretending as a doctor, an engineer, teacher, a cook etc., musical instruments such as drums, flutes, ropes and building blocks.

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Teachers should use illumine stories, stories hic van promote students' zeal, courage, patience, assiduity, Mahawthahta stries, ten-zat-tawgyi, Pho cair, crocodine and monkey, Are you my mother?, noisy night,, Ma Pu Kywe and little snail, Where are you going Ger Baut?, Considerate Bear, Three piggies, let us unify, reserved and hardworking spider, wise bird, little rabbit Phyu Phyu, a rabbit and a tortoise, a giant and three goats, an ant and a locust, a little bat, Mi Phyu, thankful ant, little mushroom Phyu Phyu and so on.

Teachers should use the which can promote students resilience, se-concept, confidence etc. illumine songs, illumine rhymes, national anthem, Myanmar school, one step ahead, little gourd, we can do it, our national ethnic, if you are happy..., allegro songs, fall-out songs, bed number 18, we all unanimous, pineapple and durian and so on.

Teachers should use the pictures of respectable national leaders, pictures showing the kindness or consideration like helping to stand up the fallen person, a person who is receiving award/ trophy, people pushing the wheel together, pictures showing different emotional expression, pictures which show paying respect to holy persons, parents, teachers, elders and so on.

Teachers should be encouraging, kind, considerate, gentle, sincere, courageous, initiative, intimate, resourceful, recognize he name o he/his students, fair and square, responsible, honest and so on.

Teachers should dress properly, presentably and decently, they must be chirpy, neat and tidy, warm, benevolent, tolerant, initiative, optimistic and caring.

Others who/which can facilitate students in building their resilience include students' families: parents; siblings, neighbours, peers, age-mates, classmates, relatives and community.

Based on the findings of this study and review of the related literature, a proposed training mode of this study was verified and illustrated. In order to verify the proposed training model, five Resilience Awareness Training Workshops (RATWs) were conducted in five different settings: preschool, primary school, middle school, high school and a training center for mentors. After conducting the workshops, the participants were interviewed and observed in their classrooms settings. They replied that before they did some of their classroom activities which they learned in the workshop without knowing the benefit of these activities. Only after attending the RATW, they feel more confident in performing these activities and realizing that they are building their students' resilience. They feel more meaningful in performing their job.

Conclusion, Discussion and Suggestions

Conclusion

Investigating the Pedagogical Knowledge Levels of Early Childhood Teachers for Building their Students' Resilience

 Pedagogical knowledge levels of participant early childhood teachers for building their students' resilience were investigated in two main parts, namely pedagogical knowledge of child development and pedagogical knowledge of resilience.

- Participant early childhood teachers' levels of pedagogical knowledge of child development for building their students' resilience were investigated with IPC values in fifteen multiple-choice items.
- According to scoring range, no participant teacher possessed *below satisfactory* level, 3 (0.97%) of the participant teachers possessed *satisfactory level* and 306 (99.03%) possessed *above satisfactory level* of pedagogical content knowledge for child development principles. So, it can be assumed that most of the participant early childhood teachers in this study had above satisfactory of pedagogical content knowledge for child development principles.
- Participant early childhood teachers' levels of pedagogical knowledge of resilience for building their students' resilience were investigated with IPC values in five matching items.
- According to the IPC values obtained, it can be interpreted that most of the participant teachers in this study had pedagogical knowledge with regard to resilience concept.
- According to scoring range, it was found that no participants in this study possessed below satisfactory level, 98 (3.72%) of the participant teachers possessed satisfactory level and 211(68.28%) possessed above satisfactory level of pedagogical content knowledge concerning resilience concept. So, it can be assumed that most of the participant early childhood teachers in this study had above satisfactory of pedagogical content knowledge concerning resilience concept.

Investigating the Resilience Levels of the Participant Early Childhood Teachers

- The participant teachers were requested to give responses on 20 items with regard to their resilience level. There were eight major components namely: *Being Able to Control Events* (item number14), *Consider Himself / Herself to be Resilience* (item number16), *Preparation through Hardness* (item numbers 5, 10 and 15), *Navigating Successfully* (item numbers 1, 6 and 9), *Bounce Back and Recovery* (item numbers 2,8,and 18), *Bing Body Wise* (item numbers 4, 12 and 20), *Managing Energy* (item numbers 3, 13 and 17), and *Building Optimism* (item numbers 7, 11 and 19).
- According to scoring direction, it was found that no participant teacher was in *Struggling* level, 10 (3.24%) of the participant teachers were in *Need to Improve* level and 267 (86.40%) were in *Resilience level* and 32 (10.36%) were in *Pro-Resilience level*. So, it can be assumed that most of the participant early childhood teachers in this study, 299 (96.76%) were in *Resilience* level.

When investigating the resilience level of participant teachers according to their personal variables, it was found that:

• both the group of male teachers (TR=3.53) and the group of female teachers (TR=3.57) were in *Resilience level*.

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- both the age group of teachers, aged 20-39 years, (TR=3.52, SD=0.35) and the age group of teachers, aged 40 years and above, (TR=3.65, SD=0.34) were found in *Resilience* level.
- All the three groups of teachers, Primary Teachers (TR=3.55), Junior Teachers (TR=3.57), and Senior Teachers (TR=3.66) were in *Resilience* level.
- All four groups of teachers, who worked in Dagon township (TR=3.55, SD=0.31), in Sanchaung township (TR=3.56, SD=0.35), in Kamayut township (TR=3.57, SD=0.38) and in Insein township (TR= 3.57, SD=0.34) were found Resilient.
- All groups of schools: teachers from preschools (TR=3.58, SD=0.31), teachers from primary schools (TR=3.59, SD= 0.34), teachers from middle school (TR=3.54, SD=0.31), teachers from high schools (TR=3.49 SD=0.41), and teachers from Others (Ba Ka (Monastic Schools) / Faith-based schools) (TR=3.62, SD=0.21) were in the *Resilience* level.
- All the four groups of teachers, whose total teaching services were <10 years, (TR=3.55), 10 to 19 years (TR=3.57), 21-29 years (TR=3.68), and 30 years ≤ (3.70) were in *Resilience* level.
- all six groups of teachers, who were under graduate (TR=3.75), B.A.(TR=3.58), B.Sc.(TR=3.53), B.Ed.(TR=3.72) B.Com.(TR=3.46), L.L.B.(TR=3.61), and M.A., M.Sc.(TR=2.55) were found resilient and among them Under-graduate group and B.Ed. degree holders got the higher resilience mean values.
- All the seven groups: Primary Teacher Training Course (PTTC) group (TR=3.53), Junior Teacher Training Course (JTTC) group (TR=3.62), Diploma in Teacher Education Course (DTEC) group (TR=3.56), Post Graduate Diploma in Education (PGDMA) group (TR=3.50), College of Education (COE) group (TR=3.50), Bachelor of Education (B.Ed.) group (TR=3.70), and Others (short training given by Ministry of Education (MOE), Ministry of Social Welfare, Relief and Resettlement (MOSWRR), Department of Myanmar Research Bureau (DMERB), Ministry of Health (MOH), NGOs, Religious Organizations, TR=3.58) were found Resilient.

Variations of Participant Early Childhood Teachers' Resilience Levels Depending on Personal Factors

- Statistically significant differences were found in the area of Navigating (df=2, F= 5.60, p<0.01) and Managing Energy (df=2, F=4.68, p<0.05) between the groups of teachers by their rank. But no significant differences were found between the groups and within the groups of teachers in the remaining six areas of resilience: Being Able to Control Events; Consider himself/herself to be Resilience; Preparation; Bing Body Wise; Building Optimism, and Bounce Back.</p>
- The post hoc Tuckey HSD indicated that, in the area of *Navigating*, the group of primary teachers differed with the group of junior teachers (p < 0.001, d = -0.26). It was also found that in the area of *Managing Energy*, the group of primary teachers significantly differed with the group of junior teachers (p < 0.05, d = 0.32).

- Statistically significant differences were found between the groups of teachers in two areas of resilience *Bing Body Wise* (df=4, p < 0.05, F=3.02) and Managing Energy (df=4, p < 0.05, F = 2.70). But no significant differences were found between the groups and within the groups of teachers of resilience in six areas of resilience: *Being Able to Control Events; Consider himself/herself to be Resilience; Preparation; Navigating; Building Optimism,* and *Bounce Back* by their school level. *Navigating* was found to be not significantly different in Post Hoc Tests.
- Statistically significant differences were found between the groups of teachers in two areas of *Being Able to Control Events (df=3, F=4.99, p<.01) and Navigating (df=3, F=3.17, p<.05)*. But no significant differences were found between the groups and within the groups of teachers of resilience in six areas of resilience: *Consider himself/ herself to be Resilience; Preparation; Managing Energy; Being Body Wise Building Optimism, and Bounce Back by their Total Teaching Service.*
- The post hoc Tucky HSD indicated that, in the area of *Being Able to Control Events*, the group of teachers who had total teaching service of less than 10 years significantly differed with the group of teachers who had total teaching service between 10 19 years (p < 0.05, d = -0.38) and teachers who had total teaching service between 20 and 29 years (p < 0.001, d = -0.73). Post hoc Games-Howell test was used to indicate that, in the area of *Navigating*, the group of teachers who had total teaching service of between 10 and 19 years significantly differed with the group of teachers who had total teaching service of between 20 and 29 years (p < 0.001, d = -0.73).
- Statistically significant differences were found between the groups of teachers in two areas of *Being Able to Control Events* (*df*=6, *F*=3.65, *p*<.01), *Navigating* (*df*=6, *F*=3.34, *p*<.01), *Bing Body Wise* (*df*=6, *F*=2.23, *p*<.05), *Managing Energy* (*df*=6, *F*=3.55, *p*<.01) and *Bounce Back* (*df*=6, *F*=3.08, *p*<.01) but not significant different between the groups and within the groups of teachers in six areas of resilience: *Consider himself/ herself to be Resilience; Preparation* and *Building Optimism* by their *Teacher Training*.
- The post hoc Tukey HSD indicated that the group of teachers who attended DTEC significantly differed with the group of teachers who attended Others (short training given by Ministry of Education (MOE), Ministry of Social Welfare Rescue and Resettlement, Department of Myanmar Research Bureau (MERB), Ministry of Health (MOH), Religious Organizations) in such area as *Being Able to Control Events* (p < 0.05, d = -0.67).
- The post hoc Tukey HSD also indicates that the group of teachers who attended JTTC significantly differed with the group of teachers who attended Others (short training given by Ministry of Education (MOE), Ministry of Social Welfare Rescue and Resettlement, Department of Myanmar Research Bureau (MERB), Ministry of Health (MOH), Religious Organizations) in such area as *Navigating* (p < 0.05, d=0.71). And it was also found that the group of teachers who attended PTTC significantly differed with the group of teachers who attended PTTC significantly differed with the group of teachers who attended B.Ed. course (p < 0.05, d=0.93) and with the group who attended Others (short training given by MOE, MOSWRR, DMERB, MOH, NGOs, religious organizations) in the area of *Managing Energy* (p < 0.05, d=0.88). Moreover, the group of

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teachers who attended JTTC also significantly differed with the group of teachers who attended PGDMA (p < 0.05, d=0.65) in the area of *Bounce Back*.

- There were significant differences between the group of participant early childhood teacher who had *Teaching KG service* less than 10 years and the group of participant early childhood teachers who had *Teaching KG service ten years and above* in the areas of *Being Able to Control Events* and *Managing Energy* (t(307) = -3.12, p < 0.00, d = -0.32). But the in other areas of resilience, participant early childhood teacher's resilience levels were not significantly different between the groups of teachers who had teachers *Teaching KG service* less than 10 years and the group of participant early childhood teachers who had teachers who had *Teaching KG service ten years and above*.
- SRS was significantly correlated with SGDB (r=.52, p<0.01) and SOT (r=.50, p<0.01). SGDB was significantly correlated with SPR (r=.73, p<0.01), SRSP (r=-.39, p<0.05) and SPRP (r=.51, p<0.01). SDM was significantly correlated with SOT (r=.48, p<0.01), and SGDBP (r=.36, p<0.05). SPR was significantly correlated with SSAP (r=.38, p<0.05), SSMP (r=.46, p<0.01) and SPRP (r=.73, p<0.01). SOT was significantly correlated with SDMP (r=.48, p<0.01), and SOTP (r=.54, p<0.01). These correlations were shown in Figure 4.5.

Discussion

The present study analyzed teachers' current performance for building their students' resilience in the classroom settings in eight components. The discussion of the research findings deals with a description and analysis of teachers' pedagogical knowledge on child development principles, resilience concept, teachers' resilience level, teachers' perceived importance levels of resilience building practices and their current practices. It was focused on relation of the results of quantitative and qualitative studies.

Most of the Participant Early Childhood Teachers defined the term resilience as the child's personal attributes of facing and surviving and overcoming. This is in line with the definition of Grotberg, (1997), Resilience refers to the capacity to survive and even thrive in the face of adversity. It can be defined in some of the following ways:

- the capacity to adapt successfully despite exposure to severe stressors
- the capacity to face, overcome, and even be strengthened by the adversities of life
- the process of, capacity for, or outcome of successful adaptation despite challenging or threatening circumstances.
- Some of the participants stated in interviews that students 'resilience capacity could be seen when they faced with adversities. This showed they might recognize students' resilience concurrently. This finding indicates the second application of the other three principles:
- Development is the joint product of nature and nurture. Resilient children are the product of innate temperamental and cognitive abilities along with positive qualities in their rearing environments.

- Developmental outcomes vary over time and contexts. The variables that predict resilience change as children grow and are different from boys and girls.
- Development is characterized by continuity and discontinuity

Poole, 2007 stated that Environments that promote resilience are those that promote school connectedness, peer connectedness, teacher connectedness, family connectedness, and community connectedness. In this study, participant EDC teachers stated that family as the most important aspects and the teachers as the second most important and relatives as the third one. This could be said true because parents especially mothers are the very first and foremost responsible caregivers in building children's resilience. Participants teachers from preschools and primary schools participated in this study reported that they believed in a children's possession of religious faith and hold perceptions of themselves as worthy and competent individuals. Therefore, these teachers gave training on meditation to students about 10 minutes in every morning. Similarly, monastic schools (Ba-Ka) and Kachin Baptist school teach how to pray.

Werner (1995) distinguished three contexts for protective factors:

- personal attributes, including outgoing, bright, and positive self-concepts;
- the family, such as having close bonds with at least one family member or an emotionally stable parent; and
- the community, like receiving support or counsel from peers.

Participant teachers also addressed that non-resilient children were the ones who demonstrated disruptive- aggressive, withdrawal, and internationalized behaviour problems. Werner (1995) stated a number of other factors that promote resilience have been identified: the ability to cope with stress effectively and in a healthy manner, having good problem-solving skills, seeking help, holding the belief that there is something one can do to manage one's feelings and cope, having social support, being connected with others, such as family or friends, self-disclosure of the trauma to loved ones, spirituality, having an identity as a survivor as opposed to a victim, helping others, and finding positive meaning in the trauma. Participants of this study mentioned all these factors as essential actors or building students' resilience.

Findings of this study indicated that group of teachers might represent any number of these developmental stages or ways of knowing when they come to resilience awareness training, the researcher tried to plan accordingly. Many participant ECD teachers were found functioning at the received knowledge stage, if not the one of silence. Thus, to address these learners, the researcher s a trainer framed their ideas about the open-ended nature of teaching as a set of guidelines to be learned, simultaneously giving them practice in self-reflection and self- rating on their own resilience level and analysis through their specific training activities. By providing multiple opportunities to work together and hear the experiences and ideas of other participants, they said that they benefit a lot of resilience related knowledge from this workshop.

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Moreover, findings of this study on the Potential Factors Affecting Participant Early Childhood Teachers' Practices in Building Students' Resilience, suggested that

- the older the teacher, the higher the resilience level the teacher have
- the higher the level of qualification, the more pedagogical knowledge of child development principles they have
- the higher the level of qualification, the more pedagogical knowledge of building student's resilience they have
- the more training courses they had taken, the higher the perceived importance level in building student's resilience
- the more training courses they had taken, the higher the performance they do in building student's resilience
- the more teaching services in KG class, the higher the pedagogical knowledge level of child development principles,
- the more the total teaching service teachers have, the higher their resilience level, this is in line with the findings concerning age
- finally, the higher the teachers' perceived importance level in building students' resilience, the higher the performance level in building student' resilience
- According to the findings on participant early childhood teachers' perceived importance level of students' resilience building activities, the following ranking orders were revealed.

With regard to the perceptions of the participant ECD teachers on importance level and performance level, they were asked to rate the resilience building activities.

Table 5.1: Participant Early Childhood Teachers	' Ranking on Degree of Importance and
Degree of performance Concerning Bu	uilding Students' Resilience According to
the Received Mean Value	

Rank of	Perceived Importance	Rank of	Performance on Activity
Importance	Activity of building	Performance	of building students'
	students' resilience		resilience
1 st	SRS (4.66)	1 st	SRSP (4.44)
2^{nd}	SSOA (4.56)	2^{nd}	SPRP (4.38)
3 rd	SDM (4.55)	3 rd	SSOAP (4.27)
4^{th}	SPR (4.3)	4^{th}	SSMP (3.89)
4^{th}	SSM (4.3)	5 th	SOTP (3.80)
6 th	SSA (4.14)	6 th	SSAP (3.79)
7 th	SOT (4.01)	7 th	SDMP (3.77)
8 th	SGDB (3.91)	8 th	SGDBP (3.69)

Moreover, according to the above -mentioned rankings in Table 5.2, it can be analyzed as follows:

 Table 5.2: A Comparison of Participant Early Childhood Teachers' Ranking on Degree of Importance and Degree of performance Concerning Building Students' Resilience

Importance vs. Performance	Ranks of Importance	Ranks of Performance
SRS vs. SRSP	1 st	1 st
SSOA vs. SSOAP	2^{nd}	3 rd
SDM vs. SDMP	3 rd	7 th
SPR vs. SPRP	4 th	2^{nd}
SSM vs. SSMP	4 th	4 th
SSA vs. SSAP	6 th	6 th
SOT vs. SOTP	7 th	5 th
SGDB vs. SGDBP	8 th	8 th

The resilience building activity "Support Relationship Skill (SRS)" was ranked as extremely important in helping children become more resilient. Accordingly, participant early childhood teachers enabled to perform the most. For supporting Social Awareness (SSOA), participant early childhood teachers perceived it as the second most important and they could perform that as the second most. But, for Support Decision Making, participant early childhood teachers could not perform very well. They only enabled to perform this as the second last.

Unlike the other activities, although the participant early childhood teachers the activity "Support Personal Responsibility (SPR)" as the fourthly important, they currently perform this as the second most. Support Self- Management (SSM)" activity was perceived as the fifth in rank for importance, accordingly they were enabled to perform fifthly. Similarly, "Supporting Self Awareness (SSA)" activity was perceived as the sixth in rank for importance, accordingly they were enabled to perform Sixthly. Although the "Support Optimistic Thinking (SOT)" was perceived as the second last important, it was found that they performed it as the fifth most. Finally, Support Goal-Directed behavior (SGDB) was perceived as the least important and accordingly performed as the least one.

Findings from analyzing the degree of importance and the extent of performance indicated that the participant teachers could not apply pedagogical knowledge on resilience building as they wished although they felt that all of these resilience building practices were so important. The results of interview and open-ended responses indicated that the main issues were the limited resources, lack of time, having over workload, lack of training on building students' resilience. On the other hand, it may be because of the motivation level of participant teachers or may be because of their body stamina, they were unable to perform the resilience building activities as they thought these activities were important.

The beta coefficients were - Performance Factors in Building Students' Resilience: Support Self Awareness (Performance), Support Self -Management (Performance), Support Social Awareness (Performance), Support Relationship Skill(Performance), Support Goal-Directed Behaviour (Performance), Support Decision Making (Performance), Support Personal Responsibility(Performance) and Support Optimistic Thinking (Performance) significantly predicted Performance Total when all eight variables were included. According to the β weights, Support Decision Making (Performance variable) ($\beta = .60, p < 0.001$) appears to be the best predictor of teachers' performances in building students' resilience. Support Goal- Directed Behaviour (Performance variable) ($\beta = .34, p < 0.001$) appears to be the second-best predictor of teachers' performances in building students' resilience. Support Social Awareness (Performance variable) ($\beta = .28, p < 0.001$) appears to be the third best predictor of teachers' performances in building students' resilience. Support Social Awareness (Performance variable) ($\beta = .27, p < 0.001$) appears to be the fourth best predictor of teachers' performances in building students' resilience. Moreover, teachers' knowledge on understanding learners and qualification (the consistency of degree and the subject to be taught) appears to be important for teachers' performances in building students' resilience.

Based on the findings of this study and review of the related literature, a proposed training mode of this study was verified and illustrated in Appendix C. In order to verify the proposed training model, five Resilience Awareness Training Workshops (RATWs) were conducted in five different settings: preschool, primary school, middle school, high school and a training center for mentors. After conducting the workshops, the participants were interviewed and observed in their classroom's settings. They replied that before they did some of their classroom activities which they learned in the workshop without knowing the benefit of these activities. Only after attending the RATW, they feel more confident in performing these activities and realizing that they are building their students' resilience. They feel more meaningful in performing their job. These responses showed that Resilience Awareness Training Workshop, as an intervening variable, really promote the participant early childhood teachers' knowledge and performances. These qualitative findings support the quantitative findings of his research. So, it can be concluded that the proposed model shown in Appendix A is now verified.

Recommendation

In sum, a high – quality early childhood programme should be designed in order to enhance students' social and emotional development especially students' resilience building. Such early childhood programmes provide children with highly qualified teachers, small class sizes with high teacher-student ratios opportunities to pursue their interests and interact with their peer, and activities intentionally designed and implemented to educate the whole child. Among the benefits fond from such programmes; children are more likely to graduate from high school, continue with higher education, and have lower rate of drop out, lower rate of teen-age pregnancy, special education placement, disruptive behaviour and arrests. They are more likely to give feedback to their neighbours as adults by participating in volunteer works these benefits and associated economic returns have only been found on programs that are highly qualified.

- In order to build the students' resilience, the whole school approach should be applied. That is to give resilience awareness training to principles / head of the early childhood centers.
- Preschool and KG classes should be well facilitated with sufficient number of kit boxes.
- Preschool and KG teachers should have opportunities to attend resilience awareness training workshop.

- Parent education concerning how to build their children's resilience as well as their own.
- Parents of younger children should be informed how to interact with their youngsters to build their resilience.
- Resilience-rich environment must be created at school as well as at home.
- Toys such as "pyit-taing-taung" (dumbling), bounce-able balls should be provided.
- Based on the findings of this study, most of the ECD teachers performed.
- The participant teachers responded this question as follows:
- Role-play, imaginative pay, illumine stories, illumine historical incidents/ stories, cooperative play, group assignments/ works, stores on national heroes, illumine songs, illumine rhymes, national anthem, creative play, excursion, toys which can give experiences of win and lose, games which can build team spirit, child-centered method, physical training, exercises and lively dances should be used in building students' resilience.
- Games or play which can promote children' cooperation, team-spirit, reasoning power, learning, illustrative/ portrayal and age-appropriate. Moreover, football, basketball, badminton, golden brown kite, Indian girl trading on lines game, snake and ladder, domino, chess, backgammon, banyan tree spirit, turtle egg and mother turtle game, salts, see-saw, swing, dosed, coloring and roping should be used in building students' resilience.
- Dice, ball, toy sets for role play such as pretending as a doctor, an engineer, teacher, a cook etc., musical instruments such as drums, flutes, ropes and building blocks.
- Stories such as illumine stories, stories hic van promote students' zeal, courage, patience, assiduity, Mahawthahta stories, ten-zat-tawgyi, Pho Kyair, crocodile and monkey, Are you my mother?, noisy night,, Ma Pu Kywe and little snail, Where are you going Jer Baut?, Considerate Bear, Three piggies, let us unify, reserved and hardworking spider, wise bird, little rabbit Phyu Phyu, a rabbit and a tortoise, a giant and three goats, an ant and a locust, a little bat, Mi Phyu, thankful ant, little mushroom Phyu Phy and so on.
- Songs which can promote students resilience, se-concept, confidence etc. illumine songs, illumine rhymes, national anthem, Myanmar school, one step ahead, little gourd, we can do it, our national ethnic, if you are happy..., allegro songs, fall-out songs, bed number 18, we all unanimous, pineapple and durian and so on.
- Pictures of respectable national leaders, pictures showing the kindness or consideration like helping to stand up the fallen person, a person who is receiving award/ trophy, people pushing the wheel together, pictures showing different emotional expression, pictures which show paying respect to holy persons, parents, teachers, elders and so on.
- Teachers' manner should be encouraging, kind, considerate, gentle, sincere, courageous, initiative, intimate, resourceful, recognizing the name of he/his students, fair and square, responsible, honest and so on.

- Teachers should dress properly, presentably and decently, they must be chirpy, neat and tidy, warm, benevolent, tolerant, initiative, optimistic and caring.
- Others who/which can facilitate students in building their resilience include students' families: parents; siblings, neighbours, peer, age-mates, classmates, relatives and community should be aware of the importance of resilience building and resilience building activities.

Need for Further Research

This study "Developing a Training Model for Early Childhood Teachers in Building Students' Resilience" was a preliminary investigation which was essential for promoting early childhood wellbeing which is recognized as the first of the six Learning Development Areas in Myanmar National Curriculum Framework for ECCD-Kindergarten (2013).

The area of should be extended to other different states and divisions as well as different school levels. Moreover, further research should be conducted to cover:

- teachers' resiliency: a key to career longevity;
- variations in early childhood teachers' work, lives and effectiveness;
- challenges and supports in the first year of novice early childhood/ kindergarten teachers;

directions in ECD teacher training for low-burnout teaching: coping with everyday life;

- teaching and learning resilience;
- early childhood teachers' misunderstandings of resilience etc.

Verified Training Model for Early Childhood Teachers in Building Students' Resilience

Based on the findings of this study, the review of related literature, the training model of early childhood teachers in building students' resilience is verified by five Resilience Awareness Training Workshops. The developed *Training Model for Early Childhood Teachers in Building Students' Resilience is illustrated in F*.

This study investigated different combinations of teachers' variables to empower the teachers' performance on building students' resilience. The relationship of teacher characteristics (presage variables) to teacher behaviours (process variables) was investigated. The relationships between such variables as teachers' pedagogical knowledge levels on child development, their knowledge levels on resilience and perceived importance level of resilience as well as the amount of performances teachers give. This study also concentrated on the relationship of contextual variables to teacher behaviour (context – process). It was investigated, among other things, whether teachers of low resilience level behave differently from teachers of high resilience level. This study has attempted to link any more than two of these variables at one time. Presumably, this limitation in the scope of research explains in part why its results have not been more revealing.

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In Conclusion, the verified model was revealed. This model (Figure 5) shows the presence of relationships between pedagogical knowledge of child development and practices of early childhood teachers in building students' resilience (r=.12, p=.25), pedagogical knowledge on resilience and practices of early childhood teachers (r=.21, p=.12), and teachers' resilience level and practices of early childhood teachers (r=.09, p=.30). And the relationship between teachers' perceived importance of building resilience level and performance level (r=.27, p = .07) was found out. Moreover, the factors which were contributing to teachers' performance on building students' resilience in early childhood were investigated. Finally, the processes of building early childhood students' resilience were coming up.

Acknowledgements

I am deeply grateful to Dr. Khin Zaw (Retired Rector, Yangon Institute of Education), and Dr. Aye Aye Myint (Rector) who allowed me to do this research. I also would like to express my heartfelt gratitude to U Ye Myint (Retired Professor, Department of Educational Theory, Yangon University of Education), Dr. Daw Mya Kywe (Retired Professor, Department of Educational Theory, Yangon University of Education), and Daw Tin Tin Hla (Retired Associate Professor, Department of Educational Theory, Yangon University of Education) for their advice, guidance and long-standing commitment for my dissertation. I would like to express my heartfelt gratitude to Dr. Aye Aye Cho (Retired Professor, Department of Educational Theory, Yangon University of Education) for her great support, expert guidance, valuable advice and encouragement. I would like to convey my heartfelt thanks to Dr. Daw Htay Khin (Professor, Head of Department, Department of Educational Theory, Yangon University of Education) for her valuable advice, kindly support and constructive remarks on this dissertation. Department of Education) for their great help and valuable suggestions during this study.

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INDUSTRIAL AGGLOMERATION OF WEAVING FIRMS IN AMARAPURA TOWNSHIP

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J-001 INDUSTRIAL AGGLOMERATION OF WEAVING FIRMS IN AMARAPURA TOWNSHIP

Dr. Thiha Htun¹

Abstract

This study attempts to examine industrial agglomeration of weaving firms in Amarapura township. The specific objectives are to analyze the relationship between the degree of industrial agglomeration and industrial growth, to determine the relationship between the effect of agglomeration and industrial growth, and to explore the suggested agglomeration model of weaving firms in Amarapura township. This study utilizes primary data from 81 owners/managers of medium-size weaving firms in Amarapura township in 2016. Multiple regression and ordered logit regression analysis are applied to analyze this study. In exploring the antecedents of industrial agglomeration of weaving firms in Amarapura township, it is found that government policy, heritage, and labor market pooling contribute to concentrate weaving firms in the specific region. In the analysis of degree of agglomeration and agglomeration benefits, it is noted that urbanization and sectoral specialization can generate agglomeration benefits such as technology spillover, specialization and services, shared market for skilled labor, innovation, and interfirm cooperation between weaving firms in the region. However, proximity acts negatively with majority of the degree of industrial agglomeration. Besides, technology spillover, specialization and services, interfirm cooperation are required for industrial growth for number of firms, productivity, labor productivity, subcontracting firms, and employment in the region. Regarding the influence of the degree of industrial agglomeration with industrial growth, although urbanization deters industrial growth, proximity and sectoral specialization directly enhance superior growth potential for weaving industry. There is a distinct feature that shows the direct effect concerning the degree of industrial agglomeration on the growth in Amarapura weaving industry. To sum up, the owners of weaving firms need to take part in getting institutional support and technical assistance from the institution in line with the industrial policy of the country.

Keywords: Industrial agglomeration, Multiple regression, Ordered logit regression, Antecedents

Introduction

Regional concentration and significant effects have become very popular research topic in many areas of the business studies. The fundamental nature of industrial concentration of specific and related industries within a region can be seen as the most distinctive feature of every emerging country, and the industries. The development of industries within the region is the basic feature of many industrial districts in many developing countries. Such kinds of development are essential for the emerging economies due to concentration of industrial activities.

The concentration of specific activities in respective industrial regions is important for the development of individual enterprises and consequently lead to regional development of manufacturing enterprises. These agglomerations can be seen as important features of the economic environment and may provide insights into the nature of the increasing-returns technologies and spillovers which are conducive to the effective implementation of

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industrialization policy in many developed countries. It is necessary to identify changes in the overall situation within the industrial agglomeration districts by analysing the industrial statistics concerned with the growth of industrial organizations and the changing patterns of interfirm relationships within manufacturing firms.

In most countries, economic activity is spatially concentrated. The concentration of specific and related supporting industries is the noticeable feature in the emerging countries and the relationship between industrial agglomeration and economic performance can be seen in the congested industrial areas in the respective regions, and there is a positive relationship between agglomeration and industrial development, and industrial agglomeration leads to superior economic performance.

Industrial concentration of manufacturing enterprises have profound impact on competition in three ways: by increasing the productivity of manufacturing enterprises, by stimulating creativity and innovation, and by creating small firms in the field. Prominent industrial agglomeration effects are specific characteristic of sectors and spaces that have been most deeply transformed by economic reforms and market orientation. The industrial development can be based on clustering of private enterprises in a specific region, and formulated on the effective use of skillful employees from the competing enterprises and nearby industrial region.

Amarapura weaving is the trademark of Myanmar traditional cottage industry in the country, and the concentration of weaving enterprises in the region is directly related with larger metropolitan area of Mandalay region. This weaving industry is the most successful and the concentration of weaving industries and other industrial organizations are successfully operated in the region. The effective use of skillful workforce from the enterprise in the region, and the development of marketing network in the region are beneficial for the policy makers to formulate and implement industrial development in the region.

Urbanization benefits for weaving enterprises are distinct in Amarapura township and the specialization of weaving skill is the most obvious in the country. The beneficial supporting role of urban feature seems to be a more productive force for the agglomeration of weaving and supporting related enterprises in Amarapura township as a whole. Training skill for weaving enterprises is mainly sourced from the training school in this township, and such kind of infrastructure and institutional support are essential for the establishment of concentrated industrial region. The establishment of successful weaving firms in the region is common. The foundation and development progress seem critical for the ongoing stream of developing region which tends to concentrate and specialize the traditional weaving business in the region. This region can be seen as a further progress pattern for industrial development and regional competitiveness in the country.

1.1 Objectives of the Study

The overall objective of the study is to examine industrial agglomeration of weaving firms in Amarapura township. The specific objectives of this study are:

(1) To analyse the relationship between the degree of industrial agglomeration and industrial growth,

- (2) To determine the relationship between the effect of industrial agglomeration and industrial growth, and
- (3) To explore the suggested agglomeration model of weaving firms in Amarapura township.

1.2 Scope and Method of the Study

This study is focused on the industrial agglomeration of weaving firms in Amarapura township which has the most famous weaving business in the country; the region has larger weaving business to develop new products and outsource suppliers from the outside area such as Windwin and other outside areas of this township; the region is near the urban area Mandalay city and enjoy urban benefits to trade weaving products and develop market for the traditional business; training school situated in the region provides technology spillover and transfer of training which are crucial for the concentration of firms at present and for the future prospect of weaving business.

This study examines industrial agglomeration of weaving firms in Amarapura township, and the determining factors of industrial agglomeration, degree of industrial agglomeration, the effects of industrial agglomeration, industrial growth of weaving industry are analysed to reflect the concentration of weaving firms in the region. Antecedents of industrial agglomeration of weaving firms in Amarapura township are measured through government policy, heritage, subcontracting, and labor market pooling. Measurements for industrial agglomeration of weaving firms in the region include proximity of firms, urbanization in the region, and sectoral specialization of weaving business, the significant effects comprise spillover, specialization and services, shared market for skilled labor, innovation, and interfirm cooperation. Industrial growth is measured through the growth of such factors: number of firms, productivity, labor productivity, subcontracting firms, and employment in the industry over the last 10 years.

This study uses primary survey data with convenient sampling from entrepreneurs/ mangers in Amarapura, and conducting personal interview with structured questionnaire. In Amarapura township, there are (387) weaving firms in total which consists of (81) medium-sized and (306) small-sized weaving firms in 2016 according to DISI. This study focuses on 81 medium-size weaving firms which represent total population of medium-sized firms in Amarapura township in 2016 to analyze the degree of agglomeration and the impact of agglomeration on industrial growth. In addition, the nature of industrial agglomeration is highlighted through in depth study of the historical evidence of the origin of weaving firms in that region. Secondary data is collected from the annual report of Directorate of Industrial Supervision and Inspection during 2013-2016.

This study applies descriptive and analytical research. A structured questionnaire with five-point Likert scale is constructed, and multiple regression and ordered logistic regression models are applied as analytical methods. Regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Ordered logit regression can be applied when the dependent variable is given the discrete, ordered nature of the response. The logit is really a function of the probabilities that results in a linear model in the parameters.

Literature Review

Most of the literature on industrial agglomeration and economic performance has been concerned with empirical situations in the advanced Western capitalist world (Fan & Scott, 2003). The phenomenon of industrial agglomeration has been well documented in the advanced economies, including Japan (e.g., Nakamura, 1985; Patchell, 1993; Kanemoto et al., 1996; Fujita & Tabuchi, 1997). Fan & Scott (2003) studied industrial agglomeration and development with a survey of spatial economic issues in East Asia and a statistical analysis of Chinese Regions, and they found that many kinds of manufacturing sectors are characterized by a strong positive relationship between spatial agglomeration and productivity.

There are many convincing reasons to expect increasing of agglomeration. Carlino & Kerr's (2015) summarized many impressive results, comprising the role of input sharing, labor market matching, and knowledge spillovers, among others. Knowledge spillovers has received an especially large fraction of attention in their work, and in the literature overall (e.g., Audretsch & Feldman, 1996; Jaffe, Trajtenberg & Henderson, 1993; Moretti, 2012; Kerr & Kominers, 2015). Quigley (2011) stated that specialization can lead to enhanced opportunities for cost reduction in goods production when the production of components of intermediate goods can be routinized or the components of final products mechanized or automated.

Empirical study on industrial development in the inland region of China conducted by Sonobe et al., (2006) is based on a case study of the motorcycle industry, and their study highlighted that clustering of private enterprises and the effective use of human resources recruited from existing state-owned enterprises are the drivers of industrial development. Economic agglomeration can be considered at different levels of aggregation. The best known examples of such highly specialized industrial districts are US carpet production industry in the Georgian city of Dalton (Krugman, 1991) and the Italian textile industry in the city of Prato (Pyke et al., 1990), Porter (1990). Review of empirical study on industrial agglomeration of different industries in some countries is shown in the following Table (2.1).

Authors	Studies	Findings
Fan & Scott	Industrial Agglomeration and	Many kinds of manufacturing
(2003)	Development: A Survey of	sectors are characterized by a strong
	Spatial Economic Issues in	positive relationship between spatial
	East Asia and a Statistical	agglomeration and productivity.
	Analysis of Chinese Regions	
Sonobe, et al.,	Industrial development in the	Industrial development is based on
(2006)	inland region of China: A	clustering of private enterprises and
	case study of the motorcycle	the effective use of human resources
	industry	recruited from existing state-owned
		enterprises
Narjoko (2008)	The Determinants of	All kind of infrastructures and
	Industrial	supporting activities, the availability
	Agglomeration in Indonesia	of skilled labor and professionals,
		and the size of domestic markets, are
		the important factors for establishing
		business.

Table 2.1: Review on Empirical Studies

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Authors	Studies	Findings	
Xayphone &	Inter-Firm Cooperation and	Cooperation with subcontractors,	
Takahashi (2009)	Firm Performance: An	business associations and distant	
	Empirical Study of the Lao	buyers influence firm performance.	
	Garment Industry Cluster		
Cainelli (2006)	Spatial Agglomeration,	Belonging to an industrial	
	Technological	district and making product	
	Innovations, and Firm	innovations are key factors in the	
	Productivity: Evidence from	productivity growth of firms.	
	Italian Industrial Districts		
Li, et al., (2011)	Industrial Agglomeration and	Industrial agglomeration has a	
	Firm Size: Evidence from	positive and statistically significant	
	China	causal impact on firm size.	
		Firms are more likely to become	
		larger by locating with a number of	
		larger firms than with a larger	
		number of firms.	
Rosenthal &	The Magnitude and Causes	Focusing on urbanization economies	
Strange (2004)	of Agglomeration Economies	the cities' population as a measure of	
		agglomeration.	
Ellison, et al.,	What Causes Industry	Market effects, such as proximity to	
(2010)	Agglomeration?	input suppliers and labor market	
	Evidence from	pooling, play a big role that cause	
	Coagglomeration Patterns	industry agglomeration.	

Source: Compilation of Previous Studies

Macasaquit (2008) made a survey on industrial agglomeration in the Philippines, and the researcher found that there is a positive result in terms of the nature of industrial agglomerations in the country. Xayphone & Takahashi (2008) studied inter-firm cooperation and firm performance by doing an empirical study on the Lao garment industry cluster and they highlighted that cooperation with subcontractors, business associations and distant buyers influences firm performance. Johansson & Quigley (2004) explored in detail about the agglomeration and networks in spatial economies and they discovered the complementarities between the productivity benefits of agglomeration and those of network linkages.

The multiple sources of industrial agglomeration, coupled with the political factors, make the studies of economic geography exciting and challenging. Lu & Tao (2006) have used a large data set of China's manufacturing firms for the period of 1998 to 2003 to study the amalgamation of economic and political forces shaping China's industrial agglomeration (Lu & Tao, 2006). There is a positive correlation between industrial agglomeration and firm size, which is previously found in developed economies. However, it is also found that while Marshallian externalities facilitate China's industrial agglomeration, local protectionism among China's various regions obstructs its process of spatial concentration of manufacturing industries (Lu & Tao, 2006).

The empirical evidence suggested that market effects, such as proximity to input suppliers and labor market pooling, play a big role, while there is less support for factors like entrepreneurial culture and industrial diversity (Edward & Kerr, 2008). Other extraneous effects from this positive feedback include a higher rate of productivity growth (Henderson, 1986), more prolific innovation (Baptista & Swann, 1999) and significant information and knowledge spillovers (Oakey, 1985). However, the feedback will not remain positive indefinitely. Beyond some saturation point, congestion and competition might slowdown individual firm's growth and entry, and eventually possibly contributing to the decline of the cluster. This was suggested by Porter and is consistent with the argument on a cluster life cycle theory advanced by Swann et al., (1998).

The gains from concentration, whether in cities or geographic clusters, come from reducing some form of transport costs. Buenstorf & Kelpper (2008) used new data on the location and background of entrants into the US tyre industry to analyse why the industry became so regionally concentrated around Akron, Ohio, a small city with no compelling advantages for tyre production. The researchers analyzed where the Ohio entrants originated and conducted various analyses of how proximity to other tyre firms affected the longevity of tyre producers. The heritage of the Ohio entrants influenced their origin and longevity, and this situations lead to concentration of firms in this place.

2.1 Analytical Framework

The analytical framework in Figure (2.2) describes the independent variables and four dependent variables in the empirical analysis of this study. Antecedents of industrial agglomeration of weaving firms in Amarapura township is firstly analyzed. After that, the degree of industrial agglomeration in Amarapura township is explored.



Figure 2.2: Analytical Framework

Source: Adapted from Previous Studies

There are four main antecedents for analyzing industrial agglomeration and industrial growth; government policy, heritage, subcontracting, and labor market pooling. Effective government policy for industrial agglomeration can be a training school, roads systems, electricity, export promotion policy, import substitution, industrial development program, cluster development program, and land reform program for the region. The important factors for heritage include family trade, traditional business, family business, family ties involvement, parents' business, and succession plan of the organization. Subcontracting relationship forward and backward linkages, enhance business functions and larger subcontractor, networking relationship, mutual agreement; market information sharing, technology sharing, risk sharing, and transaction cost reduction are used to be examined. Dominant factors for the pooling of labor market include specialized local labor, pooling local labor, labor pooling from other region, labor pooling from other industrial districts, and creating job opportunities.

Degree of industrial agglomeration is measured by proximity, urbanization, and sectoral specialization. Proximity of main and supporting industries within a concentrated area is crucial for measuring the agglomeration of industries within a region. The specific measurement for proximity degree and distance are used for agglomeration of weaving and supporting firms in the study area. Urbanization and agglomeration can be seen collectively in the emerging countries and developed countries. Urbanization benefits and share of the urban area include urban feature, area of populated region, household, concentration of enterprises, suburban area development. Various measurement for specialization are specialization of weaving firms and weaving skills, design improvement, machine repair skill, and better quality of raw material for textile weaving firms.

Analytical Results on Antecedents of Industrial Agglomeration

Industrial agglomeration and influencing factors are explored based on such factors such as government policy, heritage, subcontracting and labor market pooling. The overall level of agglomeration of mutual proximity, urbanization, and sectoral specialization is measured on a continuous scale and multiple regression analysis is applied. The antecedents of industrial agglomeration such as government policy, heritage, subcontracting, and labor market pooling on the degree of agglomeration is analysed as described in Table (3.1).

According to the results in Table (3.1), the model explains that the variation in overall level of industrial agglomeration exists as R^2 value is 35.1 percent. This indicates that independent variable can explain 35.1 percent of the variations in dependent variable. Thus, the variability of the residual values around the regression line relative to the overall variability is small, and the predictions from the regression equation are good. The value F of 10.3 with a p-value of 0.000 indicates that the model as a whole is statistically significant at 1 percent level.

Independent Variables	Coefficients	Std. Error	Sig.
Government policy	0.1257*	0.0744	0.095
Heritage	0.2396*	0.1416	0.095
Subcontracting	0.0232	0.0632	0.714
Labor market pooling	0.2525***	0.0660	0.000
\mathbb{R}^2	0.351		
Adj R-squared	0.317		
F	10.3***		
Prob > F	0.000		

 Table 3.1: Relationship between Antecedents and Agglomeration

Note: *** and ** are statistically significant at 1% and 5% levels respectively. **Source:** Survey Data, 2016

Government policy has effect on the degree of agglomeration with the regression coefficient of 0.1257 at a significant level of 10 percent and it implies that degree of industrial agglomeration of firms will increase 0.1257 if the influence of government policy increases by one unit. The formulating and implementation of government policy such as industrial development policy, upgrading basic infrastructure, and better transportation system enhance concentration of weaving firms in a region.

The antecedent factor of heritage has effect on the degree of agglomeration with the regression coefficient of 0.2396 at a significant level of 10 percent and it implies that degree of industrial agglomeration of firms will increase 0.2396 if the influence of heritage of weaving firms increases by one unit. The traditional weaving firms contribute the largest portion in the study, and weaving is the basic livelihood of many native people. Thus, such kind of traditional background of weaving firms lead to developing and agglomerating weaving firms within a specific region.

Labor market pooling has effect on the degree of agglomeration with the regression coefficient of 0.2525 at a significant level of 1 percent and it implies that degree of industrial agglomeration of firms will increase 0.2525 if the influence of labor market pooling increases by one unit. The study area is the major part of a large city and enjoys urbanization and agglomeration advantage which tend to recruit required skilled labor form the larger population area. Such kind of labor market pooling in the urban area and suburban area are significant factors contributing to agglomerate weaving business within a specific region.

The other antecedent factor such as subcontracting has no significant relationship with the industrial agglomeration. Subcontracting does not have effect on agglomeration because some important subcontractors are not within the region but in remote area of the region, major supplies are outsourced from the other regions which have no direct linkages between weaving firms and those large suppliers. Subcontracting relationship and interfirm linkages seem to be fairly few in the early stage of industrial development.

3.1 Agglomeration Effects and Industrial Growth

The important impact of industrial agglomeration is identified and so for many businesses, the growth of firms within a specific region needs to be highlighted. The overall industrial growth of weaving industry is measured on a continuous scale and multiple regression analysis is applied. The effects of industrial agglomeration in this study are technology spillovers, specialization and services; shared market for skilled labor, innovation and interfirm cooperation, and these agglomeration effects on the industrial growth are analysed as described in Table (3.2).

According to the results in Table (4.20), the model explains that the variation in overall level of industrial agglomeration exists as R^2 value is 35.1 percent. This indicates that independent variable can explain 35.1 percent of the variations in dependent variable. Thus, the variability of the residual values around the regression line relative to the overall variability is small, and the predictions from the regression equation are good. The value F of 6.9 with a p-value of 0.000 indicates that the model as a whole is statistically significant at 1 percent level.

Specialization and services have effect on the industrial growth with the regression coefficient of 0.2947 at a significant level of 1 percent and it implies industrial growth of firms will increase 0.2947 if the influence of specialization and services increases by one unit. It is found that specialization for better quality, better dye for product quality, production efficiency are directly linked with improving industrial growth of weaving firms.

Independent Variables	Coefficients	Std. Error	Sig.
Technology Spillovers	-0.0371	0.1067	0.729
Specialization and Services	0.2947***	0.1011	0.005
Shared Market for Skilled Labor	-0.1395*	0.0721	0.057
Innovation	-0.0995	0.1248	0.428
Interfirm Cooperation	0.4384***	0.1093	0.000
\mathbb{R}^2	0.315		
Adj R ²	0.269		
F	6.9***		
Prob > F	0.000		

Table 3.2: Relationship between Agglomeration Effects and Industrial Growth

Note: *** and * are statistically significant at 1% and 10% levels respectively. **Source:** Survey Data, 2016

Interfirm cooperation has effect on the industrial growth with the regression coefficient of 0.4384 at a significant level of 1 percent and it implies industrial growth of firms will increase 0.4384 if the influence of interfirm cooperation increases by one unit. Cooperation with customers, subcontractors, and government institutions are important for knowledge transfer and institutional assistance for weaving firms are vital for the development of industry currently and for the growth of long-run prospects.

Shared market for skilled labor has effect on the industrial growth with the regression coefficient of -0.1395 at a significant level of 10 percent and it implies industrial growth of firms

will decrease 0.1395 if the influence of shared market for skilled labor increases by one unit. Shared market for skilled labor is negatively related with industrial growth because the scarcity of experienced workforce impedes growth potential in the region. The presence of a training school in the study region promotes the performance of skilled workforce to some extent but does not solve the scarcity of skilled labor for weaving firms. Thus, training workforce from vocational schools in the study region is essential to develop the shared market for skilled labor for the weaving industry.

However, technology spillovers, shared market for skilled labor, and innovation are not significantly related with industrial growth of weaving firms. Technology spillover and innovation are not related with industrial growth because knowledge benefits and new products take considerable amount of time to gain growth advantage. These benefits of industrial agglomeration can stimulate the attractiveness of industry to be productive and remain the main stream of business transaction in the region, and this indirect linkages seem to be somewhat blur in the industrial area.

3.2 Industrial Agglomeration and Industrial Growth

The overall level of industrial agglomeration has substantial effect on the industrial growth of weaving firms in the study region as a whole, and the relationship between industrial agglomeration factors and industrial growth gives useful insights into planning industrial policies and development plans for industrial districts. The overall industrial growth is measured on a continuous scale and multiple regression analysis is applied. The relationship between level of industrial agglomeration and industrial growth is shown in Table (3.3).

Independent Variable	Coefficient	Std. Error	Sig.
Industrial Agglomeration	0.7171***	0.1432	0.000
\mathbb{R}^2	0.240		
$\operatorname{Adj} \operatorname{R}^2$	0.231		
F	25.0***		
Prob > F	0.000		

Table 3.3: Relationship between Industrial Agglomeration and Industrial Growth

Note: *** is statistically significant at 1% level. **Source:** Survey Data, 2016

According to the results in Table (3.3), the above model explains that the variation in overall level of industrial agglomeration exists as R^2 value is 24 percent. This indicates that independent variable can explain 24 percent of the variations in dependent variable. Thus, the variability of the residual values around the regression line relative to the overall variability is small, and the predictions from the regression equation are good. The value F of 25.0 with a p-value of 0.000 indicates that the model as a whole is statistically significant at 1 percent level.

Industrial agglomeration has effect on industrial growth with the regression coefficient of 0.7171 at a significant level of 1 percent and it implies that industrial growth will increase 0.7171 if the influence of industrial agglomeration increases by one unit. It can be concluded that industrial agglomeration of weaving business and related supporting business generate the

foundation for improving industrial growth in firms, and improving productivity of weaving firms in the region.

Conclusion

This study analyses the industrial agglomeration of weaving firms in Amarapura township. In Myanmar, Amarapura township is famous for its weaving firms, and there are many successful weaving firms and related supporting industries, and training school in this region. There is a growing trend in number of weaving firms in this township and the total number of weaving firms in 2016 is 387. Large successful weaving firms are the primary reason to agglomerate in Amarapura township, and these firms were selected in this study. With the rapid growth in the infrastructure development and market accessibility, small and micro weaving firms are emerging in this area, and such kinds of firms enjoy economies of scale and agglomeration benefits.

Major antecedent factors for industrial agglomeration are government policy, heritage, subcontracting relationship and labor market pooling within a specific region as a whole. Among the attributes concerning with government policy, roads system contribute the largest mean value concerning government policy for weaving firms within a specific region. The government policy to improve road system is essential to promote the development of the region and the faster movement of people and commodity. Land reform program of government policy has the lowest mean value for the concentration of weaving firms within a specific region. It can be found that land reform program is implemented in the newly emerging industrial districts and attractive industrial park in many special zones.

In this study, degree of agglomeration can be measured through proximity, to urbanization and sectoral specialization, and agglomeration benefits can be assessed through technology spillover, specialization and services, shared market for skilled labor, innovation and interfirm cooperation. Proximity has negative effect on technology spillovers as large firms can employ high tech equipment and some small scale firms cannot enjoy technology benefits. It is found that larger degree of urbanization attract technician and skilled labor with great expertise creating job opportunities and employment benefits. After that, sector specialization for same weaving business, enhancing weaving skills, and improving design requires great effort to outperform competitors. Such kind of endeavor lead to diffusing to other firms and related supporting business within the region.

In order to advance the industrial growth, it is necessary to utilize the spillover advantages to be compatible with the organizational resources by monitoring the nature of dynamism of industrial organization and changing nature of the market. Moreover, weaving firm's owners should attempt to have entrepreneurial spirit, and retain effective skilled labor to grasp the opportunities concerning the spillover effects in the industry. The manufacturers of weaving industry are required to forecast and implement ways to exploit and maximize the fruitful effects of industrial concentration in this region.

The empirical results show that sectoral specialization has significant effect on number of firms' growth, productivity growth, labor productivity growth, subcontracting firms' growth, and employment growth, and industrial growth in the weaving industry of Amarapura township.

Proximity of firms in the weaving industry has effect on the productivity growth, labor productivity growth, the employment growth, and industrial growth. Urbanization in the region has negative effect on the labor productivity growth of firms, and the employment growth of firms. The overall level of industrial agglomeration has significant effect on number of firm's growth, productivity growth, labor productivity growth, subcontracting firm's growth, and employment growth, and the overall industrial growth of weaving industry. Thus, it can be concluded that industrial agglomeration is directly related to industrial growth of weaving firms rather than the relationship between agglomeration effects and industrial growth of weaving firms in the region.

The study of agglomeration in this study is based on primary data of survey from weaving firms, and most points presented are mainly based on perception of weaving firm's owners to reflect the current situations of weaving industry. Information concerning the industrial data of weaving firms represents for a limited period from secondary data, and further study could be undertaken with specific time series data of weaving industry. A further study could be done using primary financial data to analyze industrial growth and other performance indicators of weaving industry.

Summary

Industrial development in some garment industries in many emerging economies was led by marketers who had excellent marketing expertise and effective and efficient distribution network. The rapid growth of weaving firms in Myanmar is of vital importance for fulfilling market demand to enhance employment growth and regional industrial development. According to previous studies and findings, industrial agglomeration of weaving firms in Myanmar is also interested to provide recommendations to entrepreneurs on how to improve firm performance through the agglomeration impacts in a competitive market based on findings by highlighting areas needed to modify.

The concentration of firms in the region enhances specialization and helps overcome the disadvantages of being small. Developing clusters, business associations, and value chains are key ways for industries to foster business linkages and increase market access. Specialization in the main industrial operations and related supporting transactions are the basic reason to agglomerate within a specific region which has natural advantage for production, distribution to the market and outsourcing required tangible resources for production process.

This study utilizes primary data from 81 owners/managers of medium-size weaving firms in Amarapura township in 2016. Multiple regression and ordered logit regression analysis are applied to analyze this study. In exploring the antecedents of industrial agglomeration of weaving firms in Amarapura township, it is found that government policy, heritage, and labor market pooling contribute to concentrate weaving firms in the specific region. In the analysis of degree of agglomeration and agglomeration benefits, it is noted that urbanization and sectoral specialization can generate agglomeration benefits such as technology spillover, specialization and services, shared market for skilled labor, innovation, and interfirm cooperation between weaving firms in the region. However, proximity acts negatively with a major degree of industrial agglomeration. Besides, technology spillover, specialization and services, interfirm cooperation are required for industrial growth for number of firms, productivity, labor productivity, subcontracting firms, and employment in the region. Regarding the influence of the degree of industrial agglomeration with industrial growth, although urbanization deters industrial growth, proximity and sectoral specialization directly enhance superior growth potential for weaving industry. There is a distinct feature that shows the direct effect concerning the degree of industrial agglomeration on the growth in Amarapura weaving industry.

Acknowledgements

I would like to express my grateful acknowledgment to Dr. Tin Win, Rector of Meiktila Institute of Economics, for his guidance during the preparation of this paper. I also wish to convey my heartfelt thanks to Professor Dr. Khine Mar Hlaing, Head of the Department of Management Studies, for her kind guidance and support from the beginning until the completion of this work. Without their support, this thesis would not have been possible.

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Ø	ည်	ပါရဂူကျမ်း/ သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
1	1	a&IvvðbpvvbvvmítzØpmayrsm; (pmay)*	Myanmar	Dr Khin Aye Thet Assiociate Professor Myeik University
2	2	rk k rke, f ræa'od, pum;avhvmcsu (bmom)*	Myanmar	Dr Mi Nwe Than Assistant Lecturer University of Yangon
3	3	&c l ft ajymo ' ģ(bmom)	Myanmar	Dr Sandar Htay Assistant Lecturer, Sittway University
4	4	All/focifq&m\ uiufplyfpmay (pmay)	Myanmar	Dr Cho Me Ye Naung Assiociate Professor Kyaingtong University
5	1	A Study of the Use of Parallelism in the Novel A Tale of Tow Cities By Charles Dickens*	English	Dr Su Khine Oo Assistant Lecturer University of Foreign Languages
6	1	Socio-Economic Conditions of Myothit Township in Magway Region (1800-1900)*	History	Dr Aye Mya Thwin Lecturer University of Magway
7	1	Resilience to Chidhood Abuse and Neglect in University Students from Yangon Region*	Psychology	Dr Hnin Thandar Linn Assistant Lecturer Dagon University
8	1	A Study on the Protection of Persons and Property of Aliens	Law	Dr NLan Roi Ja Assistant Lecturer University of Yangon
9	1	Fabrication and Characterization of NiO Anodic Electrochromic Layer for Smart Window Application*	Physics	Dr Sau Swang Lecturer University for the Development of the Nation Races of the Union
10	2	Theorerical Interpretation on D (π^+ , K ⁺) X Missing-Mass Spectrum of J-PARC E-27 Experiment	Physics	Dr Hnin Hnin Hlaing @ Nu Nu Lwin Assistant Lecturer Mandalay University of Distance Education
11	1	Species Composition, Abundance, Density, Habitat Utilization, Feeding Habit and Diversity of Birds in Pakokku Environs, Magway Region	Zoology	Dr Yandanar Myo Assistant Lecturer University of Mandalay

٩	ဉ်	ပါရဂူကျမ်း/သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
12	2	Detection of Insecticides Susceptibility of <i>Aedes aegypti</i> (Linnaeus, 1762) and <i>Ae.albopictus</i> (Skue, 1894) From Selected Townships in Mandalay and Determination of Resistance Based on Biochemical Assay*	Zoology	Dr Yi Yi Mya Director Pyin Oo Lwin Branch
13	1	Phytochemical Investigation of <i>Kaempferia</i> galanga L. And Its Antipyretic Activity	Botany	Dr Phyo Moh Moh Zin Demonstrator East Yangon University
14	1	Geology, Geochemistry and Ore Genesis of The MODI-MOMI Gold Deposit, Yamethin Towwnship, Mandalay Region*	Geology	Dr Kyaw Linn Zaw Lecturer West Yangon University
15	2	Petrological and Petrochemical Studies of Igneous and Metasedimentary Rocks in Bilin and Its Environs, Bilin Township, Mon State	Geology	Dr Mya Moe Khaing Lecturer Taunggyi University
16	3	Petrology and Geochemical Analyses of the Rocks in the Kawthaung-Bankachon Area, Tanintharyi Region	Geology	Dr Zin Mar Oo Assistant Lecturer Mawlamyine University
17	4	Petrology and Antimony Mineralization in the Taungnyo Formation of Natsan, Thwethauk and Tagundaing Areas, Kyaikmaraw, Mawlamyine and Mudon Townships, Mon State	Geology	Dr Sanda Aye Lecturer Mawlamyine University
18	5	Sedimentology of the Moulmein Limestone Exposed in Mudon and Kyaikmaraw Township, Mon State	Geology	Dr Nandar Myint Maung Lecturer Mawlamyine University
19	1	Study on the Ichthyoplankton of Myanmar Coastal Water*	Marine Science	Dr Naung Naung Oo Assistant Lecturer Mawlamyine University
20	2	Morphotaxonomy of the Agarophyte species of the family Gracilariaceae (Gracilariales, Rhodophyta) of Myanmar	Marine Science	Dr Jar San Assistant Lecturer Mawlamyine University
21	1	Sustainability of Cooperative Microfinance in Southern Shan State	Economics	Dr Kyar Ngon Sann Lecturer Meiktila University of Economics
22	2	Employee Retention In Myanmar Hotel Industry	Economics	Dr Phu Pwint Nyo Win Aung Assistant Lecturer Yangon University of Economics
23	3	The Impact of Public Spending on Economic Growth in Myanmar (1980-2014)	Economics	Dr Naw Htee Mue Loe Htoo Associate Professor Yangon University of Economics

0	ည်	ပါရဂူကျမ်း/ သုတေသနလုပ်ငန်းအစီရင်ခံစာအမည်	ဘာသာရပ်	ကျမ်းပြုစုသူ
24	4	Corporate Social Responsibility and Business	Economics	Dr Yin Min Htwe
		Growth of Myanmar Private Enterprises		Lecturer
				Yangon University of
				Economics
25	5	Investment Decisions in Myanmar Commodity	Economics	Dr Hla Hla Mon
		Market (A Case of Black Gram Trading)		Associate Professor
				Yangon University of
	,			Economics
26	6	Internal Corporate Social Responsibility and	Economics	Dr Than Soe Oo
		Employee Commitment in Private Banks		Assistant Lecturer
				Yangon University of
~ 7	_			Economics
27	/	Industrial Agglomeration of Weaving Firms in	Economics	Dr Thiha Htun
		Amarapura Township*		Lecturer
				Meiktila University of
20	0			Economics
28	8	Customer Retention of Supermarkets in	Economics	Dr Sandar Aye
		Mandalay		Lecturer
				Monywa University of
20	0		<u>р</u> ·	Economics
29	9	Relationship Marketing Tactics and Customer	Economics	Dr Myint Myint Naing
		Loyalty of Restaurants in Mandalay		Lecturer
				Monywa university of
20	1		<u>г</u> ·	Economics
30	I	An Inverstigation into the Impact of Extended	Economics	Dr Knaing Ei Phyu Tun
		Reading Exercises Focusing on Text Structure		Senior Assistant Teacher
		on Learners of English as a Foreign Language		Education
21	2	Development of a Teacher Empowerment	Education	Dr Lily Myint
51	2	Model for Improving Teaching Practices of	Education	Assistant Locturer
		Lower Secondary Science Teaching Flactices of		Vangon University of
		Lower Secondary Selence reachers		Education
32	3	Developing an Instructional Leadership Model	Education	Dr Hla Thet Paing
52	Ŭ	for Promoting Primary Students' Creative	Laucation	Tutor
		Thinking Skills		Kathar Education College
33	4	Developing a Training Model for Farly	Education	Dr Su Su Thwin
		Childhood Teachers in Building Students'	Zaadution	Associate Professor
		Resilience*		Yangon University of
				Education
34	5	An investigation into the Impact of Process	Education	Dr Yin Nwet
	Ŭ	Approach to Teaching writing in Myanmar	Lauranon	Assistant Lecturer
		Language at the High School Level		Yangon University of
				Education

*ဆုရ သုတေသနလုပ်ငန်းအစီရင်ခံစာ ဖြစ်ပါသည်။

စဉ်	စာအုပ် အမျိုးအမည်	ရှိုန်း (ကျပ်)
1	Proceeding Vol. I	700
2	Proceeding Vol. II	700
3	Journal of MAAS Vol. I., (No.1 to 3)	800
4	Journal of MAAS Vol. II, (No.1 to 6)	850
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7	Journal of MAAS Vol. III, No.3 (Phyaics + Mathematics)	1000
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11	Journal of MAAS Vol. IV, No.1 (Chemistry)	1500
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21	Journal of MAAS Vol. V, No.1B (Chemistry)&(Industrial Chemistry)	1500
22	Journal of MAAS Vol. V, No.2 A (Physics)	2000
23	Journal of MAAS Vol. V, No.2 B (Physics)	1800
24	Journal of MAAS Vol. V, No.3 (Mathematics & Comp. Science)	1700
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26	Journal of MAAS Vol. V, No.5 (Geology & Geography)	1400
27	Journal of MAAS Vol. V, No.6 A (Myanmar & Library Science)	2000
28	Journal of MAAS Vol. V, No.6 B (History, International Relations,	1400
29	Iournal of MAAS Vol. V. No.7 (Edu. Law. Psy. Eco. & Tourism)	1400
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21	Journal of MAAS Vol. VI, No.1 (Chemisury)&(Industrial Chemistry)	1700
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32	Journal of MAAS Vol. VI, No.2B (Physics)	1600
33	Journal of MAAS Vol. VI, No.2C (Physics)	1700
34	Journal of MAAS Vol. VI, No.3 (Mathematics & Comp. Science)	1200
35	Journal of MAAS Vol. VI, No.4(Zoology, Marine Science &Botany)	1600
36	Journal of MAAS Vol. VI, No.5 (Geology & Geography)	1400
37	Journal of MAAS Vol. VI, No.6A (Myanmar)	2300
38	Journal of MAAS Vol. VI, No.6B (Myanmar, History, International Relations, Philosophy, Anthropology, Archaeology and English)	2000
39	Journal of MAAS Vol. VI, No.7 (Economics, Education, Psychology, Law, Language & Linguistics and Library & Information Studies)	1800

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42	Journal of MAAS Vol. VII, No.2B (Physics)	2500
43	Journal of MAAS Vol. VII, No.3 (Mathematics & Comp. Science)	1300
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45	Journal of MAAS Vol. VII, No.5 (Marine Science)	3000
46	Journal of MAAS Vol. VII, No.6 (Geology & Geography)	1100
47	Journal of MAAS Vol. VII, No.7A (Myanmar)	2500
48	Journal of MAAS Vol. VII, No.7B (Myanmar, History, International Relations, Philosophy, Anthropology, and Oriential Studies)	2200
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50	Journal of MAAS Vol. VII, No.9 (Language & Linguistics and English)	700
51	Journal of MAAS Vol. VIII, No.1 (Chemistry & Industrial Chemistry)	2800
52	Journal of MAAS Vol. VIII, No.2 (Physics)	2000
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54	Journal of MAAS Vol. VIII, No.4 (Zoology)	1800
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56	Journal of MAAS Vol. VIII, No.6 (Geology & Geography)	1500
57	Journal of MAAS Vol. VIII, No.7 A, Myanmar (Literature) and	2800
58	Journal of MAAS Vol. VIII, No.7 B, (Myanmar (Language), Foreign (Language), English, Oriental Studies and Philosophy)	1500
59	Journal of MAAS Vol. VIII, No.8, (History, International Relations, Archaeology and Psychology)	2000
60	Journal of MAAS Vol. VIII, No 9, Education, Law and Economics	3000
61	Journal of MAAS Vol. IX, No.1 (Chemistry & Industrial Chemistry)	3000
62	Journal of MAAS Vol. IX, No.2A (Physics)	2000
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64	Journal of MAAS Vol. IX, No.3 (Mathematics & Comp. Science)	1000
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70	Journal of MAAS Vol. IX, No.8, (History, International Relations, Archaeology, Anth.and Psychology)	1800
71	Journal of MAAS Vol. IX, No 9, Education, Law and Economics	2400
72	Journal of MAAS Vol. X, No.1, Chemistry and Industrial Chemistry	3000
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86	Journal of MAAS Vol. XI, No.4 Zoology	1500
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89	Journal of MAAS Vol. XI, No.7 Myanmar (Literature)	2200
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91	Journal of MAAS Vol. XI, No.9, (History, International Relations, Archaeology, Anth.and Philosophy)	1800
92	Journal of MAAS Vol. XI, No 10, Psychology, Education, Law and Economics	1700
93	Journal of MAAS Vol. XII, No.1 Chemistry & Industrial Chemistry	3000
94	Journal of MAAS Vol. XII, No.2 Physics	2500
95	Journal of MAAS Vol. XII, No.3 Mathematics & Comp. Science	1500
96	Journal of MAAS Vol. XII, No.4 Zoology	1500
97	Journal of MAAS Vol.XII, No.5 Botany and Marine Science	1500
98	Journal of MAAS Vol. XII, No.6 Geology & Geography	1500
99	Journal of MAAS Vol. XII, No.7 A Myanmar (Literature)	1800
100	Journal of MAAS Vol. XII, No.7 B Myanmar (Literature)	2000
101	Journal of MAAS Vol. XII, No.8, Myanmar (Language), English and Library & Information Studies	1500
102	Journal of MAAS Vol. XII, No. 9, (History, International Relations, Archaeology, Anth.and Philosophy)	1800
103	Journal of MAAS Vol. XII, No 10, Psychology, Education, Law and Economics	2300
104	Journal of MAAS Vol. XIII, No.1 Chemistry & Industrial Chemistry	3000

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106	Journal of MAAS Vol. XIII, No.3 Mathematics & Comp. Science	1500
107	Journal of MAAS Vol. XIII, No.4 Zoology & Botany	1500
108	Journal of MAAS Vol.XIII, No.5 Geology & Geography	1500
109	Journal of MAAS Vol. XIII, No.6 Myanmar (Literature)	2000
110	Journal of MAAS Vol. XIII, No.7 Myanmar (Literature) and Library & Information Studies	2000
111	Journal of MAAS Vol. XIII, No.8, Myanmar(Language), English, Foreign(Languages) and Oriental Studies	2000
112	Journal of MAAS Vol. XIII, No. 9, (History, International Relations, Anthropology and Archaeology)	2000
113	Journal of MAAS Vol. XIII, No 10, Law, Economics, Philosophy and Psychology	1500
114	Journal of MAAS Vol. XIII, No 11A, Education	2000
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116	Journal of MAAS Vol. XIV No.1 Chemistry & Industrial Chemistry	2500
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125	Journal of MAAS Vol. XV, No 10, Education	2000
126	Journal of MAAS Vol. XV No.1 Chemistry & Industrial Chemistry	3000
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130	Journal of MAAS Vol.XV, No.5 Geology & Geography	2000
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132	Journal of MAAS Vol. XV, No.7 Myanmar (Literature), Myanmar	2500
	(Language) and Library & Information Studies	
133	Journal of MAAS Vol. XV, No.8 History, Philosophy, Psychology,	1500
124	International Relations	0000
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135	JOURNAL OF MAAS VOL. A V, NO 10 A, Education (Educational $Psychology \pm Educational Theory)$	2500
136	Journal of MAAS Vol. XV, No 10 B, Education (Methodology)	2000

စဉ်	စာအုပ် အမျိုးအမည်	ရှိုန်း (ကျပ်)
137	Journal of MAAS Vol. XVI No.1A Chemistry & Industrial	3500
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138	Journal of MAAS Vol. XVI No.1B Chemistry & Industrial	3500
	Chemistry	
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142	Journal of MAAS Vol.XVI, No.5 Geology & Geography	3000
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ထုတ်ဝေသည့် စာအုပ်များစာရင်း

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34	INDUCTIVE LOGIC, A Handbook for Teachers	1200
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36	q& yg&*lusrf ⊙bw⊙e∨lyfieftp&i£þmrsn (2014 cEþ)	3000
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